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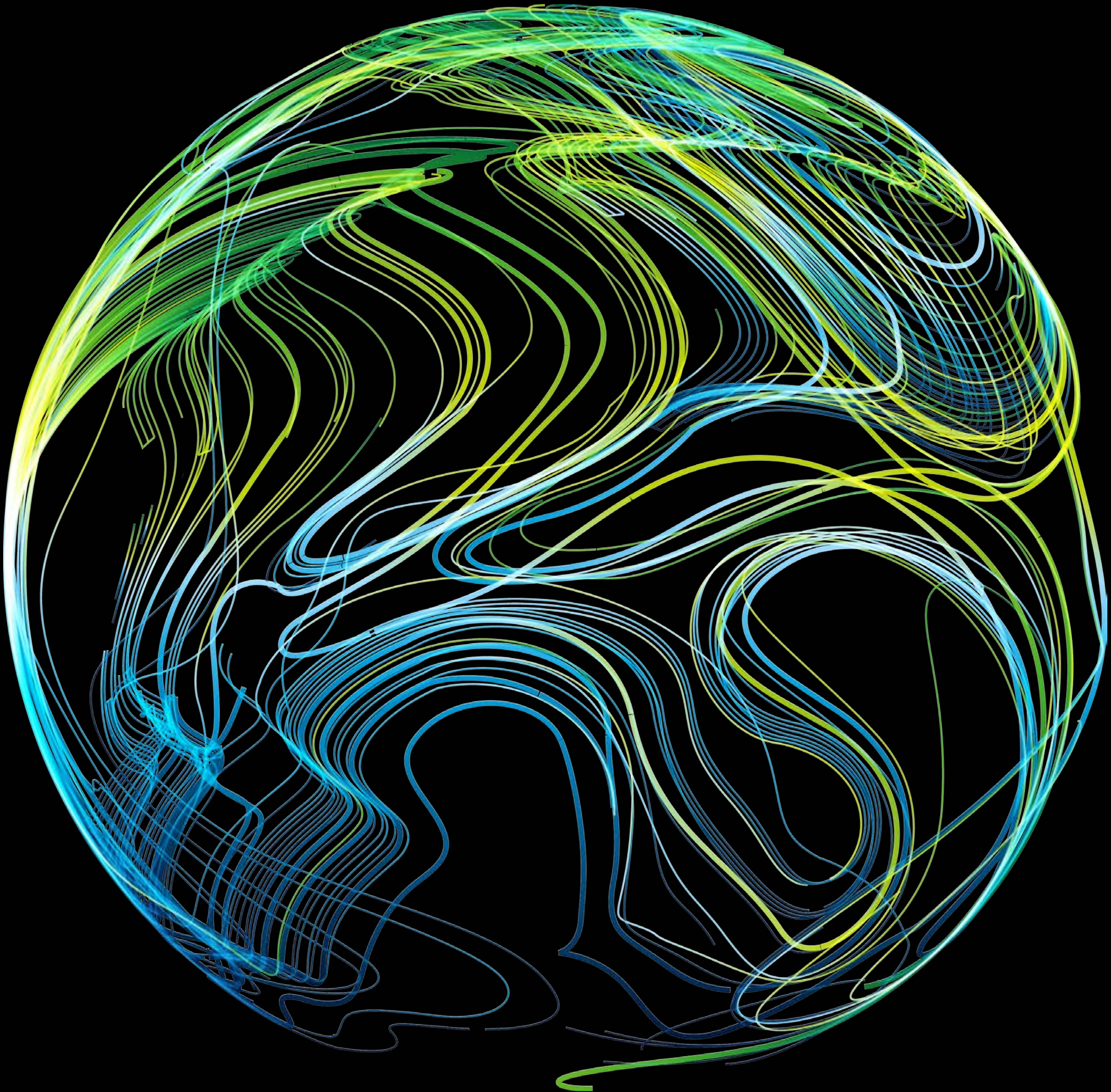

2017 Technology, Media and Telecommunications Predictions

Middle East edition

Foreword

Welcome to the 2017 edition of Deloitte's Predictions for the technology, media and telecommunications (TMT) sectors.

For the first time in our 5 years of releasing our Middle East edition, we are including predictions for all three sectors together, and not splitting them into different sub-industries. This, by itself, is a reflection of the exciting industry we are in. An industry that continues to blur the boundaries of innovation, and reshape how operators, media players and technology companies collaborate and interact in an increasingly integrated market place.

Across the global and regional predictions, we believe that the distinction between sectors is fast becoming obsolete. The introduction of dedicated machine learning capability to smartphones is relevant across all industry sectors, not just the technology or telecommunications verticals. The transition to 5G and resulting implications on machine to machine communication is a critical enabler to new technology adoption, starting with self-driving cars. IoT itself is the epitome of this borderless ecosystem with operators and technology companies working closely together to shape the cities and lives of tomorrow. Cybersecurity is an evergreen topic in the region raising threats to media companies and Telcos equally, and requiring cross sectorial regulations and safety measures.

With smart cities and nations so high in the agenda of the Middle East countries, our region is at the forefront of this borderless market place, with regional Telcos talking more about AI and IoT than network expansion. In this day and age, breaking borders, albeit at industry level, is a refreshing twist. 2017 promises to be yet another exciting year for the TMT sector. We wish you all the best for this year and trust that you and your colleagues will find this year's predictions a useful stimulant in your strategic thinking. We look forward to discussing them with you.

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The great indoors: the final frontier for digital navigation

Deloitte Global predicts that as of 2022 at least a quarter of all human and machine uses of precision digital navigation will include an indoor leg or be for an entirely indoor journey. This compares to less than five percent of all uses in 2017. Growth will be stimulated by sustained improvements in the accuracy of indoor navigation over the medium term, permitted by an array of positioning data, improved analytical tools that interpret multiple indoor location datasets in parallel, and more high-quality indoor maps.

Satellite-based digital navigation (see sidebar: Satellite Navigation Systems), accompanied by the digitization of street maps, has revolutionized how people and objects are located and guided. However, satellite navigation has one fundamental blind spot – its signals, sent from a height of 24,000 kilometers, are often too weak to penetrate solid roofs by the time they reach ground level[190]. Consequently their signal may not be visible to receivers indoors, such as smartphones, unless the user is close to a window or below a glass roof. Yet people spend over 90 percent of their time indoors. Billions of objects, from vehicles to tools to components, all of which may need to be located, are housed somewhere under a roof.

Satellite Navigation Systems

Outdoor navigation systems use signals relayed from four constellations of satellites that continuously transmit their location and their current time to the ground.

A satellite receiver, such as that incorporated in most smartphones, sees multiple satellites. It calculates its distance from each satellite by comparing the delta between the signal's emission and reception. Data from multiple satellites enables location to within a few meters for civilian usage[191].

The four satellite systems have 91 satellites in total at present: GPS (Global Positioning System), owned by the US, which has a constellation of 32 satellites; GLONASS, owned by Russia, with 24 satellites; Beidou, owned by China, with 21 satellites launched, and a further 14 planned; and Galileo, owned by Europe, with 14 out of a planned 30 satellites launched. Some receivers are able to see multiple sets of satellites, enabling greater accuracy[192].

Each satellite spans a vast area: each GPS satellite, for example, covers over 16 million square kilometers.

Being able to locate people and objects when indoors is likely to add significant value, possibly at a level equivalent to or greater than the impact of outdoor digital navigation. One study of the US market estimated the economic benefit from GPS at a minimum of 0.4 percent of GDP (see sidebar: The economic impact of maps)[193].

The economic impact of maps

Maps have been core to market economies for millennia and will likely remain important for the foreseeable future[194]. The combination of digital mapping, satellite-based positioning and low-cost receivers (most commonly incorporated into smartphones) is a core 21st century enabling technology, with impacts at multiple levels.

A first-order business impact of digital mapping has been on businesses such as haulage companies whose drivers no longer need to memorize maps, or even know how to read them. A second-order effect has been to lower the barriers of entry to becoming a delivery worker, which in turn has made home delivery for a growing range and volume of products and services viable. Home delivery of, say, ink toner or diapers becomes viable if delivery costs are low enough. Digital navigation helps make it quicker and cheaper for a delivery person to find an address that he or she has never been to before.

Realizing indoor navigation's promise requires, just as with outdoor navigation, two core components: real time communication of location, and digital maps.

Delivering indoor location demands an equivalent to the constellations of satellites that enable navigation. Regrettably there is no single, indoor direct equivalent that boasts the phenomenal range of a navigation satellite and at the same cost – ownership of a smartphone or other receiver – to the user.

However, there are an array of established and emerging data sets which can, in combination and fused together, enable indoor navigation. All these data sets, individually and collectively, are likely to get richer, enabling greater accuracy, with every year. That said, the quality of each type of data is likely to be variable, depending on where the person or object is, which is why multiple data sets are key.

Existing indoor location data sets: Wi-Fi and cellular networks

As of 2017, indoor location can be ascertained from two principal sources: Wi-Fi routers and cellular base stations.

Over the medium term, beacons, LED lighting, ultra-wide broadband UWB and magnetic fields, which are described in the subsequent section of this prediction, could be used to complement existing data sets.

Wi-Fi networks can, with sufficient network density, be accurate to a few meters[195], and are currently the richest source of indoor positioning data.

This degree of accuracy enables people to be guided to a store within a shopping mall and thereafter a department within it, to a staircase within a stadium, a meeting room on an office floor, or the right carriage on a train.

Location data via Wi-Fi routers is a by-product of the need to provide indoor connectivity, and as such there would be no need to build a business case to deploy routers solely to enable location. As demand for connectivity increases, the volume and density of Wi-Fi routers may increase, in turn improving location accuracy via Wi-Fi.

As of the start of 2017, there were significantly more Wi-Fi routers than cellular base stations. One forecast estimates that there will be 340 million Wi-Fi hotspots (shared routers) globally by 2018, a sevenfold increase on the 50 million base as of 2015[196].

Location via Wi-Fi routers is determined using a similar principle to cellular networks, by estimating the distance between a user's device and multiple Wi-Fi routers that are within range. The efficacy of Wi-Fi on its own to determine location depends on the density of the network, the accuracy of the database of router locations, and the proportion of devices with Wi-Fi enabled. If the router is moved, and the databases on Wi-Fi location not updated, then the location data for the device will be wrong.

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The system's accuracy relies on the quality of the information from the Wi-Fi router. Accuracy can be reduced by obstacles blocking the signal between the router and the device. In a busy retail outlet, the presence of shoppers between the router and the receiver can cause signal levels to fall, leading to a false estimate. Signal levels may also be distorted by metal objects, including shelves and displays. Interference can be reduced by installing more routers but this adds to the cost.

Over time, devices are likely to become smarter at interpreting signals that encounter obstacles. Algorithms can correct for signals that bounce and estimate the angle at which signals are being received[197]. During periods when the signal is lost entirely, other sensors on devices may be able to estimate location by using accelerometers and gyroscopes to estimate distance travelled and direction.

As 4G speeds get faster, and the cost per gigabyte falls, a growing number of smartphone users may be inclined to turn off Wi-Fi if its quality of service is inferior. This may include shopping malls, where multiple free and often congested Wi-Fi hotspots may have been installed. According to Deloitte research, the proportion of smartphone owners in 11 developed countries that connected their device most often to Wi-Fi dropped by 10 percentage points to 54 percent between 2015 and 2016[198]. In that period, 4G penetration rose by 16 percentage points to 56 percent.

Positioning via cellular networks is a by-product of the provision of connectivity. This approach provides localization accuracy of, at best, within a 50 meter radius on a 4G network. Accuracy should steadily improve as network density increases.

It is possible to estimate location using mobile networks by measuring the signal strength from each base station within range. The stronger the signal, the greater the proximity to each base station. The location of each base station is known, so triangulating the signal strength from multiple base stations provides the device's approximate location relative to the base station.

The degree of accuracy depends on the generation of network that the device is connected to. As of 2017, the most precise readings will occur when connected to a 4G network, as this has the highest cell density (the greatest number of base stations per square kilometer, and implicitly the smallest cells). Second generation (2G) networks have a much lower cell density and accuracy may fall to a one kilometer radius. In rural areas, which are less likely to have 4G networks, indoor positioning using this technique may work poorly.

Network cell density should increase over the next decade, firstly via 4G networks, and then via 5G. As of end-2016, there were an estimated 4.5 million 4G base stations; China Mobile added 200,000 4G base stations in the first half of 2016 alone[199]. In the US, 5G may lead the number of cell towers to increase from 200,000 as of Q3 2016 to millions[200].

Some locations may deploy a very small base station, such as a femtocell, within a single premise, simply to track visitors. This would be able to provide very accurate location.

Emerging indoor location data sets: beacons, LED lighting, Ultra-wideband (UWB) and Magnetic Positioning

In addition to the existing data sets that can be used to estimate location, there are several more that are in early or nascent stages of deployment which could be used to provide more accurate indoor positioning. Each of these has its specific set of benefits and weaknesses, and the trajectory of each is likely to be different.

Beacons can provide location to within a meter, enabling them to be used for a wide range of indoor navigation applications. A beacon is a small, inexpensive (circa $5) Bluetooth Low Energy (BLE) equipped module. As of 2016, there were an estimated seven million beacons installed globally, covering a much smaller area than Wi-Fi routers or cellular networks[201].

A densely populated beacon network would provide 1-2 meter accuracy, and could guide people to individual shelves in a store, or to seats on a train.

Deploying beacons just to provide location might be too hard a business case to make, but the returns from proximity marketing – sending offers to customer within a specific area – may pay for the deployment on its own. As at early-2017, many of the largest sports stadia in the US have had beacons installed for this reason[202]. In these cases precise indoor navigation may be a useful by-product of the installation but the network would not be deployed primarily to enable location.

Positioning via beacons works in a similar way to Wi-Fi routers and cellular base stations: the distance from each beacon is calculated by the signal strength received. The accuracy of beacon-based positioning depends on the quality of the mapping undertaken.

Beacons are typically powered autonomously, most commonly via a small battery. While BLE requires little power, constant usage ultimately drains the beacon's battery. Beacons can last up to two years on a single battery with low usage, but may last just a few weeks if set up to transmit data at a faster rate, or at a greater power, so as to improve detectability. A beacon's life can also be extended by increasing the battery size. The downside is that it may become more obtrusive due to greater bulk.

Beacons can interface with the majority of smartphones, but Bluetooth must be switched on and an app downloaded.

LED lighting can be used to provide accuracy to half a meter[203]. As at the start of 2017, deployment was still at an early stage.

LEDs, increasingly ubiquitous, generate a pulsing light signal. Each LED light can send a unique identifier to a receiving device, most commonly a smartphone[204].

As LEDs consume little energy it is possible to power them over an Ethernet network, so that connectivity and light are delivered over the same infrastructure[205]. Indeed this network could also be used to attach other devices, including beacons, cameras and other sensors. Unlike with individual beacons, there is no need to replace batteries, and as lights are rarely moved, there is no need to re-map if, for example, shelving is moved.

In a retail environment, it may be that the business case for deployment of an Ethernet-powered lighting and sensor network would cover the entire cost of installation, and that user navigation would come as a zero-cost additional benefit. Retailers are constantly striving to understand better customer behavior, and this may be the primary reason for deploying the lighting system.

The approach requires the user to download and open an app, and for the smartphone's front camera to be on and in line of sight of the light.

Ultra-wideband can provide indoor accuracy to 5-10 centimeters[206]. Ultra-wideband (UWB) indoor positioning works by measuring range and/or angle estimates from a set of fixed points to a tag positioned on an object. The set of measurements is then used to calculate position. UWB sensors are typically positioned on the ceiling of a building.

This approach is currently deployed in factories and warehouses as a way of enabling objects to be located faster. This method, however, requires a separate chip to work and is used mostly today in manufacturing environments.

If Wi-Fi routers and phones included UWB capability, tracking to one centimeter could be possible. But due to the current chip size and its specialized nature, it may be a decade before UWB features in billions of smartphones.

Magnetic positioning uses the magnetometer (compass) on the person's phone and tries to evaluate the disturbances in the gravitational field caused by metal structures inside the building[207].

These magnetic disturbances create a unique gravitational footprint for every building. This footprint can be recorded by extensive mapping, and can estimate location to within two meters.

Magnetic positioning faces multiple challenges at present:

- it may require extensive mapping
- it only works when the user is moving
- reconfiguration of the interior of a location may require remapping. If a store moves metal shelves around, the magnetic signature is likely to change.

Exploiting smartphone sensors

A smartphone's internal array of inertial measurement unit (IMU) sensors can be used in tandem with satellite positioning and internal positioning data to determine a user's location[208].

A user's last known location from GPS, Wi-Fi hotspot or other source provides a starting location.

Subsequently, the smartphone user's acceleration, angular rate (rotation) and position relative to the earth's magnetic field is used to determine the person's movements/course/path once indoors and out of satellite range[209].

This technique requires no additional investment in infrastructure and no modification to devices.

The accuracy of the approach is determined by the sensor precision, magnetic disturbances inside structures, and unknown variables such as carrying position and stride length.

IMU is likely to be deployed in combination with other indoor navigation approaches. If used on its own, this approach becomes exponentially inaccurate as distance increases: after a user is 10 meters away from a verified GPS location their positional error might be less than a meter, but after 100 meters the possible error could be 20 meters or more.

Digital indoor maps

An improvement in indoor positioning accuracy requires a commensurate increase in indoor mapping for its benefits to be exploited fully.

There are likely to be multiple players that see significant benefit in generating indoor maps. Site owners are likely to regard indoor maps as a differentiator. A shopping mall could use indoor maps to enable people to find stores, departments and even aisles faster.

Owners of mobile operating systems regard the creation of indoor maps as a core differentiator, and an extension to existing outdoor maps.

Google offers indoors maps as an extension to existing outdoor maps. As of end-2016, there were hundreds of sites around the world whose indoor maps were available[210]. Site owners are invited to upload their maps and are provided with an app to help increase their accuracy[211]. Google has also created a backpack-mounted digital cartography instrument that enables maps to be created by someone walking through a venue. The backpack features Simultaneous Localization and Mapping (SLAM) technology[212].

Apple Inc. includes software tools in their core software developer kit (SDK) that allows developers to create apps that use Apple Indoor Location[213]. For site owners it has an indoor mapping initiative, currently focused on large (at least a million visitors per year[214]) venues that are accessible to the public[215].

Over the medium term, beacons, LED lighting, ultra-wide broadband UWB and magnetic fields could be used to complement existing data sets.

The bottom line

Precise indoor navigation's potential is significant, and could be transformative. It is likely to benefit most vertical sectors, and have impacts on governments, businesses and consumers alike. However, it will be challenging to deliver and the precision of information yielded is likely to be inconsistent in the short run.

One particular obstacle to overcome will be that of fusing all available data sets available. There is never likely to be one specific data set – be this beacons, Wi-Fi or any other – which is likely to be good enough on its own to deliver precise indoor navigation.

Location is not just about people but also about objects, and indoor navigation is also likely to be used to locate items of value in a range of locations, from tools in a workshop, parts on a factory floor, barrels in a brewery, to suitcases in the hold of a plane.

There are likely to be variations in the precision of indoor location information available based on multiple contexts, including the following factors:

- the ability of the device to analyze all location inputs received, which will likely be governed by the model of phone being used
- the density of the network(s) providing the location data – the greater the density the better
- the quality of the underlying database of the fixed locations (from routers, base stations, beacons and other sources).

Private and government organizations should be both pragmatic about the status of indoor navigation in their markets and alert to the potential benefits from the availability of precise location data.

Mobile operating system vendors should consider that consumers may choose their next smartphone partly on the basis of the quality of indoor navigation available and the apps available in each ecosystem which can exploit positional data.

Emergency services need a precise location of where individuals are. Indoor navigation on a smartphone could provide these data. Previously, standard calls from traditional fixed lines would provide the location information that enterprise VoIP and mobile calls have taken away. In the US, there are an estimated 240 million calls made annually to emergency services[216]. In some areas, up to 70 percent of calls are from mobile phones[217].

Retail time is wasted when shoppers cannot find a store within a mall, or when they need to be directed to a floor and an aisle, or to a less busy checkout area. Retail sales in the US average about $300 billion per month[218]. Spend in European shopping malls was $581 billion (€525 billion) in 2014[219]. Permanent and temporary staff could find goods more quickly on the shop floor and in stock rooms with precise indoor guidance. Location data can also be used to send geographically-targeted marketing messages to customers. Robots could be also be used to fetch items from the stock room. The availability of precise indoor navigation is likely to become a differentiator for shopping malls in the medium term. This benefit may well encourage mall owners to encourage cellular networks, Wi-Fi network providers and other providers of infrastructure to deploy their infrastructure on their premises.

In entertainment venues attendees could find their way to their seats more readily, rather than rely on guides. Indoor navigation could also guide people to the refreshment stall with the shortest lines, or guests could order snacks from their seats, with vendors using indoor guidance to locate hungry customers. This could improve the productivity of waiting staff.

Travel: late arrival at an airport gate can be costly for an airline and stressful for a passenger. Over 30 airports worldwide host more than 20 million passengers per year[220]. Existing services, such as app-based taxi hailing, could become more precise with indoor navigation, and pickups at subterranean shopping-mall parking lots or under hotel canopies could take place more easily and not have to rely on spoken instructions between driver and passenger. Tagging suitcases with location sensors may be more useful with indoor navigation.

Business premises (private and public): meetings start late when people cannot find rooms. Furthermore, some people might be more punctual if their location is known to others. Employees could be more easily directed to available desks within an office that uses a hot-desking system. Floor managers could be guided to the location of printers or vending machines which need replenishment, rather than relying on printed maps. Robot vacuum cleaners may be able to track their routes more easily if they know precisely where they are. These benefits become even more applicable when looking at specific sectors. For example, in the healthcare market, precise indoor navigation could enable staff to find each other, and also specific equipment, just by looking at a navigation app. Relatives could more easily find patients when visiting for the first time.

For trade fairs or conventions: attendees and exhibitors can find their way to stands or to meeting rooms, rather than relying on (often poor or non-existent) signage[221]. There were over 67 million attendees of trade fairs in Europe alone in 2015[222].

Mobile games that use location as part of the game, such as Pokémon Go, could also be played indoors. This would also enable such games to direct players to specific locations, including shops that sponsor the game.

Communications: social networks, messaging, email, photos and videos, collectively the largest usages of smartphones, could include indoor location tags that would automatically be embedded into posts.

In the medium term, precision indoor navigation is a facility that consumers and business are likely to take for granted. In the interim, significant research will likely be required to harness all the many technologies and data sets available which collectively should enable indoor localization. The effort required will be substantial, but the rewards should be too.

Precise indoor navigation's potential is significant, and could be transformative. It is likely to benefit most vertical sectors, and have impacts on governments, businesses and consumers alike. However, it will be challenging to deliver and the precision of information yielded is likely to be inconsistent in the short run.

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