Thailand Digital Technology Foresight 2035

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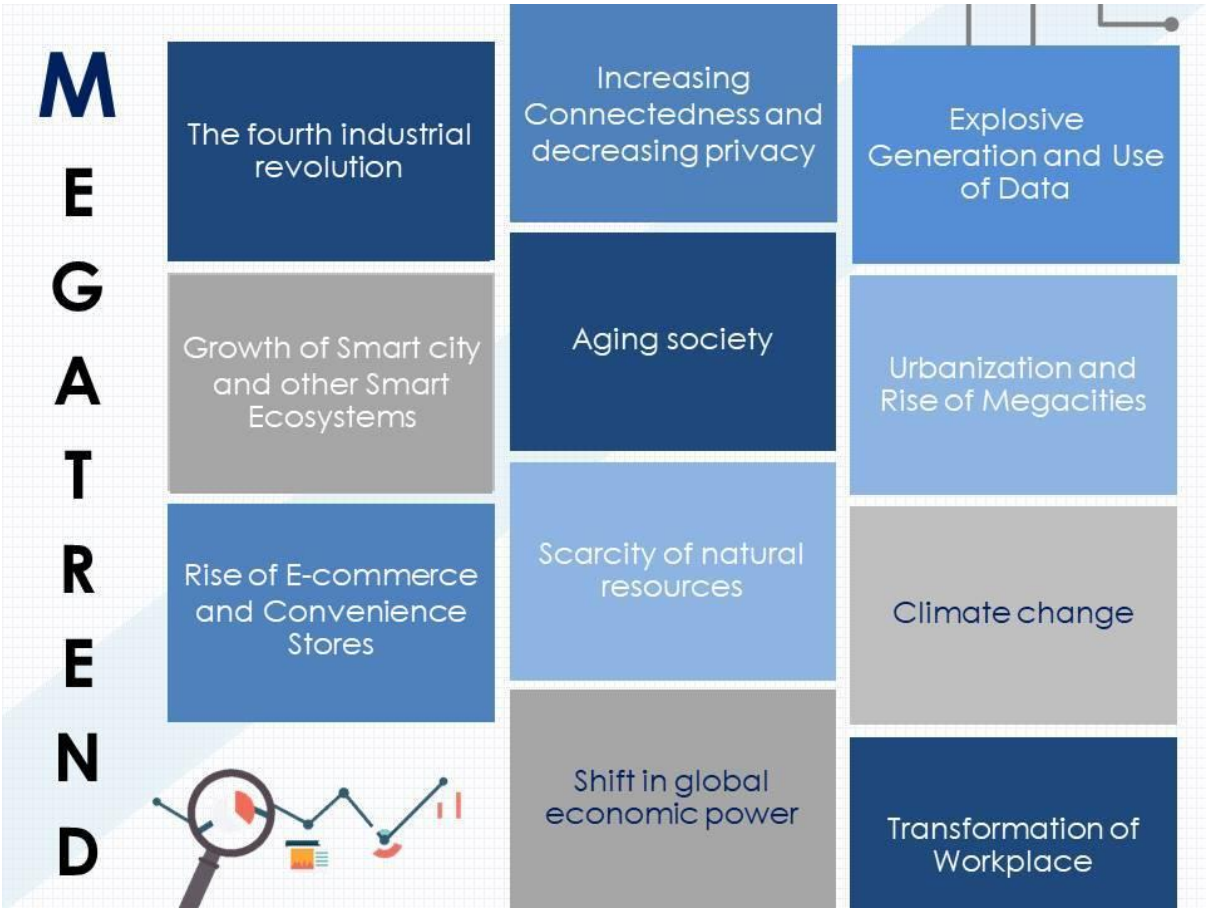
Developed for: depa

Contents

1. Megatrends and related Technology Trends in Thailand

This first section of the report presents 11 Megatrends and related technology trends that will have significant impacts on the Global and Thailand's Digital Economy in the next 15-20 years, including Explosive Generation and Use of Data, The Fourth Industrial Revolution, Growth of Smart Ecosystem, Urbanization and Rise of Megacities, Rise of E-Commerce and Convenience Stores, Increasing Connectedness and Decreasing Privacy, Transformation of Workplace, Shift in global economic power, Aging society, Scarcity of natural resources and Climate change. Each Megatrend comprises of Megatrend in Global context, Technology Trends, Impacts on Thailand, and Conclusion.



1.1 Explosive Generation and Use of Data

1.1.1 Megatrend in Global context

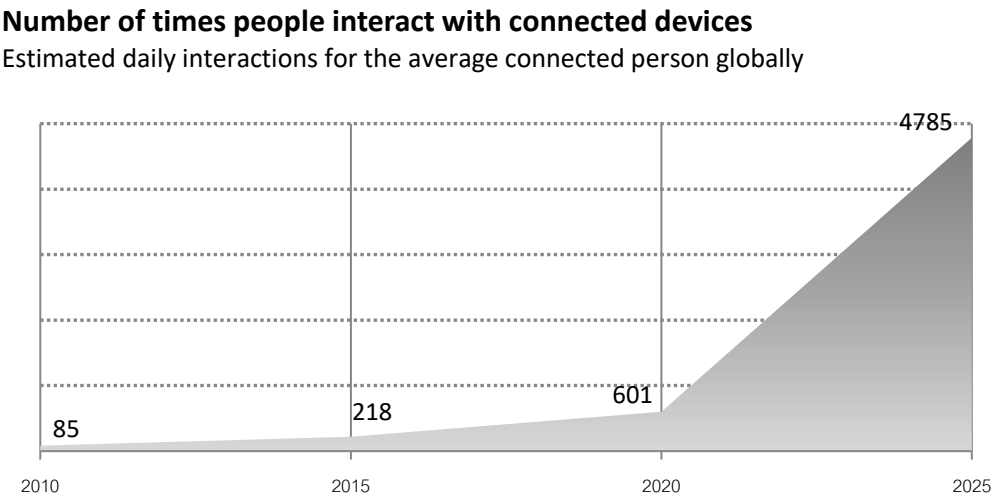
The Data Age 2025 whitepaper predicted that humans will, on average, interact with connected devices nearly 4,800 times a day (or once in every 18 seconds) in 2025 (see Figure 1). It is also predicted that data will sharply grow from 33 zettabytes, as of 2018, to 175 zettabytes by 2025 with a Compound Annual Growth Rate (CAGR) of 61%. The gigantic amount of data will come from sources like cloud, on-premise data center, cell towers, endpoints such as smartphones, and IoT devices alone is expected to account for more than 50% of total data creation. From 2019 onwards, majority of data will be located on the cloud and in data centers rather than endpoints, creating a new trend for the digital era. The explosion in data supports growth for cloud and data centers, as well as data analytics technology.[1]

[1] https://www.networkworld.com/article/3325397/idc-expect-175-zettabytes-of-data-worldwide-by-2025.html

For example, the enormous amount of data is beginning to fuel the transportation infrastructure and mechanisms of smart cities, where citizens now expect to flow to and between urban locations, using multiple modes of transport. In theory, the data harvested from increasing number of sensors and other data-points, blended with GPS technology, can provide real-time mapping to aid smoother inner-city travel.

The amount of data available is exploding; data from mobile phones, smart tickets, CCTV cameras, engine-performance systems and from social media can be used by control systems in traffic lights, emergency services, and for making long-term decisions about routes and demand.[2]

Figure 1. Increasing number of times people interact with connected devices worldwide



Source: IDC

1.1.2 Technology Trends

As the growth of data, generated from IoT devices, automation, high-speed of internet etc. is continuously soaring, businesses are looking for technologies to store and manage data, which in turn leads to an increase in demand for cloud and data centers. Businesses are also expanding their interests into technologies that can upscale business intelligence and improve user experience like data analytics and Big Data as well. The explosive data will bring about a number of use cases of these technologies.

Big Data and Data Analytics

The term “Big Data” refers to enormous data sets that would be impossible for any single human to sort through, therefore demanding the help of automated systems. Big Data and data analytics are one of the technologies coming after the age of data and they will be increasingly utilized in various industry verticals from healthcare to finance to retail in order to better understand patterns and user behaviors and streamline business processes.

Global Big Data market revenues for software and services are projected to increase from $42B in 2018 to $103B in 2027, attaining a CAGR of 10.48%. As part of this forecast, Wikibon estimated that the global Big Data market will be growing at an 11.4% CAGR between 2017 and 2027, growing from

[2] https://www.raconteur.net/business-innovation/data-city-transport-systems

$35B to $103B[3], while global data analytics market (standalone) is predicted to reach $35.78 billion by 2020.

The growth of the Big Data and analytics market is driven by growth of the digital transformation and Internet-of-Things (IoT) market in the Asia-Pacific region. According to Future Ready Singapore, the number of connected IoT devices in Asia is expected to increase to 8.6 billion by 2020, up from 3.1 billion in 2015. IoT devices such as fitness trackers, smart TVs, and smartphones contain networks of sensors that track and collect data.

With the rise of Big Data, companies are looking for skilled employees with the technical abilities to transform large amounts of data into meaningful information. Data analysts will be required to take a more active role in key business initiatives. In the U.S. alone, there will be an estimated 2.7 million job postings for data analytics and science roles by 2020. Today, 59% of the demand is driven by the finance and insurance, professional services and IT sectors.

IT professionals in data-specific roles will be tasked with analyzing Big Data to uncover hidden patterns, identify opportunities and garner insights that drive business innovation and process improvements. Not having qualified data professionals or staff can disrupt product development and go-to-market strategies. Businesses should prioritize hiring data professionals to keep pace with rapidly growing data needs.

Asia-Pacific Big Data Market Share

By component, the Big Data market is segmented into software and services. The software component accounts for majority of the market share through segments like data storage, solutions for discovery of new data, and visualization. The services component, on the other hand, is expected to grow during the forecasted period through higher awareness creation, more trainings, and better services management

By application, the market is classified into retail, manufacturing, healthcare, finance, and others. Applications of Big Data technologies are most prominent in the retail and healthcare sectors, whereby the technologies play crucial roles in the expansion of retail stores and the enablement of advanced cloud-based technologies in diagnostic centers. Manufacturing is the next leading industry for Big Data usage due to increasing adoption of mobile and smart devices for automated processes. Finally, the financial sector is expected to see higher application of Big Data technologies as a result of increasing number of banking applications and increasing preference for online banking.

Concerning geography, Asia-Pacific market is sorted into China, Japan, India, South Korea, Australia, New Zealand etc. Japan is the leading region in the Big Data market due to its higher usage of mobile and smart devices than the other countries.[4]

Artificial Intelligence (AI)

AI is one of the technologies that will be impacted by the explosion of data. However, the growth in data alone does not have a significant impact on the AI market; it needs the advancement in microprocessor along with the improvement in algorithms as well. Recently, AI technology (such as deep learning and natural language processing) has been used in various industries. Examples include medical diagnosis for healthcare and sales performance improvement in retail. The integration between AI and data analytics will be the main engine to support the adoption growth of predictive and prescriptive analytics.

[3] https://www.forbes.com/sites/louiscolumbus/2018/05/23/10-charts-that-will-change-your-perspective-of-big-datas-growth/#10fd05dd2926

[4] https://www.envisioninteligence.com/industry-report/asia-pacific-big-data-market/

IoT

IoT is one of the main data sources responsible for generating half of all data available in the future. Data is generated through tons of embedded sensors and various devices from manufacturing to personal realm. IoT will have a wide range of use cases from smart home concept to engineering aspects. The integration between IoT and data processing/analytics will bring about a new innovation known as Edge Computing, with capabilities such as object detection or collision avoidance.

Fifth Generation Telecommunication Technology (5G)

5G will be one of the main factors driving growth in data traffic. Data tsunami from 5G will be a big enabler for data centers. Its promises on low latency and high bandwidth will open up new data-intensive services and new business area like autonomous vehicles. 5G network infrastructures will immensely support other technologies including IoT, AI and Virtual Reality (VR)/Augmented Reality (AR).

1.1.3 Impacts on Thailand

Like many other countries worldwide, Thailand has been witnessing growth in data traffic. The volume of data services in Thailand as of 2017 was 6 times as much as 2014. The average bandwidth per user is now at 4.11GB per month. The high adoption rate of 3G and 4G, along with high mobile penetration in Thailand, have encouraged people to use more online services and activities such as mobile banking, PromptPay, and e-commerce. With 5G, Thailand is expected to see the exponential growth of data traffic, especially from IoT devices.

Many stakeholders in Thailand have taken actions to maximize the value from unexplored data including adopting innovative technologies such as Big Data and data analytics. Although SMEs in Thailand have not yet adopted Big Data Analytics, but 70% of them plans to do so in the near future, according to SCB survey in 2017.[5] The factors driving the Big Data industry are digital transformation, the huge and vast data created, and the demand for data analysis. Big Data is the key driving factor for supporting the 4.0 industries in Thailand. Big Data is also the key support to the digital transformation that helps maximize value from shifting channels, redefining consumer experience, reinventing new models for products and businesses, driving operational excellence, empowering talent and build teamwork, and connecting the enterprises.[6]

Trend of technology for Big Data in Thailand

The value of Big Data analytics business in Thailand in 2018 is estimated at THB 13.6 billion, a 15% increase from last year, as various sectors are increasingly spending more on systems and related services.

According to the survey, the total value of Big Data analytics in the country was THB 11.8 billion last year. Of the total value, THB 6.4 billion was from vendors, 4.4 billion from system integrators, and 906 million through distributors. In 2017, Thai corporations spent THB 6.4 billion for IT and business service involving Big Data, 3.8 billion for software, and 1.5 billion for hardware.

In 2019, the value of the Big Data market is projected to grow to THB 15.6 billion, of which 9.2 billion will be spent on IT and business services, 4.7 billion for software and the remaining 1.7 billion for hardware.

[5] https://www.thailand-business-news.com/tech/70563-how-is-thailand-using-big-data.html
[6] http://www.nationmultimedia.com/detail/Startup_and_IT/30354999

Big Data Unlocking the Future of Smarter Transportation in Thailand and Southeast Asia

In Southeast Asia, Grab became the region's number 1 Online-to-Offline (O2O) platform equipped with the capability to use Big Data to improve the transportation system due to many reasons:

1. **Large amount of data including insights gained from facilitated rides**

    - Grab is one of the ride-hailing platforms with the largest database in Southeast Asia. Information of this scale is collected over the course of 6 years of service in the region, and almost 5 years of operating in Thailand.
    - Grab has the expertise in processing Big Data from over 2 billion rides and performing comprehensive analysis on traffic conditions, user behavior and travel routes.
    - Data of this scale allows Grab to fully grasp user behavior in Thailand and Southeast Asia. The insights enable Grab to improve the traffic condition in the region and create the opportunity to grow and develop into smart cities.
    - From 2 billion rides facilitated across 235 cities, people all over Southeast Asia use Grab to commute to work, go to school, order their lunch and deliver their packages. This provides Grab with accumulated data of transportation of the future of over 3 petabytes. The size is equivalent to almost 40 years of HD-TV video or close to 690,000 DVDs. Everyday Grab processes about 20 terabytes of data. This is why Grab has the unparalleled insight to provide more tailored solutions to the challenges of each country's infrastructure and traffic conditions.

2. **Best-in-class technology to process Big Data**

    - Aside from enormous sets of data, a comprehensive understanding of the collected data and the investment to enhance the insight gained are essential elements to systematically solve traffic congestion. This is where data science, AI and machine learning come to the rescue and turn Big Data into user insights. It does not only help secure a safer, more convenient and more personalized experience to consumers, but it can also be utilized in planning and tackling larger scale challenges like the traffic congestion found in Thailand and many other Southeast Asian countries.
    - Recently, Grab has announced its 6 million SGD joint venture with the National University of Singapore (NUS) for its first Artificial Intelligence Lab (AI Lab). The lab will be used as the operation center to scientifically analyze and resolve urban transportation challenges, which will eventually lead to the development of smart cities in the future.

3. **Real world experience and a network of partnerships in the public and private sectors**

    - Part of the success in utilizing Big Data to support the government in improving the transportation system and solve traffic congestion in Southeast Asia is due to Grab's partnership with governments, academic and industry partners in each country.
    - One of Grab's Public-Private Partnership initiatives utilizing Big Data to solve traffic condition includes the World Bank's Open Traffic platform project where Grab works with the governments of the Philippines and Malaysia to provide anonymized driver GPS data. This provides insights to the real-time traffic conditions and allows officers to see the congested areas and make timely and well-informed decisions as to where the traffic should be redirected to.
    - For Thailand, Grab partners with the province of Buriram to support its smart transportation Smart Mobility initiative by implementing its ride-hailing service to

accommodate tourists and visitors that will be travelling for the MotoGP, the world's number one Grand Prix motorcycle racing event, which took place on 5 – 7 October 2018.

- Grab's latest initiative is its partnership with Tourism Authority of Thailand to launch local tourism campaign in 5 provinces, covering 25 emerging community attractions in Bangkok, Pattaya, Phuket, Krabi and Surat Thani (Samui). More projects under the partnership are also in discussion.

Using Big Data in Thailand's Finance and Banking

Thailand's State Enterprise Policy Office (Sepo) has linked information about tap water and electricity consumption to Big Data analytics technology to allow the state-owned Small and Medium Enterprise Development Bank of Thailand (SME Bank) to better assess risks and make faster loan approval decisions.

SME Bank can use the information pooled from five state enterprises; namely, the Metropolitan Electricity Authority (MEA), the Provincial Electricity Authority, the Metropolitan Waterworks Authority, the Provincial Waterworks Authority and SME Bank for Big Data Analytics to verify loan applicants' identity and location, while utility usage can imply their business activity, which can be used in making loan approval decisions.

Sepo plans to pool SME data from all specialized financial institutions with the aim of determining the best assistance measures for SMEs. The information is to be kept as a database, and the government will adopt Big Data technology to analyze information such as the nature of the business, the problems the government needs to address, and which businesses contribute to non-performing loans and where are they situated.

The database is to pave the way for SMEs to better access borrowing sources from state-owned banks as financial institutions in the past determined loan approvals based largely on financial statements. SME Bank wants to use information and Big Data technology to verify micro-SME operators' identities, affording them easier access to funding sources.

On the other hand, with Big Data analytics technology, Krungsri Consumer, the consumer-finance arm of Bank of Ayudhya (BAY), can utilize consumer data from its group and business partners in retail business, such as Tesco Lotus, HomePro and Thai Watsadu, to analyze the spending behavior of self-employed workers.

Such behavior can shed light on self-employed customers' loan demand, business trends and debt-servicing ability. At present, bank and non-banking entities regulated by the central bank use credit scoring, financial records and statements to approve loans, a process that prevents self-employed customers from accessing loans, as many of them do not have bank statements.

Using AI and Big Data to support decision making in health and nutrition

The World Bank has been supporting the use of AI and Big Data to achieve its goals of decreasing poverty and increasing shared prosperity, and launched the AI for Development initiative and the AI Lab. Boosting capacity is critical in achieving these goals. In this regard, the World Bank organized a 5-day skills-building program focusing on Big Data, AI, and decision science in health and nutrition in Bangkok. The workshop was successful in creating awareness of the need for analytics to improve decision and delivery choices in health and development, and building capacity on analytical optimization tools that can answer pertinent policy and implementation questions for sectors.

Both government officials and World Bank staff in Thailand aims to apply their newfound knowledge in improving the efficiency of resource allocations to support the national roadmap for ending the AIDS epidemic as a public health threat in Thailand by 2030 – specifically this is to further reduce annual new HIV infections from 6,500 to less than 1,000, cut AIDS-related deaths from almost 13,000 to under 4,000 and reduce HIV-related discrimination in health-care settings by 90%.[7]

Thai agencies and firms using Big Data to revise business model

According to a survey by The Nation newspaper, most of Thailand's state agencies and corporates now use Big Data to revise their business model when digital disrupts their businesses.

For example, the Bank of Thailand (BOT) is investing in Big Data and data analytics in an effort to deal with complicated transactions arising from consumers' micro-financial activities in the digital age. In this age, technology has rapidly changed and is affecting how businesses run, which poses challenges relating to their adoption of technology. In the next five years, the behavior of how people consume information will change. Thus, the BOT must change to comply with that behavior.

In another instance, Charoen Pokphand Foods or CPF announced in 2018 its partnership with JDA Software Inc., a leading supply-chain software developer, to accelerate its digital supply-chain transformation. CPF is moving towards digitalization to improve the operation's efficiency and to provide better consumer satisfaction. Big Data and integrated analytics system are critical to this transformation. With the right information and analysis, the company will be able to forecast the trend as well as conduct cross-functional planning and plant execution more effectively.

Property firm Sansiri Plc. also uses Big Data to find the location and design that match with its customers' demand.[8]

1.1.4 Conclusion

With an enormous amount of current and emerging applications utilizing data as well as Big Data in many sectors across global and national levels, producing an increasing wealth of new, informed insights, intelligence and decision making, the adoption of Data Analytics, Big Data coupled with Artificial Intelligence among the public and private sectors of Thailand should be strongly encouraged and supported by Digital Economy Promotion Agency (depa) and other related stakeholders in order to drive Thailand towards becoming a "data-driven economy". A data-driven economy holds enormous potential and opportunities in various fields, ranging from health, food safety, climate and resource efficiency to energy, intelligent transport systems and smart cities. As companies derive more value from data, with insights driving new innovations and more efficient business processes, more investments will surface from the technology sector. New startups will emerge to tackle challenges to make AI a reality.

1.2 The Fourth Industrial Revolution

1.2.1 Megatrend in Global context

The Industrial Revolution is a change that affects every aspect of daily life in one way or another. This world has passed through three major changes. The 1st Industrial Revolution was a revolution from people and animals to "Steam Machine". This revolution caused repetitive and labor-intensive jobs to be replaced by steam engines using coal as production energy. "Loom" is an important symbol in this era. The 2nd Industrial Revolution was the energy revolution characterized by the usage of electricity and the introduction of production belts. These have been used extensively to reduce the danger of

[7] http://blogs.worldbank.org/eastasiapacific/artificial-intelligence-big-data-opportunities-enhancing-human-development-thailand-and-beyond
[8] http://www.nationmultimedia.com/detail/Corporate/30349588

burning charcoals used in many steam engines. As a result, higher production efficiency and lower production costs were achieved. Mass Production was first coined in this era. The 3rd Industrial Revolution was the revolution with computers and internet, or the beginning of the digital revolution. This made accessing and connecting data, which had previously been limited to geographic and other issues, become much easier. This era gave birth to automated production, which has better production efficiency than before.

The 4th Industrial Revolution will be a big change to the world in terms of size, speed and scope of data transmission. After a decade of stagnated productivity, the Fourth Industrial Revolution is projected to create up to $3.7 trillion in value by 2025. Technologies such as IoT, advanced robotics, AI and additive manufacturing are already contributing to generate net productivity increases. However, technologies must be adopted at scale and diffused throughout the ecosystem to achieve the targeted overall economic and societal impact and to maximize productivity benefits. This requires for strengthened collaboration between governments, businesses, academia and civil society, thus unlocking the full value delivered to the economy and society.

A use case consists of applications of Fourth Industrial Revolution technologies (typically more than one in combination) oriented to reinvent production processes and drive business value by solving specific production problems. These can be across machining, assembly, maintenance, quality, supply chain, design, prototyping and engineering. Additionally, the use cases will happen in several industries such as Aerospace, Automotive, Chemicals and materials, Construction, Consumer goods, Electronics, Energy, Food and beverage, Mining and metals, Oil and Gas, Pharmaceuticals, Tooling and Machinery, and Transportation.

Some examples of new economies generating in industrial 4.0 include Digital Economy, Sharing Economy, 5G Economy, and On-Demand Economy. The On-Demand Economy is set to continue its phenomenal expansion across ever-increasing parts of the economy. Consumer expectation and demand for the immediate provision of goods and services is driving the growth in everything from cloud-based computing resources to same-day deliveries of fresh foods and other goods, facilitated by online and mobile platforms. The On-Demand New Economy Sector is composed of companies at the forefront of innovations in this space.

As illustrated in Table 1 below, the United States could capitalize on its strengths to boost manufacturing output by 14-20% by 2025. This is based on the impact of progressively higher adoption of technology, export growth and share of domestic content in finished goods. The World Economic Forum Country Readiness for the Future of Production project sees the United States as strongly positioned for the future, scoring in the top five across all drivers of production, especially in innovation and technology.

Germany was the first to launch an Industry 4.0 programme (in 2011), followed by the United States, Italy and France between 2012 and 2013. Asian countries (South Korea, Japan and China) have kicked off their national efforts more recently. China's 2016-2020 plan seeks to upgrade key areas of its 10 priority traditional manufacturing sectors to digital manufacturing. This initiative is part of the country's long-term strategic vision to develop intelligent manufacturing to generate new growth and strengthen Chinese manufacturing. Russia became the latest large economy to create a national programme by launching its Advanced Industrial Technologies in 2017. The Indian government launched the Make in India initiative, and is slated to come up with a revamped industrial policy with a key focus on technology adoption. Many other countries, including Australia, Canada and Spain, have also started national-level programs.[9]

[9] http://www3.weforum.org/docs/WEF_Technology_and_Innovation_The_Next_Economic_Growth_Engine.pdf

Table 1. Efforts to diffuse technology and innovation at the national level

Examples		Other countries analyzed
Awareness	Germany: Over 225,000 visitors joined the Hannover Messe's 2017 edition	China, India, America, the United Arab Emirates, Russia
	France: Over 2,300 events organized during "Industry Weeks"	
Financial incentives	Germany: A two-year plan valued at €3.3 billion for boosting the transformation of SME manufacturing capabilities towards Industry 4.0 technologies	Germany, the United Kingdom, Japan, Australia
	China: Manufacturer-led outbound investment in technology, with €20 billion to acquire German-based companies	
Legal framework	Germany: Ju-RAMI 4.0, a framework for understanding the main legal aspects of most common use cases	Australia, Korea, China
	America: Regulated drone operations via introduction of the Drone Operator Safety Act in the US Senate	
Accreditation	France: Alliance Industries du Futur: Agency coordinating relevant industry stakeholders (private and public sectors, academia and civil society)	Germany, China
Connectivity and data security	Germany: Cybersecurity for the Future, a research project of the Frauenhofer-Gesellschaft, with a dedicated taskforce for the industrial security of networks and systems	Australia, American, China
R&D&I	Technology development test beds:	France, Singapore, Germany, China, Australia, America, India
	Italy: Internet of things	
	Canada: Artificial intelligence	
	Korea: Augmented and virtual reality	
Talent and Education	the United Kingdom: Primary and secondary school curriculum updated, including programming skills and piloting the inclusion of 3D printing	Germany, France, Australia, Singapore
	New curriculum at universities: Massachusetts Institute of Technology's (MIT) Industry 4.0 massive open online course; the Stanford Program in Law, Science and Technology	

Source: World Economic Forum and McKinsey & Company

1.2.2 Technology Trends

The Fourth Industrial Revolution, a term coined by the World Economic Forum, is being driven by rapid and mutually reinforcing developments in AI, robotics, ubiquitous connectivity and easily accessible exponential processing power. These innovation catalysts are driving seismic changes, and their impact will be felt in almost every facet of our lives—from the cars we use, how we travel, what jobs we do, and how we generate power, to how long we live and the commercialization of space. The economic impact of the Fourth Industrial Revolution, or this period of exponential innovation, and the New Economies it is giving rise to, will be vast.

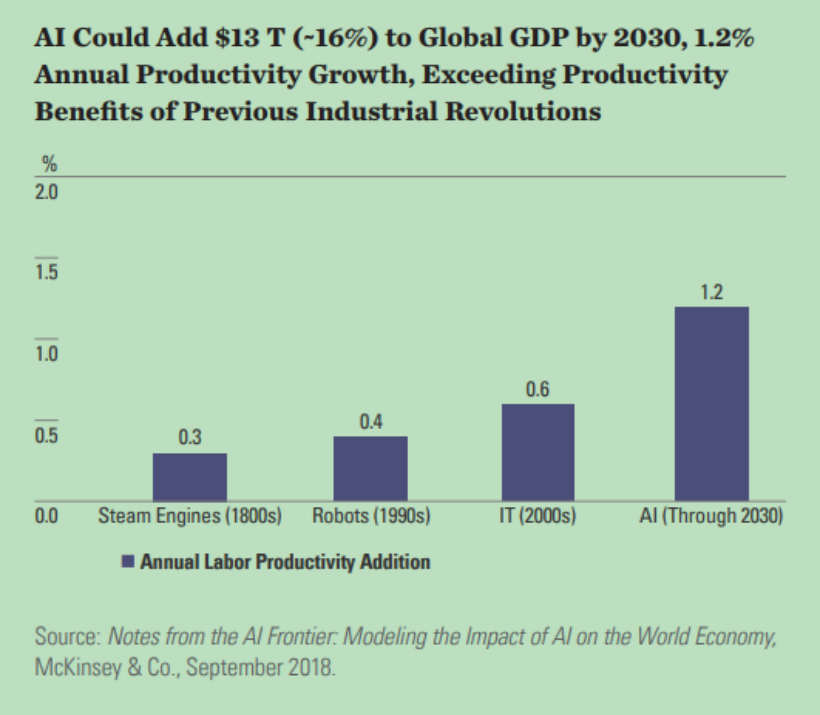
The compounding effect of the innovation catalysts has precipitated exponential innovation in each of these areas. For instance, 10 years ago it was not possible to have high-speed, high-integrity data capture from billions of devices—like smartphones—around the world. The infrastructure was not in place. The easy availability of vast, on-demand processing power, provided by services such as Amazon Web Services, is another example of a driver of innovation. The net result is that many of these barriers to entry have started to come down, prompting a surge of innovation. It is not being felt solely within the specific disciplines themselves, importantly, it is also being leveraged across many different industries.[10]

Compared with previous industrial revolutions, advancements in processing power, nanotechnology, 3D printing, AI, robotics and automation are driving innovation in the new economy, transforming every facet of our lives and creating exciting growth opportunities. Spending on AI and robotics is expected to grow by 380% and 157% from the end of 2017 to 2021, respectively.

Artificial Intelligence

AI is one of the technologies supporting the era. It could add $13 trillion (around 16%) to Global GDP by 2030, 1.2% Annual Productivity Growth, Exceeding Productivity Benefits of Previous Industrial Revolutions

Figure 2. AI could add US$13 trillion to Global GDP by 2030



Robotics

Robotics is another important part of industrial 4.0. The market for smart machines in the Americas, including autonomous robots, expert systems, and digital assistants, is growing. The expectation of the market will increase at a compound annual growth rate (CAGR) of 15 % between 2016 and 2020.

[10] https://global.spdrs.com/blog/post/2018/september/how-the-fourth-industrial-revolution-is-creating-new-economies-part-1.html

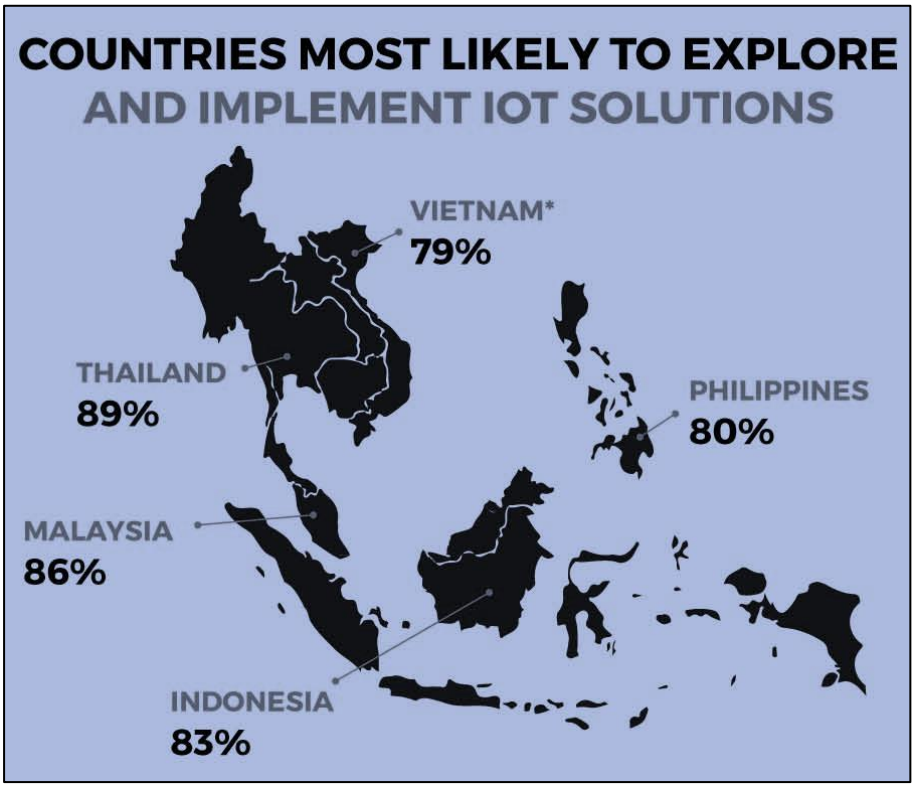
3D printing

The traditional manufacturing business model is changing and new models are emerging. 3D printing is a new technology which will drive Industrial 4.0 in the production processes. Production via 3D printing can be done anywhere as long as there are relevant base materials and a printer available. Speed, quality, and materials are the fundamental changes of 3D printing.

1.2.3 Impacts on Thailand

Industrial 4.0 will explore across the world including Thailand. With Thailand 4.0 initiatives, the country is in the right direction to eliminate the middle income trap by transforming the country to become a high income nation within 5 years of inception of Thailand 4.0. Asia IoT Business Platform conducted a survey that laid emphasis on Thailand, among other Asian countries surveyed, as the country that will most likely explore and implement IoT solutions. 89% of the Thai companies are ready to explore IoT solutions compared to 83% in Indonesia, 86% in Malaysia, 80% in Philippines and 79% in Vietnam. The IoT spending in Thailand is forecasted to increase by 1600% by 2020.[11]

Figure 3. Thailand is most likely to explore and implement IoT solutions



Source: Asia IoT Business Platform

The future of the Thailand 4.0 initiative would advance the economy to five folds using technology and innovation based on smart city, smart industry and smart people. As Thailand undertakes the ASEAN chairmanship for 2019, the focus would be on partnering for sustainability for the future. This initiative is backed by formulating ASEAN Digital Integration Framework Action Plan along with ASEAN Innovation Roadmap 2019 – 25 to augment skilled labor and service development. This would lead ASEAN to become the top 5 digital economies of the world by 2025.

[11] https://theaseanpost.com/article/thailand-40-coming-fruition

The Thailand 4.0 implementation would bring enormous potential to the economy, resulting in higher disposable income. E-commerce would emerge as the venue of choice for the millennial generation. Thus by 2025, Southeast Asia's e-commerce market is estimated to be worth $200 billion. This promises a bright future for Thailand 4.0 in terms of online presence and agile commerce.[12]

According to a US technology group, manufacturing would be a core driver for ASEAN's economy with estimated figure of $1.4 trillion by 2028.[13]

Thailand's manufacturing sector could see incremental growth of US$50 billion in productivity gains over the next decade by embracing Industry 4.0 technologies, according to a study on Industry 4.0 in manufacturing.

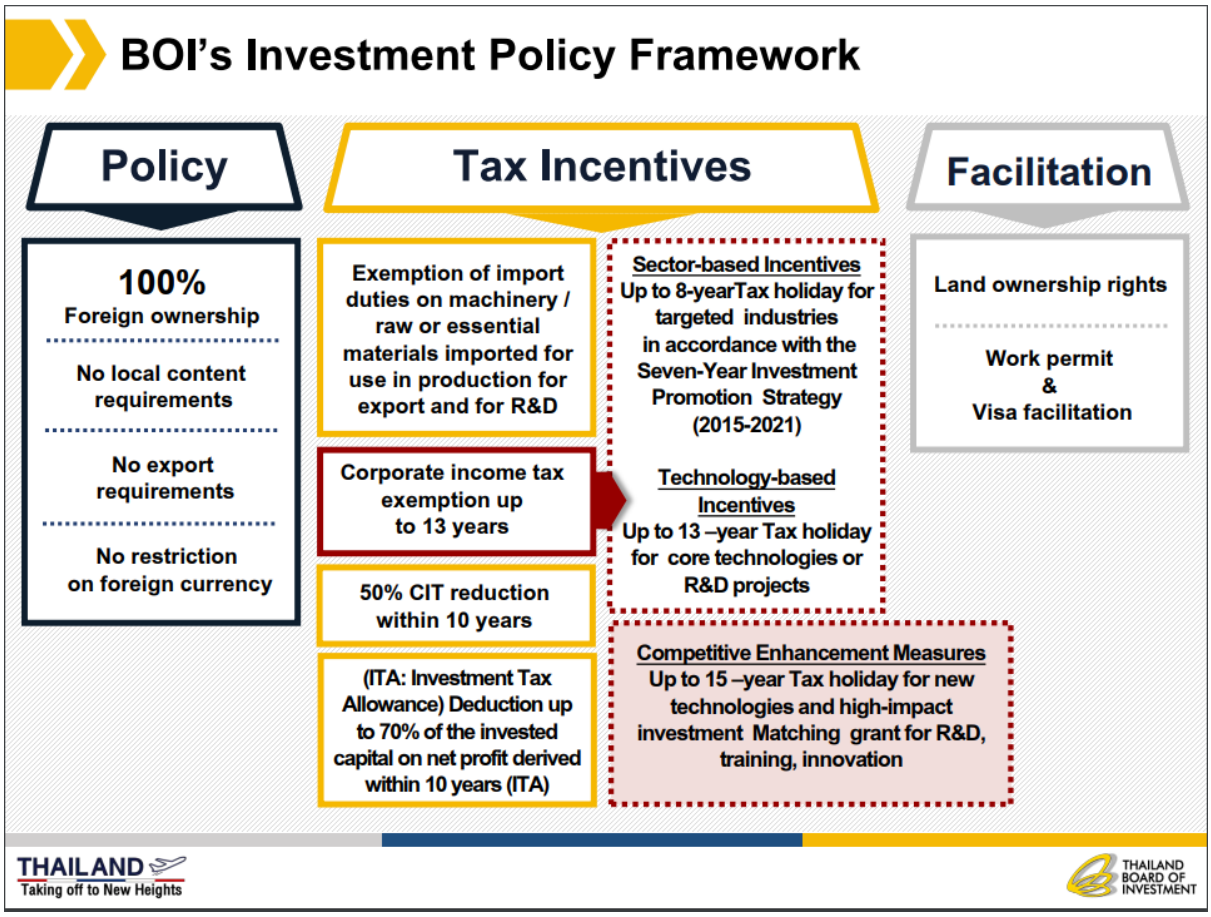
In 2018, the ASEAN manufacturing sector was worth $670 billion, or 21% of ASEAN GDP. The value should double by 2028. Thailand was the second largest manufacturer in ASEAN at $136 billion, behind Indonesia in 2018. Food, beverages and tobacco, electrical products and electronics, and motorcycle vehicles and parts are the top three largest contributors to Thai manufacturing.

According to the study, the growth will largely be driven by productivity gains: an incremental gain of $45-50 billion in Thailand from additional revenue streams via new products and quality improvements, as well as lower cost as manufacturers adopt Industry 4.0 technologies.[14]

To drive Thailand 4.0 and 10 targeted S-Curve Industries, the focus of current investment promotion policies is on Technology and Innovation; People; Productivity Enhancement and Development of targeted areas, including the Eastern Economic Corridor (EEC), Border Special Economic Zone with tax incentives and facilitation provided to attract key elements to Thailand as shown below.

[12] https://lexiconthai.com/blog/thailand-4-0-is-the-future-and-the-future-is-online/
[13] https://www.bangkokpost.com/business/news/1619050/the-road-to-4ir
[14] https://www.bangkokpost.com/business/news/1611150/industry-4-0-set-to-add-50bn-in-productivity

Figure 4. Thailand Board of Investment's Investment Policy



Source: Thailand Board of Investment

Impact of Thailand 4.0

The Fourth Industrial Revolution is bringing technologies that blur the lines between the physical, digital and biological spheres across all sectors. Technologies like AI, nanotechnology, Quantum computing, synthetic biology and robotics will all drastically supersede any digital progress made in the past 60 years and create realities that was previously thought to be unthinkable. Such profound realities will disrupt and change the business model of each and every industry.[15]

The adoption of Fourth Industrial Revolution technologies to automate processes will help to reduce labor-intensive and manual tasks. This in turn will allow people to work more productively to provide a better customer experience, and increase the competitiveness of the overall organization. Digital transformation and automation can thus drive greater customer satisfaction, loyalty and value.

Employees in companies undertaking a digital transformation stand to receive clear benefits -- more productivity, job creation and salary increases. Contrary to what some people believe, automation creates jobs as employees are needed to work the new technologies as well as manage the automation of processes.

In fact, technological disruption allows for the retrain and upskilling of employees to do more sophisticated work. Those who failed to adapt will be left behind. Plans to cut jobs have already

[15] https://www.forbes.com/sites/theyec/2018/10/19/how-the-fourth-industrial-revolution-is-impacting-the-future-of-work/#75aed27e65a7

begun in the banking and telecom sectors, signaling a trend that retail may soon follow as customers enjoy self-service through digital channels.[16]

A recent Harvard Business Review article urged employers to view the collaboration of humans and machines as a means to drive more value. Rather than resisting automation, companies should see this as an opportunity to improve the productivity and expertise of employees.

According to a digital transformation study, an estimated 45% of work activities in Thailand are set to be automated. Human resource professionals call center agents, software programmers and factory workers stand to benefit the most from the influx of digital technologies. This is in line with what have been observed in the Thai market.[17]

Thailand is working to drive digital transformation and utilize innovation to become a cutting-edge economic powerhouse. The country's digitization journey begins with the "Thailand 4.0" economic model which concentrates on important advancements and digital improvements to enhance the quality of life, productivity and efficiency of the Thai people.

1.2.4 Conclusion

The Fourth Industrial Revolution technologies such as IoT, AI, 3D printing, automation, wearable augmented and virtual reality are bringing transformations to systems of production, management and governance in Thailand. With an aim to create an "Economy of Smart" by putting a sharp focus on increasing efficiency rather than expanding scale, Thailand 4.0 policy and depa need to promote and increase the adoption of such technologies in a holistic and systematic manner to improve operations and manage resources in manufacturing, service and other emerging sectors in order to achieve such economic ideal concepts in the near future

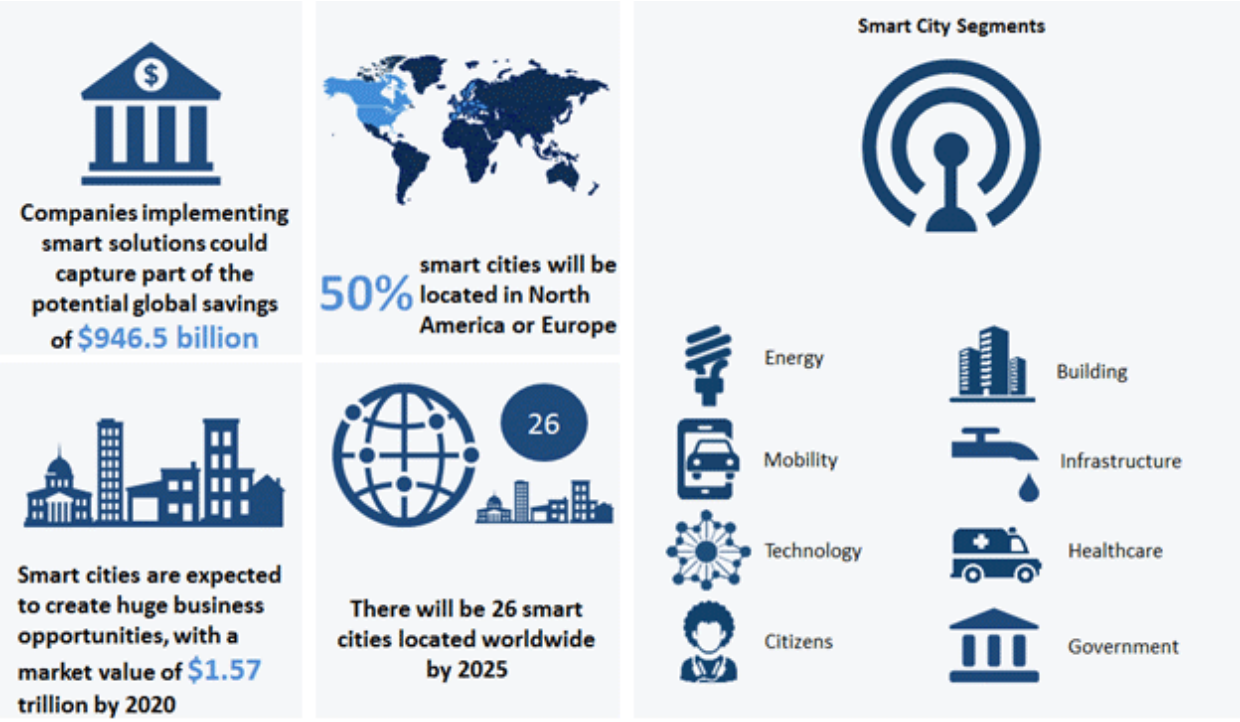
1.3 Growth of Smart City and Other Smart Ecosystems

1.3.1 Megatrend in Global context

Smart Cities: The need for smarter solutions and energy-efficient living will drive and foster clusters of smart communities called smart cities. Smart cities will be measured on the level of intelligence and integration of infrastructure that connects the healthcare, energy, building, transportation, and governance sectors. Therefore, Segments of Smart City can be divided into a variety of Smart Ecosystem, namely Smart Energy, Smart Building, Smart Mobility, Smart Infrastructure, Smart Technology, Smart Healthcare, Smart Citizens and Smart Government.[18] About 50% of smart cities will be located in North America or Europe. Frost and Sullivan estimated that there will 26 smart cities located worldwide by 2025.

[16] https://www.bangkokpost.com/tech/local-news/1407570/thailand-4-0-rise-of-the-machines-
[17] https://www.bangkokpost.com/business/news/1529802/digital-transformation-and-productivity
[18] https://ww2.frost.com/research/visionary-innovation/smart-cities-smart-new-green/

Figure 5. Global Smart City development



Source Frost & Sullivan

By 2050, over 80% of the population in developed countries is expected to live in cities. This number is expected to be over 60% for the developing world. The creation of smart cities enables a smooth transition to urbanization, with technological advances helping municipalities optimize resources for maximum value to the population, whether that value is financial, savings in time, or improvement in quality of life.

Globally, smart cities are anticipated to create huge business opportunities with a market value of over $1.57 trillion by 2025, according to Frost & Sullivan experts.

North America (NA) has been quickly catching up, with many Tier II cities such as Denver and Portland committed to building their smart city portfolios. The total NA smart buildings market, comprising the total value of smart sensors, systems, hardware, controls, and software sold, is projected to reach $5.74 billion in 2020.

Europe will have the largest number of smart city project investments globally, given the engagement that the European Commission has shown in developing these initiatives. The European e-hailing market, central to cities developing smart mobility solutions, currently generates revenues of $50 billion and is estimated to reach $120 billion by 2025.

In Latin America, cities actively developing smart city initiatives include Mexico City, Guadalajara, Bogotá, Santiago, Buenos Aires and Rio de Janeiro. In Brazil, smart city projects will drive almost 20% of the overall $3.2 billion IoT revenue by 2021.[19]

[19] https://ww2.frost.com/news/press-releases/frost-sullivan-experts-announce-global-smart-cities-raise-market-over-2-trillion-2025/

Asia-Pacific Smart City

The Asia-Pacific region is anticipated to be the fastest-growing region in the smart energy space by 2025. In Asia, more than 50% of smart cities will be in China. Smart city projects will generate $320 billion for China's economy by 2025.

Spending on technologies to enable smart cities programs in Asia Pacific, excluding Japan (APeJ), is set to reach $28.3 billion in 2018.

In its first Worldwide Semi-annual Smart Cities Spending Guide since it began tracking these projects in 2006, IDC has looked at the technology investments associated with smart city use cases. These initiatives gain traction with spending set to accelerate and hit $45.3 billion by 2021.[20]

Asia-Pacific is the region accounting for the largest share of spending in IoT. According to Frost & Sullivan, the total spending on IoT in the Asia Pacific region will reach $59 billion by 2020. South Korea and Singapore are expected to be among the top 5 global markets to adopt IoT.[21]

1.3.2 Technology Trends

AI, personalized healthcare, robotics, advanced driver assistance systems (ADAS), distributed energy generation and other five technologies are believed to be the technological cornerstones of smart cities of the future. However, there are other technologies which are very important to drive smart city such as data analytics, 5G, security, and cloud computing

AI

AI plays a key role in smart cities in the areas of smart parking, smart mobility, the smart grid, adaptive signal control, and waste management. Major corporations such as Google, IBM, and Microsoft are key tech innovators and the primary drivers of AI adoption. AI will connect working with robot. The parking, the drivers, the building and their environment will be recorded via advanced traffic management software that understands and adapts to each user's habits via Machine Learning.

Data analytics

"Data is the lifeblood of a smart city."[22] Data should be reliable to base their long-term decisions in smart city. Monitoring and anticipating urban phenomena in new ways could be happen by inserting sensors across city infrastructures and creating new data sources.

IoT

IoT involves extending internet connectivity beyond standard devices. Smart cities make use of IoT devices to fetch data and efficiently process it for implementation in a particular area. Smart city sensors and connected devices collect data from various smart city gateways installed in a city and then analyze it for better decision-making. The estimation of IoT devices to be deployed by 2020 is at 20.4 billion devices.

1.3.3 Impacts on Thailand

Thailand is one of the counties that focus on smart city. The Thai government will spend Bt40 billion to develop a smart city in the Phahon Yothin district of Bangkok that is slated to be completed within three years, and will serve as a pilot project for 76 other such cities to be established across the

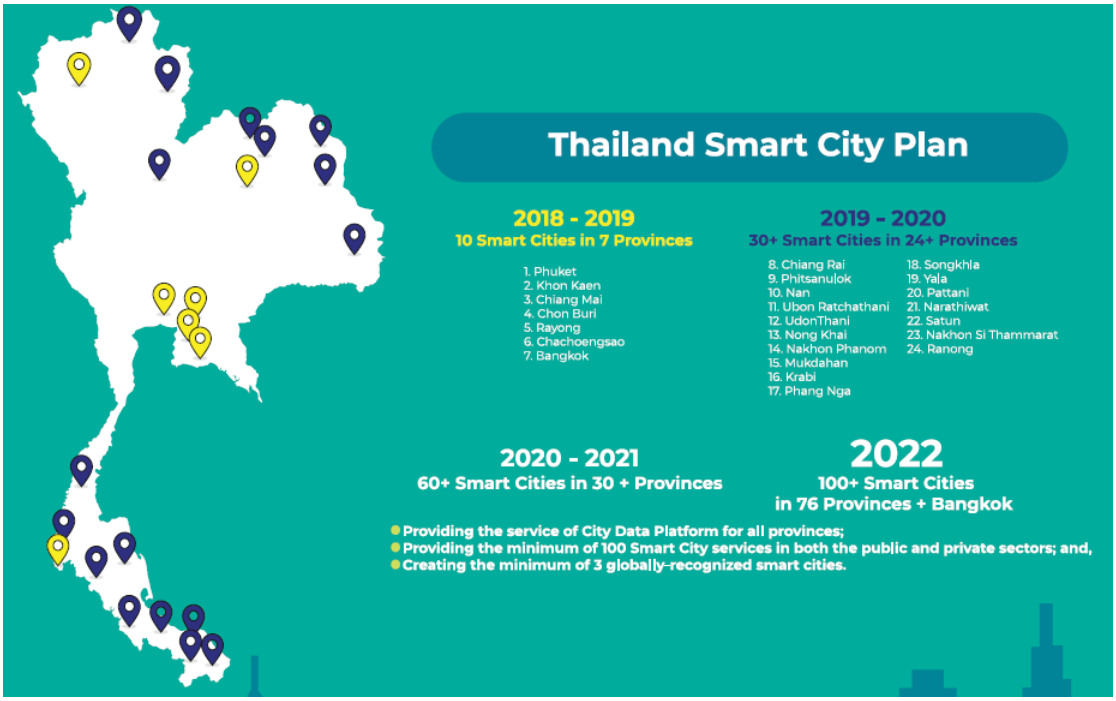
[20] https://internetofbusiness.com/asia-pacific-spending-on-smart-city-technology-to-top-28-3-billion-in-2018/
[21] https://www.innovationiseverywhere.com/smart-cities-asia/
[22] https://medium.com/dataseries/big-data-and-smart-cities-why-we-need-them-now-a194b2498fb1

country within five years. In 2018, the government started developing seven smart cities – in Bangkok, Phuket, Chon Buri, Chiang Mai, Rayong, Chachoengsao and Khon Kaen provinces.

The smart city in Bangkok will focus on smart mobility. For Chiang Mai and Phuket, the focus will be on smart tourism, smart safety, smart environment and smart economy. The project in Khon Kaen province will focus on smart health as part of a plan to set up a medical hub designed for the needs of the elderly.

Under the programme (see Figure 6), the government will develop 10 other smart cities in 2019. The government will further develop up to 30 smart cities in 24 provinces over the next 1-2 years, and aim to cover 77 provinces in 5 years. The smart cities will foster collaboration between the government and private and state enterprises as part of efforts to encourage public-private partnerships (PPP). The goal is to produce sustainable outcomes and improved quality of life for people in diverse communities over the long term. The ultimate goal is to have 100 of such cities to improve the quality of urban life.[23, 24]

Figure 6. Thailand Smart City Development Plan

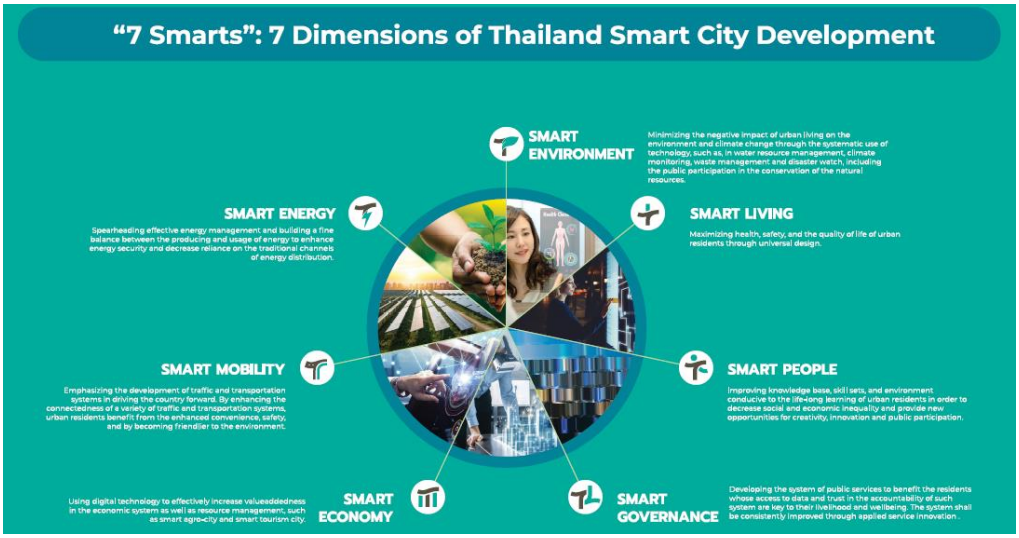


Source: Smart City Thailand Office

Smart city domains include Smart Economy, Smart Mobility, Smart Energy and Environment, Smart Governance, Smart People and Smart Living. From the smart cities roadmap, Phase 1 started in 2016, with the pilot project to develop Phuket as an international tourism hub. The public sector dedicated THB386 million (US$11 million) to begin building a digital economy. This was followed by Chiang Mai with an initial budget of THB36 million (US$1 million), focusing more on smart agriculture, and Khon Kaen, with an initial budget of THB15 million (US$425,000) in 2017, which focused on becoming a medical, transportation and meeting, incentives, convention and exhibition (MICE) hub.

[23] http://www.nationmultimedia.com/detail/Economy/30348045
[24] https://www.bangkokpost.com/tech/local-news/1362595/more-smart-cities-planned-in-2018

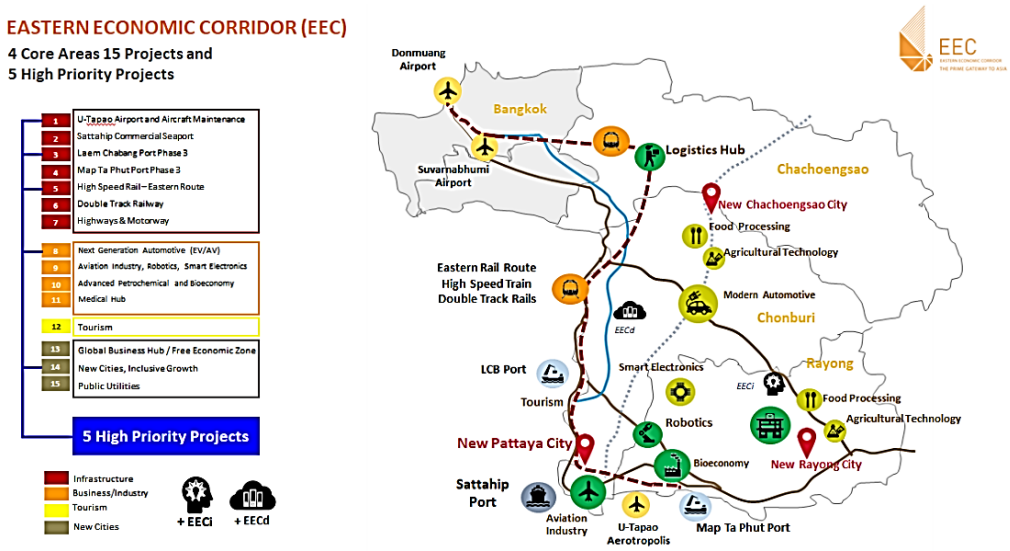
Figure 7. Dimensions of Thailand Smart City Development



Source: Smart City Thailand Office

In 2018, the government aimed to commence Phase 2 in Chonburi, Rayong and Chachoengsao with the support of depa. These three eastern seaboard cities are located in the Eastern Economic Corridor (EEC), where most high-tech industries, especially S-curves industries, are located. The total estimated investment in the EEC, from both the government and the private sector, is about THB1.9 trillion.

Figure 8. Smart City Phase 2 as part of the Eastern Economic Corridor (EEC)



Source: Thailand Eastern Economic Corridor (EEC)

depa is currently working with the Smart City Alliance in Laem Chabang Municipality and Pattaya, Chonburi to launch Smart City D-Boost Camp. Below are the ways in which they have introduced a suitable and sustainable application of intelligent urban technology:

Smart Living: school bus application to promote the safety of children's travel, road safety integrating and upgrading intelligent CCTV technology, Distance Communication Robotics for health care in the Elderly.

Smart Mobility: Smart Port with a fleet management system to reduce congestion and reduce transportation costs.

Smart Governance: an integrated information system for city management. Complaints and follow-up to solve city problems with Mobile application.

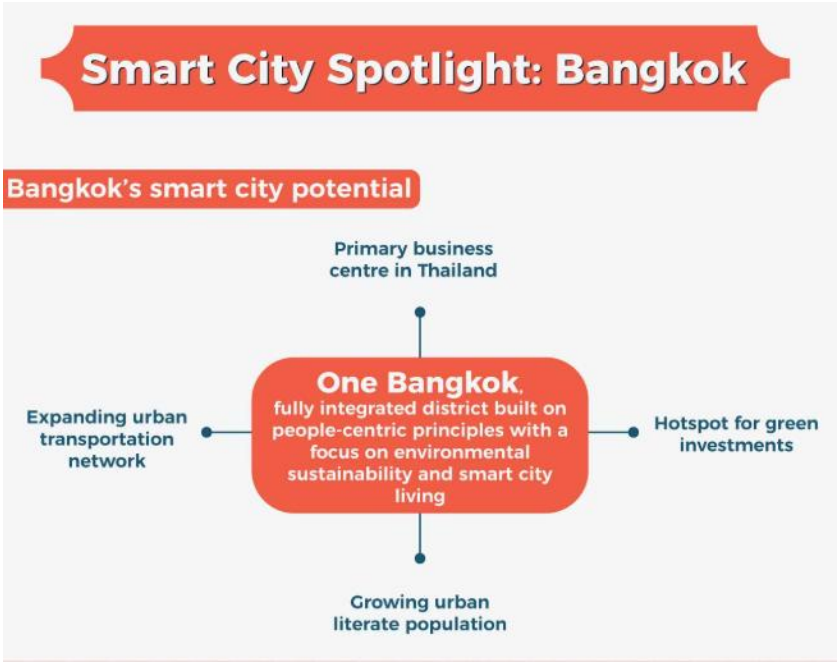
Smart Tourism: include information and promotion systems, mobile applications, robotics, communications, tourism information.

depa aimed to turn the seven cities into real smart cities by 2023 and also targeted to escalate their projects in 2018 in Phitsanulok, Songkhla and Ubon Ratchathani.[25]

Bangkok towards becoming a Smart City

Bangkok will focus on improving the infrastructure to ease the transportation barriers. The rail network is expected expand to more than 500kms by 2029. The city will be driven by IoT, sustainability, energy and environment efficient buildings.

Figure 9. Bangkok's potential as Smart City



Source: The ASEAN Post

In terms of sustainable living conditions, the One Bangkok "city-within-a-city" district will be an integral part of the smart city development. It will be driven by elements of IoT spanning an area of 16.7 hectares. With eight hectares dedicated to green and open spaces, the project is set to be a prime example of people-centric and environmentally sustainable smart city living.[26]

According to the 20-Year Energy Efficiency Development Plan (2011-2030), Thailand aims to reduce energy consumption by 20% in 2030 through implementation of smart energy efficient buildings.

[25] http://iotbusiness-platform.com/blog/will-there-be-100-smart-cities-in-thailand-by-2038/
[26] https://www.cio-asia.com/article/3315258/internet-of-things/top-10-smart-cities-in-southeast-asia.html

Electricity consumption would slash by 10% and the country would save US $1.5 billion of the power bill.[27]

1.3.4 Conclusion

Smart ecosystem can take many forms ranging from smart community, smart city, smart mobility, smart tourism, smart safety, smart environment, smart governance, smart living to smart economy. The establishment of such intelligent systems in an area-based or industry-based approach nationwide by utilizing technologies such as IoT, AI, Automation, Data Analytics and Security will not only open up new business models needed to drive Thailand's Digital Economy in its entirety where, for example, one digital service platform has a capability to meet and tailor requirements to many clients and users, but also deliver high value for customers and employees alike. This will effectively contribute in moving Thailand towards realizing value-based economy from data-driven, smart drivers for both demand and supply sides.

1.4 Urbanization and Rise of Megacities

1.4.1 Megatrend in Global context

By 2050, at current rates of urbanization, the world will be two-thirds urban and one-third rural, a reversal of the global distribution pattern of 1950. As much as 90% of that growth will occur in Asia and Africa. These regions are expected to welcome an additional 1 million inhabitants — roughly the population of Boston and Zurich combined — every week for the next 40 years. Such growth puts pressure on existing megacities to expand and for new cities to form, heightening infrastructure demand. The effects of climate change, especially rising water levels, will leave many cities in both the developed and developing world vulnerable. This puts pressure on infrastructure to be sustainable and resilient.[28]

Figure 10. More and more global population shifting to cities

Source: Ernst and Young

By 2025, nearly 58% of the global population is to be located in these hubs leading to three major sub trends in the areas of urbanization:

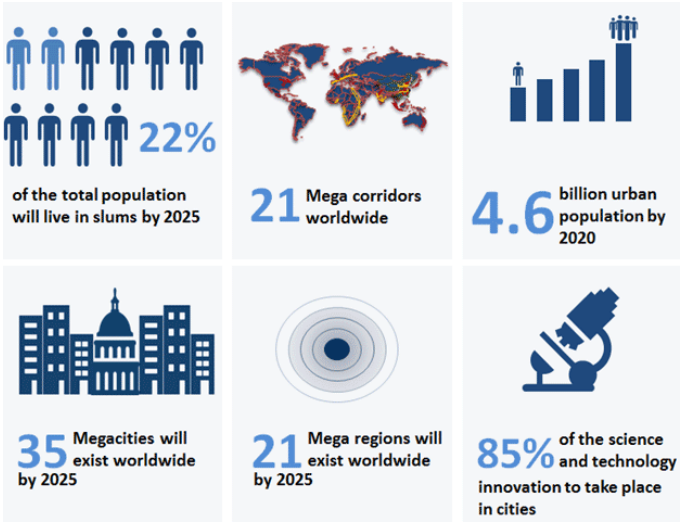
Mega Cities: A Mega City will house a population of over 8 million and will have a nominal GDP of $250 billion or more. By 2025, we will see 35 Mega cities spread out across the world.

[27] https://theaseanpost.com/article/smart-city-spotlight-bangkok
[28] https://cdn.ey.com/echannel/gl/en/issues/business-environment/2016megatrends/001-056_EY_Megatrends_report.pdf

Mega Region: Cities will soon expand in territory absorbing neighboring suburbs to form Mega Regions. Such regions will house an urban population of over 15 million.

Mega Corridors: Corridors between the Mega Regions and the Mega Cities will either naturally evolve or be planned through investments in transportation, real estate, and energy.[29]

Figure 11. The state of global urbanization by 2025

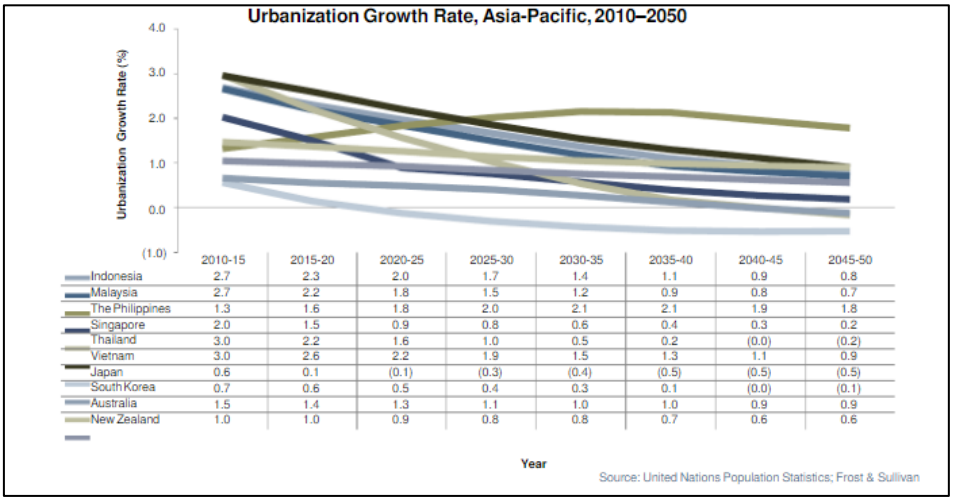


Source: Frost & Sullivan

Urbanization in Asia and Southeast Asia

By 2050, regional urban population in Asia is forecasted to increase from 1.8 billion to 3.3 billion. It would be high in small or medium within low income countries.

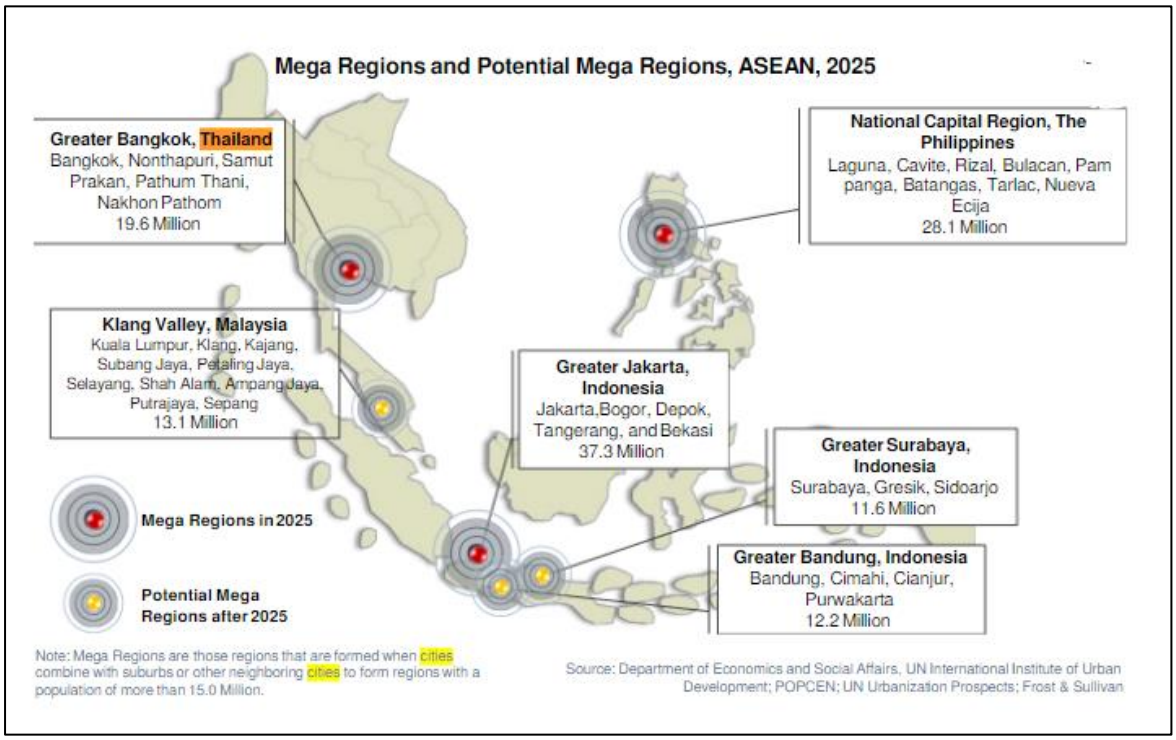
Figure 12. Urbanization Growth Rate, Asia-Pacific, 2010-2050



	2010-15	2015-20	2020-25	2025-30	2030-35	2035-40	2040-45	2045-50
Indonesia	2.7	2.3	2.0	1.7	1.4	1.1	0.9	0.8
Malaysia	2.7	2.2	1.8	1.5	1.2	0.9	0.8	0.7
The Philippines	1.3	1.6	1.8	2.0	2.1	2.1	1.9	1.8
Singapore	2.0	1.5	0.9	0.8	0.6	0.4	0.3	0.2
Thailand	3.0	2.2	1.6	1.0	0.5	0.2	(0.0)	(0.2)
Vietnam	3.0	2.6	2.2	1.9	1.5	1.3	1.1	0.9
Japan	0.6	0.1	(0.1)	(0.3)	(0.4)	(0.5)	(0.5)	(0.5)
South Korea	0.7	0.6	0.5	0.4	0.3	0.1	(0.0)	(0.1)
Australia	1.5	1.4	1.3	1.1	1.0	1.0	0.9	0.9
New Zealand	1.0	1.0	0.9	0.8	0.8	0.7	0.6	0.6

[29] https://ww2.frost.com/research/visionary-innovation/urbanization-city-customer/

Figure 13. Mega Regions and Potential Mega Regions, ASEAN, 2025



By 2025, urbanization in Southeast Asia would grow to 53% with 5 mega cities and 3 emerging mega cities. The Mega regions would include, Greater Bangkok, Greater Jakarta and Capital region in Philippines with a total population of 85 million. The city of Samut Prakan in Thailand would be one of the fastest growing in 2025. Urban growth in Thailand would be dominated by Bangkok.

Such an extensive urbanism would have huge environmental impacts. For ASEAN countries, it would be challenging to urbanize sustainably. It would lead to rise in middle class segments. It would also lead to rise in carbon emissions. With increased challenges, economic growth would be different in different nations. Thailand would face issues to cope with infrastructural challenges. Countries like Thailand, Malaysia would face large scale industrialization resulting in massive solid waste from landfills.

1.4.2 Technology Trends

According to the United Nations, more than 54% of the world's population now resides in urban areas – a figure set to rise to 67% by 2050. And these urban centers are becoming increasingly important drivers of national and regional economic growth. Clearly, with cities around the world competing on the global stage for investment and top people talent, harnessing the true potential of urbanization to boost shared prosperity and eradicate extreme poverty depends on having a clear and long-term vision.[30] The main technologies involving in the urbanization are high-speed rail systems, automation, cloud computing, data analytics, AI, IoT, security, 5G, and etc. The concept of smart city is one supporter of urbanization.

Growing Demand for Urban Rail Network across the Globe

Japan, Spain, and China are known for the world's largest high-speed rail (HSR) systems. There is a surge in the demand for high-speed rail across the globe. With more than 52% of the world's population living in urban areas, which is to reach around 66% by the year 2050, the demand for high

[30] https://www.digitalistmag.com/improving-lives/2018/01/26/from-smart-city-to-future-city-21st-century-urbanization-challenge-05809136

level transportation system at cheaper rates is growing. Growing populations are driving the growth in the number of megacities. Recently, several HSR projects have been approved in Spain, Italy, Estonia, Switzerland, the Netherlands, Malaysia, China, and Canada's Ontario. These factors are expected to increase the demand for high-speed rails, which in turn, are likely to increase the usage of high-speed rail coatings.[31]

The urban railway network in Asia-Pacific has undergone high growth in the recent years. At the end of 2017, China's urban rail trackage crossed 5,000 km. Chinese cities started 33 new lines totaling around 870 km in the year 2017, a 62.5% increase compared to 2016 with 534 km of new lines completed. China accounts for over 65% of world's total HSR systems. Indian government announced a budget of US$ 23.3 billion for Indian Railways for the year 2018-19, which is the highest in Indian Railway's history and 13% more than the railway budget of 2017-18. With the upcoming high-speed rail (HSR) projects in Singapore, South Korea, Thailand, etc., the market for high-speed rail coatings in the region is to grow at a fast rate.

1.4.3 Impacts on Thailand

Urbanization in Thailand has been increasing over the past 30 years, but for the most part remained concentrated in a few large cities, mainly Bangkok, Chiang Mai, Phuket, Nakhon Ratchasima and Khon Kaen.

According to We Are Social 2018, Thailand's urban population was 53% of its total population. Roads, rails and other infrastructure projects will play a key role in driving the economy of smaller cities.[32,33]

Bangkok is on the cusp of emerging as the world's next "megacity". The Thai capital, whose infrastructures are currently expanding significantly, should soon reach the proportions of a megacity. Within five years in 2023, the rapid expansion of Bangkok's subway system will succeed in opening up unprecedented spaces and with it huge opportunities for the travel and tourism industry.

The development of public transport in Bangkok is receiving significant government support in order to promote economic growth in the city. Underground and urban train lines are set to increase from five to seven or even eight lines by 2023, which will more than double the city's network.

The train line across Greater Bangkok would be 464 kilometers long by 2023, surpassing London, which stands at 402km with their underground, and New York City's 380km subway system.[34]

Also, Bangkok will have a high-speed rail link connecting Don Muang and Suvarnabhumi airports with the U-Tapao/Pattaya platform by 2023. Moreover, the government will spend more than $25 billion to build a high-speed rail network, of which THB 16 billion ($485 million) has been earmarked for the new Bang Sue Grand Station in Bangkok.

The station is 60% complete, according to Worawut Mala, acting governor of the State Railway of Thailand. When finished in 2020, it is expected to serve about 400,000 passengers daily as the nation's main transportation hub, connecting new high-speed trains with urban lines.

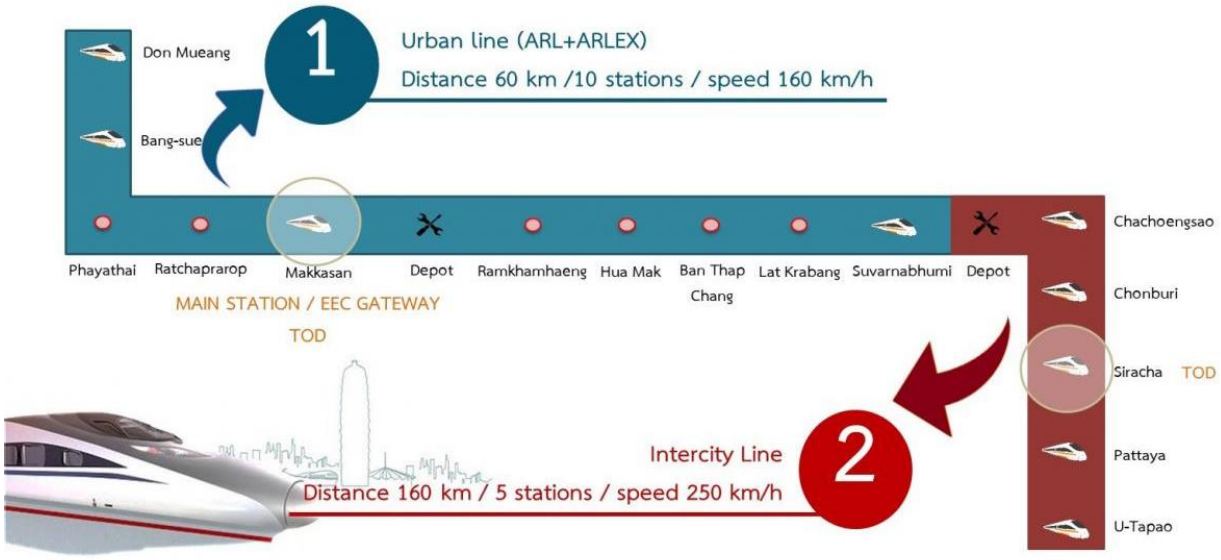
The four-story building forms the centerpiece of a 3.7-sq.-km development project that will be home to high-rise offices, condominiums, retail establishments and parks. It replaces aged Hua Lamphong Station built in 1916 and will be Southeast Asia's biggest station when completed.

Thailand's vast national railway network sprawls over 4,000 kilometers. But most lines are single-track, the trains old, and operations inefficient. It takes a staggering 11 to 14 hours from Bangkok to

[31] https://www.mordorintelligence.com/industry-reports/high-speed-rail-coatings-market
[32] https://www.slideshare.net/wearesocial/digital-in-2018-in-southeast-asia-part-1-northwest-86866386
[33] http://www.nationmultimedia.com/detail/business/30335622
[34] http://www.nationmultimedia.com/detail/lifestyle/30336992

the popular northern city of Chiang Mai via rail, for example, forcing many passengers onto faster airplanes and buses to travel the 670-km route.[35]

Figure 14. Concepts of High Speed Train Project linking 3 major airports



Source: Thailand Eastern Economic Corridor (EEC)

1.4.4 Conclusion

To accommodate a rapid rate of urbanization, an increasing number of urbanites, provide more efficient public services and better tackle urban challenges in ever-expanding city and community contexts of Thailand, Smart City and other Smart Ecosystem projects incorporating various digital technologies such as networking, next generation telecommunication, IoT, AI, automation, cloud computing and data analytics among others in an integrated fashion should be emphasized and driven forward in order to better prepare and future-proof urban infrastructure and enhance Thai people's standard of living for many years to come. High-speed rail is also one key driver in urbanization.

1.5 Rise of E-Commerce and Convenience Stores

1.5.1 Megatrend in Global Context

The ways of purchasing in the future will be changed driven by change in consumer behavior. Bricks and Clicks will become the retailing norm of the future, with every retailer expected to have a hybrid business model by 2025. Connectivity and convergence will become a key facilitator, allowing retailers to merge digital, virtual and physical into one hybrid bricks-and-clicks model. New retailing models such as interactive stores, click and collect, social commerce and virtual stores will grow in prominence as retailers open up more customer touch points. Urbanization and social trends will also compel retailers to change the traditional model and transition from big-box retailing to small-box formats. This evolution to a bricks-and-clicks model will itself become a Mega Trend, as it significantly impacts and changes other industries such as automotive, logistics and finance.[36]

[35] https://asia.nikkei.com/Economy/Thailand-on-track-to-develop-into-regional-rail-hub
[36] https://ww2.frost.com/research/visionary-innovation/bricks-and-clicks-omnichannel-retail/

Moreover, Omni-channel is a new type of channel which response the change of consumer behavior. Omni-channel customers generate a higher lifetime value in terms of sales than digital-only or in-store only shoppers. Omni-channel shoppers make up 7% of US customers yet account for 27% of all sales.

Sales are shifting away from in-store to digital purchases. Retailers estimate a 14% decrease in the amount of in-store sales in the next 12-18 months. One in 4 retailers has already implemented omni-channel customer experiences and 53% of retailers plan to implement omni-channel throughout 2018.

The prediction is that in the next year, 20% of brick-and-mortar retailers will begin implementing omni-channel strategies. While this will be more difficult for smaller businesses than large businesses, there are ways that businesses of any size can streamline and integrate their operations.[37]

All of these changes will happen according to the consumer behaviors and the technology. The rate of technological change is accelerating, and by 2040, consumers will be using automation for more of their daily tasks, according to a future of commerce study. Technological advances will continue to accelerate and redefine how people live, work, shop and play.

The rise of digital commerce and delivery will lead to a remodel of storefronts. Retailers will carry fewer inventories, repurposing the space into experiential centers. Shoppers could test products in a virtual representation of where usage will take place. Facial recognition will personalize shopping trips, tailor offers and automate the checkout process.

Venues will integrate similar technologies to offer customized entertainment shifting from in-seats to choose-your-owns. Optimized seating will offer selections based on preferences versus section. Versatile and flexible layouts will tailor the entertainment experience to the type of event and meet the need for food and delivery options.

With 65% of households expected to have access to broadband internet in 2030, up from 48% in 2018, out-of-home life will be brought into the home. Consumers will find fewer reasons to leave as consumption evolves. Connected appliances will monitor usage and automatically order replenishment products. Connected mirrors will serve as a personal stylist, purchase channel and social sharing tool.

The five key technologies driving change are worker enhancements (self-service), AI, personalization, augmented reality and supply chain.

Retail is one of six environments that will be impacted by technology, although all six environments — the home, retail, entertainment, transportation, restaurants and "on the go" — are interrelated.

Online sales will grow 10 times faster than sales of products bought in stores over the next five years. But the physical store will not disappear since 47% of consumers who buy online want to try a product before buying it.

But stores will not look as they do today. An illustration of the convenience store in 2040 is displayed, where a drone delivers a package to a store that offers pickup lockers accessible 24/7 with biometric identification. The shopping experience will be seamless, immediate, experiential and individualistic.

In addition to convenience, consumers will crave experiences — an area where technology will play a major role. Thirty-nine % of consumers want to spend money on an experience rather than on tangible products. Retailers and brands will develop experiences such as entertainment centers

[37] https://learn.g2crowd.com/2019-retail-trends

where consumers engage in games with holographic players and get real-time feedback on their performance.

Entertainment facilities will have big screens displaying social media allowing fans to participate in the experience.

1.5.2 Technology Trends

AI, AR/VR, automation, cloud computing, data analytics, DLT, IoT, security, Quantum computing, and 5G will be technologies driving the change of e-commerce and convenience stores.

To offer new retail customer experiences, emerging technologies such as AI, chatbot, and AR/VR present new possibilities for engaging with customers both in stores and online.

With mobile shopping now considered an industry standard, these emerging technologies give retailers the ability to go above and beyond to create the personalized, connected experiences customers expect today.

The value provided by emerging technologies is not lost on today's customers. According to a recent survey from Tech Pro Research, 88% of respondents using in-store technology (including mobile, AR/VR and automated payments) said it made shopping easier, while 67% said these technologies made shopping more enjoyable.

Ultimately, new retail technologies are finally providing customers with what they have been longing for – relevant products, informed and fast customer service, and the ability to experience products before they arrive on their doorsteps.

Future of Commerce

Brick-and-mortar stores will need to leverage technology to offer things that online retailers cannot do, based on a Future of Commerce 2040 report.

That means stores could introduce "cold zones" where shoppers can try on winter coats, turf-like surfaces to test out athletic cleats, and other innovations that replicate the environments where shoppers will use products.

Stores will also employ facial-recognition technology that will identify customers as they enter the store and provide them with tailored shopping experiences, the report predicted.

Physical outlets remain a critical part of today's shopping journey, both in terms of brand engagement or purchase execution and continue to play a role in 2040, though their functions will evolve.

In 2040, the report predicted:

- Consumers will be able to try on items in the environments they'll be used, like cold zones to try on winter coats and turf to try on cleats.
- Facial scanners will recognize customers as they enter the store, allowing for a tailored shopping experience.
- Virtual stylists will help consumers make choices based off what they already own.
- Payment will be made automatically upon exiting the store.
- Stores will have separate entrances for those picking up orders made online.

Technological advances are increasingly detaching the purchase decision from a physical outlet. Smart retailers will leverage technology to remove the hassles of shopping for mundane purchases while tapping into the innate curiosity to see, feel and experience specific products.

Artificial Intelligence

Personalization is maximized using AI to create a shopping experience using analytics and optimized inventory for each consumer. AI is also being used in call centers and customer service departments to improve retail experiences.

Retailers must put into place data management technology that can ingest and feed data to analytics. As AI improves operations and data, it will become less expensive and easier to use. This in turn streamlines operations further as AI turns data into actionable insights.

Embedded AI "enables an innovative approach, changing the knowledge map from customer behavior to the characterization of its social context, potential needs and decision making". It can help automate everything from customer service to low inventory re-orders based on holiday trends.

To further streamline operations, AI is combined with the Internet of Things.

Consumers, on their part, are starting to become more aware of chatbots. According to Ubisend's 2017 Chatbot Report which surveyed 2,000 consumers, the "majority of consumers are aware of what a chatbot is (57%) and over a third (35%) want to see more companies using chatbots to answer their questions."

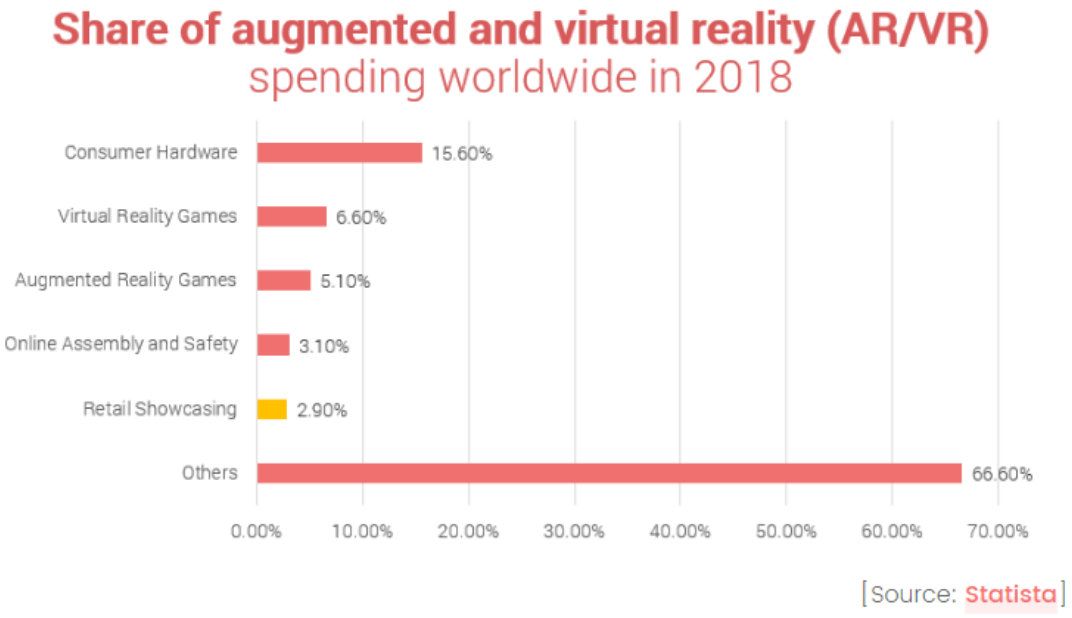
Beyond chatbots, AI can also play role in the back office, allowing merchants to improve their operations.

For example, Vend retailers have access to Dott, a tool that can surface suggestions and tips to retailers based on their activity, in real-time.

AR/VR

As we can see from the graph below, the retail industry is in the TOP-5 priorities when it comes to augmented and virtual retail spending trends:[38]

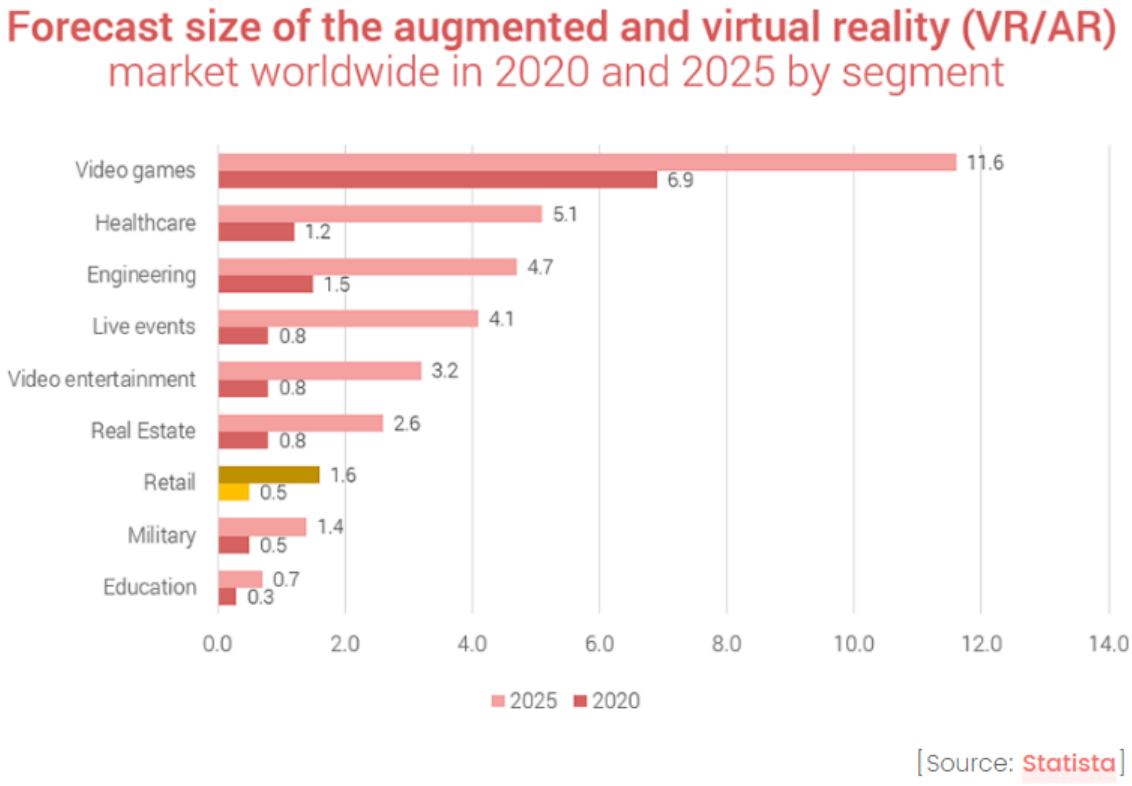
Figure 15. Share of AR/VR spending worldwide in 2018



[38] https://theappsolutions.com/blog/development/ar-vr-retail-store/

When it comes to the forecast of augmented and virtual retail market shares, retail is not at the end of the list as well, taking a proud seventh place in TOP-10. It also is forecasted to grow almost 300% in just a few years:

Figure 16. Forecast size of VR/AR market worldwide in 2020 and 2025 by segment



Worldwide spending on AR/VR solutions will be led by the commercial sectors, which will see its combined share of overall spending grow from 64.5% in 2019 to more than 80% in 2022. The industries that are expected to spend the most on AR/VR in 2019 include personal and consumer services ($1.6 billion), retail ($1.56 billion), and discrete manufacturing ($1.54 billion). Ten industries are forecasted to deliver CAGRs of more than 100% over the five-year forecast period, including state/local government (123.7% CAGR), resource industries (120.9% CAGR), and wholesale (120.9% CAGR). Consumer spending on AR/VR will continue to be greater than any single industry ($7.2 billion in 2019) but will grow at a much slower pace (36.6% CAGR).[39]

China is already digitally transforming the way people shop in person. Smart mirrors allow people to try on clothes and makeup. Retailer customers in pop-up T-malls can try on cloud products through RFID and AR, and then purchase them immediately through contactless Alipay QR codes.

These experiences attract new walk-by customers, provide value during the experience, showcase products in new exciting ways, and compel them to purchase. As these technologies advance and people begin to trust Augmented Reality overlays and fittings, we will be seeing more purchases of products like clothing from home.[40]

On a geographic basis, China will be the region with the largest AR/VR spending with 91.3% share of the overall spending ($10.2 billion) in Asia-Pacific (excluding Japan) in 2018 and this trend is likely to

[39] https://www.idc.com/getdoc.jsp?containerId=prUS44511118
[40] https://www.shuup.com/software/23-retail-technology-trends-for-digital-transformation-2018/

rise over the forecast period (2017-22) with five-year CAGR of 70.5%. AR/VR technology in other countries of Asia/Pacific (excluding Japan) are slowly gaining trend and experiments are being made on how AR/VR can improve retail and other industry experience.[41]

Digi-Capital believes the total global market potential for 2020 to be US$30bn for VR and US$90bn for AR, with revenues split among software, hardware, advertising, and other categories. [42]

IoT and Streamlining Shopping

IoT stands to eliminate a chunk of customer decision making, with devices making purchasing decisions. Smart refrigerators are already ordering groceries and are not tempted by impulse buys. Retailers want to achieve one-click checkout for quick customer experiences. This is already made possible by combining RFID tags with POS systems and connected sensors. AmazonGo has already launched a working model and the tech is seen all over China.

IoT also serves a great deal of uses behind the scenes for optimizing logistics, inventory purchases and management, manufacturing, and processing. It helps solve problems in efficiency and loss prevention.

Facial recognition, contactless payments, and other advancements will further streamline operations and shopping with IoT.

As per a recent report, nearly 85% of retailers are expected to adopt IoT technology by 2019, up only from 57% today. IoT will have many potential applications such as: [43]

- Video: With video analytics, and facial recognition technology growing in popularity, retailers will be able to build 'shopper profiles' from the moment they walk into a store. These shopper profiles will allow retailers to provide a highly individualized experience to consumers.
- GPS Enabled Shopping Trolleys: The shopping trolley of the future will allow consumers to upload shopping lists, with the trolleys then guiding them in-store with directions on finding the items they're looking for. Customers will also be able to pay for these items via the trolley itself, eliminating the need to stand in line to check out.
- Electronic Rack Edge Tags: At the moment, retailers need to update prices on products being sold in-store with printed labels. This will change as retailers adopt electronic labels, allowing them to update all product information through the internet.

Voice technology

With devices like the Amazon Alexa, Google Home, and Apple's Home Pod, consumers will use voice search to browse and purchase products. Voice technology is also becoming more advanced on mobile devices, with applications like Apple's Siri already blending AI and voice tech to become powerful personal assistants.

In a recent study, 57% of consumers who owned voice activated speakers bought something. That's a clear indicator that voice-based shopping is on the rise, and with over 20 million smart speakers now available in the US, this number is all set to grow rapidly.

Amazon's Alexa and Google Assistant are already performing numerous retail-related tasks for customers, and this trend will grow. Consumers now can purchase items from the comfort of home just by asking. This gives retailers a personal interaction with customers and compels purchase.[44]

[41] https://iotnews.asia/1158/vr/asia-pacific-augmented-and-virtual-reality-spending-to-reach-US$-11-1-billion-in-2018/
[42] http://www.digi-capital.com/news/2016/01/
augmentedvirtual-reality-revenue-forecastrevised-to-hit-120-billion-by-2020/
[43] https://www.vendhq.com/blog/retail-technology-trends/

Assistants will soon also be popping up on retail floors in the form of interactive displays and personal shopping assistants, as brick-and-mortar stores take advantage of conversational commerce.[45]

A new study shows that 62% of smartphone users in the Asia Pacific used voice-activated technology in the last six months.

The report, The Future is Voice Activated, which was conducted by iProspect insights consultancy, researched voice adoption and usage across surveyed over 1,800 smartphone owners aged 18 to 50 years old in Australia, China, India, Indonesia, Japan and Singapore.

The findings highlighted India (82%) and China (77%) as leaders in voice adoption.

Additionally, the report said that 56% of current users observed that their usage had increased over the last six months and 95% indicated their intention to continue using voice technology in the next twelve months.[46]

Blockchain

Blockchain technology is a very practical solution to the problem of storing, authenticating and protecting data. Think of a blockchain as a decentralized, extremely secure database. Or, to get slightly more technical, it is a distributed, peer-to-peer ledger of records. While nothing is ever totally 'hack-proof', blockchain represents a huge leap forward compared to our current data security technology as, unlike a centralized database, there's no one single point of failure.

1.5.3 Impacts on Thailand

E-commerce in Thailand

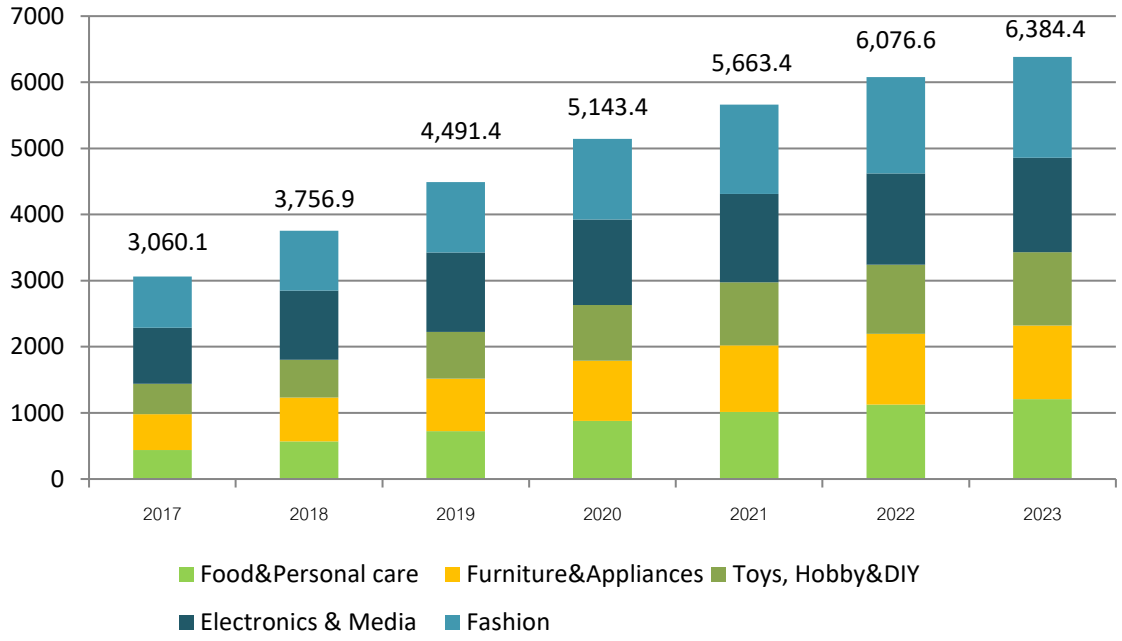
Currently, 12.1 million Thais shop online and spend an average of US$243 per year on e-commerce. The annual online expenditure per person is expected to grow to US$382 by 2021, according to research reports.[47]

Revenue in the e-commerce market is estimated to amount to US$4,492m in 2019 with an annual growth rate (CAGR 2019-2023) of 9.2%, resulting in a value volume of US$6,384m by 2023.

- The market's largest segment is Electronics & Media with a market value of US$1,201m in 2019, but by 2023 the largest one will be Fashion with a value of US$1,527m.
- User penetration is 57.0% in 2019 and is expected to hit 66.4% by 2023.
- The average revenue per user (ARPU) currently amounts to US$112.95.[48]

[44] https://www.vendhq.com/blog/retail-technology-trends/
[45] https://www.shuup.com/software/23-retail-technology-trends-for-digital-transformation-2018/
[46] https://brandinginasia.com/the-future-is-voice-activated-in-asia/
[47] https://www.aseanbriefing.com/news/2018/07/06/thailands-e-commerce-landscape-trends-opportunities.html
[48] https://www.statista.com/outlook/243/126/ecommerce/thailand#market-revenue

Figure 17. Thailand E-Commerce Revenue in million US$



Source: Statista, October 2018

Electronics & Media e-commerce sales to decline; Fashion to overtake by 2021

Electronics and Media e-commerce has been leading the online traffic in Thailand since 2017, with a projected 25.08% of total e-commerce revenue by 2020, but would drop to 23.53% by 2021 and 22.37% by 2023, consequently. Fashion e-commerce market is projected to grow to 23.89% of the total e-commerce market by 2021, overtaking Electronics and Media segment in the process, and continue to hold the largest revenue share at 23.91% by 2023. Food & Personal Care and Toys, Hobby & DIY e-commerce markets are estimated to grow steadily to 18.89% and 17.37% respectively by 2023.

By 2021, over 85% population would use smart phones to shop online, which is a rapid increase of 31%. Cash transactions would fall from 90% to 50% within the next few years. Thailand E-commerce Park will play a significant role in building the e-commerce ecosystem by providing trainings of e-commerce knowledge to students, entrepreneurs and SMEs.[49]

Moreover, Big Data and Artificial Intelligence will enable the "personalized shopping experience" and efficiently integrate online and offline trends. Voice command online shopping through smart speakers will also play a role.[50]

Thailand – the biggest social commerce market

According to market reports, over 50% of Thai online shoppers purchase products through social networks. The user base comprises mostly of young people: 76% of 15 to 19-year-olds, 52% of 20 to 29-year-olds, and 34% of 30 to 39-year-olds.

To maximize customer reach in the over-crowded online market, many e-commerce merchants set up Facebook and Instagram pages where they post images and details of their products. This enables

[49] https://www.opengovasia.com/the-dominant-role-of-e-commerce-in-thailand/
[50] https://www.bangkokpost.com/business/news/1535378/e-commerce-predicted-to-capture-10-of-thai-retail-segment

online browsers to inquire and discuss the product details directly with the company or the merchant, and further facilitate the deal.

Currently, Facebook and Instagram have over 10,000 operating online stores in Thailand. Because of their dominance and reach, these platforms should be considered as serious competitors to companies looking to disrupt the e-commerce marketplace in Thailand.

Logistics

The continued expansion of e-commerce business has increased the demand for logistics space and brought about significant changes in the supply chain and logistics operations in Thailand.

Several courier companies have launched their cost-effective and high-quality logistics services and brought domestic end-to-end delivery to the market. Many companies have established central warehouses, along with smaller drop-off and pickup point across the country, to sustain the rise in demand. For small and medium enterprises, this means greater convenience and a quicker process to deliver to their consumers, at much lesser cost.

Aden, Central Group in partnership with JD.com, DHL Express Thailand, Kerry Express, Lazada, Pomelo, and Shopee, are some of the major e-commerce and logistics companies in the country.

Digital technology for e-commerce in Thailand

The Thai retail sector is now running into what is called internationalization, especially the new working organization which relies on fewer people, but smarter technology. Many retailers are trying to encourage individual shoppers to act like their staff. “Self-cashiering” by barcode scanning is a key example of an initiative launched by major retailers who want their shoppers to act like cashier staff in a move aimed at reducing costs.

Mobile wallet

A mobile wallet is a way to carry credit card or debit card information in a digital form on mobile device. Instead of using physical plastic card to make purchases, you can pay with your smartphone, tablet or smartwatch.

An increasing number of large businesses in Thailand are developing payment wallets as a way for their existing customers to pay for their products or services, with the hope that the wallet will also be offered as a payment option by third party services – thus increasing the popularity of the brand and attracting more business. The more users a wallet has the more likely are it is to be adopted as a mainstream payment option.

As seen from Figure 18 in the following page, companies such as LINE, Garena, and Lazada have taken advantage of large user bases to promote a wallet service.

Such services seek to create an ecosystem that ties the user into the brand via multiple lifestyle services. These brands are disrupting the traditional banking system and themselves becoming facilitators of monetary transactions.[51]

[51] https://appsynth.net/blog/thailand-cashless-economy/

Figure 18. Thailand transition to cashless economy

Source: appsyth

Thailand's government too has been actively promoting digital payments by launching their own initiatives. A major one is the electronic interbank transfer system, PromptPay, which has been playing a key role in driving digital payments.

PromptPay was launched in 2017, and as of April 2018, had processed 97 million transactions, totaling THB 370 billion in transfers, across 37 million savings accounts. It had 42.6 million registrants as of July 2018.[52]

AI

Artificial Intelligence will gain more dominance with some executives predicting that 85% of all transactions will be AI-based by 2020. In 2018, we will see AI adoption continue to rise, with chatbots being one of the leading technologies. Due to increasing ease of deployment, instant availability and improved quality, chatbots will become more and more common to manage customer service queries and to make intelligent purchase recommendations. Alongside having the technology available, retailers now also have a significant amount of data to power AI and deliver personalized, customized and localized experiences to customers. This will be able to answer to the demands of customers for better, faster and personalized experiences.[53]

As a result of machine learning, automation and predictive ability, there would a huge advancement in the adoption of AI technology in Thailand by 2020. With the arrival of 5G technologies, more data will be processed, therefore the effect of AI on businesses will have huge impacts such as boosting productivity, improving cost management and creating opportunities.

According to predictions by Frost and Sullivan, 40% of digital transformation solutions will be supported by AI to develop critical insights in Thailand. The products and service derived from digital transformation would acquire a 40% space in the GDP of Thailand by 2021

[52] http://fintechnews.sg/27825/thailand/thailand-mobile-payments-adoption/
[53] https://home.kpmg/th/en/home/media/press-releases/2018/04/ressrelease-04042018-five-key-retail-trends-in-2018.html

VR/AR technology

It is anticipated that Asia would lead the AR and VR market by 2020. This industry is predicted to be worth US$120 billion by 2020. AR has played a key role in boosting the technology industry in South East Asia.

The digital natives will play a key role in leading the AR technology advancement, especially in Thailand where there are more mobiles than people. The country already possess 5 billion digital natives, summing up to 6% of the country's population and 42% of the Thais between 15 – 24 years[54]

Blockchain

The Thai government has not only been open to foreign cryptocurrency startups, it has also been actively looking to integrate cryptocurrency and blockchain, going so far as to plan a central bank digital currency (CBDC) by 2019.

BOT, alongside eight commercial banks, are currently developing a prototype platform for domestic fund transfers using the new cryptocurrency. The consortium is using R3's Corda distributed ledger platform to develop the technology.

In July 2018, the Thai SEC allowed the Thai Bond Market Association to create a bond registrar service platform for corporate bond transactions that utilizes blockchain technology.

Separately, the kingdom's revenue department is exploring the use of blockchain and machine learning to curb tax avoidance. It will be using blockchain to verify whether taxes were paid correctly and to speed up the tax refund process. Meanwhile, machine learning will be used to study how taxes are evaded; enabling revenue officials to efficiently track tax fraud and create more transparency.

1.5.4 Conclusion

Purchase decision making is increasingly taken place outside physical store landscape. That is where many digital technologies, including 5G, IoT, AI, automation, blockchain, data analytics and VR/AR play more significant roles to facilitate and speed up such on-demand transactions made anywhere, anytime by Thai online shoppers. In a long-term, Quantum computing also has a potential to help make online and e-commerce transactions more secure through a more complicated level of encryption, decryption and cryptography with high-value applications foreseen in the financial sector. depa and BOT should have related laws and regulations set in place to allow a new kind of transaction processing and management expected to be emerged in the future.

1.6 Increasing Connectedness and decreasing privacy

1.6.1 Megatrend in Global Context

The internet has become an integral component of people's daily and working lives. Never before has a single technology connected people as comprehensively. Today, every website, every app and every game has connecting features – the attribute "social" will soon become obsolete if it is included into every online interface.

A Global Digital study reports that there are now more than 4 billion people around the world using the internet in 2019 (4.388 billion, up 7% year-on-year). Over half of the world's population is now online, with the latest data showing that nearly a quarter of a billion new users came online for the first time in 2017. Africa has seen the fastest growth rates, with the number of internet users across the continent increasing by more than 20% year-on-year. Much of 2018's growth in internet users has been driven

[54] https://appsynth.net/blog/augmented-reality-southeast-asia-thailand/

by more affordable smartphones and mobile data plans. More than 200 million people got their first mobile device in 2017, and two-thirds of the world's 7.6 billion inhabitants now have a mobile phone. There are 5.11 billion unique mobile users in the world in 2019, up 100 million (2%) in the past year. More than half of the handsets in use today are 'smart' devices too, so it's increasingly easy for people to enjoy a rich internet experience wherever they are.

Social media use continues to grow rapidly too, and the number of people using the top platform in each country has increased by almost 1 million new users every day during the past 12 months. More than 3 billion people around the world now use social media each month, with 9 in 10 of those users accessing their chosen platforms via mobile devices. The number of social media users in 2018 is 3.196 billion, up 13% year-on-year. Social networks create a particularly significant aspect of this development, as they have radically accelerated, globalized and democratized communication, interaction, collaboration and knowledge sharing. Interests, opinions, experiences and even consumer goods can now be shared with others more easily than ever. Likes are the new currency on Facebook, Twitter and Instagram. The net culture has led to the creation of its very own online visual language, which is international, fun and less formal than offline. As a result, curation has grown in importance due to the variety of content and the endless feeds in social networks. The curators are influencers or media companies who offer their target groups orientation by creating order from chaos and finding quality in quantity.

Furthermore, marketplaces are also moving into the online sphere. Love and business partners can now find each other there. Positive examples of effective human solidarity can be seen in the numerous projects to found new companies, petitions for good causes and attempts to fund films through crowdsourcing or crowdfunding.

1.6.2 Technology Trends

Technologies that enhance connectivity – such as the Internet of Things (IoT) and networking technologies like the 5G network – are constantly evolving, along with the increase in the number of internet users worldwide. This phenomenon, however, not only has positive impacts to businesses and societies, but also has negative consequences that arise from being connected, particularly cybersecurity and privacy challenges.

A 2018 Global Survey on Internet Security and Trust findings show that over half of internet users surveyed around the world are more concerned about their online privacy than they were a year ago, reflecting growing concern around the world about online privacy and the power of social media platforms. And 79% said that internet companies are the primary source of their heightened anxiety.

- 52% of global users are more concerned about their online privacy compared to one year ago.
- For 81% of respondents, cybercriminals were the primary source of concern regarding their online privacy. Overall, 63% also reported that their own government has contributed to their concerns regarding online privacy.
- Users also expressed a high level of distrust of social media platforms, search engines and internet technology companies, with 63% of respondents feeling that social media has too much power.
- 42% of those responding claimed that social media influences their political views and 30% think that social media makes their life worse. As a result, many around the globe are changing their behavior online, a trend with economic and societal implications.
- 12% of global internet users report making fewer online purchases.

- 10 % have closed social media accounts and 7 % are using the internet less often overall, compared to one year ago.[55]

Consequently, technologies such as Big Data, AI, and blockchain will take center stage in the coming years as technologies that propel cybersecurity approaches toward modernization. These efforts will focus on protecting businesses from the threats that emerge from IoT devices and an expanding threat landscape. To explain in greater details, deploying Big Data solutions is essential for companies to expand the outlook of cybersecurity solutions beyond detection and mitigation of threats to proactively predict breaches before they happen, uncovering patterns from past incidents to support policy decisions. Likewise, utilizing the vast pools of data collected by companies machine learning algorithms automate the process of identification and remediation of detected anomalies in the network. The use of Machine Learning also infuses efficiency into the work of security teams by reducing and prioritizing the actions that have to be carried out manually. Finally, the inherent nature of Blockchain makes it nearly impossible for hackers to corrupt data stored on them. The absence of central authority and tractability of activities performed on Blockchain are integral to establishing a trustworthy network between endpoints, where the authenticity of the data can be assured based on the consensus mechanism.

1.6.3 Impacts on Thailand

Similar to the global trend, the number of internet users in Thailand is also increasing in the same direction. In Thailand, there are 57 million internet users, accounting for 82% of total 69.11 million populations in 2018 with 24% growth from January 2017.

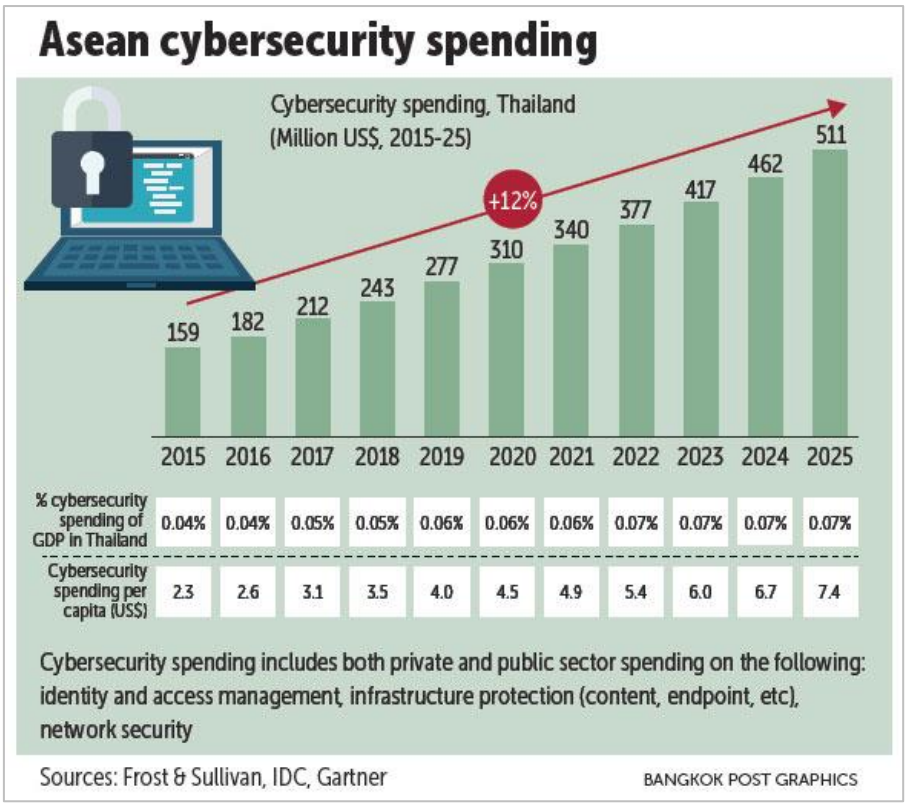
- The number of unique mobile users in 2018 is 55.56 million (80% penetration), up 3 % or 2 million year-on-year.
- The number of active mobile internet users in 2018 is 54.58 million (79% penetration).
- The number of active social media users in 2018 is 51 million (74% penetration), up 11 % or 5 million year-on-year.
- The number of active social mobile users in 2018 is 46 million (67% penetration), up 10 % or 4 million year-on-year.
- 98% of Thai population currently uses any type of mobile phone and 71% uses smartphone.

As connectedness grows, cybersecurity remains key concern for regulators, private companies and individuals, leading to higher spending on cybersecurity across regions including Southeast Asia, as well as Thailand. A combination of new policy preparedness, an absence of a unifying regional governance framework, a shortage of skilled talent, the underestimation of risk and a lack of adequate investment are among the factors that contribute to the heightened cyber risk in Southeast Asia.

ASEAN's cybersecurity spending was estimated to be US$1.9 billion in 2017, representing 0.06% of the region's GDP. The region's spending on cybersecurity is forecasted to grow at a 15% compound annual growth rate from 2015 to 2025, while Thailand's cybersecurity spending is projected to grow to US$511 million by 2025 from US$159 million in 2015 with a CAGR of 12%, increasing cybersecurity spending per capita more than 3 times to US$7.4 by 2025 from US$2.3 in 2015.[56]

[55] https://www.cigionline.org/internet-survey-2018
[56] https://www.bangkokpost.com/news/asean/1400970/cyber-risk-may-shave-off-750bn-in-asean

Figure 19. Thailand's Cybersecurity spending in Million US$, 2015-2025



Thailand was ranked 5th among 25 countries in Asia for the cybersecurity threats encountered in 2015. It was ranked 11th in the country's exposure to cyber-attacks amongst other Asian countries. Asia Pacific growth rate for cybersecurity is estimated to be at 43% by 2020 due to fast pace of digitization and threats. Thailand's cybersecurity is estimated to be $20 million every year. Thailand 4.0 has been the major force towards pairing education, technology with data protection and cyber security law. With THB 200 million, Thailand is planning to put forward 1000 cyber security specialists within the next few years.[57,58] Take Wannacry ransomware as an example for cyberattack, it paralyzed systems in many countries, including Thailand to release data that was held hostage. Therefore, cybersecurity spending in Thailand would grow by 30% by 2020. The expenditure on cybersecurity is estimated to be $511 million by 2025.[59]

In addition, the Thai government has also proposed a legislation that would give the powers to spy on the internet traffic, order removal of content or seize computers without consensus. The legislation which is hopeful to pass within the next year is expected to reduce cyber-crimes to great extent.

1.6.4 Conclusion

Through the continuous advancement of digital technologies such as 5G and networking, the connectivity coverage through mobile, wearable or embedded connected devices will keep increasing with a higher number of internet and mobile internet users estimated worldwide and in Thailand. However, the rising connectedness must walk hand in hand with more secured interactions and exchanges to protect online privacy from cyber-attacks and threats. Thus, new types of Security technologies equipped with novel applications of AI, blockchain, data analytics, cloud computing as

[57] https://www.ifsec.events/sea/visit/news-and-updates/thailand-5th-cyber-security-threats-asia
[58] https://e27.co/thailands-great-cybersecurity-push-20181129/
[59] https://www.bangkokpost.com/news/politics/1562230/the-cybersecurity-balancing-act

well as Quantum computing in the future must be utilized and well-established to build a highly-secured digital ecosystem for individuals and enterprises that facilitates and accelerates online secured interactions and transactions in terms of identity and privacy protection against all sorts of online hacking and thefts.

1.7 Transformation of Workplace

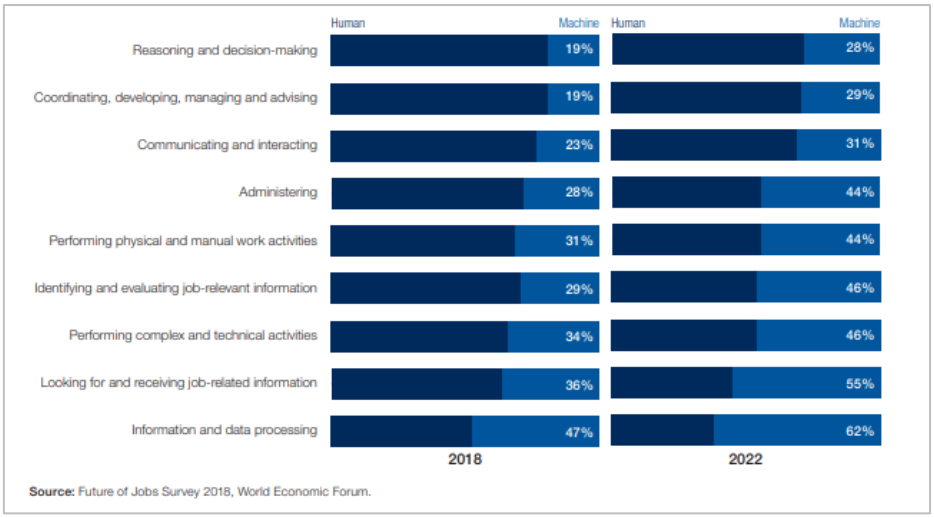
1.7.1 Megatrend in Global context

Worldwide, the nature of work is being transformed by a complex and interconnected combination of factors such as technological advancement, rapid pace of innovation, demographic shifts, climate change, rising inequality and increasingly fragmented production systems. Rather than allow these trends to further polarize society and lead to greater inequality, countries big and small must proactively address these tectonic changes.

While the Fourth Industrial Revolution's wave of technological advancement will reduce the number of workers required to perform certain work tasks, a WEF report indicate that it will create increased demand for the performance of others, leading to new job creation. Moreover, while the current popular discourse is often fixated on technology that substitutes for humans, technology will also create new tasks—from app development to piloting drones to remotely monitoring patient health—opening up opportunities for work never previously done by human workers, highlighting that different types of new technology may bring about very different outcomes for workers.

However, most automation occurs at the level of specific work tasks, not at the level of whole jobs. For example, according to one recent study, whereas nearly two-thirds of today's job roles entail at least 30% of tasks that could be automated based on currently available technology, only about one-quarter of today's job roles can be said to have more than 70% of tasks that are automatable. A similar recent analysis finds that workforce automation is likely to play out in three waves between today and the mid-2030s, increasing the share of fully automatable manual tasks in the most affected current job roles from less than 5% today to nearly 40% by the mid-2030s, and the share of automatable tasks involving social skills from less than 5% today to about 15% in the same time horizon. The most relevant question to businesses, governments and individuals is not to what extent automation will affect current employment numbers, but how and under what conditions the global labor market can be supported in reaching a new equilibrium in the division of labor between human workers, robots and algorithms. Workforce planning and investment decisions taken today will play a crucial role in shaping this process.

Figure 20. Ratio of human-machine working hours, 2018 vs 2022 (projected)



These extrapolated figures are based on employers' current projections for the set of roles with increasing, declining and stable demand in the period up to 2022, which were estimated by employers as a share of each enterprise's total workforce. The figures were then applied to the International Labor Organization's estimates and projections of global non-agricultural employment in both 2018 and 2022, adjusted for the estimated share of total employment represented by this report's respondent data, i.e. large businesses. The figures used for estimating the global share of large business employment are based on established estimates by the World Bank, US Bureau of Labor Statistics and Eurostat, holding the distribution of firm size constant between 2018 and 2022.

1.7.2 Technology Trends

One of the most important technologies driving the future workforce transformation is automation. Research has shown that at least one-third of job duties could be automated in 60% of jobs. The OECD predicts that those in their teens will be the most at-risk as automation puts them out of work[60]. Overall, predictable physical work with repeated tasks, as well as the support and administrative duties of the office will be automated. In addition, as machines are going to be built, construction will probably need far fewer builders. Customer interaction jobs will also shift, such as hotel and travel workers, food service workers, retail workers, and so on.

An analysis of more than 2,000 work activities across more than 800 occupations shows that certain categories of activities are more easily automatable than others, which include physical activities in highly predictable and structured environments, as well as data collection and data processing. These account for roughly half of the activities that people do across all sectors. The least susceptible categories include managing others, providing expertise, and interfacing with stakeholders. Furthermore, nearly all occupations will be affected by automation, but only about 5 % of occupations could be fully automated by currently demonstrated technologies. Many more professions have portions of their constituent activities that are automated, and in 60 % of all professions about 30 % of activities could be automated. This means most workers will work side by side with rapidly evolving machines — from welders to mortgage brokers to CEOs. As a result, it is likely that the nature of these jobs will change.

The World Robotics Report 2017 released by the International Federation of Robotics (IFR) forecasted 18% growth in industrial robot installations for 2017, with growth of about 15% forecast for 2018–2020. Stronger-than-expected growth in the global economy, faster business cycles, greater

[60] https://www.ucop.edu/innovation-entrepreneurship/innovation-resources/dr-christine-articles/the-future-of-work.html

variety in customer demand, and the emergence and expected scaling up of “Industry 4.0” concepts are all factors behind the optimistic forecast.[61] Worldwide, the automotive industry remains the largest adopter of robots globally with a share of 33% of the total supply in 2017 - sales increased by 22%. The manufacturing of passenger cars has become increasingly complex over the past ten years: a substantial proportion of the production processes nowadays require automation solutions using robots. Manufacturers of hybrid and electric cars are experiencing stronger demand for a wider variety of car models just like the traditional car manufacturers. Furthermore, the challenge of meeting 2030 climate targets will finally require a larger proportion of new cars to be low- and zero-emission vehicles. In the future, automotive manufacturers will also invest in collaborative applications for final assembly and finishing tasks. Second tier automotive part suppliers, a large number of which are SMEs, are slower to automate fully but we can expect this to change as robots become smaller, more adaptable, easier to program, and less capital-intensive.

Other key industries embracing automation and robotics include electrical/electronics industry and Metal industry. The electrical/electronics industry has been catching up with the Auto industry: Sales increased by 33% to a new peak of 121,300 units - accounting for a share of 32 % of the total supply in 2017. The rising demand for electronic products and the increasing need for batteries, chips, and displays were driving factors for the boost in sales. The need to automate production increases demand: robots can handle very small parts at high speeds, with very high degrees of precision, enabling electronics manufacturers to ensure quality whilst optimizing production costs. The expanding range of smart end-effectors and vision technologies extends the range of tasks that robots can perform in the manufacture of electronic products. Likewise, the Metal industry (including industrial machinery, metal products and basic metals industries) is on an upswing. Share of total supply reached 10% with an exceptional sales growth of 55% in 2017. Analysts predicted an overall growth in demand in 2018 for metals, with ongoing high demand for the cobalt and lithium used in electric car batteries. Large metal and metal product companies are implementing Industry 4.0 automation strategies, including robotics, to reap the benefits of economies of scale and to be able to respond quickly to changes in demand.[62]

AI is one of the key technologies affecting workplace. With the advent of AI and the chatbots that it powers, technology is now interwoven into many of our everyday job tasks. In fact, it has been reported that more than 80% of businesses plan to be using chatbots by 2020. AI is set to impact work in three major ways: human-to-machine interaction, smart process automation, and advanced analytics.

Human-to-Machine interaction is becoming more and more advanced, and today the goal is to make machines interact in as human-like ways as possible. Machines are just now starting to be able to detect emotion in our voices and in our written words, and they can learn to change their responses accordingly. In particular, chatbots demonstrate how technology is increasingly able to capture the human essence by evoking and responding to human emotions and actions. For example, the next generation of Siri has a much more human-like voice and better intonation. That all comes from machine learning and AI. Many enterprise-grade chatbot platforms also support cognitive emotion detection.

AI will also affect work through smart process automation, the elimination of work and the labor arbitrage associated with replacing people with bots. Today, machines are already responsible for much of the basic work being done across many industries. From robotic process automation to natural language document translation to fielding customer service requests, they are becoming smarter and more capable. Although machines powered by AI can complete some tasks, they can’t totally replace humans yet. The creativity and agility of the human brain is something that machines

[61] https://www.universal-robots.com/about-universal-robots/news-centre/ifr-world-robotics-report-2017/
[62] https://ifr.org/ifr-press-releases/

have yet to master. Take journalism, for instance. AI-powered machines today can independently write a fairly good basic news story. But although they can do a lot of it — likely about 80 % — some of the nuanced and stylistic elements of writing and editing are best left to humans, at least for now.

The third way AI impacts businesses is through advanced analytics — using data to find patterns and then using machine learning to discover insights. Advanced analytics and AI-based machine learning are about discovering patterns in data and using those identified patterns to generate value. It helps companies to better plan business operations and better understands customers. This technology enables business leaders to gain insight into their organizations as they function, allowing them to increase revenue, reduce costs and improve overall customer satisfaction. In today's digital age, companies must act quickly, and often in real time. That's why advanced analytics is becoming essential for organizations that want to be truly insight-driven.[63]

Aside from automation, robotics, and AI, other key technologies that are able to transform workplace include 3D printing, cloud computing, Big Data analytics, high-speed mobile connections, augmented reality, and use of drones.

1.7.3 Impacts on Thailand

Advances in robotics and automation technology such as collaborative robots (cobots) will change the face of work in Southeast Asia, including Thailand. The technology is transforming industries, increasing productivity and output quality while improving workers wellbeing by reducing the burden of repetitive and strenuous tasks. Key robotic solution providers OnRobot and OptoForce – now part of one single company – are aggressively targeting Southeast Asia, aiming to grow 250 % in the region in 2018. Employees are now able to program and operate robots easily with minimal training and technical skills. In addition, Southeast Asia is a powerhouse for the automotive industry in Asia. In Q1 2018, the region's production rose 7.3% to 1.09 billion vehicles, led by Thailand, Indonesia and Malaysia. The automotive industry has been the largest driver of the robotics industry worldwide for decades. The market value for cobots in the global automotive industry was $23.5 million in 2015 and is projected to reach $470 million by 2021, at an annual growth rate of 64.67% between 2015 and 2021. Furthermore, electronics - which is the largest export sector in Southeast Asia, comprising 25% of the region's total exports in goods - is the second largest cobot integrator, accounting for 18% of global demand in 2015. Top electronics producers in the region include Thailand, Philippines and Malaysia. By 2021, global electronics industry is forecasted to invest approximately $475 million in cobots.

Considering in Thailand, automation is having the greatest impact on manufacturing in the country. Over the few decades running up to the 1997 Asian financial crisis, Thailand received significant foreign investment in manufacturing, such as in the production of cars and electrical appliances in order to take advantage of the country's relatively low labor costs and plentiful unskilled and semi-skilled labor supply. This investment has significantly benefitted the Thai economy and helped propel it to middle-income status. After the crisis, the government launched a number of labor-friendly policies such as increasing the minimum wage, which reduced the Thai labor market's competitive advantage. The response by industry has been to bring in workers from neighboring countries (especially Myanmar) and to begin utilizing more robots and other advanced automation systems in the manufacturing process. Thailand is certainly not lagging behind with adopting automation. According to the International Federation of Robotics, Thailand is now the eighth largest market globally in the adoption of robotics. For the businessman, the new automation projects boosted, triggered and supported by the government, could truly be a great way to streamline processes, systems and profits at the same time. The government no doubt sees the new cutting-edge innovations as not only a way to ensure a greater and more valuable national production, but also as

[63] https://www.cmswire.com/digital-workplace/how-artificial-intelligence-will-impact-the-future-of-work/

a way to help eradicate any cultural inequalities. But for the everyday worker it can all seem a bit scary. For the unskilled employee, there is likely to be the fear that these new robots are going to be taking their jobs. But in reality, the future may not be as bleak as it at first may seem for the employee. The reason many put forward for this is – we are not talking about your everyday robot here – we are talking about cobots.[64]

In addition to its impact on unskilled and low-skilled jobs in manufacturing, automation is posing threats to information content providers that have traditionally relied on advertising, such as television, newspapers and magazines. Advertisers are now switching to social media platforms such as Facebook and YouTube, as their ads can now be targeted to particular users due in part to automation technologies. Automation in the form of ATMs and IT applications are also becoming more prevalent in the Thai banking sector, which will likely threaten banking staff numbers. Online shopping is also taking off in Thailand, especially as people become more comfortable making purchases on a "sight unseen" basis, and which is anticipated to affect retail staff numbers at Thailand's numerous department stores.

By 2030, 72% of the graduates in Thailand would be either unemployed or working without degree due to massive impact of AI and robotics. There would be loss of organic jobs due to expansion of robotics and the norm of lights out factories. About three in five jobs would face high automation risk in entire Southeast Asia. The region would experience 25% of job displacements. Although automation would sky-rocket, the demand for jobs would increase due to growth in the economy, rising income, increasing healthcare in aging countries and investment in infrastructure. People with high cognitive abilities, along with high digital skills would likely to be well-positioned. Vulnerability would lie in the workers with no digital talent or the ones who perform labor tasks.[65] AI in Thailand would replace certain workforce but it would also create jobs for new skilled workers such as data labellers, individuals who understand automated self-driving vehicles, insurance policies, security guards who could manage AI powered security[66]. According to the latest study, 95% of jobs in Thailand would be transformed within next 5 years with 30% of the jobs being outsourced or automated. Future emphasis would be on transfer of research into AI with the aid through quantum technology.

1.7.4 Conclusion

The nature of work and job in need of human workforce is being transformed at an exponential rate in many sectors and industries due to the widespread arrival of automation, IoT, data analytics, cloud computing and AI to maximize unfulfilled efficiency and minimize unnecessary costs. Therefore, depa and related stakeholders must cooperate strongly to promote and gear the utilization and usage of those technologies towards achieving efficiency-oriented goals in Thailand, while also contributing to the re-skilling and re-training to help human workers previously displaced by digital technologies re-enter and expand the Thai digital workforce market with skill sets and competency required to drive the country's Digital Economy forward in a macroeconomic level.

1.8 Shift in global economic power

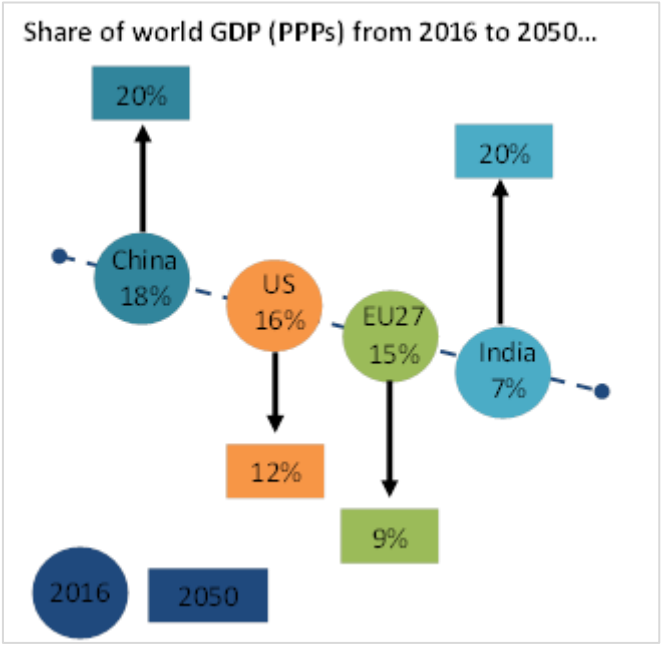
1.8.1 Megatrend in Global context

Today's advanced economies will continue to have higher average incomes, but emerging economies should make good progress towards closing this gap by 2050. The world economy could more than double in size by 2050, assuming broadly growth friendly policies (including no sustained long-term

[64] https://peak-recruit.com/rise-of-the-cobots/
[65] https://www.bangkokpost.com/news/general/1538238/robots-tipped-to-snuff-out-graduates-job-hopes
[66] https://www.bangkokpost.com/business/news/1563478/analysts-advise-widespread-ai-use

retreat into protectionism) and no major global civilization-threatening catastrophes. Emerging markets will continue to be the growth engine of the global economy and dominate the world's top 10 economies in 2050. By 2050, the E7 economies – namely China, India, Brazil, Mexico, Russia, Indonesia, and Turkey – could have increased their share of world GDP from around 35% to almost 50%. China could be the largest economy in the world, accounting for around 20% of world GDP in 2050, with India in second place and Indonesia in fourth place (based on GDP at PPPs). A number of other emerging markets will also take center stage – Mexico could be larger than the UK and Germany by 2050 in PPP terms and six of the seven largest economies in the world could be emerging markets by that time. Meanwhile, the EU27 share of world GDP could be down to less than 10% by 2050, smaller than India.

Figure 21. Share of World GDP (PPPs) from 2016 to 2050



Source: PwC

In addition, Vietnam, India and Bangladesh are projected to be three of the world's fastest growing economies over this period. UK growth has the potential to outpace the average rate in the EU27 after the transitional impact of Brexit has passed, although the fastest growing large EU economy is expected to be Poland. Beyond the top three countries, a marked movement of emerging economies up the rankings into the top 10 is worth a look, with a corresponding fall in the rankings of today's advanced economies. With the exception of Turkey, the E7 economies will dominate the top 7 places, with Indonesia, Brazil, Russia and Mexico taking 4th to 7th places in 2050.

With global economic power expected to shift to the E7 economies, as explained above, this will open up great opportunities for businesses prepared to make long-term investments in these markets. But this will require patience to ride out the storms we have seen recently in economies like, for example, Brazil, Nigeria and Turkey, all of which still have considerable long-term economic potential. To realize this growth potential, emerging market governments need to implement structural reforms to improve macroeconomic stability, diversify their economies away from undue reliance on natural resources (where this is currently the case), and develop more effective political and legal institutions.

1.8.2 Technology Trends

In terms of the contribution to overall economy, technology invasion or the dominating global presence of technology-led companies like Google, Uber, Facebook etc. is considered as one of the major forces shaping the future of world's economy. Currently, 7 out of the 10 most valuable

companies in the world are dominated by digital technology-led companies, including Amazon, Microsoft, Alphabet (Google's parent company), Apple, Facebook, Tencent and Alibaba. According to the overall estimations, Amazon employs about 230,000 employees and has more than $150 billion in assets at the given moment. Its annual turnover amounts to approximately $200 billion.[67]

Table 2. Most valuable companies in the world 2019

Company	Industry	Market Capitalization
#1 **Amazon Inc.**	Retail business	$802.18 billion
#2 **Microsoft**	Software development	$789.25 billion
#3 **Alphabet Inc.**	Internet with various digital platforms	$737.37 billion
#4 **Apple Inc.**	Electronics, Information Technology	$720.12 billion
#5 **Berkshire Hathaway Inc.**	Insurance, finances, railway transport, utilities, food and non-food products	$482.36 billion
#6 **Facebook**	Internet with social network platform	$413.25 billion
#7 **Tencent**	Internet with social network platform	$400.95 billion
#8 **Alibaba Group**	Internet with E-Commerce platform	$392.25 billion
#9 **Johnson & Johnson**	Pharmaceuticals	$347.99 billion
#10 **JPMorgan Chase**	Banking business	$332.24 billion

Source: FXSSI

Technological or specifically in this case digital startups can play crucial roles in advancing economic growth of a nation. One of the main advantages of startups is that it creates new jobs, thus the rate of unemployment also decreases. Global data shows that startups are creating more jobs than the large companies or enterprises. Startups also contribute to the creation of wealth. As entrepreneurs are attracting investors by investing their own resources, the people of a nation would get benefit when startups grow. Since the money is sharing with the society, wealth is creating within the nation. In addition, startups can implement innovations and technologies to improve the living of people. There are many startups who are working in rural areas to develop the communities marginalized by a lack of economic benefit sharing. Considering in country level, World Bank says that India will become the fastest growing country as economic growth in the world. By supporting and encouraging more startups with the Startup India Schemes, it is possible to generate more revenue domestically and consumer's capital will also flow around the Indian economy.

In terms of technological development, startups companies are some of the major players that support and facilitate the development of advanced technologies. Many of the startups have introduced latest technologies like IoT, AI, and robotics. Meanwhile, many technology giant companies outsource their tasks to startups nowadays. It will also help to increase the cash flow of startups. But every startups needs to deliver quality to their consumers in order to sustain their business. Then only these startups will grow and succeed.

1.8.3 Impacts on Thailand

Thailand will be the world's 22nd largest economy in 2050, being one of several emerging economies which will join the top 30, according to HSBC's Global Research Report "The World in 2050: Quantifying the shift in the global economy". The report also found that 19 of the top 30 economies will be countries that are currently 'emerging' and China and India will be powering global growth over the next four decades while countries as varied as Nigeria, Peru and the Philippines will also be playing a significant part. Thailand's economic size is expected to more than quadruple from US$187 billion in 2010 to $856 billion in 2050.[68] To help Thailand achieve and maintain such position

[67] https://fxssi.com/top-10-most-valuable-companies-in-the-world

[68] https://www.thailand-business-news.com/economics/34408-the-world-in-2050-thailand-to-be-22nd-largest-economy-hsbc.html

in the future, Digital Economy driven by digital and technological startups must be supported by Thai agencies and entrepreneurs as one of the major growth engines that significantly contributes to the country's economic output as a whole and propel Thailand to be among the top 30 of global economy.

According to LINE, the Thai startup scene remains relatively underdeveloped compared to Indonesia, Vietnam, and Malaysia, with only US$ 61 million invested in local startups in 2018. Thus, LINE Thailand and LINE Ventures are setting aside US$ 20 million to empower Thai startups through its post-accelerator program Line ScaleUp with an aim to help Thailand develop its first unicorn, a startup with a valuation over US$ 1 billion.

Meanwhile, in early 2019 depa has launched the Digital Startup Institute with objectives to promote both Thai and foreign startup entrepreneurs operating in Thailand to grow into global market. The new facility aimed to enhance digital startup entrepreneurs' capacities by providing many services such as co-working space and one stop service so that the digital startup entrepreneurs can apply deep digital technologies to expand their business to the international level.

1.8.4 Conclusion

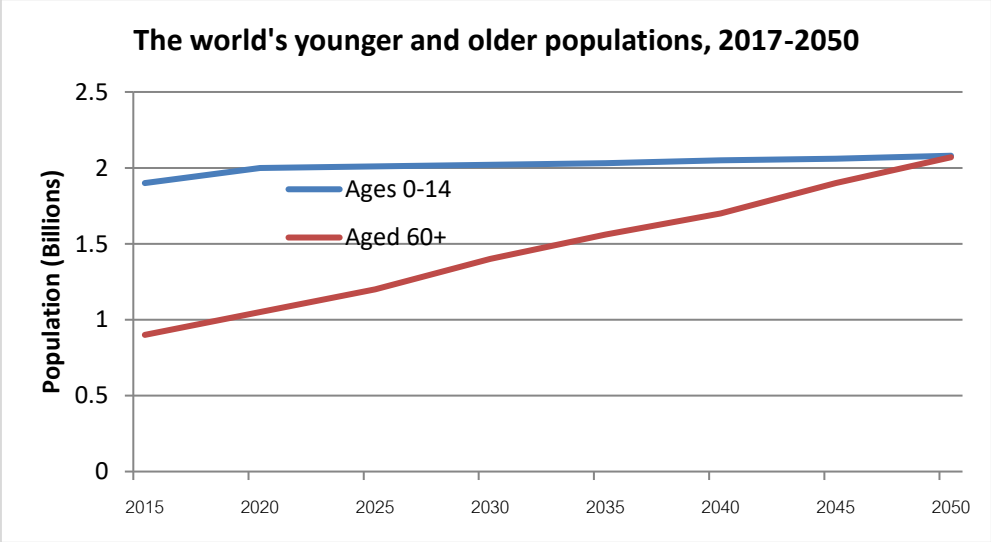
depa, relevant agencies, digital and tech startups must build a strong relationship to contribute in establishing Digital Economy as a mainstream economy of Thailand by leveraging a varied combination of AI, automation, IoT, data analytics, security, blockchain, 3D printing and cloud computing to provide various new use cases and applications of digital services such as Big Data analytics platform, AI-powered security, data-driven business models, and small-scale smart factory if Thailand's Digital Economy were to achieve a significant proportion of the country's GDP.

1.9 Aging society

1.9.1 Megatrend in Global context

The global population is aging as fertility declines and life expectancy increases. In 2017, more than half of the global population is composed of adults between 15 and 59 years of age (61%), while children under 15 years of age represent roughly one quarter (26%). Older persons aged 60 or over account for just over one eighth of the world's inhabitants (13%); however, this age group is growing faster than all younger age groups. Hence, the number of older people is likely to double by 2050. The size of the population under age 15 is expected to stay relatively stable throughout the century at about 2 billion

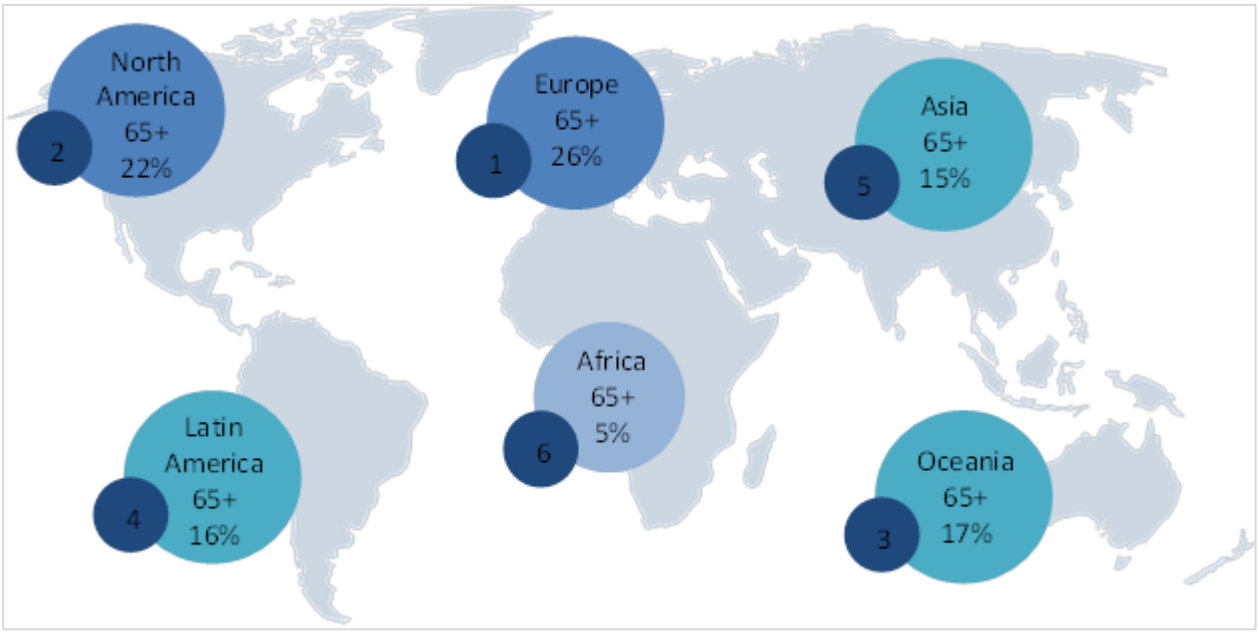
Figure 22. The World's younger and older populations, 2017-2050



Source: United Nations

By 2040, over 14% of global population is 65 years old or above, marking the beginning of global aged society. Regional differentials range from the oldest Europe and North America to the youngest Africa.

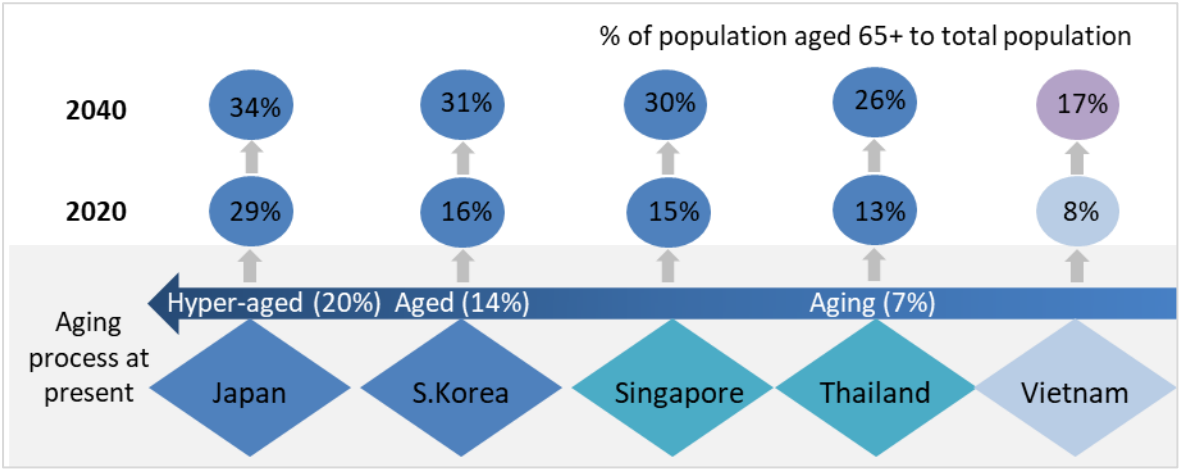
Figure 23. Proportion of aging population by 2040



Source: United Nations

Regionally, Asia is aging fastest in the world. Japan's "hyper-aged" society among the leader in region's aging process, followed by "aged" South Korea and "aging" Singapore. Thailand's aging process is just behind these 3 front runners, and slightly ahead of Vietnam.

Figure 24. Proportion of aging population Present-2040



Source: United Nations

Aging society presents a challenge for families, communities and the country as a whole, as older people require more care for their welfare and assistance in their daily lives. Family is the first supporting unit for aged people, as children generally place high value on, and exhibit gratitude towards, their parents. However, the shrinking size of families has placed strain on this network.

Family members also have limited knowledge and tools to handle the daily care of their parents. Many have to play "sandwich" roles – looking after both their own children and their parents. Worse, caregivers themselves are getting older. Family members also suffer high stress, especially when they have to look after bed-bound patients. As a result, many families have turned to private health services and these are on the rise.

However, aging society not only has negative impacts but also leads to opportunities like business opportunities. A longer life brings opportunities for older adults and their families as well as for their communities. Commercial businesses can be successful in innovating on these opportunities and achieving business expansion, according to the Asia-Pacific Economic Cooperation (Apec) International Workshop on Adaptation to Population Aging Issues, but first they need to better understand the market dynamics and spectrum of older adults as consumers and view them more as assets rather than as burdens to society, said the workshop.

The opportunities of longer life are impacted by health and underscore the importance of positive, healthy aging-related behaviors such as good nutrition and active lifestyles. Healthy aging also requires sustained commitment and actions from national leaders to formulate evidence-based policies, including systematic nutrition screening and intervention, healthcare workforce training, and education to strengthen and support an active aging population. In addition, governments should consider engaging commercial businesses to help set sustainable policies that can advance products for older adults. Finally, governments should set national and local goals to incentivize commercial business development and investment in public-private partnerships to improve the quality of care, promote healthy aging, and impact outcomes for non-communicable diseases, ultimately benefiting the populations of the APEC countries, the research said.

1.9.2 Technology Trends

Today's innovations have the potential to change the aging experience—to eliminate constraints that seniors (or their caregivers) confront in daily living. Every day, products are being introduced that enable seniors to stay connected with family and friends, to stay safe in their homes and communities, and to stay healthy and well. New voice communication technologies, combined with at-home monitoring systems, are not only enabling seniors to age-in-place but reducing costs to society. Digital solutions that allow remote tracking of vital health information are also reducing health care costs and allowing seniors to stay at home longer. But there are still challenges. Technology is expensive, especially for many seniors across the world. And seniors may not be comfortable with new technology so adoption can be slow. But the good news is that many of today's "smart" products benefit all ages of society. Concepts of universal design in housing and industrial products can be functional and also beautiful. Urban investments in age-friendly technologies will improve everyone's access to and mobility within their communities. From smart homes with voice controls to self-driving cars—these innovations will improve the everyday experience for everyone—senior and non-senior alike.[69] Smart homes will help provide safety for a growing aging population. Within the home, technologies that provide assistance for navigating around the house and performing daily tasks — like cleaning, cooking, and climbing stairs — will help older people stay independent in their later years. Health tech will be infused into homes in order to help families monitor everything from the nutrition content of their refrigerators to schedules for medications. This kind of technology will pervade not just homes, but also whole communities. China is experimenting with entire urban developments designed specifically for the elderly. Senior living facilities developed by companies like China Life Caregarden/Merrill Gardens, China Senior Care, the Nan Fun Group, and Starcastle Senior Living are in the process of developing the necessary infrastructure for such communities. Developers in Thailand used to introduce basic home security and lighting control systems to their

[69] https://www.kenan-asia.org/aging-society-the-global-trend/

residential projects. Nowadays, with more information in the market, IoT control is popular for Thai consumers as well.[70]

As one of the primary challenges of a growing aging population is finding ways to keep older citizens healthier for longer, healthcare industry plays an important role to address these challenges, by adopting healthcare and medical technologies in particular. When it comes to cutting-edge medical innovations, China is a world leader in breakthrough technology. In 2015, for example, Chinese scientists developed a way to 3D print blood vessels out of living cells — a major step toward printing entire organs that may be used to save lives and improve quality of life for elderly patients. It is not just medical technology in the most literal sense that is contributing to advancements in the healthcare arena. Innovations in telecommunications, Big Data, and machine learning are also seeping into China's healthcare system. Technologies that enable virtual examinations, remote patient check-ups, and improved online record-keeping are making a huge impact. The umbrella term for this is mobile health (mHealth), or the use of communication technology to deliver medical attention and information. This type of technology is particularly promising in China, where widespread proliferation of mobile devices creates a solid foundation for nationwide adoption of mHealth platforms. In fact, in 2016, China accounted for 37% of the mHealth market in Asia; notable companies like Alibaba are investing heavily in the industry, as well as establishing their own platforms (such as online health provider Ali Health). The implications for mHealth are far-reaching. Elderly people with limited mobility can go through the entire process of visiting a doctor — from video consultation and diagnosis, to remote treatment and prescription delivery, to online payment — without stepping foot outside their homes. Organizations like the Ningbo Cloud Hospital, an internet-based healthcare center based in northeast China, and sites like Chunyuyisheng.com are proving that routine, remote medical assessments just may be the way of the future.

mHealth has yet another huge benefit. As wearable technology and nanomedicine become more advanced, there is an increasing amount of patient data available for analysis. This data helps both parts of the healthcare equation — medical professionals and patients — develop and sustain viable, innovative treatment paths. The wrangling of Big Data via Artificial Intelligence and machine learning is making massive strides in the healthcare and medical tech industries. iCarbonx, for example, is just one company in China on the cusp of major breakthroughs in this field. iCarbonx provides individualized health analyzes through data mining and machine learning, and promises to bring new levels of understanding to health, disease, and aging. The company's app, Meum, uses algorithms to create bespoke health plans for users — tapping into a greater trend dubbed "precision science."

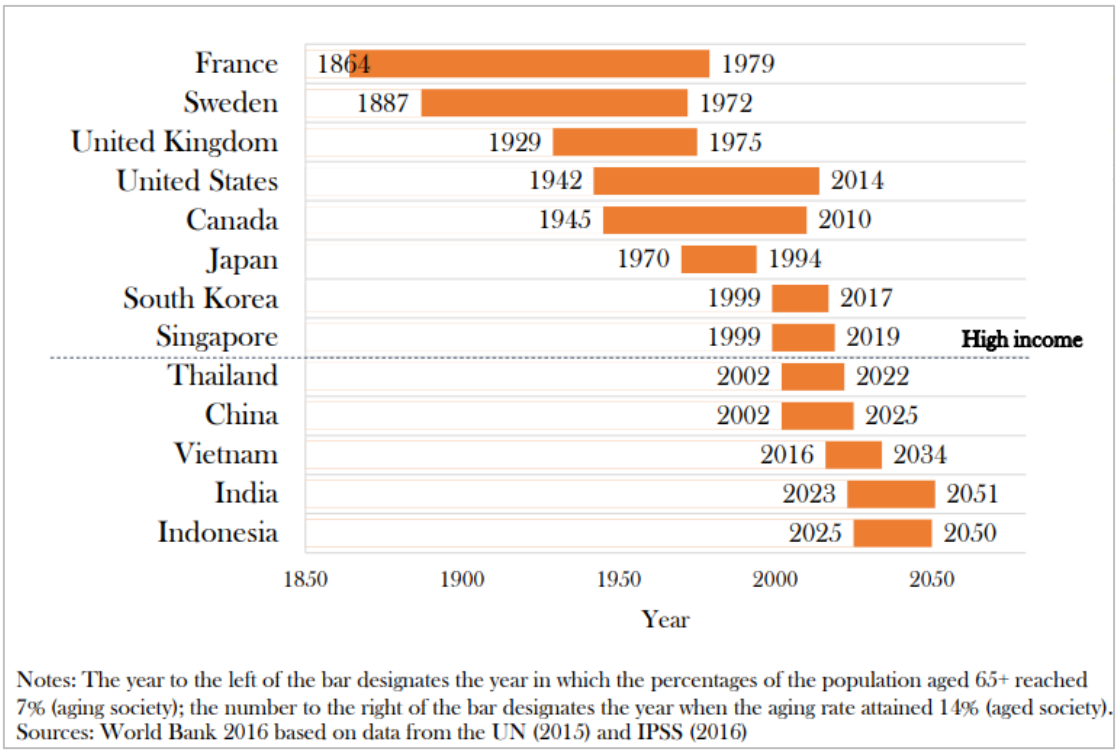
To explain in greater details, top benefits of Big Data in the healthcare industry include advanced patient care, improved operational efficiency, and finding a cure for diseases. For advanced patient care, electronic health records help in collecting demographic and medical data such as lab test, clinical data, diagnoses, and medical conditions. This helps healthcare practitioners to provide quality care. Regarding improved operational efficiency, healthcare companies use Big Data as a part of their business intelligence strategy to examine historical patient admission rates and to analyze staff efficiency. Healthcare companies can cut down on healthcare cost and provide better care with the help of predictive analytics. Big Data also helps in reducing medication errors by improving financial and administrative performance, and reduce readmissions. Finally, in terms of finding a cure for diseases, Big Data can help in uncovering unknown correlations, hidden patterns, and insights by examining large sets of data. Since a particular medication seems to work for some people but not for others and there are many things to be observed in a single genome, it is not possible to study all of them in detail. But By applying machine learning, Big Data can study human genomes and find the correct treatment or drugs to treat cancer.

[70] https://mashable.com/2017/11/06/technology-aging-population/#In_iMAffasqZ

1.9.3 Impacts on Thailand

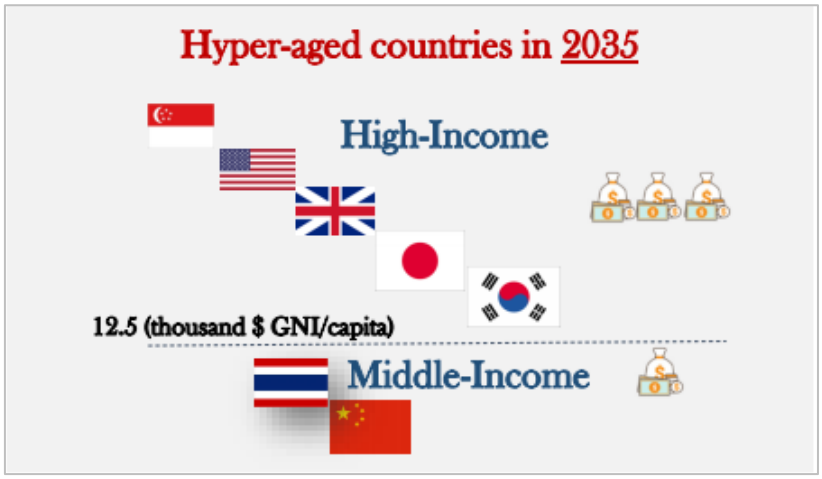
Asia is catching up with the silver tsunami and there is a dire need to harness technology to deal with the consequences of contracting and aging workforce. It is projected that 870 million people in Asia would be over the age of 65 by 2050, with countries experiencing a surge in seniors including, Korea, Singapore, Thailand and China. Thailand would experience a surge of 29% by 2050. While countries have taken 18-115 years to transition from "aging" to "aged" society, Thailand is taking only 20 years, the fastest and earliest developing country to become aged society.

Figure 25. Number of years to transition from aging to aged



By 2035, Thailand will be the first developing country becoming hyper-aged society. All countries at this aging process already escaped the middle income threshold, but Thailand is still trapped below that.

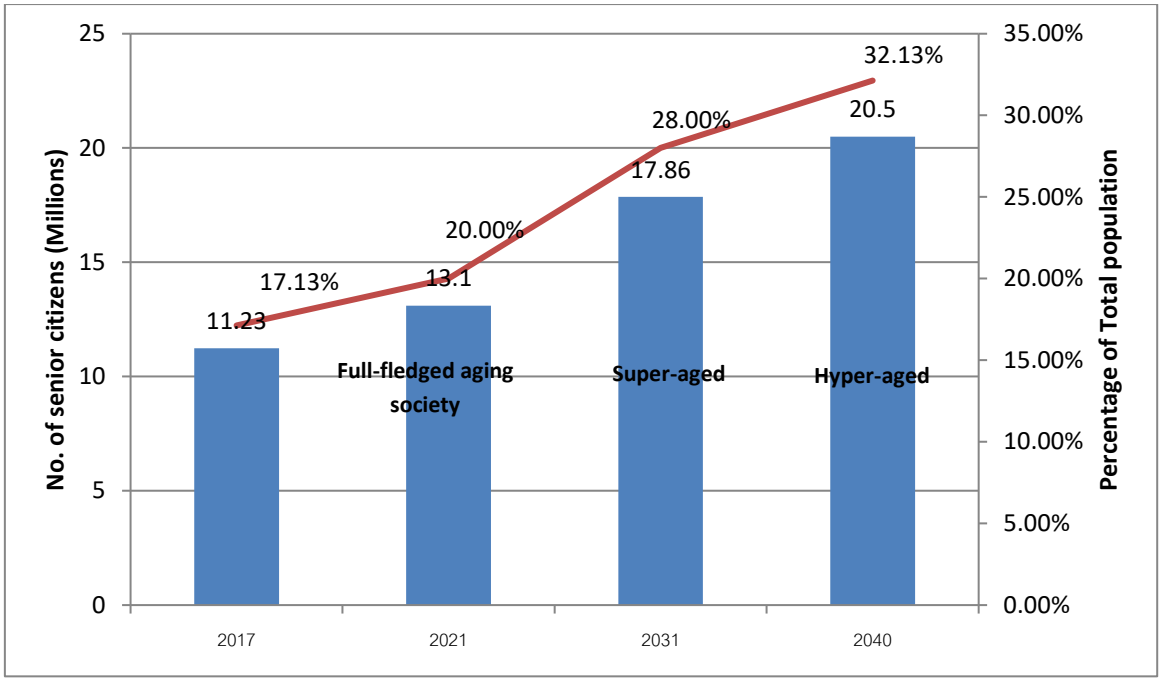
Figure 26. Hyper-aged countries in 2035



Source: Bank of Thailand (based on data from United Nations)

In 2017, the number of older persons in Thailand stood at 11.23 million. Thailand will become a full-fledged aging society in 2021, when their number will rise to 13.1 million or 20% of the total population, according to an NESDB report. By 2031, Thailand will become a "super-aged" society. By then, the aging population is expected to account for 28% of the country's population. And by 2040, its older population will reach 20.5 million or almost one-third at 32.13% of total population.[71]

Figure 27. Thailand's number of senior citizens and proportion of total population



Source: NESDB

As a result, it is imperative for Thailand to allocate funds to research & development to foster innovation and adoption of suitable technologies, especially on healthcare and pensions. According to OECD, relevant investment in cloud sourcing that would help match jobs and tasks with skills could be a great future investment to cultivate latent elderly workforce. In order to reduce the gray divide, that is the difference between seniors and the technology, it would be essential to have training programs that would fill the void and create tech savvy seniors.

1.9.4 Conclusion

Due to the rising aging population in Thailand, digital technologies such as automation, AI, IoT, nanotechnology in a form of NanoBot, data analytics, next generation telecommunication, security, realities of the future and cloud computing will all have crucial roles to play in improving their quality of lives by helping them stay connected with family and friends with higher connectivity, receive regular healthcare support and required treatment through telemedicine or mHealth, as well as make necessary daily transactions using highly-secured mobile or wearable devices. Therefore, digital technologies offer a great opportunity to reimagine how the public service, private sector and the society can support and empower an aging population to lead fulfilling and healthy lives.

[71] http://www.nationmultimedia.com/detail/Economy/30333636

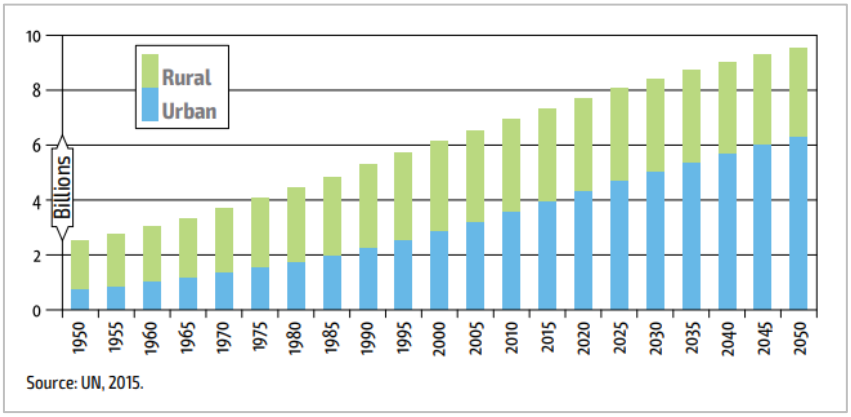
1.10 Scarcity of natural resources

1.10.1 Megatrend in Global context

The world's population numbered nearly 7.6 billion as of mid-2017, implying that the world has added approximately one billion people over the last twelve years. The growth of the world's population has slowed down in the recent past. Ten years ago, the world's population was growing by 1.24% per year; today, it is growing by 1.10% per year, yielding an additional 83 million people annually. Based on the projection assumptions made in the 2017 Revision, the growth of the world's population is expected to slow down even further in the future, and the population is projected to reach about 8.6 billion in 2030.

Considering in terms of urbanization, the world's population was predominantly rural for decades. Thirty-five years ago, more than 60% of all people lived in rural areas. Since then, the urban-rural balance has changed markedly, and today slightly more than half of the global population (54%) is urban. By 2050, more than two-thirds of all people may be living in urban areas. Changes in agriculture, notably technical progress and the adoption of labor-saving technologies, have helped underpin increasing urbanization. At the same time, agriculture, food and nutrition have been, and are likely to continue be, affected by the changes brought about by urbanization.

Figure 28. Growth in global urban and rural populations to 2050

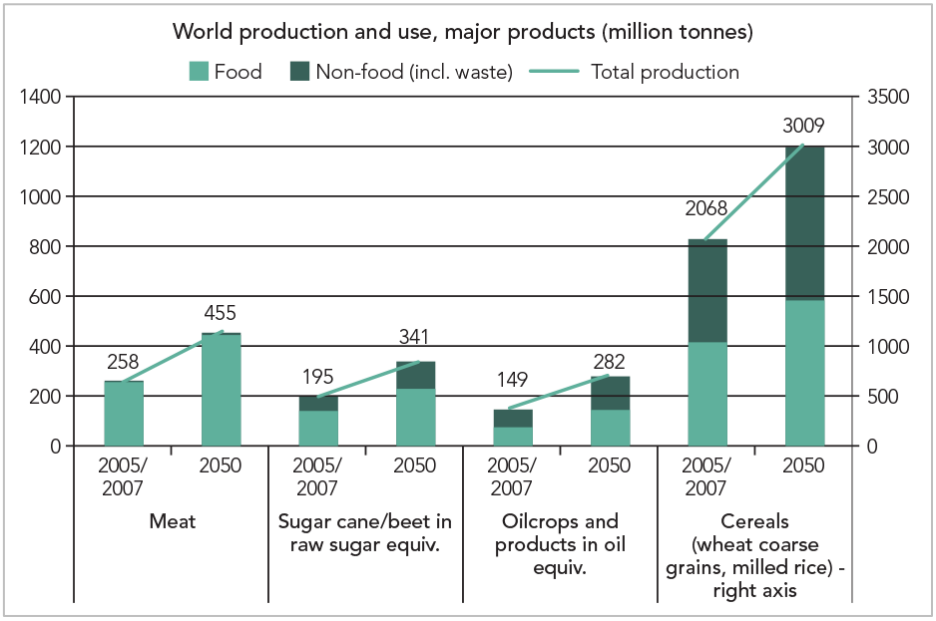


While urbanization was a high-income country phenomenon up to the 1970s, rapid growth in low-income countries has since become the defining feature of global urbanization dynamics. The sheer size of urban populations in low-income countries now determines the global dynamics. In absolute terms, global urbanization to 2050 could lead to a net addition of 2.4 billion people to towns and cities, which is more than the total global population increment of 2.2 billion people. This means that rural populations may see a net reduction of nearly 200 million people. The net reduction of rural populations reflects much more than simply an outflow from rural to urban areas – it is driven by a variety of factors, notably higher mortality rates in rural areas and shorter life expectancies. These factors more than offset the lower urban fertility rates.

Urbanization impacts food consumption patterns. Higher urban income tends to increase demand for processed foods, as well as animal-source food, fruits and vegetables, as part of a broad dietary transition. Higher urban wages also tend to increase the opportunity costs of preparing food and favor food products that have a large amount of labor embedded in them, such as fast food, store-bought convenience foods and foods prepared and marketed by street vendors. With these changes, the nutrient content of diets is changing. Typically, diets are becoming higher in salt, fat and sugar and are, in general, more energy-dense. This shift in consumption patterns also means a shift in

employment within the food system: fewer people work in agriculture and more work in transport, wholesaling, retailing, food processing and vending.[72]

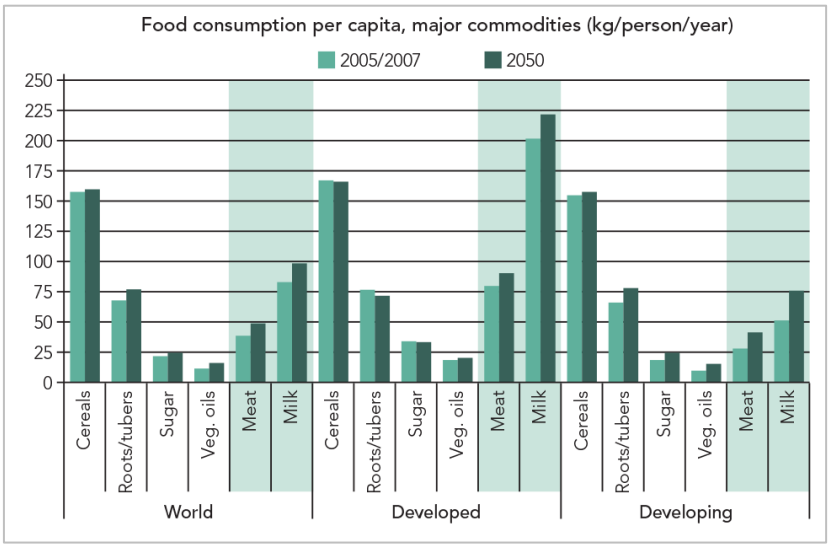
Figure 29. World production and use



Source: Alexandratos, & Bruinsma, 2012

Based on current trajectories – with rising incomes in developing countries, increases in food consumption per capita and absolute population growth – total food consumption is projected to rise significantly. Absolute demand for food (and especially animal products) is expected to increase especially steeply in developing countries. However in some regions, notably Sub-Saharan Africa, this increase in total demand can be attributed more to population growth than to major increases in per capita intakes.

Figure 30. Food consumption per capita, major commodities



Source: Foodsource, UK

[72] http://www.fao.org/3/a-i6583e.pdf

Globally, per capita consumption of animal products (meat and dairy) is projected to rise moderately, while total meat consumption is expected to nearly double. To meet this demand, an additional 200 million tonnes of meat would need to be produced annually by 2050, compared with production in 2005/07. In developed countries, aggregate meat consumption is not expected to rise much further, if at all (since population growth is likely to be negligible and even negative in some countries, while per capita intakes also level off). In some countries, such as the United States, meat consumption has even started to decrease. This may be due to increasing health concerns and awareness, and to the weakened economy since the recession in 2008. Other developed countries showing decreased per capita meat consumption since 2008, include Canada and the UK. The majority of the increase is therefore projected to occur in developing countries, where significant income rises and population growth are expected. Population size in Sub-Saharan Africa is projected to nearly double, from 730 million in 2006 to 1.68 billion in 2050. This growth in population numbers accounts for most of the overall growth in expected total animal product consumption – per capita intakes are not anticipated to rise substantially because poverty is likely to persist (per capita intakes of fish are, in fact, likely to decline). Rapid growth in demand is also expected in South Asia (although meat demand in India starts from a very low per capita baseline) and in the Middle East/North Africa.

To sum up, the increase in the world's population, together with rapid urbanization, has changed the patterns and behaviors of global consumption and created challenges in the use of natural resources. This will have considerable implications for environmental sustainability. It could also lead to significant resource constraints, thus putting increased pressure on the consumption models in particularly developed countries.

1.10.2 Technology Trends

The consumption and production of resources can be transformed by technologies and innovations - including automation, Artificial Intelligence, Internet of Things, and data analytics - together with global trends and consumer behavior change. On the demand side, energy consumption is becoming less intense and more efficient as people use less energy to live their lives and as energy-efficient technologies become more integrated into homes, offices, and factories. Similarly, energy demand in the transportation sector is also expected to decrease as engines become more fuel efficient and as self-driving and electric vehicles take off. Additionally, technological advances help reduce the cost of renewable energy sources, including water, biomass, wind, solar, and geothermal power, giving them a greater role in the energy mix of the global economy, with significant effects for both fossil fuel producers and consumers. On the supply side, resource producers are increasingly capable of deploying a variety of technologies in their operations. This helps them in bringing once inaccessible mines and wells within reach, increasing the effectiveness of extraction techniques, shifting to predictive maintenance, as well as using sophisticated data analysis to identify, extract and manage resources.

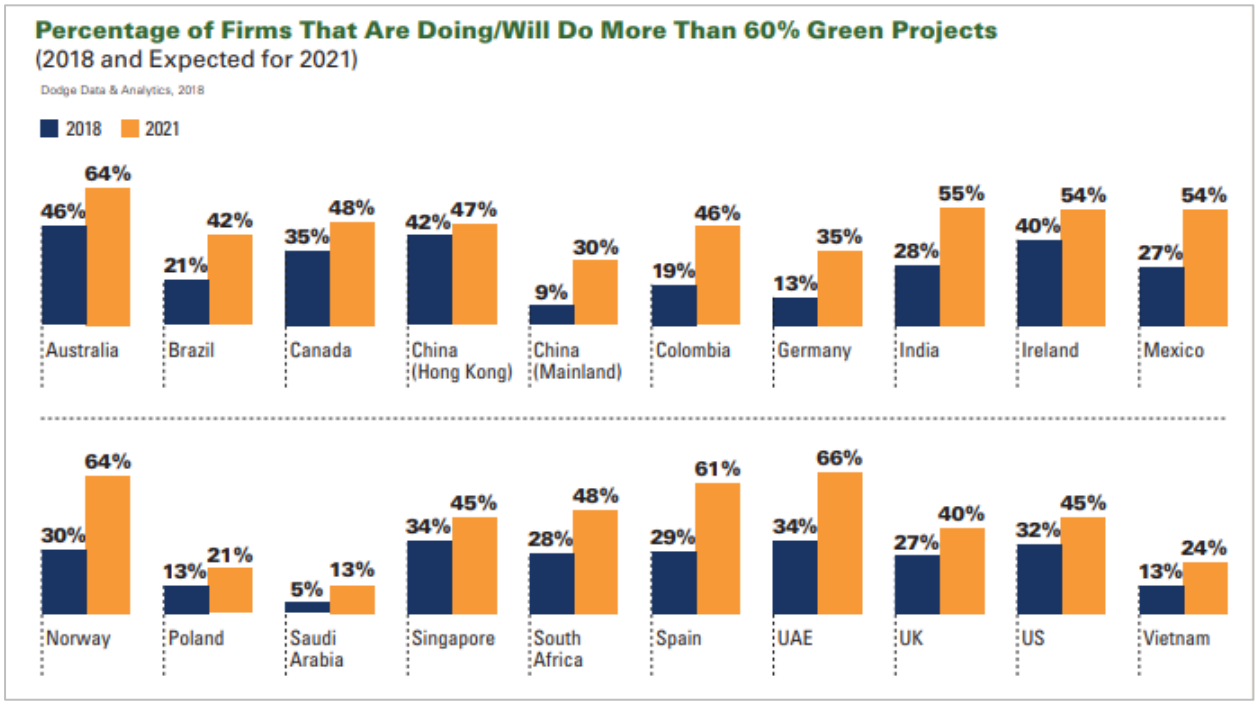
Moreover, green technologies – such as green energy, green building, green chemistry, and green nanotechnology – also play more crucial roles in driving sustainable uses of resources.

Green building – defined as environmentally sustainable buildings that are designed, constructed, and operated in an efficient manner, with regard to the utilization and conservation of natural resources and the effect on the environment – is becoming more mainstream in many countries as one of the main tools in driving the economy of green growth. The reasons of green building movement in upward are declining of cost, increase of asset value, and lower payback period. Recently research found that operating cost decrease around 8-14% last 5 years. The asset value increased around 5-7%. The payback period is 6-7 years. Moreover, many green projects are developed as the 34% of client demand, 33% of environment regulation, and 27% creating healthier building. All of these drive green building to be more important as 77% of respondents thinking that the improving occupant

health and well-being are important. However, the only barrier of the green building is the cost; even the cost is reduced by 36% from year 2012 to 2018.

Dodge Data & Analytics surveyed more than 2,000 architecture, engineering, and construction professionals and found global growth in green-building projects: 47% of industry professionals expect more than 60% of their projects to be “green” by 2021. Likewise, as world green building trends, green building activities is expected to grow more than 60%, align with the growth of the green projects. The overall of green projects is expected to increase by 47% in year 2021.

Figure 31. Percentage of firms that are doing/will do more than 60% green projects



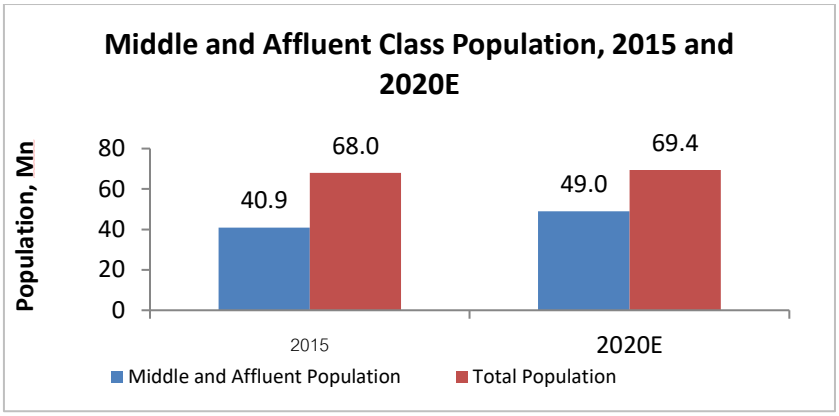
Source: Dodge Data & Analytics

In addition, energy efficiency and renewable energy technologies in conjunction with digital technologies - such as IoT, data analytics and edge analytics - will enable green buildings to move to the next step, creating the possibility of net-zero buildings (which generate the same amount of energy they consume) and even net-positive energy buildings (which generate more energy than what they consumes).

1.10.3 Impacts on Thailand

Middle class in the developing world, including Thailand, is forecasted to expand substantially. The share in global consumption of Asian emerging economies’ middle class alone will grow to over 60% by 2050, dwarfing the US and EU share. Meanwhile, the middle and affluent class population in Thailand is projected to grow to 70.6% of total population or 49 million in 2020 from 60.15% or 40.9 million in 2015.

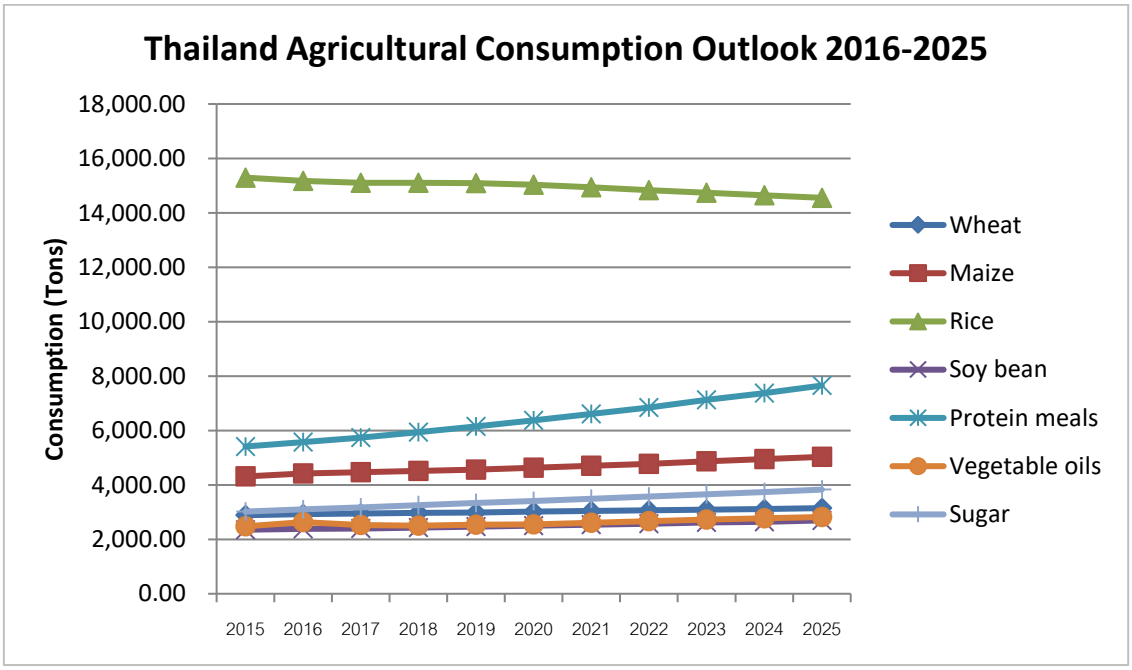
Figure 32. Thailand Middle and Affluent Class Population, 2015 and 2020E



Source: World Bank, Bank of Thailand, Frost & Sullivan

Based on the OECD-FAO Agricultural Outlook 2016-2025, Thailand's consumption of rice is expected to be on a slightly steady decline from 15,292.60 tonnes in 2015 to 14,551.30 tonnes in 2025. In contrast, consumption of agricultural commodities such as wheat, maize, soy bean, protein meals, vegetable oils and sugar is on the rise, with the most significant growth estimated for protein meals to reach 7,652.38 tonnes in 2025 from only 5,412.20 tonnes in 2015.[73]

Figure 33. Thailand Agricultural Consumption Outlook 2016-2025

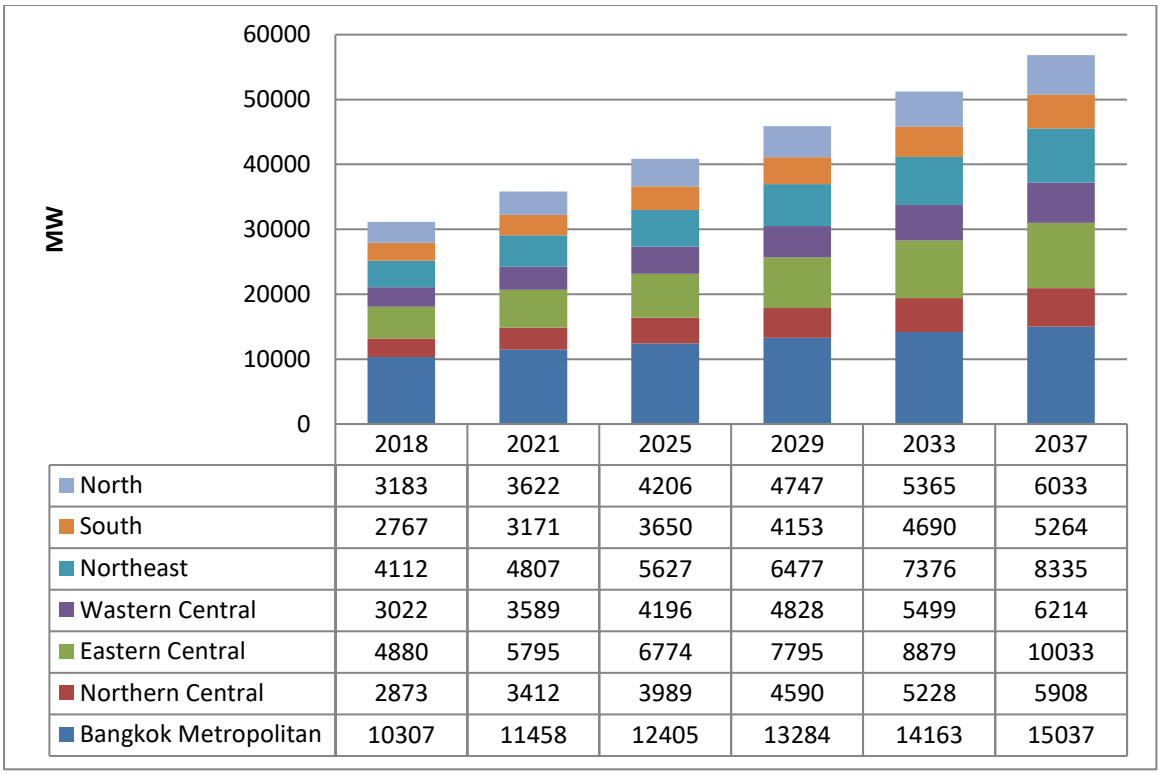


Source: OECD-FAO

Moreover, middle and affluent class growth in Thailand has had an impact not only on agricultural commodity consumption but also on energy consumption. The country's electricity demand is expected to rise steadily, with a forecast peak load demand of 56,824 Megawatts in 2037 rising from 31,144 Megawatts in 2018 at a CAGR of 4.4 %, as shown in Figure 34.

[73] https://stats.oecd.org/Index.aspx?DataSetCode=HIGH_AGLINK_2016

Figure 34. Thailand Electricity Peak load Demand Projections, by Region, 2018-2037



	2018	2021	2025	2029	2033	2037
North	3183	3622	4206	4747	5365	6033
South	2767	3171	3650	4153	4690	5264
Northeast	4112	4807	5627	6477	7376	8335
Wastern Central	3022	3589	4196	4828	5499	6214
Eastern Central	4880	5795	6774	7795	8879	10033
Northern Central	2873	3412	3989	4590	5228	5908
Bangkok Metropolitan	10307	11458	12405	13284	14163	15037

Source: Thailand's Power Development Plan 2018-2037

A growing trend in energy consumption in Thailand, as well as in other parts of the world, leads to a rise in sustainability concerns. Consequently, numerous studies have been conducted to develop green technologies to implement the concept of sustainability.

The Thailand 4.0 initiative focuses deeply on green smart technology to reduce energy consumption in the future. The US $45 billion eastern economy corridor project is estimated to generate $39 billion for the Thai economy's initiative towards sustainability within next 10 years. It would aid in creation of sustainable parks to enhance the bottom line. These green investments would help Thai people reduce and save expenses through energy efficiency and higher productivity.

In addition, as a part of green technologies, the green building development trend in Thailand continues to grow despite higher costs of 20% on average when compared to traditional building. In the past 5 years (2012-2017) the number of buildings designed to be environmentally friendly through effective use of natural resources, also known as green buildings, that passed international standards of Leadership in Energy and Environmental Design (LEED) of the U.S. Green Building Council (USGBC) and Thai's Rating of Energy and Environmental Sustainability (TREES) of Thai Green Building Institute (TGBI) have grown from 55 in 2012 to 240 in 2017. This figure represents more than 3 times increase in which 80% of these green buildings are office buildings (40%) and retail establishments (40%). Main factors driving developers to develop new green buildings, as opposed to traditional buildings, are rents that are 20-25% higher, Floor Area Ratio (FAR) that are 5-20% higher than the specified FAR in the town planning act, and the reduced electricity and water costs that are 20-30% lower.

Furthermore, the new Building Energy Code (BEC) enforcement will increase developing costs of traditional building by 5%, representing an opportunity for developers to reach green building standard. The requirement in the new BEC indicating that building with construction and renovation areas larger than 10,000 sq.m. (2019), 5,000 sq.m. (2020), and 2,000 sq.m. (2021) must pass

energy-saving evaluation. Such a process is expected to raise the project development costs by at least 5%. For this enforcement, EIC views that developers should consider upgrading their buildings to reach green building standards, LEED or TREES. Although this upgrade will face an even more stringent evaluation than BEC that represent additional costs of 15% from BEC's standard building, the upgrade will provides an opportunity for developers to receive a higher return on investment.[74]

1.10.4 Conclusion

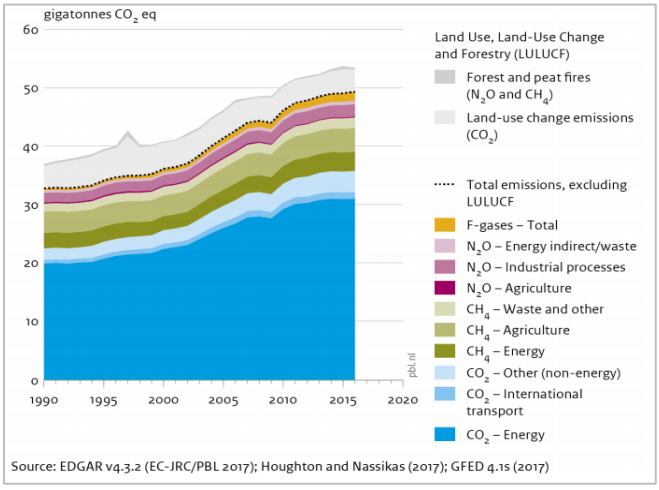
A combination of smart technologies such as IoT, data analytics, AI and automation with green technologies like green building and green nanotechnology has a very promising potential in transforming the way Thailand manages the production and consumption of water, electricity, energy, natural resources in a much more sustainable and environmental-friendly manner in the future. With such technological advances, energy demand is expected to be reduced in homes, offices, and factories, as well as in transportation, as engines become more fuel efficient and as self-driving and electric vehicles take off. Therefore, depa should support and incentivize the utilization of smart technologies in manufacturing, automotive, energy and environmental as well as other sectors to considerably increase the efficiency of limited, non-renewable resource usage. Otherwise, Thailand could deplete such resources in the near future.

1.11 Climate change

1.11.1 Megatrend in Global context

The global greenhouse gas (GHG) emissions trend has continuously increased for decades. Most of the emissions are CO2, but there are also substantial shares in methane (CH4), nitrous oxide (N2O) and fluorinated gases (F-gases). A report by PBL Netherlands Environmental Assessment Agency stated that in 2016, the five largest emitting countries (China, the US, India, Russia, and Japan) and the EU, which together account for 51% of the world population, 65% of GDP and 67% of the total primary energy supply (TPES1), accounted for 68% of total global CO2 emissions and about 63% of total global GHG emissions. However, the emission intensity of energy, represented by CO2 per unit of energy, has decreased over most of the past five years. This can be attributed to the recent trend in substituting coal with other fuels (with lower emission factors) and in increasing renewable energy in the energy mix, especially in China and the US.

Figure 35. Global greenhouse gas emissions, per type of gas and source, including LULUCF



Source: PBL Netherlands Environmental Assessment Agency

[74] https://www.scbeic.com/en/detail/product/4817

Additionally, as a result of higher total level of greenhouse gas emissions, climate change paints a far direr picture of the immediate consequences of climate change than previously thought. The IPCC report, issued in October 2018, describes a world of worsening food shortages and wildfires, and a mass die-off of coral reefs as soon as 2040 — a period well within the lifetime of much of the global population. It found that if greenhouse gas emissions continue at the current rate, the atmosphere will warm up by as much as 2.7 degrees Fahrenheit (1.5 degrees Celsius) above preindustrial levels by 2040, inundating coastlines and intensifying droughts and poverty. Previous work had focused on estimating the damage if average temperatures were to rise by a larger number, 3.6 degrees Fahrenheit (2 degrees Celsius), because that was the threshold scientists previously considered for the most severe effects of climate change.

Avoiding the most serious damage requires transforming the world economy within just a few years, said the report, which estimate that the damage would come at a cost of $54 trillion. But while they conclude that it is technically possible to achieve the rapid changes required to avoid 2.7 degrees of warming, they concede that it may be politically unlikely. Absent aggressive action, many effects once expected only several decades in the future will arrive by 2040, and at the lower temperature. Moreover, to prevent 2.7 degrees of warming, the report said, greenhouse pollution must be reduced by 45 % from 2010 levels by 2030, and 100 % by 2050. Furthermore, by 2050, use of coal as an electricity source would have to drop from nearly 40 % today to between 1 and 7 %. Renewable energy such as wind and solar, which make up about 20 % of the electricity mix today, would have to increase to as much as 67 %.

Throughout the world in 2016, investments in renewable energy amounted to US$ 241.6 billion. This led to an additional 138.5 GW of renewable energy capacity being added that year. The significance of the renewable energy market in Asia-Pacific can be seen from the fact that 47% of these new investments were made in the region. The two main technologies benefitting from these investments were solar and wind, followed by biomass and small hydro. These increasing investments are driven by the fact that many governments in the region are ramping up their efforts to increase renewable energy in their overall energy mix. For example, India is targeting a common annual growth rate (CAGR) of renewable energy of 26% every year, which will expand its installed capacity from the present 57 GW to its 175 GW target by 2022. Another big driver is that costs of renewables – particularly solar and wind – are becoming more competitive. Between 2010 and 2017, the cost of solar PV panels dropped by around 75%. Solar PV panel costs account for around 35-50% of total capital cost for a solar plant. For wind power projects, the biggest capital cost component is for the turbine (including the wind blades, tower and transformer) which comes in at around 65% of total capital cost. Since 2009, wind turbine prices have dropped by 40-50%. As costs fall – and supply chain efficiencies increase – the levelized cost of electricity also falls. For example, solar PV electricity price has dropped 58% between 2010 and 2015 and is estimated to fall a further 51% between now and 2030. By 2020, solar PV is set to become more affordable than conventional sources (coal and natural gas) to generate electricity.

Throughout this time, renewable energy technologies will continue to improve, with more efficient photovoltaic cells, larger wind turbines, and improvements in biomass and waste management stimulating bigger and more scalable projects. It is no great surprise therefore to see estimates that from now until 2025, solar and wind energy projects in Asia-Pacific countries will amount to investments of up to US$250 billion.

1.11.2 Technology Trends

As demand of the power increase, insufficient of natural resource will happen. Therefore, using technology creating the era of zero concepts is very important. Companies will shift focus and develop products and technologies that innovate to zero, including zero-emission technologies such as wind power, traveling wave reactors, solar photovoltaic (PV), and 3rd-generation bio fuels.

The building and construction sector is one of the energy-intensive industries, other than the transport or industrial sectors. Modern steel and glass buildings require huge amounts of energy to power heating, ventilation, and air conditioning (HVAC) systems. In most cases, energy is provided by power plants that burn fossil fuels, thereby generating greenhouse gas emissions. Hence, there is a need for novel technologies and methods of construction by utilizing materials that respond to environmental changes without the use of energy. One new innovation in building and construction sector is a software platform for precise integration of solar architecture into buildings.

Building integrated photovoltaics (BIPV) is an emerging technology used to replace conventional building materials in a part of a building infrastructure with photovoltaic materials that are capable of generating energy. BIPV enables buildings to improve energy efficiency, reduce greenhouse gas emissions, and take steps toward development of energy positive buildings. One of companies providing BIPV related technology includes EnerBIM. The company has developed an innovative 3 D simulation platform and interface for interoperability of building information modeling (BIM) and energy modeling called BIPV-Insight. The BIPV-Insight, a software platform, provides simulations of construction-related aspects of the PV design and installation. The platform comprises specific BIM solutions, innovative configurators, digital twins and 3 D virtual workspaces, including Software-as-a-Service. As a result, the platform provides easy visualization of BIPV benefits, and predicts the performance of BIPV products and their influence on a building's energy performance and comfort. The platform also promotes greater use of BIPV in residential, commercial and industrial buildings, contributing to widespread deployment of Near Zero Energy.

Moreover, industries, especially energy-intensive industries, have shown a growing interest in energy efficiency and climate change issues in order to save vast amounts of the energy and water resources and reduce greenhouse gas emissions. A research team from the Ecole Polytechnique Fédérale de Lausanne (Switzerland), for example, has developed a novel holistic approach for optimizing resource efficiency to address this concern in industrial processes in order to reduce water and energy consumption.

The proposed multi-stage approach is a hybrid mixed-integer nonlinear programming (MINLP) superstructure, and considers simultaneous optimization of heat, water, and power through a comprehensive process integration framework. The approach provides accurate information for the preliminary design of industrial processes using mathematical programming and various graphical tools at different stages for testing, analyzing, adapting, and improving the process. This technology, thus, attributes resource and energy efficiency, emissions reduction, and production process integration. To explain in greater details, for resource and energy efficiency, the developed resource efficiency approach is able to minimize freshwater consumption and maximize electricity generation in industrial processes, and minimize the annualized investment cost. Moreover, in terms of emission reduction benefit, the approach enables reducing the environment impact of industrial facilities by reducing water and energy consumption. Lastly, regarding production processes integration, the developed superstructure allows to combine all the production processes of the industrial plant, such as heat-integrated water allocation network, combined heat and power network, and bioprocessing systems. Such an opportunity facilitates the decision-making process for selecting a solution for an efficient processing industry. The proposed superstructure has been applied to a paper production facility, and has potential applications in different sectors and industries for improving process efficiency, for total site resource integration or achieving synergy in the context of industrial symbiosis.

Another example of technologies that address the challenge of climate change is advanced sensor technology for measuring and reducing methane emissions, a potent greenhouse gas that has more than 80 times the near-term carbon dioxide heating power per pound.

The International Energy Agency (IEA) estimates that worldwide oil and gas methane emissions are around 7 5 million tonnes - enough to generate all of Africa's electricity twice over. The IEA also

estimates that by using existing technologies, industry could reduce those emissions by 75% (two thirds of that at no net cost). The Environmental Defense Fund (EDF), thus, calls for global oil and gas methane emissions to be reduced by 45 % by 2025, which would have the same climate benefit for 20 years as the closure of one-third of the coal plants in the world. And resulting on such a scale is possible due to increased digitization in the industry. For example, reliable, low-cost sensors, remote monitoring, and Internet of Things on the oilfield can help energy firms reduce emissions and at the same time eliminate waste from saleable gas.

1.11.3 Impacts on Thailand

The impacts of climate change are already evident around the world. Thailand, as part of the Mekong River Basin, is struggling to deal with these impacts, which result in part from ecological pressures introduced by large hydropower dams, deforestation, coastal erosion and urbanization. Currently, Thailand is home to a population of about 66 million[75] and is particularly vulnerable to extreme weather events, such as floods and droughts, which are becoming more frequent and severe as a result of climate change. For example, in 2011 Thailand experienced its worst ever flood event on record, at a cost US$46 billion for repair and rehabilitation nationally; and US$8 billion in Bangkok alone. The impacts of the flood affected more than 13 million people and resulted in over 680 deaths. More recently, the National Hydroinformatics and Climate Data Center (NHC) recorded a significant period recurrent and prolonged droughts between 2015 and 2016 that led to critically low levels of water in reservoirs nationwide. In 2016, these droughts significantly reduced the length of the growing season, as well as agricultural yields. Furthermore, in an economic study, focusing on trends in extreme weather conditions along the Chao Phraya river basin, it was projected that in the next two decades, extreme droughts could create conditions for dry season irrigated rice production, where total production levels would be reduced by 30.9%.

Sea-level rise (SLR) is another impact resulting from climate change, which threatens livelihoods in coastal communities. For example, saltwater intrusion has caused a significant decline in rice yields in the Upper Gulf of Thailand, contributing to the vulnerability of mangrove forests, and degraded coral reefs. These impacts have affected the ecosystem services provided by these natural resources as well as in the fisheries in this region and the livelihoods that depend upon them. Research has shown an increase in the local mean sea level of 5 mm/year over the last 25 years in this region can be attributed to land subsidence at the river mouth and if this phenomenon is not addressed, severe coastal recession may occur in the Upper Gulf in the near future. Moreover, Bangkok, the capital city of Thailand has been identified as a city as particularly vulnerable to climate driven impacts, such as flooding due to both SLR and extreme rainfall events. For example, a case study assuming a scenario of the climate warming by 4°C, without adaptation measures being applied predicts severe flooding in Bangkok. Under these assumptions, 40% of the city would be inundated by extreme rainfall event and a 15 cm SLR by the year 2030. Furthermore, the same event in the 2080's would inundate 70% of the city with an 88 cm SLR.

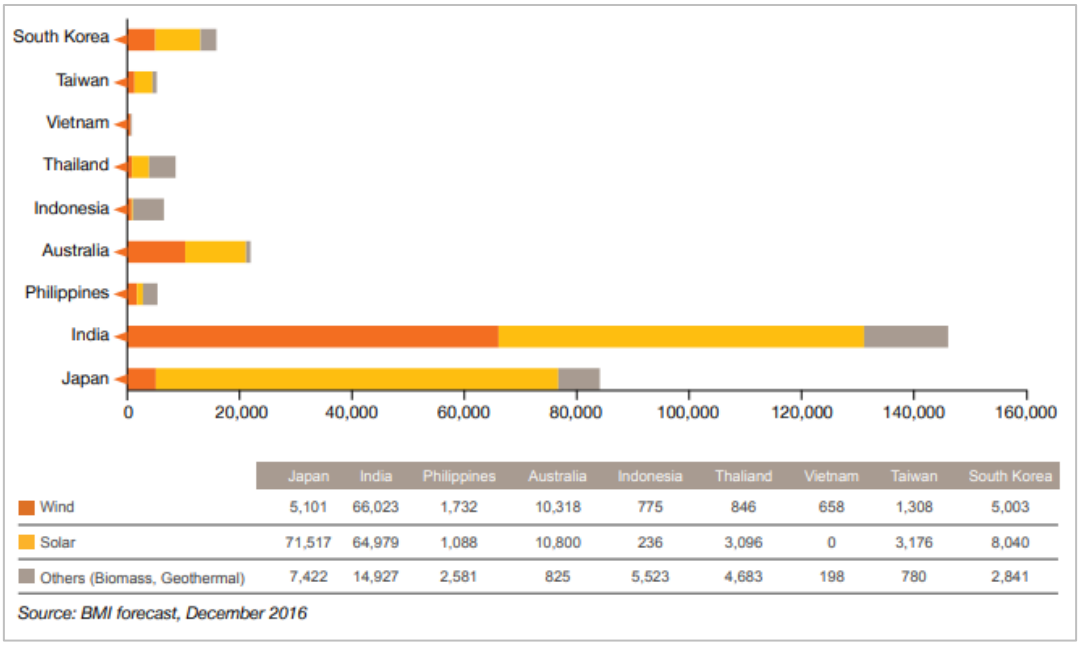
In terms of economic impact, the potential magnitude of the economic impacts related to climate change may have on at-risk resources, such as rural and urban infrastructure, the productivity of workers, crop production, hydropower dams, or the provision of ecosystem services is a major concern. Conventional studies, such as the Climate Vulnerability Monitor, estimate the net economic cost of climate change for Thailand at US$180 billion/year averaged between 2012 and 2030. However, figures at this time scale do not interact well with climate models. Alternatively, a Values-at-Risk analysis can show results that suggest that reduced labor productivity is the most the significant cost associated with climate change in the Lower Mekong Basin. It also suggested that Thailand's economic risk associated with all climate change impacts, including infrastructure, is equivalent to 14% of total rural GDP. In the meanwhile, recent reports by experts estimated that 45% of the urban

[75] Thailand's National Statistical Office

population would live in high heat conditions by 2050. Urban conditions would be worse through air quality, kidney diseases, heat strokes, cardiovascular complications and death. Single degree rise in temperature would increase local levels of pollution, cause extinction of rare animals, and lead to increase in mental illness.

The impacts of climate change, as mentioned earlier, have led to increased efforts by many governments in the Asia Pacific region, including Thailand, to increase renewable energy. Many governments have ramped up their efforts for increasing renewable energy in the overall energy mix, with renewable energy targets being significantly higher in some countries when compared to existing capacity. For instance, India had 57GW of renewable energy installed as of March 2017, and has a 175GW target by 2022, representing a common annual growth rate (CAGR) of 26% every year. In addition, there is a large potential for better technologies in renewable energy - such as more efficient photovoltaic (PV) cells, larger wind turbines and improvements in biomass and waste management, thus, leading to bigger and more scalable projects.[76]

Figure 36. 2025 Renewable energy forecast (MW) for select countries in Asia-Pacific



	Japan	India	Philippines	Australia	Indonesia	Thaliand	Vietnam	Taiwan	South Korea
Wind	5,101	66,023	1,732	10,318	775	846	658	1,308	5,003
Solar	71,517	64,979	1,088	10,800	236	3,096	0	3,176	8,040
Others (Biomass, Geothermal)	7,422	14,927	2,581	825	5,523	4,683	198	780	2,841

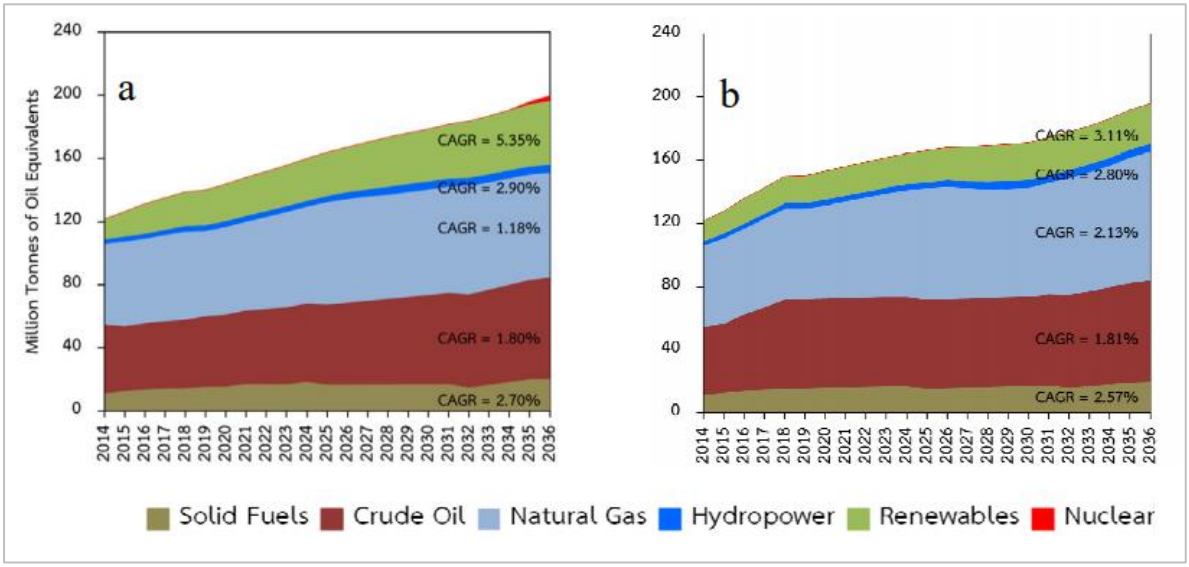
Source: BMI forecast, December 2016

Source: Towards zero movement in Thailand

Regarding renewable energy outlook in Thailand, the country has set a new renewable energy target of 30% of total final energy consumption by 2036 in its Alternative Energy Development Plan (AEDP) 2015.[77]

[76] https://www.pwc.com/sg/en/publications/assets/renewable-energy-in-asia-pacific-2018.pdf
[77] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Nov/IRENA_Outlook_Thailand_2017.pdf

Figure 37. Primary energy demand by fuel type of (a) Thailand Integrated Energy Blueprint (TIEB); (b) Possible Risk (RISK)



Crude oil and natural gas are still the main sources of Thailand's primary demand especially for transport and electricity generation. However, alternative energy has also increased due to the AEDP. Crude oil demand increases at 1.8% per year on average for both scenarios, while natural gas would grow at only 1.18% per year for Blueprint and 2.13% per year for Possible Risk. The growth for renewable energy is remarkable at 5.35% and 3.11% per year on average for Blueprint and Possible Risk, respectively, which is in line with the AEDP and the world's trend of rising climate change awareness. In addition, increasing renewable energy demand has also becomes an alternative to solve Thailand's energy sector problem especially for reducing the reliance on crude oil and excessive natural gas for electricity generation import. Transport and industrial sectors consume the most energy for both scenarios. Especially for transport sector that relies largely on petroleum products. Nonetheless, the role of cars in the Thai economy has been changing drastically due to the advancement of technology, since Thailand is a social media and technology driven country. Nissan Motors shares its futuristic plan to pursue a goal of zero emission vehicles in Thailand.[78] As for residential use, the growth rate is the lowest compared to other sectors due to slower pace of population and household growth in the long-run. Firewood and charcoal consumption is on declining trend while LPG and electricity show increasing trend. Also, agriculture sector still has to rely on diesel for machinery.

Moreover, the government has set a target of reducing the country's emissions from 555 million metric tonnes to 444 million metric tonnes, or around 20%, by 2030.[79] The country can achieve the targets for emissions if it has substantial investment in technology, financial resources and support for capacity building along with the desired projected GDP. Furthermore, the country has set a roadmap for the various sectors including, transport, energy and waste to achieve the desired targets of renewable energy. It is forecasted that the country would achieve a 20% power generation from renewable sources by 2036.

The adoption of the latest digital technologies to enhance and optimize Thailand's energy assets and networks, combined with the deployment of the most efficient gas turbines, critical coal technology and the upgrading of existing power plants and transmission and distribution networks, are expected

[78] https://en.nissan.co.th/news/Nissan-shares-its-vision.html
[79] https://www.bangkokpost.com/news/general/1554970/govt-urged-to-ramp-up-action-on-greenhouse-gas-emissions

to deliver substantial savings and huge reductions in carbon emissions to Thailand. For example, General Electric estimates that upgrades to plants such as the one in Rayong, and transmission and distribution networks, could produce savings of $6 billion, while digital optimization could add a further $2.6 billion in value, over the lifecycle of Thailand's existing and upcoming power production, transmission and distribution assets.[80]

1.11.4 Conclusion

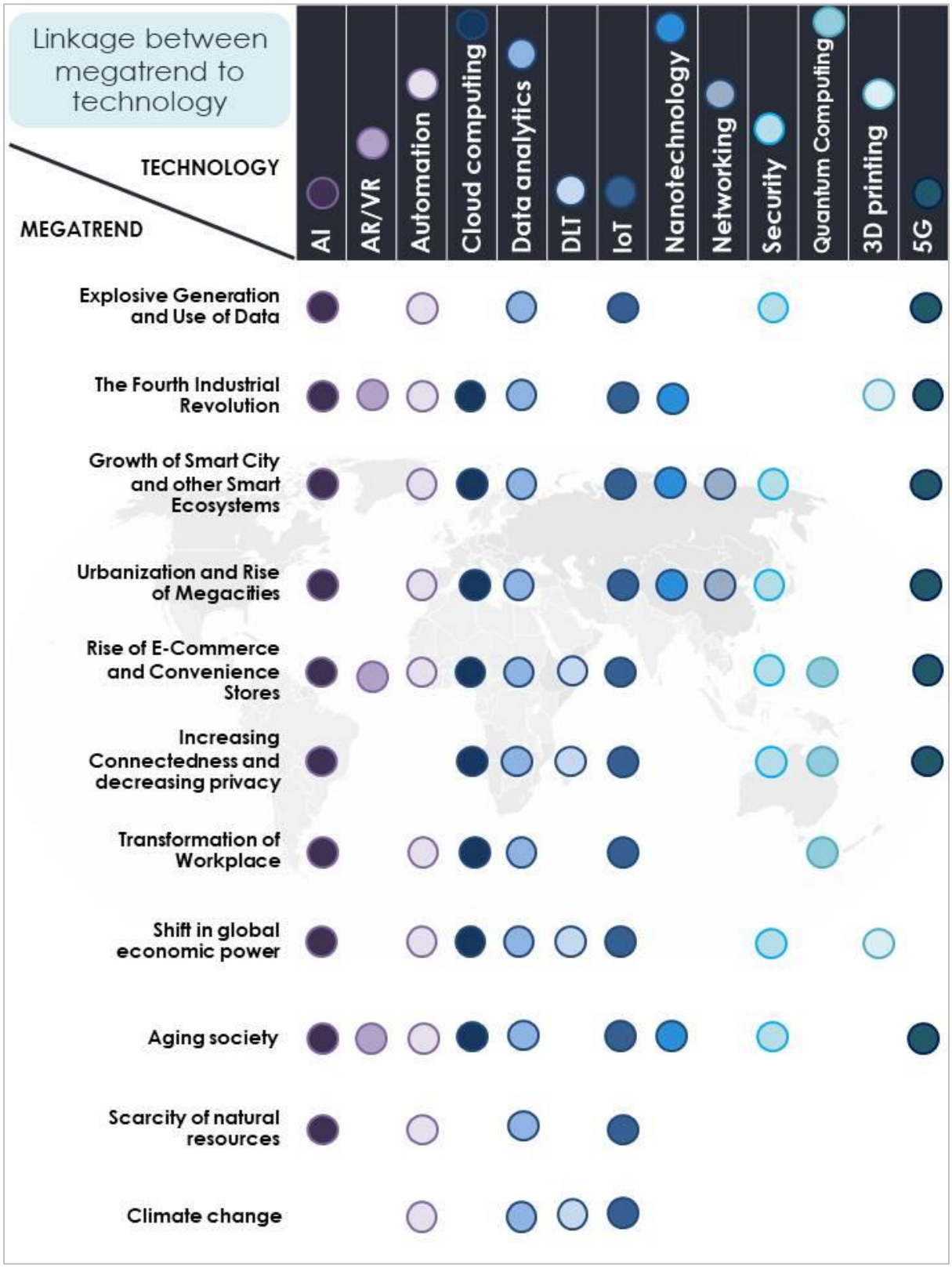
If Thailand were to achieve the reduction of overall greenhouse gas emission by 20-25% within 2030, it will need a range of technologies that will help Thai agencies and companies deepen an understanding of tough climate challenges as well as equip them with new ways to solve such high impact issues. For example, IoT sensors mounted on automated vehicles like drones, airplanes, and even Google Street View cars can measure emissions at every link in the supply chain, from remote wellheads to pipes under local streets. Advanced sensor and IoT technologies can help create a healthier environment in other ways, too – from Google cars mapping air pollution and its health effects to wearable bracelets that track daily chemical exposure. Also, retailers and consumer brands are using blockchain to improve accountability and sustainability across far-flung supply chains. Sensors can help farmers reduce the amount of chemicals on their fields, and "smart boats" can help fishermen manage their catch effectively, increasing profits and fish in the sea.

1.12 Section Conclusion

Eleven megatrends – namely Explosive generation and use of data; The fourth industrial revolution; Growth of smart city and other smart ecosystems; Urbanization and rise of megacities; Rise of e-commerce and convenience stores; Increasing connectedness and decreasing privacy; Transformation of workplace; Shift in global economic power; Aging society; Scarcity of natural resources; and Climate change – all have economic and social impacts on both global and Thailand levels, as mentioned above. Consequently, to address such concerns, there are many new technologies and innovations being researched and developed. From Megatrends and Technology Trends to the identification of digital technologies that will impact global and Thailand's Digital Economy, Data Analytics and Internet of Things (IoT) have the highest linkages with relations to all 11 megatrends, followed by Artificial Intelligence (AI) and Automation with 10 connections (See Figure 38).

[80] https://thaiembdc.org/2017/09/25/ge-believes-thailand-4-0-will-reduce-carbon-emissions/

Figure 38. Mapping megatrends and technology trends with technologies in the long list



2. Long List of Technologies

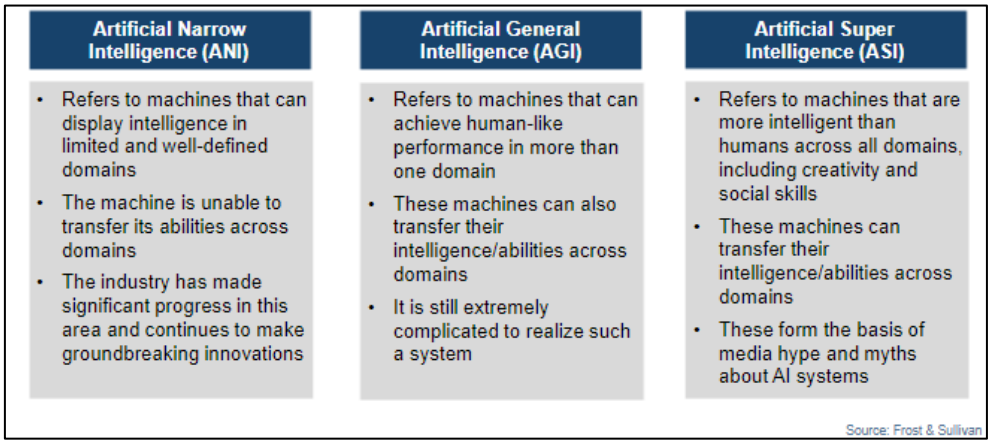
The Long list of technologies comprises of 13 umbrella technologies, which are Artificial Intelligence (AI), 3D Printing, Automation, Blockchain, Networking, Security, Next Generation Telecommunication, Quantum Computing, Digital Reality, Cloud Computing, Internet of Things (IoT), Nanotechnology and Data Analytics. The structure of this section contains Current scenario of each technology, Relevance in the future, Future developments of technology in Thailand, Trends in 5, 10 and 15 years, Sub-components of each technology and its Future outlook.

2.1 Artificial Intelligence

It refers to a plethora of technologies that enable machines to perform tasks that require human intelligence, such as visual perception, image recognition and decision making. It is a single domain phase. AI has infiltrated numerous aspects of human lives in recent years. Most of the acclamation goes to machine learning, wherein computers ostensibly program themselves.

In general terms, AI falls in three broad categories.

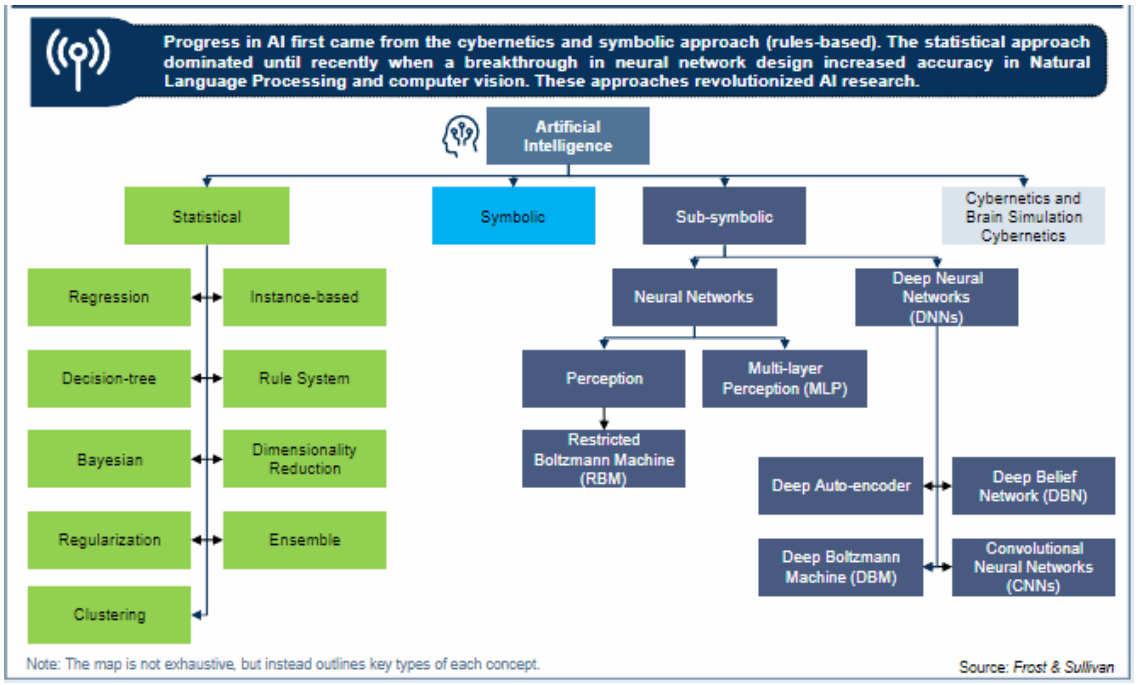
Figure 39. Categories of Artificial Intelligence

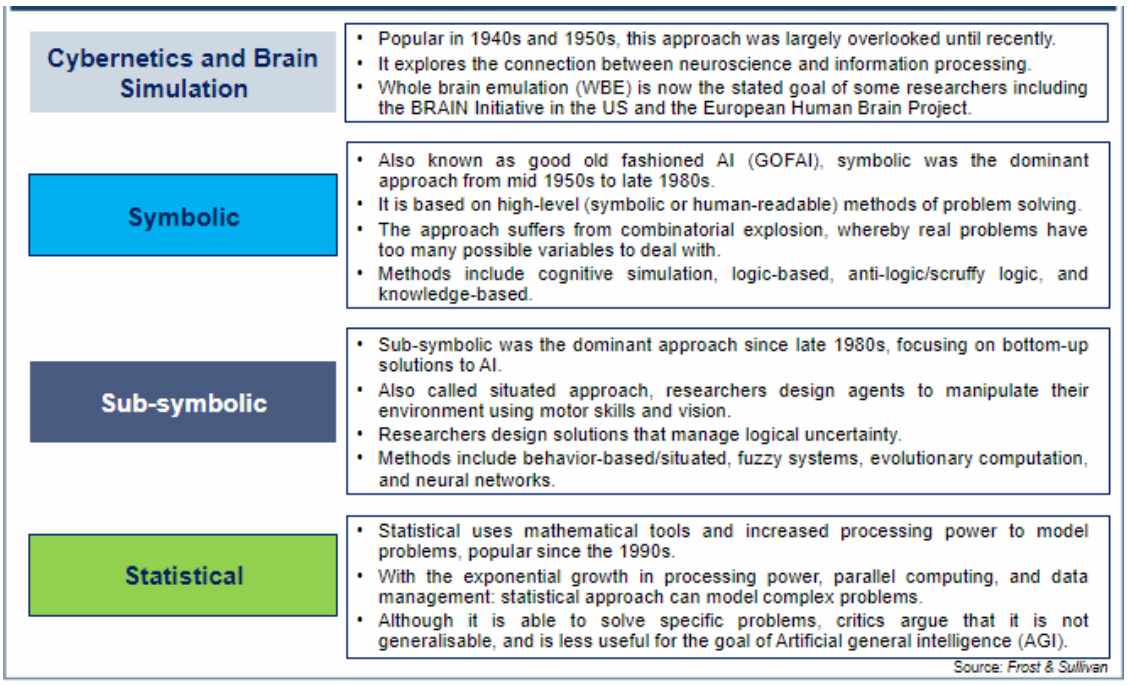


By empowering machines and applications with human-like cognitive capabilities, AI enables automated decision making with very high accuracy and speed based on data driven intelligence, coupled with self-learning abilities. It enables machines with algorithms, which render intelligence, and enhance its capability to learn from deducing patterns on raw data, by identifying the right models consisting of example inputs.

The increasing research across the globe on various disciplines of the technology has triggered opportunities and innovation in this space. The major breakthrough has been the transformation from static intelligence to incremental intelligence. Initial technology developments were restricted to solving specific problems using pre-defined parameters. However, over the past few decades, advanced research in the AI space has provided computing systems with intelligence to learn from their own experiences for enhancing their efficiency in future applications.

Figure 40. Evolution of AI approaches





2.1.1 Applications/Use Cases

AI is penetrating into every aspect of business operations to transform company's service and business models. Emerging technologies are increasingly being adopted by companies in both public and private sectors and enhancing the customer experience with different touchpoints. With the convergence of the IoT and communication technologies such as 5G, the future of AI applications is all-pervasive

AWS AI Application for Communication

Haptik applies Amazon Polly API to execute human-like reminder calls in its system. Haptik is a chatbot platform based in India. It provides a personal assistant mobile app, powered by a combination of Artificial Intelligence and human assistance. Users of the app can plan travel, check in for flights, book taxis, and set travel reminders.

Healthcare

AI is taking healthcare research, diagnostics, and therapies into new horizons. Sensing brain signals using brain computing interfaces (BCIs) and translating them into actions to control prosthesis or repairing damaged vision are some of the new uses of AI technology in the healthcare sector. The beneficiaries of this technology are usually people with different disabilities since this thought-controlled technology has the potential to provide effective support for a variety of disabilities.

Advanced medical research areas such as next-gen gene sequencing and cancer research are also being aided by AI technology. Applications such as targeted drug delivery, remote patient monitoring, and personalized medicine leverage AI for accurate results

Gaming & Entertainment

AI-powered responsive and realistic games and entertainment modalities are making a mark to deliver a more personalized user experience. AI technology is extensively used in video games to render an illusion of intelligence in non-player characters (NPCs). This makes the gaming experience more realistic with in-game objects becoming more responsive. Interactive gaming, which is capable of learning user moves and responding accordingly, is an attractive idea for both gamers and designers.

ICT

The widest range of applications of AI is in the ICT domain, where the primary focus is on technology and application development. AI algorithms form the backbone of machine intelligence. These innovations are being widely used across sectors such as retail, e-commerce, consumer electronics, robotics, homeland security. Additionally, AI is playing a key role in dramatically transforming cyber security. The integration of intelligent self-learning algorithms is enabling security solution providers to develop proactive security solutions that can identify cyber-attack threats and prevent them.

Aerospace & Defense

AI technology is being widely used in the aerospace sector to carry out virtual training programs for pilots. Additionally, AI is being extensively employed to enhance aircraft information systems to enable them to deliver the most relevant real-time information.

2.1.2 Current Scenario

In 2018, there was a considerable rise in the use of AI to improve operations, generate innovations and boost customer experience. Businesses are steadily grasping the use of data, but as people are making headway in catching up with the technology, businesses are learning how data scientists and AI developers work differently from traditional developers. Chatbots have become increasingly popular with the desire to give the same experience as in-stores. There have been deeper investments in deep learning and neural networks.

2.1.3 Relevance in the Future

Cognitive technologies such as Watson would enhance professional expertise and support decision making by finding the most accurate information million times quicker than humans. Watson's economic effect on retail sector will be noteworthy. The inventories would be checked and identified

independently through Watson's order management system. Chatbots will be able to help governments and businesses better ways than traditional user engagement channels. Siriporn Pajharawat, director of Evalgelism group of Microsoft Thailand predicts massive potential use of chat bots in AI. The similar outlook was forecasted by LINE Thailand's manager. The company owns its own chatbot translation service.

2.1.4 How is it important to Thailand?

With the advent of Thailand 4.0 and the wave of silver tsunami flooding the country, it is expected that many possible applications of AI would be in the healthcare sector, diagnosing and treating patients or helping senior citizens. According to research by Frost & Sullivan, 40% of digital transformation initiatives would be supported by AI and cognitive abilities in the coming years. It would also account for 40% of Thailand's GDP. There is enormous growth for AI in financial technology (Fintech).[81]

2.1.5 Trends in 5 years, 10 years 15 years

	5 Year	10 Year	15 Year
Technology Development	The success of vendors in applying AI technologies and conversational interfaces in smartphones and smart home virtual assistants creates higher end-user expectations for these capabilities.	Autonomous driving is expected to become a major enterprise by 2027.[82]	Home robotics will play a key role in the future of AI by 2030.
Growth in terms of usage across the world	20% of citizens in developed nations will use Artificial Intelligence assistants to help them with an array of everyday, operational tasks by the year 2020.[83]	In 10 years, people would not own cars; they would have Uber-like subscription to drive way to work. Trucking companies are expecting to save THB 15.77 billion per year due to driverless vehicles.	There is high potential for Artificial Intelligence technologies to improve the quality of life in the typical north American city by the year 2030.
Potential Growth in Thailand	With the advent of Thailand 4.0, workplace in Thailand would have AI powered bots to take notes during the meetings. Smart calendars would act as personal assistants. According to reports by IBM, it will bring huge shifts to call center and customer service industry wherein right now THB 32.2 trillion is spent on 265 billion customer calls each day.[84]	Currently, Thailand is ranked 10th in the world in automotive production at around 2 million vehicles a year, with an average 3% growth rate. However, the arrival of technology is bringing about new challenges. With the smart city projects, and with the special government support and legalization of driverless technology, it is likely to see Thailand develop driverless cars in the future.[85]	With Thailand 4.0, the government's plan to embrace an innovation-driven economy, the country is now poised to build on its existing expertise by investing in the robotics revolution to become a pioneer in tomorrow's automation-driven future.

[81] https://www.scmp.com/tech/enterprises/article/2096901/ai-making-its-way-both-business-and-daily-life-thailand
[82] https://www.zdnet.com/article/democratic-artificial-intelligence-will-shape-future-technologies-gartner/
[83] https://www.information-management.com/slideshow/10-predictions-on-the-impact-of-artificial-intelligence-over-the-next-five-years
[84] https://www.bangkokpost.com/tech/local-news/1392134/ibm-thailand-predicts-ai-upheaval-in-customer-service-this-year
[85] https://www.bangkokpost.com/tech/local-news/1444487/on-the-cutting-edge

	5 Year	10 Year	15 Year
Relevant Use case	Alexa Skills Kit, Cortana Skills, and Actions on Google give companies and developers the tools to apply the voice tech to everything from email marketing and e-commerce to expense tracking and fleet management.	Driverless cars serve as last-mile solution for mass transit systems. People are not bothered about home location relative to mass transit.	Kuri is a robot for the home designed with personality, awareness of its surroundings and the power to move about the house freely too. It's designed to fit into your home and become part of the family - entertaining your loved ones, playing music and capturing special moments.

2.1.6 Sub-components of Artificial Intelligence

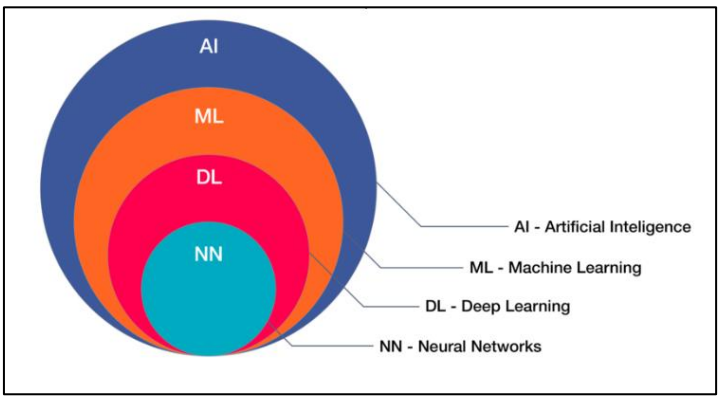
AI is the largest circle and outermost circle followed by machine learning (ML), which is further reliant on deep learning (DL). All of these concentric circles depend on neural networks (NN).

ML is the core technology seen as a significant subset of AI. It allows machines to analyze data, learn, and predict outcomes. ML is a process by which a computer is trained to identify patterns in new inputs, based on the patterns it has been "taught" with prior inputs.

DL is a machine learning technique that trains machines and software applications to understand and use algorithms that can unravel high-level abstractions in large amounts of data. DL is one of the key development areas in AI technology that is currently contributing massively toward making AI smarter than before.

NN are relied on by deep learning in multi layers to learn from vast amounts of data. NN are statistical models directly inspired by, and partially modeled on biological neural networks to replicate human brain's functionality and capabilities. They are capable of modeling and processing nonlinear relationships between inputs and outputs in parallel. The related algorithms are part of the broader field of machine learning, and can be used in many applications.

Figure 41. Layered circles of AI



Source: Intel

Machine Learning

ML refers to the use of models or algorithms to enable the recognition of data patterns in an application. While ML algorithms have been around for a long time, the ability to apply complex mathematical calculations to Big Data is a recent development. Industries such as financial services, healthcare, government, marketing, oil and transportation are using ML technology. They glean

insights from this data in real time to work more efficiently. Cybersecurity is the most used areas for ML.

Future Outlook - According to reports by Frost & Sullivan, spending on AI and ML would grow from THB 378.5 billion in 2017 to THB 1.8 trillion by 2021.

Thailand has been moving forward at full steam, due to the growth of smart algorithms that can imitate, assist and augment human tasks in foreseeable and automatic ways. Microsoft has been competing head to head with IBM to bring AI to life. Azure Machine Learning by Microsoft is been used for predictive analytics while Bot framework helps developers with natural interactions through various channels. The most common use case in Thailand is the application of machine learning to process data into predictions, for instance to analyze user data to predict future purchases.

According to insights by Bangkok Biz News, Thailand is gearing up to use machine learning extensively for the future of property development. FazWaz group is planning to launch machine learning powered Chatbots to build a virtual property agent. It would be one of the first property tech companies to do so. Adoption of AI would massively scale up within few years. The banking sector plans to use machine learning for fraud detection. The oil and gas company is positive in implementing AI on road safety to detect driver's reckless behavior. 95% of the jobs would be transformed with the wave of AI adopters within next 5 years.[86]

Deep Learning

A subset of machine learning, DL is associated with algorithms inspired by the structure and the function of the brain called artificial neural networks. DL algorithms are stacked in a hierarchy of increasing complexity and abstraction. It is currently used in image recognition tools, NLP processing and speech recognition software.

Future Outlook - The future of DL is forecasted in analytics and robotics in the medium term. The most attractive feature of deep learning is to perform efficiently without any hand crafted resource or time intensive feature engineering.

Watson by IBM is powered with 30 cognitive technologies including ML and DL to enhance efficiency and foster new discoveries in Thailand.

Neural Networks

Two AI systems can spar with each other to create ultra-realistic original images or sounds, something machines have never been able to do before. This gives machines something akin to a sense of imagination, which may help them become less reliant on humans—but also turns them into alarmingly powerful tools for digital fakery. The approach, known as a generative adversarial network, or GAN, takes two neural networks—the simplified mathematical models of the human brain that underpin most modern machine learning—and pits them against each other in a digital cat-and-mouse game. GAN's have been used to create photorealistic fake imagery and realistic sounding speech.

Future Outlook - The future is bright for GAN with its ability to hold and deliver unsupervised learning, which does not exist today. With the advent of Thailand 4.0, researchers can built healthcare AI wherein GAN's could be trained to synthetic data set of the patient records instead of dumping on the internet. The potential for GAN is huge as they can replicate and mimic any distribution of data.

[86] https://www.opengovasia.com/the-future-and-adoption-strategies-of-ai-in-thailand/

Natural Language Processing

Natural Language Processing (NLP) is a sub field of Artificial Intelligence focused on enabling computers to understand and process human language to get computers as close to understand human level of language understanding. It uses computational and mathematical methods to analyze the human language to facilitate interactions with computers using conversational language. The most common approach to NLP deploys machine learning.

IBM's debater, a radical AI technology is a NLP use case which could argue with humans on complex topics. NLP is the voice behind SIRI and Alexa.

Future Outlook - In Thailand, IBM is collaborating with the government, corporates and startups to install Watson in verticals such as customer engagement, fraud protection, cybersecurity, operations, healthcare, retail, banking and telecommunications. With Alexa, Siri and Google Duplex, and future technologies, NLP would be able to understand human emotions.
IBM and VISA would collaborate to embed payments and commerce into any device. Watson has huge potential in Thailand in major sectors. For instance, it would alert the car driver when the warranty expires. All of the IBM's future plans are in context with the Thailand 4.0 initiative. IBM plans to empower the cyber security operations. Watson would be able to help security analysts to analyze natural language research reports which are never accessible to modern security tools.

Sixth Sense Technologies

It is the interaction with the digital world in the most competent way. Sixth Sense is a wearable gestural interface that enhances the physical world around us with digital information and lets us use natural hand gestures to interact with that information. It is an advanced application of Internet of Things. It consists of a pocket projector, mirror and a camera. They can be embedded in any gadgets or wearables.

It can be used to make calls without the presence of an actual mobile device, track flight updates, navigate a virtual map and construct 3D drawings.

Future Outlook - Thailand's real estate would become more advanced as the architects and designers not only could think in three dimensions, but could also draw in 3 dimensions to make it more intuitive.

Neuromorphic Computing

Also known as neuromorphic engineering, it is a method based on the biological brain. It mimics the way the human brains work, replacing transistor based circuits with architecture inspired by nerve cells, hence the name. It might also be an efficient solution for analyzing and processing the vast amounts of data generated by self-driving cars and sensor networks. IBM is developing neuromorphic chips to enhance the computing systems used for running deep learning network

Future Outlook - The neuromorphic computing market is poised to grow rapidly over the next decade to reach approximately THB 56.1 billion by 2025.

In 10 years, neuromorphic computing approaches will be employed in training or running ML algorithms in cloud servers as well as on device applications. The future of neuromorphic computing would pave the way for automotive sector in Thailand as it would be extensively used in self-driving and smart vehicles.

Brain Computer Interface

BCI is a direct communication between an enhanced brain and an external device. AI can power future machines to understand human thoughts and emotions, even without physical or vocal

communication. The umbrella term BCI covers invasive BCI, partial invasive BCI and non-invasive BCI. It has revolutionary usage in the future in terms of patient care.

Future Outlook - The emergence of non-invasive BCI devices is representative of future accessibility of BCI technology in Thailand, in terms of aging population and patient care. It will play a massive role in 2030 when half the population of Thailand would be aging.

Real-Time Translation

Automatic language translation is the use of a computer program to translate. Near-real-time translation now works for a large number of users. One person wears the earbuds, while the other holds a phone. The earbuds wearer speaks in his or her language—English is the default—and the app translates the talking and plays it aloud on the phone. The person holding the phone responds; this response is translated and played through the earbuds. Google Translate already has a conversation feature, and its iOS and Android apps let two users speak as it automatically figures out what languages they're using and then translates them.

Future Outlook - In the coming 5 years, Amazon will be able to embed real-time translation to Alexa for seamless conversations. It would be game changers for travelers, boosting the tourism industry for Thailand.

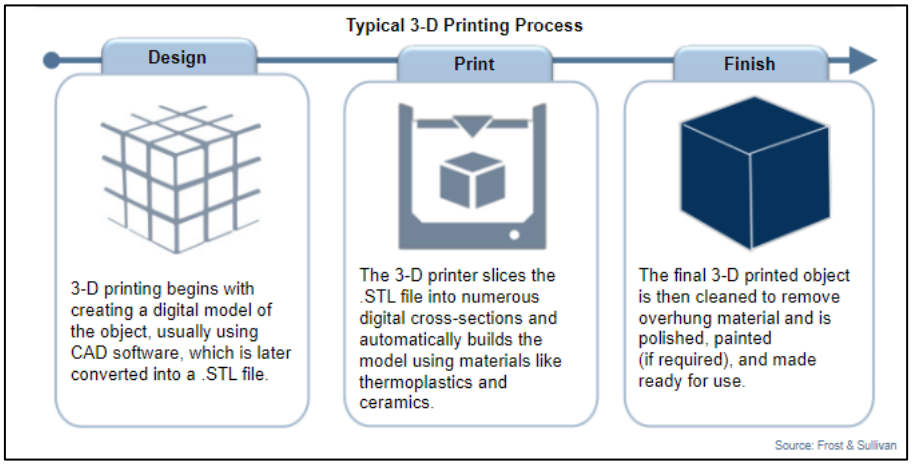
Frost & Sullivan estimated that global spending on AI and ML will grow from THB 378.5 billion in 2017 to THB 1.8 trillion by 2021. It is estimated that AI market revenue in Thailand would be THB 69.39 billion by 2025.[87]

2.2 3D Printing

Any manufacturing process that additively builds or forms 3D parts in layers from CAD (Computer Aided Design) data is referred to as 3D printing. It is a process of making three dimensional solid objects from a digital file. The processes start with the creation of 3D model in a computer for instance a CAD file then 3D scanner creating a digital copy of an object.

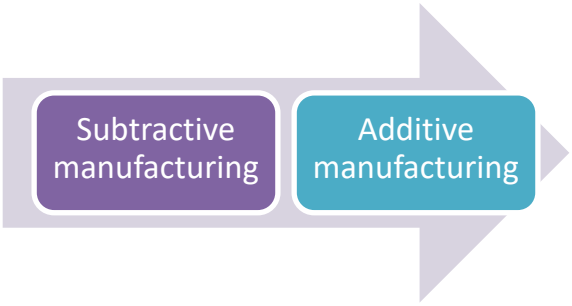
3D printing can be used in various applications such as rapid prototyping, architectural scale model, 3D printed prosthetics, movie props or paleontology. It is evident in various industries such as aviation, manufacturing, automotive, construction, and architecture and consumer products.

Figure 42. Typical 3-D Printing Process



[87] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

Figure 43. Evolution of 3-D Printing



3D printing happened from the trend of additive manufacturing (AM). AM is a technology that 3D objects are built upon by adding layer-upon-layer of materials, whether it is plastic, metal, or concrete. The term AM encompasses many technologies including subsets like 3D printing, rapid prototyping (RP), direct digital manufacturing (DDM), layered manufacturing and additive fabrication. It is the new industrial revolution from subtractive manufacturing, to which 3D objects are constructed by successively cutting materials away from a solid block of material. One of the principal advantages to subtractive manufacturing is the ability to machine an extremely thin piece of plastic into a living hinge. This kind of process is simply not yet possible in a 3D printer. Therefore, 3D printing is in the early adoption, and will come to replace the subtractive manufacturing when it is more advanced.

2.2.1 Applications/Use cases

The number of 3D printer application expanded to various industries for taking advantage of 3D printing. Although highest application is expected to found in the manufacturing industry, other industries are expected to adopt 3D printing in the future as well. 3D printer will enhance the efficiency in many areas.

Manufacturing

3D printing will be used extensively from prototyping to final product manufacturing. This will be beneficial in the product design process and development of new products to the market. Not only is there greater cost advantage, but the manufacturer also reduces work time as there will be no lead time from hiring suppliers to edit the prototype.

Healthcare

3D printing will enable the recreation of human tissues, bones, and organs that can be adapted to the patient's body. It can also be used to create devices such as hearing aids and artificial organs. In dentistry, creating oral models of patients from oral dental scans will let dentists be able to quickly and accurately study on the patient's oral.

Education

3D printing will affect the educational system in many fields of study ranging from creating models for architecture, virtual job creation for biology, atomic model, body modeling engine design, to graphic design. The classroom will become a limitless learning place for students once 3D printing has been enabled, and learning resources can become realistically materialized. The model from 3D printing will support the students to learn from the virtual educational equipment.

Sociocultural applications

Model work, design, architecture, jewelry, or even clothes can use 3D printers. The use of 3D scanning technologies allows the replication of real objects without the use of moulding techniques that in many cases can be more expensive, more difficult, or too invasive to be performed, particularly

for precious artwork or delicate cultural heritage artifacts where direct contact with the moulding substances could harm the original object's surface.

2.2.2 Current Scenario

Multi-material 3D printing has been an active research area in the advanced manufacturing space which is evident by the number of patents published in recent years. FM/FDM 3D printers are most used printers in 2018 followed by SLS printers. But there has been a sharp climb in metal printing due to the heavy research in metal additive manufacturing. Google and General Electric have invested heavily in metal printing in the year of 2018.[88] The global 3D printing industry is expected to exceed THB 662.3 billion revenue by 2020. Companies are using 3D printing for more than just rapid printing. It is regarded as an essential component in industry 4.0

In 2018, even though plastic was highly important, its share in 3D printing fell while the share of metal printing rose from 28% to 36% in 2018.[89] It might overtake plastic in the near future. They are gaining momentum in industries other than aerospace, automotive, manufacturing and healthcare.

The advent of higher speed 3D printers, production configuration and a large range of materials available for 3D printing systems continue to enable greater adoption of 3D printing across several industries.[90]

DKSH Additive Manufacturing is in line with the Thailand 4.0 initiative to transform manufacturing industry in Thailand.[91]

2.2.3 Relevance in Future

The global 3D printing market is expected to reach revenue potential THB 678.1 billion by 2025. The consumer and commercial products market are estimated to account for 28% of the 3D printing market by 2025, a growth of CAGR 19.1% from 2009 to 2025. Asia-Pacific Additive manufacturing market is expected to grow by THB 113.5 billion by 2021, with China in line to become the global 3D printing leader.[92] Critical factors that would decide the adoption of 3D printing by business and consumers are usability, functionality, and total cost of ownership. Considerable advancement in technology will lead to the development of 3D printers with higher build speed and accuracy, which in turn will bring down the total cost of ownership.

3D printing is moving from rapid prototyping to finished products with the ability to bio-print full human organs such as ears through bio 3-D printers by 2030.[93]

3D printing is expected to play a prominent role in healthcare industry. With the aging population in Thailand, there would be an increase towards personalized healthcare and customized 3D printed medical devices.

2.2.4 How is it important to Thailand?

Thailand is expected to become a 3D printing hub for the ASEAN region due to the high number of local designers and SMEs.[94] As Thailand is one of the industrial countries, 3D printing is becoming

[88] https://3dprinting.com/what-is-3d-printing/#3D-Printing-Industry
[89] https://www2.deloitte.com/insights/us/en/industry/technology/technology-media-and-telecom-predictions/3d-printing-market.html
[90] https://www.idc.com/getdoc.jsp?containerId=prUS44194418
[91] http://dksh.com/th-en/local-announcements/dksh-thailand-launched-new-business-line-additive-manufacturing
[92] https://www.enterpriseinnovation.net/article/innovating-3d-printing-asia-pacific-1470980019
[93] Frost & Sullivan Future of 3D Printing

more and more intertwined with the day-to-day operations of businesses. It will be used for rapid manufacturing which are not only prototypes, but also tools, moulds and end-use products. Additionally, increasing popularity of 3D printing will create 4 key business models—direct manufacturing, contract manufacturing, 3D printing as a service, and retail 3D printing, with the latter 2 models being very unique. 3D printing as a service is an online business model that is an amalgamation of contract manufacturing and the online marketplace model. All of these models will drive Thai economy to be digitized and drive Thai economy.

2.2.5 Trends in 5 years, 10 years 15 years

	5 Year	10 Year	15 Year
Technology Development	Nano 3D printing (3DP) is an additive manufacturing technique used for printing nano- and micro-scale components. Stereolithography is anticipated to account for a considerable revenue share, as it is one of the oldest and conventional printing technologies.	Customization and 'prosumerism' – whereby consumers become proactively involved in the design of a product that specifically fits their requirements – is a prominent feature of 3D printing. The future is bright for emergence of 3D printing as a service, providing an end-to-end 3D printing process, including consultancy services.	Bio printed organs would be seen as an advancement in the future. This is reflected in the rate of developments in 3D bio printing, as scientists are still taking the small steps necessary to become a whole 3D printed organ.
Growth in terms of usage across the world	Asia Pacific region is projected to register the highest CAGR over the forecast period attributed to the developments across the regional manufacturing industries. The region is also emerging as a manufacturing hub for the automotive and healthcare industries[95]	Siemens, Materialise, HP, GE and Deloitte partnering up to provide an end-to-end 3D printing process. Companies like Adidas are investing heavily in Speedfactory manufactured futurecraft running shoes.[96]	By 2030, the 3D bio printing will be a million dollar industry Harvard researchers 3D-printed the world's first heart-on-a-chip with integrated sensors.. A number of start-ups have recently sprung up to develop products based on bio printing; some of these are spin outs from university research. Examples include TeViDo Bio Devices (focused on printing breast tissue), Aspect Biosystems (focused on printing tissue models for toxicity testing) and SkinPrint (focused on developing human skin).[97]

[94] http://www.nationmultimedia.com/detail/Corporate/30331432
[95] https://www.grandviewresearch.com/industry-analysis/3d-printing-industry-analysis
[96] http://www.emeraldgrouppublishing.com/realworldresearch/innovation/this-is-what-the-future-of-3D-printing-looks-like.htm
[97] https://www.prnewswire.com/news-releases/3d-bioprinting-market-2014-2030-250645071.html

	5 Year	10 Year	15 Year
Potential Growth in Thailand	Due to the innovation by Thailand, the growth of Stereo lithography is substantial in Thailand. It could be seen applicable in medical devices and prosthetic limbs curing patients.	The investment in customization and 3D printing as a service is very promising in Thailand, it would enable investing companies to avoid investments in equipment's such as manufacturing machines and design software	The aging population in Thailand would require the country to focus on healthcare and medicine to a great extent in the future. The regenerative medicine would have the largest application for 3D bioprinting. The focus would be on tissue including, bone, skin, dental and complex organs.[98]
Relevant Use case	Production of hearing aids using Stereo lithography (SLA) printers.	Getting assistance on designing a 3D printed part, selecting materials, or manufacturing a design using a particular 3D printing technology, like SLS (selective laser sintering) or FDM (fused deposition modelling).	By using 3D printing, the team was able to replicate some features of the human musculoskeletal in metal and plastic materials. As a result, these robots have imitation human skeletons, tendons, articulated joints and a central nervous system.

According to Frost & Sullivan analysis, 3D printing in Thailand is moving from rapid prototyping to finished products with the ability to bio-print full human organs such as ears through bio 3-D printers by 2030. The 3D printing market is estimated to be THB 6.3 billion by 2025.[99]

2.3 Automation

The world is in the midst of digital transformation which is significantly changing the dynamics of the economy. Automation, braced up by AI and ML, has been creating a substantial impact on the society Automation makes the lives of people simpler, more comfortable and more convenient on the positive side. Automation can also bring security and productivity advantages to staff. Reducing the need for human participation, on the other hand, means decreasing jobs. Automation has been replacing mundane tasks in various sectors such as manufacturing, technology, and retail, therefore reducing fatigue and errors. Google is worth THB 11.7 trillion but employs only 55,000[100] employees paving the rest of the work to automation, for example.

2.3.1 Applications/Use Cases

Finance

Software bots can be used and leveraged in finance industry to maintain data consistency and to minimize errors in data gathering and data validation processes. It can be used in payroll management, auto generation of reports, price comparison, preparing reconciliation statements and

[98] https://www.idtechex.com/research/reports/3d-bioprinting-2018-2028-technologies-markets-forecasts-000592.asp
[99] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight
[100] https://www.forbes.com/sites/forbescommunicationscouncil/2018/10/18/automation-is-in-your-future-and-the-future-is-now/#5be2634153bc

data extraction. Software bots would avoid errors made by humans in these areas and make the process seamless.

Manufacturing

Robotic Process Automation (RPA) can be used in manufacturing to create error-free processes. It would enable companies to save 40% cost in various areas of work. It can be used in bill of materials to create a faster and accurate product. Use of RPA in administration would reduce time consumed in getting reports of their production. Data migration done by RPA would save time and cost at a granular level. When integrating RPA Transport management system, transportation of products can be monitored much more effectively.

Healthcare

RPA can streamline the administrative processes in healthcare to maximize efficiency levels and help reduce errors and cost.

Insurance

RPA can be used to manage policies, filing, processing claims, underwriting, and various other administrative tasks.

Cybersecurity

Amore Pacific has adopted Cisco's intent-based networking solution to enhance network security by virtually segmenting and operating the voice and data network through automation and ML. Automation would correlate data by pulling it from all the threat data from across the infrastructure and validating it against threat intelligence data from outside sources.

Supply Chain

RPA can be used aggressively in Supply chain domain. Organizations can use automation and ML to parse, understand and respond to questions and requests for quotes or proposals. This will result to faster turnarounds and more accurate responses to common queries.

RPA, when combined with prescriptive analytics, can be used in generating data to identify how processes can be enhanced further, resulting in greater efficiencies, reduced waste, higher quality and fewer delays. It can eliminate human error and duplication in supply chain, resulting in quality work. Retailers can get stock delivered faster due to earlier identification of inventory needs that translates into timely purchase orders throughout the supply chain. Supply chain managers use robotic process automation to create, update and manage contract and other data for better supplier management.

2.3.2 Current Scenario

The robot automation segment has seen the fastest growth and accounted for a considerable market share in the global automation industry. Articulated robots have been accepted, dominating the current automation space. Geographically, Asia-Pacific holds the highest market share with low cost of production and availability of variety of manufacturers.

Innovative enterprise resource planning (ERP) solutions and industry 4.0 initiatives are aiding to automate production lines in the likes of South East Asian countries. The US has seen a significant increase in the installation of robots. China has been one of the dynamic countries in the world with regard to development in robots. According to International Federation of Robotics (IFR), the robot

density rating of China in the manufacturing industry is 23. Chinese government has initiated the Made in China 2025 initiative which aims at making China lead in terms of automation.

Automotive industry has been driving the growth in automation and robotics in Thailand. With Thailand 4.0, the country is heavily investing in robotics revolution to create an automation-driven future. IFR has identified Thailand as an essential market for robotics. The Thai government has further various aspects to enable easy investment in robotics. The investing in the provinces of Chonburi, Rayong, and Chachoengsao are decided to be granted 13 years of corporate tax exemption. Robotics giants like ABB (Switzerland), KUKA Robotics (Germany), and Nachi Technology (Japan) have already expanded their operations in Thailand.[101]

2.3.3 Relevance in Future

Automation is expected to replace almost half the global workforce augmenting workforce capabilities. Robots will eliminate 6% of all jobs by 2021. According to reports, 2030 would see one third of American jobs being automated. Robots would deploy smart sensors at the edge of the production to collect data which was not available before. Factory floor would make key use of robotics in Big Data analytics. There would be substantial need for open automation architecture producing standard and open documentation[102]. Analysts project cobot sales to grow nearly five times as fast as traditional robots in unit terms through 2025. Industrial robotics market will grow by 11.8% in the next ten years with China and North America to see the fastest adoption. Due to high growth in the electronic space, the robotic adoption in the electronic manufacturing would be above the normal growth. This is supported in parallel by low cost cobots that would access automated technology to a variety of new applications'.[103]

2.3.4 How is it important to Thailand?

Thailand's future of industrial division lies in robotics and automation. It is forecasted that without robots, 53% of domestic industries would lose competitiveness within 5 years. Automation would expect an investment of more than THB 200 billion within next 5 years. By 2026, Thailand is expected to become an exporter of robotics and automation. In the Thailand 4.0 initiative, robotics falls under the new S-curve which would foster its economic growth in the future.[104]

2.3.5 Trends in 5 years, 10 years 15 years

	5 Year	10 Year	15 Year
Technology Development	Cobot market will see extraordinary growth in the next 5 years.	Chatbots will become humanlike in their analyzes and responses.	More than 40% of the world's jobs would be automated and done by machines. There would also be robotic invasion of the service sector.
Growth in terms of usage across the world	Total co-bot units shipped will increase from 8,950 in 2016 to 434,404 by 2025, representing a 61.2% CAGR. Over the next 10 years, we anticipate the install base of industrial	More than 90% of consumer interaction would be handled by non-human agents. By 2030, 75 million to 375 million workers globally will need to switch occupational categories. Moreover, all	55% of jobs in US are susceptible to automation by 2035. 18 million industrial robot would be installed in the world by 2035 performing work of 100 million workers.[106]

[101] https://qz.com/1442763/heres-how-thailands-manufacturing-industry-is-shaping-the-future-of-robotics-and-automation/
[102] https://www.robotics.org/blog-article.cfm/Top-6-Future-Trends-in-Robotic-Automation/101
[103] https://loupventures.com/industrial-robotics-outlook-2025/
[104] https://theaseanpost.com/article/thailand-begins-push-automation-and-robotics

	5 Year	10 Year	15 Year
	robots to increase in almost every single country, but believe China and North America will see the fastest adoption of industrial robots.	workers will need to adapt, as their occupations evolve alongside increasingly capable machines.[105]	
Potential Growth in Thailand	A growing population and increase in demand for different food have spurred Thai food production industry. To boost technology amidst the Thailand 4.0 initiative, the country is looking towards cobots to automate the processes to reduce production cost, and enhance productivity.	Thailand has huge potential in healthcare, automotive and banking businesses to employ chatbot to strengthen workforce automation. According to IBM Thailand, 256 billon customer service calls take THB 32.3 trillion requiring huge advancement in technology.[107]	The automation is pivotal in the success of Thailand 4.0 innovation to reinvigorate the economy and boost profits. AI will help increase GDP and global productivity of Thailand. Thailand has plans to introduce large robots in automotive sector.
Relevant Use case	At Atria, a Northern European manufacturer of gourmet food products for convenience markets and retail chains, Universal Robots' UR5 and UR10 cobots are used to label, pack and palletize fresh food products.[108]	Ananda Development Plc leveraged IBM Watson technology to create AI chatbot representatives to support clients on investor relations on the company's website and Facebook.	Robots would be doing routine surgery, regional economic analysis, flying planes

2.3.6 Sub components of Automation

Robotics Process Automation

RPA is a software that automates rules-based tasks/processes that are often repetitive, error prone, and time consuming in nature. It mimics tasks/processes performed by employees, while improving quality, consistency and efficiency of the workforce. RPA software —robots/agentsll can mimic humans in the handling of countless types of tasks including inputting or manipulating data, triggering other processes, or communicating with other systems. This virtual workforce can work unattended, attended, or in hybrid automations. Tasks can be scheduled or triggered automatically or manually.[109]

Future Outlook - RPA can help facilitate increased security and compliance, for instance, RPA agents can compare interactions with watch lists and look for fraudulent patterns. It will be extensively used in the healthcare sector thereby making appointments, data collections, inventory tracking and upkeep of patient's records.

[106] https://www.marketwatch.com/story/two-thirds-of-jobs-in-this-city-could-be-automated-by-2035-2017-07-05
[105] https://www.247.ai/company/blog/future-bots-and-agents-experts-weigh
[107] https://www.bangkokpost.com/tech/local-news/1392134/ibm-thailand-predicts-ai-upheaval-in-customer-service-this-year
[108] http://www.nationmultimedia.com/detail/Startup_and_IT/30336227
[109] Frost & Sullivan; Robotic Process Automation, 2019

RPA market will reach THB 91.5 billion by 2021, according to reports by researchers. It will be widely used in Thailand in manufacturing, retail, aviation and legal.

Smart Process Automation (SPA)

It is an extension of RPA. It aids in automating the unstructured data work that robotics is not capable of managing. It uses machine learning it its process with a combination of Big Data, AI and cloud. The cognitive bots are a part of smart process automation.

Future Outlook – It is a next version of RPA. It advances from RPA through collaborating business logic, human in the loop and machine learning. Banks would be able to use SPA to work with their account opening processes. Healthcare sector would be able to use SPA to claim appeals and retail businesses will be able to process invoices with the help of smart process automation.

Collaborative Robots

Industrial robots have performed precise tasks, such as welding, and tedious tasks on production lines, such as picking and placing parts, efficiently. However, these labor saving machines can injure nearby human workers, and have to be spatially isolated or kept in protective cages. This increases the footprint of robots and takes up valuable floor space. Collaborative robots, or cobots, are designed to work safely in the proximity of human colleagues without cages, minimizing footprint and enabling the automation of more industrial tasks to improve production.

Future Outlook – The essence of cobots is in its ability to work together with humans instead of replacing them. It can undoubtedly help restore manufacturing. For SMEs, cobots are substantial as they do provide the benefit of automation without breaking the bank.

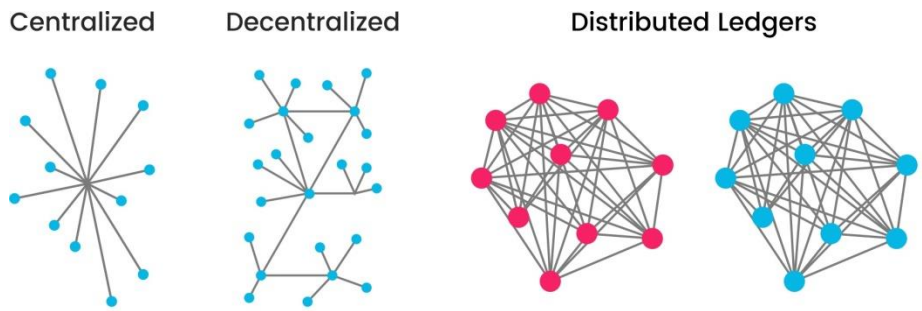
Cobots demand is on a rise in Thailand as automation is a necessity to work in lines with the Thailand 4.0 initiative.

Frost & Sullivan estimated that RPA market to reach THB 1.6 billion by 2025 in Thailand. It will be widely used in Thailand in manufacturing, retail, aviation and legal sectors.[110]

2.4 Distributed Ledger Technology (DLT)

Distributed ledger technology is one of the models of networks. The other two models are centralized and decentralized.

Figure 44. Different models of networks

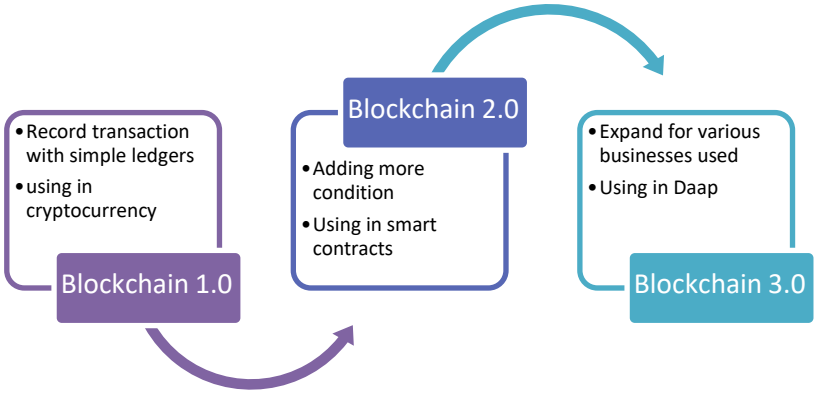


Source: Blockgeeks

[110] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

Centralized systems have many nodes connected with the central while decentralized let each node make its own decision and aggregate of the decisions to behave the final decision. Distributed ledger is only system which database is spread across several nodes on peer-to-peer network. The well-know of distributed ledger technology is blockchain. DAG, Hashgraph, Holochain, and Tempo are subset of the distributed ledger like blockchain as well. The application of DLT is changed across the evolution of blockchain.

Figure 45. Evolution of Blockchain



Blockchain 1.0 is the first implementation of distributed ledger technology (DLT) as cryptocurrencies. It allows financial transactions based on DLT. It is being used as “cash for the Internet”, a digital payment system and can be seen as the enabler of an “Internet of Money”. Next generation is smart contracts which are autonomous computer programs that execute automatically and conditions defined beforehand such as the facilitation, verification or enforcement of the performance of a contract. Ethereum blockchain is the example use case. Recently, blockchain 3.0 uses decentralized storage and decentralized communication, so most DApps have their backend code running on a decentralized peer-to-peer network. DApp is the combination of frontend and contracts. This generation will be usable in real-life business scenarios.

2.4.1 Applications/Use Cases

DLT applications are emerging quickly with more corporations adopting the technology. DLT technology provides the immutable record of transactions almost immediately. Other benefits of continuous audits, real-time monitoring and less time-intensive reconciliation of accounting data will disrupt the accounting and auditing industry. However, there are various industries adopted the technology for improving their transparency.

Financial

DLT is first used in the financial sector in the form of cryptocurrency. However, the advanced DLT will support other processes in financial sectors such as to verify digital certificates instead of a trusted central authority, to automate the process of creating letters of credit, to automate payment processing, and to send international money.

Government

Smart contract is another function of DLT supporting various business sectors including the government. Additionally, DLT also support identity application, safeguarding sensitive documents and the monitoring of business processes of local firms, or election process.

Manufacturing

DLT supports manufacturing in supply chain management. As DLT help to track goods, the goods in containers can easily be transferred to different parties, divided or redistributed. This will improve food safety as it enhanced supply chain tracking. Moreover, smart contract will also support the manufacturing to work with trust.

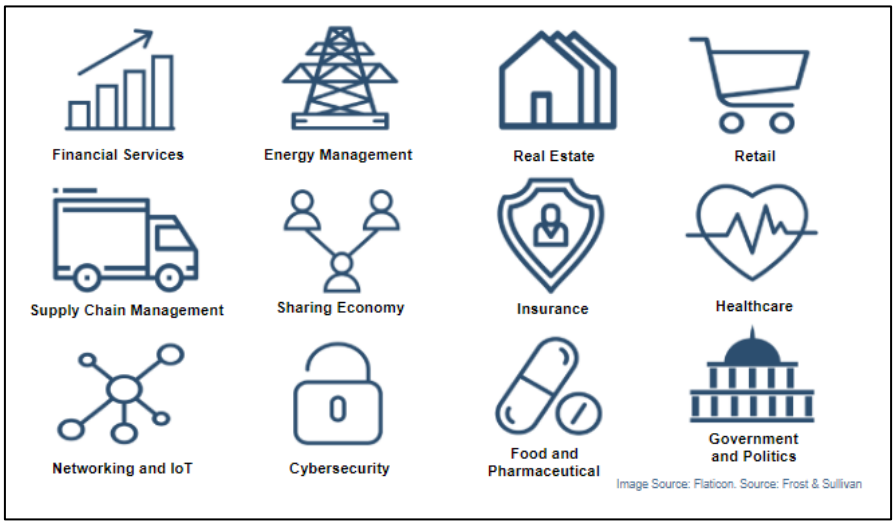
Healthcare

Patient records, disease progressions, reports and much more can be stored in the DLT and can only be activated by someone who is also allowed to receive this information. Moreover, smart contract in insurance sector will support the patient to claim for damages. The technology will manage the network and reduce the false claims for damages. Therefore, the claiming process will be faster.

2.4.2 Current Scenario

DLT is currently disrupting many industries including financial services, logistics and retail.

Figure 46. Verticals disrupted by Blockchain



In transport and logistics, DLT allows data and documents to be recorded and shared across the supply chain in a transparent way, reducing fraud. In financial services, cross border transactions are now able to leverage the use of cryptocurrency for a faster and secure exchange, eliminating the need to go through several banks for exchanges. 90% of the major banks in America and Europe are exploring DLT. In retail, a decentralized blockchain-based retail platform has been created to enable trades between buyers and sellers without the need for middlemen

Major US technology companies, such as IBM and Microsoft, are developing blockchain-based services and applications, thereby driving the global blockchain development mark. UAE and Saudi Arabia have undertaken efforts to leverage blockchain technology for license renewals, payments and visa applications. The dynamic socio-economic landscape of APAC, interconnected infrastructure, digital payment solutions, and a large number of unbanked populations are driving blockchain adoption in the region.

2.4.3 Relevance in Future

Global potential market for DLT is expected to reach THB 220.8 billion at a CAGR of 76% by 2022. There will be a 30% reduction in operating costs for financial institutions due to distributed

databases.[111] It is forecasted to reach THB 883.1 billion by 2025. The massive growth in the technology will be driven by various factors including rising rate of blockchain as a service (BaaS), increased acceptance of cryptocurrency, and high interest from traditional financial interests. The financial sector accounts for the highest share in blockchain market, it is expected to grow at a CAGR of 70% by 2025.[112]

DLT-based multitenant will have high impact on verticals such as manufacturing and packaging and retail with potential applications such as counterfeiting products, fraud, and general digital ID's. DLT has a potential to facilitate AI implementation by providing authentication to Big Data.

DLT has a potential to enhance healthcare and medical access. There will be secure patient data collected which can be further used in potential future research, curing diseases and getting better insights. Most government in the future will create virtual currency. China would be at the forefront of adopting innovative blockchain technology by 2020.

2.4.4 How is it important to Thailand?

Thai government has plans to use DLT to fight tax avoidance. Thailand's Revenue department would use blockchain to verify whether there are not any fraudulent taxes. After the SEC regulates the ICO framework, Thailand will be the first countries to award licenses to ICO portals.[113] Moreover, Thailand has been recognized as one of the most interesting blockchain countries in South East Asia in 2018. From setting up cryptocurrencies licenses, to permitting exchanges and ICO's, Thai government has been proactive in welcoming blockchain technology.[114] In June 2018, Thai government legalized seven cryptocurrencies including bitcoin, ethereum, bitcoin cash, ethereum classic, litecoin, ripple and stellar. Therefore, DLT will be the important to Thailand in term of transparency process in various field of business, especially government.

2.4.5 Trends in 5 years, 10 years 15 years

	5 Year	10 Year	15 Year
Technology Development	Blockchain likely to ease manufacturing processes and impact the areas of smart manufacturing and supply chain logistics through machine diagnosis and automated services	Blockchain based self-identity standard will be innovated for humans and physical assets.	Blockchain would be able to transform the way water resources are managed and traded. It will secure water transactions in the future.
Growth in terms of usage across the world	By 2023, 30% of manufacturing companies with more than THB 157.7 billion in revenue will have implemented Industry 4.0 pilot projects using blockchain.[115]	1.5 billion people in the developing world lack proof of identity, including more than 65 million refugees. Market for identity verification would be worth between THB 504.6 and 630.8 billion.[116]	There would be a forecasted 40% gap in global water supply and demand by 2050. According to IBM, over 400 blockchain engagements are to manage water projects in Africa and Kenya.

[111] Frost & Sullivan : Redefining the mobility with Blockchain, 2018
[112] https://www.newsbtc.com/2018/11/27/report-blockchain-market-to-be-worth-over-28-billion-by-2025/
[113] https://www.opengovasia.com/blockchain-trading-in-thailand/
[114] https://techcrunch.com/2018/08/31/thailand-blockchain/
[115] https://www.enterpriseirregulars.com/132900/how-blockchain-can-improve-manufacturing-in-2019/
[116] https://www.gsma.com/identity/wp-content/uploads/2018/09/Distributed-Ledger-Technology-Blockchains-and-Identity-20180907ii.pdf

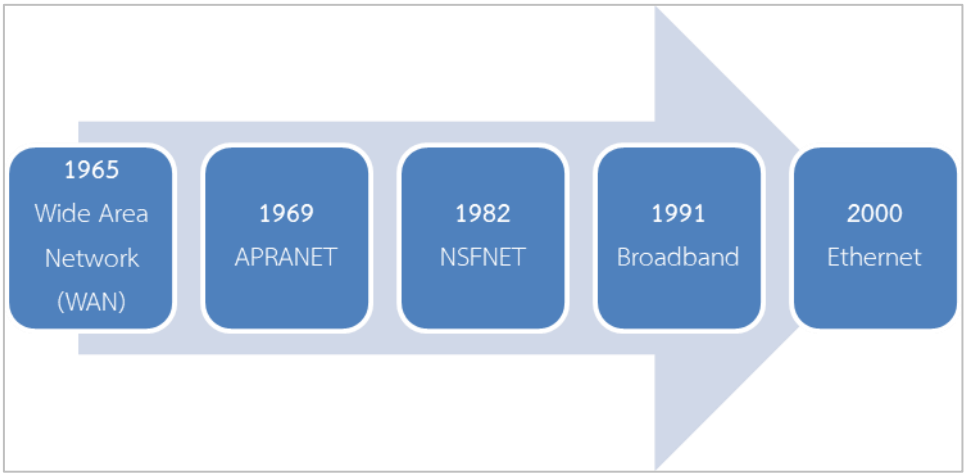
	5 Year	10 Year	15 Year
Potential Growth in Thailand	With the Thailand 4.0 initiative, the manufacturing industry will be automated, creating smart capabilities to the ability to pack and ship items, making distribution efficient.	Blockchain voting could be deployed in Thailand to conduct secure elections.	Thailand is a very vulnerable and water prone nation. Thailand is the world's largest rice exporter and the agricultural sector takes up 70% of the nation's total water supply. Use of blockchain to manage water will be a mandate in the future.[117]
Relevant Use case	Block chain is used to track automotive parts all along supply chain in real time	Using Blockchain, UN World Food Programme created virtual accounts for refugees to be used in the camps supermarket.	A block chain backed trading system that depends on leveraging smart water metering data.

The experts at Frost & Sullivan have forecasted the digital payment market in Thailand to grow at a CAGR of 13% by 2022 resulting in the total amount of THB 4.73 billion. The Thailand Blockchain market is estimated to be at THB 8.2 billion by 2025.[118]

2.5 Networking

Networking is referred as connecting computers electronically for the purpose of sharing information. Resources such as files, applications, printers and software are common information shared in a networking. The advantage of networking can be seen clearly in terms of security, efficiency, manageability and cost effectiveness as it allows collaboration between users in a wide range. Basically, network consists of hardware component such as computer, hubs, switches, routers and other devices which form the network infrastructure. These are the devices that play an important role in data transfer from one place to another using different technology such as radio waves and wires.

Figure 47. Evolution of Networking



Source: Frost & Sullivan

[117] https://thewaterproject.org/water-crisis/water-in-crisis-thailand
[118] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

The first development of network started in year 1962 when U.S. Department of Defense sponsored a project name ARPANET (Advanced Research Projects Agency Network). The goal of this project was to connect computers at different universities and U.S. defense. ARPANET became crystallization in 1969 4 years after Wide Area Network (WAN) invented. Afterwards, a new high capacity network called NSFNET was introduced but with limited access allowing only academic research. In the same period of time, some private companies started to build their own network. The next advancement was in 1972 when X.25 were deployed in commercial services and later used as an underlying infrastructure for expanding IP networks. Move to the next era when broadband was brought to light in 1991 with an ability to simultaneously transport multiple signals and traffic type. In 1996, 56K modem was introduced. In late of 2000s, Ethernet was ushered to the market and has been improved to reach the ultimate goal of enabling 100 TE by 2020.

2.5.1 Applications/Use Cases

SD-WAN

SD-WAN is coming to transform the networks. It helps increase MPLS performance with high-capacity Internet connections from a separate provider. Moreover, resiliency and availability of the network would be improved as well. At the same time, the added capacity increases overall usable bandwidth at the location. Another promise of SD-WAN is to reduce MPLS costs by leveraging inexpensive Internet connections. Furthermore, the need to extend the business into the cloud is one of the factors driving SD-WAN deployments.

LP-WAN

It is one of the key engines of IoT helping empower a new layer of operational transparency and efficiency enabled by advanced cloud analytics. 3 most common use cases are process optimization, condition-based monitoring and predictive maintenance and monitor safety.

- Process Optimization: LP-WAN can help monitoring factory environment in order to maintain the optimal ambient conditions for all manufacturing processes such as temperature, air quality, etc.
- Condition-based Monitoring and Predictive Maintenance: Continuously monitoring through massive embedded sensors enables a factory to have an early detection of any operational deviations or anomalies of machinery and assets. The communication technology that will understand tons of sensors is LPWAN.
- Monitor Safety: utilizing LP-WAN wearables and sensors enables workers to be tracked in industrial environment to improve worker wellness and productivity.

LTE-M

It is created for IoT devices and acts as a connection to 4G network without a gateway. Use cases for LTE-M are mostly for Low Density Sensors, Automated Meter Reading and Asset Tracking with LTE-M.

- Low Density Sensors: LTE-M is a better way to connect a large amount of sensors in the businesses likes Cold Chain, removing the headache of connecting via Wi-Fi or a gateway. Moreover, the technology has a long life battery that can enter the Power Savings Mode.
- Meter Connecting: Cellular-based AMR has been less popular because of its high cost. So, LTE-M will become the frontline of meters connecting due to its cheaper chip price.
- Asset Tracking: Short range connections like Bluetooth along with LTE-M are becoming the mainstream of asset tracking.

2.5.2 Current Scenario

Working to expand internet access around the world, Alphabet's Loon, in collaboration with satellite operator Telesat, is relying on high-altitude balloons to provide wireless connectivity in remote areas. These balloons are essentially helium-filled cell towers that float in the stratosphere and can reach areas with no ground-based carrier infrastructure.

Loon's network is managed by an automated software platform called the Temporospatial SDN. It enables individual balloons to coordinate with each other similarly to traditional cell towers. When one airborne system picks up a signal, it passes on the transmission to a system closer to the signal's destination, and the process is repeated until the message can be broadcast to the ground.

2.5.3 Relevance in Future

Traditional networks were built with little regards for the criticality of data flows, resulting in a network that treated all data the same, with quality of service being the primary differentiator in terms of offering differing levels of network services.

Intent-based networking (IBN), on the other hand, is an attempt to look at the intended outcome of a data flow that a particular end user or business unit finds most acceptable. Simply put, IBN is about the network having a clear understanding of the purpose, use and importance of all the applications it runs.

With that understanding, IBN uses AI to take this high-level overview of application service intent and convert that into detailed, end-to-end network policy. The IBN system then constantly reviews, updates and pushes this policy using real-time automation, thus improve network availability and agility.

2.5.4 How it is important to Thailand?

A good computer networking solution will be very beneficial for various businesses. As computers have become an important element in the life of all ages, networking will support the connection of each computer. The process of work will be more efficient and easier. This makes it a much needed tool for every business, banking, government, entertainment, daily life, industry, education, and administration. Not only connecting between computers, but networking also supports connecting between devices. Therefore, networking will be the base technology for developing other advance technologies such as IoT, 5G. This will support a recent government initiative, Thailand 4.0. As smart projects need strong connection between devices, networking will grow and be developed more than before. Several types of networking will be adopted in different devices which will create advantages for the people in communities. Not only communication in the organization, but networking also provides the communication channel in terms of business-to-business, business-to-customer and business-to-government. Therefore, networking is very important to Thailand in term of a supporter of Thailand 4.0. It will drive capacity of business and country to compete globally.

2.5.5 Trends in 5 years, 10 years 15 years

	5 year	10 year	15 year
Technology Development	Software-defined WAN (SD-WAN) continues to gain traction as enterprises examine new tools to connect their remote offices.	Hyper-converged infrastructure (HCI) combines compute, storage, networking and virtualization resources in a single integrated platform.	Using automation and policies, IBN could redefine how apps and services are delivered across networks.
Growth in terms of usage across the world	To hit THB 141.9 billion and grow at a 40.4% CAGR from 2017 to 2022.[119]	To grow from THB 129.3 billion in 2018 to THB 539.3 billion by 2023, at a CAGR of 32.9% during the forecast period.[120]	To grow from THB 20 billion in 2017 to THB 154.4 billion by 2023, at a CAGR of 42% during the forecast 2018-2023 period.[121]
Potential growth in Thailand	Thailand has growth potential as enterprises and service providers are rapidly migrating key business applications to the cloud	HCI products can help businesses across sectors in Thailand including telco, banking, healthcare, manufacturing, agriculture, oil and gas, education, government, as well as SMEs achieve cost-effective digital transformation.	Asia Pacific and Thailand is anticipated to witness the fastest growth rate among all the regions due to the surge in investments by the key players of the intent-based networking market.
Relevant Use Cases	SD-WAN Cloud Connect allows branch offices access to more distributed and cloud-based applications that reside in more than one location and may include SaaS, IaaS, public and private cloud.	Deploy HCI to support new business-critical Tier 1 applications, facilitating scaling up infrastructure as critical application require	Proactive/predictive network-assurance, elastic bandwidth deployment, real-time network topology change, dynamic service orchestration and modifications

2.5.6 Sub-components of Networking

LP-WAN

LPWA networks are intended for IoT solutions that need low power consumption, extended battery life, and good penetration in buildings and underground. Several different technologies are being developed and deployed to support such IoT requirements. An important category of LPWA is a mobile operator-managed IoT network based on 3GPP standards for IoT networks. The two most commonly identified technologies as defined within the 3GPP standards for these purposes are LTE-M (also referred to as LTE Cat-M1) and NB-IoT (Narrow-Band IoT). Due to its key characteristics, LPWA is likely to have a significant impact on the growth rate of future IoT innovation and spur even higher volume device deployments than are present today.

Future Outlook - The Internet of Thing (IoT) industry in Thailand is expected to be worth THB 31.5 billion by 2020. And Thai enterprises ranked as highest among ASEAN countries in exploring or implementing IoT solutions**,** thus increase the potential adoption of LPWAN in the country.[122]

LTE-M

LTE-M is the simplified industry term for the LTE-MTC low power wide area (LPWA) technology standard. It specifically refers to LTE CatM1, suitable for the IoT It enables IoT devices to connect directly to a 4G network using batteries and without a gateway. It offers a secure network at low bandwidth with benefits of cellular network and its features can be optimized and designed for IoT

[119] https://www.idc.com/getdoc.jsp?containerId=prUS44203118
[120] https://datacenternews.asia/story/how-hci-helps-enterprises-stay-on-top-of-data-regulations
[121] http://www.digitaljournal.com/pr/4090334
[122] http://www.nationmultimedia.com/detail/Startup_and_IT/30348708

industries and applications LTE-U technology will be in demand, as cellular networks are trying to offload traffic from their networks by making use of the bandwidth available from unlicensed networks. In terms of potential to grow, in the early phases of implementation it is expected to make a significant difference by 2020 as carriers expand LTE-M coverage.

Future Outlook – Companies worldwide are actively working on IoT use cases and opportunities in various vertical markets ranging from agriculture to energy utilities and from automotive to robotics. Thus the NB-IoT and LTE-M market is expected to grow rapidly over the next five years and for 3GPP technologies to account for much of that growth as they continue to develop.

Bluetooth

Bluetooth is low-power, short-range communications technology ubiquitous in laptops, tablets, and smartphones. Popular, as it is easy to use, compatible with a range of devices, enables voice and image data transfer. Bluetooth Special Interest Group (SIG) member companies can use Bluetooth and the number is pegged at about 20,000. Bluetooth-compatible devices include Wireless headsets, devices, and in-vehicle entertainment systems, peripherals such as keyboards and mice, audio transmission, videogame consoles, smart locks, and beacons. Its low power consumption enables long battery lifetime; while standards-based protocol enables interoperability.

Future Outlook - Smart devices, which include CCTV and Bluetooth Smart, are expected to increase 30% in 2018 (THB 101.4 billion) and 20% in 2019 (THB 121.68 billion) because the market base is still small and the popularity of Big Data and Internet of Things is growing.[123]

Wi-Fi

Wi-Fi is used across homes, enterprises, schools, hospitals, airports, and industrial settings. Compatibility with almost every operating system, existing infrastructure, and various devices make it cost effective and increase its viability. Some applications include thermostats, smart meters, patient monitoring, POS terminals. The typical range for Wi-Fi indoors is 32 meters and outdoors is 95 meters, these can be further increased with the help of antennas.

Future Outlook – With low-cost airlines in Thailand looking to offer inflight Wi-Fi connectivity service, a new channel for Wi-Fi growth will pick up in the next 5 years.

Z-Wave

Z-Wave provides plug-and-play setup dedicated to home automation. Signals can travel through walls, floors and ceilings, and devices can route around obstacles, increasing the point-to-point communication range from 120 feet to almost 600 feet. There are more than 2,100 certified Z-Wave products, with applications such as control lights, doors, locks, thermostats, sensors, and appliances. Also, one application provides homes monitoring using sensors that detect changes in the environment and send alerts. Energy savings, as heating, cooling, and lights are managed automatically. Many companies such as GE, Samsung, Jasco and Smart home hubs such as Amazon's Echo, Samsung's SmartThings are Z-Wave compatible.

Future Outlook - The global smart home market is expected to grow from THB 2.4 trillion in 2018 to THB 4.8 trillion by 2024, at a CAGR of 12.02%, thus increasing the rate of Z-Wave usage in many

[123] https://www.bangkokpost.com/tech/local-news/1619602/survey-it-and-digital-market-projected-to-increase-13-7-

smart devices and home automation for Lighting Control, Security & Access control, HVAC, Entertainment, Smart Speaker, Home Healthcare, Smart Kitchen, Home Appliances and Furniture.[124]

Thailand's networking market is projected to hit THB 18.3 billion by 2025 from THB 10.7 billion in 2018 at a CAGR of 8% during the forecast period.[125]

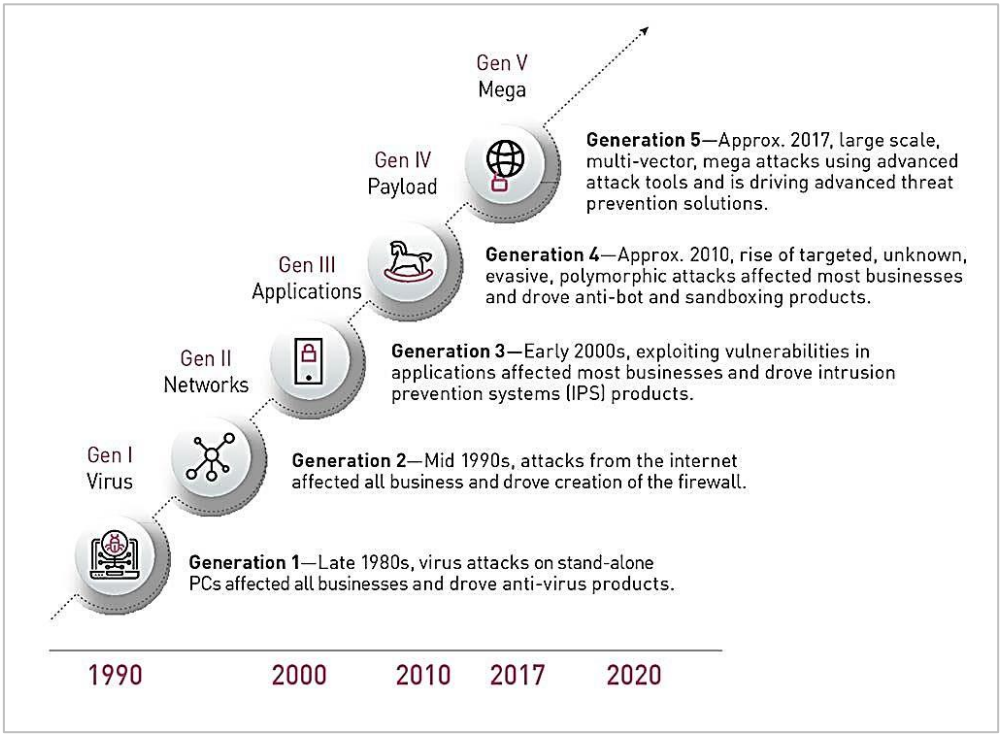
2.6 Security

Digital security is the protection of online identities people have been creating exponentially with the growing usage of social media, mobile applications, electronic payments etc. Criminals are finding new ways to operate and steal information from digital users for their own personal gain.

Digital security or Cybersecurity is an all-encompassing term which includes the tools that can be used to secure identity, assets and technology in the online and mobile world. The tools for protecting identity include anti-virus software, web services, biometrics, multifactor authentication, voice, facial and vein recognition and secure personal devices.

In terms of the evolution of cybersecurity, the latest 5th generation or Generation V cyberattacks differ from their predecessors in a variety of ways, the most prevalent difference being the wide range of technologies that they can target, from mobile phones to entire cloud networks. As a result, Gen V attacks can occur across countries, companies, and even continents. An example of this broad scale is the Wannacry attack that cancelled thousands of doctor's appointments in the UK while simultaneously crippling the computer systems of German National Railways and Telefonica.

Figure 48. Evolution of Cyberattacks and its security solutions



Source: Checkpoint

[124] https://globenewswire.com/news-release/2019/01/28/1706025/0/en/Global-Smart-Home-Market-Forecast-to-2024-Focus-on-Lighting-Control-Security-Access-Control-HVAC-Entertainment-Smart-Speaker-Home-Healthcare-Smart-Kitchen-Home-Appliances-and-Furni.html

[125] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

2.6.1 Applications/Use Cases

Security technology has been increasingly adopted in line with the increasing use of the internet and internet-accessible resources combined with an expectation of privacy. Organizations need cybersecurity approaches that are not only effective, but that deliver on effectiveness with cost efficiency, speed, and reliability. Security services and solutions can cover a range of service offerings, which can also be customized according to the end-user needs. Examples of security applications, to manage and maintain existing network security architecture and improve the security posture, include network management, threat and vulnerability management, monitoring and alerting, incidence response and recovery, as well as forensics and advanced analytics.

To explain in greater detail, network management solutions – which include services for asset management and updating the security architecture such as firewall management, patch management, updates, log management, and identity access and management – are a basic application. There is a consistent need for these services among end users. Secondly, threat and vulnerability management solutions – which include services for threat detection, vulnerability scanning, threat intelligence and analytics, advanced industry anomaly detection, etc. – are applications that users adopt to detect anomalies in their networks. Thirdly, monitoring and alerting solutions – which include services that monitor the current security posture for any anomalous behavior, including security monitoring services, 24/7 Security Operations Center (SOC), alerting services, and intrusion detection and management – are applications that end users with established security architecture prefer to outsource to other vendors. In addition, incidence response and recovery solutions - which include active services such as emergency incidence response, security incidence handling, SIEM services, and remediation - are applications that are anticipated to see the significant growth. Lastly, forensics and advanced analytics solutions – which include advanced network services such as endpoint detection and analysis, and forensic analysis of incidents – are applications that are expected to experience the highest growth in the coming years.

2.6.2 Current Scenario

The corporate world was rocked by a number of high-profile data breaches and ransomware attacks in 2018. Juniper Research estimated that the quantity of data stolen by cybercriminals could rise by as much as 175% over the next five years.[126]

The development of cyber-security applications is important to address potential cybersecurity threats. Here are some of the emerging technologies that will help improve the security of information systems from being compromised by cybercriminals:

Cloud technology

The cloud has a major impact on the revolution of security technology. More and more businesses and government agencies are embracing the cloud technology every day to store vital information. The cloud provides for more security approaches and techniques.

Mechanisms such as virtualized firewalls, virtualized intrusion detection, and preventions systems, and virtualized systems can now be used from the cloud. For example, most businesses have increased their data center security by using IaaS services.

[126] https://www.csoonline.com/article/3241242/data-protection/cybersecurity-trends-to-watch.html

Hardware authentication

The shortcomings of using usernames and passwords are well known, and there is a need for a more robust and secure form of authentication. One of the recent technologies is the use of authentication hardware.

For example, Intel is now using this technology where it combines a variety of hardware-enhanced factors simultaneously to validate a user's identity. Hardware authentication is particularly important in IoT where networks need to make sure that anything trying to gain access to it is permitted to do so.

User-behavior analytics

After a person's credentials have been compromised, a cybercriminal who has them can penetrate a network and engage in malicious behavior. Such a behavior can trigger a red flag to the existing system defenders if they are using UBA (user behavior analytics). This technology uses Big Data analytics in order to detect any unusual behavior. This technology is important and it helps address blind spots in a business security system.

2.6.3 Relevance in Future

Digital or cyber security is considered the basic prerequisite for digitization as well as digitalization as data breaches and attacks have been growing along with its widespread usage. Thus, confidence in the safety of new technologies, including connected cars, industry 4.0, automation in manufacturing, critical infrastructure and digital services is indispensable.

2.6.4 How is it important to Thailand?

Cybersecurity technologies are crucial for Thailand in terms of providing a necessary infrastructure to protect not only national security and nationwide digital backbone facilities but also online privacy, identity, integrity and secured transaction from potentially impactful cyberattacks. The country has one of the highest penetrations of internet, smartphone, and mobile internet users in Thailand with the numbers expected to grow steadily year-on-year.

2.6.5 Trends in 5 years, 10 years 15 years

	5 year	10 year	15 year
Technology Development	Biometrics: assured identity security screening solutions by bio-signature such by measuring unique heart/pulse rates, electrocardiogram sensor, blood oximetry, skin temperature	AI-based cybersecurity applies machine learning and pattern recognition techniques to tap unstructured data and uncover new patterns. It analyzes sensitive security-related structured and unstructured data to understand and learn about constantly evolving threats, building instincts, and expertise.	Quantum cryptography takes advantage of the properties of quantum physics to encrypt information at the physical network layer.
Growth in terms of usage across the world	The global biometric market is expected to grow from THB 334.3 billion in 2016 and estimated to reach THB 1.3 trillion by 2025, at	The global Ai-based cybersecurity market was valued at THB 123.6 billion in 2017 and is likely to reach THB 1.1 trillion by	The global quantum cryptography market size is expected to grow from THB 3.2 billion in 2018 to THB 15.9 billion by 2023, at a

	5 year	10 year	15 year
	17.06% CAGR during 2017-2025.[127]	2025, at a CAGR of 31.38% during the forecast period.[128]	CAGR of 37.9% during the forecast period.[129]
Potential growth in Thailand	With Thailand focusing on Smart Living, Smart City Solution and Info Security to move forward, AI enhanced surveillance systems, biometric identification systems, smart sensors, alarms and access control systems will be in demand to meet such requirements.	Thailand is using AI to monitor network traffic and conduct Big Data analyzes to detect suspicious user behavior – for instance, two unusual logins with the same credentials, but hundreds of kilometers away.	Quantum cryptography has attracted much scientists attention in Thailand due to its potential for providing absolute secret communications that cannot be broken by any amount of computational effort.
Relevant Use Cases	Workplace biometric scan via smartphone – 70% of organizations are expected to be using mobile apps to allow biometric authentication for workforce access such as a single sign-on service, allowing workers access to vital documents or files with just a scan.	Risk identification with AI - as machines possess abilities to understand technological environments, the innate nature of identifying the risks based on historical data and system breaches strengthens the organizational abilities to circumvent obstructive behaviors, thereby improving their overall security stance.	Quantum cryptography could encrypt fiber networks—i.e. the physical layer—from end to end. With fiber cable running across the entire connection, in theory encryption would not be needed at any other layer of the network.

2.6.6 Sub-components of Security

Biometrics verification and payment

This refers to the means by which a person can be uniquely identified by evaluating one or more distinguishing/multimodal biological traits such as fingerprints, hand geometry, retina/ iris patterns, voice waves and signatures. Biometric Payment is a point-of-sale (POS) technology that relies on biometric authentication to identify and authorize the user for deducting funds from a bank account; fingerprint payment, based on finger scanning is the most common biometric payment method. Facial recognition is gaining traction in this space.

Future Outlook – Since 2016, the Thai government has rolled out a national e-payment system, contributing to growth and optimism at companies providing biometric identity systems in the country. Singapore-based identity management firm i-Sprint Innovations has selected DataOne Asia Thailand as its local authorized distributor. I-Sprint has reached a 70% market share in Thailand's commercial banking sector. DataOne Asia Thailand expects its cybersecurity and identity management revenue to make up 30% of its total on the year, up from 20% in 2016. It expects revenues from i-Sprint products will reach THB 100 million within 3 years.[130]

Multifactor Authentication

MFA refers to a security system that uses more than one form of authentication when compared to the contrary method of single factor authentication that uses only the User ID and password. In many

[127] https://www.bayometric.com/global-biometric-market-analysis/
[128] https://www.marketsandmarkets.com/PressReleases/ai-in-cybersecurity.asp
[129] https://www.marketsandmarkets.com/Market-Reports/quantum-cryptography-market-45857130.html
[130] https://www.biometricupdate.com/201703/national-e-payment-plan-driving-biometrics-growth-in-thailand

countries, is a must for Second Factor Authentication (2FA) mode of authentication for banking. Such authentication methods can be thought of as three levels: something you know, something you are, and something you have. Passwords, in this case, fall into the category of something you know.

Future Outlook – With the launch of Apple's iPhone XS, XS Max and XR in Thailand, in October 2018, Thai consumers have been introduced to a multifactor authentication which will greatly reduce the risk for credential-based attacks. The global multifactor authentication market is expected to rise to THB 64.3 billion by 2025 from THB 152.3 billion in 2016. Over the forecast duration of 2017 and 2025, the global multifactor authentication market is prognosticated to expand at 17.7% CAGR.[131]

Voice Recognition (Voice ID)

This is a type of authentication that recognizes voiceprints and forms patterns to verify a speaker. Voice ID relies on vocal characteristics and they are unique for each individual. This is a set of measurable characteristics in human voice that enables the unique identification of an individual. These characteristics are converted and expressed as a mathematical formula, based on the physical configuration of the speaker's voice.

Future Outlook – Due to the influx of Chinese tourists to Thailand, Tencent Holdings is considering launching WeChat Pay, its digital payments platform service in the country with an aim to provide convenience and ease of use, and for users to feel like they are at home even while travelling, with no need to worry about currency exchange rates. They can use voice recognition or facial recognition in order to identify users when they want to make a payment transaction.

China remains the largest contributor in terms of both arrivals and tourism revenue to Thailand and, on average, they spend more than other tourists – above THB 5,000 per person a day, according to data from the tourism authority. Chinese accounted for nearly one-third of 2017's record 35 million arrivals but the number began to fall in August 2018, plunging 11.77% from a year earlier due to a boat accident that killed over 40 Chinese in Phuket in early July.[132]

Fingerprint Sensors

This refers to the process of obtaining and storing human fingerprints electronically to store it as a digital image.

Future Outlook – Fingerprint Sensors Market is expected to grow from THB 130.9 billion in 2017 to THB 722.3 billion by 2026 globally, at a CAGR of 20.9% between 2017 and 2026.[133] It is predicted that intelligent buildings equipped with face recognition and fingerprints sensors will be commonplace by 2020. In Thailand, early adopters have included oil-and-gas companies and those in the finance and banking sectors, all of whom have made facilities management (FM) a core component of this shift. More sectors will likely follow suit quickly.

Behavioral biometric

Behavioral biometric is defined as the form of identification or authentication that uses the uniqueness of a person's interaction with the device or his or her behavioral trait. Gait recognition, keystroke, signature, and cognitive biometrics are examples of behavioral biometrics. The rising trend of technology convergence and Internet of Things (IoT), along with the above-mentioned macroeconomic trends, is expected to enhance the growth prospects of behavioral biometrics.

[131] https://www.transparencymarketresearch.com/multi-factor-authentication-market.html
[132] http://www.nationmultimedia.com/detail/business/30358719
[133] https://www.maximizemarketresearch.com/market-report/fingerprint-sensors-market/2828/

Future Outlook – The global behavioral biometrics market garnered THB 22.7 billion in 2017 and is projected to reach THB 123.6 billion by 2025, growing at a CAGR of 23.7% from 2018 to 2025. The Asia-Pacific region would register the highest CAGR of 26.5% from 2018 to 2025, owing to factors such as rise in security spending among government organizations, rapid penetration of smartphones in emerging economies such as China, Japan, India, Australia, and South Korea.[134]

Facial recognition

Face recognition provides authentication by recognizing unique identification patterns on the end user's face. The mobile application gets permission to access the front camera of the mobile phone. The biometric software then maps out the unique features on the users face and confirms a match. The user then gets secure access to the mobile application to go forward with transactions.

Future Outlook – In 2018, Thailand's cabinet has given its approval in principle to a draft bill proposing an e-KYC digital ID system based on facial recognition to facilitate online financial transactions and cybersecurity. Facial recognition will be used to verify the identity of users opening new deposit accounts. Bangkok Bank (BBL) expects tens of thousands of new accounts to be opened within six months of the new service's availability.[135]

Also, the second generation of a robot provides care for the elderly and Alzheimer's patients in Thailand, with a new feature using Artificial Intelligence. The new generation of Dinsow Mini comes with facial recognition and voice recognition, training the robot to recognize family members and understand patients' sounds, even if their condition worsens and their sound changes. Its accuracy is over 80%. In 2019, CT Asia Robotics Co will also introduce a new robot for the retail sector designed as a sales assistant that can recognize shoppers and recommend products based on their preferences.[136]

Eye printing

Eye printing enables service companies to verify their customer's identities using biometrics. This type of authentication is simple to use and is also in trend with new-age digital banks. Eye printing authenticates mobile device users by verifying the eye veins and other features around the human eye. The human eye holds great detail and information that can be extracted to give high accuracy in authentication.

Future Outlook – The global eye tracking market size is estimated to reach THB 58.3 billion in 2025 from THB 9.0 billion in 2017. It is projected to register a CAGR of 26.3% during the forecast period. Increasing use of smart sensors for process control and decision making and rising demand for contactless biometrics are among the key trends stoking market growth. Growing adoption of Artificial Intelligence (AI), virtual reality (VR), and augmented reality (AR) in consumer electronics & other commercial application areas is poised to help the market gain tremendous momentum over the coming years.[137]

Vein recognition

Vein recognition systems are the newest biometric technologies that have emerged in financial services. Vein authentication uses vascular patterns of an individual's palm/finger for the personal identification of data.

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[134] https://www.prnewswire.com/news-releases/behavioral-biometrics-market-to-reach-3-922-4-mn-globally-by-2025-at-23-7-cagr-says-allied-market-research-816006460.html

[135] https://www.biometricupdate.com/201809/thailand-moves-toward-digital-id-system-with-face-recognition-for-financial-inclusivity

[136] https://www.bangkokpost.com/business/news/1584790/new-robot-to-assist-elderly-in-thailand

[137] https://www.grandviewresearch.com/industry-analysis/eye-tracking-market

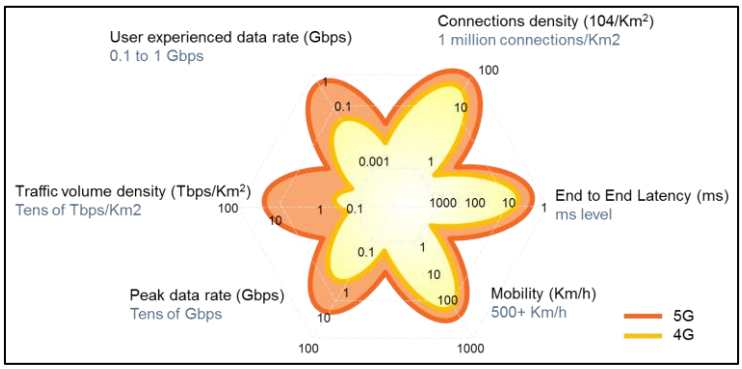
Future Outlook – As the technology uses vein information inside the user's finger, theft or falsification of information is difficult, thus increasing the level of security such as access control for potential adoption in many areas, properties and buildings in Thailand.

Frost & Sullivan estimates that cybersecurity spending in Thailand will reach THB 16.3 billion by 2025 from THB 6.9 billion in 2017, at a CAGR of 11.30% during the forecast period.[138]

2.7 Next Generation Telecom

This refers to the continuous evolution of mobile telecommunication technologies following 1G technology offering mobile voice calls, 2G providing both mobile voice calls and SMS and 3G offering mobile web browsing experiences. The current mainstream wireless technology is 4G that offers mobile video consumption and higher data speed. The next evolution in wireless connections is just around the corner with 5G expected to offer massive bandwidth, greater opportunities for connectivity and improved network reliability. When fully implemented, it will offer capacity and download speed many times faster than today's 4G LTE network.

Figure 49. Key benefits of 5G over 4G



Source: 5G PPP EU

2.7.1 Applications/Use Cases

Challenging scenarios are typical scenarios requiring 5G services. 5G is needed for niche services and ones requiring flexibility due to wide variations.

1ms low latency - 5G can support remote control and connected vehicle applications with extremely low latency and high reliability in following use cases

- **High-speed Train -** Over 500km/hour high mobility
- **Highway -** End-to-end latency
- **Subways –** More than 6 people/sq.m. super density

100 Gbps peak throughput and 1 Gbps user experience - 5G can support ultra-HD video, AR/VR, and mobile cloud services

- **Office -** Tens of Tbps/sq. km. traffic volume density
- **Wide Area Coverage –** 100 Mbps data rate user experience
- **Dense Residence –** 1 Gbps data rate user experience

[138] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

1 Million Connections - 5G can support massive connected devices

- **Outdoor Gathering -** 1 million connections/sq. km.
- **Stadium -** 1 million connections/sq. km.
- **Big Cities -** High density areas, which may not be in big cities

Use cases benefited from real time, high speed/bandwidth enabled through 5G	Use cases that will be benefited from real time enabled through 5G
• **Connected Vehicles:** 5G will transform the connected car industry and enable autonomous cars. This will result in more and more car companies transitioning into mobility services companies. • **IoT**: 5G will be the enabler for selected IoT use cases. It can help utilities cut costs, enable public safety organizations improve citizen experience, and help manufacturers reach peak productivity. • **AI in Drones:** 5G will effectively enable and increase competitiveness of AI, for example drones, for commercial purposes in the urban areas. This will lead to use of drones in logistics and delivery in urban areas.	• **IPTV with 4K UHD:** 5G will enhance content distribution by facilitating faster download speeds and new immersive experiences, particularly if CDN is used. This will lead to a better, more delightful entertainment experience. • **e-Retail:** 5G will enable real-time loading of images/videos and use of AR/VR in the retail sector. This will improve the user experience and boost sales. • **e-Brokerage**: 5G will enable real-time mobile trading and high frequency trading. It can potentially power more secure transactions.

2.7.2 Current Scenario

According to Ericsson, there were 3.4 billion 4G (LTE) smartphone subscriptions by the end of 2018. Though 4G is the most adopted wireless network as of now, it's still far from achieving the true 4G. 4G LTE is much better than 3G, but does not reach the speed specifications set by regulatory body the International Telecommunication Union (ITU). The technical standard for 4G is peak speeds of at least 100Mbps for high mobility or 1Gbps for more stationary applications but that was only reachable for carriers and manufacturers until recently with the introduction of LTE-advanced. After a bumpy initial rollout, 4G LTE has delivered on many of the predictions and expectations that were set before its launch. For example, it gave birth to the widespread consumption and use of mobile video. From the 4G LTE era, video chatting, video-driven social media like Snapchat, and mobile consumption of TV and film through apps like Netflix are common for smartphone users.

2.7.3 Relevance in Future

The world's connectivity needs are changing very rapidly. In this regard, global mobile data traffic is expected to multiple by 5 before the end of 2024. Particularly in dense urban areas, the current 4G networks won't be able to keep up. That's where 5G comes into play. The new communication technology brings new capabilities including higher bandwidth, greater capacity, security, and lower latency that will create new opportunities for people, businesses and society.[139]

2.7.4 How is it important to Thailand?

Next Generation Telecommunication technologies such as 5G has a performance and responsiveness to enable a whole host of new use cases and deliver to Thai government, society and businesses the ability to drive and generate new levels of productivity and new revenue generation streams as the country is striving to become a high-income nation with "value-based economy" or Thailand 4.0 as a new growth engine.

[139] https://www.ericsson.com/en/5g/what-is-5g

2.7.5 Trends in 5 years, 10 years 15 years

	5 year	10 year	15 year
Technology Development	5G is set to provide 100 times faster data rates, supporting instant access to services and applications, significantly reduced network latency to 1-10ms and making it possible to dedicate a unique part of a 5G network for a service.	5G will become dominant mobile technology across most of the networks. Meanwhile, the upcoming 6G mobile system for the global coverage will integrate 5G wireless mobile system and satellite network. Also called 5G Long Term Evolution, 6G will achieve terabits-per-second speeds, along with microsecond latency. Frequencies from 100GHz up to terahertz (THz) are the way to go for 6G. Frequency bands will be in the tens of gigahertz in that spectrum to provide conceivably virtually unlimited bandwidth.	The 6G momentum continues to grow strongly with new level of speed and data rates. At the same time, testing for 7G mobile technology is set to start in 15-year time. 7G mobile network is like the 6G for global coverage but it will also define the satellite functions for mobile communication.
Growth in terms of usage across the world	Ericsson expects the global number of 5G subscriptions to significantly take off with 191 million in 2021 and reach 1.48 billion in 2024.[140]	At global level, 5G mobile technology will dominate the majority of connections by 2028 with forecasted subscriptions to reach 40.88% or 3.35 billion of global population by 2025.	According to the University of Oulu in Finland, 6G will emerge around 2030 to satisfy the expectation and requirements not met with 5G.[141] 7G wireless technology is forecasted to emerge around 2040.[142]
Potential growth in Thailand	Frost & Sullivan predicts that the number of 5G subscriptions in Thailand will reach significant numbers in 2020 with 450,000 5G subscribers and grow to 9 million in 2023.[143]	Assume that the fast-pace trend continues, Over 20% or 14 million of Thailand population could adopt 5G by 2025.[144]	No potential growth yet as of now
Relevant Use Cases	Adoption of 5G is expected to elevate live-stream broadcasting, cloud gaming, cloud-based AR/VR (augmented reality/virtual reality), real-time healthcare monitoring and high-speed wireless broadband in rural areas.	5G can support massive connected devices up to 1 million connections such as outdoor gathering or sports stadium covering 1 million connections/Km^2.	According to 6G research program called 6Genesis by Finland's University of Oulu, 6G's use cases include intelligent personal edge, sensor to AI fusion, super-functional products with on-the-fly configuration and product gamification etc. In satellite system for 7G, the telecommunication satellite will be for voice and multimedia communication; navigational satellite will be for global positional system (GPS) and earth image satellite for some extra information like weather update.[145]

[140] https://www.statista.com/chart/9604/5g-subscription-forecast/

[141] https://www.networkworld.com/article/3305359/lan-wan/6g-will-achieve-terabits-per-second-speeds.html

[142] http://www.iaster.com/uploadfolder/4LatestTechnologyofMobileCommunicationandFutureScopeof7/4Latest%20Technology%20of%20Mobile%20Communication%20and%20Future%20Scope%20of%207.5G%20OL15Aug14%20Copy.pdf

[143] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

[144] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

[145] http://www.researchpublish.com/download.php?file=Future%20of%20Wireless%20Technology-1857.pdf&act=book

2.7.6 Sub-components of Next Generation Telecom

5G

5th generation (5G) wireless technologies will deliver a potent combination of network capabilities and flexible options for network deployments, service delivery, and network management. 5G deployments are envisioned as a complex amalgamation of various next-generation technological enhancements to the wireless access, transport, cloud, network applications, and management layers. It will incrementally build on various 4G technologies currently deployed, thus enabling mobile operators to preserve existing investments in network infrastructure. A significant share of 5G will be deployed at very high frequencies, which has important ramifications for coverage. In order to overcome the coverage limitations at higher frequencies, 5G networks will be overlaid with "ultra-dense" access networks such as small and metro cells.

Future Outlook – Thailand's Digital Economy and Society (DE) Ministry planned to begin the trial for the 5G testbed in the Eastern Economic Corridor (EEC) in January 2019. This move will prepare the country for 5G adoption by 2020. Initially focusing on transport, healthcare and tourism, the 5G trial will feature the alliance of private firms and state agencies, including Ericsson, Huawei Technologies, Qualcomm, Intel, Nokia, major telecom operators, the Thai Federation of ICT Technology Association, and the National Broadcasting and Telecommunications Commission (NBTC).

Following the showcase in November 2018, AIS has become the first mobile phone network operator in Thailand to commence 5G technology testing in the country, including making it available for trial at "5G the First LIVE in Thailand by AIS" in collaboration with global partners Nokia, Huawei and ZTE Corporation. It expects enhanced mobile broadband (EMBB) running on 5G will upgrade data usage speeds. 5G will also expand wireless connectivity capacity between devices based on massive machine-type communications (mMTC) which will support widespread adoption of the Internet of Things (IoT). 5G will improve network quality and provide faster responses more reliably thanks to the latest latency communications. This alone has implications for everything from medical safety to self-driving cars.

6G

6G technology refers to the sixth generation technology. It is proposed to integrate 5G technology for a global coverage. For resource monitoring and weather information multimedia video and high-speed Internet connectivity and the Earth imaging satellite networks are used. To integrate these three kinds of satellite like telecommunication, navigation, multimedia networks which provide global positions, internet connectivity with high speed and for mobile user's weather information services are major three objectives for 6G technology. The 6th generation (6G) wireless mobile communication networks integrate satellites for global coverage. It can be a combination of nanocore and Artificial Intelligence, where all the network operators will be connected to one single core. As in evolution and explosion, many will become extinct but some will change the world. In 6G the cost of mobile call will be relatively high but in 7G this problem will be improved and the cost of call will be reduced and lower level user will be benefited.

Future Outlook – The 6G mobile system for the global coverage will integrate 5G wireless mobile system and satellite network. These satellite networks consist of telecommunication satellite network, Earth imaging satellite network and navigation satellite network. The telecommunication satellite is used for voice, data, internet, and video broadcasting; the earth imaging satellite networks is for weather and environmental information collection; and the navigational satellite network is for global positional system (GPS). The four different countries which developed these satellite systems are; the GPS by USA, the COMPASS system developed by China. The Galileo system developed by EU, and the GLONASS system developed by Russia.

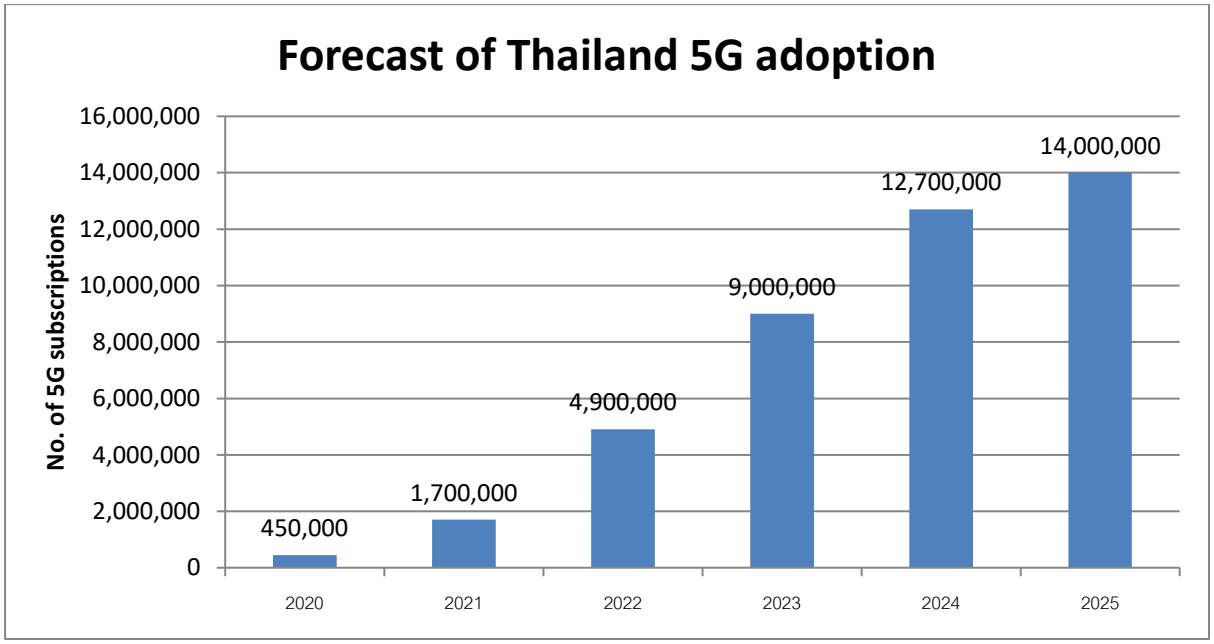
2G & 3G

2G cellular telephone technology is used for digital encryption of conversations, offered data services and SMS text messaging, followed by 3G, which offered faster data transfer rates and enabled video call. These can be used by applications that need lower bandwidth, wide coverage area, and low-cost connectivity. Mobile networks are not optimized for large number of devices per small area.

Alternative solutions are needed for devices that need very small amount of data periodically. First to offer data services, SMS text messaging, and video calls and still continue to be the primary source of communication where advanced connectivity options are limited.

Future Outlook – Thai telecoms regulator NBTC has set a schedule for the mandated shutdown of 2G networks across the country by October 2019 in order to free up capacity for 5G deployment. Thai operators have been instructed to take steps to migrate all 5.2 million remaining 2G subscribers onto 3G and 4G networks. Pending approval for the plan from the NBTC board, the regulator and operators will commence a multi-stage transition towards shutting down 2G. The first stage will involve disallowing further imports of 2G equipment.[146]

Figure 50. Forecast of Thailand 5G adoption 2020-2025



Source: Frost & Sullivan Analysis

Frost & Sullivan predicts that the number of 5G subscriptions in Thailand will reach significant numbers in 2020 with 450,000 5G subscribers, 1.7 million in 2021, 4.9 million in 2022, 9 million in 2023, 12.7 million in 2024 and 14 million in 2025.[147]

2.8 Quantum Computing

Quantum computers are an emerging technology of computer. The different of the normal computer is that digital computing encodes data into binary digits (bits) designated either as zero or one, quantum computing involves the utilization of quantum particles capable of being designated as zero, one, or some additional state in between. Quantum computers operate using subatomic particles known as 'qubits'. Potentially being in superposition of states, quantum bits (qubits), may

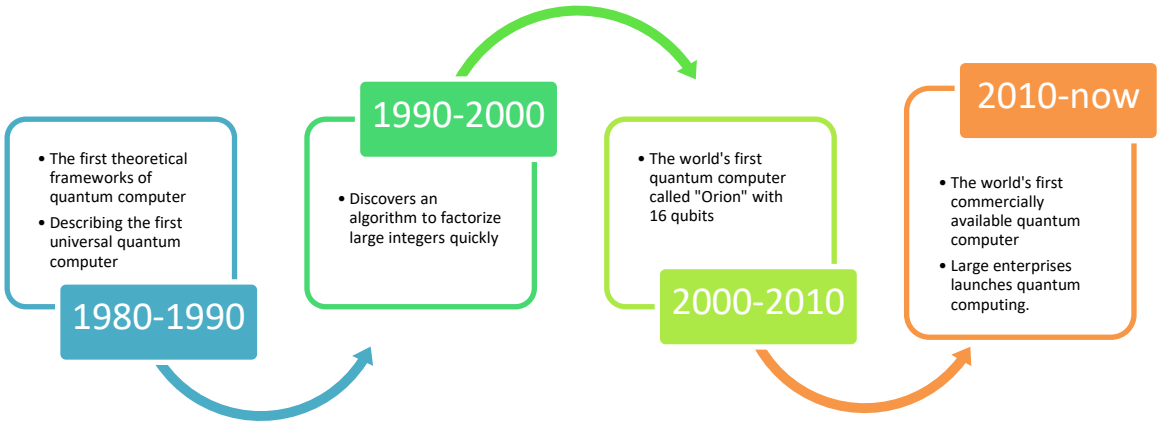
[146] https://www.telecomasia.net/content/thailand-mandate-2g-shutdown-oct

[147] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

represent both values at the same time. The supremacy of Quantum computing over digital computing has no parallel. The potential for Quantum computing is great, and quantum computers are approaching a state whereby they are capable of solving problems that are impossible to solve with a classic supercomputer.

Evolution

Figure 51. Evolution of Quantum Computing



Quantum computing had the first theoretical frameworks for quantum computer in year 1982. Paul Benioff was the person who proposes the framework. 10 year later, Peter Shor at AT&T's Bell Labs discovers an algorithm that allows a quantum computer to factorize large integers quickly. This discovery increases interest in quantum computers. Then, the world's first quantum computer called as Orion with 16 qubits launched by D-Wave. D-Wave has still developed the quantum computer and collaborates with NASA, Google and the Universities space research association. In year 2017, IBM launches quantum computers with 16 and 17 qubits and 50-qubit quantum chip that maintains quantum state for 90 secs. In the same yea, Microsoft also releases a free Quantum Development Kit including a programming language and Quantum computing simulator for people who want to start writing applications. Intel launches its 49-qubit superconducting quantum chip 'Tangle lake'. Recently, Google launches its 72-qubit quantum chip 'Bristlecone'.

2.8.1 Applications/Use Cases

Future quantum computers will be used to update high-level cryptographic systems, since they will be able to decrypt existing RSA cryptosystems much quicker than the most powerful supercomputer. The ability of qubits to mimic molecular behavior will facilitate the development of drugs with reduced side-effects, and the possible synthetic production of raw materials with a high demand. Quantum computers will be able to undertake large numbers of calculations within a short space of time. This feature could be used for automated financial market management and/or data storage. The examples of Quantum computing application are:

Healthcare

Simulate molecular structure, dramatically speeding up processes and finding cures will be simulated by quantum computers.

Farming

The Quantum computing will support to create quantum tunneling which will create the environmental benefit of reducing power consumption by a factor of 100 to 1,000.

Financial

Increasing exponentially the speed of these transactions by using Quantum computing will allow institutions to scale their processing with less costs as opposed to employing more human or IT resources.

Cybersecurity

A completely randomized environment will be created in a Quantum computing paradigm so when the data is exposed to the network, what hackers will see is just random data to the point it is impossible to identify any pattern to exploit and decrypt.

Military

The effectiveness of military will increase according to improvements in direct computational ability or in resulting materials and systems.

2.8.2 Current Scenario

IBM hit a Quantum computing milestone early in 2019 with the launch of Q System One, which is considered as the "world's first integrated, universal approximate Quantum computing system designed for scientific and commercial use." Fully integrated means that all the components are designed to work together as a unit, not assembled out of disparate pieces as previous quantum computers have been. Much as classical computers combine multiple components into an integrated architecture optimized to work together, IBM is applying the same approach to Quantum computing with the first integrated universal Quantum computing system. IBM Q systems are designed to one day tackle problems that are currently seen as too complex and exponential in nature for classical systems to handle. Future applications of Quantum computing may include finding new ways to model financial data and isolating key global risk factors to make better investments, or finding the optimal path across global systems for ultra-efficient logistics and optimizing fleet operations for deliveries.

2.8.3 Relevance in Future

In the long run, quantum machines will very likely shape new computing and business paradigms by solving computational problems that are currently far from achieving. They could change the game in such fields as cryptography and chemistry (and thus leading to advancements in material science, agriculture, and pharmaceuticals) as well as Artificial Intelligence (AI) and machine learning (ML). Additional applications in logistics, manufacturing, finance, and energy can also be anticipated.[148] Quantum computing market would be evolved and adopted in different eras.

1. 2018 – 2028

With the initial research & development, the non-universal quantum computers would be developed for low complexity simulations. These computers would be developed in the next few years and would be used thoroughly in the next decade. This phase is known for huge influx of investments, research & development, testing and experiments.

2. 2028 – 2039

Quantum Supremacy would be achieved in this phase, in which quantum computers will scale up to 50 qubits. Quantum Supremacy, or Quantum Advantage, will be the next significant milestone that many industry players are hoping to achieve. These computers would be able to perform many

[148] https://www.bcg.com/publications/2018/next-decade-quantum-computing-how-play.aspx

algorithms faster in specific applications. The focus of this generation would be on molecular simulation, R&D, and software development. There would be many usable applications in the market which would create significant value. The same generation will see the development of quantum information processing with companies generating familiarity with quantum simulation methods.

3. 2031 – 2042

This generation would foresee Quantum computing performing advance simulations for complex business commercial uses in simulation, search, and optimization with significant advantages over classical methods. It is expected to see a decade of steady progress in Quantum computing followed by a significant acceleration after about 2030.

2.8.4 How is it important to Thailand?

Quantum processing technology may support society 5.0 in the future because it will start using widespread in the next 10 years. Quantum processing will speed up the processing and solving problems. In particular, science makes new innovations happened. Additionally, quantum processing will affect economic growth from being able to change new cryptographic algorithms that are more secure. Various industries will popularly use. Therefore, it is a technology that supports the work of other advanced technologies and solves problems in the digital age.

2.8.5 Trends in 5 years, 10 years 15 years

	5 year	10 year	15 year
Technology Development	The progress of the first quantum processing depends on the number of qubits. The number of qubits will increase over the time, which increases the processing and security of over 100 million times.	Developing quantum processing will be in a level called Quantum Supremacy which is the ability to solve problems that the most powerful traditional computers cannot solve.	When the quantum is more ready, implementation to enhance the potential of other advanced technologies will occur in both using quantum with machine learning or in conjunction with cyber security.
Growth in terms of usage across the world	Large-scale technology leaders have launched quantum processing-products to experiment and develop in the future. For example, Google launched the 72 Qbit quantum processor and Microsoft announced the release of Quantum Development Kit for developers to test quantum programming etc.	The global quantum processing market will grow at 52.8% with a value of up to THB 41 billion by 2027. It is estimated that more than 20% of global organizations will invest in quantum processing projects.	The use of machine learning around the world is expected to grow with a growth rate of 39.7% per year from 2017 to 2022 and grow by 58% per year from 2022 to 2027. Machine learning working with quantum processing will achieve higher efficiency.
Potential growth in Thailand	The development of quantum processing is at an early stage with QuTe being a research team that studies quantum processing in order to disseminate this technology to Thai people.	Thailand will begin to develop in the Quantum supremacy or Quantum superiority by 2028 from the support of various important agencies and research from 7 leading universities in Thailand.	Toyota Tsusho and Denso companies operating in Thailand plan to use quantum computers to optimize real-time traffic data from 130,000 trucks and taxis in Bangkok.
Relevant Use Cases	Currently, quantum processing is still in the experimental study phase with large foreign companies offering opportunities to experiment in term of free platform.	Smartphone, tablet computer, enterprise computer equipment will be driven by quantum processing through the cloud in Thailand.	Quantum computers must be developed together with the development of cyber security system including research in analyzing molecular behavior from quantum computers.

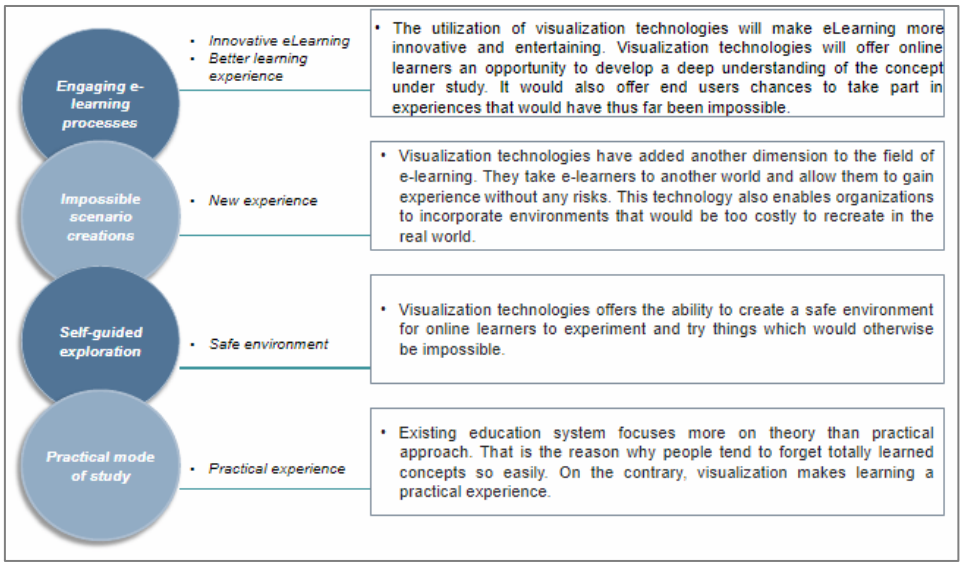
Thailand's Quantum computing market is forecasted to reach a value of THB 0.78 billion by 2025 from THB 195.2 million in 2020, growing at a CAGR of 31.92% during the forecast period.[149]

2.9 Digital Reality

Digital reality encompasses augmented reality (AR), virtual reality (VR) and mixed reality (MR). VR replaces the user's real-world environment with virtual objects. It is a fully immersive experience, limiting user movement and requiring a VR headset. AR augments the real world with digital overlays. It is partly immersive, and allows visibility through and around the AR device. MR mixes virtual objects in the real world, representing a cross application of AR and VR.

Benefits of digital realities range from increasing engagement in learning processes create impossible scenario creations, provide self-guided exploration to offer practical mode of study.

Figure 52. Benefits of AR, VR and Mixed Reality

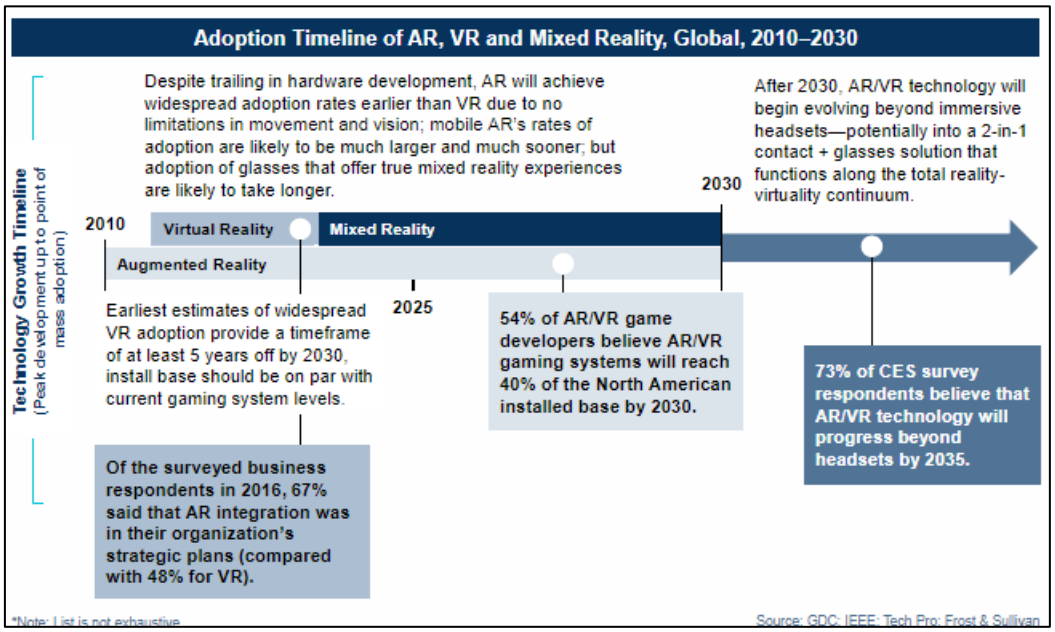


Source: Frost & Sullivan

AR will achieve widespread adoption rates faster than VR as there is no restriction in movement and vision. VR will reach wide adoption at least 5 years off by 2030. After 2030, AR/VR technology will begin evolving beyond immersive headsets as a 2-in-1 contact + glass solution.

[149] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

Figure 53. Adoption timeline of AR, VR and Mixed Reality



Source: GDC, IEEE, Tech Pro, Frost & Sullivan

2.9.1 Applications/Use Cases

A varied range of emerging use cases of digital reality encompasses automotive, healthcare, retail, entertainment verticals etc.

Automotive

Driver Assistance

- Heads Up Display (HUD): Internal CPU uses sensor data to represent and assist the driver through HUD. HUD is likely display information on but not limited to navigation, safety instructions (speed, impact probability, ETA, and so on), contact for emergency services, and other value added services.

Autonomous Driving

- Spatial Reconstruction: Use of 3D laser scanners, cameras, LIDAR, RADAR, Sonar, and GPS to scan the immediate environment and use the data collected to take reactive measures while in motion or to make iterative improvements to the car's software.

Healthcare

Therapy

- Virtual Therapy: Creating a virtual environment to treat patients for issues such as, but not limited to, chronic pain, anxiety, post-traumatic stress disorder, and depression.

Individual Health and Fitness

- Gamification: Synergizing aspects of gaming and healthcare to gamify client lifestyles; successful execution can help clients with behavioral changes, fitness, holistic mental and physical care.

Retail

Product Enhancement

- Product Customizability: Real-time customized rendering of product features and appearance.
- Product Demo: Demo of product either captured in 360 degree format or virtual replica of product with interactive features.

Advertisement and Customer Service

- Virtual Commerce: Preview of products using 3D renders of products and features before walking into a store.

Entertainment

Live Events/On-Demand Content

- Cinema, Video Playback: Streaming paid content or social media videos on demand to client devices.
- AR Overlay on Feed: Info-graphical overlay at sporting events; used to provide key statistics and can also at times be used to promote certain products and services offered by the broadcaster.

2.9.2 Current Scenario

The immersive technology market, including AR, VR and MR is expected to see huge growth in the next 5 years. Reality technologies are on the cusp of disrupting the human-machine interface, giving rise to an entirely new computing experience. The coming VR wave will be felt across every industry including healthcare where these technologies could experience significant growth across a wide range of use cases. Augmented reality, virtual reality, and mixed reality tools can increase the accuracy of diagnoses as well as provide operational and cost efficiencies for healthcare providers with capacity and resource limitations.

2.9.3 Relevance in Future

There are many technologies transforming AR and VR experiences in the foreseeable future, including 5G, robotics, AI, hologram etc. 5G will bring improved mobile broadband along with advanced capacity, more uniform experience with steadily high data rates and lower latency, which will improve the screen and equipment quality of AR/VR devices. AR, VR, and Robotics will merge to develop “virtual reality robots” that will have a huge impact on sectors such as manufacturing, retail, security, healthcare, and defense. Deep learning will elevate real-time image and speech recognition, lessen the cost of local processing and storage, and multiply network bandwidth, enabling richer data streams and cloud availability. Hologram technology merges both AR and VR into mixed reality, thus enabling the user to interrelate with both the hologram and the real surroundings simultaneously.

2.9.4 How is it important to Thailand?

Wearable augmented and virtual reality is among the key technologies that would help Thai manufacturing sector transform its production processes in the Fourth Industrial Revolution era. According to the ASEAN Secretariat, Thailand was third in the Southeast Asian region behind Singapore and Malaysia in the Fourth Industrial Revolution readiness in the areas of technology and innovation, human capital, global trade investment, institutional framework such as government policy and support, sustainable resources and environment.

2.9.5 Trends in 5 years, 10 years 15 years

	5 year	10 year	15 year
Technology Development	AR and VR are set to transform the shopping experience, replacing the pain points with captivating, interactive experiences that both inform and entertain.	AR/VR platform can build simulated gamification in an immersive landscape that offer a virtual therapy to a patient with physical and mental issues.	AR & VR in Autonomous driving – AR/VR can deliver an immersive driving experience with maps and landmarks hovering in space before the driver's eyes, directing them around. Phone calls and text messages insert themselves unobtrusively in the corners, ready to be accepted or dismissed with the wave of a hand.
Growth in terms of usage across the world	Goldman Sachs forecasts the market for AR and VR in retail will reach THB 50.5 billion by 2025.[150]	AR & VR Healthcare Market is likely to reach THB 192.4 billion by 2025. The market valued at THB 23.6 billion in 2017 and is anticipated to grow with a growth rate of more than 30.1% over the forecast period 2018-2025.[151]	The global automotive AR and VR market was valued at THB 6.7 billion in 2017 and is expected to reach THB 21.2 trillion by 2025, growing at a CAGR of 175.7% during the forecast period.[152]
Potential growth in Thailand	AR/VR can offer a powerful way to drive engagement at seasonal shopping as well as impulsive shopping. Thai consumers can be engaged in-store or in-the-home and even share such moments with family and friends.	AR/VR can be used in facilitating training and education for medical procedures as Thailand is gearing towards establishing as the ASEAN hub of medical tourism.	With Thailand being one of the world's leading automotive manufacturers, VR can allow automotive companies to design and produce smart vehicle solutions in lesser time. Automakers can use VR to develop a prototype using multiple approaches and experimentation in a short time.
Relevant Use Cases	VR is proving a great fit for use cases where the retailer wants to put the consumer into a completely new environment, like behind the wheel of a car, while AR layers images over the consumer's immediate surroundings, such as projecting a new outfit on an image of the shopper standing in the store.	Virtual Therapy: Creating a virtual environment to treat patients for issues such as, but not limited to, chronic pain, anxiety, post-traumatic stress disorder, and depression in 3D landscape that motivates the patients to feel better and recover faster.	Spatial Reconstruction: Use of 3D laser scanners, cameras, LIDAR, RADAR, Sonar, and GPS to scan the immediate environment and use the data collected to take reactive measures while in motion or to make iterative improvements to the car's software.

[150] https://www.goldmansachs.com/insights/pages/virtual-and-augmented-reality-report.html
[151] https://www.marketwatch.com/press-release/ar-vr-healthcare-market-to-reach-US$-614178-million-by-2025-2018-10-25
[152] https://www.prnewswire.com/news-releases/automotive-ar-and-vr-market-projected-to-attain-673-60-bn-by-2025-at-175-7-cagr-says-amr-300794864.html

2.9.6 Sub-components of Digital Reality

Augmented reality (AR)

Augmented reality literally means amplified reality. This is done by imposing visual layers onto everyday objects and surroundings aimed at redefining user perception and decision making. As the concept is completely artificial, technology advancements become the key enabler and disabler towards its realization.

Future Outlook – Thailand is one of the top three countries behind Singapore and Malaysia at a stage of development for the fourth industrial revolution (4IR) readiness in the areas of technology and innovation, human capital, global trade investment, institutional framework such as government policy and support, sustainable resources and environment. One of the five key technologies that help the manufacturing sector adopt and transform into 4IR is wearable augmented reality and virtual reality. ASEAN has about THB 7.9 trillion to 8.7 trillion in incremental value at stake by 2028, a 35-40% increase in manufacturing value addition (MVA) from gains in productivity and unlocking additional revenue stream such as new products and quality improvements by embracing 4IR technologies.

Mixed reality

Mixed reality is the result of blending the physical world with the digital world. Mixed reality is the next evolution in human, computer, and environment interaction and unlocks possibilities that before now were restricted to our imaginations. It is made possible by advancements in computer vision, graphical processing power, display technology, and input systems. The combination of all three – computer processing, human input, and environmental input – sets the opportunity to create true mixed reality experiences. Most AR and VR offerings of today present a very miniscule part of the mixed reality spectrum.

Future Outlook – Mixed reality (MR) has been adopted by the property and real estate industry in Thailand through the alliances of Sansiri, Microsoft and AIS by combining the advantages of Virtual Reality (VR) and Augmented Reality (AR) together, allowing prospective customers to interact and experience an immersive virtual housing environment with an aim to offer a complete living experience during a visit and initial buying decision making process. The technology enables companies to access a large number of users by sending only one link to their mobile phones for the VR. The cost of VR is also 50% lower than brochures and photographs.

Holographic communication

Smart phone based AR and the AR headset explosion would revolutionize the 3D holograms. A hologram is a 3D virtual object that is imaginary. One of the future predictions about the world of technology from Microsoft itself is Hologram and Augmented. The sophistication of this future technology will find itself on the glass and also the walls of your home.

Future Outlook – With nearly half of the US workforce expected to be working remotely by 2020, meetings of the future can't depend on the same wonky teleconferencing systems in place today. Tech companies are responding to the call for better communication tools by introducing mobile robots with iPad "faces" and even two-way hologram technology that places individuals from different locations in the same virtual conference room. The same holographic meetings of the future can be adopted and applied for business meetings as well as MICE (meeting, incentive, conference, and exhibition) events among government agencies, firms and citizens soon too.

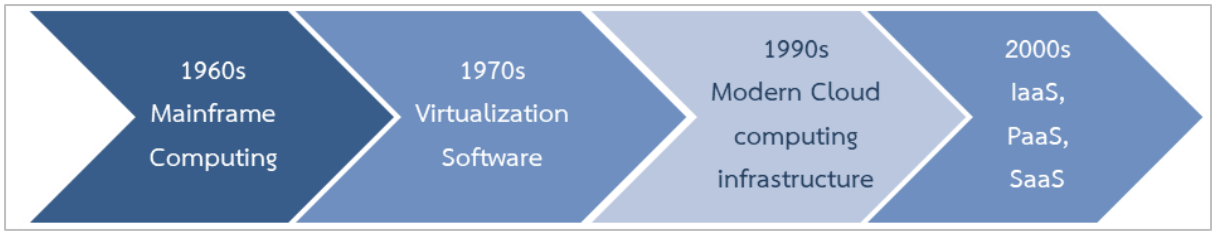
Thailand's immersive technology market is projected to grow to THB 18.6 billion by 2025 from THB 946.2 million in 2018 with a CAGR of 53% during the forecast period.[153]

2.10 Cloud Computing

Cloud computing is the delivery of on-demand computing resources (e.g., applications, data centers) over the Internet. Cloud services help to eliminate the limitations pertinent to scalability for on-premises computing resources. They eradicate the complexities and minimize cost of deployment and provisioning of physical resources.

Cloud computing has opened up a myriad opportunities to use expensive and complex computing resources as services. Having started with only providing Software-as-a-Service (SaaS), recent advancements in cloud computing technology offer almost all the major computing resources, such as infrastructure, storage, platforms and so on to be used as services, collectively known as XaaS (Everything/Anything-as-a-Service), which offers a virtualized working environment where various new technologies can be integrated together.

Figure 54. Evolution of Cloud Computing



Source: Frost & Sullivan

The evolution of cloud computing has begun since 1960s in the name of 'mainframe computing' but the machines were very expensive and huge, so the company bought only 1-2 machines, and then implement "time-sharing" schedules which enabled multiple users to access the central mainframe computer from connected stations. The next major advancement is in 1969 when APRANET was introduced. It was the first network that allowed digital sources to be shared among computers in different locations. The decade later, much further advancement in cloud technology came into being. Most of all, it evolved with the Internet, and "virtual" private networks has been offered to business sector as a rentable service, eventually leading to the development of the modern cloud computing infrastructure in the 1990s. In the early 2000s, Amazon launched Elastic Compute Cloud (EC2) allowing companies and individuals to rent virtual computers through which they could use their own programs and applications. Same as Google that launched Google Docs services that users are able to save, edit and transfer document in the cloud. Nowadays, there are a number of services emerging from cloud such as Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS).

2.10.1 Applications/Use Cases

Cloud used to be an alien idea a while ago but today multi-cloud environments have become the norm for both public and private sector. Its promise about cost saving and high latency drives the adoption to be at the fastest pace in the last few years. Cloud has been applied in every industry regardless of public, private or hybrid one. Here are the most common use cases of cloud.

[153] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

Disaster Recovery and Backup

Cloud has been built with the capability of backup. Disaster recovery in the cloud is emerging as a compelling alternative to an expensive disaster recovery plan due to its flexibility in commitment, capacity and cost. Disaster recovery in cloud help maximize enterprise's cost because there is no need to purchase hardware, hire or train new specialists and invest in a secondary physical site. This service will run replicating and recovering applications and data in the case of a local disaster or disruptive event.

Testing and Development

Public Cloud is another famous area to set up and do application development and then move them back on-premises data center for production (often for data governance or cost reasons). This is because cloud can speed up the development process. The traditional development and testing methods can be time-consuming and costly. As with traffic bursting, enterprises may not have the capacity to host lots of servers and storage in a data center for testing and development purposes. Cloud's promise for flexibility and stability, easy management, security and low costs in production are the factors that attract DevOps guys to run on cloud. Using the public cloud allows you to spin up servers as you need them, and then shut them down when you're finished.

Extend Existing Applications

The costs of deploying, managing and upgrading existing applications can be very costly. Extending applications to the cloud can provide scalable and cost effective solution. Some cloud platforms support tons of applications and loads of operating systems to run on allowing applications testing without changes required. With cloud, organizations can perform their works with the same tools and processes, no need for changing custom settings in the environment.

Cloud Bursting

Some period of the year, the demand for resources may reach a certain level; for example, retail business may get an overwhelmed interaction from customers during special holidays likes Christmas. In a traditional data center environment, businesses need to provision a compute, storage, and network capacity to reflect this. This is not an effective method of scaling. Enterprises will be paying for extra infrastructure that you may only use for a couple of months of the year. Cloud computing offers a far better method for handling peak traffic loads. Cloud can be used to scale a network and resources to manage this unusual traffic during peak period.

2.10.2 Current Scenario

Globally, hybrid and multi-cloud environments have gained momentum as enterprises look to adopt the right mix of cloud models and service to best suit their business objectives. By the end of 2019, almost two-thirds of organizations are expected to adopt multi-cloud infrastructure.[154] The emergence of open-source-based cloud platforms (e.g., OpenStack) is a key driver for growth in hybrid clouds, as they facilitate easy migration of cloud apps and enable multi-cloud interoperability. Google, for example, has been increasingly focusing on "Google Stackdriver," a dashboard tool for customers using multiple clouds, as it notes a trend of multi-cloud usage and rising private cloud deployment.

As security concern is one of the top challenges, securing data and applications in the cloud is imperative as more mission-critical apps and valuable data is moved to the cloud. Global cloud security solutions are expected to reach an annual growth rate of 28% over the next few years. [155]

[154] https://www.oreilly.com/ideas/how-companies-adopt-and-apply-cloud-native-infrastructure
[155] https://go.forrester.com/blogs/17-06-08-cloud_security_spending_will_grow_to_35_billion_by_2021/

Security and control concerns are also driving enterprises to look toward managed private cloud solutions over public clouds. In addition, managed private cloud and professional services have also been increasing in popularity, due to assistance required in migrating complex Big Data and workloads such as ERP to a cloud model. The expansion of open source technologies as well as advances in API-accessible single-tenant cloud servers also help promote acceptance toward managed private cloud providers.

2.10.3 Relevance in Future

The technology convergence will help create new opportunities in XaaS. Advancements in technologies such as AI, Big Data, VR, and others, when converged with cloud, will lead to the development of innovative applications. For instance, convergence of cloud computing, Big Data, AI, and biometrics can develop Biometrics-as-a-Service, which allows collected biometric information to be stored in cloud-based Big Data infrastructure, meanwhile, AI engine embedded in the cloud can identify patterns in biometric data to accurately recognize individuals through a cloud-based application interface. Furthermore, technology advancements might as well make supercomputing available as a service through cloud computing.

2.10.4 How it is important to Thailand?

Cloud computing will come to make a significant shift to the business and economic model that leads to an effective cost maximization. When implemented properly, the cloud computing economic model can drastically reduce the operations and maintenance cost of IT infrastructures. Thus, businesses could allocate the budget to invest in develop other capabilities. Thai SMEs should have been supported to be accessed to free cloud. This could lead to a competitive edge of SMEs to help drive Thailand economy as a whole. For government sector, cloud will help improve management of network systems and public service systems to be able to provide continuous service even in the event of a disaster and can save at least 30% of the system investment budget according to international study.

2.10.5 Trends in 5 years, 10 years 15 years

	5 year	10 year	15 year
Technology Development	Hyper-converged cloud can refer to a public cloud provider using hyper-converged infrastructure (HCI), an on-premises hybrid cloud using HCI, or a system that links the virtualization in an enterprise HCI system with a public cloud's own virtualized servers.	Container-as-a-Service (CaaS) is a cloud service model that allows users to manage and deploy containers, applications and clusters through container-based virtualization.	Technology convergence will lead to an emerging of new innovative cloud-based applications such as Exascale computing-as-a-Service (EC-as-a-Service), which allows data that is stored in cloud-based Big Data infrastructure to be expeditiously processed by exascale computing
Growth in terms of usage across the world	The global HCI market is projected to grow from THB 129.3 billion in 2018 to THB 539.3 billion by 2023, at a CAGR of 32.9% during the forecast period.[156]	Worldwide CaaS market is forecasted to grow at a CAGR of 34.8% during 2017-2023 to aggregate THB 132.8 billion by 2023.[157]	EC-as-a-Service is expected to accelerate its growth subsequent to growth of Exascale computing in the age of 5G/6G. EC-as-a-Service will also be driven by the worldwide strong growth of Big Data and AI.
Potential growth in Thailand	HCI has been increasing adopted by Thai organizations, enterprises that are embracing digital transformation in particular. Hyper-converged cloud, therefore, is expected to be progressively deployed in the next few years.	Having been initially adopting in mature cloud markets, CaaS has potential to grow in Thailand and other emerging cloud markets, amid increasing migration of data-intensive input/output (I/O) workloads to the cloud.	Similarly to the global trend, EC-as-a-Service in Thailand is also expected to be widely adopted in the future due to an increasing use of cloud and Big Data technologies by businesses, e.g. cloud-based ERP and Big Data workloads
Relevant Use Cases	HCI can simplify hybrid cloud environment and reduce the time and expense necessary to transition to hybrid cloud. HCI also benefits edge computing by eliminating configuration and networking hassles that might happen on the edge.	CaaS allows businesses to use container services, enabling users to develop, test, execute, or distribute software in so-called application containers across IT infrastructures, without having the necessary infrastructure.	EC-as-a-Service can allow a wide range of users to use high performance computing without the need to spend on such highly expensive infrastructure.

2.10.6 Sub-components of Cloud Computing

Edge Computing

Edge computing enables processing data at the edge of the network, and enables analytics at the source of the data. This reduces the volume of data that must be moved, decreasing the cost of transmission and latency. However, edge presents its own challenges, including the emerging need for high-power density networking and to reduce latency. It might require redesigning to serve different carrier environments, and could involve complicated pricing models depending on the application.

Future Outlook – It is forecasted that up to 40% of all compute will happen at the edge over the next couple of years. The global edge computing market is projected to grow from THB 41.0 billion in 2017 to THB 574.0 billion by 2022, at a CAGR of 69.5% during the forecast period.[158] The strong growth of edge computing adoption is driven by a growing number of IoT devices, an increasing cloud adoption, and a rising demand for more computing power in smaller footprint devices.

[156] https://www.marketsandmarkets.com/PressReleases/hyper-converged-infrastructure.asp

[157] https://www.infoholicresearch.com/press-release/worldwide-container-as-a-service-caas-market-worth-4208-1-million-by-2023/

[158] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

Everything/Anything-as-a-Service (XaaS)

Everything/Anything-as-a-Service (XaaS) is a collective term that refers to the delivery of services such as SaaS, PaaS, IaaS, Database-as-a-Service (DaaS), Storage-as-a-Service (STaaS), Security-as-a-service (SECaaS), Database-as-a-Service (DBaaS), Disaster Recovery-as-a-Service (DRaaS), Communications-as-a-Service (CaaS), and Network-as-a-Service (NaaS). XaaS forms the intrinsic part of cloud computing, and offers not only cost reduction, but also a flexible and scalable infrastructure for every business process ranging from new product development to data insights and innovative business models.

Future Outlook – With the increasing penetration of Big Data analytics and IoT in the ecosystem across industries, XaaS will have immense application potential in the future. The global XaaS market is projected to grow from THB 8.2 trillion in 2017 to THB 16.5 trillion by 2022, at a CAGR of 15.2% during the forecast period.[159]

Infrastructure-as-a-Service (IaaS)

In an IaaS model, a cloud provider hosts the infrastructure components traditionally present in an on-premises data center, including servers, storage and networking hardware, as well as the virtualization or hypervisor layer. Infrastructure as a service (IaaS) refers to online services that provide high-level APIs used to dereference various low-level details of underlying network infrastructure like physical computing resources, location, data partitioning, scaling, security, etc.

Future Outlook - Many companies in Thailand, especially small and medium businesses, are showing an increase in demand for cloud infrastructure services in cloud storage and Web hosting. Disaster recovery and backup continue to drive the rapid uptake of IaaS cloud solutions in the country. Thailand's IaaS market is projected to grow from THB 1.6 billion in 2018 to THB 4.5 billion by 2022, at a CAGR of 30.75% during the forecast period.[160]

Software-as-a-Service (SaaS)

Software-as-a-Service (SaaS) generally refers to a new and alternative way of accessing software, as opposed to more traditional methods of access. A SaaS solution requires no investment in infrastructure. IT resources can be redeployed to core business functions, while maintenance and updates are factored-in.

Future Outlook – It is forecasted that 75% of the total cloud workloads and compute instances will be SaaS by 2022, according to Cisco's Global Cloud Index. Thailand's SaaS market is projected to grow from THB 3.5 billion in 2018 to THB 9.4 billion by 2022, at a CAGR of 27.97% during the forecast period.[161] Popular continuous SaaS services deployed include workplace collaboration tools (email, accounting, payroll, and document management software), cloud storage services, as well as CRM applications.

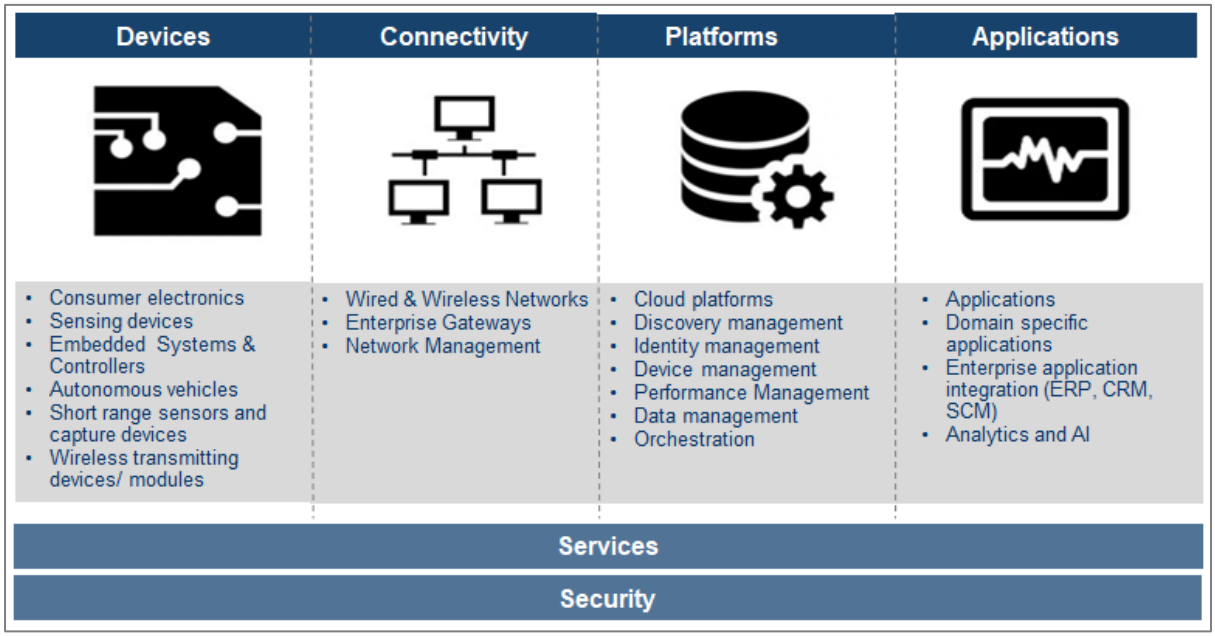
Thailand's cloud services market is expected to grow at a CAGR of 29% during 2018–2025, to reach an overall market size of THB 31.5 billion in 2025 from THB 5.3 billion in 2018. SaaS spending was the highest of the cloud services segments, at 66.21% in 2018, followed by IaaS at 29.33% and PaaS at 4.46%.[162]

[159] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight
[160] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight
[161] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight
[162] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

2.11 Internet of Things (IoT)

Internet of Things (IoT) is the connection of objects, sensors, and devices into an internet-like structure and organization – enabling the virtualization of everyday objects, providing physical and virtual objects with a digital identity, and allowing interconnecting objects to be monitored and interacted. The IoT stack comprises of 4 major layers - namely devices, connectivity, platforms, and applications - with security and services cutting across the entire stack.

Figure 55. IoT Taxonomy

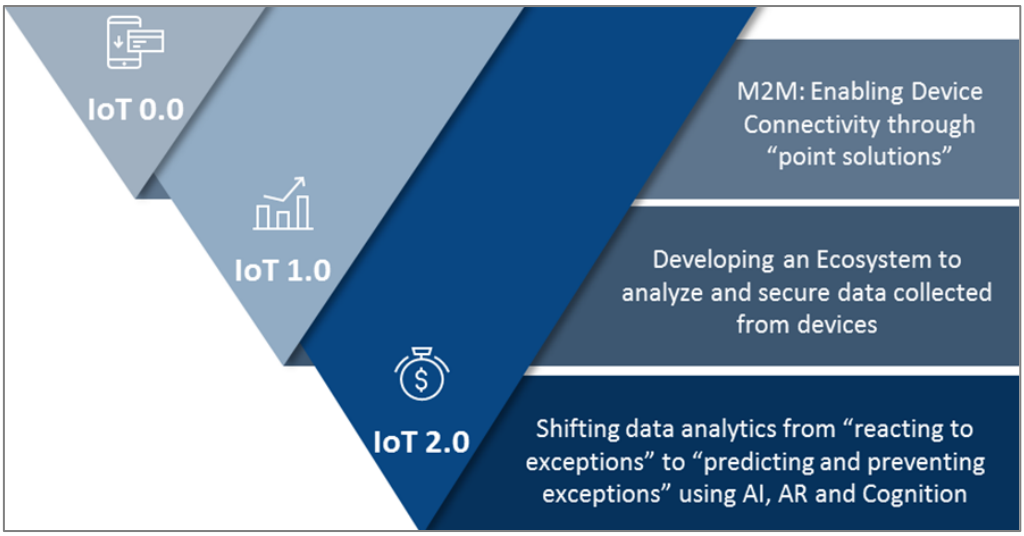


Source: Frost & Sullivan

IoT extends internet connectivity beyond traditional devices such as desktop and laptop computers, smartphones, and tablets, to other devices that use embedded technology to communicate and interact over the internet. This means that everyday physical objects, from vehicles to manufacturing equipment, which are able to be connected to the internet can link and communicate to each other. The common characteristics of any IoT-connected device are the presence of: a unique identifier, an IP address, and internet connectivity; the ability to emit and receive information; the ability to interact with other objects; and the ability to perform these functions without requiring either human-to-human or human-to-computer interaction.

The definition of IoT has evolved over the last several years. In the past, IoT has been used interchangeably with machine-to-machine (M2M) communications. Over time, the definition has evolved to include technologies such as Big Data analytics, edge computing, cloud-based platforms, and enterprise system integration that includes integrating with people and processes. While initial implementation was focused on visibility of operation, implementations today are primarily focused on optimizing business process and improving efficiency. However, several leading IoT providers have already started to offer new innovative cross convergence IoT services that leverage on IoT data.

Figure 56. The Evolution of IoT from M2M to Predictive Computing

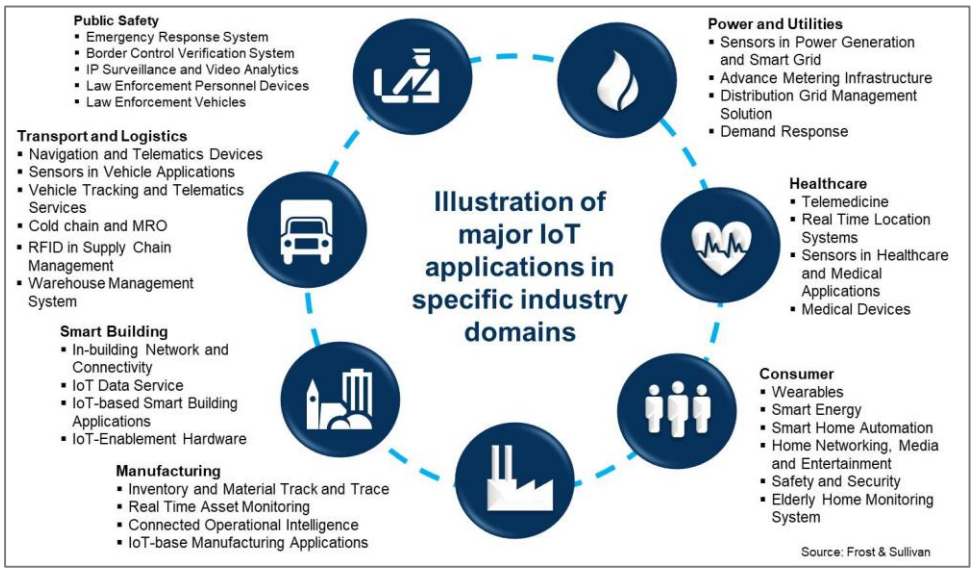


Source: Frost & Sullivan

2.11.1 Applications /Use Cases

IoT can be utilized in both consumer and business segments across industries. Providing a connected environment with everyday items will help businesses utilize the information captured from IoT networks, which will help improve the decision-making process and result in highly reliable predictive insights for business development. It can also have a substantial impact on enhancing user experience which potentially generates additional revenue streams for enterprises. With the implementation of IoT, enterprises can solve a variety of business challenges such as visibility and insights, optimization of business processes, tracking and monitoring of assets and environment, improved customer engagement, as well as enabling of new services and business models. Consequently, IoT use cases will continue to expand in the coming years. Some current use cases and applications of IoT are illustrated in the below figure.

Figure 57. Illustration of IoT Applications



Source: Frost & Sullivan

Top three industries that have been impacted by IoT include healthcare, automotive, and industrial sectors. To explain in greater detail, IoT is well suited to meet the needs of the transforming healthcare industry by supporting the transition from disjointed care to coordinated care and reactive to proactive care-delivery approaches. Almost 60% of global healthcare organizations have already adopted healthcare IoT or Internet of Medical Things (IoMT), and have realized cost savings, improved their profitability, visibility and customer experience. In addition, the automotive sector will harness IoT throughout the value chain. Automotive industrial IoT spend will grow to $37 billion by 2025, while digital retailing related to IoT spend will increase at a CAGR of 29.1% from 2015 to 2025.[163] Connected cars, autonomous driving, and the rise of AI are among the key automotive use cases compelling OEMs and Tier I suppliers to invest in IoT platforms. Finally, for industrial sector, investment in the Industrial Internet of Things (IIoT) is driven by a desire for zero inefficiencies, no machine downtime, and accurate remote diagnosis. With the introduction of automated techniques and flexible production and assembly procedures, manufacturers could improve their productivity by close to 30% and generate significant savings. Frost & Sullivan estimates that the global IIoT market could be worth $10 trillion by 2030.

2.11.2 Current Scenario

The IoT movement is growing at a significant pace and impacting virtually every industry sector. Frost & Sullivan forecasted that the number of IoT devices used across the world will reach 60.7 billion by 2024, growing from 19.9 billion devices in 2018, at a CAGR of 20.35%.

Stakeholders in IoT ecosystem worldwide have been constantly developing technologies to offer smarter IoT devices and services. Qualcomm, for example, recently unveils the Vision Intelligence Platform, a new chip-based platform, built specifically for the IoT using an advanced 10 nm FinFET process technology to deliver powerful computing for on-device camera processing and machine learning, with exceptional power and thermal efficiency, across a wide range of IoT applications. Likewise, Microsoft has introduced Azure Sphere, a new custom System-on-Chip (SoC) operating system for the IoT that includes a new security subsystem called Pluton to provide greater IoT device security starting from the microcontroller level and moving up to the cloud.

2.11.3 Relevance in Future

Many of IoT use cases that are currently supported over existing 4G networks will derive additional benefits from 5G features, such as higher reliability, enhanced capacity and coverage, as well as improved cost-efficiency and virtual network customization capabilities. Industrial IoT applications, especially those that need ultra-low latency and high degree of reliability, are likely to become a major IoT use case in 5G environments. Distributed industrial applications, which are an essential component of next-generation industrial facilities, require ubiquitous connectivity and real-time communication between machines in industrial environments.

2.11.4 How is it important to Thailand?

IoT is one of the key technologies that drive the digital transformation of Thailand and help bring the country to the Digital Thailand vision, which is part of Thailand 4.0, with a significant impact on enterprises, individuals, and societies. Nationwide, connected devices are increasingly being adopted by both consumer and business segments across industries, mainly driven by the evolving sensor technology at lower price, the rising in high speed networking technologies, the improving connectivity and mobile coverage, as well as the growing adoption and popularity of cloud computing and Big Data analytics. One reason for higher demand in business segment is that enterprises need to incorporate technologies in order to stay competitive. With the utilization of IoT, enterprises have new sources of

[163] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

data that provide end-to-end visibility of their business organization enabling them to digitize their physical business processes, optimizing these processes and improving their cost structure.

2.11.5 Trends in 5 years, 10 years 15 years

	5 year	10 year	15 year
Technology Development	To address security and privacy challenges, blockchain-based solutions can be used to facilitate next-generation IoT use cases focused on cybersecurity, automation, compliance and certification management, and privacy.	The future of IoT will bring significant advancements in Smart City concept. The development of Smart City will also be driven by the growth of cloud computing, machine learning, analytical tools, 5G, as well as the evolving sensor technology at lower price.	5G/6G connectivity will radically transform data services methods across various industry verticals, supporting advanced IoT deployment. 5G/6G will enable, for example, fully autonomous Robotics, immersive remote operations, and end-to-end life cycle management for monitoring and tracking.
Growth in terms of usage across the world	The global blockchain-based IoT (BIoT) market is projected to reach THB 8.0 trillion by 2026. In addition, APAC market is estimated to witness the highest growth, of over 13.3% CAGR, from 2018 to 2026.[164]	The Smart City concept is gathering steam all over the world. Huawei, for example, has set out its aim to become the backbone behind smart cities across the world, with its Smart City Solution being already in operation in more than 160 cities in over 40 countries.[165]	It is forecasted that the number of 5G connections globally will reach 1.3 billion connections by 2025, covering 40% of the world's population or around 2.7 billion people.[166]
Potential growth in Thailand	Blockchain-based IoT solutions are expected to be widely implemented in Thailand in the coming years, especially in BFSI sector, due to security and data privacy concerns among customers while adopting IoT technology. BIoT also allow enterprises to simplify business processes, improve customer experience, and achieve significant cost efficiencies.	The smart cities scheme is a part of the government's Thailand 4.0 initiative, aiming to integrate digital technology, energy, and transport, with the ultimate goal to develop 100 smart cities within two decades.[167] The government has also established the National Smart City Committee to stimulate adoption of smart cities.	5G/6G will have dramatic impact across industries in Thailand, particularly telecom industry. This will consequently create new opportunities for Telcos, as well as other IoT service providers, to offer advanced IoT services and solutions for both consumer and business segments.
Relevant Use Cases	Connected IoT devices can use blockchain to organize, store, and share streams of data reliably. Even if there are different networks and device sets, blockchain records allow anyone with appropriate authorization to connect and take necessary actions.	IoT use cases for smart cities include smart traffic solutions, smart public transportation, smart parking, smart utilities – e.g. smart meters, smart street lighting, smart waste management, smart public safety solutions, etc.	One of the major use cases of 5G will be connected cars coupled with AR/VR. 5G will also significantly transform the healthcare industry; use cases include live transmission of high-definition surgery videos that can be remotely monitored.

[164] https://www.prnewswire.com/news-releases/blockchain-internet-of-things-biot-market-size-worth-254-31-billion-by-2026-898549416.html

[165] https://www.techradar.com/news/huawei-launches-full-smart-city-platform

[166] https://www.gsma.com/newsroom/press-release/new-gsma-report-highlights-how-5g-artificial-intelligence-and-iot-will-transform-the-americas/

[167] https://www.bangkokpost.com/tech/local-news/1362595/more-smart-cities-planned-in-2018

2.11.6 Sub-components of Internet of Things (IoT)

Next Gen IoT using AI (including Swarm Technology)

AI is expected to have significant impact on IoT in the next 5-10 years. As a part of AI, swarm intelligence is a collective behavior of decentralized self-organized systems where each member autonomously offers its abilities. With Swarm intelligence applied to IoT, a number of discrete physical devices, with each one contributing its interfaces and processing capabilities to the collective, can be viewed in architectural and functional terms as a single entity, enabling harnessing of data and processing power. Providing massive scalability and the ability to easily integrate future interfaces and devices, Swarm technology can extremely reduce the costs of application development and deployment, installation, commissioning and maintenance out at the network edge.

Future Outlook – Swarm technology is expected to witness high growth in the coming years, mainly driven by the increasing usage of swarm intelligence for solving Big Data problems, the rising adoption of swarm-based drones in the military, and need for swarm intelligence in the transportation business. The global Swarm intelligence market it projected to reach THB 14.1 billion by 2030 grow, at a CAGR of 40.47% from 2020 to 2030, considering the Swarm technology will get commercialized by 2020.[168]

IoT Connectivity including Digital Twin

IoT connectivity protocols enabling IoT to leverage the applications have been evolving from 2G, 3G to new protocols, such as Sigfox, NB-IoT (Narrow Band IoT), and LoRa, as well as the future technologies of 5G. New technology like Digital Twin technology can help enable better connectivity, communication, and collaboration across IoT ecosystem. Representing the convergence of the physical and virtual worlds, Digital Twin is a digital model or replica of a physical asset, product, process, or system that allows users to have a digital footprint of an asset's or product's life, from the design and development phases through deployment and the end of the asset's or product's lifecycle. The connected digital twins enable businesses to proactively monitor their equipment or processes. The pairing of a digital companion with a physical object can also help enable cost effective products and an improved production process.

Future Outlook – Since Digital Twin technology incorporates advanced technologies such as Big Data, AI, machine learning, and IoT, to leverage sensor data; Digital Twin will witness wider adoption worldwide including in Thailand, following the increased adoption of these advanced technologies. The global Digital Twin market is projected to grow from THB 71.9 billion in 2017 to THB 493.9 billion by 2023, at a CAGR of 37.87%; additionally, the digital twin market in APAC is expected to grow at the highest CAGR during the forecast period.[169]

IoT adoption in Thailand has been growing fast in both consumer and business sectors. F&S forecasted that the country's IoT market would grow from THB 3.6 billion in 2018 to reach THB 9.6 billion by 2023, at a CAGR of 21.47% during the forecast period.[170]

2.12 Nanotechnology

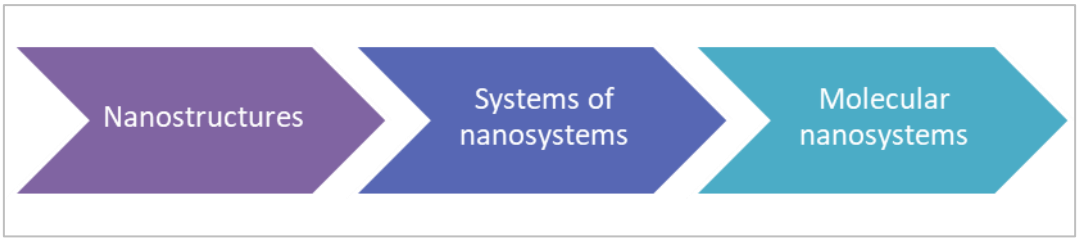
Nanotechnology is emerging field in all areas of science, engineering, and technology which conducted at the nanoscale structured between 1 to 100 nanometers. At nanoscale, scientists and engineers can create material to take advantage of their enhanced properties such as higher strength,

[168] https://www.marketsandmarkets.com/Market-Reports/swarm-intelligence-market-149256760.html
[169] https://www.marketsandmarkets.com/Market-Reports/digital-twin-market-225269522.html
[170] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

lighter weight, increased control of light spectrum, and greater chemical reactivity than their larger-scale counterparts.

Nanotechnology is helping to considerably improve, even revolutionize, many technologies and industry sectors: Information Technology, homeland security, medicine, transportation, energy, food safety, and environmental science, among many others.

Figure 58. Evolution of Nano Technology



Source: Frost & Sullivan

Nanostructures are the first nanotechnology generation. This generation used bulk technology to create small scale products such as microchip. The processes of managing things or produces use the mechanical methods such as cutting, turning, compressing, bending, or using chemical methods by trying to control various conditions. Even all of these processes could create the small things, they lack precision and highly defective.

The second generation is systems of nano systems. This use various syntheses and assembling techniques (guided assembly) such as bio-assembling, networking at the nanoscale, multi-scale, hierarchical architectures, and robotics on surfaces.

The recently generation is Molecular nano systems which use molecular technology. The processes are to manage things or products by applying atoms or molecules to precisely align the desired position. This generation support to bring molecular technology to create larger things.

2.12.1 Applications/Use Cases

Nanotechnology applications are a reality today which has changed our lives in more ways than we can imagine. It enables the development of smaller, faster, and high-sensitivity sensors that can bring in new properties and efficiency in design for future microelectronics components. The benefit of nanotechnology will affect various industries.

Transportation

Nanotechnology developing multifunctional materials which will contribute to building and maintaining lighter, safer, smarter, and more efficient vehicles, aircraft, spacecraft, and ships. All of these will improve the transportation infrastructure. Nanoscale sensors and devices may provide cost-effective continuous monitoring of the structural integrity and performance of bridges, tunnels, rails, parking structures and pavements over time.

Healthcare

Nanorobotics will be developed from nanotechnology. The nanobots will support applications of cancer detection and treatment, medicine and drug delivery, monitoring pipelines, including smart windows will control room temperature to enhance energy efficiency.

Manufacturing

Nanotechnology will provide the benefit feature to the material. Emerging nanomaterials and nanoscale processes make the devices smaller, cheaper and low power consuming compared to the current state-of-the-art. Nanoelectronics will be produced more in the future.

2.12.2 Current Scenario

Nanotechnology applications are a reality today which has changed our lives in more ways than we can imagine. Nanotechnology holds some answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption. For example, Nanotubes - minuscule rolls of carbon sheets - have been used in car manufacturers to improve the safety of fuel-lines in passenger vehicles. The electronics industry get better protect goods by relying on nanotubes in its packaging material and to aid the removal of any electrical charges before they can build to disruptive levels.

Nanotechnology and the microchip industry have made it possible to incorporate as many as 5 billion little transistors into one little chip and have developed routes that can transmit data and information at almost the speed of light.

The global defense application market for nanotechnologies was valued at nearly THB 94.6 billion in 2017. Automotive application captured nearly 5% share of the global nanotechnology market.[171]

Around THB 63.1 billion is being invested annually in nanotechnology developments around the world, with nearly 40% of this in the USA. Japan is a major contributor, as are the European Governments and major industrial economies such as Singapore, Taiwan, and China.

2.12.3 Relevance in Future

The nanotechnology market is estimated to surpass THB 4.2 trillion by 2024. The top three applications of nanotechnology are electronics, energy and biomedical. Together, they account for over 70% share of the global nanotechnology market. The largest application for nanotechnology is electronics. The energy application captured second highest share of the nanotechnology market, being followed by biomedical application. The global nanotechnology market is expected to grow at a CAGR of around 17%.

The opportunity for reaping the benefits from rising defense and space research investments in nanotechnology through long-term partnerships and providing profit by enabling nanotechnology-based applications will enhance the factors like communication, monitoring of health and surveillance.

The latest development of nanotechnology has led to the innovation of opportunities in the field of nanobots for enhancing drug delivery and disease treatment. Nanobots, Nano Sensors are the future. It is a broad term that covers many verticals of science and research. It covers things that cannot be seen with standard microscopes. Futuristics predict plausible use of nanobots in the future

Nanocircuits, i.e. routes and pathways, have dimensions in the nanoscale. There are several methods employed for the fabrication of such circuits and current efforts are on to ensure that these circuits deliver data with minimum loss of information.

[171] https://www.prnewswire.com/news-releases/global-nanotechnology-market-2018-2024-market-is-expected-to-exceed-us-125-billion-300641054.html

2.12.4 How is it important to Thailand?

Nanotechnology is expected to have an impact on nearly every industry. It has the potential to change every part of our lives. New materials are the foundation of major technological advances. In the area of nanoelectronics and computer technology, nanotechnology will allow the construction of smaller circuits and computers. Smaller circuits will run faster enabling far greater computer speeds. New nanomaterials will mean that computers will have a much longer life. A laptop computer could therefore have its efficiency increased by millions living longer and working faster to give far better value for money. These are reasons why nanotechnology is important to Thailand. The development of advance technology will drive the economy and increase effective of business process. There are many Thai organization planned to develop and use nanotechnology for digitize the business. Nanotechnology Association of Thailand, Integrated Nanotechnology Research Center of Khon Kaen University (NANOKKU), National Nanotechnology Center (NANOTEC), and National Science and Technology Development Agency (NSTDA) are the Thai government agencies focusing on nanotechnology. Therefore, Thailand will have enough nanotechnology supporting business transformation in next few years.

2.12.5 Trends in 5 years, 10 years 15 years

	5 year	10 year	15 year
Technology Development	The lab-on-a-chip technology combined with data from other IoT-enabled devices, like sleep monitors and smart watches, and analyzed by AI systems for insights giving us an in-depth view of our health and alert us to the first signs of trouble, helping to stop disease before it progresses. Nanosensors are also a key element of many lab-on-a-chip systems.	Nanomaterials and Nanoelectronics enable sensors to be smaller, more complex, and more energy efficient. The sensors with very fine features can be printed in large quantities on flexible rolls of plastic at a low cost.	Nanobots will be used in various fields for different tasks to be performed in order to reduce human errors. Nanobots used in healthcare consist of various types, each one performing a particular function. This technology will be widely used among healthcare professionals on a large scale, most of them applying it for patient diagnosis and treatment.
Growth in terms of usage across the world	The global Lab-on-a-Chip market is accounted for THB 133.4 billion in 2016 and is expected to reach THB 250.7 billion by 2022 growing at a CAGR of 11.0% during the forecast period.[172]	The global nanomaterials market is projected to reach more than THB 1.7 trillion by 2022 from THB 463.6 billion in 2015, growing at a CAGR of 20.7% during the forecast period.[173]	The global Nanobots market is expected to reach THB 3.2 trillion in 2023 from THB 2.3 trillion in 2016 with a CAGR of approximately 21% during the forecast period of 2017-2023.[174]
Potential growth in Thailand	Nanoelectronics and MEMS Laboratory (MEMS Lab), established under the National Electronics and Computer Technology Center (NECTEC), is a key organization that drives the adoption of lab-on-a-chip technology in Thailand.	Government agencies – particularly NANOTEC, NECTEC, and MTEC – have significant roles in driving the development and adoption of Nanomaterials and Nanoelectronics in the country.	With the increasing cancer patients rate at 5% each year, Thailand's National Nanotechnology Center (NANOTEC), as a national R&D and a funding agency to support universities and other research institutes, will potentially do further

[172] https://www.reuters.com/brandfeatures/venture-capital/article?id=5650
[173] https://www.matec-conferences.org/articles/matecconf/pdf/2017/43/matecconf_icmtmte2017_02013.pdf
[174] https://www.marketresearchfuture.com/reports/nanobots-market-1301

	5 year	10 year	15 year
			research over Nanobots.
Relevant Use Cases	New medical labs on a chip using nanotechnology health detectives will track invisible clues in people's bodily fluids and let them know immediately if they have reason to see a doctor.[175]	Nanoelectronics increase the capabilities and improve display screens on electronics devices, while reducing their weight and power consumption.[176]	Nanobot will begin pre-clinical trials using stem cells to fight cancers and other diseases in animals. And cell surgery robotics could start. Nanorobots are expected to perform cellular repairs that could cure almost any disease.[177]

Thailand's nanotechnology market is projected to grow from THB 17.3 billion in 2018 to reach THB 52.0 billion by 2025, at a CAGR 16.5% during the forecast period.[178]

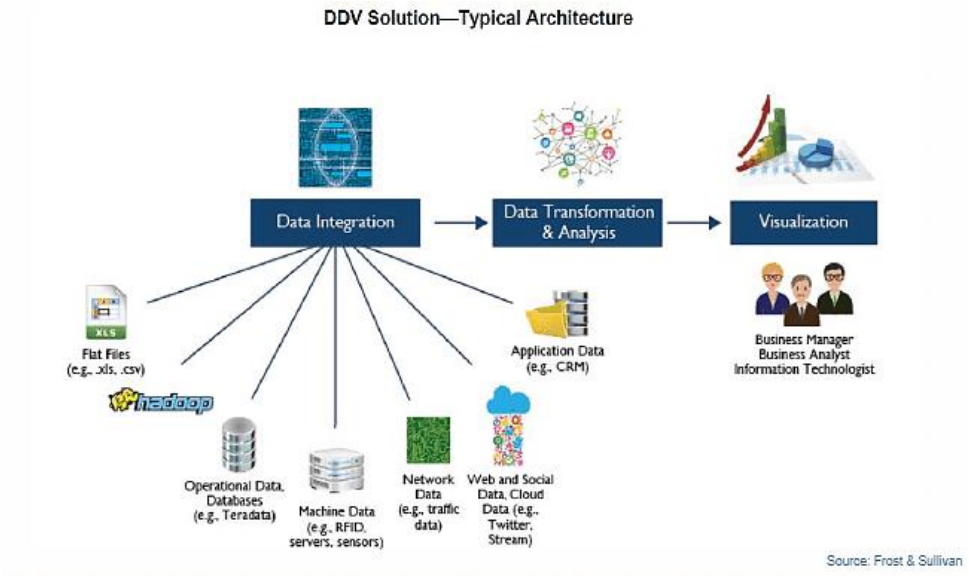
2.13 Data Analytics

Data Analytics is defined as the process of analyzing data to explore patterns using computing algorithms, programming, and statistical modeling techniques to find valuable and timely correlations, resulting in actionable insights that drive business decisions inside an organization. Data analytics techniques can reveal trends and metrics that would otherwise be lost in the mass of unstructured data. Moreover, data analytics supports an organization's capability to make proactive real-time decisions. In short, data analytics facilitates access to traditionally silo data and uncovers previously inaccessible information. At a high level, data analytics methodologies include exploratory data analysis (EDA), which aims to find patterns and relationships in data, and confirmatory data analysis (CDA), which applies statistical techniques to determine whether hypotheses about a data set are true or false.

The availability of ever increasing amounts of structured and unstructured data, along with higher, cheaper and faster computing power, have been key drivers for the development of data analytics.

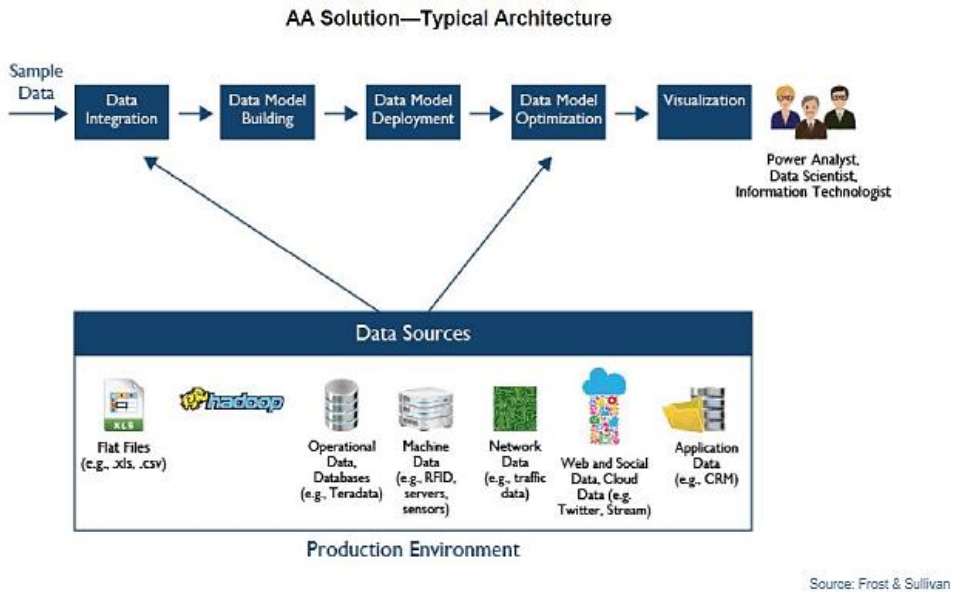
[175] https://www.networkworld.com/article/3154724/software/ibm-next-5-years-ai-iot-and-nanotech-will-literally-change-the-way-we-see-the-world.html
[176] https://www.understandingnano.com/nanotechnology-electronics.html
[177] https://www.dummies.com/education/science/nanotechnology-timeline-and-predictions/
[178] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

Figure 59. Evolution of Data Analytics: DDV solution



Source: Frost & Sullivan

Figure 60. Evolution of Data Analytics: AA solution



Source: Frost & Sullivan

The first generation of analytics termed Analytics 1.0 was based on Data Warehousing and Business Intelligence platforms in the 1990s. The type of analytics in this phase was mainly classified as Descriptive (what happened) and Diagnostic (Why something happened). This evolved to Analytics 2.0, which involved the adoption of newer platforms such as Hadoop to extend analytics capabilities in the Internet age, where there was an explosion of data. Open Source community had begun in this era which started to integrate Predictive analytics into the platform. Moving on to Analytics 3.0, data handling and insights were more sophisticated, more predictive and prescriptive than before. We are now in the age of Analytics 4.0, which advanced technologies – such as AI, machine learning, and

data science technology along with descriptive-predictive-prescriptive analytics – helps humans in making better decisions.

2.13.1 Applications/Use Cases

Data analytics is being used in various industries to address the key challenges and identify unexplored opportunities from all of data regardless of source, type, size, or format. However, most of the use cases are in Customer Analytics, Operational Analytics, Fraud and Compliance and Data Driven Products and Services.

Customer Analytics help improve customer conversion rates, personalize campaigns to increase revenue, predict and avoid customer churn and lower customer acquisition costs. It is challenging nowadays when customers interact with companies through various interaction points – mobile, social media, stores, e-commerce sites, and more – which dramatically increases the complexity and variety of data types that needs to aggregate and analyze. With data analytics, companies can combine, integrate and analyze all of your data at once to generate the insights needed to drive customer acquisition and loyalty.

Operational Analytics help companies to understand machines, devices and human interactions in order to optimize asset utilization, performance and service quality. It helps analyze product availability and predict product failures to plan right maintenances. Data analytics plays a role to unlock insights buried in log, sensor and machine data to see trends, patterns and outliers that can improve decisions, drive better operations performance and maximize cost effectiveness. The most important thing is analytic tools allowing you to integrate and analyze historic machine data and failure patterns to predict and improve downtime and supplier data to optimize supply chain operations.

Fraud and Compliance is another area that data analytics could come to help identify issues before they turns to be problems. It is all about uncover hidden and suspicious issues in order to mitigate those risks. Data analytics will directly help reduce the operational costs of fraud investigation, prevent fraud and ensure regulatory and compliance. Apart from breach detection and data profiling, it can also perform identity verifications, risk profiles, and data visualizations and perform master data management.

Data-Driven Products and Services use data analytics tools to help develop new products and shorten product life cycle as well as a prototype process. Moreover, with data companies can respond to growing demand better. This will lead to customer loyalty, cost savings or revenue increase through alternative channels because it helps benchmarking information about other similar companies in their industry.

2.13.2 Current Scenario

The adoption of data analytics has been growing in both consumer and business sectors in various segments. For instance, the advertising and media space requires the adoption of advanced analytics in order to stay agile and competitive. Analytics help provide data on consumer sentiment, emotions, preferences and behaviors, helping media companies in deciding on content, trends and strategy. Social media analytics enable marketers to tune in to the “voice of the customer," identifying influencers and instances of consumption. Besides, surveillance systems have increasingly used analytics to detect irregularities in security in commercial, airports, train stations and public service environments. Analytics for surveillance has moved beyond the traditional motion detection to include tracking, anomaly detection, abandoned object, crowd counting, and so on.

2.13.3 Relevance in Future

Advanced technologies will be increasingly converged or integrated into data analytics, leading to the development of new products and services. The convergence of advanced analytics, Big Data, and 3D Printing, for example, will enable hyper-personalization in product design. Analytics will be embedded into everyday life through social media, web browsing patterns, IoT, which will enable micro-segmentation of markets and products targeted to individuals at a micro level in real-time. As another example, AI will be increasingly integrated into the development of autonomous vehicles so that vehicles are trained to learn and improve. Infotainment applications would increasingly incorporate gesture recognitions, speech recognition, driver monitoring, eye tracking and natural language interfaces.

Advancements in analytics will also drive the development of new business models. Analytics-as-a-service will grow in importance, and other new revenue streams such as data brokerage will increase as companies realize the value in data. Organizations will buy and sell data from each other to increase value.

2.13.4 How it is important to Thailand?

To move toward a value-based economy under 'Thailand 4.0', Big Data analytics has been put at the focal point. As we can see that, the government has begun collate data from 20 ministries into a centralized Big Data management system. Once the system is fully integrated, all government agencies will have access to the data, enabling them to analyze and better implement policies and facilitate the country's digital transformation. Moreover, the data will be shared to the public allowing start-ups and investors to utilize these data to develop solutions. Finally, Big Data analytics will serve as a backbone of Thailand's economy that helps entrepreneurs to better understand market scenario and customers' behavior.

2.13.5 Trends in 5 years, 10 years 15 years

	5 year	10 year	15 year
Technology Development	Machine Learning will be increasingly adopted in mainstream data analytics use cases. For example, there will be a use of IoT to combine Streaming Analytics and Machine Learning, which streaming data provides useful information from IoT to offer Machine Learning to be analyzed in real time, and in a less controlled environment.	Considering AI platforms will have remarkable impact over the next decade, using AI platforms to process Big Data will be a significant improvement in gathering Business Intelligence and improving organization's efficiency. AIs will also provide data governance, ensuring that high data quality exists throughout the complete lifecycle of the data.	Augmented analytics, which automates data insight by utilizing Machine Learning and Natural Language Processing to automate data preparation and enable data sharing, will evolve to next generation augmented analytics, which capable of automatically and actively preparing and cleansing data, finding key insights and hidden patterns, and performing feature engineering.
Growth in terms of usage across the world	Within the Business Intelligence & analytics market, Data Science platforms that support Machine Learning are	The global AI platform market is expected to grow from THB 66.9 billion in 2016 to THB 311.6 billion by 2022, at a CAGR of	The global augmented analytics market is projected to grow from THB 151.4 billion in 2018 to THB 580.3 billion by 2023, at a

	5 year	10 year	15 year
	predicted to grow at a 13% CAGR through 2021.[179] Also, the global Machine Learning market is expected to grow from THB 44.5 billion in 2017 to THB 277.9 billion by 2022, at a CAGR of 44.1%.	30.5%[180], mainly driven by a proliferation in data generation, increasing demand for AI-based solutions, increasing operational efficiency and reduced cost, and growing need to enhance customer experience.	CAGR of 30.6%[181], mainly driven by the increasing volume of complex data and growing adoption of advanced business analytics tools.
Potential growth in Thailand	Advanced analytics, including AI-powered data analytics, have potential to be progressively adopted by Thai enterprises. The soaring adoption are expected to be driven by organizations' higher demands for embracing digital transformation as well as increasing demands for improving customer experiences.	AI platforms used in processing Big Data have potential to grow in Thailand, especially in the BFSI sector, as they help enterprises to stay competitive by getting insights from a large amount of data, analyzing trends and customers' behaviors, enhancing customer experience, as well as enhancing decision-making process.	Augmented analytics solutions are expected to be widely adopted by both large enterprises, as well as small and medium businesses throughout the world, including Thailand. Augmented analytics, for example, benefit SMEs by helping them to monitor the growth of their businesses and generate insights to deal with their future prospects in order to compete with large firms.
Relevant Use Cases	Organizations can use Machine Learning to augment elevate everyday operational analytics pipelines and normal line of business activities. They can also use Machine Learning to gather intelligence to identify and analyze potential risks in a particular growth initiative to help organizations mitigate the risks and make better decisions.	AI platforms will enable data analytics to be faster and more efficient. This will help reduce costs in multiple ways, such as by preventing the duplication of efforts, automating basic tasks, and eliminating simple, but time-consuming activities (e.g. copying, data processing, and constructing ideal customer profiles).	Augmented analytics can benefit businesses in multiple ways, such as helping business to get deeper data analysis by identifying factors that truly influence business' output, allowing business users to get answers to their questions directly in a matter of seconds, and simplifying the data analysis process leading to actionable insights.

2.13.6 Sub-components of Data Analytics

Imagery Analytics

Imagery analytics is the process of extracting useful data from images or videos by using algorithms to monitor, analyze and manage large volumes of data. The analytics can be real-time, or retroactive, where events that have already occurred are analyzed. For image analytics, basic image data is processed into higher level constructs by using advance analytics. The objective of image analysis is to organize unstructured image data into a set of variables that are easily analyzed by a machine, including revenue, emotion, health data and consumer sentiment. Image analytics is becoming

[179] https://www.forbes.com/sites/louiscolumbus/2018/02/18/roundup-of-machine-learning-forecasts-and-market-estimates-2018/#ddd4f892225c

[180] https://www.marketsandmarkets.com/Market-Reports/artificial-intelligence-ai-platform-market-113162926.html?gclid=Cj0KCQiAnY_jBRDdARIsAIEqpJ0ZkA08qPwioTdSpQWx8rJxOWJfV_kKsEOr0V0JepU5RlqpMwavM10aAqaFEALw_wcB

[181] https://www.marketsandmarkets.com/Market-Reports/augmented-analytics-market-262507096.html?gclid=CjwKCAiAwJTjBRBhEiwA56V7q40AyhbfYKv5J9WQ2w89JVBymCF0m9ZJDyChRrFQVd9p2i9JMAnjnxoCi_0QAvD_BwE

increasingly important in the marketing space and is able to capture a lot of insights that text analysis cannot, including sentiment analysis, gender, age, activities, objects, scenes and landmarks; meanwhile, video analytics is expected to see huge adoption, especially in the fields of surveillance, retail, media, advertising, and autonomous vehicles.

Future Outlook – Image analytics is the most optimal analysis option in cases where image is the starting point of analysis, such as analysis of scans, images, maps, location information, 3D landmarks, and so on. Increasing application of imagery analytics in healthcare, gaming and entertainment and military is expected to drive the growth of imagery analytics market. In addition, the global video analytics market is projected to grow from THB 101.9 billion in 2018 to THB 269.7 billion by 2023, at a CAGR of 21.5% during the forecast period. Thailand's video analytic spending is growing at 19% a year, slower than in China (21%) and India (22%). Demand for video analytics increase caused by concerning over public safety and use for criminal investigations. Moreover, the retail sector implements these systems to gain insight of consumer behavior. The adoption of video analytics by rising application of intrusion detection, license plate recognition, crowd management, and congestion detection are implied in transportation and healthcare industry.

Text Analytics

Text analytics, also called text mining or opinion mining, comprises data analytics techniques that extract rich, meaningful structured data from largely unstructured data in order to inform strategic decision making; discern customer sentiment about products, services, or events; extract competitor information; organize enormous amounts of data, such as in the healthcare space; and ultimately suggest predictive models to facilitate business agility.

Future Outlook – Text analytics will be used with advanced techniques such as machine learning and natural language processing (NLP). Therefore, the global text analytics market was valued at THB 124.6 billion and is expected to reach THB 327.4 billion by 2023 with an expected CAGR of 17.3% during the forecast period of 2018–2023.[182] The rising acceptance of social media platforms and a growing inclination towards cloud technology for data storage are the drivers of the text analytics.

Audio and Speech Analytics

One of the applications of audio analytics is in the smart home industry. Audio analytics today can differentiate the sound of window glass breaking from similar noises such as that of a dropping coin. Unusual sounds such as dripping water and creaking are also detected. AI systems are developed that are trained to recognize entire taxonomies of sound. Contextual awareness is a key to identify anomalies and deliver a superior experience in smart homes.

Future Outlook – The capabilities of audio analytics have been leveraged through the Internet of Things increasing customer interactivity in various industries such as entertainment and healthcare. The global speech analytics market size is expected to grow from THB 29.7 billion in 2017 to THB 68.6 billion by 2022, at a CAGR of 18.2% during the forecast period. APAC is a highly potential market from increasing focus on higher customer satisfaction.[183]

Emotion Analytics

Emotion analytics involves analyzing the gamut of human moods, sentiments, attitudes and perceptions via a range of tools such as text, image, video and speech. Emotion analytics can be based on facial expression or analysis of speech by recording and analyzing a person's facial and/or verbal cues to identify moods, such as happiness, anger, sadness, fear, disgust and surprise.

[182] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight
[183] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

Future Outlook – Emotion analytics or "facial coding" will be increasingly engineered into analytics systems as the next natural interface will be more interactive and perceptive. In the future, devices will be able to react to human emotions in real-time. Emotion AI is seen as being critical to establishing ethical AI systems, and emotion AI systems will augment human capabilities and not replace them. Emotion analytics is projected to witness a CAGR Of 32.7% over the forecast period of 2018 – 2023, driving the market to reach THB 780.3 billion by 2023.[184]

Virtual Agents

Today's personal assistants - now more commonly termed virtual assistants, or VAs - are speech-driven applications designed to assist consumer's complete tasks, such as accessing information on mobile devices. VAs takes advantage of the broad capabilities provided on smartphones, making the phones themselves more useful in hands-free mode. A well-known example is Siri, a consumer-grade virtual assistant, which makes it easier to use a mobile device. Chat Bots, also termed Chatterbots or Chatter Robots, are AI-based computer programs that simulate an intelligent conversation with a person through text or speech.

Future Outlook – The Virtual Agents market value is projected to exceed THB 283.9 billion by 2023, expanding at a CAGR of 32% during 2018-2023. However, Asia-Pacific would witness the highest CAGR of 38.97% during the forecast period.[185] For Thailand, the enterprises are increasingly adopting this technology to enhance their customer engagement along with reduced cost of operation.

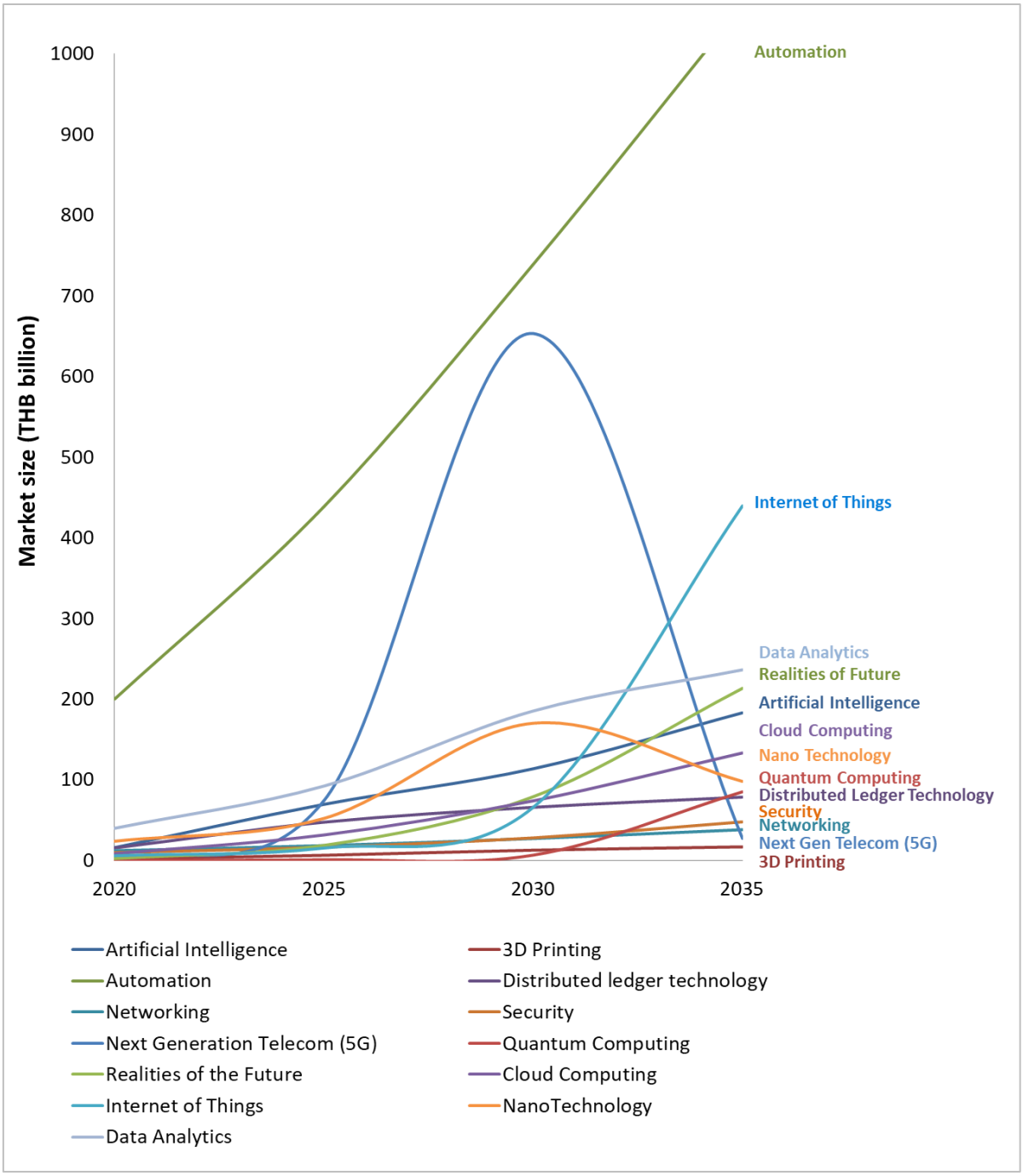
The value of Big Data analytics market in Thailand is estimated to grow from THB 14.8 billion in 2018 to reach THB 47.9 billion in 2025, at a CAGR 18.3% during the forecast period.[186]

2.14 Conclusion

Some existing and emerging technologies that have had, as well as expected to have, an important role over the next 5, 10, and 15 years include Artificial Intelligence (AI), 3D Printing, Automation, Distributed Ledger Technology (DLT), Networking, Security, Next Generation Telecom, Quantum Computing, Digital Reality, Cloud Computing, Internet of Things (IoT), Nanotechnology, and Data analytics. However, as each technology affects different sectors and industries at different levels, depa should prioritize digital technology promotion by focusing on selected technologies (referred to in Chapter 3) to accelerate the development of digital ecosystem in order to drive the country's digital transformation of the country. The market size of 13 longlisted technologies are summarized in the below graph.

[184] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight
[185] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight
[186] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

Figure 61. Market sizes of 13 technologies in Thailand



3. Shortlisted Technologies

Following the scoring of technologies identified in the Long List and the results of relevant expert interviews, 7 technologies were selected as crucial for Thailand's Digital Economy, namely Internet of Things (IoT), Artificial Intelligence (AI), Data Analytics, Next Generation Telecommunication, Distributed ledger technology (DLT), Quantum Computing and Automation. This section comprises of the rationale behind selection, the way technology supports Digital Thailand, Sub-classification of technology, Trends across the world, Trends in South East Asia, Trends in Thailand, Digital innovation, Potential and Use cases of technology, Technology Adoption Cycle, Technology Consumption in Thailand, Outlook of Local Companies, Outlook of International Companies and Key Issues in Adoption.

3.1 Internet of Things (IoT)

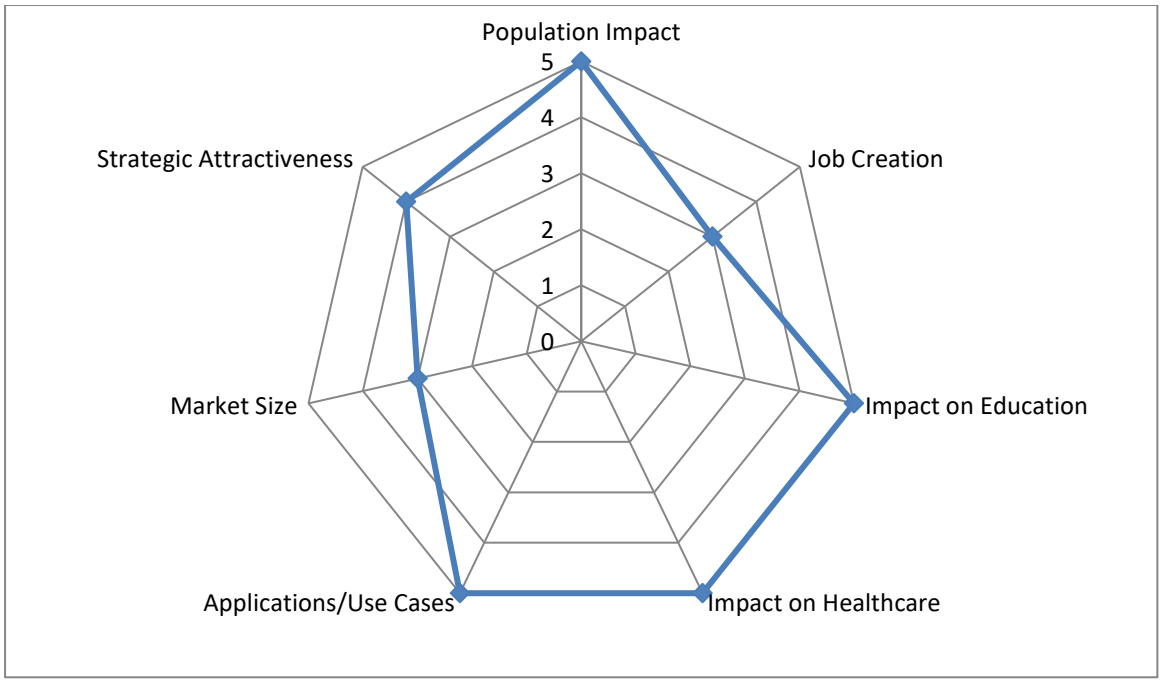
Internet of Things (IoT) refers to phenomenon of leveraging technologies like connected devices and sensors, data analytics, and cloud computing for the purpose of optimizing existing business operations and creating new business models and services. With billions of connected devices expected to be in use in the world in the next few years, global IoT market is expected to grow at a fast rate. In Thailand, IoT market is projected to reach THB 188 billion by 2033, rising from THB 3.6 billion in 2018 at a CAGR at 30.18%.

Almost all major verticals are now implementing or testing IoT applications to improve productivity and enhance user experiences. Smart health, smart home, smart energy, Manufacturing 4.0, and so on are just some of the traditional industries that are using IoT and altering their operations, products, and services. As companies realize the benefits and consumers demand better services, the use of IoT will increase further. Moreover, IoT for consumer segment would see great success over the next 15 years, expected to spend the most on IoT in the country.

Why IoT has been selected?

IoT has been selected as one of the seven shortlisted technologies considered to have significant impact on Thailand's digital economy. It has high scores in terms of population impact, impact on education, impact on healthcare, applications/use cases, as well as strategic attractiveness as showed in the below chart.

Figure 62. Scoring of IoT



Source: Frost & Sullivan

Population Impact: Score 5/5 (Highest)

IoT is already having a widespread impact and sees a rapid adoption in many industries. This technology affects people's lives on a daily basis, making lives easier, more comfortable, and safer. By 2025, more than 80% of Thai population will be impacted by IoT through a vast number of connected devices at home, in workplace, or even in public and commercial areas. Moreover, since the future of IoT will involve billions of connected devices (such as smartphones, computers, and sensors) communicating with one another, regardless of manufacturer, operating system, chipset, or physical transport, security and data privacy will be a major concern that can affect both businesses and individuals. Whether malicious or accidental, malfunctioning IoT devices such as a connected car or components of a smart grid can pose a significant risk to consumers, businesses, and societies.

Job Creation: Score 3/5 (Neutral)

In the near future, industries will struggle to create new jobs and address new challenges and technologies. Many low-skilled jobs are likely to be replaced by automation. As a result, the existing and upcoming talent pools needs to be redirect to new domains, including IoT, which will reshape the way industries work in the future. By 2030, there will be approximately new 84,500 jobs related to IoT in Thailand [187], for example, circuit designers, microcontroller programmers, hardware designers, smart solution designers, app developers, network security developers and electrical installation engineers, to name a few. Moreover, there will potentially be more new startups developing and providing IoT solutions and services, which will also lead to a number of job opportunities.

Impact on Education: Score 5/5 (Highest)

IoT has a significant impact on education by delivering a seamless experience of multimedia and interactive course content, enabling a connected learning ecosystem. IoT not only allows institutions to move away from siloed, homegrown, and point solutions, but supports the entire learning flow

[187] Frost & Sullivan analysis for depa: Thailand Digital Technology Foresight

across digital learning solutions and devices from content creation with Lecture Capture Solutions (LCS) – a platform that records an educational meeting, lesson, or presentation in digital format for concurrent or later viewing; to publishing with massive online open courses (MOOCs) and dynamic publishing tools; to management with Learning Management System (LMS) – a software application or a web-based technology to plan, implement, automate, organize, track, assess a specific learning process, and predict learning outcomes; and to accessing the information via devices.

As a result, the definition of a traditional student is evolving. By accessing to multiple devices and educational technology, education is no longer restricted to a specific age group, location, or time. Learners can now access education on-demand, anytime, and anywhere. Moreover, IoT together with Big Data help enterprises and institutions measure the success of their educational and training programs, as well as creating a customized learning experience to help students meet their educational goals.

Impact on Healthcare: Score 5/5 (Highest)

IoT plays an important role across various stages in healthcare, facilitating, for example, invention and development of new drugs, diagnostics, disease management, and health insurance. With IoT, a connected ecosystem, comprising multiple areas of smart devices and services, can perform the functions of capture, measure, identify, stratify risks, inform, make decisions and take actions.

Take Organ in a chip – a clear polymer that contains living cells lined by microfluidic channels that help to understand the function of living human organs including the lung, brain, kidney, skin, and intestine – as an example. This innovative IoT device helps improve productivity in R&D, reduces reporting time and cost, and increases drug effectiveness, which ultimately accelerates new drug development and advancing personalized medicine. In addition, IoT devices in home healthcare (telehealth) can be used for chronic disease management – focusing on slowing down the progression of long-term diseases by constantly monitoring patients using remote devices; acute home monitoring – focusing on continuous monitoring of discharged patients to enhance fast recovery and prevent re-hospitalization; and medication monitoring – focusing on medication reminders and dosing helping improve medication adherence and outcomes. Another example is wearable device – performing a number of functions, including, but not limited to, data recording, reporting, analyzes, and communication – that enables new business model in health insurance. Data provided by wearables can be utilized by insurance companies to design and customize products, as well as offering rewards or discounts to customers who adopt the healthcare solutions, while insured people can benefit from lower premiums based on their health records. Wearables also help individuals improve assessments, manage treatment options, and document therapy progress for physician referrals and insurance companies.

Applications/Use Cases: Score 5/5 (Highest)

The number of IoT devices worldwide could reach 1 trillion devices by 2035[188], enabling a large number of applications (more than 70 applications) across industries, for both consumer and business segments. Consumer-related IoT comprises IoT devices and applications that are utilized for personal benefits. These include smart wearables, gadgets, smart home appliances, and so on. On the other hand, IoT for business includes deployment of IoT solutions at an enterprise or company level helping industries transform completely to enhance their growth and competitiveness by providing real-time insights on process optimization, consumer behavior, asset tracking, resource utilization, and so on through data analytics.

[188] Frost & Sullivan analysis: Global Internet of Things (IoT) Device Market, Forecast to 2024; Year 2018

Market Size: Score 3/5 (Neutral)

IoT is expected to grow exponentially over the next 10 years due to the ubiquity of network connectivity, the increasing number of cost effective proliferation of connected devices, and the economical prices of cloud. From 2018 to 2030, the expected IoT market value in Thailand will be around THB 65.74 billion, rising from THB 3.6 billion, with a CAGR of 27.39%. Consumer segment is generally expected to dominate the IoT market share of the country, followed respectively by manufacturing, and transportation and logistics sectors.

Strategic Attractiveness: Score 4/5 (High)

IoT technology is an important technology that allows physical objects to connect to the internet - making individuals and organizations able to store a wide variety of data as many as never before. Consequently, IoT helps in the digital transformation process and becomes an important factor in driving the digital economy in Thailand. In addition, IoT is considered as a cross-cutting technology for all industries, including public services, as it can boost productivity while reducing business operating costs. Moreover, in terms of economic impact, a study found that a 10% increase in IoT investment resulted in an average 0.7% increase in GDP.

How IoT supports Digital Thailand Agenda?

Having significant impact on both consumer and business segments across industries, IoT is one of the important technologies that drive Thailand's digital transformation and help bring the country towards the Digital Thailand vision, which is a part of Thailand 4.0. To explain in greater details, digital transformation is the evolution of business from analog, people-dependent processes to data-enabled processes. It begins with collecting telemetric data from sensors, devices, people, infrastructure, and processes (IoT) and continues with consolidating telemetric data into large data lakes (Big Data) and converting that data into actionable information using advanced analytics (Analytics). Because this process of digitizing the business involves collecting and moving data in real time at high reliability, security and highly capable networks are required. In addition, because a data-intensive company needs massively scalable computing, cloud services are also needed.

Before the IoT era, businesses ran their operations and made decisions only from a data warehouse which took a lot of time to be analyzed and converge to a meaningful insight. But with the use of the IoT, connected devices can generate real-time data from different data types. These devices where data is collected can also communicate and exchange with each other in an ecosystem.

IoT is gradually changing the way work is done across all industries. For instance, in industrial IoT, apart from manual and technical skills, processing, evaluating, and securing of data becomes increasingly important. Companies can improve a wide range of business processes for contextual data and real-time analysis by using data, collected from IoT devices, and analytical solutions. For example, if some machinery vibrates too much, IoT solutions can slow down the production line sufficiently to ensure that the equipment can operate without damage until the technicians can operate it. Moreover, as companies continue to invest in hardware, software and IT services, they will need to take advantage of the large and growing quantities of existing data needed as a basis for highly efficient production. Smart manufacturing enabled by IoT ultimately provides significant value-added services to customers. The flow of data on the production performance of available materials, for example, helps manufacturers reduce inventory costs, disrupt workflows, and reduce the total amount of capital needed to run their business.

In the near future, IoT together with 5G network will enable advanced and new applications for Thai consumers, such as augmented reality (AR), virtual reality (VR), and autonomous cars; industry applications, such as smart vehicles and transport infrastructure, remote healthcare and robotics; as

well as smart city, an urban development that securely integrates multiple ICT solutions to manage the assets of a city, including transport systems, hospitals, water supply networks, waste management and other services in the community.

Sub-classification of IoT

IoT Connectivity including Digital Twin

Representing the convergence of the physical and virtual worlds, Digital Twin is a digital model or replica of a physical asset, product, process, or system that allows users to have a digital footprint of an asset's or product's life, from the design and development phases through deployment and the end of the asset's or product's lifecycle. Digital Twin plays an important role in enhancing the manufacturing industry, by allowing things to be visible, understandable, and adaptable in order to support future change. Digital twin also enables data to be continuously exchanged, from production planning, processing, to the operational level of the machine. This virtual display of machines on a digital platform can benefit companies in terms of product design, production planning, and system improvement to name a few.

Digital twin technology has already been introduced in Thailand by some companies include B&R Industrial Automation. ACOPOStrak, the company's solution, is the flexible transport system with digital twin software installed, enabling the system to avoid collisions from finding the right path. The operation of the digital twin technology in the ACOPOStrak system starts from copying the system of the machine created directly from the real application code. The motion control system, thus, can help identify future problems from the beginning of production, by providing detailed information of the connected system, which allows the transport system to run smoothly.

As digital twin can be considered as an enabler for Industry 4.0 initiatives, depa should promote digital twin and encourage local companies to embrace this technology in order to drive the development of Thailand's Industry 4.0. Moreover, not only plays a role in the manufacturing industry, digital twin is also expected to expand to other areas, such as consumer products which allow companies to get information on the use of products and customer behaviors to help them design better goods.

Next Gen IoT using AI (including Swarm Technology)

The combined power of IoT and AI will lead to new and innovative IoT solutions and applications. Swarm intelligence, unanimous AI, is a collective behavior of decentralized self-organized systems where each member autonomously offers its abilities, which can be found widely in ants, fishes, honey bees, etc. Using of a distributed form of control makes a system more efficient, effective and scalable. The main aim of swarm intelligence is to increase the performance and robustness. Swarm algorithms are faster and more robust solutions to solve complex set of problems. There are different algorithms like artificial fish swarm algorithm, dynamic optimization with which different SI systems were built which could solve various problems. Swarm intelligence algorithms have been widely applied to many applications, which include robotics, DNA computing, and vehicle routing. Recently, these algorithms are being applied to data intensive IoT operations and services. With swarm intelligence applied to IoT, a number of discrete physical devices, with each one contributing its interfaces and processing capabilities to the collective, can be viewed in architectural and functional terms as a single entity, enabling harnessing of data and processing power. Providing massive scalability and the ability to easily integrate future interfaces and devices, Swarm technology can extremely reduce the costs of application development and deployment, installation, commissioning and maintenance out at the network edge.

Swarm technology is expected to witness increasing growth in the coming years, as it provides a basis on which it is possible to explore collective (or distributed) problem solving without centralized

control. With features and benefits of swarm technology, depa should work on building awareness about how swarm technology can improve businesses to promote swam technology adoption in the country. Swarm technology can be utilized across industries. In transportation and logistics, for example, swarm intelligence applications can be involved in companies' complex movement of goods along different routes. This allows companies to reduce freight transfer costs and reduce employee workload, so that companies are able to substantially reduce storage space and accompanying wage costs, leading to higher productivity and higher profitability of the companies.

Trends of IoT across the world

IoT has continued to grow rapidly across regions around the world. The global IoT market is projected to grow from THB 4.1 trillion in 2018 to reach THB 10.0 trillion by 2023 at a CAGR of 20%[189], while the number of IoT devices worldwide is expected to reach 60.7 billion by 2024, growing from 19.9 billion devices in 2018, at a CAGR of 20.35%[190]. Building automation systems and security systems are expected to account for over 50% of all IoT devices over the forecast period. Other leading verticals for IoT include connected transport, manufacturing, fixed asset tracking, smart grid, oil and gas, and smart utilities. Many IoT applications are emerging in China, India, and the rest of Asia Pacific, resulting in these markets being the largest region for connected IoT devices.

In the business segment, companies have begun to use IoT for more than just improving productivity and operational efficiency. They see opportunities to generate new revenue streams through the development of new products and services by enhancing IoT with new technologies such as Artificial Intelligence (AI) and machine learning (ML). Amazon Web Services (AWS), for example, has introduced Greengrass ML Inference to push AI applications to IoT devices, allowing users to run inference directly on the device which reduces the latency and cost of sending device data to the cloud to make a prediction. Also, Alibaba and Intel have developed an IoT platform, by integrating AI and cloud technologies, to make it easier for enterprises to perform compute intensive tasks such as training AI and ML models at the edge of a network.

In addition to AI, blockchain technology can also be used to enhance IoT. Leading IT and telecommunications industry participants have taken a keen interest in understanding how blockchain can be used in IoT, however, security remains the prime use case for blockchain in the IoT. By combining a set of existing cybersecurity, data management, and consensus protocols within a resource-optimized implementation, blockchain solution providers can deliver effective security solutions for the IoT. Besides cybersecurity, other IoT services can be offered through blockchain as well. For example, sharing of IoT device certification information can be facilitated through consortium blockchain. Or, secure firmware updates can be implemented by using blockchain-based content delivery platforms.

Even though there are many IoT applications readily available in today's market, the launch of 5G in the next few years will significantly increase the scale and possibilities of the IoT market. It will bring more use cases to IoT, allowing new applications for both consumer and business segments, like Augmented Reality (AR), Virtual Reality (VR), and autonomous cars. The global industry revenues from 5G and IoT are expected to reach THB 19.5 trillion by 2026[191]. The industries set to be most affected by 5G will include manufacturing, energy, and smart cities. Further developments in the IoT market will facilitate real-time applications in verticals e.g. healthcare and smart cities. Applications such as connected health wearables and smart city devices associated with street lighting, parking, and metering will continue to grow.

[189] GlobalData
[190] Frost & Sullivan : Global Internet of Things (IoT) Device Market, Forecast to 2024; Year 2018
[191] Ericsson and Arthur D Little

Trends in South East Asia

Most economies in the Southeast Asia region are industry-oriented, with heavy emphasis on manufacturing, construction, agriculture, and energy. In general, industry-oriented industries are expected to see strong adoption of IoT, thus, IoT adoption in the region is expected to continuously grow over the next coming years, with one of the major drivers of the IoT adoption is the use of the technology for the optimization of existing business processes. Besides, in terms of ICT readiness, service-oriented economy like Singapore has the highest ICT readiness in ASEAN, followed by Malaysia, which ranks the highest among industry-oriented economies in ASEAN, and Thailand, coming in at a close second. These countries with high ICT readiness also have an advantage in the IoT readiness and more likely to adopt more IoT technology across different verticals than other countries in the region. Furthermore, diversity in the rate of IoT development is expected across the region. Singapore is taking the lead in pioneering new service applications driven by IoT-enabling technologies across many sectors, on the other hand, IoT development in emerging markets is driven by better connectivity and proliferation of low cost applications. IoT deployment approach is extended and fragmented with the aim of reducing cost with better visibility across the value chain.

In terms of IoT spending, the region's spending in IoT is expected to reach THB 203.7 billion by 2020 from THB 103.8 billion in 2016, at a CAGR of 18.37%. Regionally, IoT deployments are led by government agencies in public safety and government services before extending to strategic industries. Investments are channeled towards IoT infrastructure and platforms that will enable applications to be built on top to solve urban challenges. While building up capabilities in IoT, agencies facilitate collaboration among private companies, research institutes and start-ups. Meanwhile, in the private sector, the transport, logistics, and manufacturing sectors are key drivers of IoT spending. Standalone internet-connected devices using cloud-based software via a subscription model are typically deployed to create a network where assets can be monitored, communicated and controlled from a remote location.

Regarding IoT exploration, according to a survey by AIBP, 84% of ASEAN enterprises were exploring or implementing IoT solutions in 2017, of which 43% were at fact-finding stage, 27% had explored IoT, and 14% had implemented IoT, in addition, 89% of enterprises in Thailand were exploring or implementing IoT solutions, the highest %age in ASEAN, followed by Malaysia, Indonesia, the Philippines, and Vietnam. Moreover, the need for IoT adoption in three major sectors of the seven surveyed countries - namely Vietnam, Myanmar, Thailand, Malaysia, Singapore, the Philippines, and Indonesia – are mostly shown in government and public services, followed by industrials, and agriculture.

Trends in Thailand

IoT adoption in Thailand has been growing fast in both consumer and business segments. Thai IoT market is expected to grow at a CAGR of 21.47% during 2018-2023, from THB 3.6 billion in 2018 to reach THB 9.5 billion by 2023. Key important factors driving the growth of IoT adoption are the rapid development of infrastructure to embrace digital economy transformation; the supporting initiatives and projects from Thailand's government; as well as the growing demand for IoT technologies in various industries.

Thai government has invested in infrastructure for broadband internet on a nationwide basis, aiming to provide access to at least 95% by 2020, with submarine communications cables as part of the investment scheme. Thailand also has readiness in IoT network infrastructure which includes the nationwide NB-IoT network provided by AIS and True, as well as the LoRaWAN network provided by CAT Telecom. Furthermore, the country is pushing to develop the telecom infrastructure necessary to fully adopt 5G by 2020. The National Broadcasting and Telecommunications Commission (NBTC)

expects some 5G use cases to be implemented by telecom operators and other companies in the country in late 2020. As a result, in collaboration with local telecom operators and global suppliers, the NBTC has worked through several public forums to raise awareness of 5G in both private and public sectors.

In terms of government initiatives, Thai government is pushing the development and adoption of IoT via several initiatives, which includes Thailand 4.0 policy, the development of Digital Park Thailand and IoT Institute, as well as Smart City plan.

As a part of New S-Curve industries under Thailand 4.0, Digital industry focuses on IoT and AI, which could offer foreign investors opportunities to develop IoT solutions for various industries in the country, such as industrial and manufacturing industries, transport and logistics industries, agriculture industry, and so on. Thailand's IoT expenditure is currently focused primarily on the manufacturing and logistics industries, while agricultural expenditure is relatively low. Agriculture, however, accounts for 40% of employment and 10% of GDP. Agriculture is definitely an important sector to which the government pays attention, as it actively encourages companies to make agriculture 4.0 more feasible. In the industrial and manufacturing industries, demand for robotics and automation is also increasing. The country's demand for robots and automation systems is driven by lower operating costs through automation and increased productivity. Manufacturers have invested heavily in machinery and systems over the past few years to remain competitive in the global digitalized production landscape and meet the growing demand for exports of food and beverages, automobiles and petrochemicals. 50% of Thailand's manufacturers are expected to adopt automation systems in the next few years.

Digital Park Thailand is a new economic cluster, located on Eastern Economic Corridor (EEC) area with an aim to be the destination for global digital players. The government will provide maximum incentive packages both tax and non-tax measures, including RDI regulator exemption, ease to do business, and privileges for investors and digital specialists. Locating in the Digital Park, the IoT Institute is a future project to accommodate the full range of activities and businesses related to IoT in order to enhance and develop Thailand's digital economy. The center is divided into six sections: Open Labs, IoT Design Center, Office Space, Exhibition Area, Auditorium, and Common Area.

Thailand is set to develop more smart cities following their pilot project involving three cities, Phuket, Chiang Mai and Khon Kaen; with an aim to have 100 smart cities within two decades to improve the quality of life in urban centers, according to Deputy Prime Minister Prajin Jungtong. The government plans to develop Bangkok as a smart city, as well as developing three provinces in the EEC areas, namely Chonburi, Rayong and Chachoengsao. These smart city projects will further boost many more usages and adoptions of IoT in the country, as can be seen in the piloted project, Phuket Smart City, where there is a test for tracking services combining GPS and IoT communications enabling cars, motorbikes, dump trucks and coaches to be tracked across Phuket. moreover, there are other developments on which stakeholders in the project have worked to support the smart tourism campaign, such as the mobile application Smart Phuket 4.0, the Beacon devices, which provide tourists and foreigners in the province with accurate information about product deals and tourist attraction data directly from information sources, and Digital Signage, a massive digital screen that displays basic information such as well-known restaurants, tourist spots, accommodation, hospitals, and locations of key government offices, to name a few.

Additionally, in the consumption side, local companies in Thailand have shown an increasing interest in implementing digitalization and IoT projects. This demand creates an innovation ecosystem locally, as it encourages investments by technology startups and established providers in Thailand. Connected devices are increasingly being adopted by both business and consumer segments. One reason for higher demand in business segment is that enterprises need to incorporate technologies in order to stay competitive. With the utilization of IoT, enterprises have new sources of data that provide

end-to-end visibility of their business organization enabling them to digitize their physical business processes, optimizing these processes, and improving their cost structure. The evolving sensor technology at lower price as well as the growing adoption and popularity of cloud computing and Big Data analytics are also the important factors that drive IoT adoption. The cost of communication and sensing modules is falling and is expected to continue to fall over the next few years; meanwhile, Thailand cloud computing market is also growing estimated to reach THB 31.5 billion by 2022, with a CAGR of around 29%.

Digital Innovation in IoT

IoT is a technological revolution aimed at adding a new dimension to the world of information and communication technology by embedding short-range mobile transceivers into gadgets or things used in everyday life. Rapid developments are being seen from wireless sensors to nanotechnology in order to create an entirely new network of networks. As IoT keeps evolving, many innovative IoT related products and services have been developed and launched in the market, ranging from devices, connectivity, platforms, and applications, for both consumer and business segments.

NuSIM, which will be commercially available in the second half of 2019, is an example of innovative IoT devices. Deutsche Telekom, together with world-leading partners in the fields of IoT chipsets, modules, and digital security, have developed nuSIM which moves the traditional SIM functionality from the physical SIM card directly to the chipset, specifically designed for low-cost devices used in mobile IoT applications with a long life-span, such as asset trackers, smart motion, and temperature sensors. The elimination of the physical SIM card simplifies the form factor of an IoT device as there are no additional contacts, circuit paths or SIM cardholders to consider. Providing a minimum hardware and software footprint for cost-efficient implementations with minimal power consumption allows device vendors, IoT service providers, as well as consumers, to benefit from nuSIM. The benefits for device vendors include better design options due to smaller package size and extended battery life; meanwhile, IoT service providers can save costs through a simple digital process. NuSIM's open specification set also ensures interoperability for the secure provisioning of operator credentials during module or device production.

One example of recently developed technologies for IoT connectivity is Wi-Fi HaLow or IEEE 802.11ah, which a 900-MHz version of this Wi-Fi targeting long-range links especially for the IoT, covering a range of IoT use cases, ranging from farm fields to utility meters, warehouses, supermarkets, and remote video surveillance cameras. The Halow products promise delivery of up to Megabit/s over distances of tens of meters to a kilometer, supporting for thousands of nodes on an access point. They will occupy a space between ultra-low-power and -cost LoRa and Sigfox networks and below more power-hungry LTE Cat-M and Narrowband-IoT (NB-IoT) networks that come with data plans. Some of the initial products will be single chips made in 40-nm processes, a new option for IoT unlicensed bands. Although only one Korean startup, Newracom, have shipped chips for 802.11ah so far, many more vendors are expected to launch the chips for Halow in the market in 2019.

Technology convergence can lead to an emergence of new innovative IoT platform such as AI-powered IoT platform. For instance, Megvii, a Chinese AI startup, has recently launched an IoT platform powered by AI to enable the operation of multiple robotic systems. The robotics operating system is named Hetu and has already been deployed by Alibaba online retailer, Tmall, to operate 500 warehouse robots. With AI technology, Hetu is able to connect with IoT and provide a whole set of solution on planning, simulation, application and operating. Digital twin is also required in the application of Hetu.

Focals, smart glasses made by North, is one of newly launched innovative IoT products. As North is a startup backed by Amazon, Focals have Alexa built in. Focals is designed to look like any other pair of

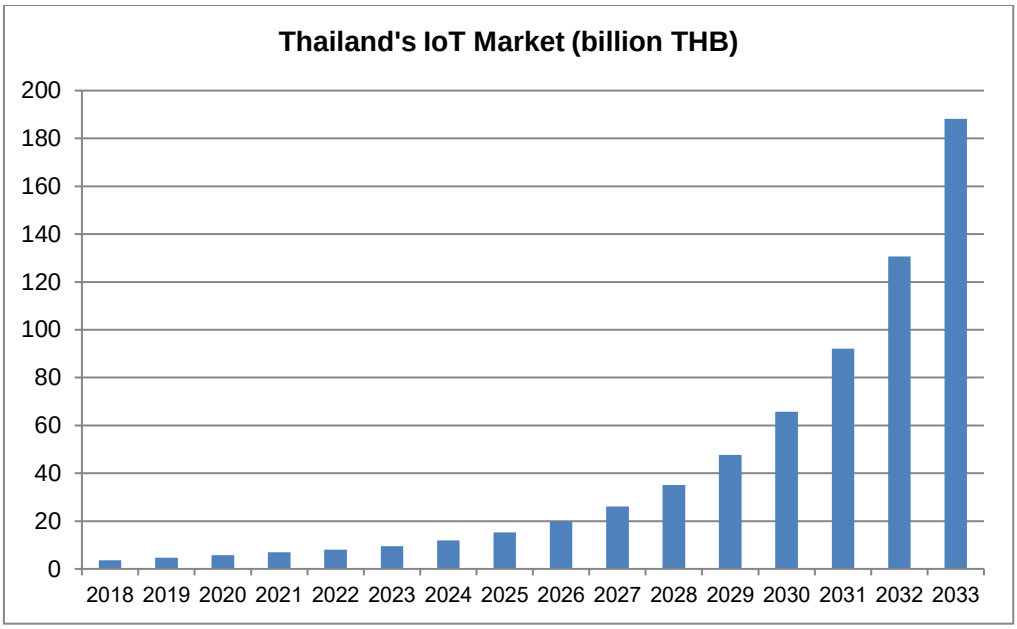
glasses. They appear to be targeted at a consumer context and overlap with many of the use cases of smart watches, smartphones, and tablets. Without having a privacy-threatening camera, Focals project a simple interface onto the right-hand lens, with graphics that appear to float just in front of the wearer thanks to a holographic element in the lens. To interact with the glasses, wearers can interact with the interface via a smart ring on their finger, called Loop. This ring features a miniature five-way joystick for flicking through the simple interface.

Furthermore, the arrival of 5G will also bring new opportunities to IoT technology. For example, 5G-enabled Tactile Internet – defined by the International Telecommunication Union (ITU) as an internet network that combines ultra-low latency with extremely high availability, reliability and security – is considered to be the next evolution for IoT comprising human-to-machine and machine-to-machine real-time interaction with the environment, while on the move. It will enable haptic interaction and provide visual feedback. Tactile Internet can be utilized across industries, such as for industrial IoT, the Tactile Internet will enable the efficient manufacturing of highly customized products, remote mining in high-risk areas, and remote inspection, maintenance and repair of everything from industrial plant to airplanes. In healthcare, Tactile Internet, for an instance, will allow physician to command a tele-robot at the patient's location, enabling remote physical examination with full audio visual and haptic feedback. Although Tactile Internet concept has been studied for years, an implementation has been constrained by the limits of current networks until 5G becomes reality. Some demonstrations of the technology include Huawei's TAC-2020 robot artist, which enables a shadow-like follower for human actions. It can imitate every stroke on a tablet by a human and reproduce an identical stroke on the canvas with complete precision. This indicates the possibility of remote and synchronous duplication of human actions based on one-millisecond latency capability of 5G.

Potential of IoT

The IoT market in Thailand is expected to have a CAGR of 30.18% from 2018 to 2033. Overall, the country's IoT market share will be dominated by consumer segment, followed by manufacturing industry, and transport and logistics sector respectively. During 2018-2023, the market is expected to grow to from THB 3.6 billion to THB 9.5 billion, at a CAGR of 21.47%. The growth is mainly driven by an increasing demand for connected devices and IoT solutions from both consumer and business segments. In the next 10 years, the market is projected to reach THB 35.0 billion by 2028, at a CAGR of 29.77% during the forecast period of 2023 to 2028. Throughout 2028-2033, the country's IoT market will sustain a CAGR of nearly 40% through the forecast period, surpassing the THB 100 billion mark in 2032 and reaching THB 188.2 billion in 2033.

Figure 63. Thailand's IoT Market 2018-2033



Source: Frost & Sullivan

Use Cases of IoT

Top three industries that are expected to spend the most on IoT in Thailand, as mentioned earlier, are consumer segment, manufacturing industry, and transport and logistics, respectively.

In terms of consumer segment, the adoption of consumer IoT devices is continuously increasing in Thailand, with smart home devices and applications are expected to dominate the consumer market. **During the next 5 years,** smart home devices will take convenience and home security to the next level. Although IoT is applied to smart homes at different levels, the best is the one that combines smart utility systems and entertainment. For example, users' electricity meter with an IoT device provides them with insights into their daily use of water, a set-top box that allows them to record shows from remote, automatic lighting systems, advanced locking systems, and connected surveillance systems all fit into this concept of smart homes. Popular smart home devices and applications in the country include Wi-Fi security camera, smart switch, smart lighting control, and smart home appliances, to name a few. **Over the next 10 years,** health and fitness IoT devices are expected to have significant impact on consumer segment, particularly IoT solutions for elderly care. The benefits and features of elderly care solutions such as Vitals-Tracking Wearables, for regular activity monitoring and heart rate monitoring that can be achieved by one of several available consumer wearable devices and smartwatches; Personal Emergency Response Systems, which the related products can serve many needs of seniors, inside and outside of their residences, such as fall detection, emergency assistance and navigation guidance back to residence as well as allowing users to press the button for assistance, or medical-alert products to communicate with emergency services automatically in the event of a detected fall or incident; Medication Adherence Tools, to help users remember when to take their medication; Portable Diagnostics Devices, smart and portable diagnostics devices that can help seniors perform diagnostic tests in their homes, and get results in formats that allow them to be instantly shared with their care providers; as well as Smart Elderly Home, connected home devices and systems that can integrate with medical devices, for example, when a blood pressure machine detects unusual data, it can tell the connected home system and trigger related alerts to families and healthcare providers. **Within the next 15 years,** various new advanced IoT devices will be widely developed and available, such as solar-powered clothes,

wearable drones - a concept that personal computing would evolve with drone technology in the future. Moreover, wearable devices would be developed in various shapes and sizes, e.g. as glasses, clipped onto clothing, clipped onto shoes, embedded into clothing, embedded in jewelry, and embedded in headphones. Various mobile devices would also step aside for things beyond wearable, such as embedded devices in human body.

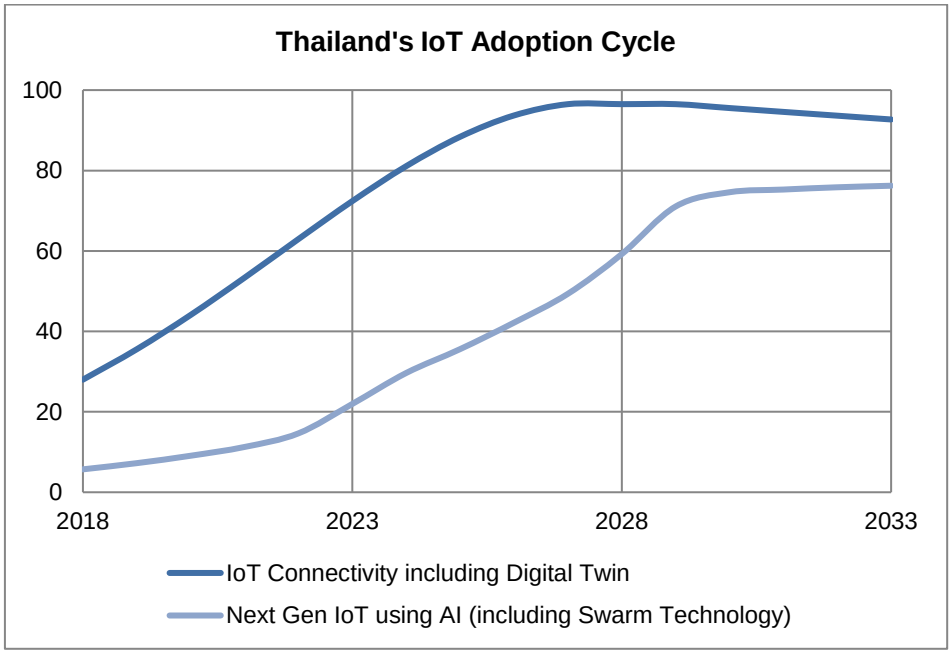
Regarding manufacturing industry, manufacturers across industries are increasing their automation efforts, adding sensors, software, wireless connectivity and robots to the factory floors and setting the foundation for the IoT. The main opportunities for IoT technology in the manufacturing industry such as supply chain tracking, equipment and machinery management, inventory management, mobile asset management and utilization tracking, security and surveillance, as well as fleet management. **During the next 5 years,** manufacturing IoT is expected to grow rapidly in Thailand, with companies' goal of IoT implementation to leverage manufacturing operations by adopting multiple solutions e.g. asset management, intelligent manufacturing, performance optimization and monitoring, planning, human machine interaction, end-to-end operational visibility, etc. Predictive maintenance solution is also one important use case and expected to be widely adopted by domestic companies. Predictive machinery maintenance based on collected sensor data, and monitoring of production lines with sensors to optimize the use of equipment, aims at helping manufacturing organizations enhance product quality, identify new business opportunities, and reduce operational inefficiencies. Other IoT use cases in manufacturing industry include field service, connected factory applications, staff safety applications, real-time health monitoring, facility management, smart environmental measurement, smart measurement of presence or levels of liquids/gases/radiation/dangerous materials, risk measurement, and so on. **Over the next 10 years,** most manufacturing factories will move significantly towards Industry 4.0, mainly driven by cyber physical systems, IoT, and cloud computing. Several companies across industries such as FMCG and automotive factories will be fully automated thanks to the advancement and combination of technologies like sensors and actuators, robotics, AI, 5G connectivity as well as digital twin technology. Humans will be increasingly displaced by advanced robots in manufacturing plants. Robotics will evolve to be smarter and more versatile, for example, pick and place robots will be able to handle enormously heavy and unwieldy loads with extreme precision. Automated guided vehicles (AGVs) will become truly autonomous vehicles capable of sensing their environment and will shut down to prevent damage to buildings and other equipment or injury to humans. **Within the next 15 years,** advanced technologies such as 3D/4D printing, advanced robotics, industrial IoT (IIoT) and many data driven technologies will not only redefine manufacturing, but will also fundamentally reshape the product design. Industries and manufacturers will increasingly adopt these technologies to achieve maximum benefit from the technologies in terms of operating profits and achieving sustainability in manufacturing. The entire new transformation and revitalization in manufacturing will make the future of manufacturing highly automated and self-sufficient entities. AR and VR would also be utilized to complement various IoT-based manufacturing innovations in factories, such as connected devices or equipment for product development or production monitoring.

The transport and logistics sector is among the earliest vertical to adopt IoT applications and extract insights that improve safety, asset utilization, and increase on-time delivery. In Thailand, companies have increasingly adopted IoT solutions for improving efficiency as well as providing new services to customers. Use cases in transport and logistics sector include fleet management, telematics for vehicle or transported goods monitoring, vehicle trip/route management, asset tracking, smart parking, connected bike-sharing service, cold chain logistics, location management systems, and so on. **During the next 5 years,** Thailand's telematics market - one of important connected car features - is expected to grow with a remarkable growth rate owing to the increasing production of passenger vehicles and commercial vehicles, the increasing demand, as well as the government initiatives. Telematics can be implemented in various sectors as it brings multiple benefits to users, for example, enabling users' vehicles to self-diagnose potential difficulties, providing valuable vehicle performance

data, reducing the number of road accidents and delays, offering in-car entertainment and other value-added services, as well as preventing theft and assisting in the recovery of stolen vehicles. Example telematics use cases include fleet management and usage-based insurance (UBI), which relies on telematics to collect data on driving behavior. Both insurer and consumer can benefit from UBI solution - while insurers can accurately determine risk factors to adjust insurance premiums accordingly, customers can benefit from lower premiums based on their driving habits. **Over the next 10 years,** connected car will be further developed which will be enabled by advanced technologies such as AR, VR, 5G, advanced analytics, as well as vehicle-to-everything (V2X) technologies. For instance, the successful implementation of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) technologies can reduce collisions while changing lanes as well as during intersections. With the advancement in technology, V2V and V2I technologies have potential to create a zero accident environment in the future. V2X technologies will also enable new use cases such as smart public transportation, real-time adaptive traffic management, and traveler information systems, to name a few. **Within the next 15 years,** Thailand would widely experience semi-autonomous cars which the vehicle would be able to take most of the decisions on its own, but a driver would be required to supervise the actions and handle complex roadside situations since the automation would be limited to clear environmental conditions. With stakeholders' drives including the government initiatives, the country would also potentially witness the adoption of fully automated vehicles, which would be capable of making complex decisions and taking appropriate decisions in all environmental conditions without human intervention.

IoT Adoption Cycle

Figure 64. Thailand's IoT Adoption Cycle



Source: Frost & Sullivan

IoT Consumption in Thailand

Refer to the IoT adoption cycle above, although the IoT adoption is currently in its early stages, Thailand will continue to witness the IoT market's steady growth over the next 10 years as both Thai companies and consumers are becoming more aware of IoT. Connected devices will therefore increasingly be adopted in Thailand, driven, for example, by evolving smart technologies at lower prices, rising high - speed networking technologies, improving connectivity and mobile coverage, as well as increasing cloud computing and Big Data analytics adoption and popularity, to name a few.

One reason for increased demand in the business segment is that in order to remain competitive, companies need to incorporate technologies. For example, using IoT enables businesses to have new data sources that provide end-to-end visibility of their business organization to digitize their physical business processes, optimize these processes, and enhance their cost structure.

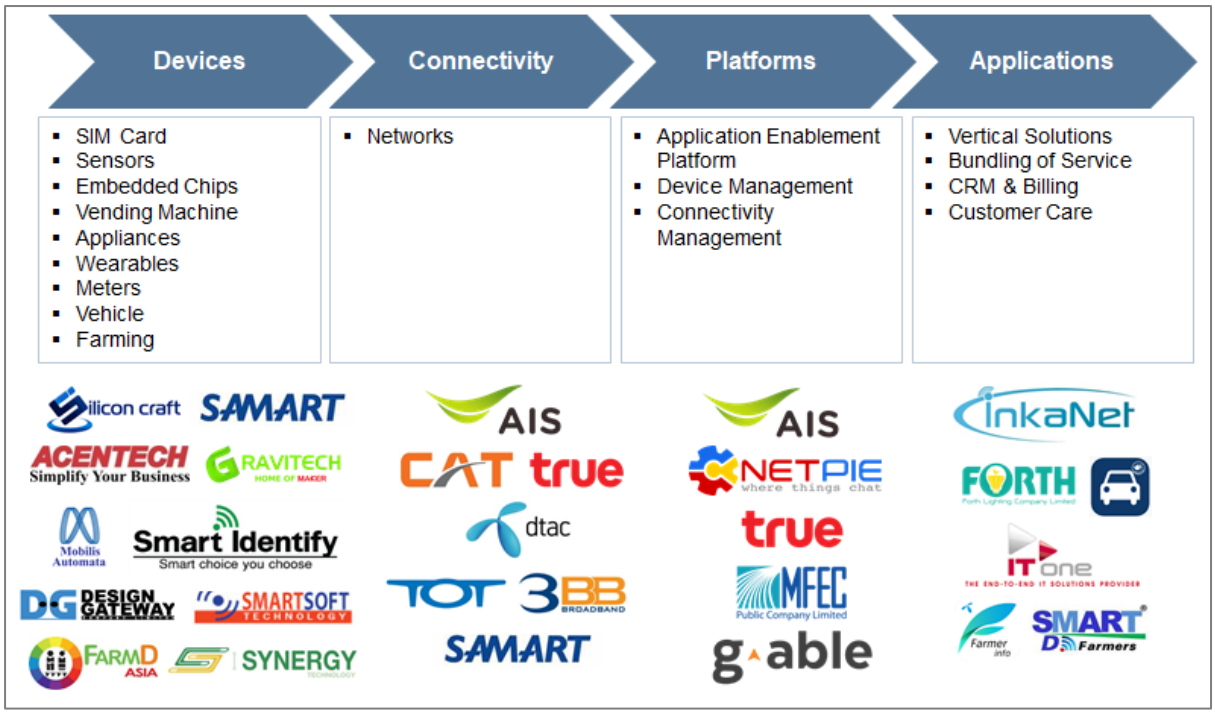
In terms of IoT spending in the country, most of the spending takes place in consumer segment, followed by manufacturing industry, and transport and logistics industry. Within the consumer segment - namely wearable health and wellness devices such as fitness trackers, smart watches, and consumer home health devices; connected consumer electronics, including smart entertainment devices and AI personal assistants; and smart home security and energy solutions - IoT adoption has grown rapidly. The adoption of such smart devices has been driven by more affordable prices and the familiarity of users with IoT devices. Meanwhile, manufacturing as well as transport and logistics companies are also playing a key role in driving IoT market. Companies have implemented IoT solutions for remote monitoring, production asset management and fleet monitoring to prevent theft and enhance route optimization in particular. Thailand as a manufacturing and key production network hub in the ASEAN region with investment driven by foreign entities including many Japanese manufacturers, will witness the higher implementation of IoT due to a need for end-to-end visibility of manufacturing and logistics integration. Increasingly cost pressures will also driving automation and IoT adoption. One of the IoT applications in automobile manufacturing is the smart worker system. Combining RFID technology with sensor-to cloud software, real-time position of any product part in the shop-floor can be identified with a unique ID and alarms are generated using near-field technology to warn a worker in dangerously close quarters. The same technology is extended to ensure safety of remote workers using mobile or satellite communication technology. Furthermore, transport and logistics IoT applications are expected to grow rapidly even though it is relative mature compared with the other IoT market segments. Key to the adoption is security and availability of network which might limit some large scale (geographical spread) implementation.

In the near future, the arrival of 5G will also significantly drive market growth, bringing new opportunities for IoT technology. Many of the IoT use cases currently supported by existing 4G networks will derive additional benefits from 5G features, such as higher reliability, increased capacity and coverage, as well as enhanced cost-efficiency and customization capabilities for virtual network. In 5G environments, IoT applications, especially those requiring ultra-low latency and high reliability, are likely to become a major case of IoT use.

Outlook of Local Companies

Thailand’s IoT ecosystem continues to expand in terms of the number of both local and international companies providing IoT products, services, and solutions, as well as the number of companies and consumers using IoT technology. Some players providing IoT related products and services in Thailand’s market are illustrated in the below figure.

Figure 65. Thailand's IoT Value Chain



Source: NECTEC, Frost & Sullivan

Examples of local companies who develop and offer IoT related services include large telecom operators, IoT platform developers, RFID solutions providers, SCADA system companies, and startups, as followed.

True Corporation has integrated digital technologies to develop innovative solutions and IoT offerings in various areas including healthcare, transport and logistics, building automation and security, smart cities, retail and manufacturing. The operator, moreover, has continued to place an importance on AI and Big Data. Robotics is also one of True's focused areas. True has invested more than THB 20 million in robotics R&D to study the new patterns of robots and develop in-house robots, including robotic kits for education sector, over the past three years, with an aim that robots will become a new revenue source for IoT businesses. It plans to bring out in-house robots for the Thai market in 2019. Recently, True, together with Savioke (robotics start-up), has introduced Relay robot, the first autonomous delivery robot in Thailand. Relay robot is targeted at operators requiring delivery services in sectors such as hotels, premium condominiums, service apartments, high-rise buildings, hospitals, logistics, and manufacturing with assembly line operations. True said it would provide robots in the market for sale and rent, with an aim to distribute 50 Relay robots within the next three year. Furthermore, True Digital Park - an open innovation platform that promotes collaboration between multinational companies, startups, SMEs, investors, universities, and public sector - is considered as the largest startup park in Southeast Asia. The project will showcase True's potential of digital innovation, which will consequentially improve the company's positive brand perception, enhance customers' awareness and engagement, including promote and demonstrate True's integrated IoT solutions to its potential customers.

CAT Telecom - traditionally focusing on operating the country's international telecommunications infrastructure, which includes international gateways, and connections to submarine cable networks and satellites - has moved in the direction to provide digital services and to focus on developing a LoRaWan network to support an IoT platform and a smart city platform, as well as IoT services such as smart metering, smart buildings, smart lighting, smart parking, smart farming, smart logistics and

smart tourism. In 2017, CAT laid down the LoRaWAN wireless network in the piloted project, Phuket Smart City. It has worked with many partners to offer several IoT services and solutions. It has also launched a 'LoRaWAN IoT by CAT' platform to support the commercial sector in developing innovative industrial IoT services. Currently, the company is testing a tracking service combining GPS and IoT communications enabling cars, motorbikes, dump trucks and coaches to be tracked across Phuket. In addition, CAT is implementing the Model Phuket in major provinces across the country. It is expecting to soon open the LoRa IoT by CAT in Bangkok and its vicinity, Chiang Mai, Chonburi, Rayong, Chachoengsao, Nan, Saraburi, Nakhon Nayok, Prachinburi, Songkhla, Surat Thani, Nakhon Ratchasima, Maha Sarakham, Udon Thani, Ubon Ratchathani and Nakhon Pathom.

Nexpie - a joint venture between Mandara Communication, a subsidiary of INET, and a team of former researchers of the National Electronics and Computer Technology Center (NECTEC) - is the first local IoT cloud platform provider in Thailand. NETPIE, developed by Nexpie, comprises two major components, the cloud platform and MicroGear, an open-source library providing authorization, authentication, communication and co-ordination services. NETPIE platform is a cloud-based platform-as-a-service that facilitates interconnecting IoT devices together in seamless and transparent manner by pushing the complexity of connecting IoT devices from the hands of application developers or device manufacturers to the cloud. The connection to NETPIE is done through the functions of the Microgear library. To compete with the global market, NETPIE will play a part in serving local developers as a tool for involving the businesses and industries of Thailand. Key verticals of IoT adoption include wearables, cars, homes, cities and industries. The initial target groups of the NETPIE platform are developers and SMEs who will utilize the platform for innovative product development. In the long run, Nexpie expects that these developers and entrepreneurs will drive the IoT applications to full utilization, creating value across many industries. Recently, True Corporation has also joined force with Nexpie to further develop NETPIE platform to connect with True's NB-IoT network.

IE Technology, together with partners along the RFID value chain, focuses on providing end-to-end RFID services and solutions to customers. The company's RFID products and solutions include production track and trace, asset tracking (RF Trace), real time locationing system (RTLS), laundry management solution, and vehicle management. More specifically, real time locationing system (RTLS) is a system that uses RFID technology for tracking and identifying locations in real-time over a Wi-Fi network. It can be used to locate people or assets that are on the move within the connected areas. This system aims to increase the efficiency of human resource management and asset management by minimizing property losses, maintaining the health and welfare of employees working in the area. Data collected from the system also enable businesses to improve quality and productivity in the workplace. The ideal location for adopting RTLS is hospitals, industrial plants, power plants, warehouses, cold storages, restricted and danger areas, etc. Furthermore, one of other IE Technology's solutions is RFID Vehicle Management (VMS). The VMS system is designed to check and store the data of all vehicles in the system. It allows users to monitor and track each of their vehicles by showing the working status and automatically recording data in the entire system. So companies can utilize the collected data to improve business efficiency.

Scada Automation is specialized in SCADA and automation system, offering solutions and services to both government agencies and private companies. Providing system installation and devices invention, the company has experienced in installing and integrating multiple systems, replicating machines, as well as developing new equipment such as EV charger and water quality monitoring devices. SCADA Automation has also involved in various research and development projects, including designing a lab for renewable energy experiments with the PTT Research & Technology Institute. For SCADA and automation control system services, the company provides customized and end-to-end services which covers both hardware and software, for production line, machine automation controls, manufacturing process, batching control, product QA testing, etc. Besides, to support organization's digital transformation in Thailand, Scada Automation has a range of products

and solutions, which include solar farm system, building automation system, machine controls, oil and gas related solutions, tracking system, measurement and monitoring system, IoT smart farm, smart City, and so on.

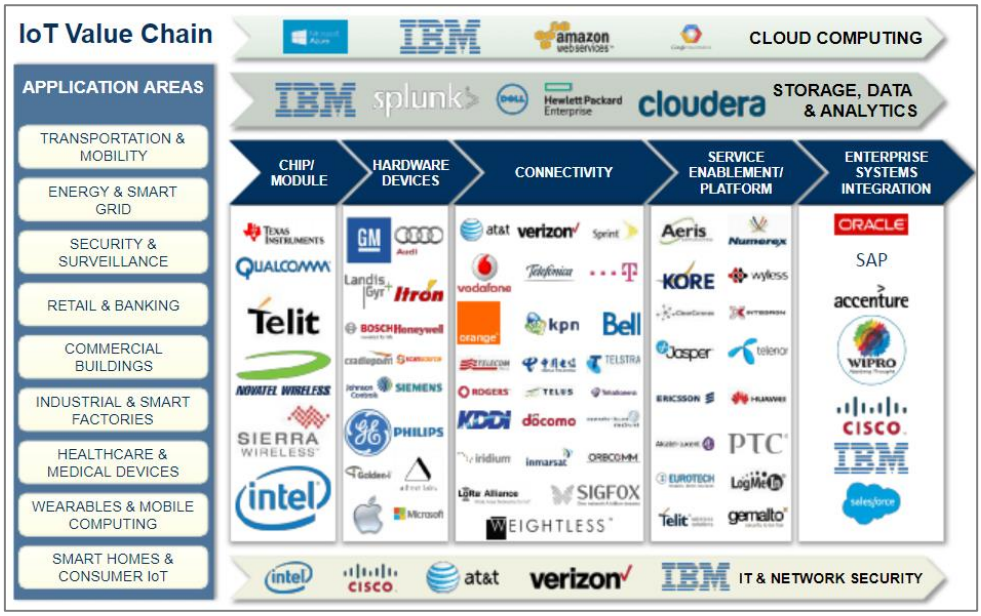
Technimal is a robotics and industrial IoT solution provider which spun off from Prince of Songkhla University Business Incubation Center (PSUBIC) in 2016. In terms of IoT, Technimal provides the one-stop service with in-house platform including wireless connectivity device, IoT gateway, data management, cloud storage, data processing and data visualization for smart factory, smart farm, and smart home that allow users to monitor and track their assets anytime, anywhere with any devices. OWL - a smart factory platform for production monitoring, asset tracking, logistics traceability and predictive maintenance - is an example of the company's IoT solutions. For robotics services, Technimal provides robotics related solutions and consultation. It assists clients to develop any kind of machine from scratch to achieve the clients' objectives, such as autonomous inspection robots. The company also provides industrial digital transformation consultation and collaborates with clients in many different technical areas in order to enable clients to flourish in Industry 4.0.

Last but not least, FarmD Asia is the first full service provider for smart farm technology in Thailand. It is an agritech and foodtech company founded in 2015. The company focuses on providing smart farm related solutions and consultation that will help clients increase production capacity and capability. Responding to the needs of farmers and businesses, FarmD Asia has developed smart farmer technology to solve problems related to agriculture and food businesses, from upstream to downstream - starting from growing, harvesting, transporting, to distributing agricultural products. Its products and solutions include Yeawlek, an agriculture drone; Aiyabot, an autonomous pesticide spraying robot; as well as Agrilligent, an intelligent mushroom cultivation house that allows farmers to set and control humidity and temperature for growing mushrooms.

Outlook of International Companies

IoT has a fragmented ecosystem with multiple stakeholders working together to provide an end-to-end service. International companies that have an important role in Thailand's IoT market include Huawei, Ericsson, Cisco, and Hitachi, to name a few.

Figure 66 Global IoT Value Chain



Source: Frost & Sullivan

Huawei provides various enterprise services and solutions, such as IoT, cloud computing, Big Data, and AI solutions. The company supports over 1,000 partners in the SEA region with more than 400 partners based in Thailand, working with partners to build an open, flexible, elastic and secure platform to support 5 key industries – public safety, transportation, energy, finance and manufacturing. Huawei not only develops and provides IoT technologies and solutions, it also boosts IoT ecosystem in Thailand by supporting Thai organizations in implementing IoT. For example, it has launched OpenLab Bangkok, the seventh of Huawei worldwide labs, with a total investment of 15 million US$. The OpenLab Bangkok facilitates Huawei's joint innovation and solution launches with its customers and partners in Thailand and other SEA countries, from various sectors including smart cities, public safety, smart grid, finance, education, transport, and internet service providers. At OpenLab Bangkok, Huawei has co-developed safe city usage cases, including smart surveillance with the Royal Thai Police and smart metering with the Provincial Electricity Authority (PEA), which leads to an opening of PEA-Huawei Innovation Center to facilitate the collaboration and materialization of IoT and Cloud technologies that will enable PEA to improve its smart-grid systems while reducing investments and operational costs. In addition, in 2018, Huawei signed a 3-year-MoU with National Innovation Agency (NIA) and National Science and Technology Development Agency (NSTDA) to stimulate innovation in Thailand through the development of deep technologies and startups. The MoU covers R&D exchange in deep technologies, robotics, smart cities and medical devices.

Ericsson, the leading ICT companies with presence in more than 180 countries providing communication software and infrastructure, is a frontrunner in 5G technologies, as it aims to establish itself at the forefront of the emerging IoT connectivity protocol. It is aggressively promoting and pioneering tests and trials with partners across verticals and governments to develop use cases and test different parameters. Its end-to-end IoT solutions include a full-stack IoT platform with connectivity, device and data management, monetization, analytics, and security. Being present in Thailand for more than a century, Ericsson focuses on bringing technology and innovation, strong partnerships and ecosystem, to combine with the company's local expertise to support its customers. Some of its milestone actions include conducting the first live 5G end-to-end demonstration in Thailand, exhibiting the use of VoLTE wireless broadband communication technology for IoT devices in CatM1, and showing some uses of narrow band IoT technology for True Corporation. With its portfolio of 5G ready network products, Ericsson is positioned to help telecom operators in Thailand migrate from 4G to 5G network. The company is also currently discussing with Thai government and its customers about the advent of 5G and its benefits to the country to support the government's Digital Thailand vision.

Cisco is one of the leading global Information Technology and Networking companies. Cisco assists governments as well as company of all sizes transform how their people connect, communicate and collaborate. The company's services cover networking, wireless and mobility, security, IoT and software, data center, as well as analytics and video. In Thailand, Cisco and True Corporation has jointly launched Cisco Kinetic platform to enhance the telecom operator's end-to-end IoT services and strengthen its IoT ecosystems nationwide. Cisco Kinetic is an IoT Data Fabric with the strength of its management where it can make the most of IoT information which can be retrieved from IoT devices for prompt information process. This helps businesses leverage information to create value, and enables to transfer data by automated connection among a variety of applications with highly-secured environments. In addition, Cisco Kinetic also has an end-to-end service offering enhancing the capabilities of True IoT smart solutions for a wide range of business applications, particularly in logistics business and smart cities, as well as Cisco Jasper that helps operate the connectivity management for customers. Apart from collaborating with private companies, Cisco is also interested in collaborating with the government's IoT institute under Eastern Economic Corridor of Innovation, particularly in testing and training workforces. As a result, Cisco together with depa and King Mongkut's University of Technology North Bangkok have entered into an alliance to train professionals in IoT and cybersecurity in the country.

Hitachi, a Japan-based technology solutions provider, offers a comprehensive range of products, services, and solutions, which covers information and telecommunication systems, social infrastructure and industrial systems, electronic systems and equipment, construction machinery, high functional materials and components, automotive systems, smart life and eco-friendly systems, etc., as well as financial services in Japan and internationally. In terms of digital solution, Hitachi launched Lumada platform in 2016 as parts of the efforts to generate original value and solve problems by utilizing its track record in OT/IT and broad internal base. With its target in manufacturing investment in the Southeast Asia region, Hitachi regards Thailand as a strategic and important market since Thailand has a lot of traditional factories that has potential to transform to smart factories, which is part of the government's Thailand 4.0 scheme. As a result, Hitachi launched “Lumada Center Southeast Asia,” the Hitachi’s first Lumada Center set up in the world, at Amata City Industrial Estate in Chonburi, Thailand, aiming to develop Smarter City, Smarter Medical, Smarter Security, Smarter Logistics, Smarter Building, Smarter Railway, and Smarter Factory across the country. The Lumada Center offers IoT solutions that can facilitate the co-creation of customized digital solutions to suit different business needs, aiming to increase the operational productivity of factories across Thailand through the use of data analytics and AI tools to drive predictive and corrective maintenance.

Key Issues in Adoption

The top challenges faced by businesses in deploying IoT solutions include IoT adoption costs, security concerns, incompatibility with legacy systems, lack of clarity on standards, and limited end-to-end solutions.

Despite customers are enthused to adopt IoT, they concern about IoT adoption costs and the return on the investment. The lack of clear ROI and use cases demonstrating the quantifiable benefits and cost savings of IoT implementations results in unwillingness to embark on costly IoT investments by enterprises in certain industries, particularly small and medium enterprises. The enterprises, consequently, prioritize their spending on other initiatives over IoT. In addition, the relatively low cost of manpower in the emerging economies, including Thailand, might be indicative that enterprises are not prepared to replace labor with autonomous machines.

Moreover, security and data privacy remain key concerns among customers while adopting IoT technology since the ability to do harm increases exponentially as everyday physical objects get digitized. There will be large volumes of information gathered from sensing devices due to the penetration of sensing devices into residential, commercial, and industrial areas; therefore, IoT services providers need to ensure cybersecurity across a range of touchpoints. An information security and privacy framework needs to address ownership, accessibility, and use of data. Network connections also need to be secured and have robust quality of service mechanisms to ensure that critical and time sensitive IoT services are not disrupted.

In terms of incompatibility with legacy systems issue, even though the awareness of IoT has been growing as more Thai enterprises explore the technology, the adoption is still at the beginning stage. One of the barriers that restrain companies to adopt IoT is their current legacy infrastructure. To implement and utilize IoT solutions, companies need to make changes to their existing systems. The cost associated and resistance to change, thus, further slows down the IoT adoption.

Furthermore, competing standards and lack of clarity on standards delay the deployment of IoT. Numerous vendors providing different implementation and lack of clear coordination of regional standardization result in a proliferation of IoT protocols, especially at the object and translation layers, with each solution provider implementing their own variant of their IoT solution. The lack of standardization is creating confusion for some enterprises contemplating deploying IoT solutions, resulting in a lengthy IoT exploration stage and a “wait and see approach”. Enterprises are concerned

that there will be a lack of interoperability of deployed solutions, the extensibility of current solutions and inability to achieve economies of scale if there is no standardization.

Limited end-to-end solutions also affect companies' decision making in adopting IoT. The highly customized nature of IoT solutions coupled with the need for technologies that span multiple domains make it challenging for providers to offer end-to-end IoT solutions. The IoT has a fragmented ecosystem with multiple solution providers from adjacent markets competing to establish presence in the IoT space. The need to form partnerships comprising of networking providers, domain application providers, system integrators and business/operational support systems providers to offer coherent customized solutions is one of the reasons why certain adoption of IoT applications has been slow.

Conclusion

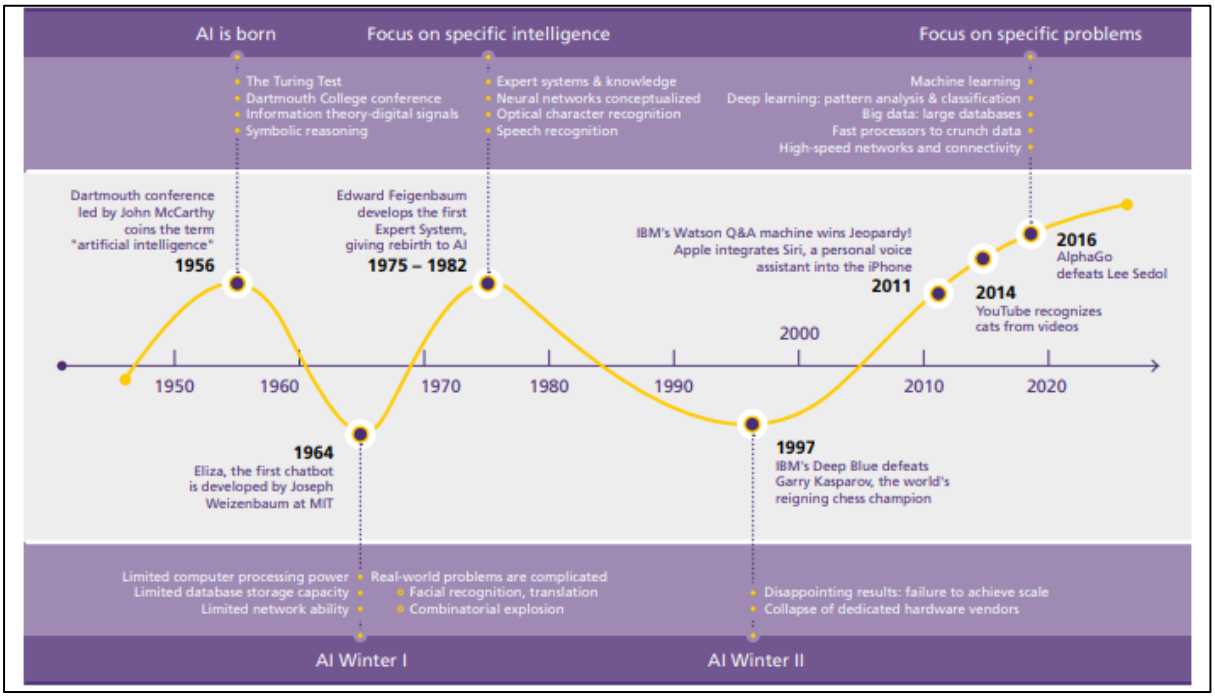
IoT is growing at a significant rate as it can be utilized in every industry sector. Frost & Sullivan forecast that by 2024, the number of IoT devices used worldwide will reach 60.7 billion, rising from 19.9 billion devices in 2018 to 20.35% CAGR. Moreover, many of the IoT use cases currently supported by the existing 4G networks will derive additional benefits from 5G features, such as higher reliability, increased capacity and coverage, as well as enhanced cost-efficiency and virtual network customization capabilities.

In Thailand, IoT is one of the key technologies, driving digital transformation and helping bring the country to Digital Thailand Vision, with a significant impact on enterprises, individuals, and societies. IoT related products, solutions, and services are increasingly being adopted across industries by both consumer and business segments. Thailand's expected IoT market value will rise from THB 3.6 billion in 2018 to around THB 439.5 billion in 2035, with a CAGR of 27.39% during the forecast period.

3.2 Artificial Intelligence

Artificial intelligence (AI) empowers machines (computer systems, robots) with intelligence and the capability to learn from deducing patterns on raw data by perceiving a model consisting of example inputs. Integration of smart algorithms to enable AI to learn from its own experiences is rendering incremental intelligence capabilities. By leveraging advanced knowledge engineering mechanisms on very large computational databases, advanced search and analytical tools, AI delivers the capability of informed decision-making based on logical reasoning to computing systems. This kind of intelligence is being relied upon in the present world to develop innumerable smart applications across sectors. These applications can efficiently take critical decisions autonomously and accurately without human intervention.

Figure 67. Rise of AI



Source: Lavenda, D./Marsden, P.

Current Forms of Artificial Intelligence

Voice Assistants

The voice assistants are becoming the face of the modern AI. They are AI programs that can be accessed via smartphones, specialized devises such as Amazon's Echo speaker, smart TV's and cars. 77 million US adults use voice assistants in their cars at least monthly as compared to 45.7 million adults who use them on smart speakers.

Siri, Alexa, Cortana are growing more common. Chatbots are a growing subset of Artificial Intelligence designed to simulate conversation with human users, especially over the internet. Most chatbots rely on machine learning and natural language processing (NLP). It is predicted that the most common use case for a chatbot would be to get quick answers in an emergency followed by resolving a complaint.

In 2018, Google assistant rolled out support for Thai language speakers to its Asian language portfolio to establish brand loyalty in its voice assistance product category. Google Assistant enabled smart speakers would be available in Thailand by the end of the next year as an extension of the voice assistant experience.[192]

Local Thai developers such as Betimes Solutions have used Microsoft Technologies to develop chat bots that can receive input and provide responses in Thai. Wongnai, Citibank, Lazada, Krungthai AXA, Shell, Unilever and Maybank are among the few local brands that have incorporated chat bots into their services. LG has integrated digital assistant with the help of Amazon Alexa voice recognition to introduce Hub Robot in Thailand to complete household tasks.

[192] https://voicebot.ai/2018/07/05/google-assistant-expands-in-asia-with-support-for-thai-and-indonesian/

Translation

These AI's translate objects, pictures and sounds into data which can be further used in various algorithms. The use of AI in translation has been heralded as a major breakthrough in machine language translation.

Predictive Systems

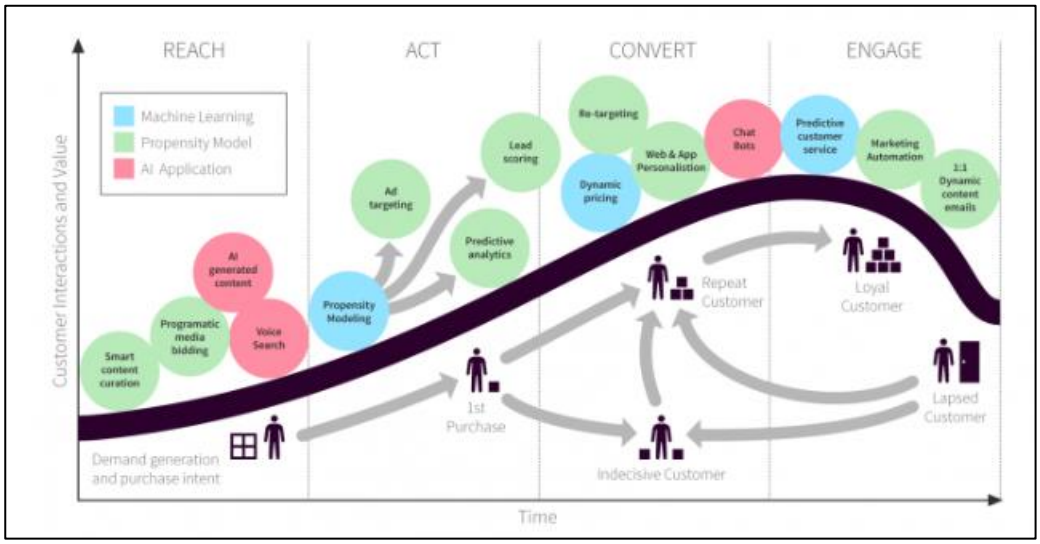
The predictive Artificial Intelligence systems follow statistical data and form valuable conclusions for government's, investors, doctors and meteorologists. Machine learning has made this technology very effective. It has already been used in Thailand to forecast demand, predict churns, suggest advertisements on social media and recommend products to potential buyers.

Marketing

The marketing AI's analyze buyer behavior to choose tactics and deals for recommendation and best fit said behavior. There is a lot of cross discussion between behind the scenes tools and voice assistants in the current scenario.

Due to AI, marketing online ads have become insightful and focused. Audience analytics have gone past the demographical analysis to understand consumers from a granular level. AI Bots have enhanced consumer engagement rates.

Figure 68. Development of AI



According to Asian Institute of Technology professor, Thailand should embrace AI in digital marketing and advertising. Target groups can be located with accuracy along with sorting out data from online and offline shopping to get better insights.

Awareness

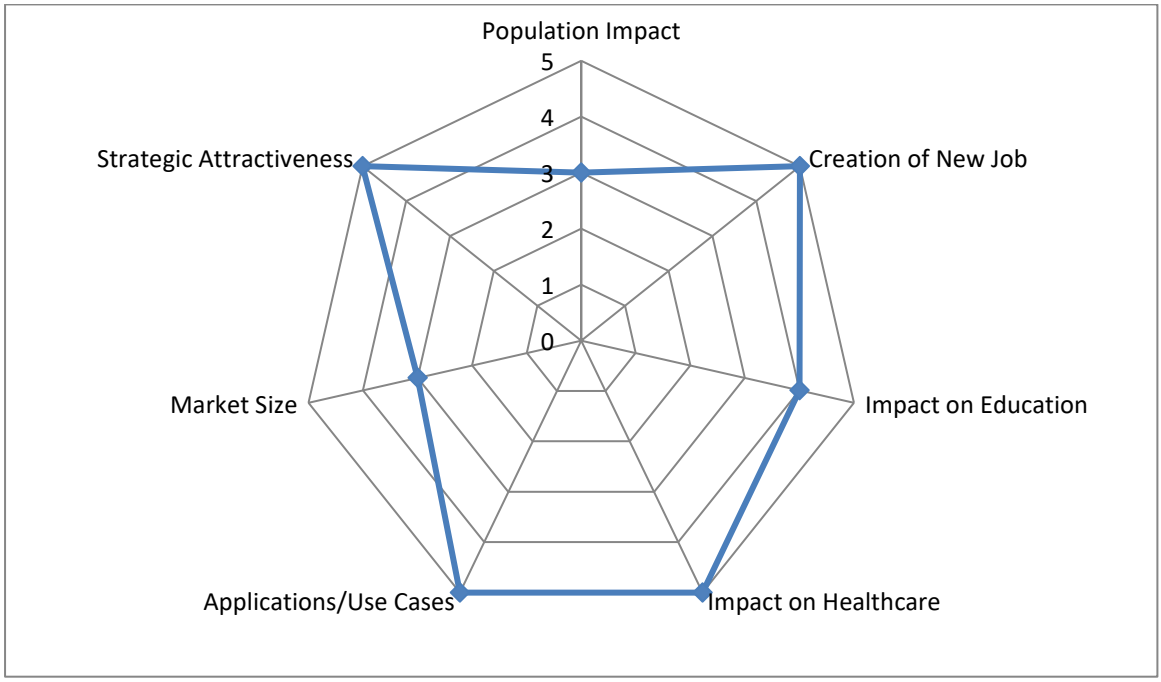
The unusual events which humans cannot locate are reports by these AI's. For instance, theft detection that reports unusual behavior or self-driving cars that use AI systems to detect dangers are possible AI use cases.

IBM's debater, a radical AI technology is a NLP use case which could argue with humans on complex topics. NLP is the voice behind SIRI and Alexa.

Why AI has been selected?

Artificial Intelligence has been selected as shortlist technology because it will have a potential impact on the Thailand economy in the next 10 years. Even though many jobs will be automated, the technology will create many jobs to develop the economy. It is strategically very attractive for Thailand and is expected to have many applications in the future.

Figure 69. Scoring of AI



Population Impact: Score 3/5 (Neutral)

Artificial Intelligence has been massively adopted by people. It is making the lives easier to solve technology problems or deter security intrusions or to reduce production management through automation. AI would impact population in the future to make lives better through reduction in time to perform a task, increase in efficiency and productivity.

Aging populations make robots necessary. Faced with the prospect of a shrinking workforce, companies increase automation and use robots to maintain productivity. AI adoption could reach more 50% in Thailand by 2030, as it is 17% in 2019. The impact of AI will depend on its scale, distribution across the workforce and its timing. People who perform jobs that require relatively less skills are prone to a higher risk of automation than the people with skilled jobs.

Thailand will see further adoption of AI because the technologies will strengthen human capabilities.

Creation of New Job: Score 5/5 (Highest)

1.23 million Jobs by 2030 will be created in Thailand replacing low and labor intensive jobs. One-fourth of the current work will be displaced by automation. Most jobs would be created in manufacturing, followed by wholesale, retail and restaurants. The market value of AI in Thailand is estimated at US$ 3.6 Billion in 2030.

AI will create million more jobs than it will destroy. With this positive growth, there would be a shift in the quality, location and permanency for the new roles. Many people would need to upskill in order to harness the growth opportunities. 40% organizations are expecting to enhance and extend their

workforce. It would be essential that individuals take a proactive approach to their learning and that government creates an enabling environment to facilitate this workforce transformation. Some of the jobs that AI would create include data analyst, software developers, and social media specialists. The jobs that would require human skills, such as sales & marketing, innovation, customer design would also see increase in demand. In the next 5 years, aviation and tourism would see the highest amount of retraining due to enhancement required in AI skills.

In 10 years, there would be jobs like, master of edge computing, AI business development manager, AI assisted healthcare technician, cyber city analyst and digital tailor.

In 15 years, there would new jobs created that would include, quantum machine learning analyst, genetic diversity officer, personal memory curator, AR journey builder and man machine teaming manager.

Impact on Education: Score: 4/5 (High)

AI brings in innovation, and education is one area that can hugely get impacted by innovation. The ability to tap into AI for new technologies to enhance the learning process can make everything seamless from admissions, grading, and student access to resource planning.

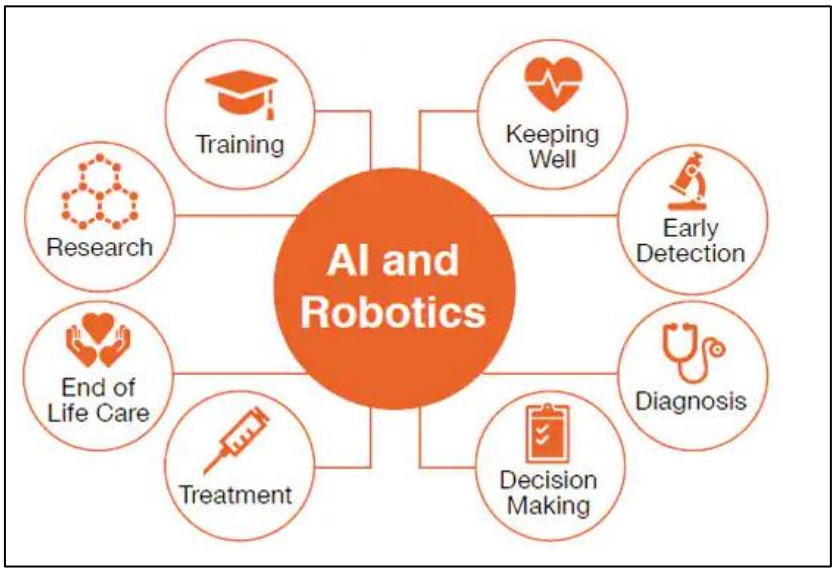
The future will see an increase in adoption of robots for education and for children with specialneeds, as it is expected to create value in terms of social development and cost savings. It would speed up the administrative process for everyone so that focus is on lesson planning. Grading process would be automated, reducing workload for high volume admissions. Through AI, tutoring and study programs are growing more advanced, capable of teaching fundamentals to students struggling with basic concepts. In 10 years, visual and dynamic learning channels outside the classroom will become more prevalent.

IN the future, AI would be a major part of students, teachers and the entire education system.

Impact on Healthcare: Score 5/5 (Highest)

The potential for AI in healthcare is vast. AI and robotics is increasingly becoming closer and efficient for healthcare ecosystem.

Figure 70. AI and Robotics contributing to Healthcare



The amalgamation of AI and Internet of Medical Things is helping people live a healthier life. Fitness apps, technology and virtual assistants are encouraging people to maintain a healthy life.

It is used to detect early stages of cancer with 99% accuracy, oversee early stage heart diseases, detect life threating diseases at treatable stages. IBM Watson has been a useful use case for healthcare organizations helping to unlock data and power diagnosis. Google's DeepMind Health is working in partnership with clinicians, researchers and patients to solve real-world healthcare problems.

Drug Research & Discovery is the most recent application of AI in healthcare. It aids in cutting time and cost for drugs to enter markets.

In 2020, Robots can replace pets and can also acquire knowledge and speak like human beings The University of Electro-Communications, Tokyo are conducting research that will enable robots to learn concepts and language.

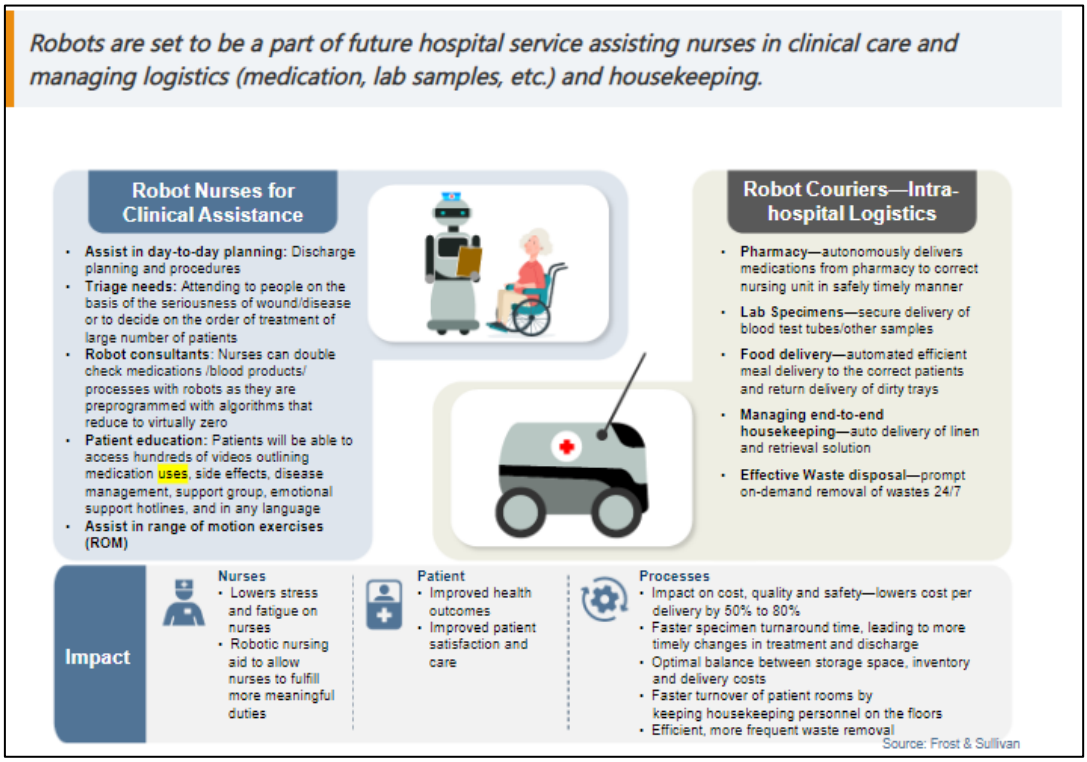
By 2025, Robots that will collaborate with humans in rescue operations. These robots will be self-manned and will be able to adapt to unforeseen situations using previous data and information.

By 2030, Robot assistants that will be able to offer guidance or solution to any social problem, collect data, recognize and, empathize with human beings; they will be placed in public places, like retail stores, clinics, restaurants, schools, and gyms.

By 2035, the future of hospitals could well be controlled by fully autonomous intelligent robots with no human intervention including, help desk to diagnostics to operative procedures,

By 2040, robots will not only help in providing proper food and medicine to the aged people but will also be able to detect abnormalities in a person's behavior or health or situation and will have the capability to act accordingly.

Figure 71. Robot applications in Healthcare



Applications/Use Cases: Score 5/5 (Highest)

There will be 300 use cases of AI by 2030 with major contributions in manufacturing, insurance, automotive and healthcare. Artificial Intelligence (AI) is penetrating into all aspects of a company's business operations. The purpose of using AI applications is to create a smooth and effortless experience for all users. AI domain specialists focus on specific AI functions such as natural language understanding for intelligent chatbot and computer vision for object recognition.

In 5 years, AI would be used extensively in chatbot and virtual assistants, making lives easier for customers. The main purpose would be to enhance customer experience and make the conversation seamless without human intervention. AI can analyze large volumes of data across the entire customer journey and therefore provide suitable suggestions and effective feedback to service providers.

In 10 years, AI is expected to have huge potential in cyber security. Increasing volumes of data, which might consist of sensitive information, for AI-enabled applications raise concerns around information security. Prevention of cyberattacks requires holistic arrangements encompassing different layers from the infrastructure to the end points. The advanced capability to foresee malware with pre-trained data and provide AI-enabled cyber security solutions to prevent malware is an emerging trend.

In 15 years, with the advent of 5G and AI, the world would see an epitome of ICT enabled digital transformation. Autonomous cars would become common r reducing traffic accidents by eliminating human error, increasing road capacity and traffic flow.

Market Size: Score 3/5 (Neutral)

By 2030, Thailand's AI market size is estimated to be around THB 114 billion.

Strategic Attractiveness: Score 5/5 (Highest)

AI would add 16% to the global economic output by 2030. It will boost economy by THB 410 trillion. There would be massive disruption in major industries, including healthcare, retail, and logistics. 40% of customer oriented business would consult AI supported VA on a day to day basis in Thailand. Thailand economy would grow 2.1% per annum due to AI infusion in industries and processes. 72% of Thai Graduates could lose jobs if AI skills are not incorporated.

How AI supports Digital Thailand Agenda?

The use of AI has opened enormous potential for the Thailand economy to contribute to the Thailand 4.0 initiative. Digital economy with the help of AI is growing leaps and bounds in Thailand. The main aim of Thailand 4.0 is to boost the quality of life in Thailand with the help of technology and innovation. AI is contributing to the agenda by creating a competitive growth engine to provide expertise at a sustainable level. AI would be very crucial in the Thailand digital park, which is the hallmark of the Eastern Economic Corridor's initiatives. There are many developments underway that are integrating AI, such as smart cities, smart mobility and smart homes.

AI is able to handle vast amount of data and do complex computations within no time. It also aids in declining cost of IT infrastructure. It has reduced the speed of data processing along with improved analytics capabilities. Digital economy in Thailand is already using AI for forecasting, roiling data, recommendations and predicting churns. All of these use cases make AI imperative for Thailand 4.0 to transform, innovate and upgrade the economy of Thailand.

World Bank has invested in AI in Thailand to implement training workshops that aid in creating awareness of analytics in improved decision making. The government and world bank in Thailand is using the AI knowledge to improve efficiency of resource allocation to support the goal of end the AIDS campaign 2030 and reduce HIV related discrimination in healthcare by 90%.

The Thai government is going beyond digital to support the initiative. AI is being used to detect network traffic and conduct data analyzes to monitor suspicious behavior. The government is focusing on connected systems to make the information flow securely and in real time.

AI along with digital transformation will energize the employers to take the digital route, boosting innovation and competitiveness.

In order to digitize the judicial system as one of the 4.0 agendas, Thailand Institute of Justice is infusing AI and machine learning tools to find insights and anomalies so people can be free to monitor suspicious contracts or payments in depth.

AI is paving its way into businesses in Thailand 4.0 initiatives. In 2018, 20 Thai entrepreneurs were early adopters of AI, including banks, retailers, and telecom operators, driven by the need to match up with the Thai 4.0 initiative. The banking sector moved to facial recognition for fraud detection while oil and gas has been using AI for road safety. IBM's Watson would be utilized to enhance professional expertise and support decision making by finding the accurate information million times faster. IBM is working with private entities, government and start-ups to infuse Watson in areas such as fraud detection, cybersecurity, knowledge driven expertise, healthcare, retail, manufacturing and telecommunications. IBM and VISA would collaborate to embed payments and commerce into any device. All of the IBM's future plans are in context with the Thailand 4.0 initiative. IBM plans to empower the cyber security operations. Watson would be able to help security analysts to analyze natural language research reports which are never accessible to modern security tools.50% of Thai manufacturers are investing in adoption of automation systems, leading to an increase in demand for robotics by 133% in 2018. Thai government would support robotics, automation to sustain Thailand 4.0. Thai Beverage Group (ThaiBev) and Charoen Pokphand are proposing to develop robots to respond to Thai 4.0 scheme, to boost productivity and efficiency.

Start-ups, which are the unicorns of the Thailand 4.0, are investing heavily in AI to attain digital transformation. The government has plans to invest in start-ups which are incorporating AI in their businesses. AI would make their companies agile and ahead of changing consumer demands and suppliers availability, which supports the visions of the digital Thai agenda. AI is going to be pivotal in the cyber landscape which is integral in the digital transformation landscape in the 4.0 initiative. Frost & Sullivan research estimates that 30% of top 500 enterprises in Thailand will depend on digital products and services by 2020.[193]

Sub-classification of AI

Artificial Intelligence (AI) is the largest circle and outermost circle followed by machine learning, which is further reliant on deep learning. All of these concentric circles depend on neural networks.

Machine Learning- Machine learning refers to the use of models or algorithms to enable the recognition of data patterns in an application. Industries such as financial services, healthcare, government, marketing, oil and transportation are using machine learning technology. A subset of machine learning, deep learning is associated with algorithms inspired by the structure and the function of the brain called artificial neural networks.

[193] Frost & Sullivan Analysis for depa: Thailand Digital Technology Foresight

Neural Networks - The approach, known as a generative adversarial network, or GAN, takes two neural networks—the simplified mathematical models of the human brain that underpin most modern machine learning—and pits them against each other in a digital cat-and-mouse game. GAN's have been used to create photorealistic fake imagery and realistic sounding speech.

Natural Language Processing - Natural Language Processing (NLP) is a sub field of Artificial Intelligence focused on enabling computers to understand and process human language to get computers as close to understand human level of language understanding

Sixth Sense Technologies - It is the interaction with the digital world in the most competent way. Sixth Sense is a wearable gestural interface that enhances the physical world around us with digital information and lets us use natural hand gestures to interact with that information

Neuromorphic Computing - It is also known as neuromorphic engineering, It is a method based on the biological brain. It mimics the way the human brains work, replacing transistor based circuits with architecture

Brain Computer Interface - BCI is a direct communication between an enhanced brain and an external device. AI can power future machines to understand human thoughts and emotions, even without physical or vocal communication.

depa should focus on machine learning in the five year plan. Industries such as financial services, healthcare, government, marketing, oil and transportation are using machine learning technology. Cyber security is the most used areas for machine learning. Machine learning attracted almost 60 % of AI investment, because it is an enabler for so many other technologies and applications, such as robotics and speech recognition.

Thailand has been moving forward at full steam, due to the growth of smart algorithms that can imitate, assist and augment human tasks in foreseeable and automatic ways. Machine learning is integral to AI technology. Its use cases have made its applicability within the 5 years extremely rampant. Government agencies in particular, would have a vital use of machine learning since they have multiple sources of data that can be mined for insights. It is also going to be highly effective in detecting fraud and minimizing identity theft.

depa should focus on natural language processing and deep learning in the next five year plan. IBM's debater, a radical AI technology is a NLP use case which could argue with humans on complex topics. NLP is the voice behind SIRI and Alexa. With Alexa, Siri and Google Duplex, and future technologies, NLP would be able to understand human emotions. Businesses are already able to understand the importance of NLP as they made AI pocket assistants. The ever growing myriad of NLP will grow and expand with time. It would help government understand the key meaning behind words, aiding in detection of fake news and cyber-attacks. Thailand would use NLP to understand the most important cases from the thousand others. In ten years, all governmental support in Thailand would use some form of NLP, enabling transformation as part of the 4.0 initiative.

depa could focus on sixth sense technology in the next 15 years. It can be a part of the long term digital transformation strategy for depa. It could be installed in any wearable devices. The real estate development is a vital area for tech movement in Thailand. Under the policy of one belt one road, the Thai government could use sixth sense technologies to create three dimensional structures. It is a massive digital transformation wherein Thai people could use internet anywhere, fingers could be the brush to draw, and palm could be the dialer to call. It would provide easy control over machinery in industry. New markets would evolve, which is the key to the plan of the 4.0 initiative in Thailand.

According to Frost & Sullivan analysis, depa should not focus on brain computer interface, neuromorphic computing and neural networks for the 15 year plan. Neuromorphic computing requires high density off chip interconnect. It is still young and unconventional space. Implementing neuromorphic would not be feasible for depa in the digital Thailand 4.0 initiative. There is no current technology that would aid in implementation of brain computer interface for clinical trials. Even though it is essential as Thailand population is aging, and it would aid to the medical and healthcare division, the high investment and not availability of realistic estimates of trials makes this technology improbable for the Thailand 4.0 objectives.

Trends of AI across the world

Businesses are steadily grasping the use of data, but as people are making headway in catching up with the technology, businesses are learning how data scientists and AI developers work differently from traditional developers. Chatbots have become increasingly popular with the desire to give the same experience as an instore. There have been deeper investments in deep learning and neural networks. 25% of the companies will have infused virtual assistant by 2020.[194]

Emerging AI trends of the future

1. **Change in jobs -** It is imperative that AI will impact job changes. Many redundant and routine processes would be automated leading to replacement of human jobs. According to Frost & Sullivan estimations, 15% of global workforce would switch jobs to occupational divisions such as automation, digitization and advancement in AI.

2. **Efficient Logistics –** The infusion of robots in supply chain leads to an average of THB 693.9 million per year savings or 20% reduction in operating costs. AI is massively used in supply chain processes to optimize, better manage and lower the cost of supply chains to make them more efficient.

3. **Confluence of AI and IoT**
   AI will collude with industrial IoT because AI would enable cutting edge precision and would increase IoT's functional ability. Advanced machine learning models will also see light.

4. **Rise of Automated machine learning -**
   Frost & Sullivan has estimated that automated machine learning will take ML to leaps and bounds. It would make ML experts to focus on only the root cause and not the entire process, saving loads of time and effort. [195]

5. **Cybersecurity & AI**
   With the rise of cyber-attacks and lack of cybersecurity experts, the infusion of AI and ML in cybersecurity would see tremendous increase. The amalgamation would make the system robust, blending experts and AI together to vigilantly monitor threats.

According to Frost & Sullivan estimates, AI would become the drug discovery tool by 2028.It would have a huge impact on defense industry by 2020. It is even predicted that AI would have the biggest impact on customer experience industry by 2020.

Trends in South East Asia

The main development centers for AI are US and China. However, the other South East Asian countries are catching up with huge technological advancements.

[194] https://deepsense.ai/ai-trends-2019/
[195] Frost & Sullivan Analysis for depa: Thailand Digital Technology Foresight

The South East Asian region is a hub for start – ups and millennials, resulting in huge acceptance of technology. According to Frost & Sullivan estimates, the AI adoption rates have doubled from 2018.[196]

In the South East Asian region, players with enormous expertise in telecom and banking are in the process of launching AI initiatives, for example, IBM Watson. In SEA, with the growing pace of digitization, the adoption of AI is accelerating.

Across all major Industries, early adoption of AI's achieved higher profits with lesser costs. The major industries that are benefitting are manufacturing, financial, transportation and logistics. High technology, telecom and financial service have been leading the way for the AI infusion. However, there have been an upsurge and future involvement of AI by government in various countries, including Thailand, Malaysia, Singapore, in their smart city initiative.

It is predicted that Chinese firms would aggressively invest and adopt robotics by 2020. Bye 2030, seamless mobility would be unexceptional in most cities in the region, though not at the same time. Singapore has been in the front for smart mobility using AI in all its systems. Malaysia has undergone similar processes, with Cambodia, Indonesia and Philippines following the same path with the smart city program.

According to the experts, 25% of customer questions would be handled by AI in 2020, reducing the human involvement in sales assistance. It would predict questions before even asked, creating a seamless customer experience in retail industry.[197]

The South East Asian region has seen widespread adoption of AI in healthcare sector. Singapore government agency has pledged to create a nationwide analytics program that would analyze patient data from all healthcare platforms for better insights. Vietnam has a Vicare chatbot to help patients Facebook chat care.

It is important for these nations to focus on current enhancement of technology and future investment in research & development to boost productivity and opening up huge possibilities.

Trends in Thailand

Advances in AI have been growing rampantly in Thailand across various industries, with government playing a key role to deliver benefits across the society. AI technology will have a disruptive impact on the economy with the potential to automate around 55% of the region's work. Adoption of AI would be seen majorly in telecom, high technology and healthcare sectors, though other industries are also coming up with various AI infusions. Many firms and hi tech industries find Thailand as an interesting market for AI investment. Robotics, healthcare, digital and medical have shown growth opportunities in Thailand as per Frost & Sullivan analysis. The Thai economy is likely to grow more than 5% with the advent of digital technology and AI. Frost & Sullivan experts forecast this rise with the growth of start-ups and medium sized enterprises

According to MD of IBM, Thailand, causal modelling would be a key trend in AI that would enable data structures to efficiently select interventions to test putative causal relationships, thereby making better decisions. There would be a focus on advanced research in trusted AI, enabling quantum technology to assist AI.[198]

[196] Frost & Sullivan: AI Innovations in Future of Manufacturing, Dec 2017
[197] https://www.cio-asia.com/article/3311756/artificial-intelligence/how-is-artificial-intelligence-benefiting-industries-throughout-southeast-asia.html
[198] https://www.bangkokpost.com/news/special-reports/1614790/powering-up-on-ai

Supply Chain

DHL pioneered intelligent route optimization with 'Smart Truck Technology' to increase efficiency and improve transportation and delivery.[199] DHL & IBM jointly have concluded the importance of AI in logistics for Thailand to enrich customer experience through conversational engagement and deliver articles before even orders have arrived.[200]

Retail

E commerce is big business in South East Asia with Thailand, Singapore, Malaysia, Indonesia generating THB 473.1 billion in online sales, according to reports by Frost & Sullivan.

Consumers in Thailand use mobile phones for shopping. Smart phones have come fully equipped with AI assistants with each retailer using chat bot to engage customers. It is the era of social media and filters. With further advances, deep learning would provide more doctored photos. A huge amount of work is going on with generative adversarial networks.

The future of AI in retail is very promising in Thailand. Frost & Sullivan predicts that AI would make customer journey fairly easy, for instance, when a customer would send a product photo via Facebook connecting with chatbot, AI engine would reply with the available product within seconds, enabling customers to make the order through chatbot. This could help the aging population in Thailand by greatly increasing convenience to order online.

7- Eleven in Thailand is going to opt for AI, including facial recognition of employees across 11,000 stores. CP, a convenience store in Thailand has signed contracts with US – Chinese Technology to use its Kankan data intelligence and AI based behavior analysis technologies to provide customer support.

Media & Communication

AI has also been adopted by the Ministry of Information and Technology in Thailand to increase efficiency and personalize services. The Thai THB 441.6 billion media industry would generates huge data through video consumption, AI would improve delivery of content along with automation. It would make content worthy, relevant and monitor live events.[201]

Microsoft is pitching high with AI involvement in Thailand. Its partnership with depa is focused on reskilling and training for AI by offering teaching programs. It's focusing on language localization through the launch of text-to-speech with Thai-language support on the Azure cloud-based platform.

Government

AI in educational sectors in Thailand would see a massive support by the government, with AI educated hub advancing the goals of improving connectivity and building data sets. Government collaborations with private organizations, universities have been evidently seen in Smart Health, Smart Education, Smart Tourism and Smart Agriculture. Government along with cyber security start-ups would use machine learning to tackle online threats in real time. Government agencies would also use machine learning to educate and skill people with the wealth of data. It would also be used in various public sector initiatives such as detecting tax fraud and managing governmental programs.

[199] http://www.dhl.com/en/press/releases/releases_2011/group/081011.html
[200] http://www.nationmultimedia.com/detail/Corporate/30347039
[201] https://www.opengovasia.com/how-ai-will-accelerate-growth-in-thailands-media-industry/

Manufacturing

Manufacturers would use machine learning to collect data by IoT sensors. This would aid in anticipating equipment failures and reduce maintenance costs.

The Thai food and beverage conglomerate Thaibev is the only one to introduce Industry 4.0 technology in their plant, according to Frost & Sullivan analysis. Thaibev expects a demand rise of 15% with the introduction of robots to boost innovation and productivity.[202] Manufacturing is the key sector in Thailand for digital 4.0 agenda, with 40% AI use case coming from this industry.[203] Products related to robotics, machine automation and AI would interest the local manufacturers to a great extent.

Thailand is one of the main countries in Asia to import robots every year. THB 44.2 trillion is expected to be spent on robotics expenses by 2020. Robotics and automation would be promoted as an agenda in EEC. According to Frost & Sullivan analysis, there is 83% opportunity for robotics and automation to grow in manufacturing sector. 50% of Thai industries are prepared to adopt the technology.[204]

Telecom

Maximum use case for AI would come from information & telecommunications sector in Thailand. NTT Communications has plans to bring AI to Thailand to enhance customer service. Telecom and high tech industry in Thailand are the early adopters of AI. By 2020, Frost & Sullivan estimates that 89% of adults will have mobile subscriptions. Telecom companies would be using AI to predict churns, cross sell and visualize data. According to Frost & Sullivan analysis, major investments of AI in telecom would be to developing AI systems while a minor chunk would be to utilize current infrastructure.

Forward looking CSP's have ventured into network optimization, preventive maintenance, virtual assistance, and robotic process automation as an in road to AI. Frost & Sullivan has predicted that telecom industry would post a CAGR of more than 40% by 2020 due to usage of AI.

The future of telecommunications in Thailand paves the way for using AI to detect and predict network anomalies, a pattern recognition capability which would be useful for network security.

AI would allow operators to collect and analyze data from customer base to achieve real time behavioral insights. DTAC, which is the third best telecom in Thailand, is continuously innovating with IoT and AI technology. They initiated a machine learning usage to assess which call package best suits an individual usage using a static algorithm.

Digital Innovation in AI

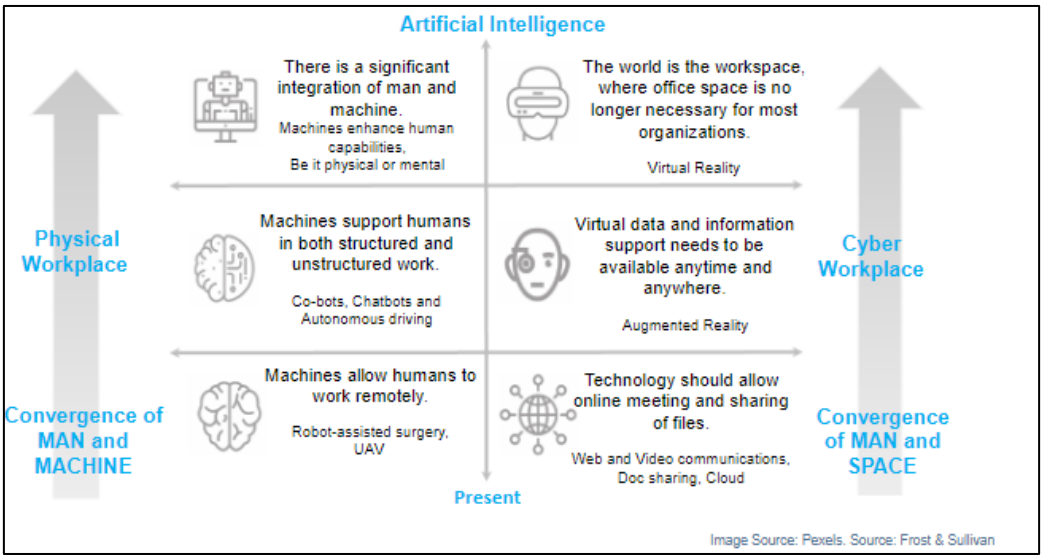
Companies will a strong base in core digital technologies would adopt AI tools like virtual agents, machine learning, NLP, image recognition, robotics and Robotics process automation. According to Frost & Sullivan, one in three companies has the capabilities to adopt AI completely. [205]

AI would be used as a digital healthcare tool for disease prediction, early detection and personalized disease management. The advent of digital health start-ups will encourage the use of AI in the global healthcare sector.[206]

[202] http://iotbusiness-platform.com/blog/of-ai-and-robots-thailands-fb-giants-investing-in-automation-to-drive-thailand-4-0/
[203] Frost & Sullivan: AI Innovations in Future of Manufacturing, Dec 2017
[204] https://eit.or.th/paperseminar/Robotics%20Cluster.pdf
[205] Frost & Sullivan: AI Innovations in Future of Manufacturing, Dec 2017
[206] Frost & Sullivan: Innovations and Initiatives in AI for the Pharmaceuticals Industry, May 2018

High speed digital connections would be provided through development of optical processing unit, which is a tailor-made component for machine learning. This would facilitate high speed AI's for image processing, computer vision or virtual reality.

Figure 72. Convergence of MAN and MACHINE



Convergence of modelling solutions, sensors, actuators, analytical tools, IoT, cloud computing, and Artificial Intelligence would lead to digital twin, which would lead to better understanding of a product "failure modes and would facilitate optimized design of a product to provide attributes such as greater energy efficiency and robustness.

Advances in technology areas such as Artificial Intelligence, will boost the endpoint security management capabilities, as forecasted by Frost & Sullivan. The rise of advanced threats like distributed denial of service (DDoS) attacks and phishing attacks would compel companies to deploy AI to restructure their security monitoring process. Adoption of technologies such as Artificial Intelligence and machine learning would help security teams to defend against the sophisticated cyber security attacks in future.

Amalgamation of AI with advanced robotics would provide long range detection, instant identification of all types of drones, thus protecting them from hackers and infiltration

Frost & Sullivan estimates that 50% of the companies will adopt chat bots by 2020; hence it is as one of the major emerging digital transformation trend of 2019.

Big multinational's such as Google and Atos are collaborating to strengthen their joint commitment to facilitate enterprises transform digitally by opening their first Artificial Intelligence (AI) Lab in London. It would enable public and private sector organizations to utilize AI technology for their needs. Some use cases include using connected sensor in the supply chain of an energy company to create efficient operations or using machine learning algorithms to reduce fraud in financial services.[207]

Over the next few years there would be augmented transformation for knowledge workers and professionals, aiding to strengthen the economy. It would create more jobs that it eliminates by 2020, with manufacturing demanding the greatest growth. 2020 would be the tipping point of mainstream AI. It is estimated that 70% of the data will come from external sources and IoT.

[207] https://atos.net/en/2018/press-release_2018_10_15/atos-launches-inaugural-ai-lab-london-google-cloud

It is predicted by various experts that 19 trillion of value will be created by 2020, vindicating the word 'AI Gold Rush'.[208]

Digital Innovation in Asia

AI is transforming the economy; there are few industries that are using AI to do business. These use cases would indicate the future potential of AI at workplace.

Autonomous Digging for resources

AI is powering autonomous trucks. Autonomous vehicles are more than the proof of concept in many industries. For instance, in mining, over 200 driverless trucks operate. In mining industry, AI is also powering drones to monitor operations and scout for new resources. The future of mining also involves use of smart, mini, nano bots that would lead to sustainable, safe and less costly means of productivity.

Healthcare

AI is transforming the healthcare industry massively. There are various use cases that shown that AI is helping researchers identify diseases before its occurrence. It would help the future healthcare experts to lower cost by assisting surgeons in complicated surgery, reducing human errors by assisting in diagnostics and managing readmissions through predictive capabilities.

Digital Insurance Agents

AI is driving innovation in insurance sector with Chatbots that can answer client's queries and machine learning that can work through claims. It is in testing phase right now, but Prudential Singapore has been trailing it in the private sector.

Smart City brains

China is in the forefront of deploying AI in the city planning and management. Hangzhou has developed a 'city brain' that uses data collected from sensors and cameras to run the government. Suzhou and many other Asian countries use AI in traffic management.

Potential of AI

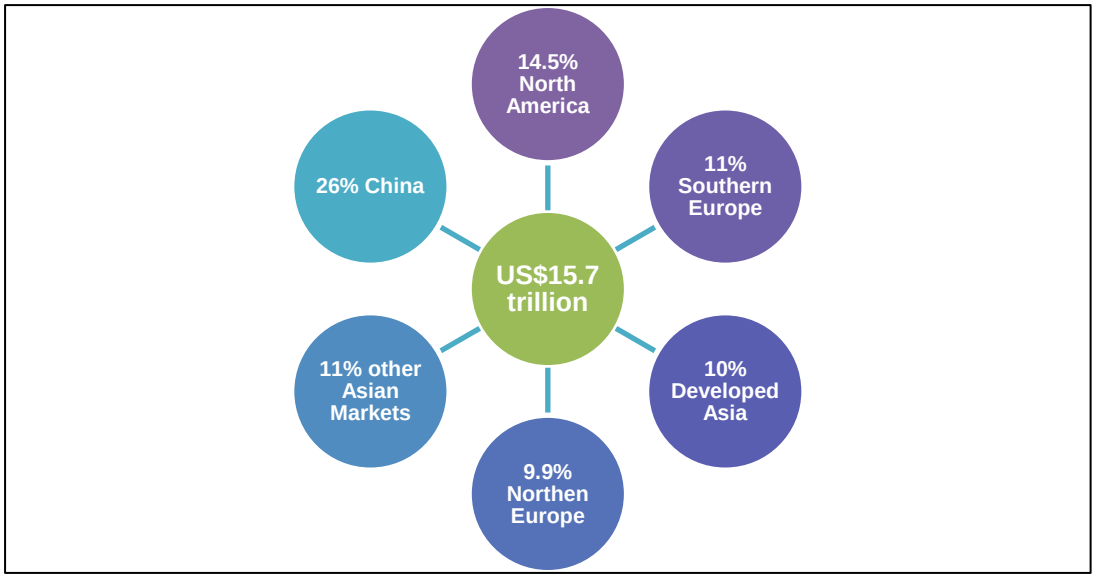
According to Frost & Sullivan's analysis, the global Artificial Intelligence market revenue is expected to rise to THB 6.0 trillion by 2025, from THB 43.5 billion in 2016. The market for AI is growing at a rapid pace, with increasing awareness in Big Data technology, Industrial IoT in manufacturing, robotics, and computer vision technology in manufacturing, cross-industry partnerships and collaborations. Advancements will focus on deep learning, machine learning, natural language processing and machine vision. Over the next few years, technology advancements and capabilities will only increase to capture increased range of application segments. The market for services is expected to grow the highest between 2018 and 2025. APAC market for AI is forecasted to grow at the highest CAGR with increased adoption of deep learning, NLP in finance, agriculture and law applications.

By 2020, AI market size for robo advisor would be THB 8.0 trillion, analytics would be THB 2.2 trillion and personal and bot care would reach THB 536.2 billion. By 2022, size of surgical robotic market is expected to be worth THB 567.7 billion.[209]

[208] https://www.digitalistmag.com/future-of-work/2018/10/08/ai-gold-rush-artificial-intelligence-machine-learning-06188069

[209] https://www.statista.com/statistics/621656/worldwide-artificial-intelligence-robotics-segment-estimates/

Figure 73. Future growth potential of AI in 2030



Source: Frost & Sullivan

The high potential use case would lie in industries including, healthcare, automotive, financial services, transportation, technology, retail and manufacturing.

With continuous advancements in AI, sensors, and communication technologies, the road to 2025 will experience an increased growth in enabling technologies such as robotics, drones, and autonomous vehicles. These segments are in turn expected to be holding the major share in the market with increased range of applications across sectors. The transformation and adoption of AI technologies will allow industries to overcome the physical limitations of capital and labor Market.

According to future estimates, AI could create a boost of THB 410.0 trillion in the world economy, uplifting the GDP by 16%. 70% of the companies will adopt at least one type of AI by 2030.[210]

45% of total economic gains by 2030 would come from product enhancements, up surging consumer demands. AI would drive product variety with enhanced personalization and user experience.

Use Cases of AI

Artificial Intelligence is making a huge impact in various industries, majorly in healthcare, supply chain management and marketing. Telecommunication, banking, and other industries with the high use of technology are the constant sectors leading the adoption of AI.

Short term

Engineering & Manufacturing

AI has been paving the way to shape the physical world engineering and manufacturing sectors. The agricultural machinery used by John Deere uses IBM Watson and a smart manufacturing platform to deliver AI powered assembly and maintenance in Germany. A plant worker has a deep learning enabled camera application on the mobile which can be used to photograph machinery, Watson uses AI image recognition algorithm to determine the cause of any fault.

In Thailand, many manufacturers would turn towards quality 4.0 by 2025, which involves the use of AI algorithms to notify manufacturing teams of emerging production faults, including deviations, subtle

[210] https://internetofbusiness.com/a-i-2030-13-trillion-boost-to-economy-but-deep-disparity-mckinsey/

abnormalities and more. It would also enable many Thai manufacturers to use data collected about the performance of their products, helping in future product development processes.
Bosch has opened its first smart factory in Thailand for injection technology where manufacturers analyze latest production data using an active cockpit'.[211]

Medium term

Safety & Security
By 2030, cities and homes would rely heavily on AI to detect and predict crime. Automatic processing of CCTV and drone footage would allow people to spot malicious behavior. Techniques like gain analysis would help interrogators to detect unruly conduct.

With Thailand 4.0, the government is using AI to monitor network traffic and conduct Big Data analyzes to detect suspicious behavior.

Long Term

Healthcare
Potential for AI in healthcare has helped to review data massively to review data related to serious illness. Many companies in Thailand and other parts of South East Asia have adopted IBM Watson to digitally process claims. The government in Thailand would use technology to analyze patient data to generate greater insights. By 2035, the developed deep learning platform could provide doctors with an automatic analysis of the brain structure with the patient being in the scanner.

AI can be used as a solution to avoiding costs in producing and shipping drug samples to medical practitioners. A data robot model automation can accurately predict whether a given drug sample order could be associated with another upcoming order to the same location or department

Maxwell MRI adopts Google Cloud Platform (GCP) Machine Learning Engine to provide services aimed at helping clinicians diagnose prostate cancer through medical imaging.

AI Adoption Cycle

AI marketplace adoption is likely to follow an S curve with a slow start in the beginning with few innovator firms in the early years, followed by a steep acceleration as the technology grows and matures. Firms would gain trust on the technology and get expertise to leverage AI in their business. In the present year, 30% of firms are in the AI pilot phase. According to Frost & Sullivan estimations, around 45% of firms have entrenched at least one AI capability in their processes. AI is being tested and implemented in various business units; however its major impact has been seen in the manufacturing sector.

Most investment made in AI is in the research & development phase, with an annual spending of THB 1.1 billion by digital giants. Non technology companies are investing in AI rampantly. With deeper understanding, there are even deeper investments. The gap between leaders and laggards of AI adopters is growing faster.

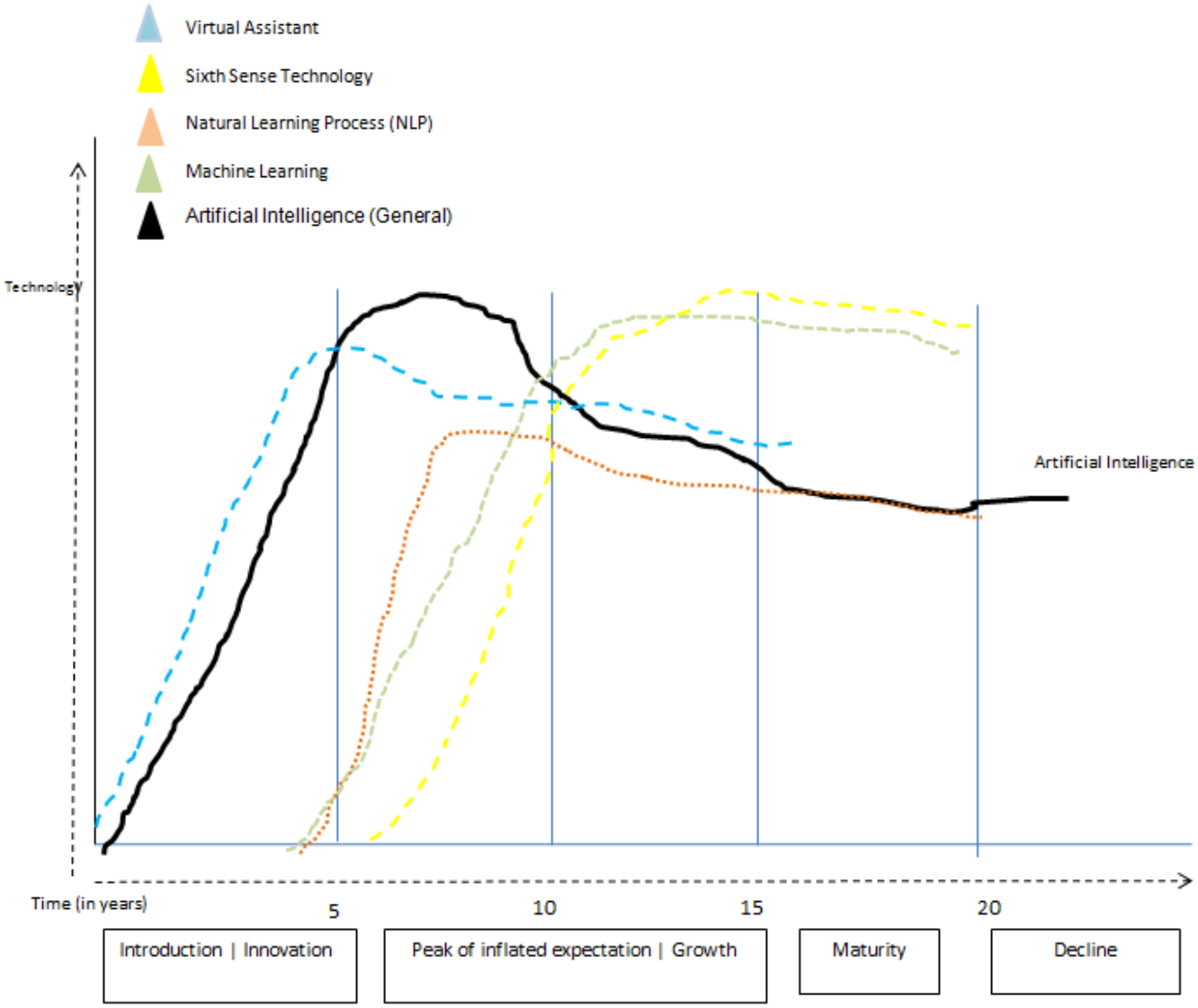
Artificial Intelligence is still in the introduction phase, creating new innovations each day. It would take the generic AI 5 years to reach tipping point of growth; it would remain stable for few years and then would decline a bit to remain stable thereafter.

[211] https://www.enterpriseinnovation.net/article/bosch-opens-first-smart-factory-thailand-1355108544

Natural Language Process is in the midst of introduction and growth phase, it is innovating with some part of technology already in testing and growth. It is entering the peak of inflated expectations phase. There have been a number of successful stories while failure is common too. It will reach its peak in 2026 and is forecasted to stay stable for a long time.

Deep Learning would reach its tipping point of growth within 10 years. There have been various use cases of Deep learning, with more so coming in the future. Machine learning and AI is in the process of entering mainstream of business technology. Google, Netflix, Uber have embedded machine learning in their business. But the actual adoption is relatively low in the real world. It would ideally take less than 5 years for machine learning to reach growth whereas deep learning would reach tipping point of growth within 10 years. Deep learning usually induces a lot of training time of organizations and is forecasted to be in house by most companies in the future.

Figure 74. AI Adoption Cycle



Virtual Assistant Market is forecasted to hit THB 362.7 billion by 2024. Around 80% of companies would adopt at least one form of intelligent digital assistants in their companies by 2025. It helps reduce costs including, email response, technical support and assistance on call. Speech recognition will witness growth in the next 5 years.[212]

There would be 1 billion action users for virtual digital assistants by 2025.[213]

AI Consumption in Thailand

Thailand has been moving forward at full steam, due to the growth of smart algorithms that can imitate, assist and augment human tasks in foreseeable and automatic ways.

In the next 5 years, there would be a massive rise of virtual assistants in Thailand. Frost & Sullivan predicts that by 2023, 40% of customer oriented business would consult AI supported VA on a day to day basis in Thailand.[214]

The government has already implemented AI in the traffic systems to monitor suspicious behavior and traffic lights. It would be operating the traffic lights at all 505 intersection in Bangkok.[215] In the banking sector, facial recognition technology would be used in e-KYC, machine learning for fraud detection while oil and gas would use AI for road safety and detecting malevolent behavior

To expand the adoption of AI in Thailand, the country needs training and expertise in the technology. Thailand would need to develop a data science and software development skilled workforce along with experts from abroad. Thailand lacks the capability to adopt the technology. The country should collaborate with experts to build innovative products in key areas. It is vital for Thailand government, businesses and public sector agencies to partner together to develop the appropriate data analytical skill set needed to consume and adopt AI. It is essential that top management develops an enterprise-wide portfolio view of AI opportunities, take necessary actions to close the talent gaps and implement refined data strategy to enable AI adoption in full swing. The country should target AI first strategy, making it more accessible and affordable for sustainable growth.

Outlook of Local Companies

Thailand is moving at full pace to implement AI strategies into business and daily lives. Few local companies in Thailand are leading the footsteps in infusing AI, such as Betimes Solutions, Line Corporation, The Mall group, Kasikorn Bank, SCB, Bangkok Bank, Krung Thai Bank, Thai Airways and Central group. There are various startups in Thailand that are in progress with AI technology in their businesses, such as Ranked, 30 Seconds to fly, Lunch Actually Group, EATLAB and Humaan.ai.

Local Developers such as Betimes Solutions are collaborating with Microsoft technologies to develop Chatbots that can receive input and provide Thai responses.

Line Corporation is in the process of developing its own Ai platform Clova that would offer various languages. Wongnai, Lazada, Krungthai AXA, Maybank have already implemented chatbots into their services.[216]

The Mall group collaborated with Siam Commercial Bank to introduce cashier less supermarket in Bangkok, using machine learning models. Central group has partnered with JD.Com, China's e commerce giant to use AI to implement retail innovation.

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[212] https://globenewswire.com/news-release/2018/12/19/1669235/0/en/Intelligent-Virtual-Assistant-Market-to-hit-11-5bn-by-2024-Global-Market-Insights-Inc.html
[213] https://buildingradar.com/construction-blog/digital-trend-virtual-digital-assistants/
[214] Frost & Sullivan Analysis for depa: Thailand Digital Technology Foresight
[215] http://www.nationmultimedia.com/detail/national/30362348
[216] https://www.scmp.com/tech/enterprises/article/2096901/ai-making-its-way-both-business-and-daily-life-thailand

Kasikorn Bank, SCB, Bangkok Bank, Bank of Ayudhaya, and Krung Thai Bank have infused AI to introduce QR code and e payment service. SET, the stock exchange of Thailand has adopted AWS to boost scalability. It is planning to introduce LIVE', electronic trading platform to Thai tech star ups that would use democratize AI to aid in mobilizing funds.

depa would work with Microsoft to reskill people and offer teaching assistance to prepare for digital transformation. The revenue department of Thailand is using supervised learning, which is a component of machine learning, to identify theft and fraud detection

Thai Airways is using chatbots and analytics to boost sales and enhance customer experience. Its chat bot, Nong Fah' has been an enabler, transforming the Thai services.

Outlook of International Companies

There are about 100 enterprises in Thailand to embrace AI by 2019 to bolster human capabilities. These international companies include Microsoft, IBM, Google, Fazwaz group, Amazon, Shell, LG, Samsung, Oracle, Bosch and AXA Investment.

Microsoft has been competing head to head with IBM to bring AI to life in Thailand. The most common use case in Thailand is the application of machine learning to process data into predictions, for instance to analyze user data to predict future purchases. Microsoft's Azure Machine learning is implemented for predictive analytics to bring AI technology to life in Thailand.

According to insights by Bangkok Biz News, Thailand is gearing up to use machine learning extensively for the future of property development. FazWaz group is planning to launch machine learning powered Chatbots to build a virtual property agent. It would be one of the first property tech companies to do so. Adoption of AI would massively scale up within few years. The banking sector plans to use machine learning for fraud detection. The oil and gas company is positive in implementing AI on road safety to detect driver's reckless behavior. 95% of the jobs would be transformed with the wave of AI adopters within next 5 years.[217]

Google had launch AI program in Thailand to screen for diabetic eye disease that causes permanent blindness. The program was partnered with Thai state run Rajavithi Hospital. It analyzes patient's eye screen results to assess a risk of vision loss. It would achieve Thai government's target, a nationwide eye screening rate of 60%, as reported by Channel News Asia.[218]

Shell launched AI chatbot for B2B lubricant customers and distributors with Shell Lube Chat. It can solve day to day challenges such as obtaining access to information quickly.

IBM is working in collaboration with the private firms, government agencies and start-ups to infuse Watson, the AI wing of IBM in various areas such as cyber security, healthcare, retail, banking and insurance.

LG has incorporated robot technology with Alexa's voice recognition to introduce hub robot in Thailand households.

Amazon introduced five new machine learning services and deep learning video camera application services in Thailand. Other Amazon products include AWS transcribe, translate, comprehend, and recognition video which use machine learning to build speech into text.

[217] https://www.opengovasia.com/the-future-and-adoption-strategies-of-ai-in-thailand/
[218] https://www.channelnewsasia.com/news/asia/google-launches-thai-ai-project-to-screen-for-diabetic-eye-disease-11029556

Samsung and LG have introduced AI powered air conditioners in Thailand that would allow users to control other devices with Wi-Fi.

Key Issues in Adoption

Thailand has signed many free trade agreements, bilateral and multilateral agreements with different nations to support economic expansion through adoption of AI and other digital technologies, but it lacks the clear vision to fully adopt AI. The country faces the major issue from the lack of expertise and skills needed in the process of AI adoption. Many organizations and industry experts still lack the need to comprehend the importance of embedding AI into their processes. The country lacks the cooperation of all the major stakeholders in technology adoption. There is a mismatch in the strategy followed by the policymakers, venture capitalists, entrepreneurs and researchers to promote a culture that embraces digital transformation. Most of the leaders lack the necessary commitment to adopt AI. Most functions work in silos which hamper the use of AI solutions. Thailand does not have a strong digital backbone, due to which AI systems and processes lack the training data vital to build better models. Legislation, which always fails to keep at par with the changing technology, has a major role in the hindrance of quick adoption of AI. For instance, one law suggests that citizens would have the right to get an explanation for decisions made about them by AI, which might be very confidential to the technology developers. Digital monopoly and regulatory uncertainty are crucial in the lower adoption of AI in Thailand.

There is a gap in the perceived urgency of AI adoption and the available means to address it. There is a dire need to accumulate proper leverage, tools and platform to alleviate the impact of talent shortage.

Conclusion

The market for AI is growing at a rapid pace, with advancements in deep learning, machine learning, and natural language processing and machine vision. The AI market size in Thailand is THB 15.7 B and is expected to be THB 182 B by 2035. It is extremely pivotal for DEPA to focus on AI as an emerging technology as it is contributing to the agenda Thailand 4.0 by creating a competitive growth engine to provide expertise and digital innovation at a sustainable level.

3.3 Data Analytics

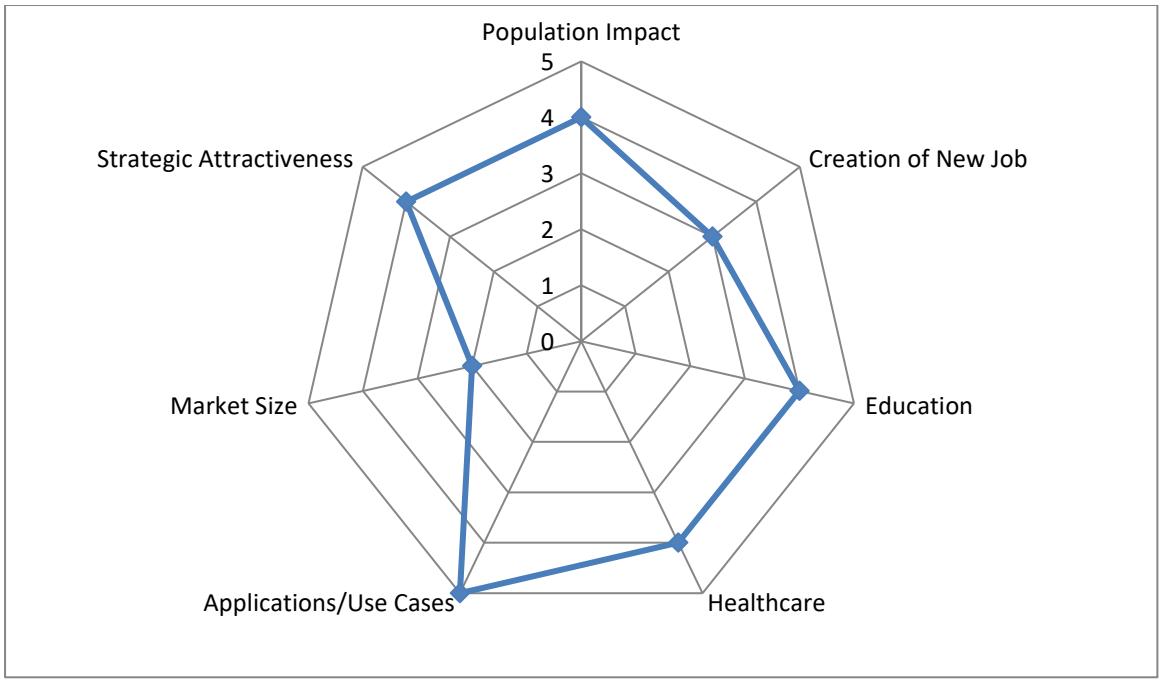
Data analytics is the concept to examine large amounts of data to categorize and get an insight that helps business to move faster and smarter with right track of products and services, with happier customers and with more efficient operations.

Major trends expected to influence the market positively include the surge in data traffic and the subsequent rise in network densification, the proliferation of Internet of Things (IoT) and the rise in adoption of connected devices, the adoption of virtualization amongst network operators, and the expected launch of 5G services. For Thailand, the volume of data services in 2017 is 6 times as much as 2014. The average per user is 4.11 GB per month. The adoption of 3G and 4G in Telecom Thailand market has encouraged people to use data service and propel several activities to be acted and done through online system such as mobile banking, PromptPay, e-commerce and etc.

Why Data Analytics has been selected?

57 million is the number of active Internet users in Thailand which is around 82% of total population. Furthermore, an average daily time spent on the Internet on any devices in Thailand is 9 hours 38 minutes. The increasing number of online activities creates a huge amount of data. These large amounts of data need to be interpreted to be understandable and then analyze to see the relationship of data to gain an insight.

Figure 75. Scoring of Data Analytics



Population Impact: Score 4/5 (High)

By 2025, more than 70% of enterprises will adopt data analytics as one of the business intelligent tools in order to gain insight from unstructured Big Data and improve customer's services as well as business operations. People will be involved with data analytics because their data will be stored to gain an insight in modern business era.

Creation of New Job: Score 3/5 (Neutral)

Data analytics is estimated to create approximately 50,000 jobs in Thailand by 2030. According to LinkedIn, Data scientist has become the fastest growing jobs over the five year period. However, it turns out that there still is a shortage of data scientist in the market over the world. The most important thing is we need to have a specific course to train young generation to have a set of skill.

Impact on Education: Score 4/5 (High)

Data analytics has been applied in education system to evaluate student performance in classrooms so that educators/teachers can personalize module to improve their weaknesses and lead to an improved student achievement outcome giving students the competitive edge. One deniable truth is each of the students comes from different socio-economic backgrounds, and then teachers should have an adaptive teaching policy and study plan for each group of the students.

Modern education system should not be based on a single curriculum because every student doesn't have the same potential to study. Thus, data analytics will come to help personalize the study plan. IBM is one of the companies developing the data analytics platform to reboot education system. A university or school can utilize this platform to extract the student data and use it to monitor and predict their student performance. Moreover, mining student data will help to identify courses in which students show a poor performance and create a supplemental instruction program to help with those courses. It can say that data analytics will play an important role to solve issues of retention and course completion.

Impact on Healthcare: Score 4/5 (High)

Data analytics will make a big wave and grow faster in healthcare sector. Important application in healthcare is health tracking that can monitor beyond basic health like heart rate or distanced walk but it will monitor complicated health likes the patient's blood pressure or glucose. Predictive analysis will immensely reduce hospital cost by predicting the admission rates and help with staff allocation. Digitized hospital records will pave the way to understand pattern of patients. It can identify the patients approaching the hospital repeatedly and identify their chronic issues. Such understanding will help in giving such patients better care and provide an insight into corrective measures to reduce their frequent visits. It is a great way to keep a list and check on high-risk patients and offer them customized care. Data analytics can be leveraged to analyze user data and the prescribed medication. Moreover, it will be able to provide accurate solutions and also offer customized solutions for unique problems.

Applications/Use Cases: Score 5/5 (Highest)

Data analytics will be applied across every industry from manufacturing to entertainment; around 100 applications would be occurred in the next 10 years. One very important benefit is that the use of data helps companies save so much money, develop better marketing strategies, improve the efficiency in procurement, support the growth of business and differentiate themselves from other competitors in the industry. There are several other areas where the application of data is known to be useful apart from companies alone such as homeland security, policy analysis, traffic control, sport performance and etc.

Market Size: Score 2/5 (Low)

By 2030, the expected data analytics market value in Thailand would be around 185.14 billion THB. And in 2025, it is forecasted that data analytics market value would be around 92.1 billion THB. So, Thailand would witness the double growth from 2025 to 2030. The increase in IoT devices and the data generated from them is one of the factors helping the market's success. The growth of organizational data is also a key factor in the growth, as analyzing such large data sets manually is a tedious task, hence the company's decisions to use Big Data analytics.

Strategic Attractiveness: Score 4/5 (High)

Data analytics is the key driving factor for supporting the 4.0 industries with the contribution to Thailand GDP around 0.5% between 2020 to 2025. It is also the key support to the digital transformation that helps maximize value from shifting channels, redefine consumer experiences, reinvent new models for products and businesses, drive operational excellence, empower talent and build teamwork, and connect the enterprise. Data analytics finds its place in various industries but will be the most adopted in financial and telecommunications services with the CAGR around 18.3% (2018-2025) for Thailand market.

How Data Analytics supports Digital Thailand Agenda

The government itself has also emphasized that Big Data is one of the key drivers of Thailand's digital economy, hence, the government focuses on developing digital manpower throughout Thailand, especially in Big Data, data science, coding as well as encouraging start-ups. Big Data will help maximize value from shifting channels, redefine consumer experiences, reinvent new models for products and businesses, drive operational excellence, empower talent and build teamwork, and connect the enterprise.

To move toward a value-based economy under 'Thailand 4.0', Big Data has been put at the focal point. As we can see that, the government has begun collate data from 20 ministries into a centralized Big Data management system. Once the system is fully integrated, all government agencies will have access to the data, enabling them to better implement policies and facilitate the country's digital transformation. Moreover, the data will be shared to the public allowing start-ups and investors to utilize these data to develop solutions. Finally, Big Data will serve as a backbone of Thailand's economy that helps entrepreneurs to better understand market scenario and customers' behavior.

One of the focuses of 'Thailand 4.0' is to increase output and contribution of agriculture sector. This is because one-third of country's workforce is in this sector but it contributes only 10% to national GDP. Big Data will come to help push the sector to be more productive by collecting data on farmers, crops and soils and then suggest that what kind of crops would be suitable to grow in each period.

Sub-classification of Data Analytics

Virtual agent

Today's personal assistants - now more commonly termed virtual assistants, or VAs - are speech-driven applications designed to assist consumer's complete tasks, such as accessing information on mobile devices. Current conversational technology allows virtual agents to go far beyond interactive voice response (IVR) systems; virtual agents understand customer intent and can provide personalized answers to customer questions in a humanlike manner. Virtual agents typically communicate with customers via email or live chat on corporate websites.

Most companies use virtual agents to handle highly repeatable tasks. For complicated tasks, live customer service agents are required. In the world of customer relationship management (CRM) software, virtual agents are used to provide 24/7 customer service including answering questions on accounts, help with a password, providing recommendations or following up on sales and marketing leads via email correspondence.

For example, Thai Smile launches 'YimYim'; a new system of interactive virtual agent to help increase call center efficient by reducing call waiting time to share workloads from live agents. At this time, 'YimYim' is able to interact to provide initial information to customers such as flight schedule information and ticket price.

The importance of this technology lies at the effective of cost maximization. This is because virtual agents cost significantly less than human employees and an enterprise can free some employees to do more value-added work. Moreover, virtual agents will drive the business's competitiveness with customers are easily able to reach the information of the business. This technology helps enhance Thai business's capabilities to remain competitive in the region.

Emotion Analytics

Emotion analytics records and analyzes a person's facial and/or verbal cues to identify moods such as happiness, anger, sadness, fear, disgust and surprise. Emotional analytics will be increasingly integrated into the wearables space. Wearables will use metrics such as blood pressure, galvanic skin response, and temperature, to measure the stress levels and emotional state of an individual and make personalized recommendations, such as breathing and meditation exercises. Frost & Sullivan believes that the advertising space will also increasingly incorporate predictive analytics through data obtained from wearables to enable even greater levels of hyper-personalization and push notifications based on customer context.

Emotion analytics has been adopted in many industries and being useful. For example, emotion analytics is used in retail to measure the buying behavior of consumers, and ascertain products that consumers are interested in. This helps retailers optimize store displays and enhance their product lines. Customer engagement can be measured in order to drive marketing strategy and product mix decisions.

Emotion analytics also finds applications in law enforcement and public safety by studying human behavior at mass events and public locations in order to observe any deviations from the norm. Potential security threats can be identified in this way.

Video and Image analytics

Video and Image analytics adoption is currently moderate, and is witnessing a high adoption in the social media analytics space specifically. Videos and Images are able to capture a lot more than text, and this is highly relevant for sentiment analysis to target marketing and advertising to the right customer segments. Amongst industry sectors, healthcare is perfectly poised to unleash the potential of image analytics and provide real-time insights to providers for diagnosis and treatment. It enables faster diagnoses, greatly increasing patient access to care and improved patient outcomes. For Thailand, healthcare is one of the most growing industries compared with other countries in the region and contributed around 2% of GDP in 2017.

Video analytics will help with the development of smart security solutions, public safety solutions and intelligent traffic management systems. They will also be increasingly used in the development of smart cities. As we know, smart city is becoming a focal point under Thailand 4.0 and the government put this as a national agenda with 5 core strategies including supporting Big Data analytics as one of those 5.

Moreover, an emerging application area for video analytics is in the mining industry. Theft is rampant in gold, silver, and diamond mines. Supervision of operations is required not only to monitor theft but also to keep an eye on the safety of personnel who operate dangerous machinery. Looking deeply into GDP, we will see that mining is one of the important sectors for Thailand which contributed around 2.7% of GDP in 2017.

Audio and speech analytics

Audio analytics analyzes unstructured audio data to arrive at insights. When applied to human speech, audio analytics is referred to as speech analytics. Audio analytics can be used to build conversational intelligence, music platforms, the home security industry, surveillance, customer service, to name a few.

Audio analytics combined with sensing technologies find applications in the surveillance and professional security industries. This also includes home security where the capabilities of audio analytics have been leveraged through the Internet of Things. Moreover, it has also been useful in increasing customer interactivity in various industries. Platforms are becoming increasingly sophisticated through incorporating different languages, dialects and applications.

Text analytics

Text analytics, also called text mining or opinion mining comprises data analytics techniques that extract rich, meaningful structured data from largely unstructured data by bringing data in term of texts and analyze into statistical data in order to find the hidden insight in those data. To be useful in the current business scenario, text analytics need to be used with advanced techniques such as machine learning and natural language processing (NLP). Such advanced analytics enable an organization to stay competitive.

Currently, text analytics has been adopt to better respond to business's needs as we can see that in social media people express their opinions and feelings in term of texts. So, text analytics would be another method to drive Thailand toward digital society.

Trends of Data Analytics across the world

Primarily, Big Data had captured within large enterprises only. Today, the scope of Big Data is changed and ushers small and medium enterprises (SMEs) to look for business intelligent insights in

Big Data. The interest from both large enterprises and SMEs led to Big Data evolving at an unbelievably fast pace.

The best example of the growth is Big Data in the cloud which has led to even small businesses taking advantage of the latest technology trends.

Facebook, one of the platforms that stores loads of data and offers basic data analytics tools, said that more than half of worldwide Facebook users connect to SMEs pages which will benefit SMEs to analyze customers' behaviors from page visit. Meanwhile in Thailand, most SMEs accepts the role of Facebook in helping them expand their market by reaching new customers, because of information about potential customers on Facebook and intelligent algorithm to boost businesses.

In this coming year, the world will witness the Big Data trend includes …

- **IoT** networks that will generate tremendous data from physical objects, people, places and systems powered by real-time data collected by sensors. There will be loads of unstructured data that contain many insights to explore which will require a modern data platform using an automated data integration solution that engages in data cleaning, de-duplication and unification of disparate and unstructured sources.
- **Predictive analytics** offers customized insights that lead organizations to generate new customer responses or purchases and promote cross-sell opportunities. Predictive Analytics helps technology to integrate into diverse domains like finance, healthcare, automotive, aerospace, retailing, hospitality, pharmaceuticals, and manufacturing industries
- **Dark data** is type of data collecting during regular business activities but usually left unexplored and not in use for business analysis, taking up a lot of storage without being monetized either directly or through analytics to gain a competitive advantage.. However, when data analytics trend is in light, these dark data will be reconsidered to look for an opportunity lost and may lead to a potential security risk.
- **Quantum computing** is another heated innovation that many big players are competing to develop and launch in the market including IBM, Microsoft, Google and Intel. Quantum Computing enables seamless data encryption, weather prediction, solving complex medical problems, real conversations and better financial modeling to make organizations develop Quantum computing components, algorithms, applications and software tools on qubit cloud services.
- **Edge computing and analytics** uses the concept of proximity to process information as physically close to sensors and endpoints as possible, thus reducing latency and traffic in the network. Moreover, it also helps increase security due to its decentralized approach, which localizes processing and reduces the need to send data over networks or to other processors. However, it's worth noting here that the explosion in edge computing and analytics means an even greater need for a flexible data warehouse that can integrate all your data types when it's time to run analytics.

Trends in Thailand

Government Perspectives

All 20 ministries focus on formulating strategy about Big Data by monitoring the implementation of database integration and amending regulations and related laws. The initiative of Big Data utilization will be in use in 3 main areas which are public health, tourism and meteorological to protect natural resources and be prepared for natural disaster through the integration of government data across different agencies. Big Data will benefit from demonstrating problems and circumstances (Descriptive Analytics), predicting and forecasting upcoming situations (Predictive Analytics) to analyzing the data to see possible results (Prescriptive Analytics).

In addition, the government plans to use Big Data to make itself more efficient which will have an impact on important government functions like budgeting, planning and solving socio problems. With Big Data, budget will be allocated to appropriate entities with better transparency throughout the government as data becomes more easily trackable.

Enterprise Perspectives

Many large enterprises in Thailand have come up with digital transformation policy and place Big Data analytics as one of the priority that need to be implemented especially enterprises that rely heavily on digital marketing such as financial sector, e-commerce and telecom. However, in the next coming year Thailand will be expected to see 80% of private sector using Big Data to gain business insight. For SMEs, only a few has realized the importance of Big Data while SMEs in developed countries are more active to utilize data sets.

Even though Thai business sector is awaken to embrace Big Data and use it as one of the marketing tools, less than 20% is success on effective use, more than 40% is on pilot stage and another 40% still has no plan on implementing Big Data within organization. The challenges of embracing Big Data lie at the misunderstanding about the concept of Big Data and the lack of experienced data scientists and data analysts. In general, Thai business is in the stage of storing Big Data but lack of further exploring it into business intelligence.

Big Data market in Thailand was valued THB 6 million in 2017 which will be expected to see the double growing rate in every year and expected to reach THB 12.2 billion by 2022. This means that there is increasing amount of information that needs to be further explored and 80% of that will be unstructured data.

In Thailand, one of the used cases of data analytics is digital marketing. Product-based is still a focus for digital marketing which is a kind of advertising to non-specific customers. This leads to the lack of understanding in offering suitable products to each type of customer such as offering products based on customers' preferences and applying appealing promotion to each customers. So, new digital marketing focuses on customer-based with Big Data analytics as a tool. However, Big Data analytics requires large amounts of data (i.e. customers' information, trading information, PR campaign and etc.)

Digital Innovation in Data Analytics

In the next coming years, advanced analytics will be considered as a core capability to detect the market trends and customer preference in order to remain competitive in the market for many enterprises. Predictive and prescriptive analytics, involving advanced analytics techniques or more complicated models or statistical methods, will be further developed and replace traditional descriptive analytics.

Predictive analytics is a form of advanced analytics requiring more complicated information. This method will try to 'forecast' and 'predict' what is possible to happen next by using the past information, mathematical model together with data mining (in some case). Predictive analytics will allow a business to analyze future opportunities and risks (i.e. market trends, sales prediction or ROI from campaign).
Prescriptive analytics is the most advanced form of data analytics. This method will not only predict the outcome but also give a suggestion to each alternative. Moreover, prescriptive analytics model is adjustable based on add on information and it is the method that links to Big Data the most.

Data analytics will be improved to be able to analyze data and deliver results within hours, minutes, seconds or even milliseconds which are much faster than today that takes days or weeks. This improvement is the result from the increasing of Internet of Things (IoT) and corresponding streaming data that generate loads of data which require more real-time and continuous analysis. Hence, the process of data analytics need to be able to deliver both the simplest, most basic analytics in real time and more comprehensive analysis that is sufficiently effective.

Next enhancement that would be integrated in is context-aware analytics that could deliver a high degree of personalization based on context. The information about consumer's location and time of day would be also taken into consideration.

Another significant improvement that we could witness in the future would be augmented analytics. During data preparation During data preparation, machine learning automation is starting to augment data profiling and data quality, modeling, enrichment, and metadata development and cataloging. Techniques including supervised learning, unsupervised learning, and reinforcement learning are taking data preparation to a new level. Unlike the processes of the past, which relied on rule-based approaches to transform the data, these enhanced machine learning processes evolve based on fresh data to become more adept at responding to changes in the data, especially outliers. Moreover, these algorithms can help visualize and narrate relevant findings such as by automatically exposing correlations, exceptions, clusters, links, and prediction within the data without having end users build models or write algorithm themselves.

One of the advanced innovations in Data Analytics is 'Precision Medicine' which use Apache Hadoop as a tool to help analyze and store Big Data. Precision medicine (PM) is a medical model that proposes the customization of healthcare, with medical decisions, treatments, practices, or products being tailored to the individual patient. In this model, diagnostic testing is often employed for selecting appropriate and optimal therapies based on the context of a patient's genetic content or other molecular or cellular analysis. Tools employed in precision medicine can include molecular diagnostics, imaging, and data analytics.

Potential of Data Analytics

Data analytics will provide opportunities to both public and private organization in creating new jobs, structuring knowledge of R&D, pushing growth of SMEs, and managing the state effectively. Various industries adapt to use data analytics driving the value of analytics growth year by year.

The data analytics accounted for THB 517.3 billion in 2017, and is expected to grow at a compound annual growth rate (CAGR) of 29.7% to THB 2.5 trillion by 2023 globally. The market is driven by organizations realizing the operational advantages of data analytics, empowering organizations to better target consumers, increased access to cloud-based models, enterprise-grade security and data governance solutions offered by market vendors, and continued vendor consolidation.

For APAC, the revenue from data analytics is projected from THB 74.1 billion in 2017 to THB 414.8 billion in 2023 with CAGR at 33.3%. Asia-Pacific businesses are more mature than companies in other regions when it comes to data analytics. As organizational maturity improves to enterprise level and beyond, organizational and funding issues tend to rise. Data analytics will be concentrated more for the several businesses.

For Thailand, investments on data analytics are likely to be driven by banking and telecommunication industries. The value of data analytics market in Thailand is estimated to grow from THB 28.5 billion in 2018 to reach THB 92.1 billion in 2025, at a CAGR 18.3% during the forecast period. According to

Thailand 4.0, every business is driven by data. The benefit from data analysis will support the organization to grow.

The five potential and leading industries which will invest in data analytics within 5 years are banking, telecommunications, discrete manufacturing, federal/central government, and professional services. These five industries will spend more than 55% of the total spending. Additionally, professional service, healthcare provider and resource industries will grow at a highest pace at 5-year CAGR of 16.9%, 16.1% and 15.5%.

Next 10 years, a decision-making process based on data analytics will produce better results; the step to "automated" decision-making will be small. Machine learning will be a method of data analysis that automates analytical model building. The global Machine Learning market is expected to grow from THB 44.5 billion in 2018 to THB 277.9 billion by 2022, at a CAGR of 44.1%. The growth rate of machine learning will drive the growth of data analytics globally. For Thailand, CAGR of data analytics will be at 15.3% after 2025. The growth rate is smaller as there will be other technologies come to place in some part. The potential and leading industries which will invest in data analytics next 10 years are SMEs, banking, Telecommunication, healthcare, and energy.

Data analytics is expected to radically change the way we live and do business in the future. Next 15 years, people will feel normal with data analytics in their single life. All devices will be connected and exchange data within the "Internet of Things" and deliver enormous sets of data. Sensor data like location, weather, health, error messages, machine data, etc. will enable diagnostic and predictive analytics capabilities. We will be able to predict when machines will break down and plan maintenance repairs before it happens. The global AI platform market is expected to grow from THB 66.9 billion in 2016 to THB 311.6 billion by 2022, at a CAGR of 30.5%. Data analytics with AI platform are expected to be widely adopted by both large enterprises, as well as small and medium businesses throughout the world, including Thailand. Every public agency will use Big Data as usual make a CAGR of data analytics be 8.67%. Data analytics will slightly increase next 15 years.

Use Cases of Data Analytics

Big Data analytics can be adapted to use in several industries. Information from Big Data will benefit to the businesses those used the Big Data in different way such as creating business value, supporting decision making, or assessing financial budget. Therefore, the below use cases show how different industries use data analysis in 5 years, 10 years, and 15 years.

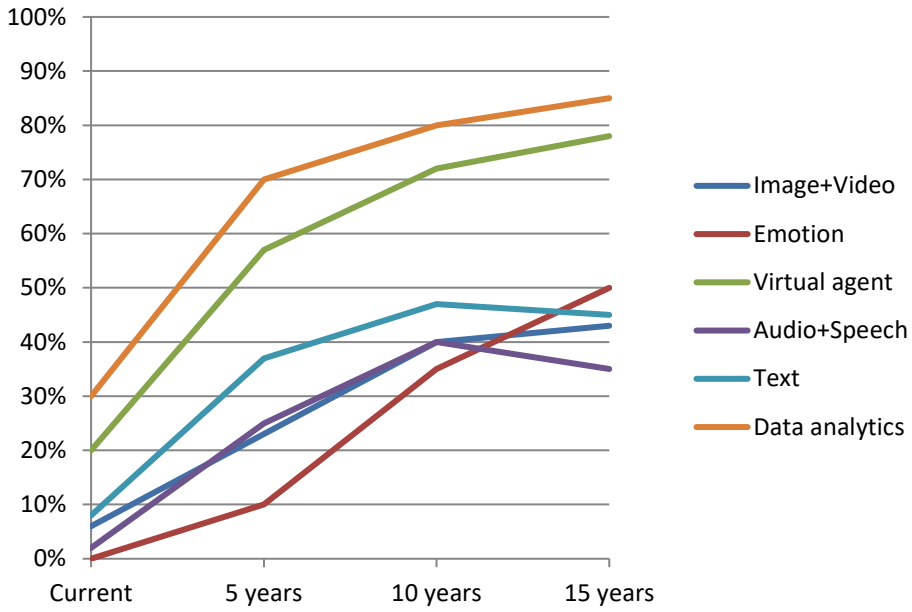
Retail industry: As retail sales in Thailand is projected to increase by at least 5% YoY and Big Data is applied in retail industry, the market of Big Data for retail business will grow along with the retail's growth. The use cases of data analytics in the best retail will share to others in order to keeping their market share. Within 5 years, more than 70% of current companies which currently plan for use data analytics for their businesses will use data for operational analytics and supply chain analysis. As faster product life cycles, retailers will use data analytics to understand more over supply chains and product distribution to reduce costs. Moreover, data analytics will support operational analytics in term of optimizing asset utilization, budgets, performance and service quality. Next 10 years, data analytics will use in personalizing the in-store experience. Customers in the store will be tracked their behavior to measure the impact of merchandising efforts. The retailers will use the data to increase sales across all channels by optimizing merchandising tactics and driving timely offers to incent consumers. Lastly, data analytics will be more advance and incorporate with other new technology next 15 years. Data analytics will be not only using for managing and optimizing power and utility consumption base on temperature controls, lighting management, etc., but it also bringing analytics to the decision in every process of the business supporting with AI.

Telecommunications industry: This industry can analyze data mostly as they have volume of customers which are the source of data. Every customer's transaction will be used to support the data analytics. Network infrastructure, service, and security will be structured according to analyze from the data next 5 years. Customer churn, networking usage, and network performance will be analyzed to monitor, manage, and forecast network capacity and plan effectively for potential outages. Moreover, data analytics will help to build competitive advantages and have efficient cost structure for the telecom. New business models will launch innovative products and services driven by the analytics information. The businesses will optimize capabilities and increase revenue from more-targeted marketing activities. Next 10 years, emotion analytics, audio analytics and predictive analytics will provide satisfaction on customer expectation. As new technology of mobile phone could change to holophone, analyzing data from customer emotion and audio help the firm to get deeper data analysis and lead to get customer's insight. The firm will customize service according to information from data analytics. In 15 years onward, advanced analytics could incorporate with IoT and AI to identify the weakest part in the organization and networking. Automation will support to fix and adjust the weakest part. Real-time analytics could support decision making in the organization.

Financial services and banking: Data analytics has become an integral part of financial services industry as competition with FinTech companies. The financial services firm will detect fraud accurately to reduce costs and improve customer satisfaction via data analytics. The firms will examine transactions as they occur and stop fraudulent activities before they cause serious damage. Therefore, next 5 years, most banks can articulate an analytics strategy and have implemented a set of use cases. The firm will concentrate in sales management (for example, next product to buy, digital marketing, and transactional analytics), financial risk management, and nonfinancial risk (Cyber security) through data analytics which will save more than 50% of resource effort, enabling customer analytics, operational analytics and risk management capabilities. Next 10 year, advanced predictive analytics will be smarter to provide next best offer solution to the customers. The next best offer solution allow the firm providing customize service for each customer though micro personalization feature. They will provide the right offer with the right message to the right customer in the right time on the right channel. For 15 years, financial services and banking will change differently their business model. Bank will deals with other industries supporting the customer to access the data such as the bank could update you with alternative shops or websites where you could buy the same products more cheaply when you just walk into a shop. Virtual agents is one part of the bank helping customers to decide on their spending, saving, and money process incorporating with audio, image, emotional analytics for protecting customer's privacy.

Data Analytics Adoption Cycle

Figure 76. Data Analytics Adoption Cycle



Data Analytics Consumption in Thailand

Image/video analytics

Image analytics adoption is currently moderate, and is witnessing a high adoption in the social media analytics space specifically. Images are able to capture a lot more than text, and this is highly relevant for sentiment analysis to target marketing and advertising to the right customer segments. Therefore, there are only few of Thai enterprises adopting the technology. The trend of image analytics is increasing upward. As social networks have progressed into more visual mediums, it's only natural image recognition and analysis is emerging as a necessary operational to-do. These make the adoption rate sharply increase next 5 years. Amongst industry sectors, healthcare is perfectly poised to unleash the potential of image analytics and provide real-time insights to providers for diagnosis and treatment. It enables faster diagnoses, greatly increasing patient access to care and improved patient outcomes. Without image analytics, brands would miss out on a significant portion of social conversation about their brand, competitors, products and customers. Image analytics significantly impacts marketing strategy and mix. Image analytics is becoming increasingly important in the marketing space and is able to capture a lot of insights that text analysis cannot. These include sentiment analysis, gender, age, activities, objects, scenes and landmarks. For example, text analytics of a children's movie review may suggest that the audience are adults in their 30's; however, image-based analysis will reveal the audience are indeed children. Therefore, the adoption rate will still grow next 10 years with quite faster and slower growth next 15 years.

Emotional analytics

Thai enterprises are planning to adopt emotional analytics for the future. There are little enterprises adoptions but nearly 0%. The ability of Artificial Intelligence (AI) systems to recognize and analyze human emotion and sentiment, owing in large part to accelerated access to data (primarily social media feeds and digital video), cheaper compute power, and evolving deep learning capabilities combined with natural language processing (NLP) and computer vision are main component for emotional analytic. As the emotion analysis needs various technologies to analyze, the growth of

adoption will quite low next 5 year. However, the important of emotion analytics are being quickly realized by enterprises all over the world. Emotional analytics will be increasingly integrated into the wearables space. Wearables will use metrics such as blood pressure, galvanic skin response, and temperature, to measure the stress levels and emotional state of an individual and make personalized recommendations, such as breathing and meditation exercises. Frost & Sullivan believes that the advertising space will also increasingly incorporate predictive analytics through data obtained from wearables to enable even greater levels of hyper-personalization and push notifications based on customer context. Thai people will use a wearable device, up 9.2% over this year. While wearables are still far from mainstream, usage will reach a milestone next 5 years—more than one in five (21.2%) internet users will use a wearable device. Therefore, the trend of emotional analytic will grow after 10 years. New advance technology will support emotional analytics to increase continuously until next 15 years.

Virtual agent

Virtual agent is implemented, especially by early adopters. There is a lot of publicity about both successful and unsuccessful implementations. In Thailand, Line and Facebook provided the platform for enterprises to communicate with their customers through chat bot. Virtual agents' capabilities continue to increase as they improve at capturing inferential data on personal preferences, biases, expectations and habits. The technology will be able to predict the people's needs and wants. Moreover, adoption of virtual agents will reduce the cost which makes the organization meet the effectiveness. Although sales objectives have not been widely adopted for virtual agents, their potential to up sell or cross-sell is expected to be a key factor for increasing acceptance across smaller enterprises. Increasingly demanding for high quality services to improve customer satisfaction is the driver leading enterprises adoption of virtual agents. However, the key to consumer adoption success are the ability of being more personalized, contextual conversation with digital assistants so next 15 years the virtual agents is projected to increase slowly.

Audio/speech analytics

One of the applications of audio analytics is in the smart home industry. Audio analytics today can differentiate the sound of window glass breaking from similar noises such as that of a dropping coin. Unusual sounds such as dripping water and creaking are also detected. Therefore, audio analytics will be applied to each industry when the smart home is adopted. Only little of Thai enterprises have already adopted while the others are planning. However, the useful of audio analytics will drive the various enterprises developing this technology. Frost analyzed that there will increasing number of Thai enterprise adopt the audio analytics to use next 5 years with the continuous growth until next 10 years. The entertainment and healthcare industry will adopt the audio analytics the most. Sales and CRM function will also take advantage from audio to improve user experience and to enable more real times. A better understanding of human emotion will support AI technology create more empathetic customer and healthcare experiences, drive our cars, enhance teaching methods, and figure out ways to build better products that meet our needs. However, flaws and failures lead to some disappointment in the technology. Some producers are unsuccessful or drop their products. Continued investments in other producers are contingent upon addressing problems successfully which will make the audio analytic adoption drop a little bit next 15 years.

Text analytics

Text analytics growth is driven by the technology's central role in social-media analysis and by text analytics' contribution to advanced, semantic search and search-based applications. Currently used in fraud detection and security, a wide range of automated assistants, and applications for mining unstructured data. Feedback180, which is a Thai startup, developed a technology supporting Thai text

analytics. This text analytics tool collects and analyzes every customer feedback from the enormous message on the online world in order to let the organization improve their products and services. If the adoption trend continues, the use of text analytics will continue to increase. Next 5 year, text analytics will be more effective to understand customers' insight so text analytics will be used more and is projected increasing sharply. One of the major reasons for high adoption of text analytics is increasing competitive nature in business is making companies to seek for value added solutions. The main industries, which will apply of text analytics, are airlines, finance, healthcare, journalism, and retail. With this acceptance of the technology, text analysis is becoming a mainstay of the customer service industry, instead of being thought of as cutting-edge as it was before. The trend of text analytics still increase next 10 years with slower rate of growth as the text analytics can detect positive and negative emotions, and also assign scores to denote sentiment strength. However, expensive analytic software and software handling professionals are key factors restraining growth of the global text analytics market. Moreover, government institutions also avoid the use of such analytical tools due to its high cost. This can also hamper growth of the global text analytics market next 15 years.

Data analytics

The technology is just come around 5 years in Thailand; however, it is evolving rapidly and most companies only just started exploring the opportunities. Telecom and financial services are the leading early adopters. The benefit of the analysis information will let the data analytics have a strong upward trend in adoption. Telecommunication, advertising, and insurance are the top three industries investing in data analytics following by financial services and healthcare. However, many manufacturing companies in for example Oil & Gas, Energy and Chemical industries still have little or no experience with Big Data analytics. Manufacturing, retail/wholesale, government, and higher education institution are planning to apply data analytics to their business. These plans make the data analytics trend will grow next 10 year with little growth. The rise in demand for advanced analytics is expected to increase across the country as organizations recognize it is imperative to adopt analytics in order to stay competitive. The data analytics will be going through a strong cycle of development and deployment in enterprises until next 15 years. Data analytics will have machine learning helping to get more value from data and turn into actionable intelligence.

Outlook of Local Companies

Sertis is a Thai company with expertise in Big Data analytics and implementation, data science, and AI-driven solutions such as research tool, medical diagnostic tool, and block chain. The company has capabilities in developing software and platform for data-related services, as well as developing customized solutions. Finally, the company owns a series of "modern" products that are in demand by the market e.g. cancer diagnostic tool, Big Data analytics platform, and block chain platform.

Key Strengths and Strategies

- Offering a range of products including innovative industry-specific solutions that may be a better appeal to the market e.g. cancer detection device and software
- extensive product portfolio and skillsets for data-related services, as well as other services including security platform, geo-analytics tool, and IoT
- Has internal capability to design and implement management platforms and Big Data infrastructure, as well as the capability to provide end-to-end data analytic solutions
- Over half of the current headcounts are working on data. around 10 people are data scientists, around 10 people are data engineers, and over 20 people are data analysts-- data scientist team, specifically, consists of data experts are foreign countries
- The company is targeting financial institutions, retail companies, FMCG, and public sectors as their target segment, with most of current accounts

- Currently, most of the accounts are from retail, healthcare, and energy sector

Intelligist is the outcome of a joint venture between iNET (one of the Thai market leaders in cloud and data centers business), M-Focus (ERP and supply chain consulting), and AIT (ICT and telecom consulting). The company provides services related to data engineering, data science, and Big Data.

Key Strengths and Strategies

- The company has strong expertise in data analytics domain, with possession of skillsets including data science, Big Data, data engineer, and platform development
- The company has complete product profile on data-related services including IaaS, PaaS, and SaaS as well as on-demand training and services
- The company primarily focuses on developing and providing digital platform and also places great emphasis on Big Data virtualization technology.

CDG is one of the Big Data and analytics service providers in Thailand that starts from providing a data backup since Vietnam War. CDG Group has become a professional service provider of integrated and comprehensive total IT solutions in Thailand. The group has been serving leading organizations – from public sector, state-enterprises, to large corporations in private sector. CDG Group has well-calibrated teams and products to deliver Big Data solutions and customize to industrial requirements to maximize business impact, for instance, ability to construct customer profile for marketing purpose i.e. churn rate, retention rate, in order to come up with the most effective and attractive promotions to target consumers.

Key Strengths and Strategies

- CDG group consists of 6 companies which each of them focuses on leverage different capability to the group. For example, GlobeTech, one of the affiliates, provides digital map data and dynamic location content in both Thailand and South East Asia.
- The company has strong expertise in 3 core areas which are 1) Big Data/ Data Analytics 2) IoT and 3) Privacy/ Security. The company primarily focuses on public sector which counts for 90% of the revenue.

G-ABLE is an IT/digital developer and service provider in Thailand partnering with world-class companies in Modern Digital Solutions, Enterprise Business Solutions and IT Infrastructure Solutions. For data analytics, the group has a well-established team certified with world-class partner like Cloudera and Hadoop. The group offers end-to-end data analytics solutions including

- 'Data Processing Platform' – a platform for storing various types of data in order to serve different kinds of information such as data analysis and Horizontal scalable platform based on the need for expansion.
- 'Data Management Platform' – a platform for storing and transforming data to be ready to support group work (Batch) and real-time or near real-time.
- 'Data Analytics & Visualization' – a system that presents information through graphs or diagrams in various formats that are suitable for the data type which facilitates users to work in an interactive manner with tools.
- 'Data Science' – a form of advanced analytics based on data mining to form an analytics model that is suitable with data type and business's demand.

Key Strengths and Strategies

- **Acquisitions to build stronger capabilities**: Despite already having a long list of business partners and subsidiaries, G-Able still aims to acquire more local tech startups that have strong capabilities to develop wide range of technological solutions for enterprise customers through a joint venture or partnership model
- **Expertise**: The group has gained a strong expertise in Big Data and analytics from serving the industries like telecommunications and BFSI.
- **Transformation to become a digital business solutions service provider:** G-Able strategizes its growth strategy by leveraging from the effect of digital transformation trend that is growing significantly in Thailand market into becoming a digital business solutions provider, originally a technological reseller. In its five year strategic plan, G-Able aims to focus on delivering high-demand technologies with enhanced performance and capabilities, one of which is the Big Data analytics.

Feedback 180º is a local startup company who successfully invents deep technology which is a Thai text analytics to offer digital innovation services in order to understand customers' insight and drive a business. "Thai Text Analytics" is originally built from AI that Feedback 180º had been developed. The tool will function by collecting and analyzing every customer's feedbacks from online media and then translating those texts into an insight to improve products and services as well as reduce cost. The company focuses to serve both public and private sector such as BFSI and energy industry.

Key Strengths and Strategies

- The company has put an important on developing its own technology with more than 70% of staffs are product developers and researchers that invest effort and time to develop and enhance technology aspects.
- Another key strategy is to partner with other technology companies to drive business toward but the company has no focus to usher investors for financial aspect.
- The company's long term goal is to be listed in the MAI stock exchange market and be one of the top start-ups in the region.

Outlook of International Companies

SAP SE is a German-based European multinational software corporation that makes enterprise software to manage business operations and customer relations. The company developed SAP HANA. HANA in-memory relational database combines database, advanced analytics (predictive, spatial, text analytics, sentiment analysis, search), enterprise information management (bulk load, real-time replication, transformation, cleansing) and application server capabilities all running in-memory, on one data copy and on a single platform. Moreover, SAP HANA can run analytics on 80 terabytes of data and support volumes of up to a petabyte of data in-memory while returning query results in under a second. It can integrate with Hadoop including a number of analytic engines for various kinds of data processing.

Oracle is an American multinational computer technology. The company specializes primarily in developing and marketing database software and technology, cloud engineered systems, and enterprise software products, especially database management. Oracle has its Big Data Appliance that combines an Intel server with a number of Oracle software products. They include Oracle NoSQL Database, Apache Hadoop, Oracle Data Integrator with Application Adapter for Hadoop, Oracle Loader for Hadoop, Oracle R Enterprise tool, which uses the R programming language and software environment for statistical computing and publication-quality graphics, Oracle Linux and Oracle Java Hotspot Virtual Machine.

Microsoft is an American multinational technology company. They develop, manufacture, license, support and sell computer software, consumer electronics, personal computers, and related services. Microsoft's Big Data strategy is fairly broad and has grown fast. It has a partnership with Hortonworks and offers the HDInsights tool based for analyzing structured and unstructured data on Hortonworks Data Platform. Microsoft also offers the iTrend platform for dynamic reporting of campaigns, brands and individual products. SQL Server 2016 comes with a connector to Hadoop for Big Data processing, and Microsoft recently acquired Revolution Analytics, which made the only Big Data analytics platform written in R, a programming language for building Big Data apps without requiring the skills of a data scientist.

Google is an American multinational technology company that specializes in Internet-related services and products, which include online advertising technologies, search engine, cloud computing, software, and hardware. Google continues to expand on its Big Data analytics offerings, starting with BigQuery, a cloud-based analytics platform for quickly analyzing very large datasets. BigQuery is server-less, so there is no infrastructure to manage and you don't need a database administrator, it uses a pay-as-you-go model. Google also offers Dataflow, a real time data processing service, Dataproc, a Hadoop/Spark-based service, Pub/Sub to connect your services to Google messaging, and Genomics, which is focused on genomic sciences.

Tableau is a software company that produces interactive data visualization products focused on business intelligence. Tableau started out by offering visualization techniques for exploring and analyzing relational databases and data cubes and has expanded to include Big Data research. It offers visualization of data from any source, from Hadoop to Excel files, unlike some visualization products that only work with certain sources, and works on everything from a PC to an iPhone.

Splunk is an American public multinational corporation that produces software for searching, monitoring, and analyzing machine-generated Big Data, via a Web-style interface. Splunk Enterprise started out as a log analysis tool but has since expanded its focus and now focuses on machine data analytics to make the information useable by anyone. It can monitor online end-to-end transactions, study customer behavior and usage of services in real time, monitor for security threats, and identify spot trends and sentiment analysis on social platforms.

Key Issues in Adoption

The complexity

The complexity is a result from several factors including the types of Big Data projects that need to be solved, the variety of tools they are using, the high level of technical complexity to deal with unstructured Big Data, the large amount of Big Data that getting bigger and bigger as well as real-time data that keeps updating every seconds and organizations need to be aware of that too. The concept of Big Data itself may feel a bit confused to conventional decision-makers who are not aware of new technology and core benefits of data analytics. Moreover, the analytics that is being done on the database is continuously changing putting data analytics with more complexity. We can conclude that the data complexity is the same but the technology complexity as well as the analytic complexity has both increased, being a big hurdle holding enterprises in Thai market back.

The lack of human resources

There is a definite shortage of skilled Big Data professionals available at this time. This has been mentioned by many enterprises seeking to better utilize Big Data and build more effective Data Analysis systems. There are a lack experienced people and certified Data Scientists or Data Analysts

available at present, which makes the “number crunching” difficult, and insight building slow. Plus, training people from an entry level can lead to cost-ineffectiveness. However, it is not surprising that there aren’t enough skilled data scientists. Very few universities offer pure data science degrees (as opposed to computer science). Many schools still don’t even offer computer science course as one of the alternatives. It’s going to take some years before there are enough skilled data scientists in the workforce.

Poor collaboration among key stakeholders

Teamwork among a cross-section of departments is essential for evaluating, championing and implementing analytics-driven initiatives. It’s especially important to foster close collaboration between two areas—lines of business and IT. When these groups are in sync, people can outline their key objectives for IT personnel, who in turn can act as expert advisors who explain what analytics innovations are available to support the business. So, it is important to establish a cross-functional analytics team that includes stakeholders in technology, business, operations, legal and HR to promote the use of analytics in individual departments as well as across the enterprise.

Data Security

Most of Thai company conceive and understand the power of data but remain concerned about how analytics tools might expose them to security or compliance threats. This is especially true in industries such as government and banking, where the stakes of losing critical data are high. The data that comes into enterprises is made available from a wide range of sources, some of which cannot be trusted to be secure and compliant within organizational standards. They need to use a variety of data collection strategies to keep up with data needs. This in turn leads to inconsistencies in the data, and then the outcomes of the analysis. Hence, it is necessary to introduce Data Security best practices for secure data collection, storage and retrieval.

Conclusion

Data analytics will become a big technology market in Thailand reaching market value of 185.14 billion in 2030. The drivers for the market come from the surge in data traffic and the subsequent rise in network densification, the proliferation of Internet of Things (IoT) and the rise in adoption of connected devices, the adoption of virtualization amongst network operators, and the expected launch of 5G services. The technology will not be limited to only text or picture analytics but also include emotion analytics, audio analytics and virtual agent. Data analytics will not only increase private sector’s performance but it will be the key transformation to government as well. In Thailand, there is strong evidence that data analytics will be implemented to improve agricultural sector as a main priority due to its lower productivity contribution compared to other sectors. However, the government and related education entities must find an important in offering data science course to solve talents shortage in the market.

3.4 Next Generation Telecom

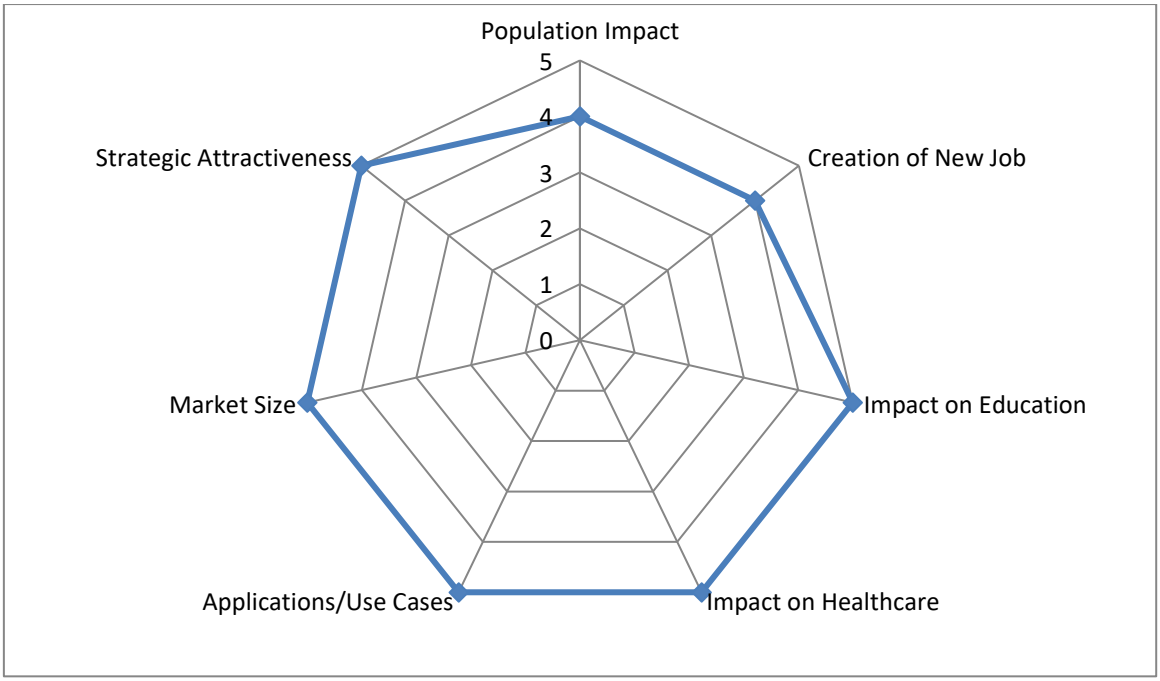
5G is the fifth generation of cellular mobile communications. It will ultimately replace 4G LTE to provide faster and more reliable service with lower latency. The evolution of telecommunication technology started from 1G for only calling, 2G adding more SMS, 3G providing web browsing experiences, and 4G offering video consumption. Next generation, 5G, will support the change of data traffic. The capabilities including higher bandwidth, greater capacity, security, and lower latency will create new opportunities for people, businesses and society. Not only improving from 4G, but 5G also supports other new technology to work effectively such as Internet of Things (IoT) and driverless car. However, telecommunication technology will not stop developing to be more advance. The sixth generation technology or 6G will come to replace 5G in offering faster capacity. The 6G will integrate 5G providing people to monitor and getting information about weather or Earth imaging satellite

networks. In the future, there will be 7G coming to solve the problem of the cost from the last generation so that the user will be benefited.

However, this technology required huge investment and a lot of infrastructure. Only corporation develop this technology is not enough. The government support and cooperation with other industries will help to reduce the challenge of adoption this technology. The challenge of developing 5G are latency in the air link, latency end-to-end, connection density, system spectral efficiency, peak throughput per connection, and energy efficiency. As the 5G technology has potential to grow and develop, 5G-specific R&D has to focus on these challenges. Therefore, study of potential and readiness is important for the countries which are developing 5G technology.

Why Next Generation Telecom has been selected?

Figure 77. Scoring of Next Generation Telecom



Population Impact: Score 4/5 (High)

5G adoption could reach and have impact on 75-80% of Thai population by 2030 as 4G penetration is currently at least 85%. 5G technology is expected to cover more than 40% of the global population by 2024, accounting for 1.5 billion subscriptions, according to Ericsson. By 2020, 5G is aimed at increasing wireless capacity 1,000 times, connecting 7 billion people around the world, connecting 7 trillion IoT devices, saving 90% energy with zero downtime perception, thus it will increase connectivity coverage and use cases significantly in urban areas as well as rural areas in countries like Thailand. The key factors behind this growth are increased network capacity, lower cost per gigabyte and new case requirements coupled with increasing adoption of affordable smartphones and mobile internet packages. However, apart from increasing connectivity, Thai population will also get exposed to a higher number of cyber incidents such as identity theft, phishing and fraud as a result of the rise of 5G-powered connected devices if cybersecurity infrastructure were not put in place to cope with such trend.

Creation of New Job: Score 4/5 (High)

5G will create new 130,000 jobs in Thailand by 2030. The underway rollout of 5G networks in Thailand will further increase not only the economic importance of the telecommunication industry but also social impacts in terms of employment opportunities. The investment that Thai mobile operators will put over the next 5 years will create a significant number of jobs and boosting GDP. IoT, which has the potential to revolutionize and improve numerous industries from manufacturing to energy to transportation, will depend on robust and quick 5G networks. As such, an expansive 5G network will form the bedrock of IoT enhancements, like predictive maintenance on factory machines or constantly-connected smart products (fridges, washing machines).

Impact on Education: Score 5/5 (Highest)

With AR/VR enhanced by 5G technology, students in Thailand can have improved experience with meaningful learning from more interactive, immersive means by viewing content through their headsets where pictures and study notes pop off the page, instead of reading text books, hence considerably transforming the provision of education. 5G-powered AR/VR offers opportunity to interact with content in a completely different way, for instance visualize 3D models in the real environment, in real time, and at scale and predict future trajectories. It also provides enhanced understanding and recall of historical events, as AR enables students to experience the smell, sound, and visuals of people living during different eras. In the near future, it will have a significant impact on education sector in terms of ease of provision, material creation, learning and development at most levels from primary, secondary, tertiary, professional and other forms of education and skilling.

Impact on Healthcare: Score 5/5 (Highest)

Utilizing AR with 5G performance, medical professors can leverage the augmented technology to educate medical students and doctors in Thailand on new therapies and drugs, thus streamlining communications. Through AR technology, medical students can easily access and understand complex body models as well as images and text found in medical textbooks. AR also contributes to healthcare training by allowing students to discover the health risks around the locality using GPS in conjunction with AR to support delivery of situated contextualized learning. In addition, in nurse training, AR enabled tablet-based simulation of patient scenarios are capable of helping nurses to better connect with their patients. With help from AR, nurses and other staff are able to handle daily work situations requiring a combination of social, technical and team skills. 5G will also fuel mainstream integration of payments into everyday life, including receiving healthcare services. There is tremendous potential for growth alongside connected devices in IoT, enhancing productivity and increase customer satisfaction. Thus, 5G technology will have significant impact on Healthcare sector and impacts the following 4 areas in diagnostics, disease prevention, disease management (healthcare provision) and payments.

Applications/Use Cases: Score 4/5 (High)

5G's main features provide ultra-high data throughput, ultra-low latency, massive connections, high reliability, and high mobility. Thus, there will be more than 60 different 5G use cases, covering mobility, manufacturing, media/entertainment, health, farming, and smart city applications. The majority of use cases demanding the highest requirements for 5G are found in business-to-consumer (B2C) media, especially in augmented/mixed reality and in mobility, where highly automated vehicles will influence demand in the foreseeable future. Virtual reality (VR), augmented reality (AR) and mixed reality (MR) will benefit from the mobility of 5G and the processing power of mobile edge computing, which puts processing power close to the base station. The computing power must shift from the glasses into the smartphone as a temporary hub, then onto the edge of the network once the 5G radio interface can sustain low latency, to keep wearable devices light and conserve battery life. Meanwhile, the automotive industry and especially autonomous driving is among the most likely areas that will be boosted by 5G. For higher levels of automated driving, communication between vehicles

(V2V) and between a vehicle and the infrastructure (V2I) is needed to handle tasks like collaborative sensing, cooperative driving (e.g. turning left), platooning (the linking of two or more vehicles in convoy), collisions, and hazard or queue warning.

Market Size: Score 5/5 (Highest)

Thailand's 5G market size will reach a value of THB 653 billion by 2030 due to a higher adoption of affordable smartphones and mobile internet packages as well as the rising deployment of 5G-powered connected devices in a large number of verticals, namely manufacturing contributing to Industry 4.0, automotive, healthcare, tourism, education, public safety, media, retail/E-Commerce, logistics and delivery, payment as well as, collectively, the development of smart cities and smart ecosystems across the country. For example, 5G will enable real-time loading of images/videos and use of AR/VR in the retail sector. This will improve the user experience and boost sales. Also, 5G will effectively enable and increase competitiveness of AI, for example drones, for commercial purposes in the urban areas. This will lead to use of drones in logistics and delivery in urban areas.

Strategic Attractiveness: Score 5/5 (Highest)

5G can enable global economic output of US$ 12.3 trillion by 2035, equivalent to US consumer spending in 2016. Global 5G will create output of US$ 3.5 trillion, larger than today's value of entire mobile value chain and 22 million jobs. 5G will contribute 5.5 times to Thailand's GDP volume between 2020 and 2035. In case of failing to adopt 5G by 2030, Thailand would face an opportunity loss at THB 2.3 trillion or 20% of the current gross domestic product. Manufacturing would be the most affected sector, expected to lose between THB 700 billion and 1.6 billion of economic output by 2030.

How Next Generation Telecom supports Digital Thailand Agenda?

As the Ministry of Digital Economy and Society is driving Digital Thailand, there are 3 important points which are to reduce social gap through technology, to distribute income on the foundation of sustainability, and to empower the development of knowledge to be a digital workforce. All of these important points are supported by strategic plan of Digital Agenda. Digital Agenda focuses on developing the foundation of being a smart city to achieve sustainable growth in 5 ways as follows:

1. Digital Infrastructure: 75,000 villages throughout the country will have to access the internet equally including having laws regarding digital.
2. Digital Manpower: Enhancing digital knowledge for people as well as collaborating with the private sector to push to create an ecosystem suitable for the community.
3. Digital Tech Development: Supporting the emergence of Eastern Economic Corridor (EEC) through focusing on developing digital industries such as Digital Applications, IoT Institute, Internet of Things (IoT).
4. Cyber security: Establishment of National Cyber Security Agency
5. Digital Government: To bring Big Data to be useful and there will be a National ID, Paperless and Cashless project.

Technologies such as 5G and Artificial Intelligence are key battlegrounds, so the large operators in many countries are making advanced bets. As Digital Thailand agenda would like to focus on Digital Tech Development. 5G will be the key technology supporting the plan. The combination of speed, responsiveness and reach could unlock the full capabilities of other hot trends in technology, offering a boost to self-driving cars, drones, virtual reality and the internet of things. As more technology tools like 5G enter the market, IoT will have more opportunities to expand on features, products and quality. Networks are building 5G with an open access approach, and with multiple connectivity schemes at its heart, it will also pave the way for a whole new range of services, solutions and applications, with a progressive technology shift towards new frontiers.

The 5G wave will unleash new levels of creativity, use case execution and will not only accelerate the digital transformation of business but also reinvent how governments and organizations protect and enhance the lives of citizens worldwide. 5G will therefore help with the future development of smart cities, supporting applications that will enhance the lives of citizens by bringing about greater efficiency to a large number of vital services.

Sub-classification of Next Generation Telecom

As sub-classification of the 5G technology is the evolution from the previous generation of the technology, government should select 4G sub-classification onward. However, the timeline of support is different in each class.

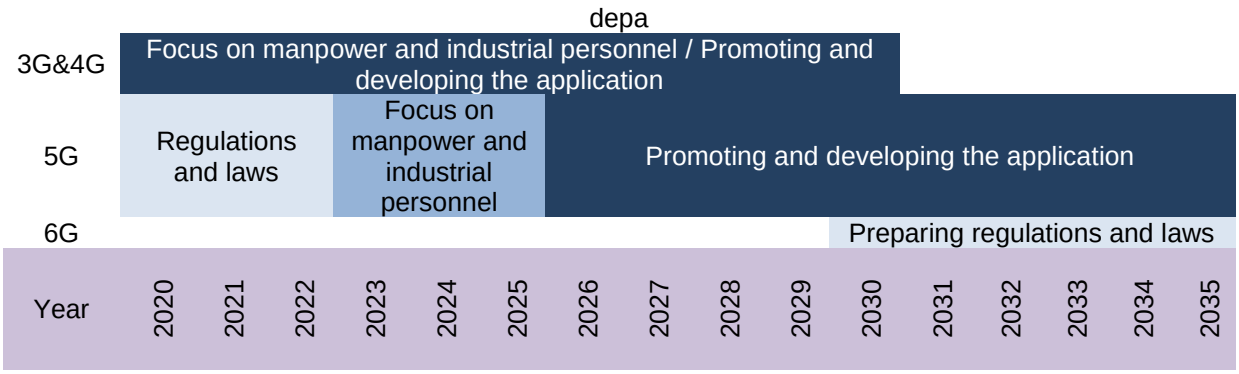
As 2G networks across the country has been set a schedule for the mandated shutdown by Thai telecoms regulator NBTC. The end to all 2G services will be in October 2019. Therefore, depa does not have to focus on 2G anymore.

For 3G and 4G, Thai telecommunication has provided the services since 2012. 3G Technology is designed for multimedia communication. It provides services like higher data transfer rates. However, 3G may not be sufficient to meet needs of future high-performance applications like multi-media, full-motion video, wireless teleconferencing. This reason makes 4G happen. 4G is beyond 3G which will enable another leap in wireless data-rate and spectral efficiency. Some country such as Taiwan has already shut down 3G network as 4G can use instead. However, Thailand still supports both 2 networks' services. The development of internet services, 3G and 4G, give a positive impact on the economic growth through investment, employment and upgrading of labor productivity. Therefore, depa has to support 3G and 4G technology through providing knowledge and encouraging Thai people to use 3G and 4G in the right ways which will drive the Thai economy growth. They also push the various businesses to apply the technology for creating new innovations. The timeline for depa on 3G and 4G is about 5 years until 2025.

Now, the trend of 5G is coming. All countries concern about preparing for 5G technology including Thailand. Within 2021, Thailand could have enough capacity for using 5G. This make depa should focus on this technology in term of the regulation and human resource. Recommending, expediting, and following up the law and regulation for 5G before it comes in year 2021. Moreover, promoting, supporting, and carrying on the development of manpower and industrial personnel are main key to drive 5G being used effectively. The timeline for depa on 5G is about 15 year until 2035. Promoting and developing the application of 5G to apply in businesses, industries, communities, and local are the step after 5G is ready.

Lastly, year 2030, depa will plan to focus on 6G. The regulation and infrastructure will be prepared and readied before in order to be a leader of 6G technologies. After that, the strategy plan for 6G will be created within 2030 along with developing infrastructure for 6G in Thailand.

Figure 78. Approaches to drive Next Generation Telecom in Thailand



Trends of Next Generation Telecom across the world

High bandwidth of 5G will be a game-changer in today's rapidly transforming digital world. However, service providers need to be smart when it comes to planning and rolling out this multimillion investment. 5G will bring a new era in digital services as well as a new revenue source for mobile network operators (MNOs). It will be the enabler for real time use cases such as AI, AR/VR and connected vehicles. Additionally, 5G will result in opportunities for cloud, software, network equipment manufacturing and IoT applications/sensors industries to increase their sales and market share.

According to the World Bank, a 10% increase in internet connection speed translates into economic growth of approximately 1.3%. With 5G, today's 4G speeds of up to 1Gbps could potentially increase to up to 100 Gbps. To date, speeds of 20–70 Gbps have already been demonstrated using pre-standard 5G, and 5G specifications cover speeds of up to 20 Gbps. Therefore, countries are looking forward to the positive impact that full-fledged 5G will have on their economies.

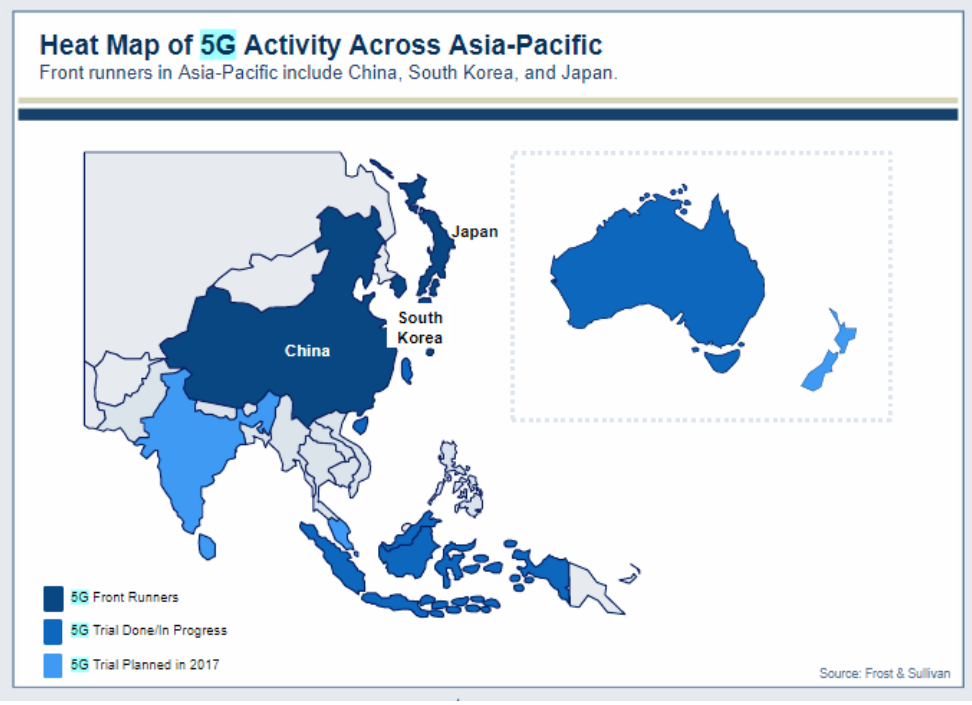
Global digital economy transformation has resulted in similar initiatives replicated all over the world, that is, in the field of automotive, health, and factories. Industrial Internet of Things (IIoT) is the latest convergence of information technology (IT) with operational technology (OT), and 5G has been identified as the platform of choice to support global industrial and economic transformation.

5G represents a fundamental shift in communication network architectures that will enable future revenue generation through innovative services facilitated via 5G devices inclusive of smartphones and wireless devices. Further with 5G offering latency below 1ms and larger bandwidths, MNOs can gain an edge over fiber networks and regain competitiveness amidst declining revenues from traditional core services. 5G will trigger a quicker transition to distributed, cloud native networks that will combine the principles of NFV, SDN, and MEC, thereby reducing the cost to serve and improving on efficiency and profitability for MNOs. This, in turn, will result in entire industries transforming and new industries emerging as internet speeds go up and data costs come down.

Trends in South East Asia

Southeast Asia is fast becoming one of the hubs of the Fourth Industrial Revolution. Countries in the region are already planning to develop and deploy their respective 5G networks. Over the past five years, the region has established itself as a leader in implementing the latest technologies such as blockchain, Artificial Intelligence (AI), robotics, cloud computing and fintech among others. To implement such technological solutions, 5G internet is essential.

Figure 79. Regional 5G activity



Singapore: M1 conducted a 5G trial and reached peak surfing speeds of 35 Gbps. StarHub has been testing technologies that offer speeds of greater than 1Gbps, but will deploy it when it gets new spectrum. Singtel plans to offer up to 1 Gbps on its 4G network by end 2017 at high-traffic locations such as the Central Business District. Compatible phones will be made available by then. It is contributing to 5G standards through board membership of NGMN and by participating in its 5G Committee. However, 5G is already expected to be rolled out by 2020.

Malaysia: Malaysia is reported to have started running its tests for 5G although the network won't be commercially available until 2020. A local expert shared that MCMC will likely incorporate more stringent conditions in the AIP for 5G and there is possibility of a third-party infrastructure provider for 5G similar to Digital TV. Celcom plans trials from May 2017.

Indonesia: Indonesia has also dabbled with 5G internet. Recently, two mobile network providers there, Telkomsel and XL conducted 5G trials during the 2018 Asian Games. Trials ongoing in Indonesia, with Telkomsel trials having reached 1Gbps; 5G deployment planned for 2020. Telkomsel achieved a demonstration of Massive MIMO on its 4.5G network in April 2017.

Vietnam: the Vietnamese government awarded the country's first trial 5G license to its largest telecommunications company, Viettel which will work in conjunction with Ericsson and Nokia. The trials are expected to run until 2020 throughout Hanoi and Ho Chi Minh City, although Viettel will not be able to generate any revenue from the project until the pilot is over.

Cambodia: Expand and modernize 4G networks in interim in order to leapfrog to 5G later on; target to deploy 5G in 2021.

Philippines: In the Philippines, work is already being carried out to usher in 5G. Philippine telecommunications firm Smart has announced plans to deploy a 5G pilot network in the first half of 2019, while Globe Telecom has said that a 5G network could be available as early as the second quarter of 2020.

Myanmar, Laos, and Brunei: No updates on 5G as of now, as these countries have only recently started rolling out 4G networks.

Trends in Thailand

Thailand plans to be the first ASEAN country to adopt 5G. They have conducted a 5G demonstration in January 2017. 2.6GHz will be auctioned by 2017, 1.8GHz and 850 MHz by March 2018, and 700 MHz by 2020. NBTC targeted Thailand to have 5G used by October 2020. They have prepared for the spectrum to be well supported. Additionally, NBTC has approved AIS to import devices to perform 5G demonstrations and officially launch 5G demonstrations on the 26.5 - 27.5 GHz frequency band in October 2018.

It is believed that the first demonstration of 5G usage from AIS will spark 5G to be used in Thailand at the end of 2020 until 2021. The country's economy will be affected by happening of 5G.

AIS said that as AIS is a provider of digital infrastructure services or Digital life service provider, the company will bring new technologies like 5G into the country. They will prepare the country's infrastructure for future competition, especially the business sector that will transform the industry to the next level with 5G technology.

Other telecommunication company such as True also invested in 5G technology as well. TrueMove H established technology service in global standard called FDD Massive MIMO 32T32R which will be important technology for 5G. The advantage is the distribution of channels to support the transmission of data for individual users, as well as having a private channel to increase capacity up to 4 times enabling more users.

Huawei Technologies, Nokia and Ericsson are among the companies taking part as Thailand begins testing fifth-generation wireless network technology, hoping to do business in one of the first Asian countries to make the jump to 5G.

Ericsson (Thailand) expects that the 5G network will be rolled out in Thailand from 2020 to 2022. Telecoms operators will be first movers for this technology in the country. The 5G network would boost the update of the Internet of things (IoT) and enhance the use of mobile broadband, among other benefits. Around 70 per cent of IoT leaders are focusing on cellular IoT and around 80 per cent of operators around the world want to move up the value chain of the 5G network

Ericsson also estimated that number of LTE/5G registration in Thailand will be double during 2017-2023 with the market share of over 60% in 2023. The Thailand economic value is projected to increase 22%. Therefore, operators in Thailand and the government should be prepared to deal with 5G for the benefit of the country in all dimensions.

5G will be applied in all industries such as machine intelligence, ubiquitous web, mobile broadband, unmanned vehicles, and AI translation software. Aside from the manufacturing, energy and utilities, and public safety sectors, 5G would also be a draw for providers of healthcare, public transport and companies in the media and entertainment industries. 5G will eliminate the obstacles of accessing to education and public health service.

SME's and start-ups, both of which are prolific in Thailand, are also set to capitalize on the opportunities bought about by 5G to generate business growth and support digital transformation initiatives.

However, there are some expert provided recommendations on 5G technology. Pacharasut Sujarittanonta, Assistant Professor in Faculty of Economics Chulalongkorn University, said that 5G is more than just connection. It still needs to focus on transparency and fairness of management and

operations. 5G has to be provided comprehensive service and have a policy to communicate information through the network which will maintain the privacy rights of users as well.

Ericsson Thailand said that 5G will happen if consisting of 3 components which are frequency band, network expansion, and 5G ecosystems.

Therefore, governments and telecom companies need to ensure that the necessary infrastructure is made available to not only mobile carriers but small rural providers, community connectivity organizations, building owners, factory owners and schools. Only then can 5G become a reality.

The drive for governments and industry regulators to push for faster internet speeds through 5G comes from the angle of its potential contribution towards a country's economic growth and digital economy transformation. Industry regulators need to understand what 5G is and why the right regulatory strategy will be essential to the success of 5G.

Digital Innovation in Next Generation Telecom

Whilst 5G is still broadly in proof-of-concept stage today, its network capabilities have the potential to effect unprecedented change. New levels of connectivity offered by 5G will have a far-reaching impact in paving the path to widespread adoption of automation – a key building block for digital cities and smart industries. These low-latency, high-bandwidth networks will bring intelligence to the edge, where data is generated. Edge devices, enhanced with analytics capabilities and computing power, will broaden the horizons of what is possible with data, both in its collection and application. With real-time insights becoming readily available, organizations across all industries, from automotive to medical to manufacturing, are granted access to a wealth of information they can mine and exploit to boost their success. With growing intelligence at the edge and unprecedented network capabilities – made possible by the arrival of 5G – the business possibilities of real-time insights are endless.

Potential of Next Generation Telecom

In the next 5 years, it is forecasted the 5G service revenue in Thailand will grow to THB 7.5 billion by 2023 and will reach THB 2.32 trillion in the next 10 years by 2028 at a CAGR of 315.1% during the 10-year forecasted period due to the continuous expansion of digital economy, the increasing rate of 5G adoption in many industries including manufacturing, utilities and professional and financial services with various uses cases and applications such as the growth in IoT services, the integration of VR/AR into the 5G service, the facilitation of Smart City. With 5G infrastructure, Thailand will be able to compete on the basis of "economy of speed" rather than economies of scale, while at the same time opening up new business and industrial opportunities, such as those related to autonomous cars. However, in the next 15 years, the 5G service revenue will begin to drop to THB 97 billion by 2033 with a CAGR of 53% during the 5-year forecasted period as the technology will reach its peak and maturity and step aside for the faster, next generation of mobile technology in 6G to take over.

Use Cases of Next Generation Telecom

In the next 5 years – WTTx (Wireless to the Everything) is a new 5G-based broadband access solution, which use wireless to provide fiber-like broadband access for household in rural areas of Thailand with an aim to offer universal connectivity to areas unreachable by other types of broadband access. WTTx does not rely on permanent infrastructure installation, thus requires lower investment cost compared to other wired access with fast deployment and roll-out as well as easy maintenance, offering quick win for both operators and subscribers. WTTx allows wide network coverage and fast deployment by leveraging existing infrastructure, helping operators to shorten their network deployment time and reduce network construction costs. End users can enjoy a range of high-speed

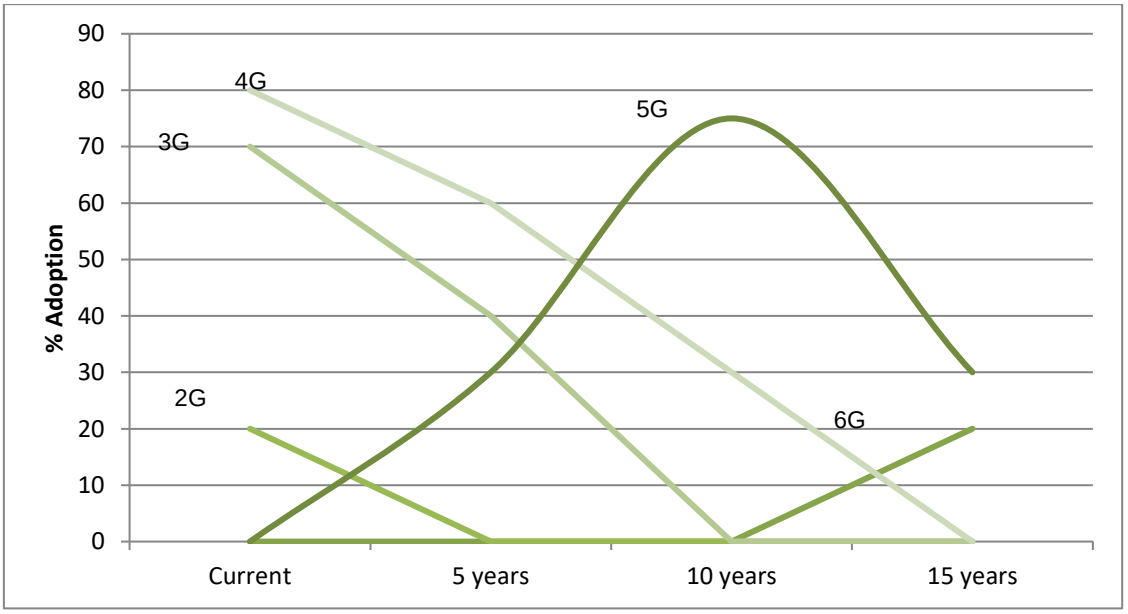
broadband services by simply switching on a plug and play modem. This also helps reduce the operation and maintenance costs of operators.

In the next 10 years – For automated manufacturing enabling the smart factory of the future in Thailand, the mobile 5G technology will allow for higher flexibility, lower cost, and shorter lead times for factory floor production reconfiguration and layout changes, leading to reduced system setup time, increase productivity and minimize machine downtime. 5G technologies provide the network characteristics essential for manufacturing. Low latency and high reliability are needed to support critical applications. High bandwidth and connection density secure ubiquitous connectivity. To manage the large amount of data and information from these connected devices, Thai manufacturing companies will need 5G's capacity and speeds. From procurement to distribution, 5G will mean manufacturers can connect more sensors, devices and assets through a single network giving them better visibility into the supply chain. The possibilities for these connected devices are nearly endless. For example, these connected devices could help improve predictive maintenance and operational efficiency on the factory floor as well as prevent theft and quality issues within logistics channels.

In the next 15 years – autonomous driving is the self-driving of a vehicle to a specific target in real traffic without the intervention of a human driver. Such a vehicle gets its input data primarily from visual information sources that are also available to the driver. In the preliminary stages of autonomous driving, technology enhanced a driver's awareness by providing information that enabled him or her to make a decision and react quickly. But when a vehicle reacts autonomously – without active intervention from a driver – through algorithms that force the vehicle to react in a specific way, one speaks of autonomous driving. When it comes to self-driving, the speed and data processing capabilities are needed to mimic the timing of human reflexes. In other words, how long it takes for the computer to make a decision has to be in less time than a human would take to make a decision – 2 milliseconds. That's where 5G can play a crucial role. The benefits of autonomous driving are reducing accidents, reducing traffic congestion/lowering fuel consumption, reducing CO2 emission and offering more efficient parking.

Technology Adoption Cycle

Figure 80. Adoption cycle for 2G, 3G, 4G, 5G and 6G



Source: Frost & Sullivan

Next Generation Telecom Consumption in Thailand

5G will see a large scale commercial adoption in Thailand by 2020-21 as operators begins the trials and roll-outs in the next few years. In order to increase the 5G consumption, the most pragmatic choice is to create an environment where all vendors can compete fairly with each other, leading to the most efficient investment in 5G infrastructure and benefits the general public with site sharing being one of the options to speed up 5G progress due to huge investment and site readiness required for the transition.

There are now more than 100 million phone numbers in Thailand using the 4G network a dramatic figure given the country's population of 69 million with 80% penetration of unique mobile users,. The penetration rate of smartphones in Thailand is among the highest in all of Asia.

2G networks across Thailand have been set a schedule for the mandated shutdown by Thai telecoms regulator NBTC. The end to all 2G services will be in October 2019.

Outlook of Local Companies

AIS is putting the brakes on 5G implementation and investment, saying the technology should not be commercially launched in the country before 2021 as the next two years should be a period of lab tests and business experimentation. AIS has adopted more cautious approach as they believe 5G implementation and investment should come at a proper time, when local businesses establish a system for its use. AIS is also urging the telecom regulator to facilitate 5G infrastructure investment by designing practical conditions for spectrum auctions in which the highest bid is not first priority. In November 2018, AIS became the first mobile phone network operator in Thailand to commence 5G technology testing in Thailand, including making it available for trial in collaboration with global partners Nokia, Huawei and ZTE Corporation.

AIS and True have both set up 5G development labs through collaboration with Chulalongkorn University, in line with regulatory requirements. Both 5G facilities will be fully operational by March 2019.

True is establishing the 5G & Innovative Solution Centre through Truelab@ChulaEngineering at the university's engineering faculty to develop 5G technology and solutions. TrueLab@ChulaEngineering will occupy 600 square meters and aims to make contributions in the fields of education, medicine, transport and industry. The venue is for learning and training, exhibiting relevant case studies, exchanging innovative ideas and sharing experiences in the form of open innovation, for which True will provide technical support in the form of equipment, devices, expertise and funds for researchers and students.

Meanwhile, AIS is working with the Faculty of Engineering to open the 5G Garage Innovation Lab for developers to innovate using the first 5G Live network in Thailand. The Lab consists of comprehensive basic knowledge for 5G technology structure, network equipment, signal-receiving equipment and examples of use cases that come from the cooperation of world-class equipment manufacturers, along with Co-Develop 5G prototype service workshops to support the management of organizations in both the public and private sectors.

Outlook of International Companies

The key market leaders in Thailand's 5G landscapes are Huawei, Ericsson, Nokia and ZTE as they are attempting to push and increase the adoption of next generation wireless technology in the South East Asia country.

Globally, Huawei has shipped more than 40,000 5G base stations and obtained 30 5G commercial contracts till now. Apart from that, Huawei has increased its R&D spend in areas such as fixed access

transmission, wireless and core networking. Huawei is also planning to introduce a new technology to support autonomous driving, which requires faster operation for driverless cars by automating network workflows. In addition to these developments the company has also built a number of smart and innovative products, including ultrafast flash storage, a datacenter switch backed by Artificial Intelligence, a Wi-Fi 6 access point, and AI-powered software-defined cameras.

In Thailand, Huawei is among the companies taking part as the country begins testing fifth-generation wireless network technology, hoping to do business in one of the first Asian countries to make the jump to 5G. China's Huawei spent $5 million on related facilities as it tries to sustain its overseas expansion while countries around the world move to restrict its participation in local network projects. The companies hope that by winning contracts in Thailand, they can secure new opportunities in its neighbors as well.

Ericsson will switch on 5G globally in 2019, backed by a strong, secure and available portfolio. It also stressed the role of 5G as a critical national infrastructure, and emphasized the advantages for early adopters. Ericsson has announced commercial 5G deals with 10 named service provider customers, as well as 42 memorandums of understanding. The company is already rolling out 5G networks across the globe: in the US, Europe, Asia, and Australia with more roll-outs expected. According to Ericsson ConsumerLab research, one-third of smartphone users globally will change either immediately or within six months to a service provider that switches on 5G. The first commercial scale 5G beneficiaries will be mobile broadband consumers with massive and highly cost-efficient capacity expansions facilitating new applications in augmented reality and virtual reality in areas such as gaming and sports broadcasts. Also, 5G would move the industry beyond consumer products and into the industrial internet, with ongoing collaborations in both mobile robotics and all-electric, autonomous vehicles as examples.

ZTE established its leadership in 5G by investing heavily in 5G standardization and product R&D, and subsequently deriving profound insights into 5G technologies. Working in 5G deployment for years, ZTE has launched a series of commercially oriented all-band 5G AAU, 5G transport, 5G core network, 5G devices, and other end-to-end 5G solutions to prepare for large-scale 5G commercialization. As a technology and network supplier, ZTE provides 5G terminals, radio networks, transmission networks and core networks and also support certain 5G applications. ZTE aims to support Thailand as a leader in 5G technology in Asia-Pacific as part of Digital Thailand or Thailand 4.0.

Verizon plans to deploy the 5G next-gen wireless technology in 30 US cities by the end of 2019. Verizon 5G Mobility will launch in the first half of 2019, and Verizon 5G Home will expand coverage to more markets in the second half of the year. The launch will be for standards-based 5G, which is different from the non-standard form of the technology it deployed last year when it launched its wireless home internet service. 5G is poised to majorly impact the enterprise, paving the way for smarter cities, improved industrial automation, and better enablement of Artificial Intelligence (AI) and Internet of Things (IoT) deployments, according to Verizon.

AT&T’s 5G network went live in parts of 12 US cities in December 2018, making it the first wireless carrier to launch a mobile network based on the 5G standard. A small number of customers will be able to use the network when AT&T will begin distributing its first 5G device: a mobile hot spot that can connect to the network’s much faster airwaves. AT&T won’t charge customers for the hot spot or their 5G service during this launch period. Sometime in the spring, AT&T will begin selling the hot spot for $499. AT&T is also announcing the price of its first 5G plan: $70 per month for 15GB. The announcement suggests that future 5G devices will also require “5G compatible” data plans in order to connect to the faster network. That initial plan is more expensive than the LTE plan offered with a similar 4G hot spot ($50 for 10GB), but it also offers more data. And despite the hot spot launching,

AT&T still isn't offering real-world speed estimates as the hot spot has peak theoretical speeds of 1.2 Gbps, but that actual speeds will be lower.

Sprint revealed that Atlanta will be one of four cities that will see the mobile 5G service launched in May 2019. According to Sprint, Atlanta will join Chicago, Dallas, and Kansas City will join Houston, Los Angeles, New York City, Phoenix, and Washington, D.C. in the initial roll out. Sprint said it would cover 1,000 square miles across nine markets when the service is launched. True 5G service is expected across multiple carriers in the next few years and has the potential to revolutionize how the Internet is delivered. 5G coverage could push data rates as high as 1Gbps in some specific cases and at least 50mb in most places. If 5G coverage can achieve those speeds, it would become a major player against companies like Comcast, Charter, and other cable internet providers. Theoretically, an Internet user could hook into a 5G connection and have plenty of speed for all devices in the home without needing cable internet.

T-Mobile's 5G network won't launch in full until the second half of 2019 because there aren't any phones yet that fully support T-Mobile's 5G network. The initial wave of 5G phones don't take advantage of the main chunk of airwaves that T-Mobile is using to deploy 5G, and without that support, they just won't be very useful. T-Mobile will still be launching 5G millimeter wave installations. But there'll be few locations that support millimeter wave, and because millimeter wave has a very short range, their reach will be quite limited.

Key Issues in Adoption

- Changes to MNO operations - New skill sets will be required to handle network provisioning and management.
- Higher costs than for 4G network - 2x more sites than 4.5G network with increased use of small cells on the fronthaul, increased capacity for fronthaul and backhaul, and additional O&M to run 5G network concurrently
- Security in the converged 5G ecosystem - the new Converged IT-OT 5G ecosystem will require a new approach by the Service Providers. Also, automated Response Monitoring & detection, Predictive Analytics and Open approach will become important
- Overall investments required - pricing for 5G equipment by mobile network equipment vendors are yet to be released, but secondary research uncovered some estimates.
- Uncertainty in regulation – including factors such as frequency auction, rollout obligations, privacy, security and compensation.

Conclusion

5G will contribute 5.5 times to Thailand's GDP volume between 2020 and 2035. In case of failing to adopt 5G by 2030, Thailand would face an opportunity loss at THB 2.3 trillion or 20% of the current gross domestic product. Thus, Thailand can't afford to miss the adoption of fifth generation wireless technology by 2020 to prevent the country from lagging behind other countries with similar developments. Also it's crucial for Thailand to adopt and establish 5G ecosystem in the next 1-2 years if they were to drive its economic potential in a form of Digital Economy to achieve exponential growth like China.

3.5 Distributed Ledger Technology (DLT)

Network can be separate to 3 models which are centralized, decentralized, distributed networks. Centralized systems are system which has many nodes connected with a central server. In decentralized systems, every node makes its own decision. The final behavior of the system is the aggregate of the decisions of the individual nodes. Lastly, decentralized systems, every node make its own decision. The final behavior of the system is the aggregate of the decisions of the individual nodes.

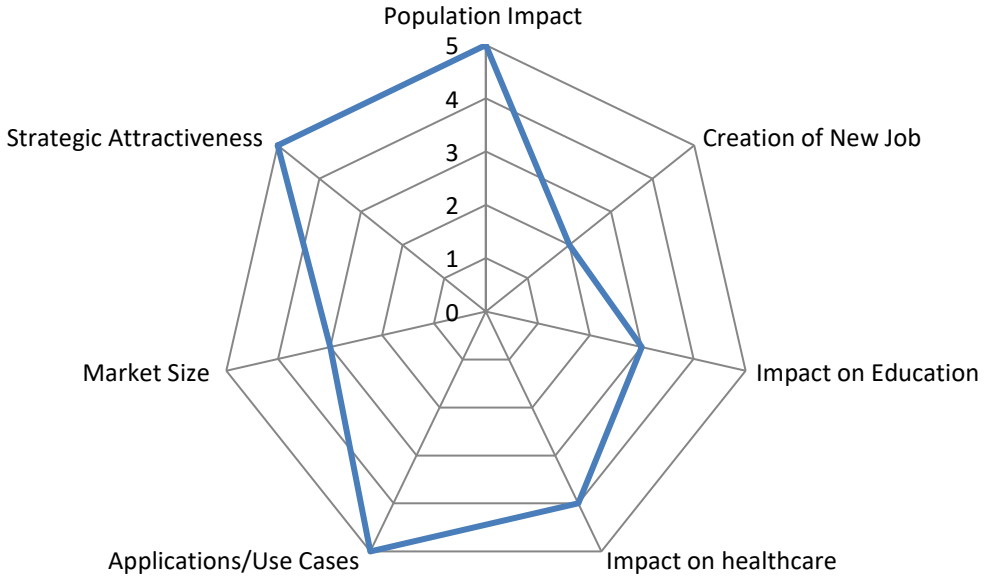
Therefore, the distributed ledger technology (DLT) is a digital ledger that is different from centralized networks and ledger systems in two ways. Firstly, information is stored on a network of machines, with changes to the ledger reflected simultaneously for all holders of the ledger. Secondly, the information is authenticated by a cryptographic signature. Together, these systems provide a transparent and verifiable record of transactions. All the information on it is securely and accurately stored using cryptography and can be accessed using keys and cryptographic signatures.

The distributed ledger database is spread across several nodes (devices) on a peer-to-peer network, where each replicate saves an identical copy of the ledger and updates itself independently. The well-known use case of DLT is Blockchain. Cryptocurrency Bitcoin is an example of applying Blockchain. However, DLT also explore in other industries not only in financial sector. The other sub-classification of DLT which are DAG, Hashgraph, Holochain, and Tempo will support DLT to be adopted in various industries.

Why DLT has been selected?

Distributed ledger technology is one of technologies which in the development process. Many big companies adopted the DLT to use in their company as the first mover. However, DLT is still in the early adoption which should have many supports from the government. Therefore, the assessment of the technology could separate into social impact and economic impact. Population impact, job creation, education impact, and social impact are recognized as social impact assessment while use cases, market size, and strategic attractiveness are economic impact. The radar below shows the total score of DLT.

Figure 81. Scoring of DLT



Population Impact: Score 5/5 (Highest)

As DLT is in the early adoption, the growth stage of the technology will be happen in next few years. Many enterprises are interested in the technology to support organization's security and trust. Therefore, DLT will impact the population in Thailand when they approach data of the enterprises. Many people will relate to DLT in some ways as currently there are based projects being piloting or already in production in government, utility and supply chain security use cases. Next 5-10 years, DLT will be around people like internet. Therefore, the estimate of population impact from DLT could reach more than 80% in Thailand as the potential of DLT growth is in the upward trend. Even only Blockchain is the popular DLT used currently, other DLT will be evolved to replace the traditional network. People will be able to share data via DLT with more secure.

Creation of New Job: Score 2/5 (Low)

As an emerging disruptor in the tech industry, DLT has the potential to challenge traditional job. The exponential rise of DLT has also caused an increase in demand for skilled practitioners, with over various companies currently looking for decentralized ledger technology professionals. Demand for DLT professionals has gone up a lot in recent years. Even now there are few positions related to DLT opening, by 2030, there would be approximately 15,000 jobs in Thailand which is more that 700% increasing from 2020. Most jobs would be created in public sector, financial sector, technology and telecom through implementation of DLT. However, there's a serious shortage of qualified DLT professionals, especially those focused on the more technical side of the business. This means that the demand would not be met.

Impact on Education: Score 3/5 (Neutral)

Distributed ledger technology does not affect directly to education system but it supports the operation in education industries to be more effective. DLT will make the education process digitize to verify academic credentials. It will be federated repository of academic information specific to classes, professors, and students. The technology would allow universities, institutions or public offices to issue unalterable diplomas and certificates that can be easily retrieved with a personal key. This will eliminate fake diploma fraud problems and help to manage tracking of people's identity by keeping track of student progress. For libraries in the institute, as it is easier to keep track of and store information, the DLT could be used to enhance library and information services in schools. Moreover, DLT also creates educational opportunities for the next generation of startups.

Impact on Healthcare: Score 4/5 (High)

As distributed ledger technology support transparency of the organization process, healthcare industries could take the benefit of DLT as well. Since the DLT can be set up so that only certain people have access to the data and one can still use the worldwide distributed network to store the data, it is perfectly suited to store sensitive data such as patient records, disease progressions, reports and much more. Individual database called silos are mutually shielded and only forwarded on special request which lead to inconsistent data and can also lead to problems during treatment. Moreover, with DLT, medical records can be cryptographically secured and shared between health providers, increasing interoperability in the health insurance ecosystem. DLT will support the insurance process in term of payment. Therefore, the use of DLT to solve the most widespread problem in healthcare information systems and payment process related to interoperability and non-standardization that has created data silos in the industry.

Applications/Use Cases: Score 5/5 (Highest)

DLTs are often praised for introducing efficiencies and reducing costs, a larger disruption for the humanitarian sector may lie in the increased transparency that would result from implementation of DLT-enabled monitoring and reporting systems. Many industries covering financial services, healthcare, public sector, energy resource, technology, media and telecom will adopt DLT into their businesses which create more than 70 use cases by 2030. The most number of applications is estimated to be in insurance industry with non bitcoin blockchain solutions.

Market Size: Score 3/5 (Neutral)

As transparency is one of the main problems faced by today's entrepreneurs, especially in the supply chain, DLT will be advanced to solve those problems. DLT market will grow continuously to reach about 10% of Thailand GDP in year 2030. Therefore, Thailand market size of DLT is around THB 69.3 billion by 2030. The DLT will grow sharply next 5 years to reach the estimated market size as it is in the early adoption stage now. However, DLT will become a technology at the level Infrastructure that is covered by Application or API and connected to other systems so it will become a part of almost every system that relate to everyone's work life or daily life.

Strategic Attractiveness: Score 5/5 (Highest)

DLT projects, including blockchain, are appearing with increasing regularity in various industries. By 2030, DLT adoption would be considered mainstream and integral to capital market ecosystem. The economic output will exceed THB 97.77 trillion by 2030, globally. There would be a CAGR of 12.5% for the global blockchain technology market. Thailand has emerged as the most interesting cryptocurrency and blockchain country in South East Asia, paving its way towards Thailand 4.0 initiative.

How DLT supports Digital Thailand Agenda?

Normally, the form of exchange trade, which exchanges at least 2 assets, could have a middle man to support the contact. The middle man should create credibility for the trading process in exchange for compensation. However, a new technology likes distributed ledger technology currently happened to be in the process providing the network without the middle man. Distributed ledger technology can record each transaction continuously and safely. Therefore, Thailand 4.0 will be more reliable when using the distributed ledger technology.

As blockchain is the well-known use case of DLT, the adoption of blockchain support digital economy in different field. Firstly, it could be used to enhance the efficiency of the work process via Smart contract which allow trade operations to comply with the criteria specified in the agreement. Secondly, Blockchain gives the advantage over transparency. The clear details of the transaction will increase the credibility of the trading process. It also helps to build a stronger relationship based on the level of transparency available. Therefore, this will be used in digital government policy in term of transparency of the transaction. Thirdly, blockchain help to record the transaction safely, each transaction is monitored within the network using complex encryption and is independently verified. Lastly, blockchain is to be used in FinTech which will be developed to support Digital Park project which will be the base for Eastern Economic Corridor.

Moreover, there are currencies using blockchain. However, there will be currencies using DAG-chain which is other technologies underlie in DLT. Cryptos based on DAG-chain have more benefits than blockchain-based cryptos. And with the number of users and transactions within the DAG-chain growing, so does the speed. All of these examples will support Digital Thailand Agenda in some point such as R3's Corda blockchain is being used by Thai Central Bank's (Bank of Thailand (BoT). The

Corda will support the transactions in the organization with smart contacts ensuring the highest levels of privacy and security.

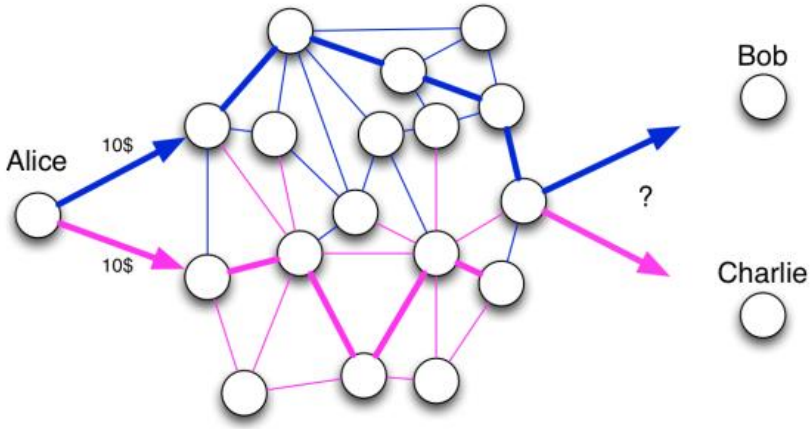
Therefore, the distributed ledger technology will support digital economy in Thailand covering various industries. The main parts are security and transparency which should be in every organizations. It also drives the potential of the organizations to engage with the client effectively and faster.

Sub-classification of DLT

The term distributed ledger technology is one kind of umbrella-term that covers the technologies. Currently, there are 5 sub-classifications. Blockchain is the well-known sub classification currently but there are also other technologies having their own way to reach an agreement while storing the information on the ledger which are DAG, Hashgraph, Holochain, and Tempo(Radix). We will focus on detail of each sub classification before selection process.

Blockchain

Figure 82. Illustration of Blockchain

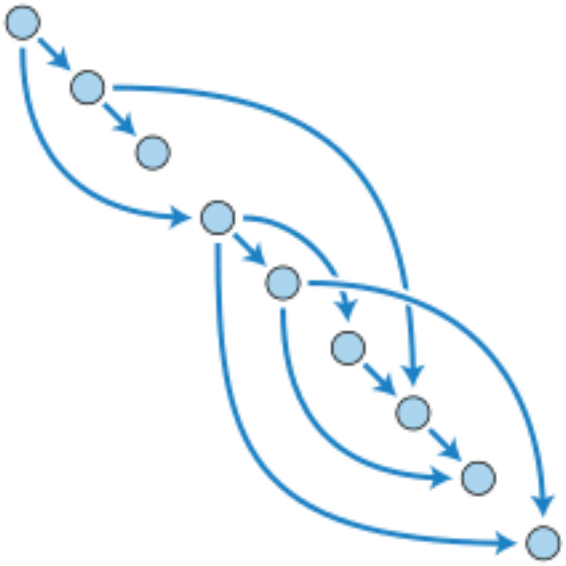


Source: Marmelab

Blockchain is the most popular type of DLT. It is a chain of blocks in the distributed peer-to-peer (P2P). Each transaction records in a block and each block connected together as a chain. There will be a long list of records. The processes of working start from transaction making by someone. Then, the various way of verified step will happen depended on the nodes on the network. After the checking process, the agreement of the true transaction from the consensus on the network will be stored in a block. The block will get a unique ID before getting a sport on the ledger. A new block will also contain the recent block to maintain the chain.

DAG (Directed Acyclic Graph)

Figure 83. Illustration of DAG

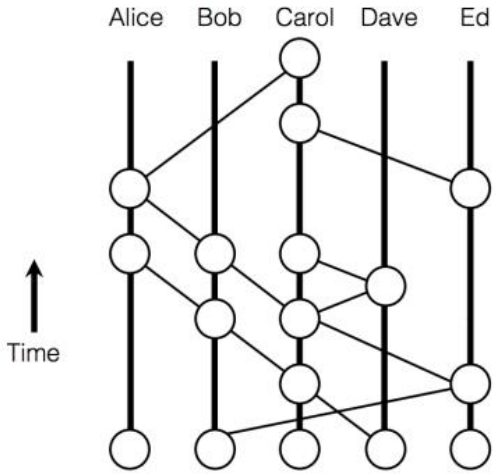


Source: Siam Blockchain

DAG is an alternative to blockchain with a different structure of the ledger. DAG offers fee-less Nano-transactions because the scalability improves as the network grows. DAG also records transaction in node on the network. Any node can initiate transactions; however, to validate them they have to randomly verify at least two of the previous transactions on the ledger. The more a person validates, the more his/her transactions become a valid transaction on the distributed ledger database. Therefore, a greater volume of transactions support the greater scalability of the Hashgraph.

Hashgraph

Figure 84. Illustration of Hashgraph

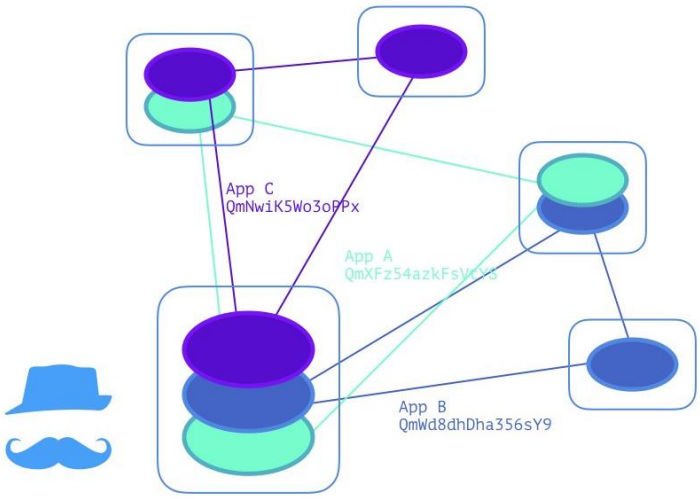


Source: Icodog

Hashgraph records a transaction as an event on the ledger. Multiple transactions will be stored on the same timestamp and connect as a graph. Each node on the network can send out information (known as “event” and they are pre-signed) on a new transaction. Every node will randomly choose the neighboring node to relay this information. A node will then aggregate the event with other received information and then relay it out to other neighboring nodes. Compared to blockchain, hashgraph solves the problem of blockchain in 3 ways which are fast, fair, and secure. Hashgraph could record more than 250,000 transactions per second. Mathematically Proven Fairness (via Consensus Time Stamping) and Bank-Grade Security (Asynchronous Byzantine Fault Tolerant) are supported hashgraph being the future of DLT. Each verifier node in hashgraph will include all transactions in the manner they transacted while each verifier node in blockchain could be selectively chosen without focusing on timestamp.

Holochain

Figure 85. Illustration of Holochain

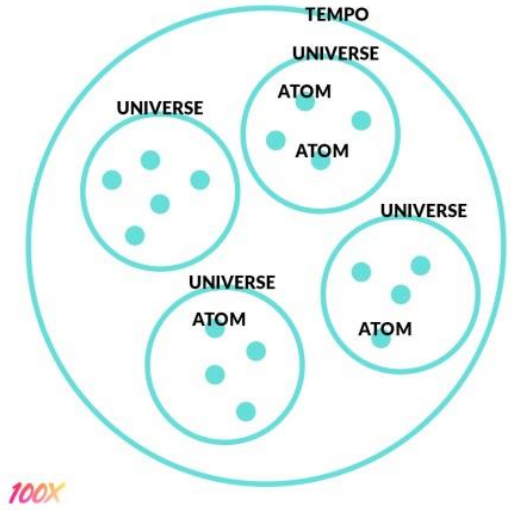


Source: Coinman

Holochain is one of the most advanced levels of ledgers. It is agent-centric instead of data-centric structure liked others. Every node keeps its own distributed ledger and communicates with it through its own unique signature. As ledgers will revolve liked DNA, any node on the network trying to add new information on the public ledger will get validated. Every people on the network will relay the transaction to other nodes after the verification with the DNA is done. Once they find dissimilarities, they will reject it and broadcast it across the network and warn others of this malicious node. Therefore, there will have different DNA if there is someone who hack or store false data on the network.

Tempo (Radix)

Figure 86. Illustration of Tempo



Source: 100X

Radix is the company introduced the brilliant new tech. Radix uses Trust-less consensus with having Tempo as the main of distributed ledger. Tempo will preserve the sequence of the information on the ledger but offer to timestamp along with other functionalities as well. With Tempo you will be able to create your own decentralized applications, token, coins, transact extremely fast and many more. The Tempo works from any node choosing to carry a subset of the full global ledger called “shards”. There will be a unique ID for their subset of the ledger so the nodes are not need to carry the burden of the global ledger on the network. Every instance on this distributed ledger database is known as the Universe. Within the Universe, every event is called an “Atom.” When the transaction which is called Atom happens, node will take a role to carry or share to others depending on the shards that the nodes selected. Logical Clocks will be used to validate transactions. For solving the perspective of time changes from person to person, nodes will record the event sequence rather than the actual time.

The sub-classifications of DLT are important to various businesses. The use cases of each sub-classification will be happened depend on the organization structure and nature of business. Therefore, depa should focus on DLT overall. Providing knowledge over the DLT and sub-classification will motivate people and enterprises to take benefits from the technology. Moreover, the regulation on the DLT has to be set as a standard so depa could be the driver for this part.

Trends of DTL across the world

The DLT market is segmented on the basis of geography including North America, Europe, Asia Pacific, Latin America, Middle East, and Africa regions. The market in North America is expected to be dominant in the global market. This is owing to rising awareness and increasing applications of this technology in various segments. The sub-classification of DLT which is implemented the most currently is blockchain. The others are in the investment process. However, DLT will be used to support in various industries such as government systems based on DLT, the crypto-banking system, full transparency in industries, ecosystem connecting different social chains, and security protocols based on DLT.

However, there are many projects out there that are dealing with the whole concept of different types of DLTs rather than only sticking with blockchain. There are already many different types of DLTs into play, and hopefully, we will be able to see more additions in the newer future. But for now, shifting to distributed ledger implementation would be the wisest choice for any kind of growth.

Trends in Thailand

The blockchain is one kind of DLT and more preciously the first ever functional one. The technology kind of stormed the new digital world and many people started to believe it's the only form of distributed ledger system. Even there are other 4 DLTs, Blockchain is implementing in Thailand.

Thailand is in Blockchain 3.0 era. Many people think blockchain is only in bitcoin but in blockchain 3.0, it is more than only in cryptocurrency. First of all, the era of blockchain started from Blockchain 1.0 which is currency era. Bitcoin is the first of the 1,000 cryptocurrencies that use blockchain as the network. In this era, 'Demand is speculative'. Next, Blockchain 2.0 used for Smart contract. Not only focus on speculative, but blockchain also use as transaction. The transformation is emerging even demand is still speculative. Currently, Blockchain 3.0 is the era of Decentralized application called Dapp which could be used in various industries. Entrepreneurs could bring smart contract to create an application for solving problems and disrupting traditional business model. However, Thailand is in the early adoption stage of DLT. There are some industries started adopt the DLT as blockchain.

CEO of Dtac, the third telecommunication in Thailand, said that blockchain is the digital innovative which will drive the digital social and economy around the world. Not only support to transform the businesses, but blockchain also enhance and change the way of life. Therefore, Dtac have already prepared to face with the challenges and be ready to use blockchain in their business in order to enhance their effectiveness.

Moreover, Dr. Chinawut, Vice President & Director of Digital Startup Institute Digital Economy Promotion Agency, comment over the potential of blockchain that it will come to solve the economic problems such as Asymmetric Information. For example, the use case of asymmetric Information is in the second hand car industry. The buyer does not have the second hand car's information so the price should be in average of standard price. The seller will not sell if their car has higher quality than the average price. Therefore, blockchain will support to record the information of each second hand car so the seller and buyer will be able to access to trusted data source for the good deal.

The overall trend of DLT in Thailand will grow across next 10-15 years. Although blockchain has already been widely applied in financial industries in the form as cryptocurrency, the other DLTs will be more readily used as the technology advances. The applications of DLT will not be in only financial industries, but will expand to various industries such as logistics, retails, healthcare, manufacturing, and government. Especially, startups will invest in DLT which will disrupt the traditional business model. Next generation of DLT will connect with other advanced technologies such as digital twin or quantum computer to support the security of sharing information. Therefore, the DLT will play in important role in future digital technology.

Digital Innovation in DLT

DLT could be used with other advance technology which will create new application and innovation to the economy. The development of blockchain will drive the use case in new business area.

<u>Development of customer experience with easier adoption</u>

The emergence of DLT is designed to solve various problems over the transparency. The easier use of DLT will drive the growth of DLT. Currently, there are many projects create blockchain application to use in multiple function such as identify the identity, connection between blockchain network, etc.

All of these applications with non-complicated will let various businesses to take the benefit from the DLT.

Digital twins with Blockchain

One of the situations that Blockchain can be used into real-world applications in every industry is to convert various products to be digitized and stored them on blockchain. This will increase tracking capabilities, increase transparency in various work processes, make Regulatory Compliance be automated and more efficient, sharing information easier, changing the ownership of property and real estate in the form of digital, etc. The interesting case of connecting digital twin and blockchain is a concept of making thing has E-Wallet itself. This will make the things work automatic and create new business models.

Potential of DTL

In next 5 years, Global potential market for DLT is expected to reach THB 220.8 billion at a compound annual growth rate of 76% by 2022. There will be a 30% reduction in operating costs for financial institutions, due to distributed databases.[219] In Thailand, DLT market will be reach THB 17.30 billion by 2022 with the CAGR 10%. The main early adopter is financial industries. The key market player in other businesses will start adopting as well. Therefore, the trend of DLT will be growing continuously until next 15 years.

In next 10 years, it is forecasted to reach THB 883.1 billion by 2030 globally. The massive growth in the technology will be driven by various factors including, rising rate of blockchain as a service (BaaS), increased acceptance of cryptocurrency and high interest from traditional financial interests. The financial sector accounts for the highest share in blockchain market, it is expected to grow at a CAGR of 70% by 2030.[220] For Thailand, market size of DLT is around THB 65.74 billion by 2030. The main industries which adopted the DLT are entertainment, financial, logistics, and government. The government will use the DLT to create transparency over all processes.

In next 15 years, DLT will be used with other advance technologies such as IoT over the security issue. Since there is a lot of data that often also contains personal information, the DLT is a secure means of transmitting this data. The secure encryption and fail-safe infrastructure solve many problems and increase security for users. Therefore, DLT will be growing in the supply chain management, manufacture, and healthcare. Especially, DLT will be popular in smart city as well. Even DLT will still grow; the growth rate is slower than last 5 years. The adoption rate of enterprise is 54% with the market growth of 5%.

Use Cases of DLT

Election

Election has always been a hot-issue in Thailand and only 65% of eligible voters made it to the polls this year. The electoral process from Election Commission of Thailand has been largely questioned and this leads to the lack of confidence in voting and voter turnout. Allegations of fraud and outside influence will continue to rise, if we don't apply technology to eliminate tampering. We need a platform that ensures proper voter registration, identification and streamlines the process of counting votes -- all while providing transparency to the results.

Many countries have come up with the name of blockchain as the answer of this issue. Blockchain-based voting platform has been studied over 30 countries to ensure that election votes are not being

[219] Frost & Sullivan : Redefining the mobility with Blockchain, 2018
[220] https://www.newsbtc.com/2018/11/27/report-blockchain-market-to-be-worth-over-28-billion-by-2025/

tampered. The technology offers four features. Firstly, security: the fundamental nature of blockchain makes it nearly impossible for fraudulent data to be entered into the system and the votes will be recorded in a private blockchain. Secondly, transparency: votes cannot be changed in a blockchain-based platform. Thirdly, accessibility: with this new level of security, elections could be safely conducted online, making them accessible to any citizen with a mobile device or computer which benefits overseas voters. Lastly, auditability: because every record, or vote, receives a date, timestamp, and hash of the previous block, auditing for errors or fraud becomes a fast and easily automatable process.

Even though, many advanced democracy countries launched a trial of blockchain-based voting platform, Thailand is expected to implement this technology in the next 10 years due to a lot of controversy from both public and private sector.

Regulatory compliance

In any industry, compliance with government standards and regulations is a time-consuming, expensive affair. Certifications need to be checked and rechecked, updates to procedures need to be incorporated, and an increasing number of agencies need access to records. Many solution providers are working to use blockchain and other technologies to make compliance faster, simpler, and cheaper. By loading regulatory compliance verification processes onto a blockchain, a company can provide regulators with an immutable, trustworthy record on demand, with complete audit capability built in.

Legal agreements

Smart contract is not a new idea but still limited to some specialty cases like stocks. For example, a stop-loss order is a contract with a stock brokerage to automatically sell an investor's stock if the price drops below an agreed-upon number. Bringing distributed ledger technology to improve smart contracts will help provide a greater security to store all legal contractual documentation on that such as wills, bank statements, property bills and many more. DLT will help leverage the speed of legal process which will create many new use cases across the globe. Another great aspect is to use it to validate inheritances. For example, smart contracts with DLT have been implemented to facilitate the payment for logistics; a sender makes a deal with a logistics provider with the agreement that when the item arrives at the destination within X days, the system will transfer money to the logistics provider. Then, the system will store this deal as a code on blockchain and when the item successfully reach a recipient, the system will automatically transfer money since the order matches the specified conditions. It is expected that in Thailand blockchain-based smart contract will pilot the first trial within 5 years.

Trading and Supply Chain

Trading is another area that we can see the contribution of distributed ledger technology. The fundamental of trading business is risky and based on emotional decisions. And when you have to deal with typical banking systems, it leaves a lot of paperwork and therefore becomes quite obsolete over the time. DLT will provide a transparent method to trade area and help eliminate the paper works driving a lot of business's process to run faster in competitive market. Moreover, the nature of DLT is security which will prevent a manipulation from an individual. The distributed ledger solutions will stop irrational decisions and help to preserve the assets in a better way. DLT will significantly improve transparency. It would also create a more efficient and liquid market, moving commodity trading away from bilateral deals struck directly between two parties to transactions based on electronic platforms to match buyers and sellers. Major companies around the world have tested blockchain across commodities such as diamonds and oil and have developed a blockchain-based platform ready to go by the end of 2018. Powered by the distributed ledger technology projects organizations would be

able to administrate every process from manufacturing to shipping. Logistics processes will ensure full customer satisfaction every time. The Distributed ledger technology would be able to track the raw materials and luxury goods. This type of use case will be expected to emerge in Thailand within 5 years with the main drivers from MNC.

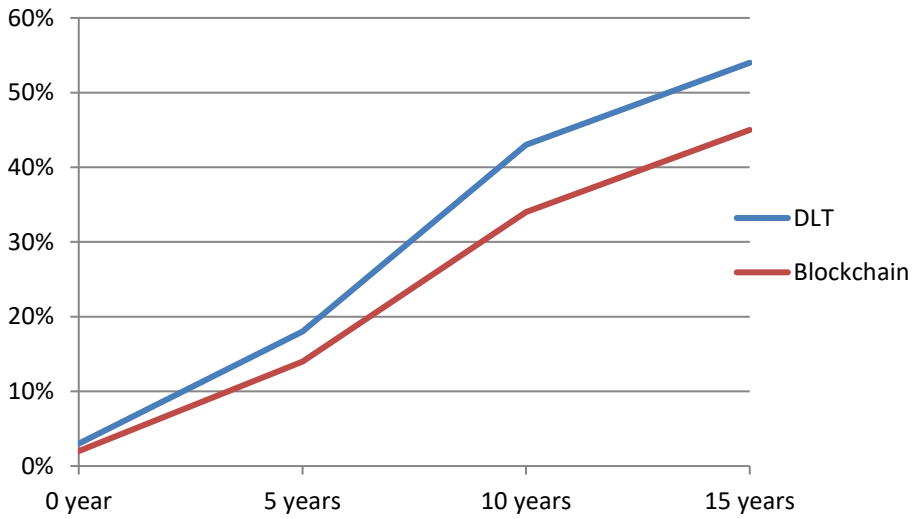
Manufacturing

New manufacturing models, such as 3-D printing or agile manufacturing, eliminate the delays and costs of the tooling and production setup that once had to be spread across massive production runs. The combination of blockchain technology and 3-D printing allows organizations to quickly and easily reconfigure real-time supply chains, enable and scale a model of global micro-manufacturing. Overall blockchain can greatly ease the deployment of such distributed manufacturing value chains, as it offers low-cost, distributed and assured integrity for contracts, product histories, production processes etc. Moreover, blockchain enables the creation of secure digital product memories – immutable records of everything from the source of the raw materials used, to where and how they were manufactured, to their maintenance and recall histories. Additionally, blockchain greatly improves manufacturers' traceability when it comes to finding and isolating faulty or expired materials making their way into finished products—a must-have for any business that's sensitive to safety-compliance regulations and traceability requirements. In addition to facilitating a faster response to product recalls, blockchain can also help risk-averse industries prevent counterfeit parts from entering their supply chain. This has been of especially keen interest to consumer-electronics manufacturers recently. In the interest of sustainability and customer satisfaction, manufacturers can also use blockchain to ensure clean and ethical chains of custody for their products.

Technology Adoption Cycle

Distributed ledger technology will grow sharply next 5 years. The below chart shows the adoption cycle of DLT and Blockchain which is the most well-known DLT.

Figure 87. Adoption cycle for DLT and Blockchain



DLT Consumption in Thailand

DLT have low adoption rate currently as it is quite new and need a lot of skill people to develop. However, the use case of DLT will increase according to the evolution of the application. The different industries will take DLT to improve their operation in order to be more secure. The applications of DLT will be in various business area such as real estate, entertainment, supply chain, detecting

counterfeits, mobility, health services, energy, government, and especially financial. Moreover, the application of DLT which connect with other advance technologies will let the DLT growth in long term.

From blockchain perspective, a growing number of financial services are using this system to introduce innovations, such as smart bonds and smart contracts. The former automatically pays bondholders their coupons once certain pre-programmed terms are met. The latter are digital contracts that self-execute and self-maintain, again when terms are met. Next 10 years, there are a lot of use case for blockchain that are transforming society such as asset management in trade processing and settlement, insurance in claims processing, payments in cross-border payments, unconventional money lenders/ hard money lending your car/ smartphone, blockchain internet-of-things (IoT), smart appliances, supply chain sensors, blockchain healthcare, blockchain music, blockchain government, public value/ community, vested responsibility, blockchain identity, passports, birth, wedding, and death certificates, and personal identification.

Outlook of Local Companies

I Am Consulting is an IT development and management consultant helping clients to develop strategies and innovations for organizational development. The company has been in Thailand for over 15 years specialized in Enterprise Resource Planning (ERP). The company has over 350 employees. Moreover, the company is one of the JFIN blockchain platform developers, collaboration with Cais Manai - Corda Developer Relation Lead and R3 Consortium team from Singapore.

Its main business concludes SAP Business, Extend Business which is a system expansion from ERP such as blockchain, Application Management which is a support service for installed system and Training Center which is a SAP knowledge center providing to other organizations.

Sertis is a Thai company with expertise in Big Data analytics and implementation, data science, and AI-driven solutions such as research tool, medical diagnostic tool, and block chain. The company has capabilities in developing software and platform for data-related services, as well as developing customized solutions. Finally, the company owns a series of "modern" products that are in demand by the market e.g. cancer diagnostic tool, Big Data analytics platform, and block chain platform.

One of the examples of blockchain implementation is the smart building hub project that Sertis has teamed up with PTT. This project aims to explore new business opportunities for a new smart energy building complex to drive energy sector towards renewables. This “Smart Energy” will be developed based on the combination of technology blockchain and Artificial Intelligence. Blockchain will play an important role to leverage energy management that helps support transactions without an intermediary to control and help increase efficiency in data management in term of security and transparency during the whole operation. The system users will be able to check the data from the production of electricity both from the grid and the solar cell system of the energy center to the amount of power supply running to various units in real time.

Bitkub is a Thai blockchain solution provider and ICO consulting firm. The company provides both tailor-made and on-the-shelf solutions. Its strengths lie at its long expertise, sole focus on blockchain and 24/7 customer service which leads to a fast response time. Bitkub has a wide range of services including

- ICO Services: providing a full consultation from initial consulting to coin listing to the businesses that aims to launch their own ICOs
- Training: giving a training about all aspects of blockchain to prepare for its next move
- Smart Contract Audit: providing top-level audit experts to each case and producing a combined report.

- Smart Contract Development: implementing smart contracts with automated enforcement by using RootStock and Ethereum to help secure smart contract writing
- Private Blockchain Development: creating and integrating a private blockchain to a business
- Blockchain Development: providing enterprise-grade blockchain services and tailor-made development solutions.

Outlook of International Companies

IBM is one of the biggest platform developers in the market and one of the early members of the Linux Foundation's Hyperledger project which will immensely improve Opensourced Blockchain. This means that the IBM uses Hyperledger Fabric as the foundation for the IBM Blockchain Platform. IBM is the leader in secure open-source blockchain solutions built for the enterprise. IBM has associated with over 400 clients in various industries including financial services, supply chains, IoT, risk management, digital rights management and healthcare to implement blockchain applications delivered via the IBM Cloud. The company also provides the IBM Blockchain foundation developer course which is a free 6-hour course that provides a more detailed picture of the components and structure of blockchain.

IBM continuously focuses on contributing code to several active Hyperledger projects and offering enterprise-grade blockchain technologies with 4 key characteristics; a shared permissioned ledger, a consensus protocol, Cryptography and chaincode (mart contracts).

Intel is one of key players in DLT developers market. The company is a member in Hyperledger, an open source collaborative effort created to advance cross-industry blockchain technologies. In 2016, Intel contributed Sawtooth to Hyperledger which is an enterprise-grade blockchain platform for building distributed ledger applications and networks. The core capability of Sawtooth is to make smart contracts safer particularly for enterprise use.

Moreover, Intel is a founding member of the Enterprise Ethereum Alliance, the industry's first global standards organization to deliver an open, standards-based architecture and specification to accelerate the adoption of Enterprise Ethereum. Apart from Hyperledger and Enterprise Ethereum Alliance, R3 is another blockchain ecosystem that Intel is a member. R3 has over 200 members and partners across multiple industries from both private and public sector to develop on Corda, the open source blockchain platform designed specifically for businesses.

Hitachi is another main key member in the Hyperledger project. The company believes in the benefits of sharing the unprofitable and unsexy work of building the libraries and standards that underlie systems. A shared code base also serves as an excellent way of concurrently building a standard for coexisting on a blockchain. Hitachi is working on blockchain R&D by drawing on the security technology and distributed data processing technology it has accumulated from building mission-critical systems.

Hitachi plans a three-phase to expand the application of blockchain. In phase 1, the company studies the blockchain use cases in the financial industry such as syndicated loans and post-trade processing of securities. The most important thing, Hitachi plays an important role in Hyperledger project by developing globally standardized versions of core functions provided by blockchain platforms such as distributed ledger management and transaction approval. Another crucial requirement will be strengthening the blockchain platform functions that are mostly unrelated to blockchain functionality itself, since financial infrastructure demands high reliability. In phase 2 and 3, the company will look deeply in the correlation between finance and other industries such as logistics or healthcare to draw out the best use cases for cross-industry coordination.

Samsung is one of the blockchain frontrunners in Asia-Pacific. In 2017, Samsung introduced Nextledger, a blockchain-based enterprise solution. The system can be used across all industries and supply chains. Nextledger is developed with the aim at creating faster and more secure financial transactions and a sharing environment across the entire organization. Samsung supports many blockchain startups and also involves in several ICOs. Samsung's strength lies at the heart of their know-how from being a system integration service expertise. The only disadvantage of Nexledger is it was designed for private enterprises making it lacks of the features commonly found in public blockchains.

PATRON is one of Japan's leading blockchain companies, currently building a decentralized influencer-marketing platform to eliminate inefficiencies in branded content and social media. Patron is the platform for supporting the influencers' market. It is provides influencers' sharing economy. The company is currently expanding operations to the United States. Started by influencer, Atsushi Hisatsumi, PATRON has gained international attention for its strategic partnerships and its strong advisory board of blockchain experts and industry leaders. One of the best known products of PATRON is Initial Coin Offering (ICO)

ICO is a method for procuring funds by issuing and selling proprietary digital tokens. It is not the form of transferring equity like stock procurement, but just like to purchase type cloud funding, the company will do what they simply sell tokens. Influencers and Social media users around the world will be able to post, discover and book social media sharing economy information on the internet and mobile tablet. PATRON is a highly reliable marketing place of influencers' sharing economy, where the influencer's SNS delivery frames are tokenized utilizing blockchain technology.

TraDove is one of the companies in the market that contributes to develop a trustable B2B blockchain payment network for international transactions. The company finalized one of the top ICOs in 2018. It launched the world's first B2B token, BBC, opening up corporate demand for cryptocurrencies for sales and marketing, a $76 billion market. A core capability of TraDove's product is to connect corporate buyers and sellers with faster discovery and better transparency. Lately, the company has partnered with DG Investment Fund which has a globe-spanning banking and business presence, which will help execute the successful adoption of payment network. This partnership will help boost financial status of TraDove with US$ 5 million in order to develop its blockchain-based B2B payment network.

TraDove's blockchain-based B2B payment network has been established to resolve the traditional one that transaction blocks are stored in all nodes and recorded on other companies' computers (possibly even competitors). Main features are super light, because transaction will be stored with transacted parties only making the network significantly lighter than any traditional blockchain network, and on mobile which is the first company to be able to build blockchain on smartphones.

Key Issues in Adoption

There are limitations of adoption DLT in Thailand. Firstly, Thailand still needs development guidelines which will take time to adopt DLT. As developing a system requires more credibility and security than traditional systems, investment in both human and financial resource is very important. Therefore, finding a partner, who has enough experience in complex DLT for various industries, is the main part to solving the problem of DLT development.

Secondly, lack of readiness of IT infrastructure poses a major threat to the adoption of blockchain technology. The technology is difficult to integrate into existing IT systems; it has to overcome latency and scalability issues.

Thirdly, DLT is dealing of regulation issues. This lack of regulation or limited regulation is compromising user rights on the network. Uncertainty is making the DLT more volatile, and people are investing in cryptocurrency associated with DLTs are falling victim. This means that even if somehow you lose your token on the network due to a hack, there won't be any backup for it. Therefore, the regulation will provide the protection to the people's asset.

Fourthly, overcoming privacy issues is another concern from mass people. Many companies feel that sharing their activities on the ledger with the public or their competition would result in their downfall. Even though some of the distributed ledgers are permissioned, still the people getting access to the ledger will be able to see each other's transactions. However, there has been some distributed ledger technology that focuses more on the user's right and privacy. If they can fully utilize this scheme, then DLT will surely prevail in the future.

Lastly, as the DLTs will keep growing, many DLTs promise infinite scalability but it's still only in theory. No technology is perfect in the first development. Improving them and offering better technology has been the priority in the last few years. If in practice, things don't work out, then they would have to improve it again and again. Therefore, distributed ledger technology is still considered to be immature, and most people are avoiding it due to this nature.

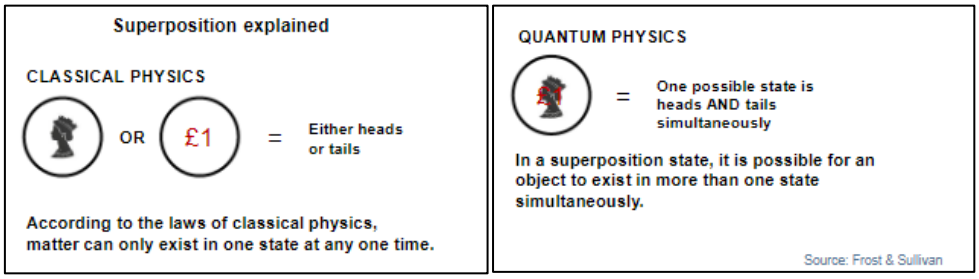
Conclusion

DLT is the one type of network which is spread across several nodes (devices) on a peer-to-peer network, where each replicates and saves an identical copy of the ledger and updates itself independently. The Blockchain is one of DLT which is very popular as it is used in cryptocurrency, 'bitcoin'. Other sub-classifications in DLT are DAG, Hashgraph, Holochain, and Tempo. The main use cases of DLT are in financial industries but it will explore to other industries nearly future. For Thailand, market size of DLT is around THB 69.3 billion by 2030. The potential of DLT is in the upward trend as it will be able to use with other technologies such as Quantum computing. However, the regulation of adopting DLT is one of the key issues that government agencies should concern.

3.6 Quantum Computing

Quantum theory is a type of modern physics that explains the nature and behavior of matter and energy at an atomic and subatomic level. It is also referred to as quantum physics or quantum mechanics. At a subatomic level, particles behave contrary to the laws of 'classical' physics. This is an important characteristic that has been used to develop Quantum computing. One example of this contrary behavior is wave-particle duality. This describes the ability of a single quantity of matter to exhibit wave and particle properties. Another important type of contrary behavior is one whereby two or more quantum states can be added together resulting in another quantum state. This is known as superposition. Quantum computing is a type of computing based on the principles of quantum theory. Quantum computers are capable of undertaking calculations that are either impossible with a classic supercomputer or would take an unreasonable amount of time.

Figure 88. Explanation of Superposition property



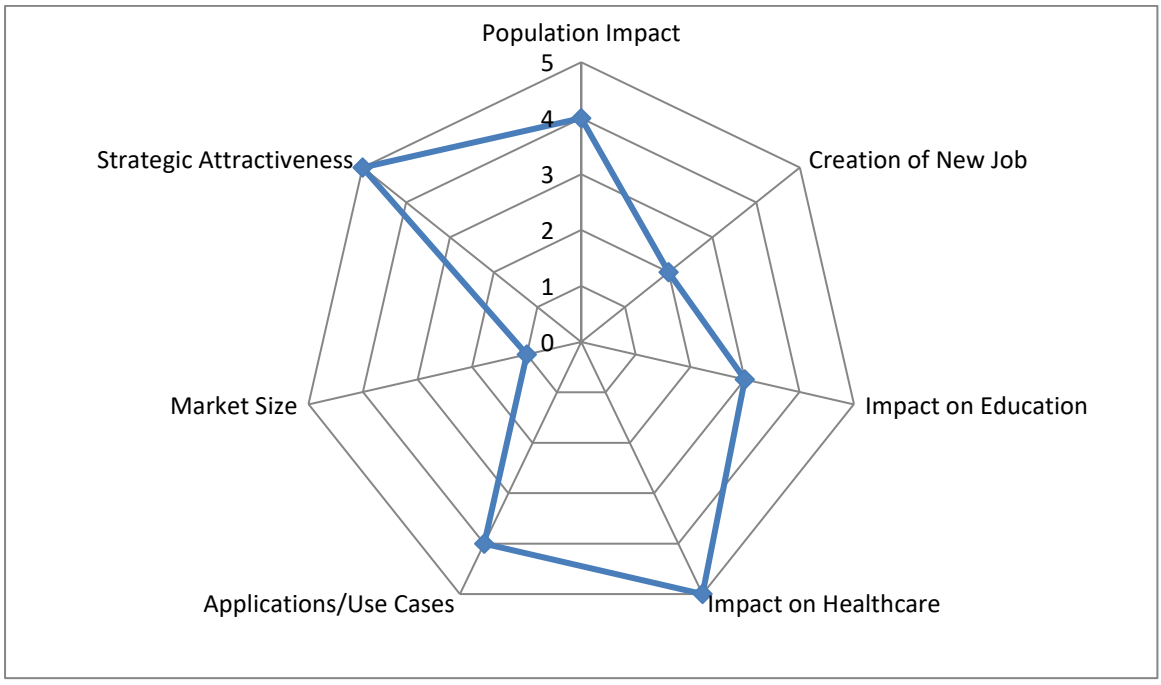
Quantum computers operate using subatomic particles known as quantum bits or 'qubits' which are capable of superposition and entanglement. Superposition allows qubits to exist in multiple states simultaneously, and entanglement is a description of how subatomic particles can interact with one another such that the behavior of one particle can be predicted by looking at another related particle, even when they are separated by large distances.

Due to superposition and entanglement, the difference between a 'two bit' classical computer and a two qubit' quantum computer in terms of processing power is vast; therefore the potential for Quantum computing is great. The ability of Quantum computing to solve problems that cannot be realistically solved by the most powerful classic computer is known as 'Quantum Supremacy or Quantum Advantage.[221] Quantum Supremacy is the enhancing version of Quantum Computer with higher efficiency than the first supercomputer in the world. Therefore, the potential ability will solve problems that classical computers practically cannot. Additionally, Quantum advantage is the potential to solve problems faster.

Why Quantum Computing has been selected?

Quantum Computing has been selected as one of the shortlisted technologies as it is expected to have a potential impact in the future of Thailand. 15 years from now, the technology will have the most use cases and applications, impacting the economy and job situation in Thailand. Even though the technology is in the experimental phase right now, It is expected to be very attractive to the country in terms of strategy, population impact and applications.

Figure 89. Scoring of Quantum Computing



Population Impact: Score 4/5 (High)

By 2030, Quantum Computing will impact 45% of Thai population as the technology. The full impact of technology would take more than a decade. The new computers could change the game in the fields of cryptography, chemistry, AI and machine learning. It promises big leaps and changes in

[221] Frost & Sullivan Analysis: Digital Transformation Beat - Quantum Computing: The Race to Quantum Supremacy; year 2019

people's lives in the future. Leaders will take their investments and stakes in this emerging technology. It could improve imaging, diagnosis, treatment, and population health. It is yet to be determined if and when quantum computers will be accessible for daily use in medicine and research.

Creation of New Job: Score 2/5 (Low)

Quantum Computing Jobs would be created in the field of hardware, and in the fields of physics, computer science, and chemistry. It is estimated that 13,000 – 15,000 People would get jobs in Quantum Computing by 2030 in Thailand. The struggle to understand the technology, research and implement would lead to lesser jobs by the next decade. Jobs would be created in Machine learning, AI, cryptography and science. It would be difficult to hire people for such jobs as training would be required. There would be massive need to train students, professionals for Quantum computing related jobs in the next 15 years. To be able to work in Quantum computing, right coding and developers would be required along with the expertise in chemistry and physics. Government funding would be required to help companies and universities work together to train students. IBM and Google have put their versions of quantum computers as open source on the internet for individuals to gather knowledge.

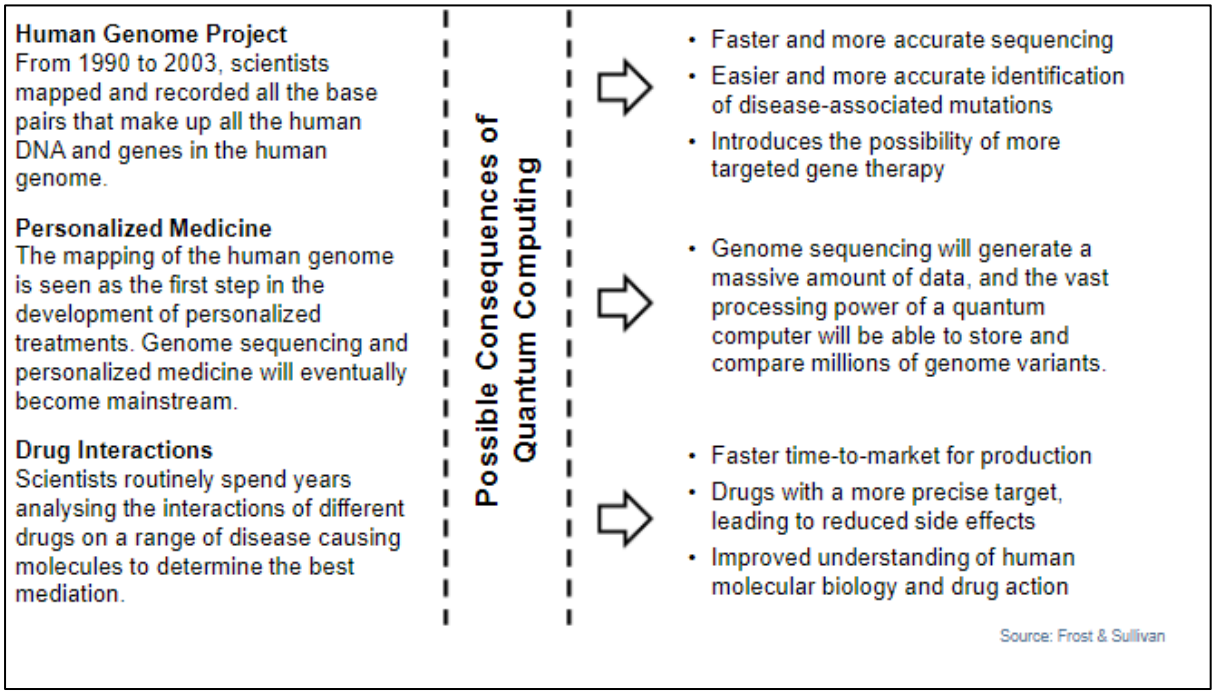
Impact on Education: Score 3/5 (Low)

Currently, many professionals and students would need to be trained on Quantum computing for the future. Quantum computing will not affect education directly but some curriculum will use the technology to research in science field. Therefore, the technology support in some field of education in the future which could be explore to various education in long future.

Impact on Healthcare: Score 5/5 (Highest)

Quantum Computing has significant impact on Healthcare sector and impacts 3 or all areas from: invention of new drugs, diagnostics, disease prevention, disease management (healthcare provision including the way healthcare is provided to hospital management etc.).

Figure 90. Possible consequences of Quantum Computing



Research is currently being undertaken to assess how quantum computers can be used for the analysis of molecular behavior. This ability will be very important for the healthcare market.

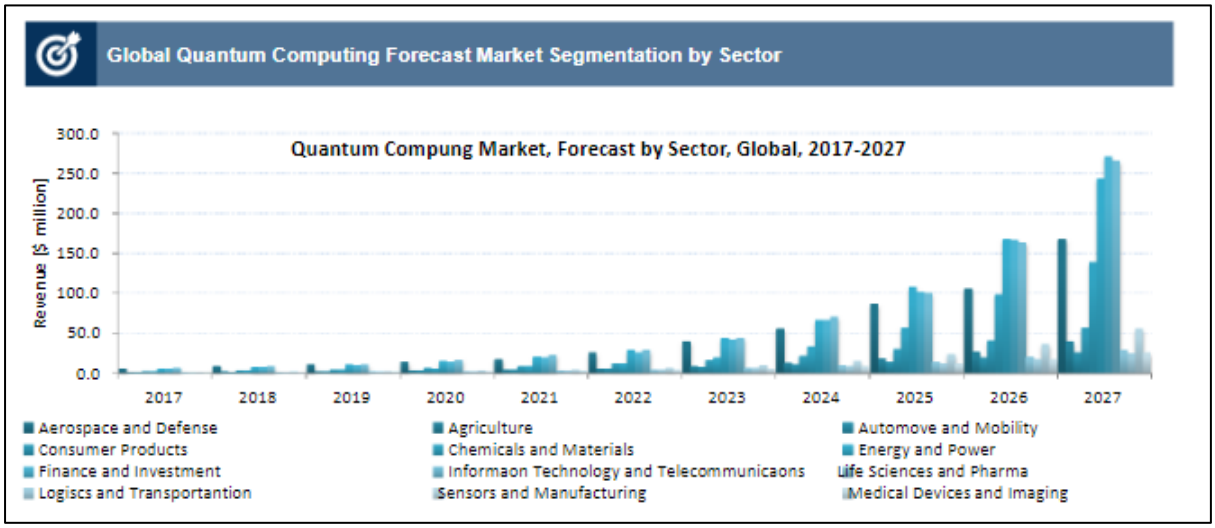
The healthcare sector will be majorly impacted by Quantum computing due to rise in demand for effective medicines. It usually takes 8 years to 10 years to develop a medicine due to proper research & development required and billions of possible reactions on the body. With Quantum computing, such possibilities and complexities can be reduced and solved, and also the time & cost to the market can be reduced at greater extent. Quantum computing has scope in determining the cures for several diseases by mapping proteins in DNA, which provides the major opportunities for the medical and healthcare industries.

Applications/Use Cases: Score 4/5 (High)

Information technology and telecommunications, aerospace and defense, energy and power, finance and investment represent nearly 70% of the present market value of Quantum computing. Chemicals and materials, and sensors and manufacturing demonstrate high growth rates and are expected to reach a CAGR of 39.6% and 39.8%, respectively between 2017 and 2022, and 65.5% and 53.9%, respectively between 2022 and 2027. Machine Learning Applications in Quantum computing are expected to exhibit a leap of 34% in CAGR by 2027.[222]

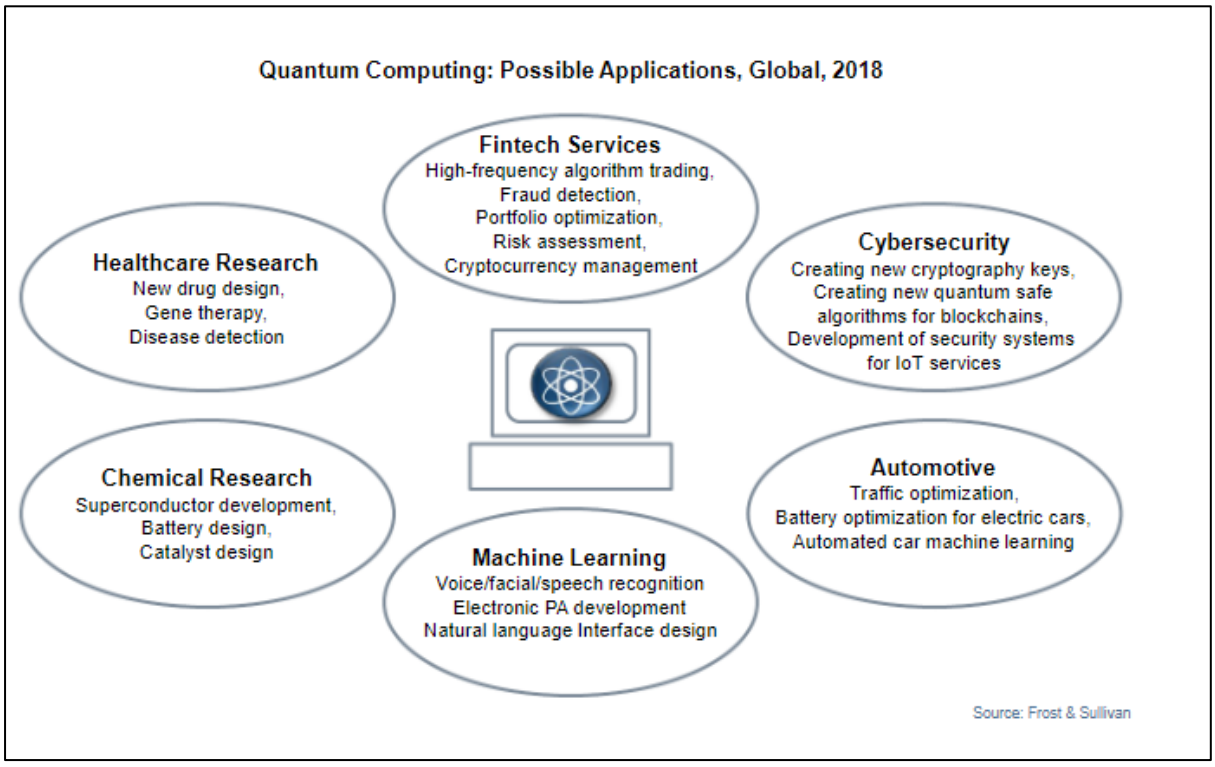
[222]Frost & Sullivan Analysis for depa: Thailand Digital Technology Foresight

Figure 91. Global Quantum Computing Forecast 2017-2027



The potential applications of Quantum computing would be seen in various sectors:

Figure 92. Possible applications of Computing Forecast



Market Size: Score 1/5 (Lowest)

Thailand's Quantum computing market is forecasted to reach a value of THB 6.5 billion by 2030 from THB 780 million in 2025, growing at a CAGR of 52.81% during the forecast period. Major global companies driving the Quantum computing market are D-Wave Systems Inc. (Canada), IBM Corp. (US), Google Research (US),Microsoft Research (US), Lockheed Martin Corp. (US), Intel Corporation (US), Hewlett Packard Enterprise (US), Rigetti Computing (US),Anyon Systems Inc. (Canada),

Cambridge Quantum Computing Limited (UK), and QC Ware Corp. (US). The promise of quantum physics applied to business will become a reality in Thailand with the success of Quantum computing.

Strategic Attractiveness: Score 5/5 (Highest)

Quantum computing is rapidly evolving towards commercialization exhibiting a remarkably high growth rate (52.8% global for the period 2025-2030). Aerospace and defense, energy and power, finance and investment and information technology and telecommunications are the sectors which are highly impacted. The global Quantum computing market is expected to reach US $ 50 Billion by 2030.[223] It is going to gain maturity over the next three generations spanning 25 years.

How Quantum Computing supports Digital Thailand Agenda?

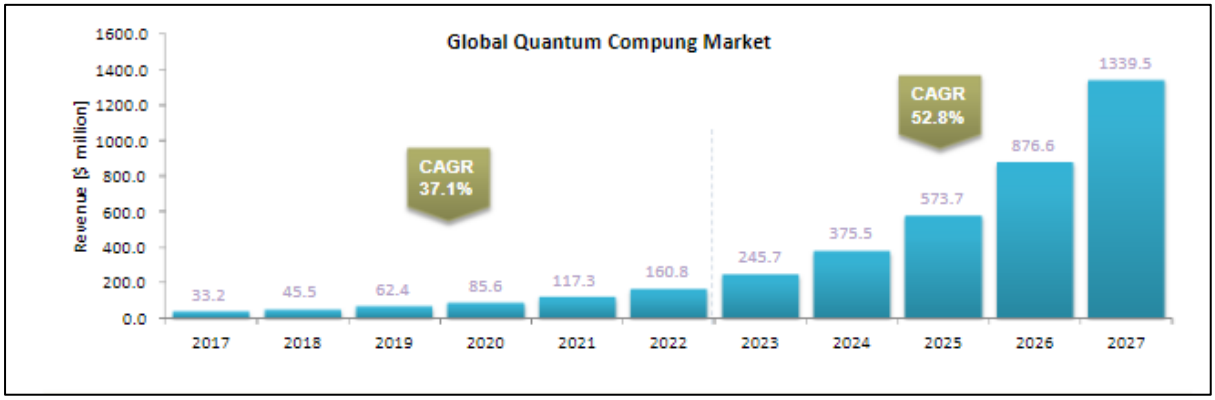
Quantum computing will be used mostly in the next 10 years so it did not support Thailand 4.0 recently. However, this technology will be supported society 5.0 in the future. Society 5.0 will connect everything both human and things through internet. There will be sharing community using advance technology such as AI, cloud, AR/VR, IoT etc. Quantum computing will be a technology supporting the machine learning in AI technology in term of the processing. The technology will enhance the level of processing with faster and also create new solution for human, especially in science sector. A lot of innovations will be created globally. Moreover, it will work with IoT advising the best route with safe. Not only everyday life use case, but the technology also supports the blockchain in cybersecurity. Therefore, Quantum computing will support digital Thailand agenda next 10 years as it will be the base technology enhancing the capacity of other advance technology in the future.

Trends of Quantum Computing across the world

Research has shown that quantum supremacy can be achieved with a quantum computer containing 50 or more interactive qubits. It is forecasted that Quantum Computing will see first ever proven example of quantum supremacy in 2020.

The global Quantum computing market was worth about $33.2 million in 2017 and is expected to reach $160.8 million by 2022 at a CAGR of 37.1% from 2017 to 2022. Between 2022 and 2027, the global Quantum computing market is expected to grow at 52.8%, reaching $1.3billion by 2027.Major companies driving the Quantum computing market are D-Wave Systems Inc. (Canada), IBM Corp. (US), Google Research (US),Microsoft Research (US), Lockheed Martin Corp. (US), Intel Corporation (US), Hewlett Packard Enterprise (US), Rigetti Computing (US),Anyon Systems Inc. (Canada), Cambridge Quantum Computing Limited (UK), and QC Ware Corp. (US).[224]

Figure 93. Global Quantum Computing Market 2017-2027



[223] https://www.bcg.com/en-sea/publications/2018/coming-quantum-leap-computing.aspx
[224] Frost & Sullivan Analysis: Quantum Computing - R&D Portfolio Analysis and Road mapping, Year 2018

According to Frost & Sullivan, market for Quantum computing is expected to grow at CAGR 4.5% between 2018 and 2024.

By 2024, 20% of the organization globally would be budgeting for Quantum computing projects which are less than 1% right now. Quantum Computing has a global potential market of US$50 billion by 2030.[225]

Machine learning applications are expected to exhibit a CAGR of 39.7% between 2017 and 2022, and 58.0% between 2022 and 2027. Numerical simulation applications are expected to exhibit a CAGR of 36.5% between 2017 and 2022, and 48.2% between2022 and 2027. Model optimization applications are expected to exhibit a CAGR of 34.0% between 2017 and 2022, and 48.7%between 2022 and 2027[226]

National Quantum Initiative Act was passed in early December 2018. The act allocated US $1.2 B to National Quantum Initiative Program, establishing goals for a 10- year plan to develop quantum information science and technology applications[227]

Major players are on the use case of providing a platform for development of quantum algorithms and applications that would be useful over the longer period. IBM announced a 20-qubit quantum processor and a simulator that would emulate up to 49 qubits. Google, in collaboration with the University of California, Santa Barbara, launched a 72 -qubit chip known as Bristlecone in early 2018 The chip is undergoing test. Other companies such as, Intel, Microsoft and Yale are active in the field.

Quantum simulations would represent a potential market of US$ 20 billion in pharmaceuticals by 2030, with future investments of $7 Billion from other industries such as chemicals and material science. There would be an expected rise in the market for $20 billion in search & machine learning applications to develop because Quantum computing methods would displace GPU based platforms. This process would follow Google and IBM's curiosity in SEO Quantum computing platforms.[228]

Hosted at NASA's Ames Research Center, the Quantum Artificial Intelligence Lab is a joint initiative involving NASA, Universities Space Research Association (USRA), and Google Research. The main goal is to understand the potential applications of the synergy among Quantum computing, machine learning, and other computing science advances to resolve problems that are difficult to address.

Quantum computing is expected to lead a paradigm shift toward quantum supremacy. The introduction of this technology to industries and sectors is expected to lead to historic milestones. Google's Quantum AI Laboratory covers all the fronts, leveraging potential opportunities across different research areas, hence allowing diversified Quantum computing applications. [229]

Quantum computing has progressed rapidly over the last 5 years. Conducting experiments no longer require having a physical presence in a university computer lab. Industry Players expect Quantum computing to follow Moor's law and double their capacity every 1 to 2 years. Hardware and System Development would be an important aspect of Quantum computing market advancement over the next few years. Quantum Advantage in the later years would raise the prole of Quantum computing

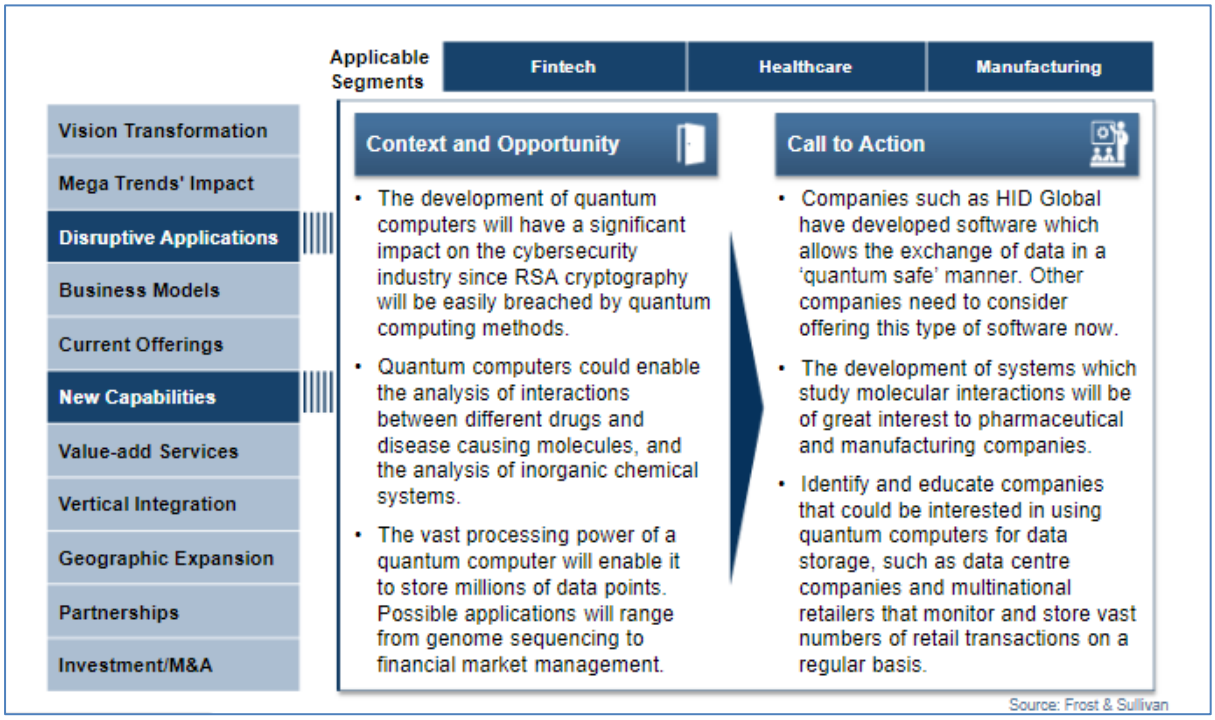
[225] Frost & Sullivan Analysis: Quantum Computing - R&D Portfolio Analysis and Road mapping, Year 2018
[226] Frost & Sullivan Analysis: Quantum Computing - R&D Portfolio Analysis and Road mapping, Year 2018
[227] https://quantumxc.com/quantum-computing-trends-2019/
[228] https://www.bcg.com/en-sea/publications/2018/coming-quantum-leap-computing.aspx
[229] Frost & Sullivan Analysis: Quantum Computing - R&D Portfolio Analysis and Road mapping, Year 2018

industry. According to industry experts at Frost & Sullivan, quantum advantage would be reached in the next 3 – 5 years.[230]

Amongst all countries, China leads the way in terms of investing in quantum, with US $10 billion quantum program spanning the next 5 years, of which US$3 Billion is reserved for Quantum Computing.

Future growth opportunities globally would be seen in fintech, healthcare and manufacturing sectors leading to creation of different business models.

Figure 94. Applicable segments for Quantum Computing



Quantum computing market in terms of end users, academia and government research institutions are leading the market at present due to the remarkable advancements that Quantum computing is representing across many disciplines and they are leveraging this breakthrough innovation to resolve many of humanity's concerns. Academia and government are expected to reach a CAGR of 36.4% and 35.5%, respectively between 2017 and 2022, and 44.6% and 46.1%, respectively between 2022 and 2027. Private companies are increasingly involved in the development of novel quantum microprocessors, as well as, the development of nano-sensing technologies through new materials and semiconductors. The private sector expects to demonstrate growth at a higher CAGR, 39.8% between 2017 and 2022, and 65.5% between 2022 and 2027.[231]

Trends in Thailand

Thailand's Quantum computing market is forecasted to reach a value of THB 1.4 billion by 2025 from THB 195.2 million in 2018, growing at a CAGR of 33% during the forecast period.[232]

[230] Frost & Sullivan Analysis: Quantum Computing - R&D Portfolio Analysis and Road mapping, Year 2018
[231] Frost & Sullivan Analysis: Quantum Computing - R&D Portfolio Analysis and Road mapping, Year 2018
[232] Frost & Sullivan Analysis for depa: Thailand Digital Technology Foresight

Siam Commercial Bank is the first South East Asia Company to invest in 1Qbit, a software company on quantum and quantum inspired computing. Thailand holds great potential for Quantum to propel forward and shape the technology landscape through the next century.

Toyota Tsusho and Denso have stated their plans to use quantum computer to optimize live traffic data from 130,000 trucks and taxis in Bangkok. This way the technology would enter our daily lives while it would not be used in directing the vehicles in real time.

Thailand will see progress in Quantum supremacy or Quantum superiority by 2028, as forecasted by Frost & Sullivan experts. Even in 2030, the smartphones, computers, tablets, lower level enterprise computing devices will be quantum powered, but they may be use Quantum computing via cloud in Thailand. The larger market will develop post 2030 as mid 2020's will see little progress.

Thailand will see rapid investments and development in the application of Quantum computing in the areas of security and cryptography 15 years from now. The AI powered government is already investing heavily in security. Shor's algorithm is expected to break many current public key cryptosystems in Thailand. Quantum Cryptography relies on the principle of quantum mechanics. It is yet to develop as there are many challenges in its process. Quantum Key Distribution which is the most widely used cryptography protocols is expensive and does not work efficiently with telecommunication networks. It has low transmission range. In the next 10 years, CiViQ will create technology in Thailand to meet specific network security challenges.

Industries that would benefit from this technology include healthcare, manufacturing, pharmaceuticals, media and cryptography in Thailand. Quantum computing would get huge help from the Big Data to improve and enhance services.

In 15 years, Thailand is forecasted to see the qubit chips in phones or personal devices; though it is forecasted that commercial QC's would enter the market in Thailand by 2028. Confidential data, over the air software's and identity management systems is hoped to be made quantum safe before the major QC's are developed.

The organizations in Thailand will develop crypto agility, which is the ability to switch out cryptographic algorithms for newer, more secure ones. They are expected to have a roadmap in place to follow the change that comes with further development. Companies like IBM are set to achieve quantum advantage in the near future, basically not only speed up the current computers, but also solve problems that are impossible to solve on classical computers.

Presently, the most advanced quantum systems have fewer than a hundred qubits which aren't sufficient to solve any business problem. But the future holds bright for QC in Thailand with continuous running of millions of experiments and published research papers. It is not a fiction in Thailand anymore, it is more than reality.

Quantum computers will need to be developed in tandem with the development of new cyber security systems. Many of the existing cyber security systems currently being used are not quantum safe, so these will need to be replaced with systems which cannot be easily decrypted using quantum computers. Thailand is going on with researches to assess how quantum computers can be used for the analysis of molecular behavior. This ability will be very important for the healthcare market and other manufacturing markets in the country.

Information technology and telecommunications, aerospace and defense, energy and power, finance and investment would represent nearly 60% of the Thailand's market value in the future.

Digital Innovation in Quantum Computing

As Quantum computing is an emerging technology, the idea of innovation in this technology is not quite clear yet. However, the advance in Quantum computing will be in term of quantum processor number. Although computers normally use "Bit" to present values 0 or 1, quantum computers use "Qubit" to present values 0, 1 or both at the same time instead. The higher quantum processor number or qubit will improve connectivity and better electrical and thermo-mechanical performance. In year 2017, Intel has joined the Quantum Computing War by announcing the delivery of Quantum Computing chips at Superconducting 17-qubit level performance. In the future, the quantum processor number will be higher than today which will process the data faster and more secure 100 million times than currently computers. Moreover, the technology will be developed through quantum Key Distribution (QKD) which the sender and receiver can detect the third parties who want to intercept. Another feature of the no-cloning theorem also makes third parties be not able to access the data copy without the encryption key. The key exchange systems of quantum channels can disconnect itself if someone is intercepted which is considered to increase the strength of data protection.

Potential of Quantum Computing

Quantum computing is in the research and development process but the technology has potential to growth in nearly future. Currently, international large enterprises focus on developing Quantum computing to be used in commercial. International cooperation is also expected to play an important role in the development of extraordinary quantum computing machines. Therefore, next 5 year, the technology will be ready to use in some special industry first. The market value of Quantum computing in Thailand expected to be THB 780 million in year 2025. The Quantum computing market exhibits a dramatic growth rate, with the advent of the first quantum computers carrying out real-world interactions with the industry dynamics. The promise of quantum physics applied to business is becoming a reality with Quantum computing success. The use cases of Quantum computing will increase sharply as it will be used commercially. Therefore, the market size is expected to increase with 52.81% CAGR reaching THB 6.5 billion by year 2030. Quantum computing will be applied to practically all industries and sectors. Novel applications are expected to lead to a completely new generation of products and services that leverage quantum systems infrastructure to address the critical issues. By year 2035, the quantum technology market will increase to THB 85 billion, with CAGR 67.22%. In the future, Quantum computing could be used in everyday life like the normal computer. The size of Quantum computing will be smaller which is suitable to use in many devices.

Use Cases of Quantum Computing

The most common use of Quantum computing refers to machine learning algorithms for the analysis of classical data executed on a quantum computer. Quantum machine learning increases machine learning capabilities intelligently, by creating opportunities to conduct analyzes on quantum states and systems

Globally, chemicals and materials, and sensors and manufacturing demonstrate high growth rates in terms of potential use case industries for QC and are expected to reach a CAGR of39.6% and 39.8%, respectively between 2017 and 2022, and 65.5% and 53.9%, respectively between 2022 and 2027 [233]

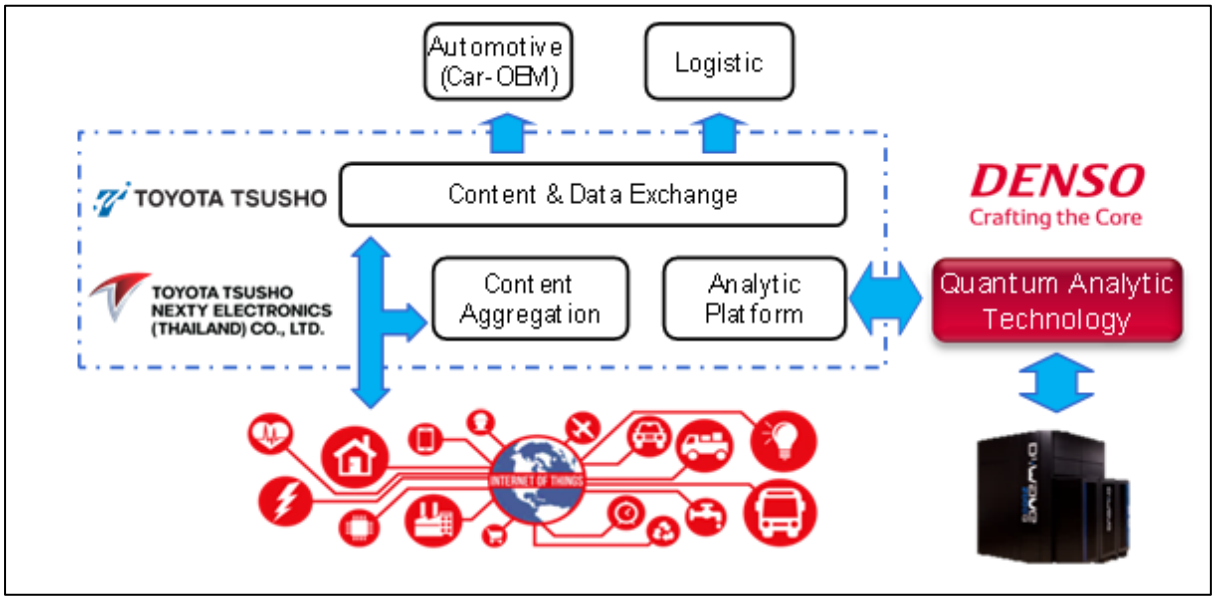
Denso Corporation and Toyota Tsusho Corporation are in the process of conducting world's first test using a quantum computer to process data from a traffic IoT platform. They are expected to process real time vehicle location and travel data from 130,000 commercial vehicles in Thailand with an aim to create best use case of quantum computer application in transportation. This technology would be

[233] Frost & Sullivan Analysis: Quantum Computing - R&D Portfolio Analysis and Road mapping, Year 2018

useful in connected era wherein, vehicles and mobility systems needs processing of large amounts of data in real time. This process would work by analyzing information from 130,000 taxis and trucks in Thailand through cloud based quantum computer devices created by D- Wave Systems, Canada.

These companies will also implement QC based technology from TSquare, a traffic information system application from Toyota Tsusho Group Company, Toyota Tsusho Nexty Electronics (Thailand) Co., Ltd. Denso is expected to create algorithms whereas Toyota would integrate the algorithm it into a new application. These algorithms' will also aid in translations of calculations into logical decisions.

Figure 95. Illustration of traffic information system application



National governments have been the biggest users of Quantum computing for the longest time. The government of Thailand is expected to use QC in a big leap in the future. Shor algorithm could breach the largest secured networks; hence government investment in Quantum Computing is expected to see a high rise within next 10 years.

Advances in Quantum computing could potentially jeopardize RSA cryptosystems and as such, steps are being taken to develop new 'quantum-safe' cybersecurity systems that safeguard against its misuse. Research scientists in Thailand are looking at effects, such as superposition and entanglement, to develop random number generation systems that could form the basis of quantum-safe cryptography.

The most common use of Quantum computing would be seen in collaboration with simulations, optimizations, machine learning and AI.

In High Tech industries, Thailand will see future uses in machine learning and AI for bidding strategies for advertisements, cyber security, marketing for online products and software validation. Most companies such as Google, Alibaba, Baidu and Microsoft are already researching and experimenting in the following fields.

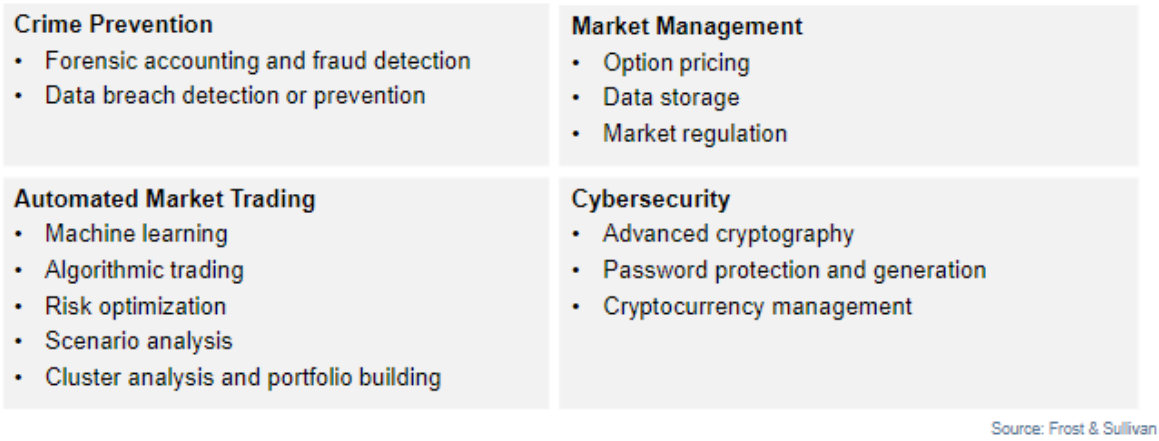
In the industrial goods space, Thailand is expected to see investment in logistics for scheduling, planning, product distribution and routing. Thailand has a huge automotive sector where in the future holds potential in QC for traffic simulations, E charging stations, parking search and autonomous driving. Thailand should expect the automotive sector to see potential use case within 10 years. With the advent of Thailand 4.0, the manufacturing sector would benefit the most amongst other industries;

therefore it is evident to see major breakthrough advancements in QC in the field of chip layout optimization.

In 10 years, the finance industry in Thailand is going to see major use cases in Quantum computing to trade strategies, optimize portfolio, asset pricing, analyzing risk and detecting fraud.

According to Frost & Sullivan analysis, most of the Quantum computing use cases in financial sector would fall under these four categories.

Figure 96. Quantum Computing use cases in financial sector



Source: Frost & Sullivan

Quantum Advantage is still in the experimental phase, with no deemed use case in Thailand. However, it is forecasted that in next 15 years, there is huge potential for many use cases pertaining to quantum advantage to flourish through different industries in Thailand.

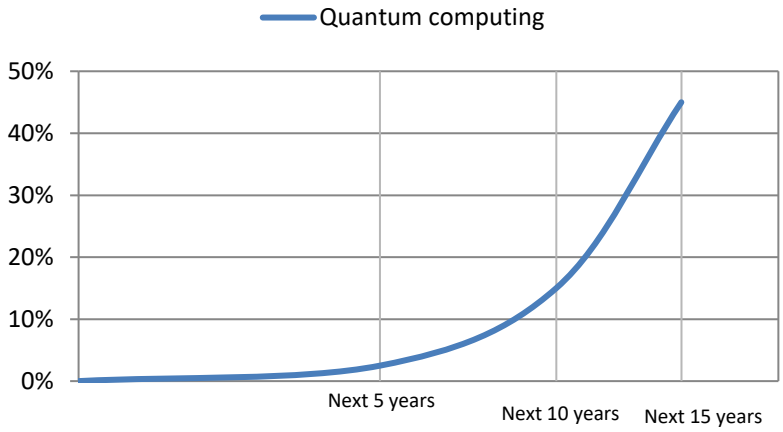
D-Wave, the next generation Quantum computing company will come in the Thailand market within 2028 with 500 qubits. The Pegasus topology connects every qubit to 15 other qubits, aiding machines to solve larger problems. D-Wave is expected to launch LeapTM, its real-time Quantum Application environment in Thailand within the next decade. Leap would be available for developers, researchers, and businesses. Leap would allow free real-time access to its 2000Q quantum computer to submit and run applications, and it would also provide open source development tools, interactive demos and coding examples, educational resources, and knowledge-based articles. It is hoped that it will accelerate the development of real-world applications. Hardware and system development will be crucial over the next few years. In particular, the construction of hardware with increased qubits and error correction will be very important. In the meantime, Leap will enable start-ups and researchers to test applications without purchasing hardware,

Many companies in Thailand are hoped to build a network of quantum data centers to eventually be able to compete with the three providers of cloud data services, Amazon, Google and Microsoft.

Quantum Computing Adoption Cycle

As Quantum computing is not quite easy to understand, the commercial use case will start next 10 years. The figure below shows the adoption cycle of Quantum computing from currently to next 15 years.

Figure 97. Adoption cycle for Quantum Computing



Technology Consumption in Thailand

Quantum computing will have a huge impact in the future on optimization, machine learning, analytics and image analysis. Quantum computing is in experimental stage right now, with the expected innovation and potential use case to be seen in a few years. It will reach its growth in 15 years with many use cases. Though general purpose Quantum computing would never be realized, the technology holds great potential in narrow confined areas.

The technology is hyped right now in many areas but its potential should not be ignored in the coming years. It is climbing the innovating trigger phase but currently offering limited business applications due to various complexities.

As the potential of Quantum computing is in the upward trend, the adoption rate of the technology will be in the similar trend. Even there is no one adoption now as it is in the research and development process, the quantum will impact various industries in the future.

Outlook of Local Companies/Institutes

The development of Quantum computing comes from the combination of knowledge from various disciplines. This is because educational institutions are sources that combine many experts in one place. As educational institutions have a suitable working system from the beginning of the experiment to developing into ready-to-use products, researching the early stage technology like Quantum Computing must first be in educational sector and supplement by giving opportunities, appropriate areas and facilities together with cooperation from other important sectors. Therefore, 7 leading universities in Thailand that focus on innovation based on education formed U.REKA project which is one of the projects that focus on Deep. InThai and QuTe are Deep Tech researchers in the U.REKA project.

QuTe a Thai researcher studies on Quantum Computing in order to disseminate this technology to Thai people. They also access to a community abroad through various collaborations and spend time building a stable ecosystem for a long term. Their object is to focus on developers, investors and technology users to understand the process and visualize the usage in the next phase.

Outlook of International Companies

The world is changing drastically as the technology advances. However, it is in the beginning stage. The real change is going to happen in the next few decades as the large enterprise invested in the Quantum computing. Now, giant IT companies such as Google, Microsoft, IBM and power countries

like United States, China, and Europe are seriously investing in the development of this technology. The medium and small enterprises will take few years to develop.

Google launched Google AI Quantum which developed quantum processors and novel quantum algorithms. The quantum processor 72-Qubit is larger than 50-Qubit, which CPU or GPU technology will not able to keep pace of the processing. The quantum processor called Bristlecone which use Gate-based Superconducting System reducing the error rate of processing. Moreover, they also test the processor processing with system of Simulation, Optimization and Machine Learning.

IBM has announced the appearance of Q System One or Quantum Computer for the first time with an internal circuit of up to 20 Qubit. Even the size of quantum computer is quite big, IBM has mobilized industrial designers, architecture and material manufacturers to work with the researchers of the company in order to create a computer that can be used commercially. Moreover, IBM also announced a partnership with ExxonMobil and a research lab like CERN and Fermilab to create Quantum's commercial and research society under the IBM Q Network program. Organizations that join IBM will have access to Quantum computer and Quantum software on Cloud. Currently, IBM Q Network partners include JPMC, Daimler, Samsung, JSR and Minho University in Portugal. Our members include Honda, Nagase, Barclays, Hitachi Metals and 8 startups, including Zapata Computing, Strangeworks, QxBranch, Quantum Benchmark, QC Ware, Q-CTRL, Cambridge Quantum Computing (CQC) and 1Qbit.

Microsoft has announced the launch of the Quantum Development Kit, a preview version for developers to use to create programs for working on Quantum Computer, especially with Q # language. This Quantum Development Kit is compatible with Microsoft Visual Studio and designed to work with the Quantum Simulator. This supports the simulation of Quantum Computer system up to 30 Qubit on general laptops. Moreover, Microsoft has launched the project "Microsoft Quantum Network" to support the collaboration of start-ups, universities and developers.

Key Issues in Adoption

1. **Hardware Challenges -** Quantum Computing is moving at a very slow pace due to the hardware challenges, for instance

- The technology is emerging technology so there are very less qubits available. For Quantum computing we need 64, 128 and further more qubits. The currently development of Quantum computing is about 50 qubits only.
- There is barely any connectivity in today's world. Quantum Computing requires greater connectivity with fewer restrictions.
- There is a very high error rate with the current experiments and research along with smaller coherence

2. **Interference and Error Correction -** Disturbance remains a challenge for the development of fully efficient quantum computers. Problems are associated with undesired interference demand enhanced error correction and fault tolerance tools

3. **Qubit Processor Units and architecture** - New paradigm architectures still demand significant work to create quantum processor units with higher number of qubits that efficiently work together, while demonstrating superior performance over traditional computers.

4. **Room Temperature Solutions** - Cryogenic conditions demand important amounts of energy and turn out to be systems highly dependent on extreme conditions. Non-cryogenic, room temperature solutions are needed to make quantum tools affordable.

5. **Integrated Circuit and Design Optimization -** The implementation of qubits networks demands innovative solutions for circuits capable of integrating adjacent technologies, such as nanofluidics and advanced materials to provide vital quantum solutions.

Quantum software is encompassing hardware development; physical quantum systems constitute the most critical aspect to restrain high growth. The synergy among diverse disciplines in quantum development is still growing, and there are multiple attempts to solve the same types of problems to develop optimal solutions

Experts need to start watching now for key milestone indicating that quantum computers are approaching supremacy. Various organizations which need to capitalize on the opportunity should start investing and building capabilities to take full advantage of the coming quantum technology.

Conclusion

Quantum computing is an emerging technology but the potential of the technology will enhance the effective of other advance technology. Therefore, the technology will grow in upward trend next few years. It will start in some specific sector such as healthcare but other industries will adopt the technology to use continuously. Currently, international large enterprises such as Google, Microsoft, and IBM have already developed the technology while QuTe a Thai researcher studies on Quantum Computing in Thailand. The technology will be developed more advance in term of qubit. The market size of the technology is expected to be THB 6.5 billion by 2030.

3.7 Automation

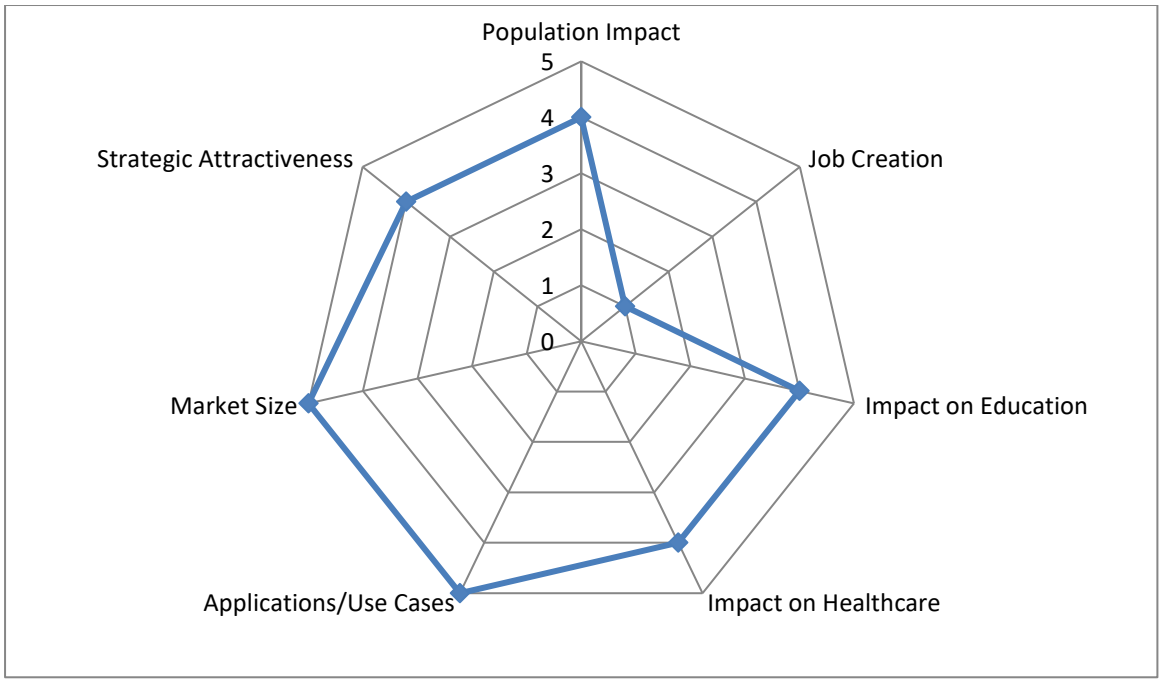
Automation is the technology by which a process or procedure is performed with minimal human assistance and its application in order to control and monitor the production and delivery of various goods and services. Automation has been replacing mundane tasks in various sectors including, manufacturing, technology, retail, therefore reducing fatigue and errors. The fastest growth in the global automation industry is in the robot automation segment which is used mainly in manufacturing. The automation implies the integration of machines into a self-governing system and support human labor. Therefore, the dimensions of job are charged along with many positions will be replaced by robots. There will be a lot use cases in the future and create a lot of impacts on various industries.

The automation has mainly 3 sub-classifications, which are Robotics Process Automation, Smart Process Automation, and Collaborative Robots, driving adoption's growth. Automation would expect an investment of more than THB 200 billion within next 5 years. By 2026, Thailand is expected to become an exporter of robotics and automation.

Why Automation has been selected?

Automation is one of important technologies supporting the digitalization of various industries. Not only supporting human being's task, but automation also creates more efficiency and effectiveness in working processes. Moreover, population will be impacted from the technology adoption in both positive and negative ways. Therefore, automation has been selected due to its overall high-scoring outcomes on the criterions below.

Figure 98. Scoring of Automation



Source: Frost & Sullivan

Population Impact: Score 4/5 (High)

As automation will work effectively and efficiently, many businesses will adopt automation in some processes. Population will be affected in one of processes. In manufacture, people need to have skills which cannot be replaced by automation. It will be leading the population to age and experience a reduction in the workforce. In medical, automation will offer higher precision for medical operations. The doctors can work effectively with the automation supports. People life-time will possibly extend as the death rate decrease. Therefore, automation will create both positive and negative impacts to population globally.

Job Creation: Score 1/5 (Lowest)

Automation could bring a lot of benefits to employers in term of productiveness, management, and cost reduction. This will lead the number of automation use case increase. From research, more than 50% of job activities will technically automate. Additionally, more than 30% of sixth-ten of current occupations will technically automate. As the automation will come to replace the human being work, less than 10,000 jobs would be created by robotics, automation and AI in Thailand by 2030. However, there are some job position increasing as the jobs about IT controller, system integration providers, software development, maintenance, parts suppliers, and related job which support the automation use cases will be created. Therefore, the job creation over automation technology is in the mid-point.

Impact on Education: Score 4/5 (High)

Automation's impact in education will continue to augment the way staff and faculty work and improve how students engage and learn. Manual and repeatable activities have weighed down this system for decades, but they have met their match with automation. Once fully operational, faculty will be able use automation to take the busy work out of their jobs, freeing up time for meaningful student interactions in the classroom.

Impact on Healthcare: Score 4/5 (High)

By implementing automation successfully, healthcare organizations can reap the benefits of streamlined processes, including a simplified product lifecycle, faster time to market, easy-to-maintain regulatory compliance, and cost savings throughout. For example, low-code helps workers in the healthcare industry build their own applications that circumvent such problems and bring drugs to market much faster. It can also work alongside emerging technologies like robotic process automation (RPA) and Artificial Intelligence (AI) to streamline drug development processes and leverage data to inform lifesaving decision making. However, automation might give drawbacks in failure, mistaken, eliminating of doctor's assistant jobs. It could also possibly destroy doctor's judgment and diagnosis gradually when they getting used to the automation helping.

Applications/Use Cases: Score 5/5 (Highest)

Automation will have more than 100 use cases across industries. The main use cases will be in the manufacturing industry to which machines are used to enable fast and automated productions. Collaborative robots will support the human being works which increase efficiency and effectiveness. Not only automatic machines, but automatic business process will help the organization be more convenient. For example, the processes of ordering fulfillment, application management, or invoice management/billing are automated which reduce the time consumption of many positions. Every single process starting from manufacturing to services to end-user could be covered by automation. Additionally, other industries like banking, utilities, defense, and transportation will take benefits of using automation in their organization as well. These drive the number of automation use cases in long term.

Market Size: Score 5/5 (Highest)

More than 60% of Thai manufacturers will adopt the adoption of automation systems within one to three years while medium-sized businesses will be ready in three to five years, followed by small companies in five years or more. Additionally, more than 24 industries will be impacted by automation. Manufacturing, healthcare, construction, law enforcement, and agriculture are major industries impacted. The market size of automation will rise continuously as the increase of automation adoption. The expected market size of automation in Thailand will be over THB 1 trillion by 2035.

Strategic Attractiveness: Score 4/5 (High)

Automation involves a very broad range of technologies including robotics and expert systems, telemetry and communications, electro-optics, Cybersecurity, process measurement and control, sensors, wireless applications, systems integration, test measurement, etc. Therefore, the technology has high impact and covers most key high impact applications and industries. The technology will have a strong impact and will become a main-stream technology of future.

How Automation supports Digital Thailand Agenda?

To drive digital economy, automation is a key technology as it will rise productivities and reduce cost. The benefits of automation in term of effectiveness and efficiency will drive digital economy in Thailand to achieve the goal. Moreover, many government agencies have supported the adoption of the technology. For example, BOI approved 50% corporate income tax exemption for businesses that use robots and automation systems. Ministry of Finance allowed 300% income tax reduction for robotics and automation research. Ministry of industry In support of low interest loans for small and medium enterprises (SME) in order to improve production efficiency by using robots and automation through SMEs funds and other funds. Therefore, the support in the development of the robotics industry and automation systems that are going to happen in the future are likely to affect the Thai

industry in a wide range. Enterprises and owners of small and medium enterprises (SME) will drive new innovation for the business. For large industries, not only create and use modern technology, but also trade technology with both domestic and foreign investors. Modern robotic technology and automated systems will assist in the industry so that products could have more quality with low price. The modern technology is highly flexible and can help to produce products that are in high standards with consistency. Development of the robotics industry and automation systems with being supported will drive the digital economy to grow rapidly.

Sub-classification of Automation

Automation is an umbrella technology which has a lot of sub-classifications under. However, the sub-classification, which we will focus on, consists of Robotics Process Automation, Smart Process Automation, and Collaborative Robots according to the trend of use cases.

Robotics Process Automation

Robotics Process Automation or RPA is a technology which allows a company configures software, or a robot, to capture and interpret applications for processing a transaction, manipulating data, triggering responses and communicating with other digital systems. As it is automation, RPA will support the organization to reduce staffing costs and human error. Therefore, it will use to transform working process and improve office work to be more effective. There are several enterprises adopting RPA which are Walmart, Deutsche Bank, AT&T, Vanguard, Ernst & Young, Walgreens, Anthem and American Express Global Business Travel. In Thailand, Frost & Sullivan estimates RPA market to reach THB 1.6 billion by 2025. It will be widely used in Thailand in manufacturing, retail, aviation and legal sectors.

Smart Process Automation

Smart Process Automation or SPA is an extension of robotics process automation version 2.0. As RPA is the foundation of smart process automation, SPA will work similar to RPA with some differences. SPA let robots utilized AI and ML to perform cognitive tasks with yielding great value when dealing with Unstructured Data. SPA shifts the workload to the machines. It intends to mimic humans as they perform a task. The obvious by-product is that of human capital becoming available to perform high value work. Therefore, it will be next leap in business process automation. The technology will be used in leading banking, insurance, and healthcare organizations to improve service delivery and operational agility by automating the unstructured data work that robotics alone cannot address.

Collaborative Robots

Collaborative robots or cobots are robots that can work alongside humans. Their ability to ensure worker safety and integrate with the existing environment is enabling them to gain steady traction in recent years. Cobots, are designed to work safely in the proximity of human colleagues without cages, minimizing footprint and enabling the automation of more industrial tasks to improve production. Their interaction with humans is more natural. They share the same workspace and can be easily reprogrammed. Enabling technologies, such as artificial intelligence (AI), sensor technologies, facial recognition, and other technologies supporting Internet of Things have also contributed to advancements in collaborative robots.

Government agencies globally are actively pushing development and adoption of automation as it will support other advance technology in some part. As industrial is one of the main industries in Thailand, automation will be very important technology to drive digital economy in industrial sectors. Therefore, depa should focus on all of these sub-classifications in different period. For 5 years from now, cobots

and RPA will be important technologies regarding to the development measures of the robotics industry and automation systems approved by the cabinet. This will increase the efficiency of Thai industrial production and development to the industry 4.0. Next 10 years, other advance technologies will be more adoption which will be suitable time for SPA. As SPA is developed version of RPA, technology like machine learning will be supported to let robot work more effectively. Next 15 years, other technologies will come and support SPA to be more advance. Automation will possibly create driverless car like drones to work in digital economy nationally.

Trends of Automation across the world

The world is witnessing a radical transformation in industrial automation especially in term of a technological shift. Worldwide organizations have leveraged intelligent automation to help drive digital transformation in order to fine tune of their operational and business model with a fast changing situation. Another factor driving globally automation and robotics adoption is talent shortages as a result of aging society in many developed countries. The goal of automation deployment is not simply to achieve greater cost reductions, but to use human capital in the best possible way. Cobots and RPA will be the mainstream in scale across number of organizations because RPA is a tool which helps saving operational cost and cobots can be deployed to work alongside humans.

Many companies go beyond pilot and start-up phase of RPA deployment. They have structured a new business model to speed up their operations with the help by RPA and some have gone further to scale a new technology with IT processes by integrating fully with existing business processes and strengthening the established Center of Excellence. On this advanced phase, organizations can wider the scope and increase impact of the RPA programme.

The engine to drive the growth of industrial automation in the last few years is that robots have become readily setup compared to the old days that it needed weeks or months to program and dial in with production line. The 3 main use cases across the world for RPA are back-office processes (such as within HR or finance department), customer care and front office processes, and as an enabler for Artificial Intelligence.

Automation and robotics industry will contribute to the greater economic around $15 trillion to global GDP by 2030. Their ubiquitous in various industries will generate the demand for many jobs as well as displace some existing jobs. According to PwC analysis, as the first wave of automation called as algorithmic, around 3% of jobs will be displaced by the early 2020s but the rate of job displacement could increase in later wave as the technologies evolve maturely and are rolled out across the economy in increasingly autonomous form. As the third wave coming by the mid-2030s, up to 30% of jobs could be automatable.

Many sub-classifications under automation will see the most advancement in term of technology integration. One of them is Robotic Process Automation (RPA) that has been programmed to handle repetitive tasks but in the coming future, RPA will be integrated with Artificial Intelligence (AI) and Machine Learning enabling RPA to handle more complex and less repetitive activities. This advancement will add more value to the various industry and overall economy.

Trends in Southeast Asia

Market growth in emerging Asian countries will increase APAC's market share to 36.5% in the global automation market revenues in 2018 with Southeast Asian nations currently ahead of the curve. According to the International Federation of Robotics (IFR), SEA nations took six of the top seven positions in the ranking. South Korea leads the world with 2.4 times more robots adopted than expected, followed by Singapore, Thailand, China and Taiwan. Although Thailand has only 48

industrial robots per 10,000 manufacturing workers, its adoption rate is 159% higher than its wage levels would predict.

One of the key engines driving the adoption in SEA is the establishment of national goals and strategies to support robotics innovation and adoption. On the top of that, SEA countries have collectively grown faster in term of economic than any other Asian countries since 2000. For industrial robotics adoption, Thailand has been positioned as the most developed countries due to its strength in the manufacturing vertical. However, according to Asian Robotics Review, in 2016 non-industrial robots have dominated the robotics market revenue with 59% share and this is the first time that we see non-industrial robots have shared this large contribution. In addition, the non-industrial robots are estimated to grow at a higher rate in the future.

Trends in Thailand

Automation and robotics have been set as one of the new S-curve industries that will help accelerate Thailand to the value-based, innovation-driven economy of Thailand 4.0. Thailand is the world renowned as a home of ton of manufacturing hubs. Almost 85 % of the manufacturing industry in Thailand can benefit from adopting automation but today less than 30 % are ready to implement it.

Most of the Thai companies in the Automation & Robotics industry are doing business in the areas of system integration and mechanical brain & software development leaving parts & components and high-tech robots in demand. Thailand Institute of Field Robotics (FEBO) reported that Thailand's spending annually on importing Automation & Robotics is over THB 260 billion with conveyer systems as the highest demand and robots along with automated storage and retrieval systems (ASRS) running after orderly. Thailand was ranked 10th in 2016 in applying Automation & Robotics technologies to the local manufacturing sector, measured by robot density per 10,000 workers.

Automotive, electrical & electronics, and food processing are the three main industries investing in automation in Thailand. Food processing industry has increasingly embraced automation and robotics, especially cobots, due to the promotion of smart farming from the government. In healthcare industry, medical robotics is welcomed more and more including international expertise due to Thailand's aspiration as the medical hub of Asia. Example of Thai medical robotics are DINSOW; claimed to be the best of elderly care robots in the world), B-Hive; a pharmacy automation system and FHASAI; helping autism children.

Logistics is another area that we will see the rise in Automation & Robotics adoption in Thailand in order to support the supply chain of Thailand's industrial automation and the maniac growth of e-commerce. This leads to the widely adoption of automating warehouses and picking or anything that falls into an intelligent warehouse term.

The Thai government has put a number of financial and non-financial initiatives toward Automation & Robotics' industry support. On the demand side, incentives have been provided on a wide range to both new investment projects and existing investments. Incentives include a waiving of corporate income taxes for three years and exemptions of import duties on machinery under the identified conditions. On the supply side, Thailand's Board of Investment's offers incentives covering a wide area of business activities related to automation & robotics industries ranging from conceptual design solutions to installation.

However, Thailand's workforce is still far behind in term of skills and knowledges in order to handle automation and robotics technologies because they evolve quickly. Both private and public sector cannot turn a blind eye on this issue anymore. They need to address these skills gap and provide an appropriate technology training to stay ahead of the curve and remain regionally and globally competitive. A Manufacturing Automation and Robotics Academy (MARA) is an example of the

initiatives between the Thai government and the Federation of Thai Industries focusing on developing workforce, advancing skillsets and training vocation over 10 years and 3 phases.

Digital Innovation in Automation

Automation has a lot of use cases in long term. However, the technology will still be adopted in the future with the new innovation. For example, Smart Process Automation is one of automation which integrates between automation and machine learning so the work is more effective. In the future, there will be other digital innovation from automation combined with other advance technology. The potential digital innovation in automation is listed below.

Robotic integrate with AI.

AI technology will let robot work with intelligence ability. A recreation of human thought process from AI will include the ability to learn just about anything, the ability to reason, the ability to use language and the ability to formulate original ideas. Physical robotic design is a handy tool for understanding animal and human anatomy, AI research is useful for understanding how natural intelligence works. Therefore, if robotic integrate with AI, some robots could learn by mimicking human actions.

Automation and IoT

The Internet of Things (IoT) is about to connect with automation. The primary drive for automation IoT is to significantly reduce operating expenditures when automation devices, sensors and actuators become Internet-enabled devices. IoT must be self-organizing, self-configuring, self-healing, scalable to large sizes, with very low energy consumption, low cost, simple to install and based on global standards which current automation network standards simply cannot meet.

Potential of Automation

In the past few years, automation and robotics has become the main engine to digital transformation in industrial and many industries. Amidst of the labor shortage, high competition and drop of efficiency, entailing high technology likes the automation and robotics will pave the way towards the Industrial 4.0 model as same as an advanced economy under Thailand 4.0.

Automation is proved to deliver faster and safer solutions which are more efficient, flexible, reliable, sustainable and cost-effective; in short conclusion, economies of scale. For example, automated operation in retail industry will help business running 24/7 without high-intensive on staffs. In this case automation will help ordering process, checking warehouse, shipping orders, billing an invoice – the list goes on. Businesses may consider investing in automation and robotics as a too much digital way and waste IT budget but actually, automation can immensely reduce production cost and has a quick return on investment (ROI). Automation can benefit a factory to become a lean manufacturing due to its unique characters to work longer and faster which decreases in part cycle time. Moreover, its accurate and repeatable benefit the products to be manufactured with same standards and processes every time and its accurate also help reduce waste due to the decreasing amount of raw material that needs to be used.

In term of economic, consumers have gained the convenience of greater choice of goods and services. For example, ATM cash machines are a very simple example of automation which enables people to get cash when banks are closed. With automation, cost of production is lower leading to lower prices and then more disposable income to be spent on a wider range of services. Most importantly, automation will indirectly create new kinds of jobs which are more creative, less repetitive and enable more flexible labor markets. Employees would be free to take on a more value added tasks and contribute more to the firms. Automation also lies at a heart of the country to remain

competitive internationally. If one country doesn't embrace automation or support (i.e. tax incentives, training, funding, etc.), production from many multinational companies will shift to those countries that do, and then gain comparative advantage. In short, automation will be a major driver on the economy and remain over the next decade. It will lead to significant benefits including greater GDP, overall higher productivity and higher-level of customization for consumer experience. Past trends in automation since 'Industrial 1.0' had served the economy well and human cannot be in this convenience without the development of automation. Automation frees many people that shouldn't be trapped on dull tasks and those people can utilize their own abilities to join a fast changing economy and sometimes leads to a whole-new industry.

Potential of automation in Thailand is huge and the market will significantly rise supporting by the country's position as a regional automotive hub, electronics & electrical appliances hub, center of food processing industries and medical services as well. This is going as the same way the International Federation of Robotics (IFR) considers the automotive and electrical and electronics industries to be the highest contributor to drive the global automation and robotics growth with the market share of 64% roughly.

In Thailand, the robotics and automation market is estimated to reach THB 200 billion in 2020. RPA will grow more than 200% due to the high adoption in Thailand. For the year 2020 to 2025, the market is predicted to grow with CAGR of 13.98% leading to the market value of THB 438 billion in 2025 driving by the purpose to become the world exporter of robots and automation systems. In the next 10 years, Thailand market will grow at the similar rate of global seeing the CAGR around 9% from the year 2026 to 2030 with THB 739 billion market value in 2030. The market would soar over 1 trillion by 2035 with the CAGR of 6% in forecast period (2031-2035).

Use Cases of Automation

Automation will be adopted in various industries as it is enabling industries to achieve enhanced productivity and cost reduction. More than 24 industries will be impacted by automation. The top 5 industries are manufacturing, healthcare, construction, law enforcement, and agriculture. The use cases of automation in 5 years, 10 years, and 15 years is listed below.

Manufacturing

The use cases in manufacture industry could be occurred in several areas. Automation will support in quality inspection, assembly, machine tending, dispensing, pick and place, welding, packaging, palletizing, or injection molding. An automated production line consists of a series of workstations connected by a transfer system to move parts between the stations. In the normal operation of the line, there is a work part being processed at each station, so that many parts are being processed simultaneously and a finished part is produced with each cycle of the line. For next 5 years, modern automated lines are controlled by programmable logic controllers, which are special computers that facilitate connections with industrial equipment (such as automated production lines) and can perform the kinds of timing and sequencing functions required to operate such equipment. Next 10 years, autonomous driverless car like drones will be used in manufacture helping to move products and other processes in the organization. Next 15 years, automation could possibly process in every unit of manufacture. People will just only monitor and control in each process.

Healthcare

Automation will support in surgical robots, nursing assistance, elderly care, supporting to disabled, therapy, rehabilitation, training, tele-presence robot, and physiotherapy. For 5 years, automation can lead to substantially faster and error-free processing, thereby laying down administrators of appreciable burden. The technology will create more effective management of supply processes such

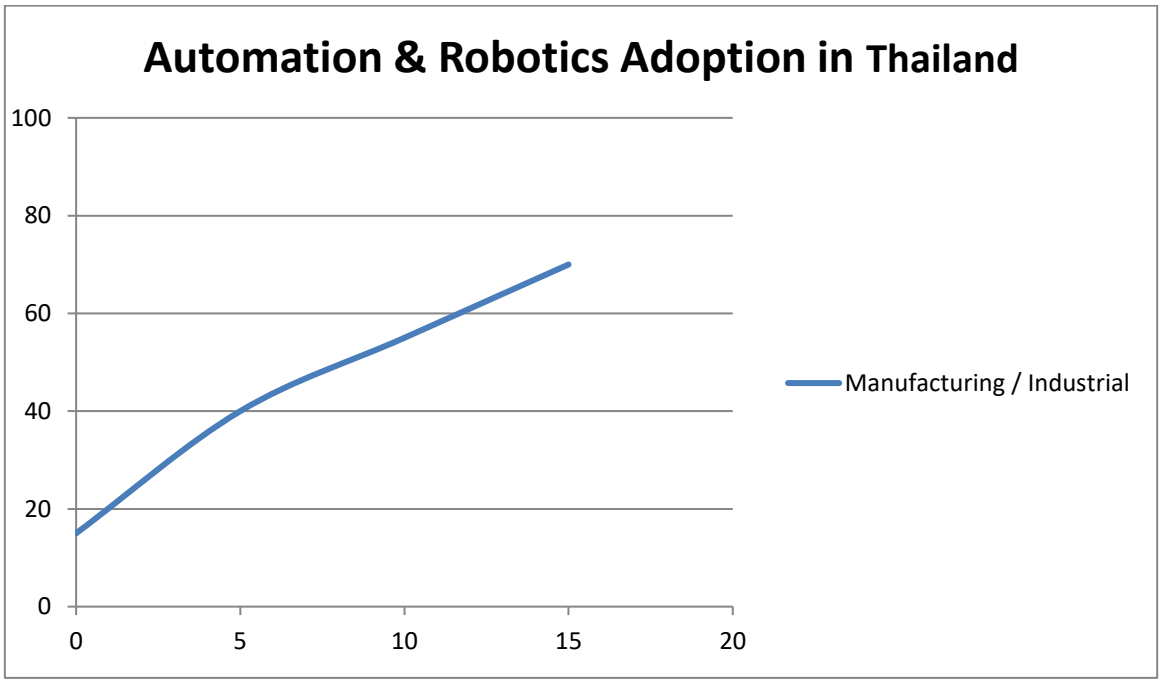
as claims and billing. For next 10 years, healthcare sector will adopt RPA in their processes. RPA in healthcare results in tracking more standardized, patient-specific routes towards patients' desired health objectives. Next 15 years, RPA use cases in healthcare offer valuable insight into why it's worth passing on some repetitive tasks, like entering patients' blood test results into specific files and then consistently updating those files, to software robots.

Agriculture

Automation in agriculture could be used in different areas such as autonomous tractors, crop seeding, crop monitoring, fertilizing and irrigation, weed control, thinning, pruning, picking and harvesting, and herding. Currently, there are many farm using automatic watering and irrigation. Next 5 years, the development of automation will happen by integrating with IoT. The real-time monitor will happen from using of drones. Imagine the benefits of using a small fleet of drones instead of a team of workers spending hours on their feet or in a vehicle travelling back and forth across the field to visually check crop conditions. Next 10 years, automation will be main part of smart farm as it will improve the quality of life for farm workers by reducing heavy labor and tedious tasks. Software can automate the frustrating task of resource tracking and management. There will be other advance technologies supporting in smart farm which will increase effectiveness of agriculture. IoT and farm management software will be available and growing in popularity and sophistication. Next 15 years, as the tractor is the heart of a farm, used for many different tasks depending on the type of farm and the configuration of its ancillary equipment, autonomous driving technologies advance will be used in tractors.

Automation Adoption Cycle

Figure 99. Thailand's Automation Adoption Cycle



Source: Frost & Sullivan

Automation Consumption in Thailand

Robotic Process Automation (RPA) is still in the early stage of adoption in Asia-Pacific region as same as in Thailand. Less than 35% of Thai companies will adopt RPA in the next 5 years but RPA is estimated to have the fastest growth among 3 major sub-classifications because of its less

complicated characteristics and easily adaptable with low-cost. Most of Thai organizations think that automation is not related to their businesses. The barriers for adoption are the lack of technology recognition and the IT strict budget. Then, the first priority for organizations is to realize that RPA will help digitize operation and increase the effectiveness. With the introduction of RPA, a company can develop a repetitive work process into an automated process for both back end and front end. In the first 5 years, Financial & Banking and retail will see the highest growth in term of adoption rate. For the next 10 years, RPA will be wide-spread across different industries and becomes fundamental software for digitalization. By 2023, Frost & Sullivan believes that RPA will be developed into a more advanced technology called cognitive automation which is similar to AI.

Smart Process Automation (SPA) will see much of growth in next 10 years after the adoption of RPA. For the first 5 years, less than 15% of Thai companies are considered to adopt it with banking and finance as the early vertical adopter. This is because it will help reduce loan approval time as well as reduce half of the number of employees who have to work in the loan approval process. SPA will help to enhance digitization after RPA has become a basic digitization for organization. In short, RPA can be evolved to SPA by integrating with AI and Machine Learning. SPA will be most adopted in service industry due to its unique characteristics to mimic human tasks. In the next 10 year with regard to the application of SPA, Banks, Insurance, Healthcare and other transaction intensive industries will widely adopt this technology. More than 40% of Thai companies will be linked with SPA including service industry, electrical and electronics industry and automotive industry.

Collaborative Robots is expected to grow continuously due to the shortage of labor and rising competition. So, many manufacturers and service providers have embraced cobots for greater production efficiency purpose because of its safety and flexibility. A number of factories, industrial parks and warehouses will be filled with cobots working side to side with humans every day. More than 12,000 units will be fully employed within 5 years. The initiative of Eastern Economic Corridor in 2018 plays as a key engine to usher cobots employment in Thailand. Moreover, cobots will drive Thailand to achieve the objective of Thailand 4.0 and this sets cobots to become the fastest growing in robotic sector. For the next 10 years, cobots will be the fundamental tool in automation with a less growth compared to 5 years before.

Outlook of Local Companies

CT Asia Robotics is a subsidiary of CT Asia, a leading best in class software focusing on contact center based in Asia. The company is the first commercial robot producer in Thailand and launched its first robot in 2009 named DINSOW which is the first service robot of Thailand and ASEAN region. A year later, the company developed restaurant service robots for MK, one of the largest restaurant chains in Thailand in order to take orders and deliver foods for customers. Not only does CT Asia Robotics develops service robots for domestic companies but also manufactures to export, such as for the restaurant in Lidköping, Sweden.

The biggest advancement of the company is to partner with hospitals in Thailand and Japan and successfully launch robots for healthcare sector which is robot for elderly care service. The elderly care robot has not only been employed in Thailand and Japan but also in Europe region as well. Until now, DINSOW has 3 series and will be launched series 4 in the near future. The latest commercial robot from CT DINSOW series is DINSOW mini. According to the founder of CT Asia Robotics, Dinsow is currently considered to be number one in the world among elderly care robots.

Eureka Design Public founded in 2002 specializing in design and manufacturing of special machine for automotive and part industry. It has 3 subsidiaries which are Eureka Design International (investing in overseas business such as ASEAN region), Bekutoru (Thailand) and Eureka Automation (main role is to support Eureka Design Public). The company focuses to serve in domestic market but not limited to overseas such as Vietnam and India. In 2007, the company successfully exported its

first leak test machine overseas. On the top of everything, the company made a big jump in 2012 to get listed in MAI stock market.

The company manufactures and designs automation machinery customizing to the needs of each customer in term of both features and appearance. Eureka provides a wide range of machineries including testing, cleaning, assembly and marking system for automotive component such as engine, steering, transmission, suspension, brakes, and etc. Main customers are in automotive industry both car and motorcycle (i.e. Toyota, Mitsubishi and Thairung).

Yip In Tsoi is an innovative leader in providing comprehensive technology solutions as systems integrator. The company has established since 1926. They have supported several projects from both public and private sectors. In the past, the company was mining business before explored to 3 different field which are agriculture Fertilizer, Sissons paint and IT solutions business. They also have many subsidiary companies such as tangerine, Enrich broker, Yip In Tsoi energy, etc.

As they provide complete IT services, they are called as total solution provider. Automation system is one of the provided solutions. For example, IT Automation used to help organizations realize the use of various systems that need to consider the interoperability of different devices and brands to increase the efficiency of the organization's IT system. Moreover, as-a-service solution from Yip In Tsoi will combine various technologies such as compute storage and network which will be able to be further expanded into automation.

Outlook of International Companies

Businesses around the world are preparing for the transition into Industry 4.0. Many corporations and factories in Thailand have been investing heavily over the past few years in automation machineries and systems with the world's leading automation technology providers. Together with the attractive incentives offered by the government, major global automation and robotics firms are motivated to expand their operations and services in Thailand. Here below are the outlook of several renowned firms who came to join the Automach 2018 event which is one of the largest automation and machine technology showcases in Thailand.

ABB

ABB is the leading global technology and automation company which develops digital connection with industrial machine and systems. Company's strong reputation in manufacturing robotics and automation enables customers in various sectors such as utility, automotive and construction to improve their performance with the minimum impacts.

The company claimed that one of the successful strategies is the setting-up ABB office in Thailand as the hub of the region. ABB thought that the location of Thailand is very convenient for supporting neighboring countries such as Vietnam, Cambodia, Myanmar and Indonesia who have huge potential shifting for automation in many sectors. Thailand where the industrial sector substantially grew in the recent years has very high local market demand for automation, robots and innovation technical improvement. For example, ABB has just involved with many giant firms in Thailand to improve their productivity such as SCG's cement plant, Thai Bev's Brew, and new greenfield sugar mill and biomass power plant of Mitr Phol Group in Thailand.[234]

Supporting and facilitating research and development for industrial robots in the educational institutions is another drive for automation of ABB in Thailand. It aims to enhance knowledge, skills and experience in programming and operating the technology particularly in robotics and create new career paths along with new Thailand digital policy which is aligned well with ABB's future direction.

[234] https://www.boi.go.th/upload/content/Advance%20robotics_ABB%20Limited_5a3b46e362519.pdf

This support and policy will boost the market not only in robotics and automation hardware, but it will also drive the growth of system integration and software development services sustainably.

Siemens is one of the world's largest engineering companies focused on digitalization and automation solutions. Siemens Thailand is rolling on the same road to Thailand 4.0. One of famous software of this technology from Siemens is TIA Portal (Totally Integrated Automation) which was launched for customers within South East Asia in 2017. Its "One for call" concept helps the automation system to be worked on Cloud network and integrate all manufacturing processes, machines controllers, and product cycle management to work together smoothly.

With the increase of upcoming projects and businesses in Thailand which are accelerated by global and Chinese investors, the firm is willing to provide help and support with its advanced model in automation and aims for the double-digit growth of revenue in Thailand and in neighboring markets for the next five years. However, the company realized that although there are many supportive aspects for building the country towards Industry 4.0 age, different manufacturers are at different levels in implementing digitalization and automation solutions due to the varying sizes, processes and financial conditions.

Unlike ABB, Siemens said the company has no plans to build Thailand as a center of digital services for the region. "It requires a high cost of investment and Thailand lacks the same labor force availability and talent found in Singapore" said by CEO of Siemens Thailand[235]. He also suggested all businesses in the region not to just wait for external drives, he expects organization leaders to prioritize and push strategies about automation solutions forward.

Mitsubishi Electric is a world's leading electronics equipment manufacturer from Japan. As the merger between Mitsubishi Electric Automation Thailand (MEATH) and F.A. Tech in 2012, Mitsubishi Electric Factory Automation (Thailand) Co., Ltd. or MELFT was established for providing products and services in the field of factory automation in Thailand. MELFT has supplied many automation systems ranging from automated machines to industrial robots to many companies in the region.

Mitsubishi sees that SMEs who have factories in Thailand tend to implement more and more Factory Automation (FA) system as well as CNC machines (Computerized Numerical Controllers) at breakneck speed. The company believes that its latest technologies in robot system solutions and supervisory control and data acquisition (SCADA) software can meet today's industrial needs. Therefore, Mitsubishi Electric is now moving forward with the e-factory policy which will integrate robots and automations with many digital technologies such as AI and IoT in order to build seamless operations as the smart factories for their customers.

In addition, Mitsubishi is ready to develop and advice the people in the industry. Many technical experts of the company who have a lot experience in automation systems in many countries have collaborated with many educational institutions within the country such as KMITL, Burapha University and Thai-Nichi institute of technology. They aim to cultivate specialists in the automation system continuously for ensuring that the local workforce of this technology will not be shortage.

Key Issues in Adoption

As the arriving era of Industry 4.0, many technologies will accelerate all the sectors to another level and automation is one of the crucial piece of the evolution. However, there are several aspects which are likely to be the bottlenecks of the automation adoption in Thailand.

[235] http://www.nationmultimedia.com/detail/Corporate/30347393

Skill labor is the topic that is probably talked about the most. While many incentives for automation and digital solutions offered by the government are very attractive to the foreign investors and global automation service providers, many corporates are still unable to adopt the system due to the lack of knowledge and experience of local workforces. Education quality on the technology in the country might be one of the difficulties for adopting. Automation needs special skillsets combining Electrics, Mechanics, Computer Sciences, creativity and analytical thinking. Even though new employees are sent out for training, they still do not understand because of the skill mismatch. Federal of Thai industries (FTI) survey[236] said that just only 30% of vocational students can serve the market and 70% are mismatched in term of skills.

The technological disruption from automated systems and robots puts some pressure on the labor market in Thailand. Due to various benefits of them, many companies are trying to let automation come in and take existing employee's jobs. Although automation can create some new jobs, the unemployment rate in 2019 is predicted to jump from 1% in 2018 to reach 1.2-1.3% in 2019 and most of those will come from industrial sector as National Labor Development Advisory Council announced[237]. It means roughly 400,000-500,000 workers in the country would possibly be jobless. Rushing in this adoption might affect the labor market situation harmfully and give dramatic drawbacks to the Thailand's economy.

The readiness of the business is also another pain point of the technology implementation. Replacing human with the robot and automation systems need a lot of capital investment. Most of them are from the other countries and the prices are not cheap. It also requires many changes in the organization such as factory layout, working process, management plan, and organizational culture. Business owners need to think thoroughly because spending a bulk of cash on automation might not give positive return on investment in the short run especially for small and medium size businesses. From the Thailand robot summit in 2018[238], it showed that only 50% of businesses are ready to use automation system in these 3 years and most of them are the large MNCs. While another half needs more than 3 or 5 years to prepare for the automation adoption.

Conclusion

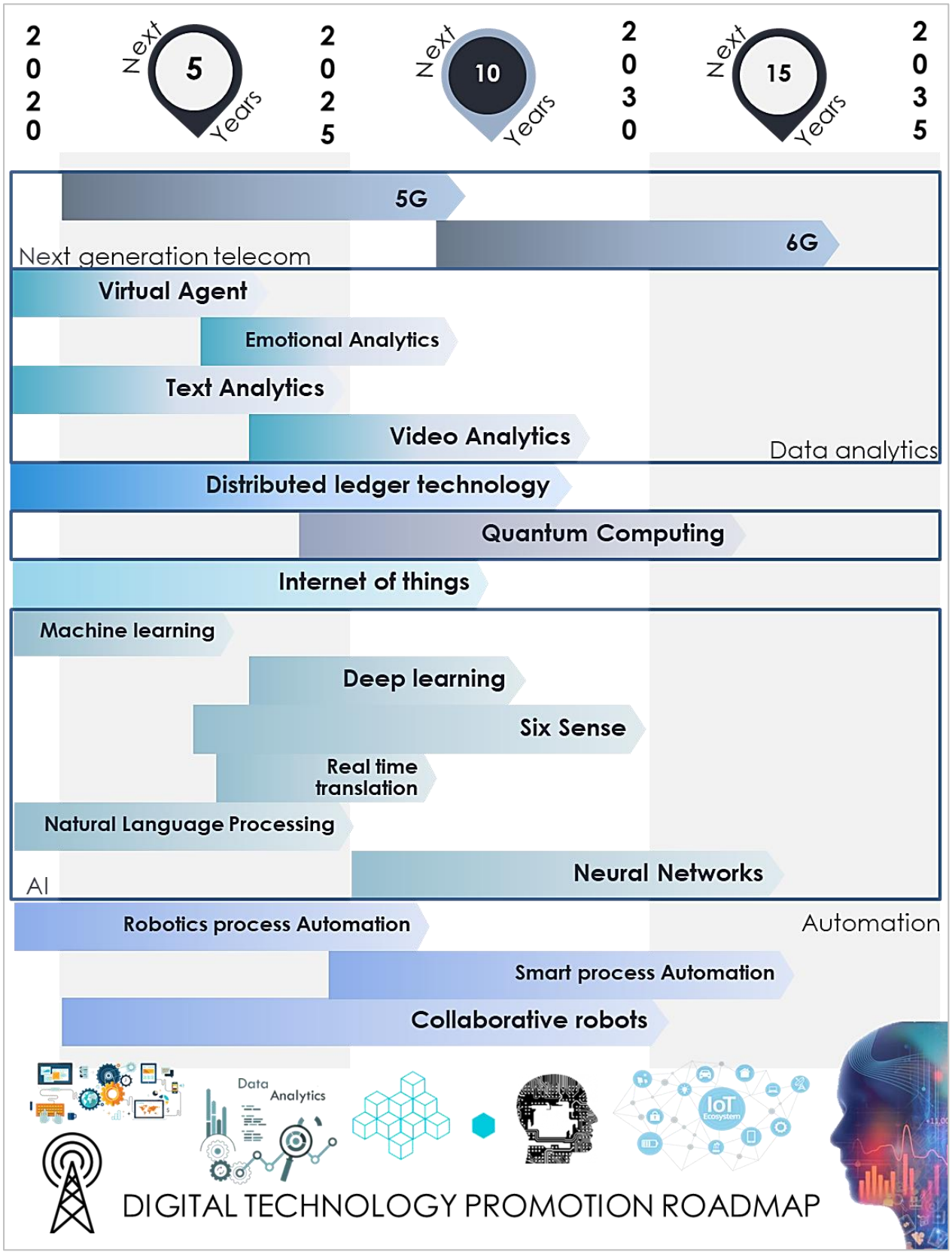
Automation & Robotics market in Thailand will be one-fifth of the biggest in the world with the value over 1 trillion by 2035. Thailand has strategic advantages from being many regional hubs ranges from automotive and electrical & electricity manufacturing hubs to a medical hub. These industries will be the main engine driving automation and robotics adoption in Thailand. Moreover, the Thai government has set automation and robotics industry as one of the new S-curve industries that will be promoted and supported by both financial and non-financials initiatives. The demand side has been growing significantly due to a number of located manufacturing hubs pushing Thailand to think about being a major automation and robotics exporter by 2026. This will decrease an investment flowing out of country and help circulate Thai economy by supporting Thai designers and manufacturers. With continuous adoption of this technology, it is now time for Thailand to go for more advanced technology to support the transformation of its economy under the Thailand 4.0 model.

3.8 Section Conclusion

From the assessment of 7 shortlisted technologies, Frost & Sullivan derived at the Digital Technology Promotion Roadmap for depa in the next 5, 10 and 15 years as shown in Figure 100.

[236] https://www.bangkokpost.com/tech/local-news/1630714/automation-ai-pressure-factory-labour-market
[237] https://www.bangkokpost.com/tech/local-news/1630714/automation-ai-pressure-factory-labour-market
[238] https://robotics-summit.com/assets/files/ปาฐกถา%203%20Government%20Vision%20-%20Robotics%20As%20A%20New%20S%20Curve.pdf

Figure 100. Digital Technology Promotion Roadmap



4. Economic Impact Assessment

Economic Impact assessment is specific form of analysis technique that calculates the impact of a particular project or in this case technology on the economy, especially relating to employment as well as impact on education and healthcare. These economic technological assessments assume that employment and productivity would increase as a result of the infusion of technology. Technology assessment defines the evaluation of impact, influence or consequence of technologies on the global health of the economy.

The world is drastically transforming with continuous outpour of numerous technologies. It is imperative to ask the question of how much the technology would impact the economy, businesses and consumers. Businesses want to know how they can capitalize on the opportunities that technologies would bring; how much investments are required and consumers want to know opportunities created for jobs and employment.

Economic assessment helps to provide a clearer picture of the economic potential that these technologies would create to the global economy. It is essential to analyze economic impact to ascertain opportunities and risk, detect possible undesired developments early on, to improve alternative solution approaches.

Digital technologies are often seen as disruptors and can significantly alter the status quo by impacting the existing processes, participation and contribution of the labor force and getting newer products and services to the market. The impact of these technologies on the economy is very significant thus making its assessment vital to the process. Technology spending, gross margins and economic growth are directly related and measured with GDP and productivity. A drop in spending on technology leads to a downturn in the GDP thereby impacting the labor workforce.

In every industry and within most companies, impact of technology is pervasive on the revenues. It is clear that technology infusion is important for success of any organization or economy. Thereby it is essential to look beyond the present scenario and assess the potential and impact of the technologies. This would help the companies to invest in real time according to market conditions. It would make all the difference for the organizations and the economy as a whole.

Our Framework for Economic Model

Our assessment consists of 3 axis view of Economic Model. First axis is **Economic Impact** based on Population impact, Job Creation, Impact on Education, Impact on Healthcare and Strategic Attractiveness. Second axis is **number of use cases and applications** that will emerge in the next few years. Lastly, **market size** will be shown as the third axis.

This is a powerful way of analyzing complete impact of the technology on Thailand because it will show that what happens when technology starts to achieve wide scale adoption and impact on society, then we can see that how society respond to this impact and take advantages from the technology. Digital technologies are often seen as disruptors and can significantly alter the status quo by impacting the existing processes, participation and contribution of the labor force and getting newer products and services to the market. In disruption, one has to factor in the time for transition and the micro level effects it may have on the people.

Framework detailing

Socio-Economic Impact

- Population Impact: It is the criteria showing the proportion of impacted population from the technology both directly and indirectly. The scoring is ranged from 1 to 5 with the details as per below.
    - 1 (Lowest) meaning that less than 10% of population has been impacted by the technology
    - 2 (Low) meaning that only 10-20% of population has been impacted by the technology
    - 3 (Neutral) meaning that 20-40% of population has been impacted by the technology
    - 4 (High) meaning that 40-80% of population has been impacted by the technology
    - 5 (Highest) meaning that more than 80% of population has been impacted by the technology

- Job Creation: Innovation is actually creating jobs faster than automation and technology are destroying them.[239] Some may have a concern about the technological advancement becoming a threat to the society but innovation can ignite the light of new industries, creating jobs that never exist before. Technology has disrupted industries in new ways, creating investments and job opportunities for people. However, it is undeniable that some technology may cause a termination for some section of jobs but it will create opportunities and industries faster than the termination rate. So, this measure will tell us that how many jobs will be created due to the technology adoption. The scoring is ranged from 1 to 5 with the details as per below.
    - 1 (Lowest) meaning that less than 10k jobs will be created by 2030
    - 2 (Low) meaning that around 10-50k jobs will be created by 2030
    - 3 (Neutral) meaning that 50-100k jobs will be created by 2030
    - 4 (High) meaning that 100-150k jobs will be created by 2030
    - 5 (Highest) meaning that more than 150k jobs will be created by 2030

- Impact on Education: Education is one of the top priority social factors that directly links to quality of life and technology has significantly impacted the education system from classroom materials to a candidate interview. It has disrupted some educational processes and connects everything at once. Some technology has greatly expanded access to education as well as communication and collaboration. Technology has come to dissolve the walls of barriers. In this criterion, we will assess that how much educational system has been improved from the technology. The scoring is ranged from 1 to 5 with the details as per below.
    - 1 (Lowest) meaning that the technology has very minimal impact on education sector and does not impact ease of provision, material creation, learning and development at any level: primary, secondary, tertiary, professional and other forms of education and skilling.
    - 2 (Low) meaning that the technology doesn't have much impact on education sectors, it can refine few characteristics of provision of education only.
    - 3 (Neutral) meaning that the technology will have a slow but significant impact on the education sector especially in the area of education provision and education consumption.
    - 4 (High) meaning that the technology has significant impact on Education sector in terms of ease of provision, material creation, learning and development at least 2 levels from : primary, secondary, tertiary, professional and other forms of education and skilling.
    - 5 (Highest) meaning that the technology has significant impact on Education sector in terms of ease of provision, material creation, learning and development at most levels

[239] https://www.governmenteuropa.eu/innovation-creating-jobs-technology/88071/

from: primary, secondary, tertiary, professional and other forms of education and skilling.

- Impact on Healthcare: This is another important criterion on social factors because healthcare is one of the realms that relates to people's lives. It is important knowing that technology has not only changed experiences of patients' journey but it has also had a huge impact on medical process and practices of healthcare professionals. In this factor, we will assess that how much technology has improved diagnostic tools, treatments, formulated new medicine or facilitated patients during hospital stays. The scoring is ranged from 1 to 5 with the details as per below.

    - 1 (Lowest) meaning that the technology has very minimal impact on Healthcare sector and does not impact invention of new drugs, diagnostics, disease prevention, disease management (healthcare provision including the way healthcare is provided to hospital management etc.).
    - 2 (Low) meaning that the technology doesn't have much impact on healthcare sectors, it can refine few characteristics of provision of healthcare only.
    - 3 (Neutral) meaning that this means, the technology will have a slow but significant impact on the healthcare sector especially in the area of diagnostics and disease management.
    - 4 (High) meaning that the technology has significant impact on Healthcare sector and impacts 2 of the 4 areas from: invention of new drugs, diagnostics, disease prevention, disease management (healthcare provision including the way healthcare is provided to hospital management etc.).
    - 5 (Highest) meaning that the technology has significant impact on Healthcare sector and impacts 3 or all areas from: invention of new drugs, diagnostics, disease prevention, disease management (healthcare provision including the way healthcare is provided to hospital management etc.).

- Strategic Attractiveness: It will show the impact of technology on key sectors and assess it capability to use across various industries. The scoring is ranged from 1 to 5 with the details as per below.
    - 1 (Lowest) meaning that the technology has very minimal impact on the key sectors and applications, and can be conveniently ignored for time being from this parameter perspective as it is not so worthy to be invested in. High impact on 1 and mid to low impact on all other areas.
    - 2 (Low) meaning that the technology doesn't have much impact on key sectors, it can refine few characteristics, and can be good to have but not necessary.
    - 3 (Neutral) meaning that the technology will have a slow but significant impact on the industry ecosystem.
    - 4 (High) meaning that the technology has high impact and covers most key high impact applications and industries. The technology will have a strong impact and will become a main-stream technology of future.
    - 5 (Highest) meaning that the technology will be poised to become a very powerful technology of all times and will disrupt many existing technologies and infrastructure in future.

Use Cases and Applications

This parameter will evaluate competency in applying this technology into various areas of industries. A use case is a list of actions happening related to those technologies. Use case analysis is an

important and valuable requirement analysis that has been used to predict the wide adoption of the technologies. The scoring is ranged from 1 to 5 with the details as per below.

- 1 (Lowest) meaning that less than 10 applications will be emerged by 2030.
- 2 (Low) meaning that around 10-30 applications will be emerged by 2030.
- 3 (Neutral) meaning that 30-50 applications will be emerged by 2030.
- 4 (High) meaning that 50-70 applications will be emerged by 2030.
- 5 (Highest) meaning that more than 70 applications will be emerged by 2030.

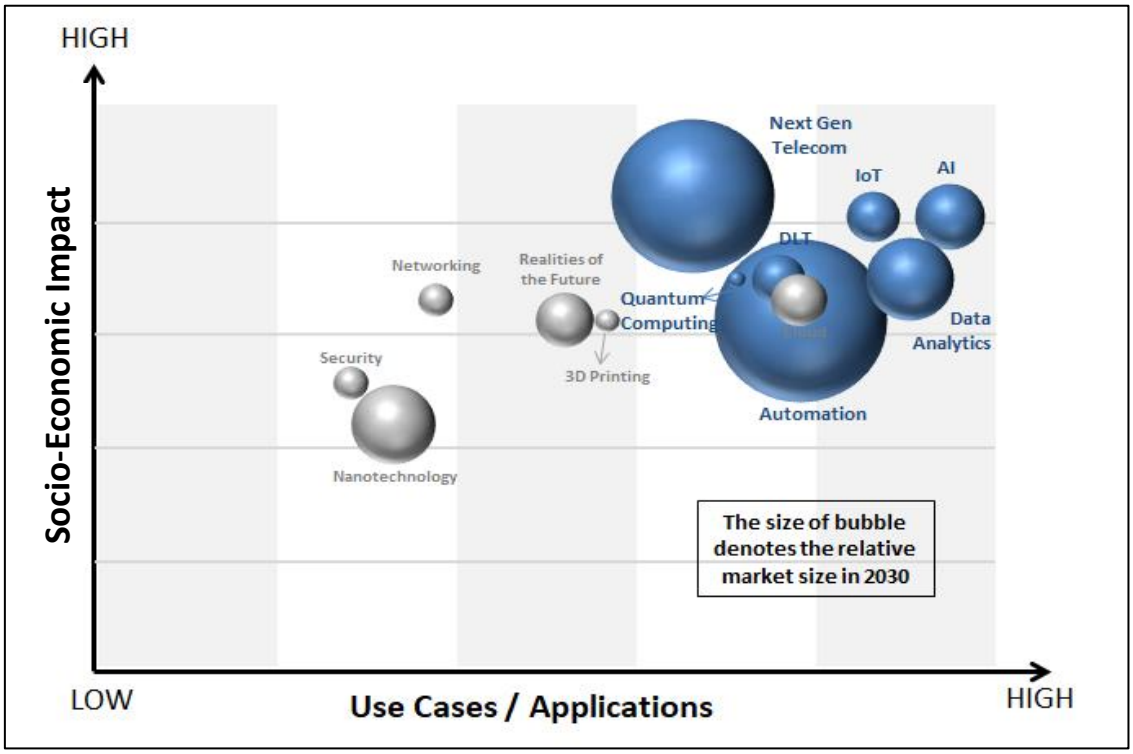
Market Size

This parameter will show the maximum total number of sales happening in the market over a given period of time. It is really important to know the potential market size before strategize the new products. Market size can identify the potential of new markets as well. However, in this study only domestic market will be addressed. Market sizing will give you a sense of market trends. It can clue you in on the necessary drivers of demand, as market movements often continue in one direction or another for a period of time. The scoring is ranged from 1 to 5 with the details as per below.

- 1 (Lowest) meaning that Thailand's market size of a technology will be valued less than THB 10 billion by 2030.
- 2 (Low) meaning that Thailand's market size of a technology will be valued between THB 10-50 billion by 2030.
- 3 (Neutral) meaning that Thailand's market size of a technology will be valued between THB 50-150 billion by 2030.
- 4 (High) meaning that Thailand's market size of a technology will be valued between THB 150-300 billion by 2030.
- 5 (Highest) meaning Thailand's market size of a technology will be valued more than THB 300 billion by 2030.

Assessment

Figure 101. Economic Impact Assessment based on Socio-Economics, and Vendor Economics



Next Generation Telecom will be expected to create a market value of more than THB 600 billion in 2030 and it will have the second largest market size in a given period of time. However, it will see the greatly drop in the next 15 years. From the chart, 5G not only has a high value of market but also has a very high Economic Impact on society. Thai companies will be able to innovate and generate new revenue streams through various 5G-based service platforms applicable for data-driven usage in many industries such as delivery by drones or precision farming. In term of economic contribution, 5G will contribute 5.5 times to Thailand's GDP volume between 2020 and 2035 with adoption expected in various verticals, including manufacturing, mobility, automotive, healthcare, tourism, retail etc. In case Thailand fails to adopt 5G by 2030, it would face an opportunity loss at THB 2.3 trillion or 20% of the current gross domestic product. Manufacturing would be the most affected sector, expected to lose between THB 700 billion and THB 1.6 trillion of economic output by 2030.

Artificial Intelligence (AI) will have the fourth largest market size in 2030 with market value of around THB 114 billion and will continue its growth reaching THB 182 billion in 2035 with a CAGR of 9.81% in the forecast period. Even though it only ranked 3rd largest in market size, AI will have a high impact on economic realm. In the present, the adoption of AI is very miniscule in Thailand with 17% of organizations currently being able to infuse AI in their processes. Some 20 Thai enterprises were early adopters of AI, in particular conglomerates, banks, telecom operators and retailers. Currently, most organizations lack the necessary infrastructure and expertise required to take up AI. Ongoing refinement of techniques and applications, and significant transition costs may limit adoption by smaller firms in Thailand. In term of economic contribution, Digital economy in Thailand is already using AI for forecasting, roiling data, recommendations and predicting churns. All of these use cases make AI imperative for Thailand 4.0 to transform, innovate and upgrade the Thai economy. World Bank has invested in AI in Thailand to implement training workshops that aid in creating awareness of analytics in improved decision making.

IoT may have a smaller market size in 2030 of around THB 65 billion but it will grow swiftly reaching THB 440 billion in 2035 with a CAGR of 46.23%. The technology has been predicted to have a high degree of impact on economic and social realm similar to AI because IoT has been applied across industries with more than 200 use cases. For Thailand, IoT adoption is still at the beginning stage. One of the barriers that restrain companies to adopt IoT is their current legacy infrastructure. To implement and utilize IoT solutions, companies need to make changes to their existing systems. In term of economic contribution, as IoT is one of key technologies in digitization process, embracing IoT will drive digital transformation among enterprises in several industries in Thailand. Moreover, the future of IoT will bring significant advancements in Smart City concept, which is a part of the government's Thailand 4.0 initiative, aiming to integrate digital technology, energy, and transport, with an aim to improve the quality of life, in line with Thailand 4.0 era. The development of Smart City will also be driven by the growth of cloud computing, machine learning, analytical tools, as well as 5G.

Data Analytics is expected to reach market value of THB 185 billion by 2030 which is ranked as third largest from all 7 selected technologies and it will continue to grow with a CAGR of 5% until 2035. Its impact on social and economic areas is significantly higher especially for education and healthcare. However, Thai companies nowadays are not well prepared for adoption of data analytics. Less than 30% of Thai companies use it nowadays. Data analytics is not for IT and marketing department only. Various other departments should step up and take advantage of this technology too. Wide spread use of Big Data analytics across heterogeneous industries could increase annual GDP especially in retail, finance, telecommunications, healthcare and government services. Data analytics will lead to cost savings in many industries as well. Data analytics will be one of the most important catalysts to spur economic growth because data will not stop generating anytime soon. Enormous amount of data needs to be handled properly to identify new opportunities and address problematic issues within both public and private sectors.

Distributed Ledger Technology; Large private enterprises in Thailand have started to test adopting DLT for use in their business processes. Although still in its embryonic stage, blockchain technology already plays a major role in making DLT itself to be easier to utilize. The adoption rate will increase in various industries such as financial services, government, manufacturing, healthcare, etc. Therefore, the market value of DLT is expected to reach THB 65.74 billion by 2030. DLT has the potential to be a key enabler supporting the digital economy by providing a secure, low-latency digital infrastructure. Moreover, the technology will still be in the upward trend with a CAGR of 4% from 2030 to 2035.

Quantum Computing is at the infancy stage in Thailand and will not create much impact in the current year as it is an emerging technology. The adoption rate will increase next 5 years on an upward trend. Therefore, the market size of Quantum computing is expected to be THB 6.5 billion in Thailand by 2030. Though the market size is not large compared to other selected technologies, this technology will create significant economic impact to several industries such as healthcare, farming, financial, military etc. The potential of the technology will be continuously growing with a CAGR of 67.22%. Information technology and telecommunications, aerospace and defense, energy and power, finance and investment would represent nearly 60% of the Thailand's Quantum computing market value in the future. The focus of this technology will be on molecular simulation, R&D, and software development. There will be many usable applications in the future which would create significant value.

Automation & Robotics will have the largest market size with the market value jump from THB 200 billion in 2020 to over THB 1 trillion by 2035. The highest CAGR would be around 13.98% in the year 2021-2025 with RPA sets to see the highest growth of all sub-classifications in Thailand. The high adoption rate is driven by its promises to help enhance productivity and reduce cost. Moreover, Thailand national strategies have identified automation and robotics as two of the new S-Curve

industries. A number of the government's financial and non-financial initiatives create a friendly business environment to attract the investment into these technologies. Thailand has been ranked as the top 10 countries for industrial robot adoption. The adoption growth rate would climb higher according to the report by International Federation of Robotics (IFR) that Thailand would be positioned as top 5 countries in the world by 2020. Such high adoption rate has been supported by the automotive, electrical & electronics and food processing industry which are the main 3 consumer sectors for Thailand. Local companies and companies in the Eastern Economic Corridor (EEC) region are supported by both tax and non-tax incentives to invest in this technology. However, Thailand needs to fill the gap in talent shortage. Thai workforce possesses inadequate knowledge and lacks the necessary skills to handle with these technologies especially in term of safety standards.

Conclusion

F&S has arrived at the conclusion of the 7 shortlisted technologies covering Internet of Things (IoT), Data Analytics, Automation & Robotics, Next Generation Telecom, Quantum Computing, Distributed Ledger Technology (DLT) and Artificial Intelligence (AI). These 7 technologies are shortlisted from the measurement framework of socio-economic impacts such as impact on education and job creation, number of use cases/ applications and market sizes. Some technologies may rise to prominence earlier compared to other technologies, while others may become a fundamental digital technology (i.e. data analytics). Whatever the case maybe, the important thing to take note is technologies cannot be developed and implemented in the right manner without the necessary ecosystem being established between public and private sectors.