IOTA

Towards Open & Transparent Cities

An IOTA Ecosystem Report

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Thank you

Acknowledgments

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Enabling smart cities

The world is becoming more and more urbanized. By 2050, it's estimated that 66 percent of the world's population will be living in cities. 1.3 million people move into cities every day and the world's building stock is expected to double by 2060; according to Bill and Melinda Gates' 2019 Annual Letter, the "equivalent of another New York City between now and 2060" will be added each month. Today, cities occupy only two percent of the world's landmass but consume over two-thirds of the world's energy and account for more than 70% of global CO2 emissions. The amount of material that's going to be used for this growth is impressive. However, what's equally impressive is the new opportunity to build cities in ways that weren't possible before. They can be designed and built from the ground up: interconnected, sustainable and adaptable to everyone's needs.

"A smart city is a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business. A smart city goes beyond the use of information and communication technologies (ICT) for better resource use and less emissions".

~ European Innovation Partnership on Smart Cities and Communities

What is the current scenario

A smart city is an urban area that incorporates information and communication technologies (ICT) into its systems enabling sensors to gather data and leveraging communication. The main goals are to enhance life for its citizens reduce waste, contain costs, and make resource consumption more efficient.

There are 25 billion smart and connected devices today and counting, growing to 75 billion by 2025. Each device with sensors collecting and sending data. These networked devices - known as **Internet-of-Things** devices or IoT for short - combine communications technology and physical machines and bridge the digital and physical worlds.

IoT changes the way one connects, interacts, and exchanges data as individual citizens, communities, cities and nations. From data privacy and ownership to peer-to-peer energy and integrated transportation. From predictive maintenance and additive manufacturing to eHealth and eGovernance. There is potential everywhere.

The smart city is envisioned as a location that uses IoT, DLT and artificial intelligence to work together. All of these technologies are still in the early stages of development. Their deployment and consequent usability in urban lives, however, will be seen in the very near future.

Although the methods may differ, all smart cities share the goal of improving the urban experience through technology.

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What will smart cities look like?

Above all, smart cities are efficient. With the collected data, the pattern recognition enabled by artificial intelligence and the communications ability of Internet-connected sensors, the smart city tools will, among other things:

- Eliminate redundancies
- Improve the flow of traffic
- Control temperature and lighting
- Eliminate waste
- Optimize existing and future infrastructure
- Allow for informed decision making by local authorities

Embedded sensors will react to the presence of humans in a room, reducing light and heat when no one is present. Similarly, street lights with motion sensors will turn on and off as needed. Urban spaces will regularly include driverless vehicles and other autonomous devices that will react on an as-needed basis to fit human needs. Traffic lights will react and adjust to the presence of extra vehicles, regulating flow and road access.

The data created by such deployments will be used to shape the long-term trends of the urban landscape. Planners and entrepreneurs will be able to recognize patterns of activity that provide clues on how to further improve city life.

A key to this brave new world is distributed ledger technology (DLT) and blockchain, immutable database technologies using a decentralised peer-to-peer network.

and artificial intelligence, activities can be verified and, in some cases, monetized. Urban dwellers and businesses will then pay for consumption, thereby incentivizing efficiency and renewable solutions.

Governments will also benefit from the increase of the use of technology: citizen centric solutions respecting e-privacy will be developed; more efficient transportation will free up infrastructure for more people-friendly uses; additional public waste bins with sensors will be available, potentially even automating recycling processes in the bin. These are just some examples of results that can be achieved when a data driven approach is in place.

With DLT, eGovernance becomes streamlined. Whether paying a fee, remitting taxes, obtaining a license or reporting an issue, eGovernance permits communication and payments that are transparent, immutable, private, instant and without the need for human manipulation. The system grows without requiring additional bureaucrats. Allowing the savings to be applied elsewhere.

The use of such sensors even in progressive smart cities is growing rapidly. Some researchers estimate that 50 billion objects will have some form of sensor by 2020, generating trillions in economic impact.

Working in conjunction with sensor data collection

Some challenges exist

The world mentioned above is the vision that's being sold and spread out. A relevant challenge to the successful implementation of a new reality, however, can't be ignored: the human factor. Some attempts to create a smart city have become failures due to the exclusive focus on the technology and government functions around it.

At its core, smart cities have to be about improving the lives of the people who live in the city, not just collecting raw data and back-patting from public officials and businesses about progressive notions. Clarity in the projects and accountability regarding the final goals concerning the deployment of the technology are key to success. Without an end-to-end strategy, projects are merely churning money.

Another major challenge concerns the financial aspect of the project. Many cities draw up elaborate plans for what they wish to do when implementing smart cities. Cities that look progressive are a great marketing tool to lure businesses and revitalize urban areas. However, what's the real benefit if most of the budget is spent on debt service or existing infrastructure with little left for the actual improvements?

Solving the problems across silos

Every industry is facing an unprecedented transition as demands on the business are changing. There is a shift as computers and automation come together in new ways. Machines have the possibility to enrich everyone's lives, contribute to economic development and raise the standard of living around the world.

The challenges are indeed many: convincing long-standing organizational hierarchies to cede power, the potential for security breaches on even the most firewalled systems and the red flags surrounding data privacy are just some of the hurdles. Regulations currently in place are designed for a human-run world so, by necessity, they must change to adapt to what's coming. Citizens also play a role as they will have to adapt to a world in which there is less human interaction and more personal responsibility.

There are technical hurdles as well. The data collected today is usually held in distinct silos instead of open data environments capable with IoT and DLT. The data collected must also be verified in a distributed data environments and the devices communicating must be interoperable. The technologies envisioned have the potential to be transformative and will challenge the entrenched status quo, leading to new challenges around digital trust.

To ensure the full potential of human centered smart cities, certain requirements have to be fulfilled in regards to DLT and smart city networks. These requirements should aim to provide equitable access to innovation & full interoperability with technologically advanced and legacy systems while connecting previously centralized data silo's. The core of the requirements can be seen as:

Permissionless systems:
nobody should control the network and everyone should be able to access it as a true public utility of societal interest. This will allow every user to create a personal address and begin interacting in the network, by submitting transactions, and hence adding entries to the integrated ledgers. This allows for the creation of interoperable systems with open collaboration and ease of integration and access.

Zero fee structure:
to ensure that business models remains viable, and the focus revolves around the betterment of citizen services and quality of life.

Open-source:
to ensure transparency and future development and remove centralized control of the development process with regard to public good systems.

High transaction throughput:
localized for latency efficiency, and organized with regard to data sets and storage requirements. This will allow the networks to process billions of IoT communication and transactions and scale efficiently.

Low energy footprint: to enable edge sensors and actuators with limited access to power supply to participate to the network sustainably with built in energy generation capabilities, or with minimal infrastructure requirements to alleviate energy grid surges and transfer requirements.

Building IoT devices or networks cannot be done alone by any one organization (or country). By its nature, IoT involves multiple parties. Devices and systems need to communicate across various applications and domains. These parties need an easy and trustworthy way to interact and share information. This is where DLT and IOTA come in.

IOTA offers a better way

Established in Germany in 2017, the IOTA Foundation is a world leader in the development of Distributed Ledger Technologies (DLT) for the Internet of Things (IoT), smart cities and smart industries. As of July 2019, the IOTA Foundation consists of a global team of over 100 individuals distributed in more than 25 countries, a distributed ledger technology (the IOTA Tangle), and a growing ecosystem of leaders and partners all working together to co-create a shared Economy of Things.

The IOTA Tangle is a secure data communication protocol and zero-fee microtransaction system for the IoT. IOTA provides a single source of truth and trust in data, with a goal of being the backbone of (every)things in a highly networked world. It can be used to generate machine-to-machine (M2M) micropayments and share data across an ecosystem of devices, generating further data, producing results and co-creating new business models.

IOTA offers a better solution than traditional blockchains. It's a blockchain alternative that does not rely on node operators, transaction fees, or extensive mining operations. In the IOTA Tangle, transactions are linked to each other without dealing with block by block processes like in traditional blockchain solutions. Each transaction is verified using the age old social philosophy of paying it forward. Every time a device needs to send information to the Tangle, it will link the

transaction further to two more random transactions. This process is known as Proof of Work in the context of the IOTA protocol, and helps to ensure the legitimacy of the transaction, while also allowing for the feeless methodology behind the IOTA protocol.

The whole process also helps to promote high transaction throughput and increases the number of transactions that can be dealt with at any particular time. A crucial demand in a world in which sensors constantly need to communicate and billions of devices proliferate.

The IOTA Tangle offers all the benefits of a DLT with the underlying principles of a blockchain, but it has a different underlying infrastructure, which allows the network itself to determine transaction approvals. Its interoperability and speed thus make it ideal for devices that need to talk to each other in a wide variety of situations.

How does it work? The Tangle is based on a mathematical concept referred to as a Directed Acyclic Graph (DAG). For each transaction to be verified, each node in a DAG network is required to approve two previously issued transactions from other nodes. This is done autonomously with the use of what is known as a consensus algorithm, which eliminates the need for individual manual node operators, similar to how a blockchain operates.

The IOTA Tangle

High scalability:
Increasing network activity with more nodes actually decreases transaction settlement times, unlike in a traditional blockchain.

Zero-fee microtransactions:
If a device sends .001 cent the intended recipient receives .001 cent. If a person or organization sends $1,000,000, the intended recipient receives $1,000,000.

Real-Time transactions:
No block times or lengthy validation periods. Transactions and data can be published, validated and digested within milliseconds.

Secure data transfer or organization:
All data is encoded, enabling secure data transfer, storage and referencing. The data can also be organized in data streams for easier querying, authorization allocation and use.

Low resource requirements:
Designed for micro and IoT devices (eg, sensors and microprocessors) to participate, it allows the secure of the data at the source of aggregation. Low energy is required regarding sustainable IoT growth and data proliferation.

Offline transactions:
Devices don't need perfect connectivity and can be validated when connectivity is available.

Quantum resistant:
Using special signatures, IOTA is resilient to the next generation of computing.

Towards a new economy of things built on digital trust

In a hyperconnected environment, the rapid development of real time machine-to-machine interactions, distributed intelligence and automation is feeding a new wave of value creation and data-driven business models. Thanks to IOTA technology,
zero-fee micropayment allows the real time and cost efficient monetization of data streams. In a city context, new digital infrastructure is now expanded into data marketplaces to support the exchange and trade of data across connected assets and machines. An Economy of Things is at hand. The feasibility of this potential, however, is dependent on a collective effort to shape a new Digital Trust framework which can address growing pains of cybersecurity, need for data integrity and respect of e-privacy in a decentralised data environment. Leveraging on its zero fee secure data communication protocol for the IoT/M2M, IOTA plays its part and provides a secure backbone for a new digital infrastructure and IoT enabled economy, on top of which a data monetization is enabled whenever needed.

Some concrete examples of the use of IOTA technology across the energy, mobility, real estate & urban digital infrastructure industries:

Energy

IOTA enables new digital infrastructure and services to create positive energy districts. City assets such as solar rooftops, buildings, electrical vehicles or batteries can now trace and trade electricity in real time to balance the power supply and demand in a decentralised and cost efficient way.
In November 2018, IOTA joined +CityxChange, a consortium funded by the Horizon 2020 EU research and innovation programme, with the goal to create smart
positive energy districts, using digital services and improving the quality of life for and with its citizens. Over 5 years, 11 enterprises including ABB, Avis Budget Group, ARUP, Statkraft, nine SMEs, three not-for-profit organisations including IOTA, and two universities are developing positive energy districts

together with seven cities across Europe.
A digital infrastructure based on an IOTA-enabled decentralised energy market place and e-mobility-as-a-service platform is currently being developed. District
testbeds are available for piloting in the cities of Trondheim, Limerick, Alba Iulia, Písek, Sestao, Smolyan and Võru.

"Intelligent infrastructure based on decentralized systems such as IOTA can help shape self sufficient energy mini grids which will eventually grow into districts and cities. DLT can ease the integration of distributed renewable sources of energy in new built city environments and bring new value to citizens while reducing power grid capital expenditure. As a regional DSO and power company, Tronderenergi proactively explores new business models needed to facilitate this developments"

~ Bernhard Kvaal,
Senior Project Manager, TronderEnergi

Real Estate

Buildings are becoming smart(er) and green(er) as Internet of Things (IoT) technology revolutionizes the way buildings are designed, operated, monitored and maintained. The buildings, their different systems and their occupants data are integrated into a single ecosystem, which enables additional operational improvements, better traceability and micro transactions for facility and space management.Digital twins, virtual replication of the real estate

asset, can now be developed and rely on ledgers to track activities during its lifespan. IOTA provides a new alternative to
ensure data integrity and traceability at
the moment data is captured by multiple IoT sources and decentrally stored by
different organizations.

ENTRA's POWERHOUSE Brattørkaia, located in one of the +CityxChange testbeds in Trondheim, is already tracking its energy footprint in real time and is further exploring new innovations.

"ENGIE LAB CSAI has developed proofs of concept, tools that leverage DLT/Blockchain technologies with AI to support new services for Facility Management. To be able to deploy and test it in such advanced sustainable building like Powerhouse is a real opportunity to make tangible innovative solutions happen. Given its high level of digitalization that supports the implementation of a digital twin, the Powerhouse is at the forefront of what can be imagined for the future services for facility management and optimization and management of energy. A reality built today by ENGIE LAB inside this type of projects and collaborations."
~ Philippe Calvez,
R&D Director at ENGIE LAB CSAI

This is only the start: from mobility to energy and buildings, the interoperability of systems is key and DLT offers tremendous opportunity. With simpler and interoperable processes, interconnected infrastructure and an economy of things, we observe a complete paradigm shift in how we use the infrastructure in the cities.

Urban Digital Infrastructure

Smart cities and nations need to shape digital trust and data marketplace frameworks on the basis of reliable, secure and interconnected digital infrastructure with trusted mechanisms established as bridges between citizens, hardware and all things digital. Such interoperable infrastructure should be developed as a pu
blic - private partnership opportunity and focus on value added to the citizen and society in compliance to GDPR. This complex development is cross industrial and needs to be able to scale to support all the above use cases, be replicated witho
ut vendor or tech lock-in and expand to intercities and cross border ecosystems.

"Trust is a topic rarely covered in the smart city projects of the world as proof of concept projects most often focus on the simpler aspects of an ecosystem. The trust mechanisms in place today, more often than not, rely on human interaction. In a smart city ecosystem with billions of entities, creating smart contracts and transacting data or services with each other, this will not be the case. Authentication, access delegation and accountability processes will make or break the design of any smart city or smart nation ecosystem.At Energinet we develop proofs of concept digital trust processes for smart meter data access, critical infrastructure data access and distributed auxiliary services within the smart city or smart grid ecosystem. No one societal entity is responsible for creating such a trusted digital infrastructure. Great solutions within digital trust and digital infrastructure comes from cross sectoral partnerships, public and/or private with citizen centricity, data minimization and design thinking at heart."

~ André Bryde Alnor,
Innovation Manager at Energinet

Co-creation with IOTA

As devices become smarter and more connected, there is tremendous opportunity to develop new business models to support smarter industries that create new value for and with society.

IOTA is focused on working within and across several organizations, industries and geographies. Our inclusive approach brings various actors together within a global and cross-industry ecosystem into the process of applying the technology. We establish common learnings and share experiences as the application of the technology and use cases mature.

City testbeds is where much of IOTA innovation comes to life as partners at play are in most cases local / regional and often regulators in their local context. In that space, they focus on specific locational problems to be solved. They leverage their commercial and regulatory capabilities (as well as other partners) to develop and implement new solutions and standards. While many of the solutions are designed locally, the learnings from one city or region can be implemented more broadly and shape co-creation opportunities in other geographies.

One such co-creation initiative is a series of connected testbeds hosted in Trondheim, Norway under the +CityxChange project.

https://entra.no/news-and-media/brattorkaia-in-trondheim-will-soon-be-norways-most-high-tech-urban-area/1729
http://www.powerhouse.no/en

Testbed at Brattørkaia in Trondheim, Norway hosts IOTA co-creation activities

In the Brattørkaia testbed area, Entra's Powerhouse Brattørkaia is a newly commissioned smart building located at the heart of the demonstration area. It provides a potential starting point for aggregating the IOTA ecosystem towards a real world environment. Powerhouse is the world's northernmost energy-positive building designed and operating as smart green commercial buildings. A power mini-grid pilot led by Tronderenergi - the regional power utility - connecting the building is also underway, in parallel with the development of the +CityxChange project.

On 30th August 2019, IOTA, ENGIE Lab, Jaguar Land Rover and ENTRA showcased a proof of concept that utilizes IOTA to enable "sustainable energy traceability". A Working Group was initiated in 2018, including ENGIE Lab, Energinet, Trianel, Entra, TronderEnergi and Enexis to explore smart energy proof of concept. Scoping was further discussed in January 2019, during a co-creation workshop in Trondheim, in cooperation with a number of +CityxChange partners, Trianel, Entra and ENGIE Lab.

"There are two themes we are particularly excited about," says Åse Lunde, Director of Digitalization and Business Development. "The new Powerhouse Brattørkaia will make more power than it uses. One theme is how that power can best be used by neighbors and the other is how to pay for it. In addition, when buildings like Powerhouse are filled with innovative technology and become more connected to the network, one needs to be able to share this information safely and securely. In the workshop, participants discussed how to use distributed ledger technology like IOTA to do just that."

Silja Rønningsen, City Trondheim, +CxC Project Coordinator added, "We are experimenting together with local businesses and our citizens in Trondheim on how to develop smart positive energy cities that use digital services to improve the quality of life within the city and generate more energy than we consume. At the same time, we aim to share our learnings across cities in Europe so we can learn faster, together. This workshop was a crucial first step to help us realize our vision of enabling the co-creation of the future we want to live in."

"Reaching beyond the company boundaries and innovating together with stakeholders of our network, as well as third parties, is part of our DNA at Trianel. Thus we are very happy to be part of the IOTA innovation community, exploring the possibilities and chances of the technology. Not only we can enrich the idea generation by the multi-layered perspectives of the individual partners from different industries, but also we can accelerate the testing of prototypes by an ecosystem of most diverse abilities. This beats inbound innovation in every aspect and helps us to be fast in development and close to market."

~ Trianel Trendscouting,
Aachen, August 2019

The learnings from IOTA's ongoing testbeds and co-creation initiatives may also be relevant to others as they develop use cases and form their own ecosystems:

Identify problems worth solving:
The environmental and technological challenges of the future are large and complex. Understand the problems worth solving by: (1) using systems thinking to explore problems as part of a large system; (2) observing the problem firsthand by engaging with people on the ground and identifying where to intervene; and (3) determining whether DLT is the appropriate solution to solve the problem at hand - it may not always be the best solution.

Open innovation:
Complex problems are likely not solved by an organization alone. Gather a group of proactive and complementary partners and anchor the group commitments around clear ambitions, hypotheses and resource plans.

(Eco)System thinking:
Most people think about designing a Minimum Viable Product (MVP). To co-create, try starting with the design of a Minimal Viable Ecosystem (MVE) of trusted partners, with complementary capabilities and ready to cooperate. You may need, sometimes, to look beyond core or first-order competencies to foster alignment. Remain open to bring in additional parties as you learn more and progress.

Take action:
Experimentation is key, as much of what you'll be doing may be new: new technology applications, new partnerships, new business models. Be open to start lean - conduct small tests to figure out what works - and learn large. Continue to iterate as you assess whether you achieved what you set out for in the "tests" or not. Once you have enough empirical evidence, backed by real world experience, concentrate your resources and begin scaling the initiative.

Looking ahead

Information and communication are essential to the continued growth and operation of smart cities. Right now, the technologies are on the cusp of building cities that are interconnected, sustainable and adaptable to everyone's needs. A vision, in the near future, in which the technological tools, recently developed, revolutionize everyone's lives and the environment.

IOTA plays a key role in that revolution: as an open source technology provider and as an innovation community. The concrete examples of the use of the technology across different industries, presented in this report, are the beginning of new business models that are already creating new value for and with society.

IOTA aims to continue establishing common learnings and shared experiences, to bring together private and public stakeholders in order to shape a scalable, interoperable and secure digital infrastructure for future smart cities.

About IOTA

IOTA is a global not-for-profit foundation incorporated and headquartered in Germany. The IOTA Foundation's mission is to support the research and development of new distributed ledger technologies (DLT), including the IOTA Tangle. The Foundation encourages the education and adoption of distributed ledger technologies through the creation of ecosystems and the standardization of these new protocols.

The IOTA Tangle moves beyond blockchain by providing the world's first scalable, feeless and fully-decentralized distributed ledger technology. The Tangle uses its own unique technology to solve three fundamental problems with blockchain technology: high fees, scaling and centralization. It is an open-source protocol connecting the human economy with the machine economy by facilitating novel Machine-to-Machine (M2M) interactions, including secure data transfer, fee-less micropayments, and secure access control for devices.

The IOTA Foundation's primary goals are to:

- Research and secure the foundational protocol layer, and create new knowledge to benefit the ecosystem behind the economy of things.

- Develop production-ready software for the community, partners and ecosystem to use and expand upon.

- Educate and promote technologies and use cases for new generations to understand and to ensure the Foundation's success.

- Standardise and ensure the maturity and widespread adoption of the economy of things.

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