WHITEPAPER

Internet of Things: Last Mile Connectivity Options Explained

CLX communications

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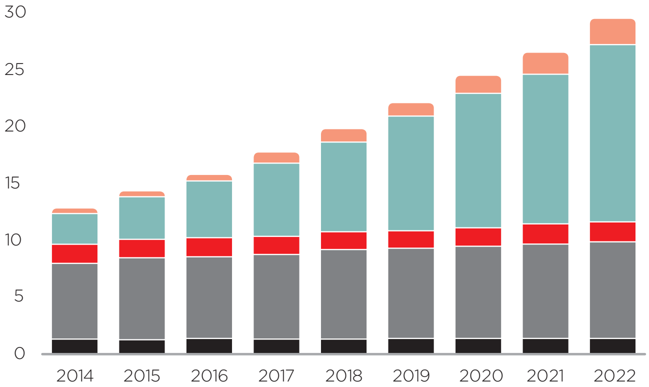
Introduction

The Internet of Things has been hyped and hyped. And for good reason: It is now becoming feasible to connect almost anything and everything, giving individuals and organisations new and valuable insights.

However the question remains, which connectivity technology should be used for which purpose? An enormous and diverse ecosystem has created a wide variety of connectivity options, of varying maturity, generating confusion for both large and small businesses.

Today, the Internet of Things (IoT) relies heavily on short-range wireless technologies, such as WiFi, Zigbee and Bluetooth. Over the next five years, long-range wireless technologies will play an increasingly important role. Leading equipment maker Ericsson anticipates that the number of wide area IoT connections will grow rapidly at a CAGR of 30% over the next five years, compared with a 20% CAGR for short-range IoT connections (see graphic).

Connected devices (billions)



	2016	2022	CAGR
Wide-area IoT	0.4	2.1	30%
Short-range IoT	5.2	16	20%
PC/laptop/tablet	1.6	1.7	0%
Mobile phones	7.3	8.6	3%
Fixed phones	1.4	1.3	0%
	16 billion	29 billion	10%

[1] In our forecast a connected device is a physical object that has an IP stack, enabling two-way communication over a network interface. Traditional landline phones are included for legacy reasons
[2] Connected devices connecting to a wide-area network through a common gateway

Source: Ericsson Mobility Report, November 2016

Wireless wide area technologies are in demand because they can provide flexible connectivity over distances of several miles, eliminating the need to dig up roads and lay cables. Moreover, cellular technologies can support mobile connections, such as those needed by connected vehicles and wearable devices, such as fitness trackers.

This paper outlines the numerous ‘last mile’ connectivity options now available to enterprises, while weighing the pros and cons of alternative technologies. In particular, it considers how new low power wide area (LPWA) cellular technologies are making it cost-effective to expand the IoT into new markets and applications. The discussion continues to explore the likely impact of reprogrammable SIM cards, which make it straightforward for devices, machines, appliances and vehicles to switch between different service providers.

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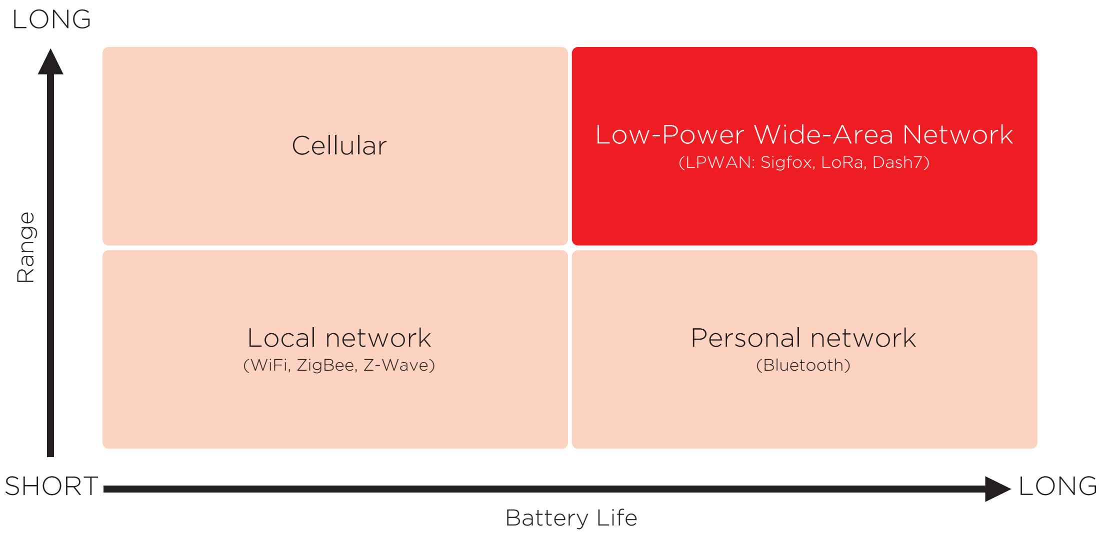
Last mile connectivity options

A device, machine, appliance or vehicle can be connected in many different ways. It can use a wide area network to relay data directly to a server or it can use a short-range technology, such as WiFi or Bluetooth, to connect to a mesh network, hub or gateway. Wide area networks tend to be less complex than mesh networks as the endpoints can be connected directly to a gateway or base station, rather than relying on a relay system to transmit messages.

There are many different wide area and short-range technologies available, but they can be divided into two categories: those that are designed for high throughput rates and, therefore, have relatively high power consumption and those that are designed to minimise energy consumption and, therefore, provide relatively low throughput. Conventional cellular technologies and WiFi tend to offer high throughput rates, while new low power wide area (LPWA) technologies and Bluetooth are low energy technologies (see graphic).



Source: Alexander Vanwynsberghe, Blog article 'Long-range radios will change how the Internet of Things communicates'

Low power wide area options

Designed specifically to support IoT, LPWA technologies are optimised for use in low cost devices that need to transmit small amounts of data. The objective is typically to provide low cost and energy-efficient connectivity for a large numbers of devices in a small geographic area. Such devices include sensors that can monitor city infrastructure, environmental conditions, mobile assets and supply chains, as well as energy and water meters. Typically these connected devices transmit regular updates, such as a temperature reading, or configurable event triggers.

Broadly, there are two kinds of LPWA technologies: Standardised technologies that use the licensed spectrum belonging to telecoms operators and proprietary technologies that operate in unlicensed spectrum.

Proprietary LPWA technologies in unlicensed spectrum

A number of LPWA technologies, such as Sigfox and LoRa, have already been deployed to connect sensors and other devices to the Internet of Things. As they use unlicensed spectrum and haven't gone through a standardisation process, these proprietary LPWA technologies have come to the market quickly.

However, these technologies are vulnerable to interference from other radio signals transmitted using the same blocks of unlicensed spectrum. Moreover, they are only supported by a small number of vendors and typically don't support roaming across international borders.

Stockholm-based CLX Communications, a global provider of cloud-based communication services and solutions to enterprises and mobile operators, says that these issues present a significant barrier to the adoption of LPWA technologies in unlicensed spectrum. “Quality of service is high on the agenda for many value-added resellers servicing both domestic and international roaming use cases,” says Jon Campbell, Director, Messaging & IoT EMEA at CLX. “It is simply unrealistic to rely on unlicensed spectrum for ad-hoc connectivity, especially where regular contact is required. The consistent feedback is that cellular is the default connectivity of choice, with other technologies playing a complimentary role, such as checking in at home locations via WiFi and using cellular whilst in transit.”

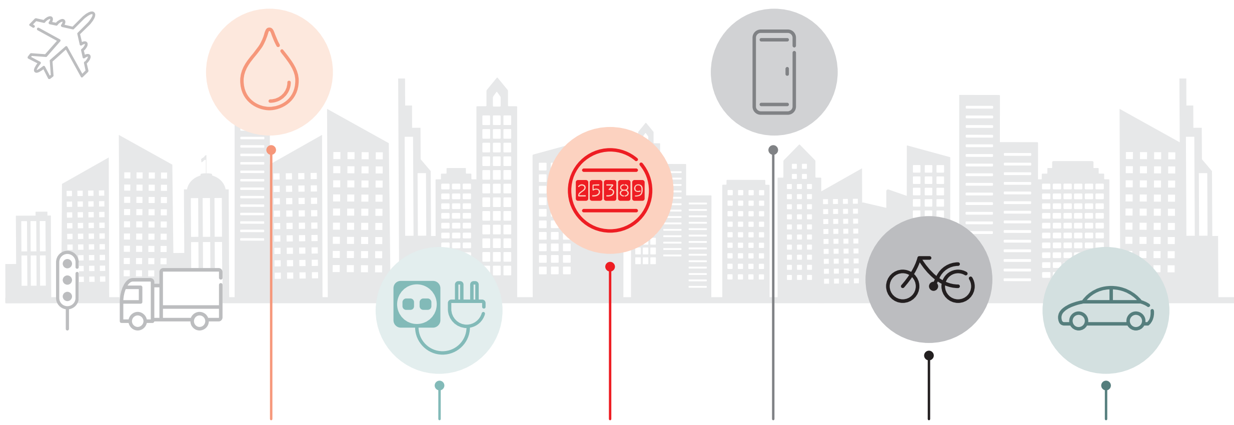
Indeed, one of the main challenges facing unlicensed spectrum LPWA technologies is ensuring widespread coverage. “With LoRa and Sigfox, you need to make sure there is coverage in a particular market for that particular technology,” notes Andrew Brown, Executive Director, Enterprise and IoT Research at Strategy Analytics. “But contrary to some suggestions that everything will shift to NB-IoT and 5G, unlicensed LPWA is going to stick around because it is meeting the needs of specific use cases and price points. LoRa will likely be the winner in this segment because it is rapidly building an ecosystem of solution providers, aggregators and chip vendors, whereas Sigfox remains more proprietary with a closed ecosystem. Fundamentally, the use case will determine the most appropriate technology.”

Standardised LPWA technologies in licensed spectrum

Three new LPWA technologies, NB-IoT, LTE-M and EC-GSM-IoT, have been standardised by 3GPP for use in licensed spectrum. Mobile operators around the world are now adapting their cellular networks to support these technologies, paving the way for commercial services during 2017. They make use of operators’ existing infrastructure, but are designed to provide better coverage than traditional cellular services. Early operator trials suggest that 3GPP-compliant LPWA technologies can provide connectivity in previously hard-to-reach locations, such as basements and deep inside buildings. In addition, the use of licensed spectrum means 3GPP-based LPWA connectivity won’t suffer from interference, increasing reliability and quality of service.

NB-IoT and EC-GSM-IoT, in particular, have been optimised to transmit brief messages – about the length of an SMS – such as those required by the use cases shown in the graphic below.

Traffic characteristics of deployed massive IoT connected devices in a city scenario



	WATER METERS	ELECTRICITY METERS	GAS METERS	VENDING MACHINES	BIKE FLEET MANAGEMENT	PAY-AS-YOU-DRIVE
Typical message size	100 bytes	100 bytes	100 bytes	150 bytes	150 bytes	150 bytes
Message interval	12 hours	24 hours	30 minutes	24 hours	30 minutes	10 minutes
Device density	10,000/km²	10,000/km²	10,000/km²	150/km²	200/km²	2,250/km²

Source: Ericsson Mobility Report, November 2016

3GPP-standardised technologies are underpinned by the scale and breadth of the well-established existing cellular ecosystem, meaning solutions will be available from a large number of vendors and in a consistent way across the world. As a result, vehicles, wearables and other mobile assets will be able to stay connected across international borders, while manufacturers will be able to ship connected products internationally and benefit from the resulting economies of scale.

Standardised technologies also benefit from economies of scale making it feasible to deploy large numbers of connected sensors in relatively small areas, such as a farm or an industrial plant. Andrew Brown of Strategy Analytics says it should be feasible to sell NB-IoT modules for US$5-10 a piece, about the same as for a LoRa module.

"Standardised technologies have the advantage that you know they will work. They are a worry-free option supported by an ecosystem alignment," says Sylwia Kechiche, Lead Analyst at GSMA Intelligence. "And I have been impressed with how fast things have come together for NB-IoT, in particular."

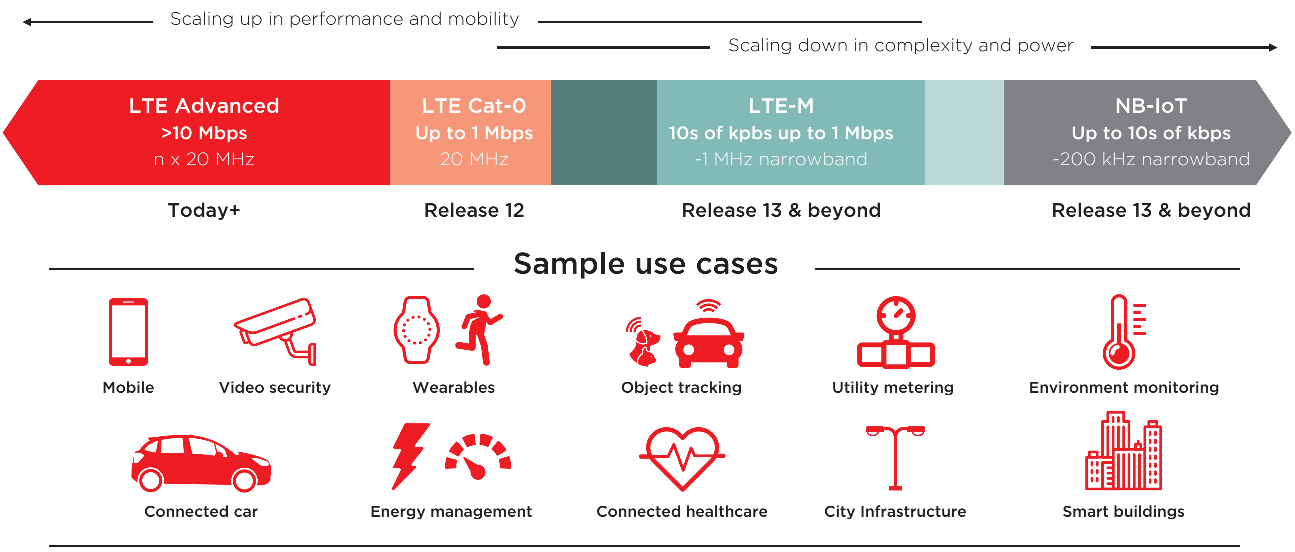
LPWA technologies in licensed spectrum can also benefit from mobile operators' built-in security systems and end-to-end control over the connectivity. Operators can deliver secure connectivity and support for authentication appropriate to the IoT use case.

Conventional cellular technologies

There are high throughput IoT use cases, such as streaming video to a passenger in a car or connecting security video cameras, which need a higher level of performance than that delivered by LPWA networks. These use cases generally need to use 3.5G or 4G cellular services, such as those provided by LTE Advanced, to provide the necessary high bandwidth connectivity (see graphic below).

Although 2G cellular networks are still widespread and widely used, particularly in the developing world, Sylwia Kechiche of GSMA Intelligence says adoption of LPWA technologies is being driven in part by uncertainty around the future of 2G cellular networks that currently serve a large portion of M2M applications. She notes that some operators have closed down 2G networks in South Korea, US, Australia and Japan, as they look to re-farm the spectrum for use with 4G and 5G.

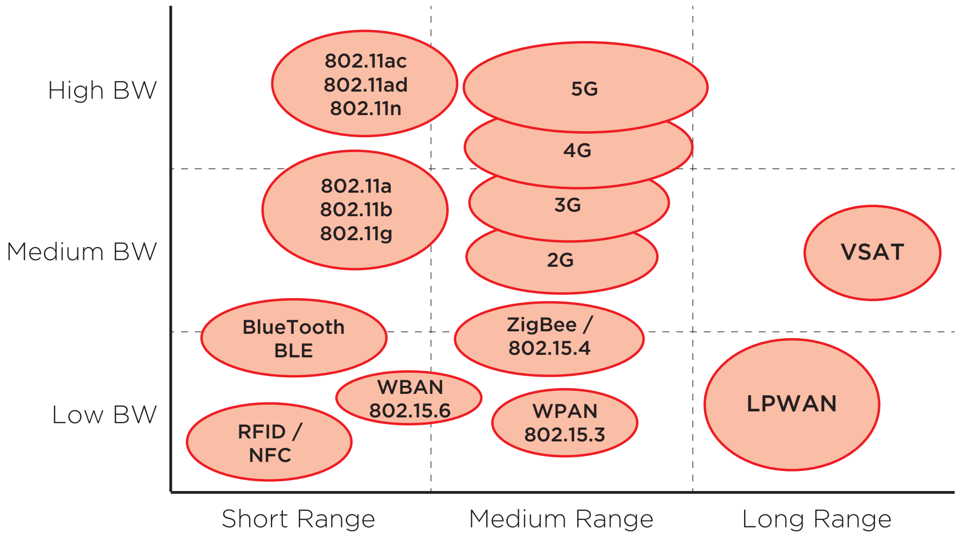
The development of 5G is the next major step in the on-going evolution of the global mobile ecosystem. The mobile industry is on course to begin deploying commercial 5G networks from 2020 onwards. Currently being standardised by 3GPP, 5G networks should be able to support vast numbers of connected devices, while also enabling ultra-reliable and low latency connectivity for demanding applications, such as live virtual reality broadcasts and remote control of equipment and vehicles.



Source: Qualcomm, Harmonizing the industry on a narrowband IoT (NB-IoT) specification, September 2015

Short range technologies

Short-range technologies typically use unlicensed spectrum and provide coverage of up to 100 meters. Short-range technologies include WiFi, Bluetooth, ZigBee and NFC (see graphic),



Source: Peter R Egli 2015 (appeared in the article by Alain Clapaud 'IoT: Waveband Wars about to hot up'

Although many of these short-range technologies are proven and mature, their reliance on unlicensed spectrum makes them susceptible to interference. Their short range also means they need to be connected to a mesh network or a local hub or gateway, which is then connected to a cellular network or a fixed-line network.

Short-range technologies often rely on building owners configuring and maintaining them correctly. "CLX is seeing a growing number of solution providers using cellular to support a static solution, such as home oil monitoring and home automation, to enable them to retain control of the connectivity and bypass unreliable and changeable home WiFi services," says Jon Campbell of CLX.

In some cases, cellular and short-range technologies are used together in a tethering arrangement. For example, a 4G cellular connection can be used to connect a WiFi hotspot to the Internet. This configuration can be used to enable passengers inside a vehicle, for example, to connect tablets and laptops to online services and apps. "Short-range technologies are very fragmented, but many of them, such as WiFi, Bluetooth and ZigBee, are low cost and proven," says Sylwia Kechiche of GSMA Intelligence. "They can also be used in conjunction with cellular, whereby short-range technologies can leverage the security credentials from the SIM, for example, using the Generic Bootstrapping Architecture (GBA)."

The existing market momentum continues to fuel the evolution of short-range technologies. For example, the latest version of Bluetooth (Bluetooth 5) has been designed to work over a range of 200 meters (4X that of Bluetooth 4) and double the bandwidth. Bluetooth 5 also has better location awareness and increased broadcast message size (8X that of Bluetooth 4), enabling the technology to be used to push alerts to users from beacons, such as those deployed in retail stores.

At the same time, WiFi is expanding into new frequency bands, with 802.11ad enabling high-speed data transfers in high frequencies and 802.11ah operating below 1GHz. Whereas 802.11ad could be used in the networking, mobile device, computing, and peripheral spaces, 802.11ah could support low power IoT devices and wireless sensor network applications.

Reprogrammable SIM Cards

The expansion of the IoT is also being enabled by the growing availability of reprogrammable SIM cards. This technology enables a manufacturer to embed a SIM card in a device, appliance, machine or vehicle and then have it provisioned to work on a specific operator's network once the product has been deployed in the field. This makes it straightforward for the customer to change the connectivity provider without having to service the device, appliance, machine or vehicle – the SIM card can be reprogrammed over the air.

"It is extremely important that you can put a SIM in a vehicle and activate it anywhere on anyone's network," says Andrew Brown of Strategy Analytics. "In many IoT markets, manufacturers are looking to deploy standardised kit and they don't want to interfere with it once it is integrated into equipment. You don't want to produce vehicles or meters and have to go and customise them in particular markets. Standards-based technology, such as eUICC, and reprogrammable SIM cards are extremely important for those markets."

The GSMA has created an Embedded SIM Specification designed to be a single, de-facto standard mechanism for the remote provisioning and management of M2M connections, allowing the "over the air" provisioning of an initial operator subscription, and the subsequent change of subscription from one operator to another. The GSMA says more than 20 operators, two leading M2M Alliances and numerous equipment manufacturers have backed the Embedded SIM Specification.

Analysts say this technology will be particularly important for connecting assets that travel across international borders, as it will enable them to switch from one network to another. Experts expect companies in the automotive, fleet management, asset management, supply chain and logistics sectors to be the leading adopters of reprogrammable SIM solutions.

Conclusions

As explained in this paper, new cellular technologies are paving the way for a major expansion of the IoT. Over the next five years, the number of cellular IoT connections is set to grow rapidly. Ericsson forecasts there will be 1.5 billion cellular-connected IoT devices by 2022, up from about 400 million cellular IoT devices at the end of 2016. Similarly, Machina Research, which uses a different methodology, anticipates that cellular IoT connections will grow from 334 million at the end of 2015 to 2.2 billion by 2025, of which the majority will use variants of LTE.

Demand for LPWA connectivity will be one of the key engines driving this growth. Machina forecasts the industry will add 83 million LPWA connections in 2017, taking the total at the end of this year to 142 million. By 2025, Machina anticipates 2.97 billion connections will use LPWA technologies - 11% of all IoT connections. LPWA technology will be most widely applied in homes, with building automation, security, white goods and household information devices accounting for more than a billion connections by 2025, according to Machina. Other analysts are even more bullish about LPWA. Strategy Analytics, for example, predicts there will be 5 billion LPWA connections as early as 2022.

Conventional cellular technologies are also set to play a major role in the development of the IoT. Ovum anticipates there will be 212 million 2G and 212 million 4G IoT connections in 2021, while 3G will have 172 million.

As these forecasts highlight, no single connectivity solution can serve all IoT use cases. The connectivity requirements of rural farms, for example, are vastly different to those of an urban home automation system. However, industry experts believe the IoT will increasingly gravitate towards standards-based technologies. Leif Östling, CTO at Symsoft and key participant in the GSMA Connected Living project, which developed the Subscription Management for the Embedded SIM specifications, concluded 'Given the long life cycle of IoT devices, a key factor in reducing the overall cost of ownership of cellular IoT connectivity will be the ability to change the Operator on a SIM remotely. A common, open, standardised and secure architecture exists today and will pave the way for massive adoption of eSIM technology not only in IoT but in consumer communications over the next 5 years.'

Indeed cellular networks are now versatile enough to connect everything from dense clusters of sensors tracking local environmental conditions to high definition video cameras monitoring a home or manufacturing plant and in-vehicle systems navigating busy urban roads.

Although some enterprises will continue to employ application-specific connectivity, many will want to harness the economies of scale and interoperability associated with standards-based services. The recent standardisation of several LPWA technologies by 3GPP, together with the availability of reprogrammable SIM cards, looks set to usher in an exciting new era for the IoT.

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