Maximising the Next Generation of IoT Connectivity

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An assessment of the key challenges faced by enterprises seeking advanced connectivity technologies and how service provide choice can maximise these benefits.

Introduction

Connectivity has always been at the core of Internet of Things (IoT) solutions. Whether tapping a local ethernet connection for Programmable Logic Controller (PLC), monitoring or deploying gateways and backhauling data over a cellular network, connectivity starts the IoT solution journey.

Fortunately, the choices are increasing for connecting the machines and equipment that drive industrial and business processes. Over the last few years, wireless connectivity has seen the most advancement, evolving to offer more choices that are fit-for-purpose in the IoT and providing more flexibility to the IoT solution designer. These include several of the Low-Power Wide-Area (LPWA) technologies from both the 3rd Generation Partnership Project (3GPP) and proprietary versions. It also includes 5G, which offers options for enterprises to improve connectivity reliability, capacity, and latency all within a single network and technology stack. Even the tried and true Bluetooth and Wi-Fi technologies have evolved from being purely consumer-focused to enterprise-ready. The IoT market has evolved to a new stage of advanced connectivity combined with more network choice.

But enterprises need to think carefully about their choices. It is not just choosing the technology that best suits the needs of the application. It also includes understanding the services for managing that connectivity, as well as other services layered on top, such as device management and security services. Connectivity choice also needs to consider the device life cycle from commissioning and onboarding devices, as well as reverse logistics services with more and more devices having multiple uses and stakeholders.

This white paper identifies the top advanced connectivity options that will make up the majority of connections in the IoT moving forward. It assesses the key challenges faced by enterprises seeking advanced connectivity technologies and how service provider choice can maximise these benefits. It concludes with the benefits that advanced connectivity and provider choice bring to the enterprise sector.

Technologies providing advanced connectivity for building Smart Industrial Products

LPWA

LPWA technologies are a class of connectivity technologies that have been designed for serving the IoT market where low data rates and infrequent transmissions are common. This includes many traditional IoT segments of meters, vending, and tank monitoring. But this also includes the asset tracking market, such as pallet and parcel sharing, which is forecast to reach billions of connections.

There is no formal definition of LPWA according to data rates, but LPWA is generally considered to have data capacity similar to 2G and lower. For this discussion of advanced connectivity, three LPWA technologies are highlighted for their importance to IoT.

1) **Cat M/NB-IoT:** Cat M and Narrowband IoT (NB-IoT) are standards within 3GPP specifications operating on licensed spectrum. Cat M is the higher data rate technology providing peak rates of 1.4 Megabits per Second (Mbps). It is considered a better technology for monitoring and asset tracking applications that send more data either from sensor readings or from Global Navigation Satellite System (GNSS) data points with real-time tracking. NB-IoT's peak data rates are about 1/20 of Cat M peak rates. Cellular modules of this technology are about half the cost of Cat M modules and will maintain that price advantage for the foreseeable future. Devices with NB-IoT technology have a longer battery life than Cat M devices if the data transmissions are small packet sizes and infrequent.

   Deployed by mobile operators, these technologies offer lower power consumption for improved battery life through longer paging cycles for receiving network data, as well as longer device sleep cycles before transmitting data to the network. Both standards have a higher broadband version of M2 and NB2, which provide at least triple the data rates of M1 and NB1.

2) **Proprietary LPWA:** This class of LPWA is led by LoRa and Sigfox, but also includes a long list of other companies, such as Sensus, Microchip, Silicon Labs, Kerlink, etc. The latter group generally finds the most adoption in the metering segments. Both LoRa and Sigfox have low link budgets, enabling broad coverage and good in-building penetration compared to 2G and 3G technologies. LoRa is proprietary only because there is one firm, Semtech, that owns the Intellectual Property (IP), which it monetises through the sale of chipsets. The rest of the ecosystem uses LoRa technology to build end points and gateways. LoRa networks can be deployed to cover local areas or be built to cover large areas, such as a municipality or city. Sigfox is a network operator of its version of LPWA and is supported by an ecosystem of device vendors. It offers some of the lowest data rates and generally is considered to have some of the least expensive devices in the LPWA category. Proprietary LPWA technologies usually operate using unlicensed spectrum in the 2.4 Gigahertz (GHz) range.

3) **Cat 1bis:** Cat 1 technology is technically not considered an LPWA technology, as its peak throughput is 10Mbps. However, its capacity is far less than Cat 3, which has a downlink of 150Mbps. From a performance perspective, it has always had interest for applications that want more than LPWA throughputs, but do not need a Cat 3 pipe, including use cases in security, industrial monitoring, and as backhaul for IoT gateways. However, the pricing was never quite low enough when considering the performance trade-offs with 2G.

These drawbacks are about to change and was witnessed in 2019 when worldwide Cat 1 cellular module shipments jumped nearly 2X over 2018. The reason is that China module vendors began to offer Cat 1bis products as a replacement for 2G in China. Cat 1bis is the single antenna version of the Long Term Evolution (LTE) specification, making it less costly. Some module vendors were offering it for half the price of Cat 1 modules with two antennae. The significance of Cat 1bis is that the volumes it can drive will help bring down costs and promote adoption of both single and double antenna devices. In addition, Cat 1 devices can use the same battery-saving features as Cat M and NB-IoT, making it a price-optimised version for supporting higher-performance use cases not suitable for LPWA technologies.

5G

5G is raising the bar for connectivity choice because a single technology can enable connectivity for applications requiring low-power access, low latency or high bandwidth. As a relatively new specification, only the high bandwidth version of 5G, Enhanced Mobile Broadband (eMBB), is available today, offering peak data rates of 1 Gigabits per Second (Gbps). By 2023, 5G networks and devices will be available for low latency connections, Ultra-Reliable Low-Latency Communication (URLLC). Depending on the network type, latency targets are about 50 Milliseconds (ms) over public networks and 10ms when deployed in local area environments. The most recent 3GPP release specifies that the low power variant, Enhanced Machine Type Communication (eMTC), will use the Cat M and NB-IoT specifications enabled on a broader range of spectrum bands.

Private network deployments will become more common when devices and networks can support the low latency use cases with manufacturing environments being a top use case. In private network settings, the full power of 5G will be most obvious as applications with varied throughput and performance needs can all be carried on the same spectrum and delivered using the same network technology. 5G will also offer more options for network-based location services with specifications aiming for 3-metre accuracy outdoors and up to 0.2-metre accuracy indoors.

BT5/WI-FI 6

Bluetooth and Wi-Fi have both made significant advances in their specifications to drive more use in the IoT, particularly in industrial environments. Bluetooth 5's (BT5) improvements are reflected in Bluetooth 5.2, which was standardised in December 2019, increasing throughput to 2Mbps and extending its range to 1,000 metres. Location features have also been improved, as well as the addition of mesh networking. The value of these improvements is the flexibility for serving markets where coverage and throughput needs will vary, such as sensor environments where, in some cases, data capacity will be more important, while in other environments, range and massive connections will be more important.

Wi-Fi 6 has a marked improvement in capabilities that will drive more adoption into the industrial and product Original Equipment Manufacturer (OEM) domains. Wi-Fi 6 uses Orthogonal Frequency-Division Multiple Access (OFDMA) for signal modulation, which will greatly reduce interference issues and significantly improve throughput and range. But even more important is that Wi-Fi 6 can operate in the 6GHz band, which has seven available 160 Megahertz (MHz) channels. This is called Wi-Fi 6E and was introduced because more countries are opening the 6GHz spectrum band for Wi-Fi use.

Adding another band for Wi-Fi is expected to help reduce crowding in the 2.4GHz and 5GHz bands, which in turn, when combined with Wi-Fi 6 radios enable higher throughputs and range in the lower Wi-Fi bands. Some trials of Wi-Fi 6 in manufacturing settings show 700Mbps in the 5GHz band over an 80MHz channel. It is expected that over a 160MHz channel, throughputs will increase to greater than 2Gbps!

Network choice: Private versus Public

Traditionally, networks for IoT connectivity either were available from public cellular networks or private wireless networks based on Wi-Fi or 802.15.4 mesh technologies. However, more availability of spectrum and private network operators, as well as a well-developed LoRa ecosystem, are providing new options for deploying enterprise private networks using wide area technologies.

Spectrum access is coming from private spectrum owners that have purchased spectrum at auctions and either leased it to an operator of private networks or combined it with their own network equipment and services. Another source of spectrum has become available in the United States called the Citizens Broadband Radio Service (CBRS). This spectrum spans the 3.5-3.65GHz band and is available for free for general access, or for a fee for priority access for a fixed time period. This spectrum is leased regionally, giving enterprises options for its use.

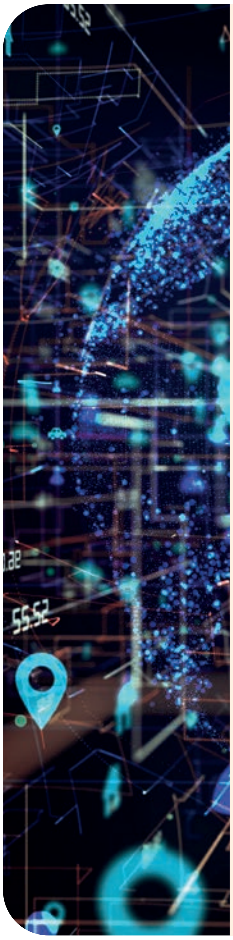
Private cellular network operators come in two flavours. The first provide private 4G networks and eventually will be providing 5G private networks. The second are proprietary LPWA network operators typically serving the utilities segment.

LoRa is giving enterprise even more choice for private network wide area access. Because LoRa operates on unlicenced spectrum, any enterprise can purchase gateways to build their own network.

SIM 2.0: eSIM/iSIM

Subscriber Identity Module (SIM) technology provides the software and infrastructure that allows devices to connect to cellular networks based on operator credentials and user preferences. Traditionally, SIM technology has been delivered using a physical card inserted in a device and owned by a single operator. Two technologies are changing these boundaries. The first is Embedded SIM (eSIM), which allows changing network access profiles based on customer preferences. With this technology, the operator that originally was the primary network operator can be switched to another - pending contractual obligations - at any point in the connected device life cycle.

The second is Integrated SIM (iSIM) which integrates SIM functionality into the device's chip architecture, thereby eliminating the need for a physical SIM. The technology will provide efficiencies in the logistics of device deployments and returns because the physical SIM is not part of the provisioning process. iSIM will also reduce the size and Bill of Materials (BOM) for connected devices and lower power consumption as well as enhance security.



Case Study

The utilities market has seen a marked increase in electricity usage, as more products use electricity, not to mention the increased use of communications technologies, such as smartphones, PCs, gaming, etc. Looking ahead, utilities know their grids will be strained as these trends continue, but also from greater use of renewables and electric vehicles.

The Netherlands has been particularly aggressive in upgrading its electric grid to address the greater use of smart meters and connected sensors. One of this country's top utility providers was seeking a cost-effective and long-term solution for connecting over cellular networks its planned deployments of meters and sensors. The challenge was how to limit the manual swapping of SIM cards as network operators transition from 2G and 3G technologies to 4G and 5G technologies. In addition, the utility needed the ability to manage its connectivity costs to avoid raising rates on their electricity customers, as well as to access highly-reliable networks to meet regulatory requirements.

The solution for these challenges was using a full-service MVNO (Mobile Virtual Network Operator) that supported eSIM technology. The MVNO provided the utility with a customised Multiple International Mobile Subscriber Identity (multi-IMSI) ruggedised SIM for deployment in more than 1.7 million new smart metre and smart grid sensor installations. MVNO services also included a carrier-independent interface supported by eSIM technology that allowed managing connections without having to physically replace SIMs as operators sunset 2G networks and transition to LPWA networks. Another benefit provided by the MVNO was eSIM management from the cloud. This capability greatly simplifies subscription management operations and changing MNOs if necessary. Overall, the utility received a future-proof solution for optimising connection reliability and controlling costs, including avoiding roaming fees.

Summary

Advanced connectivity technologies in the wireless domain are offering enterprises new ways to architect IoT solutions to better serve customers and build new products and services. LPWA technologies are enabling a long tail of monitoring and tracking solutions by lowering network and services costs. 5G is changing the value of networks for IoT solution enablement, allowing applications of various requirements to leverage a single network and technology stack. Private network offerings are becoming more available through greater spectrum access and technology advances both in wide area technologies and in the Bluetooth and Wi-Fi short-range wireless technologies.

Service providers will play a critical role in supporting the development of IoT solutions that can benefit from advanced connectivity technologies. Both MNOs and MVNOs can enable access to networks and the devices for the latest wireless technologies. They can also provide services necessary to cost-effectively manage and scale IoT solutions in important areas of connectivity and device management, as well as security.

An important technology that will ensure enterprises have access to the most reliable networks is eSIM. Unfortunately, MNOs (Mobile Network Operator) have not made this technology as accessible for IoT solutions, as they are now doing for smartphone services. This situation underscores the importance of understanding the service providers that will support it and when it will be available.

Service providers are more important now than ever before, as the networks and devices of advanced connectivity technologies grow in accessibility and capabilities. By choosing the right service provider, enterprises can enjoy the full capabilities of advanced connectivity through solution designs that can tap networks as needed; leverage eSIM where appropriate; and be supported by core operational services of connectivity and device management, along with the right security services.

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