Low Power Wide Area Networks: Making IoT Connectivity Ubiquitous and Affordable

WHITE PAPER

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IN THIS PAPER:

Several new LPWA connectivity technologies, cellular and non-cellular, licensed and unlicensed, are trying to win the hearts, minds, and pocketbooks of companies worldwide. Overall, these connectivity strategies will afford a diverse range of business sectors to seek out operational efficiencies and competitive advantages through collecting, storing, and analyzing business-critical data at levels of granularity previously unseen.

OVER THE NEXT DECADE, THE NUMBER OF INTERNET OF THINGS (IoT) DEVICES UNDER CONTROL WILL INCREASE EXPONENTIALLY, INTO THE TENS OF BILLIONS OF UNITS.

This growth will be spurred by new technologies for fixed consumer or industrial IoT uses. Though not the only choice, cellular technology offers the best overall solution for low power wide area connectivity applications, even though it does have some drawbacks.

The cost of cellular deployment, initially developed for high speed, high data volumes, was considered too expensive for widespread use due to excessive power consumption and complex protocols that lower battery life. It has taken some time for these technologies to be simplified or striped down for widespread, low-power IoT usage. A static solar sensor doesn't need the same capabilities as a mobile smart iPhone.

But challenging this concept are several new low-power technologies, cellular and non-cellular, licensed and unlicensed, that are trying to win the hearts, minds, and pocketbooks of companies worldwide. Overall, these connectivity strategies will afford a diverse range of business sectors to seek out operational efficiencies and competitive advantages through collecting, storing, and analyzing business-critical data at levels of granularity previously unseen.

The purpose of this paper is to help provide a high-level overview of Low Power Wide Area (LPWA) options and their use cases. We will try to sort out some of the technologies, how they work, and the benefits and drawbacks of each.

Low Power Wide Area Networks

The advent of low power wide area networks, both licensed and unlicensed, provide greater choice for the consumer looking for a business-specific IoT solution. It is predicted that by 2019, 30% of connected devices will be on LPWA networks. This shift to LPWA is promising to bring in many more industries under the IoT umbrella.

For many industrial functions that require sensors or devices obtaining and sending only small amounts of data, LPWA offers the best low-cost option. Additional factors are weighing heavy in the promotion of LPWA networks,

including less expensive devices that are reaching the market; low throughput for long- or short-distance transmission; data transfers that support small blocks of data intermittingly sent; and the ability for extended coverage, both indoors and underground. What this all means is extended reach, a much lower cost of entry, and a much lower total cost of ownership.

For businesses, however, one size, or sometimes, one technology or one cost structure, doesn't fit all. So the growth of multiple LPWA IoT solutions is a good thing. And yet, a problem for consumers is that no global standards have, so far, been adopted, leading to some confusion. Imagine a ten-year project with no rules or standards — yet.

How They Work

LPWA networks are designed for IoT and machine-to-machine (M2M) applications that have low data transmission rates, need long battery lives, can provide low-cost services, sometimes operate in remote or hard to reach locations (underground or geographically dispersed), and be easy to deploy across basically every business sector, including manufacturing, automotive, energy, utilities, agriculture, healthcare, wearables (for humans or animals), or transport.

Present-day cellular mobile technologies are designed to work on more costly consumer-oriented networks where the premium is placed on fast connections that can transport large amounts of data, whereas low-cost LPWA networks can support devices requiring low mobility, low power consumption, long-range abilities, and heightened security. One of the benefits of LPWA is that data transfer rates, as well as power consumption, are very low. Device connectivity in this case requires less bandwidth than standard cellular, which means that LPWA networks can operate with far greater power efficiency. Additionally, LPWA networks can support more devices, at a lower cost, over a larger coverage area than consumer mobile technologies.

Initially, IoT / M2M services relied on licensed cellular, wireline, and satellite networks for wide area connectivity requirements. These, however, were not a good fit for widespread IoT usage due to excessive power consumption and complex protocols that lowered battery life. Recently, to help alleviate these issues, several (more) LPWA alternatives have appeared on the market. These networks, generally, are more business friendly, with low data rates, extended battery life, and extended coverage.

TECHNOLOGIES, PROTOCOLS, AND PLAYERS

There literally are dozens of participants in the burgeoning LPWA sector. Basically, they can be broken into two overarching categories: standardized and proprietary. The differences between standardized (licensed) and proprietary (unlicensed) technologies are fairly basic. Standardized IoT connectivity runs in a managed spectrum, with existing cellular standards. Unlicensed, or proprietary technologies, run in an unmanaged spectrum. They can get to market faster, but will the rest of the world buy into their way of doing business? Below, we will define some of the technologies at play in the IoT sector, along with some primary advocates of each protocol.

Random Phase Multiple Access (RPMA)

RPMA is a low-power, wide-area channel access method used for IoT / M2M communications. RPMA employs direct sequence spread spectrum (DSSS) modulation to access the best signal for both the network and its devices. It is IEEE 802.15.4k compliant; uses a globally available, cost-free unlicensed spectrum; requires low power support, thereby extending battery life; and provides high network capacity. Additional selling points of RPMA include extended coverage with high capacity for multi-million-node networks. RPMA uses standards-approved algorithms for both device and messaging security.

In the RPMA sector, companies such as Ingenu (formerly OnRamp Wireless) are using RPMA protocols designed specifically for wireless machine-to-machine communications. The company's commercial deployments are in the unlicensed 2400MHz range. This service initially was deployed for private networks but now is moving to public coverage and has deployed in the U.S. in early 2017.

RPMA has excellent noise immunity for range/throughput, with a high link budget (less interference). Data is highly secure (AES 128 bit) and the product has seen some success in utility markets with private networks. On the downside, this technology is playing catch-up in the U.S., has radio costs that, generally, are higher than other protocols, and, as a proprietary technology, deployment and support are limited.

Ultra Narrow Band (UNB)

UNB technology transmits over a low bandwidth, in a very narrow license-exempt radio spectrum channel (less than 1KHz) to achieve long-distance data links between a transmitter and a receiver. UNB is fully bi-directional, meets the long-range, low-cost needs of business connectivity, does not rely on other networks, and already is in use in multiple smart applications (lighting, meters, etc.) UNB is gaining success by combining long-range connectivity with an extended battery life (up to a decade).

As a major proponent of UNB, Sigfox provides a software-based LPWA communications solution, where all the network and computing data is managed in the cloud. Working in the unlicensed spectrum, its UNB proprietary solution uses a simple protocol with slow data speed. France and European Union focused, Sigfox just started to deploy in the U.S. in early 2017 and has partnered with a number of firms for advancing UNB technologies, including Texas Instruments, Silicon Labs, and ON Semiconductor.

UNB provides end users with low device costs and low energy consumption. It employs a simple API to integrate radio modules, and this protocol has several chip suppliers. As stated, though, this technology is not fully engaged in the U.S. Its message size of 12 bytes (by design) limits its applications, and it has shown some reliability issues.

Feature comparison: Licensed (LTE-M, NB-IoT) vs Unlicensed LPWA

Feature	LTE-M	Unlicensed LPWA
Coverage	✓	✗
Carrier-Grade Security	✓	✗
Standards Based	✓	✗
Dedicated Spectrum	✓	✗
Long Battery Life	✓	✓
Low-Cost Modules	✓	✓

LoRaWAN

The LPWA network specification LoRaWAN focuses on secure bi-directional communication, mobility, and localization services and is a protocol supported by the LoRa Alliance. It is intended for wireless, battery operated devices. This open standard, developed by Semtech, and supported by IBM, SoftBank, and several other carriers, operates in the unlicensed spectrum, using narrow bandwidth in the 868-915 MHz ISM, up to 500 kHz bandwidths ranges.

LoRaWAN uses an adaptive data rate (along with radio frequency output) for each device so as to extend battery life and increase overall network capacity.

LoRaWAN data rates range from 0.3 kbps to 50 kbps. This protocol uses a spread spectrum technology, along with virtual channels, to separate cross-channel interference. Additionally, LoRaWAN provides encrypted data for higher security levels, provides gateways and radios from multiple suppliers, and has no device charges or subscription fees. However, its message limit, defined by the user, can be no more than five seconds in length to meet compliance requirements. Its radio costs still are high and, as of the publication of this paper, U.S. coverage is limited to test networks.

The LoRa Alliance is lobbying hard for its global protocol, LoRaWAN, in LPWA networks. IBM is using LoRa's wireless sensor network with its Long Range Signaling and Control (LSRC) software, as well as its IoT cloud-hosted service, to create large-scale M2M deployments. Its open standard is supported by several organizations and businesses, and IBM's global influence could be the thumb on the scale, providing the business recognition, along with a low price point, for this solution's continued growth. But a lack of an American public network will be a challenge.

THE LICENSED GROUP

IoT industry standards, as set by the 3rd Generation Partnership Project (3GPP)*, recently saw more protocols join this LPWA sector. These include LTE-M (also known as LTE-CatM1 or LTE-MTC) and Narrowband IoT (NB-IoT). Each wants the crown of global LPWA standards coming their way. Each has an argument for dominance. On the downside, they have yet to be deployed (but coming soon).

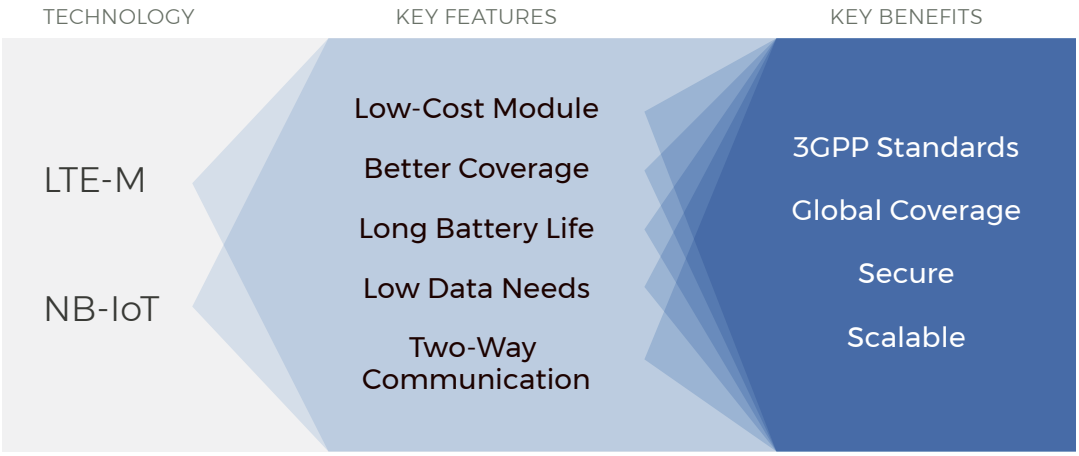
LTE-M

LTE-M is a bi-directional, standards-based protocol within a dedicated spectrum. It provides carrier-grade security, long battery life, low data needs, and low cost modules. This protocol has many active followers, including, Altair, Ericsson, Qualcomm Technologies, WNC, Sierra Wireless, Telit and Xirgo, as well as a host of U.S. carriers.

One of the strengths of LTE-M is that it does not need a new infrastructure as it can piggyback on existing LTE networks. What that means is that a carrier can update software on its network, get LTE-M functional, and not spend any additional funds on infrastructure or support services.

Additionally, using an extended discontinuous repletion cycle (eDRX), the data collection devices can transmit data on a non-continuous schedule, as set by the end user. The device, when not sending data is not off, but just asleep. When data is scheduled to be sent, the device does not need to be re-activated to join the network, it just wakes up. Having intermittent data send-schedules, which are not active 24x7, can save battery life, leading to significant cost savings. LTE-M, however, is a much simpler product, only understanding and digitizing 1.4 MHz of the channel instead of 20 MHz. Data rates for LTE-M are somewhat higher than either NB-LTE-M or NB-IoT, but it can transmit larger blocks of data. LTE-M has an expected American roll-out in the second half of 2017, with Mexico following by year's end.

*The 3rd Generation Partnership Project (3GPP) is an association of seven telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), providing standardization oversight for cellular telecommunications network technologies.



Mobile IoT: 3GPP standard technology for LPWA

NB-IoT

NB-IoT is the newest entry to the IoT scene. With its standards-based LPWA IoT technology, NB-IoT has a global reach with better bi-directional data than any of its unlicensed counterparts. And, unlike LTE-M, NB-IoT is based on Direct Sequence Spread Spectrum (DSSS) modulation, which 'widens' the signal so as to reduce interference. It also might make it a bit harder to go national (since it can't yet hook into the LTE network).

NB-IoT has several large organizations, including Huawei, Ericsson, Qualcomm, and Vodafone, actively involved with this standard. Additionally, NB-IoT is supported by all major mobile equipment manufacturers and can work with 2G, 3G, and 4G mobile networks, so it enjoys the heightened security of mobile networks, including user ID, authentication, data integrity, and more.

The NB-IoT LPWA solution is optimized for applications that need to communicate small amounts of data over long periods of time. Because of its point-to-point topology, NB-IoT results in lower latency with a higher transmit power limit (200 kHz bandwidth), which improves range and reliability, even underground or inside buildings. And since it operates in a licensed spectrum, it is secure with highly reliable data transmission, assuring a high quality of service.

NB-IoT devices and hardware are at the lower end of the cost spectrum and improved efficiency helps batteries last more than a decade, allowing for long-term projects. With its simpler underlying technology, costs for NB-IoT modules will continue to decrease as demand increases. The technology roll-out, with a commercial module and network, is due in late 2018. The present expectations are that AT&T will be involved in the national deployment.

COST AND COVERAGE WILL DECIDE WINNERS AND LOSERS

At Aeris, we believe that the future will see the expansion of NB-IoT over the other technologies in the field. One of the reasons will be cost. Another will be coverage. Like LTE-M, network upgrades will enable NB-IoT growth through already existing towers, making it an IoT force to be reckoned with. And while many of the above mentioned technologies might be highly applicable for many IoT deployments, tower distribution, or lack thereof in the U.S., will limit coverage and growth. NB-IoT, with fewer such restrictions, will be the big player in the expanding LWPA sandbox.

The Aeris IoT Services platform is capable of supporting any of the protocols listed in this paper. We've done it before with all the then 'new' technologies. The bottom line for customer choice will come down to cost and coverage. Proprietary solutions will continue to grow for now, but their limitations are an impediment to long-term growth.

Until standards emerge, many players, both licensed and not, will compete in the enormous IoT marketplace. The issue for companies will be to decide whether to be locked into a low-cost proprietary system or to go with an IoT service provider linked into multiple carriers, thus providing seamless reliable, low-cost coverage.

ABOUT AERIS:

Aeris is a technology partner with a proven history of helping companies unlock value through IoT. For more than a decade, we've powered critical projects for some of the most demanding customers of IoT services today. We strive to fundamentally improve their businesses by dramatically reducing costs, accelerating time-to-market, and enabling new revenue streams. Built from the ground up for IoT and road tested at scale, Aeris IoT Services are based on the broadest technology stack in the industry, spanning connectivity up to vertical solutions. As veterans of the industry, we know that implementing an IoT solution can be complex, and we pride ourselves on making it simpler.

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