Scaling the Internet of Things with cellular technology

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Wi-Fi and Bluetooth are the de-facto standards for consumer networking but they do not translate equally well to the IoT. Fortunately there is an already existing viable solution to the IoT networking problem, and we use it every day - the mobile communication network.

XBee application example: embedded modem provides a simple way to integrate cellular connectivity into devices (Source: Digi).

■ The Internet of Things (IoT) has gone, almost overnight, from buzzword to major technology trend. IoT devices are showing up these days in everything from consumer electronics, like wearables and smart home sensors, to industrial automation, healthcare, warehousing/logistics and much more besides. But as the IoT develops and matures it is also experiencing what can only be described as fairly severe growing pains. Many of the technologies and protocols that made sense for a world of centralised desktop, laptop and mobile computing, are not equally valid for the decentralised network of ultra-low power devices that IoT technology is creating.

Wi-Fi and Bluetooth, the de-facto standards for consumer networking, do not translate very well to the IoT. Wi-Fi has decent range, but heavy power consumption. Bluetooth has low power consumption, but poor range. Both solutions do not scale well because they require routers. In fact however there is a viable solution to the IoT networking problem that already exists, and we use it every day - the mobile communication network.

The term IoT encompasses a wide variety of 'things', from smart thermostats and white goods on the consumer side right through to pressure sensors, water meters and smart irrigation systems on the industrial side. But while the applications and the markets they serve can be extremely varied, IoT devices share a few key characteristics.

Many IoT devices are battery powered. For mobile applications, such as wearables or asset trackers, battery power is the only solution. However, even IoT devices which do not spend time moving around, such as smart water meters, pressure sensors for a pipeline, or a thermostat in an industrial automation process, may also be battery powered for convenience's sake, as there might be no readily available mains power nearby.

IoT devices are often located in unexpected, and often inconvenient places. Whereas most consumer and enterprise electronics sit on our desks, in our homes, or our offices and can rely on easy access to electricity, Wi-Fi and cellular reception, and are not difficult to reach for maintenance purposes, the same is not true for IoT. A smart parking meter might be situated in an underground garage with poor cellular reception and no power source nearby. A pressure sensor may be sited in a remote pipeline in the desert. An asset tracker may be stuffed into the bottom of a shipping container and inaccessible for months at a time. Finally, IoT devices are being deployed in greater numbers than almost any other class of electronic device in history. Rather than a single computer per person, IoT applications often are most effective when deployed in large volumes. Whether as parking meters, beacons, irrigation sensors, or asset trackers, IoT deployments often number in the dozens, hundreds or even thousands of discrete devices.

These characteristics - battery power, mobile or out-of-the-way installations and large-scale deployments - present a unique and seemingly contradictory set of challenges for IoT connectivity. The communication protocol used needs to be wireless and have good range/penetration, yet also have minimal power consumption to allow for long battery life and infrequent maintenance.

Wi-Fi, the traditional wireless protocol for consumer and enterprise networks, has decent range and penetration, but is intrinsically power hungry, making it unsuitable for battery-driven devices. Bluetooth, while low power, has limited range in real-world environments, impacting on its effectiveness for all but the smallest scale IoT deployments. Another solution is needed and cellular seems to be the best route to go down. In some ways, mobile phones share many characteristics with IoT devices. These battery powered, mobile devices are connected to the Internet, filled with loads of sensors and interface our physical world with the cloud. So it makes sense that an ideal IoT protocol may have certain cellular attributes.

The most salient benefit of cellular networking is that it presents an incredibly easy to setup and easy to use communications protocol for the end user. As already mentioned, Wi-Fi networks require a router to connect to the Internet and client devices, then need to subsequently be programmed to connect to the Wi-Fi network. Bluetooth networks require similar steps.

Cellular networks, on the other hand, require the end user to simply install a SIM card in their device, which then configures itself and connects to the available network automatically. If the device is moved to a different location, as long as there is a compatible network, it will hand off and automatically. There is no provisioning, no router setup, no passwords to set and very few connectivity issues for end-users to debug. It simply works.

For IoT applications, this kind of easy-to-use networking is game-changing. Instead of having to hire networking specialists to plan out how many routers are needed to support a certain number of devices, configure them and then provision client devices, the plug-and-play nature of cellular networking allows end users to add IoT connectivity without needing a networking department.

Cellular connectivity is also massively scalable. There is no need to buy and configure additional routers as more devices are added to a network. As long as there is network coverage, scaling up just means adding more devices.

For all its inherent benefits, the cellular connectivity we are familiar with in our smartphones is not ideally suited to most IoT applications. As anyone who has bought a power bank for their smartphone knows, LTE connectivity can drain batteries quickly.

To address these concerns, 3GPP, the standards body in charge of maintaining and advancing LTE, has introduced LTE Cat 1 and LTE-M. These new categories of LTE curb power consumption by reducing bandwidth and protocol complexity. In addition, they improve signal penetration and lower module cost, all while preserving many of the easy-to-use characteristics that make cellular connectivity well suited for the IoT market.

LTE Cat 1: This is a simplified cellular protocol which decreases peak speeds to 10Mbps for downlinks and 5Mbps for uplinks. Power consumption is thereby kept in check - with products like the XBee LTE Cat 1 module from Digi drawing just 10µA while in deep sleep, and a few hundred mA while active (depending on the exact operating conditions). The reduced complexity of the protocol also means lower cost radios. LTE Cat 1 provides enough bandwidth to support video or voice data, but at lower power consumption and hardware costs than higher category levels of LTE. Relevant applications include digital signage, ATMs, video surveillance, and vehicle telematics.

LTE-M: Also known as LTE Cat M1, this is an even lower bandwidth protocol which goes further to lower power consumption, protocol complexity and cost. Operating at a channel bandwidth of 1.4MHz, peak download and upload rates are 1Mbps for full duplex or 375kbps for half. These lower speeds, reduced protocol complexity and additional power savings modes help LTE-M achieve lower energy consumption than LTE Cat 1 - the SARA-R4 from u-blox, for example, only needing 100mA to deliver LTE communication. This will enable battery life of up to 10 years to be achieved.

Besides enhanced battery life, LTE-M also provides greater coverage, with up to 21dB of gain relative to legacy LTE devices. This means improved range as well as better indoor penetration for applications in buildings, underground, or in other locations where traditional cellular reception becomes weak. Relevant applications for LTE-M include asset trackers, wearables, sensors, utility meters and monitoring systems. Based on the existing LTE protocol, LTE Cat 1 and LTE-M have the benefit of operating in licensed spectrum, as well as being easy to deploy for network providers. LTE Cat 1 and LTE-M networks are already available across most of North America and are increasingly being deployed here in Europe.

As the IoT grows, it needs to have the right infrastructure to allow it to reach its full potential. While traditional wireless protocols like Wi-Fi and Bluetooth are already familiar to us, they do not work as well at the scale that IoT implementations will expect. The latest versions of the LTE standard from the 3GPP group have introduced new categories of this cellular standard to specifically address IoT use cases. By adjusting bandwidth to match IoT requirements, these LTE categories can achieve very low power consumption and strong signal penetration. Battery life in the order of years is possible, plus devices will have the benefit of long range connectivity and the intrinsic mobility of cellular communication. But most importantly, LTE-based IoT connectivity offers incredible ease of setup and scalability. With no need for routers or network configuration, it will mean that IoT devices are considerably more straightforward to deploy. ■