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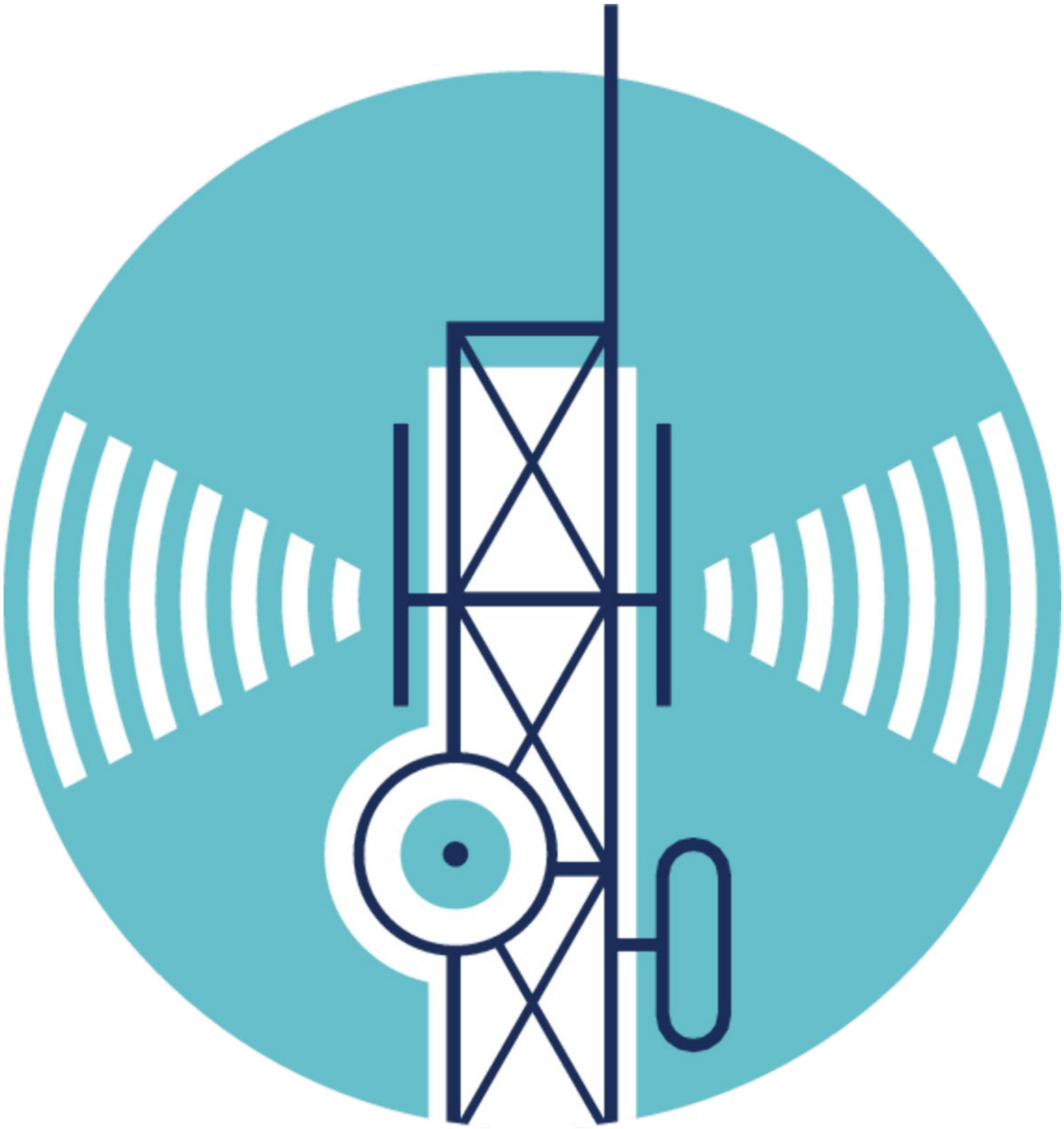

The Future of Connectivity in IoT Deployments

IoT & Connectivity

Like a wildfire racing across the dry prairie, the Internet of Things (IoT) is expanding rapidly and relentlessly. It sounds like an incredibly complex, but putting it in simple words, the Internet of Things (IoT) is nothing but a network that connects physical objects, such as vehicles, machine tools, street lights, wearables, wind turbines, people, and other devices, via connectivity solutions in order to enable communication, exchange data, and derive actions.

With the underlying goal of having access to relevant information in real time (or at least near real time), IoT sensors transform analog inputs into digital signals and thus create a digital reflection of what is happening in the physical world. This setup enables the development of intelligent applications and services and allows objects to be sensed and actuated across existing network infrastructures. Developments in the IoT field happen at a breathtaking pace, and IoT is the source of many promising business opportunities, which are expected to result in yet unimaginable increases in efficiency, accuracy, and economic benefits across organizations, industries, and markets. Moreover, IoT leads to new business models, moving the focus from products to services.

The number of physical objects that are connected via the Internet of Things increases at a tearing speed. Gartner, Inc. estimates that 8.4 billion connected things will be in use worldwide by the end of 2017, up 31 percent from 2016, and that the number will reach 20.4 billion by 2020.[1] Dell's CEO estimates that as many as 70 billion connected devices will exist by 2020.[2]

As IoT grows, so do the volumes of data produced by some estimates, connected devices will generate 507.5 Zettabytes (ZB) of data per year (42.3 ZB per month) by 2019, up from 134.5 ZB per year (11.2 ZB per month) in 2014. (a Zettabyte is 1 trillion Gigabytes). Globally, the data created by IoT devices in 2019 will be 269 times greater than the data being transmitted to data centers from end-user devices and 49 times higher than total data center traffic.[3] Currently, only 30% of the data created in areas like the supply chain is leveraged for optimization, but it is expected that this number will increase significantly in the future.

[1] Gartner | Press Release Feb 07, 2017
[2] Marketplace.org | By 2020 there will be 10 web-connected devices per human
[3] Deloitte | Tech Trends 2016

Looking at this incredible increase in global data from IoT devices, several crucial questions should present themselves to IT decision-makers: How can all this data, generated by sensors attached to 'things', be transferred efficiently into data-processing applications and turned into smart decisions? What connectivity solution is the cheapest/fastest/most reliable one? Which connectivity solution should organizations choose in order to leverage IoT potential in their environment and what does the selection process look like? What data do companies even transfer, and what can be processed locally? How can decisions be standardized for communication based on use case requirement mutualisation?

Due to the seemingly endless variety of IoT applications available, organizations struggle when it comes to an appropriate selection process of the right connectivity solution in their specific business use case. Current connectivity solutions for IoT extend from low-range connectivity solutions, such as Bluetooth, via familiar technology like cellular connectivity to completely new concepts provided by less-known or new providers and alliances, such as LoRa or Sigfox.

It is worth mentioning that each connectivity solution has its own strengths and weaknesses, and obviously, there really is no 'one size fits all' approach out there, as all connectivity solutions are tailored to specific use cases and fields of applications. Rather, it is important to understand the variety of options available and the factors that influence the decision, such as network costs, required battery life, data rates, latency, mobility, range, coverage, and many other factors that need to be balanced when it comes to the connectivity selection process for a specific IoT application within the company. In addition, requirements for the underlying use cases of an IoT application are likely to change during its life cycle, as the volumes or selection of data gathered from machines etc. might need to be adjusted once patterns have been analyzed.

Taking a safari into the confusing jungle of connectivity solutions for IoT applications in order to make informed decisions and understand the current and future landscapes might eventually reward organizations with a cutting-edge advantage in the Internet of Things.

In this paper, Deloitte will present its point of view on the current market of technologies, expected connectivity trends, and relevant IoT connectivity solutions for different use cases, as well as the impact that different IoT connectivity solutions may have on a company's IoT applications and business success. The paper will focus exclusively on common connectivity standards rather than details of different protocols and systems. It is therefore the right information source for IT decision-makers who currently have little or no knowledge about IoT connectivity and are aiming to gain a broad overview in this area.

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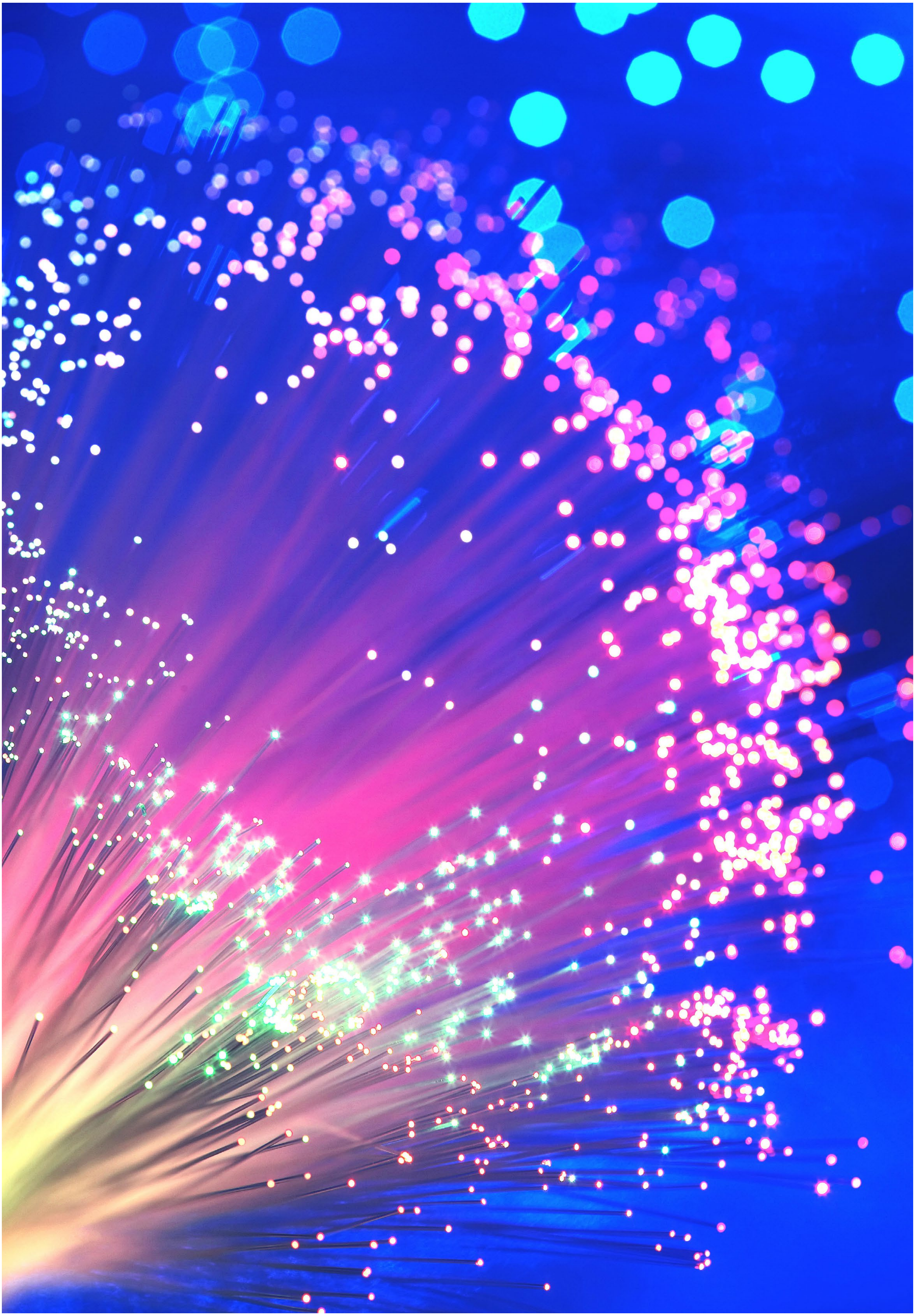

Market Overview

A wide variety of IoT connectivity standards are already available in the market.

In general, standards vary in their technical specifications, which determine the specific IoT use cases that can be served by any particular connectivity solution. Some of these specifications are:

- Frequency
- Max data throughput (data rates)
- Latency
- Battery life in connectivity modules
- Manufacturing costs of connectivity modules
- Maximum data range
- Coverage
- Mobility
- Security
- Scalability (Mesh Network Availability etc.)
- Robustness
- Mobility

The following part will provide a high-level overview of different connectivity solutions, potential fields of applications, and technical specifications.

Connectivity solutions for IoT can be structured into two high-level categories: wireless and wired connectivity solutions. From these two main choices, wireless solutions can be further divided into long-range and short-range connectivity standards. Long ranges go up to 200km (HSPA), whereas short-range solutions cover a maximum of approximately 100m (Bluetooth Low Energy). Long-range connectivity solutions can then be further subdivided into licensed (cellular) and unlicensed standards, known as LPWAN (Low Power Wide Area Networks).

I. Wireless Solutions

1. Short-Range Solutions

Short-range IoT connectivity solutions transfer data over small physical distances, with the distance between the 'thing' that collects data and the gateway that processes it (or sends it over the internet to another platform) usually less than 150 meters.

A frequently used example that is currently available is Bluetooth, which uses a frequency of 2.4GHz to achieve a maximum throughput of approximately 2 Mbps. Another well-known short-range solution is Wi-Fi (at either 2.4 or 5 GHz), which has a maximum range of only about 50 meters, but transfers data at much higher speeds of up to 600 Mbps, depending on the Wi-Fi standard. However, it should be mentioned that there are some security issues related to the Wi-Fi standard. Comparing Bluetooth and Wi-Fi, it already becomes clear that even among short-range IoT solutions, the differences in potential use case are substantial. A solution that comes with an even lower range and bandwidth is called Z-Wave. Transferring data at a frequency of 900 MHz, the connection is very energy efficient and gives a long battery life in the connectivity hardware.

Typical fields of IoT applications for short-range connectivity solutions are wearables and smart waste management in smart city ecosystems, as the distances between the 'things' and the next gateway are usually very short. As an example, the city of Vienna, which received the "Best Smart Project 2016" award, uses Bluetooth in its smart parking concept.[4, 5]

The following table provides a more detailed overview of current short-range connectivity solutions:

Tab. 1 – Detailed overview of current short-range connectivity solutions

Solution	Frequency	Max. Range	Max. Throughput	Latency	Topology	Power Consumption	Use
Wi-Fi HaLow (IEEE 802.11ah)	Various (sub-1 GHz)	1 km	40 Mbps	100 ms	Mesh	Low	Smart lighting, smart HVAC, security systems
Bluetooth Low Energy	2.4 GHz	100 m	2 Mbps	6 ms	Point-to-point	Low	Mobile phones, gaming, wearables
Z-Wave	800-900 MHz	100 m	100 kbps	N/A	Mesh	Low	Smart lighting, thermostats, locks, sensors
Zigbee	2.4 GHz	100 m	250 kbps	10 ms	Mesh	Low	Lighting controls, smoke and CO_2 detectors
NFC	13.56 MHz	10 cm	424 kbps	100 ms	Point-to-point	Low	Commerce, smartphone automation

[4] Wirtschaftswoche | Wettrennen um die Stadt der Zukunft
[5] Der Brutkasten | Payuca: Wiener Smart Parking-Startup startet Testbetrieb

Tab. 2 – Detailed overview of current short-range connectivity solutions

Solution	Frequency	Max. Range	Max. Throughput	Latency	Topology	Power Consumption	Use
GSM/ GPRS / Edge	Various (Depending on region)	Up to 100 km	384 kbps	0.15–1 s	Star	High	Smart metering, asset tracking, sensors
UMTS/ HSPA			10 Mbps	0.2–0.4 s		High	
LTE CAT 1			10 Mbps	0.05–0.1 s		Medium	
LTE CAT 0			1 Mbps	N/A		Medium	
EC-GSM-IoT			2 Mbps	0.7–2 s		Medium	Health monitoring, smart cities, sensors
LTE Cat NB1 (NB-IoT)			250 kbps	1.6–10 s		Low	
LTE Cat M1 (eMTC)			1 Mbps	10–15 ms		Low	

2. Long-Range Solutions

a) Cellular

Cellular provides solutions for IoT solutions that require long-distance data transfers combined with low latency. While cellular is clearly capable of sending high quantities of data, especially for standards such as 4G, the hardware costs, maintenance expenses, monthly costs for rates and data plans, and the power consumption of older LTE releases will be too high for many IoT applications. However, cellular standards in more recent releases, especially LTE Cat-0, 1, M1, NB1, can provide the low power, low throughput, wireless technology required by many modern IoT applications. Moreover, the lower prices charged by mobile network operators for these standards are an advantage over regular cellular standards.

At this point it is worth mentioning that connectivity costs are sometimes measured relative to the overall cost of a 'thing', which explains why some companies might choose to connect an expensive machine via cellular standard, as the potential cost savings from switching to a cheaper connectivity standard are minimal in relation to overall machine costs.

One important advantage to consider is that to implement the new standard, cellular operators only need to upgrade their network software without also installing new antennas, a cost saving that can be passed on to cellular company clients.[6] The commercial launch of solutions such as LTE Cat M is expected for 2017/2018[7], and it might take some time until the global rollout is completed.

Typical fields of IoT applications for cellular connectivity solutions are smart meters and retail point-of-sale terminals, as these applications rely on low latency and are located in areas covered by most cellular companies. An example is Trilliant, a company that focuses on smart energy and provides several smart metering systems that use cellular connectivity standards.[8]

The following table provides a more detailed overview of current cellular connectivity solutions:

[6] Farnell | Trends in Cellular IoT Part 2
[7] GSMA | Long Term Evolution for Machines: LTE-M
[8] Trilliant | CellReader Digital AMI Cellular Solution

b) LPWAN

The term LPWAN is made up out of two sub-terms: Low Power (LP) means that the hardware power consumption is generally very low and therefore can operate on small, inexpensive batteries for several years. Wide Area Network (WAN) indicates that the connectivity solution can bridge an operating range that is typically more than 10 km in urban areas. It is important to understand that LPWAN itself is not a connectivity standard, but rather an umbrella term encompassing various implementations and protocols that share common connectivity characteristics.

Two examples of LPWAN implementations are LoRa and Sigfox. While both solutions rely on mobile network operators to adopt the technology and implement it across geographies, they have very different business models.

LoRa's approach means that even crowd-sourced networks are possible, with lower cost gateways and a reach of a few kilometers. This is possible because LoRaWAN is not a company, but a standard maintained by the non-profit LoRa Alliance. Each of the companies in the alliance profit in some way from having an open standard for IoT applications, and the LoRa Alliance promotes this standard to get the many developers and companies on board. Implementation examples are KPN in the Netherlands, Orange in France, and Digimondo in Germany.

Sigfox, on the other hand, is a single company maintaining a patented, proprietary technology. They roll out and maintain their own network (sometimes through partnerships with network operators). They profit directly from subscription to their network. Implementation examples are AEREA in the Netherlands, WND in South America, and UK and Engie M2M in Belgium.

Typical fields of IoT applications are precision farming in urban areas and fleet tracking, as these usually have only limited or no cellular coverage, while high latency is acceptable.

The following table provides a more detailed overview of LPWAN connectivity solutions:

Tab. 3 – Overview of LPWAN connectivity solutions

Solution	Frequency	Max. Range	Max. Throughput	Latency	Topology	Power Consumption	Use
LoRaWAN	Various (sub-1 GHz)	15 km	50 kbps	128-bit AES	Star on star	Very low	Logistics, utilities, smart cities, industrial IoT
Sigfox	900 MHz	50 km	10 kbps	N/A	Star	Very low	Asset tracking, mHealth, remote monitoring
Weightless (W,N,P)	Various (sub-1 GHz)	5 km	10 Mbps (W)	128/256-bit AES	Star	Very low	Smart metering, asset tracking, smart cars
Ingenu	Various (sub-1 GHz)	500 km	38 kbps	128-bit AES	Star	Very low	Agriculture precision, smart grid, asset tracking

II. Wired Solutions

Even though wired solutions might seem outdated at first view, they can turn out to be important connectivity options in the IoT context. Often, wired solutions are applied when a) the 'thing', for example a machine, usually stays at the same location and there is no need for mobility, and b) the distance between the sensor and the gateway is short.

These solutions are usually aimed at broadband applications, such as in-home distribution of IPTV, Internet connectivity, and smart grids, where data is transferred through the existing electrical wires installed within the building.

Wired IoT connectivity standards include ANSI/CEA-709.1, a protocol initially developed by Echelon Corporation and now used by the LonWorks solution, and ITU-T G.9960, which is promoted by the HomeGrid Forum to detail the specifications of G.hn solutions for home networking. Also, PRIME Alliance conceived a specification for narrow-band powerline communication, aiming to drive the evolution of intelligent metering solutions.

The following table provides a more detailed overview of current wired connectivity solutions:

Tab. 4 – Overview of current wired connectivity solutions

Solution	Frequency	Max. Range	Max. Throughput	Latency	Topology	Use
HomePlug	N/A	100 m	500 Mbps	128-bit AES	Bus	Powerline solution for extended wired connectivity
G.hn		N/A	1 Gbps	128-bit AES	Multiple	IPTV, home networks, smart grid
LonWorks		1.5 km	78 kbps	None	Multiple	Municipal and highway/ tunnel/ street lighting
PLC PRIME		More than 100 km	128 kbps	128-bit AES	Tree	Smart metering, smart grids, street lighting control

IoT Connectivity Use Cases

As already mentioned in the introduction, every IoT application has unique requirements when it comes to selecting the right connectivity solution. The following section provides an overview of selected use cases, which reflect different fields of IoT applicability and thus represent connectivity challenges for different IoT applications.

a) Precision Farming
IoT contains considerable potential for increasing efficiency and reliability in farming. Sensors on the soil, for example, can collect data about moisture, temperature, alkalinity, and potential threats from pests. This data is then transferred over long distances to the farmer's office, where it serves as a valuable source of information for further activities. If moisture is required, the farmer now only needs to drive to specific fields and irrigate them, which saves time and water. In this area of IoT application, connectivity hardware with low battery consumption is required. Furthermore, as fields are usually located in rural areas, data needs to be transmitted over a long range to the next base station. The bandwidth however can be small, since data about moisture levels is typically less than a few Mbit. Also, latency does not need to be high, because conditions change slowly and updates are required only a few times an hour. All these connectivity requirements can be fulfilled by LPWAN solutions like LoRaWan or Sigfox. As described in the market overview, these connectivity solutions usually have low-priced hardware and long-range data transfer capabilities, and provide good connectivity coverage even in rural regions. In addition, most farms in rural areas today do not have cellular coverage at all, much less 4G/LTE, therefore NB-IoT based on cellular connectivity is currently not a viable option.

Other use cases for LPWAN:

- Tracking the location of delivery trucks (Fleet Tracking)
- Air pollution monitoring
- Home security
- Tank flow monitoring
- Smart cities (Smart Lighting)

IoT contains considerable potential for increasing efficiency and reliability in farming. Sensors on the soil, for example, can collect data about moisture, temperature, alkalinity, and potential threats from pests.

b) Wearables – Health Tracking

In today's performance-oriented society, many people have a deep desire to track and optimize every part of their lives, a trend that includes fitness and health. Consequently, wearables like smartwatches, fitness bands, and sleep trackers allow us to carefully monitor our sleep, workouts, and heartrates every minute of every day. In most cases, sensors built into the trackers send regular updates to people's smartphones or laptops. These applications have specific requirements for connectivity solutions: First, the data packages transferred are small, usually less than a few Mbits. Second, the connectivity range is typically less than a few meters between a tracker attached to the body and a smartphone. In addition, the latency required by this type of IoT application can be high, as receiving an update about the heartrate every few minutes is more than enough for most users. To avoid users having to charge wearables and smartphones every few hours, the connectivity solution should enable an energy-efficient data exchange. The most suitable connectivity solution for short ranges is Bluetooth. This solution, designed for mobile personal area networks (PANs), is characterized by low frequency, low data throughputs, and a limited connectivity range. The recently published Bluetooth Low Energy (LE) standard is designed for low-power data transfers, with implementation expected in 90% of smartphones by 2018.

Other use cases for Bluetooth:

- Connected home (Smart Temperature)

c) Connected Cars – Smart Traffic Management

Connected cars, or Vehicle-to-Everything (V2X) communication, involves communication among vehicles and between vehicles and roadside infrastructure. Real-time communication enables vehicles to deal with situations that neither the driver nor the vehicle's sensors could otherwise identify, enabling more predictive driving. In-vehicle information-based services increase road safety, improve driver comfort, and will enable fully automated driving in the future. While traffic information and diagnostic data do not generally require low-latency connectivity, other applications depend on reliable vehicle-to-vehicle communication with low latency. When augmented with Multi-access Edge Computing (MEC), LTE advanced, NB IoT, and LTE V2X, LTE can provide a viable and cost-effective solution that can accelerate the adoption of V2X communications in transport authorities and the automotive industry. The hybrid use of the LTE portfolio will meet automotive industry needs on the way to 5G. It provides support for automated driving, increased comfort, and improved infotainment, as well as increasing road safety and traffic efficiency.[9]

Every IoT application has unique requirements when it comes to selecting the right connectivity solution.

[9] Nokia White Paper | IoT Connectivity – Understanding the options & choices

d) Health sector – Connected Medical Devices

The health sector is increasingly driven by cost efficiencies, result-based compensation for treatments, and patient well-being. IoT can play an important role in addressing the changing demands of patients, professionals, hospitals, and insurers in this respect.

For instance, connecting medical devices in patients' homes allows important operational data to be gathered, which generates value in numerous use cases. Through geo-fencing, device owners can ensure that the devices in their fleet remain at the designated location, minimizing the financial damages resulting from loss or theft. Other operational data tell them the status of the device, enabling preventive maintenance and battery replacement, and minimizing the number of routine inspections by mechanics, which not only enables cost savings in the field force, but also reduces intrusive visits to the patient's home.

Although privacy and cyber security issues need to be addressed, remotely sharing medical data will enable doctors to improve their diagnostics, because they have access to a wider range of relevant data, while patients benefit from a potentially lower number of hospital visits.

With new low-power wide area (LPWA) technologies like NB-IoT, these use cases become more attractive. This is due to their enablement of companies to deploy solutions transmitting small amounts of data, in hard to reach (indoor) locations, for longer periods of time (less energy consumption means longer battery life), and therefore in a more cost-efficient manner, while continuing to use existing mobile networks for use cases demanding more throughput and latency.

Other use cases for cellular:

- Real-time surveillance monitoring
- Connected cars

As an intermediate summary, we can state that different IoT applications require different connectivity characteristics.

Use cases located in rural areas require long-range connectivity standards to connect to base stations far away, while those located near cities and with close access to base stations or gateways can rely on short-range connectivity solutions. Moreover, use cases that rely on a short interval between data generation and action should focus on deploying solutions with low latency, such as cellular LTE Rel.8, while use cases that do not require immediate action can accept standards with higher latency, such as Sigfox. High bandwidth standards like LTE Rel. 8 are important when the data packages collected by sensors and sent by a 'thing' are large. In cases where only small data packages need to be sent, it is worth considering solutions like LoRaWAN. Cost is another consideration, so when the costs of deploying and maintaining the connectivity solution are high relative to the cost of the 'thing', that is, when operating many small sensors with low hardware value, usually low-cost connectivity solutions such as LTE Cat-M are appropriate.

Long Term Implications

With the increasing quality of connectivity, more and more value-generating IoT use cases can be deployed for the benefit of people and organizations.

NB-IoT already makes it possible to connect to more devices, in more difficult to reach areas, and at lower battery consumption, than other connectivity technologies before it. However, with the deployment of 5G technologies in the near to medium future, a truly big shift in IoT will take place: Key characteristics of 5G enable large-scale IoT adoption and success to a degree which is impossible with the current state of connectivity technology. Two of those key characteristics are lower latency and higher throughput. The combination of these aspects enables real-life implementations of use cases that are currently only possible in small-scale lab environments, such as self-driving cars, remote surgery, remote construction robots, and real-time AR/VR applications. However, lower latency and higher throughput alone are not enough for the large-scale adoption of such use cases. Two other key aspects enable mass adoption of these types of innovations: support for more simultaneously connected devices and a more efficient use of energy. Finally, 5G makes 'network slicing' possible, a technology that enables network operators to create multiple (virtual) networks within one network. This means that different priorities, availability, latencies, and throughput can be set to meet the requirements of different uses cases; for instance, mission-critical latency can be provided for applications relating to self-driving cars, while de-prioritized traffic could be offered for more price-sensitive uses cases like tracking bulk containers during road or rail transport. All these aspects combined mean that organizations will have access to connectivity technology that enables scaling up of their current proof-of-concept setups.

Mass deployment of 5G-enabled applications has a major impact on the architecture supporting the application. To keep the right balance between performance and infrastructure costs, applications will need to be able to scale with actual (and forecasted) demand. Incorporating intelligence at the edge of the application's network, or even in the connected device itself, is another way of reducing stress on the back-end infrastructure.

A different barrier for cost-efficient mobile IoT use cases is the physical SIM needed to connect to cellular networks. Various developments, such as embedded SIMs and connectivity management platforms, allow connected equipment manufacturers to switch between networks and providers without physically adjusting the connected device (i.e. no change of SIM needed). This enables improvement of connection quality and new cost reduction scenarios by dynamically selecting an operator/network based on local signal quality and data costs.

Business Implications

The dynamic market for IoT applications and connectivity requires an ecosystem-oriented business mindset to be successful. The complex nature of IoT applications results in involvement of several specialized parties to realize an application: e.g. device and sensor manufacturers, software vendors, connectivity network providers, connectivity management providers, cloud (storage and processing) providers, analytics platform providers, orchestrators etc. Some players will combine various ecosystem functions, but in the end, close collaboration and orchestration will be necessary to realize valuable IoT use cases. Organizations will need to have or develop the capability to manage their partnerships effectively and create trust-based business relationships. Sharing resources is inevitable in such ecosystems (e.g. the connectivity network, potentially also various platforms), which further emphasizes the need for trusted and capable partners.

When successfully deployed, IoT applications have the potential to improve companies' revenue and costs by reinventing the way in which they do business. On the one hand, revenue can be improved by launching new business models enabled by IoT. For example, a vendor of coffee machines may start offering a usage-based model instead of selling individual machines or subscriptions. In that case, a consumer would buy a coffee subscription and receive a connected coffee maker that charges the customer a fixed fee, or even by the cup. The vendor receives usage and maintenance data to optimize the maintenance and coffee bean delivery schedule. This new business model is made accessible through the application of IoT technology. On the other hand, costs can be reduced with IoT through timely delivery of maintenance information. For example, having accurate status and maintenance information reduces the chance of an engineer routinely investigating a device only to find everything is running smoothly. Instead, advanced predictive models can be used based on actual usage and diagnostic data provided by the connected machine/device. In that case, operating costs can be optimized through higher uptimes and lower maintenance costs.

When successfully deployed, IoT applications have the potential to improve companies' revenue and costs by reinventing the way in which they do business.

Summary

The Internet of Things (IoT) is praised by experts around the globe as the beginning of the next industrial revolution. If a company's product is not connected and the business model does not include a service component, it is likely to miss substantial opportunities for increasing efficiency throughout the value chain, and thus faces the risk of falling behind its competition. Companies that invest in setting up a useful IoT application landscape today, however, are very likely those who will be rewarded with a cutting-edge competitive advantage tomorrow.

An important component in designing an IoT ecosystem in an organization is the selection of the underlying connectivity solution that the IoT application uses to transfer data from the sensors attached to 'things' to the data-processing applications and derive 'smart' decisions or insights. The sheer variety of connectivity solutions available today, however, is overwhelming for organizations all around the globe. Different use cases in this white paper showed that there really is no 'one size fits all' solution, as each of those IoT applications fields comes with different challenges and requirements regarding its connectivity solutions. Therefore, only the companies that select the most appropriate connectivity solutions for their IoT ecosystem can leverage the full potential of IoT.

So what can organizations do today in order to make smarter decisions during the selection process of IoT connectivity solutions?

At Deloitte, we believe that organizations should first determine their needs before they can successfully select, plan, and deploy the right connectivity solutions. An organization's needs in this case are derived directly from the connectivity requirements of the IoT applications in the company's application landscape. As already outlined, there are several factors that need to be weighed and balanced, for example the required battery life, network coverage, data range, and latency. Moreover, it should be considered that non-connectivity requirements of the underlying IoT applications inside an organization are likely to change over time. For example, the selection of data that is gathered at the beginning of an IoT application's life cycle might differ significantly from the data that is gathered once specific patterns in the data have been analyzed. Thus, having flexibility in contract designs can turn out to be a great asset in the end. Once the requirements are understood, companies should place a strong focus on clustering their different IoT applications by their respective connectivity requirements and select IoT connectivity solutions that provide unique characteristics to satisfy the demands of each cluster. Incorporating this approach in the selection process of IoT connectivity solutions will likely lead to a more efficient and holistic setup of the organization's IoT ecosystem.

While choosing the right connectivity type(s) for the company's uses cases, careful consideration needs to be given to the different OPEX drivers, such as fixed or volume-based fees (for cellular connectivity), energy consumption and installation, repair, maintenance fees, and CAPEX drivers like hardware. Generally speaking, short-range and LPWAN solutions require more CAPEX, whereas cellular results in OPEX. Furthermore, it is important for any organization to ensure future flexibility and avoid lock-ins and costly changes caused by dependence on SIM cards already installed.

The complexity that comes with the selection process of IoT connectivity solutions might seem intimidating to organizations. Deloitte is convinced that it takes experience, knowledge, and expert guidance to master this task. However, organizations should be reminded that investing the time to carefully evaluate and plan connectivity options for the IoT ecosystem will very likely be rewarded with significant cost savings and/or productivity gains once the right connectivity solution has been selected.

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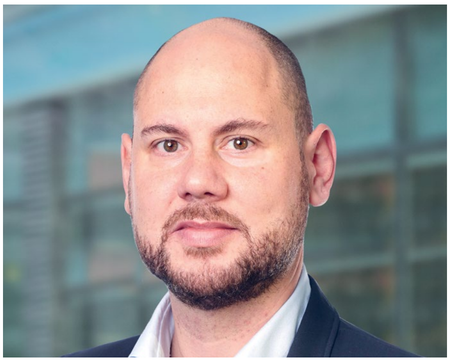

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