XONA PARTNERS

Mobile and Wide-Area IoT: LPWA and LTE connectivity

Technical and Economic Analysis: Matching each application with the best standards

Abstract

Low-power wide-area (LPWA) technologies promise to open new market opportunities by providing power-optimized IoT connectivity instead of data-optimized connectivity that's the hallmark of existing mobile wireless protocols or short-range technologies. Consequently, LPWA received much attention in recent months from the investor community, and with it important questions have been raised on which wireless technology and ecosystem is best positioned to win in this market.

This report takes a comprehensive approach of investigating the spectrum regulatory framework, the wireless protocols, the ecosystems and business models and the IoT applications to develop a complete strategic assessment of the market. We developed techno-economic models for LPWA and LTE-based technologies to couple performance metrics such as coverage and capacity with the Total Cost of Ownership for SigFox, LoRa, Weightless, RPMA, and other LPWA technologies in addition to emerging LTE-based technologies such as Cat-m1 and NB-IoT. Additionally, we show how these technologies and incumbent short-range wireless solutions such as ZigBee, ISA100.11a and WirelessHART match up with more than 80 different IoT applications.

January 2016

Frank Rayal

Published in collaboration with Mobile Experts LLC

Table of Contents

List of Figures

List of Tables

Executive Summary

The low-power wide-area (LPWA) market is in a hype cycle that is closely tracking the evolution of IoT. Hundreds of startups, aside from established companies, expect LPWA to create a new big market. Our research of LPWA markets and technologies explores the potential for LPWA to have a disruptive impact in IoT connectivity. We accomplish this by taking a systematic, layered approach:

First, we explored LPWA and 3GPP cellular technologies in deep technical detail, along with other formats that we call short-range wide-area (SRWA) technologies that are extensively used in both industrial and commercial applications. Our analysis is conducted within the framework of spectrum regulations that immensely impact performance. The LPWA technologies we cover include: LoRa, SigFox, RPMA, Weightless (P, N, and W), Qowisio, N-Wave, Telensa, and DART.

Second, we derived key performance metrics and estimated the CAPEX and OPEX required for an effective network, to benchmark the economic feasibility of wide-area technologies. We additionally analyzed the business models of LPWA proponents which will be critical to understand future market evolution.

Third, we mapped the requirements of 86 IoT applications to performance characteristics of the three categories of IoT connectivity technologies above to pinpoint the market segments where each category can take hold.

With this framework, we find that LPWA technologies are primarily targeting applications that SRWA networks address today. In fact, the competitive nature between LPWA and SRWA is the most underestimated and least understood in the market. The importance of this point cannot be over-stressed as it will set the tone for future market development. While LPWA currently compete on secondary-basis with 3GPP technologies, the competitive positioning between these two categories has been fiercest as they both expect to tap in the future into the same share of the IoT connectivity market. This competition is largely responsible for much activities, interest, and even hype, in this market.

In light of the above market qualification, some of our conclusions include:

- 3GPP technologies are 2-4 years away from providing a competitive solution with similar performance characteristics to LPWA technologies. The lynchpin of 3GPP strategy is the development of LTE Cat-m1 and NB-IoT technologies, both defined in 3GPP Release 13, with anticipated commercial availability in early and late 2018, respectively.
- This time-gap provides the LPWA ecosystem an opportunity to establish market presence, the success of which will be the result of a complex interplay of different

factors that include foremost the ability of LPWA proponents to penetrate a fragmented market landscape with long-sales cycle.

- The LPWA ecosystem has the advantage of diversity and vitality which include startups as well as major technology players in adjacent markets that see LPWA as an opportunity to chip away at the traditional service provider market. For this reason, mobile network operators have been making investments in LPWA technologies which are essentially insurance policies on future market uptake in light of the late arrival of a standardized technology which they consider critical requirement.
- LPWA are set to play a major role in private networks that address specific application requirements. Their success in public networks is gated to a great extent on the service value proposition and return on investment, the regulatory framework, and the competitive landscape.
- Licensed-exempt spectrum regulations strongly impact network performance and the investment required to build LPWA networks, and consequently impact the financial viability of LPWA networks. The regulatory framework in the United States is more advantageous than it is Europe where between 2x – 8x more in capital expenditure is required to achieve a similar level of service as in the US, depending on technology. The regulatory framework in many other major markets such as Japan, Korea, China, and others is still evolving.
- ISM and SRD-band spectrum regulations are defined according to the type of the air interface. The capacity of LPWAN networks based on DSSS/CSS and UNB technologies is limited by duty cycle requirements and the range is limited by transmitted RF power limits whereby:
    - LoRa cell range performance exceeds that of SigFox in both Europe and the US, but its capacity falls below SigFox which supports a larger number of devices per base station. This increases operational efficiency, especially in loaded networks characteristic of mature markets and provides SigFox with an edge in public networks. On the other hand, LoRa offers wider technology options than SigFox which makes it amenable for customization and for use in private networks.
    - RPMA cell range is competitive with LoRa in the US and exceeds LoRa in Europe for outdoor deployments. RPMA offers the highest capacity among LPWA technologies. However, its cell range performance is limited for indoor applications.
    - Weightless-P offers a competitive mix of range, capacity, and a host of other features not available in LoRa or SigFox. It differentiates by being the only LPWA technology that is based on an open standard. Weightless-P offers the highest competitive challenge to 3GPP technologies from a technical perspective. Its success will be based on the ability of the Weightless SIG to develop and grow an ecosystem, especially larger companies in market segments where LPWA has a competitive advantage.
- Mobile network operators (MNOs) are likely to base their business model around 3GPP technologies over the long-term, especially LTE Cat-m1 devices as defined in 3GPP Release 13. The NB-IoT standard provides the ultimate in range and

performance, but it is the last of the reviewed standards to become commercially available. For some service providers, existing radios can be used with a software upgrade, so the business case for NB-IoT vs. LPWA will depend on the pricing set by the network OEM for the software upgrade. Many network operators will need to deploy IoT in new bands, which will require a hardware upgrade.

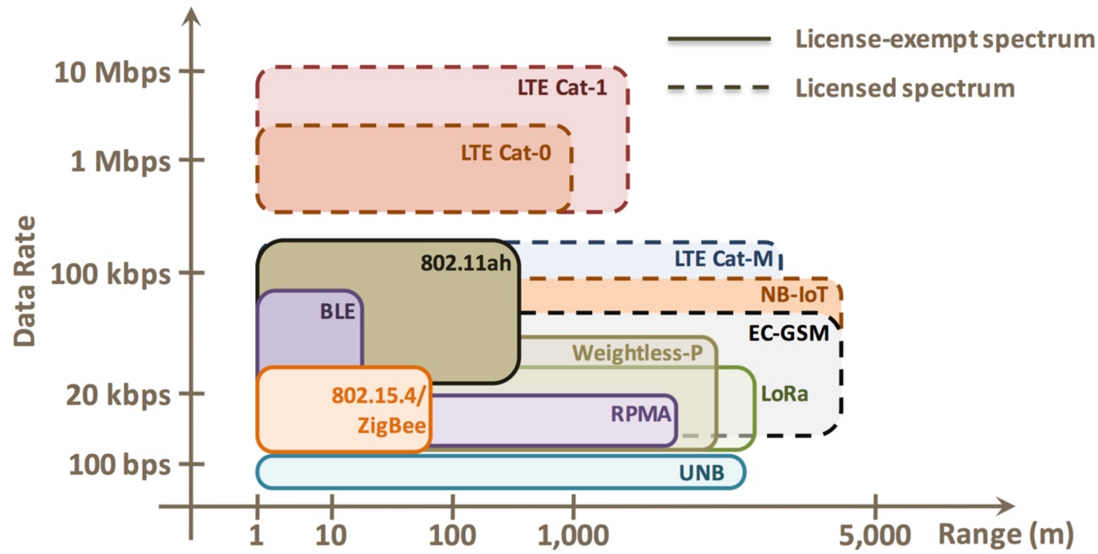

Figure 1 Range vs. data rate for IoT connectivity technologies.

Table 1 Relative ranking of LPWA technologies.

Rank	Indoor Cell Range Performance		Capacity
	US	Europe	
1	LoRa	LoRa	RPMA
2	SigFox	Weightless-P	SigFox
3	Weightless-P	SigFox	LoRa
4	RPMA	RPMA	

Note: No information is available yet on Weightless-P capacity; standard was released at the same time as this report.

- MNOs have a major strategic advantage in licensed spectrum holdings, physical infrastructure assets, and operation and maintenance processes efficiency over IoT service provider entrants. IoT service providers must leverage their agility to tailor a nimble go-to-market strategy that addresses a fragmented market with differing requirements where custom services will play an important role in business success (i.e. no "one-size fits all" in IoT).
- LPWA is well suited to target private networks with optimized performance for specific applications. However, the success of LPWA in public networks is less certain and will play out over a longer term than it would in private networks. We foresee the key factors impacting the success of LPWA in public networks as follows:
    - The requirement for open standards that assure multi-sourcing in all stages of the value chain

    - Long-term assurance of the business model, as timeframe for IoT connectivity stretches into years unlike broadband subscriber services where users can switch service providers at any time. The engagement of large companies plays a stabilizing role which LPWA proponents, many of whom are small companies, need.
    - Licensed-exempt spectrum which raises infrastructure demands on the service provider to assure reliability in addition to imposing restrictions on scalability.
- Wireless IoT connectivity is a commodity. Therefore, scalability to support high volumes of connected devices is critical for capital efficiency. LPWA networks are not as capital intensive as broadband mobile networks which have a higher operational costs as a percentage of total expenses. Technologies such as NFV and SDN will play a key role in enabling cost effective scalability by leveraging data center economics for the IoT connectivity core network to further lower operational costs. From a revenue perspective, service providers need to move higher in the value chain to provide data management and analytics services in order to improve the return on investment. This is an area that MNOs have been slow to develop, but whose value will become more important in IoT connectivity networks. The importance of data management is amplified in IoT networks.
- LPWA protocols have relatively low-complexity waveforms. 3GPP technologies use more complex waveforms and require higher levels of integration in semiconductors to compensate. LPWA devices use commodity-priced micro-controllers while 3GPP technologies rely on SoCs that require high initial investment. SRWA technologies leverage existing device markets to achieve economies of scale. Overall, LPWA technologies have the potential to achieve a sub-$5 device cost target more quickly than LTE. This distinction will be key in the short term, as volumes will be low in the early stages of the IoT market.
- The prime applications for LPWA networks include agriculture, smart city, transport and environmental monitoring. Applications where LPWA should have the lowest adoption rate include smart health and smart buildings. LPWA should have mixed adoption in smart living, smart manufacturing, smart industry and smart energy segments where it competes against other technologies.

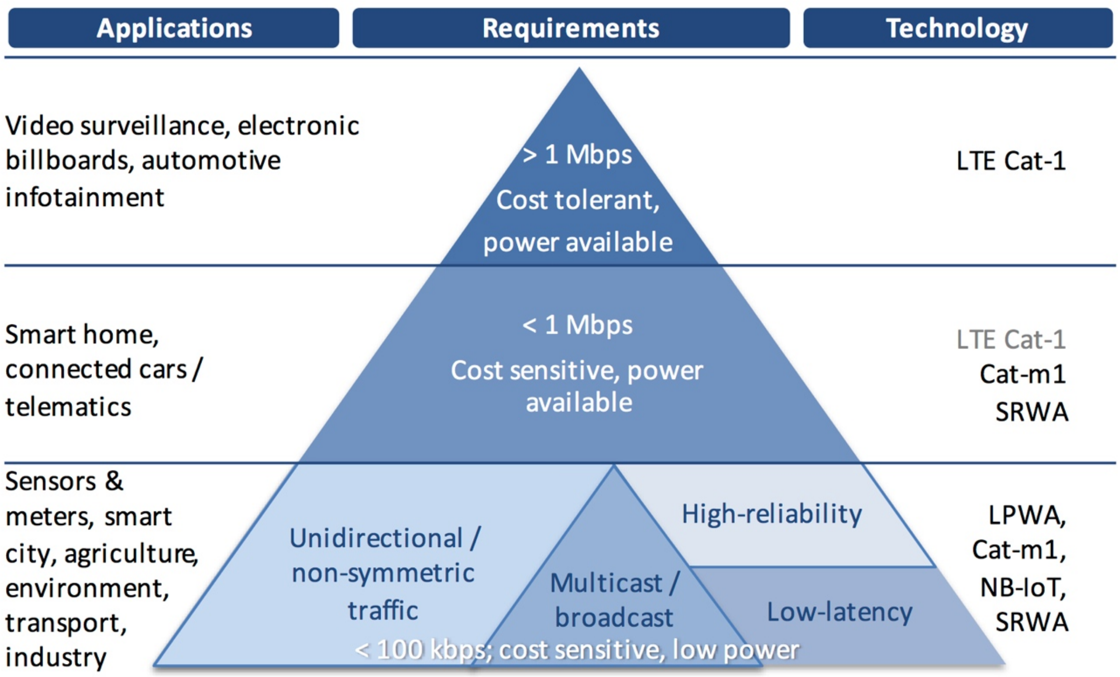

Figure 2 IoT connectivity market structure.

- We estimate that organic growth of LPWA devices will reach only 200-250 million units by 2020. By this, we mean that new wide-area business opportunities will grow pretty slowly over the next 5 years. The relatively slow short-term uptake in LPWA is due to multiple factors, including:
    - Deployments driven by industry and private sector in agriculture, environment, industry utilities and transport with limited adoption in smart buildings, consumer, and smart city applications where traditional LPWA forecasts are focused. Long sales cycles will affect volume uptake in the short term.
    - Fledgling public networks require time to evolve to provide the required coverage and density to support volume deployments. To achieve mass volume, public networks play an important role by expanding the access for multiple users and suppliers in the ecosystem.
    - Fragmentation of the market within the next 2 years works to slow down big deployments, as enterprises and service providers face some confusion about multiple options, and economy of scale is delayed due to multiple parallel activities.
- In the longer term, we expect that public LPWA networks and ecosystems will be more developed, and the number of confusing options will be reduced, driving economy of scale in one or two specific options. In the 2020-2025 timeframe, we expect accelerating growth of LPWA into the billions of units per year.
- In addition to "organic" growth of LPWA applications, we believe that there is a larger opportunity in the near term for LPWA to steal IoT business from short-range

technologies such as Wi-Fi, Bluetooth, and Zigbee. This growth holds the potential for larger numbers in the next five years, as the existing installed base for short-range IoT devices is roughly 7.5 billion units today.

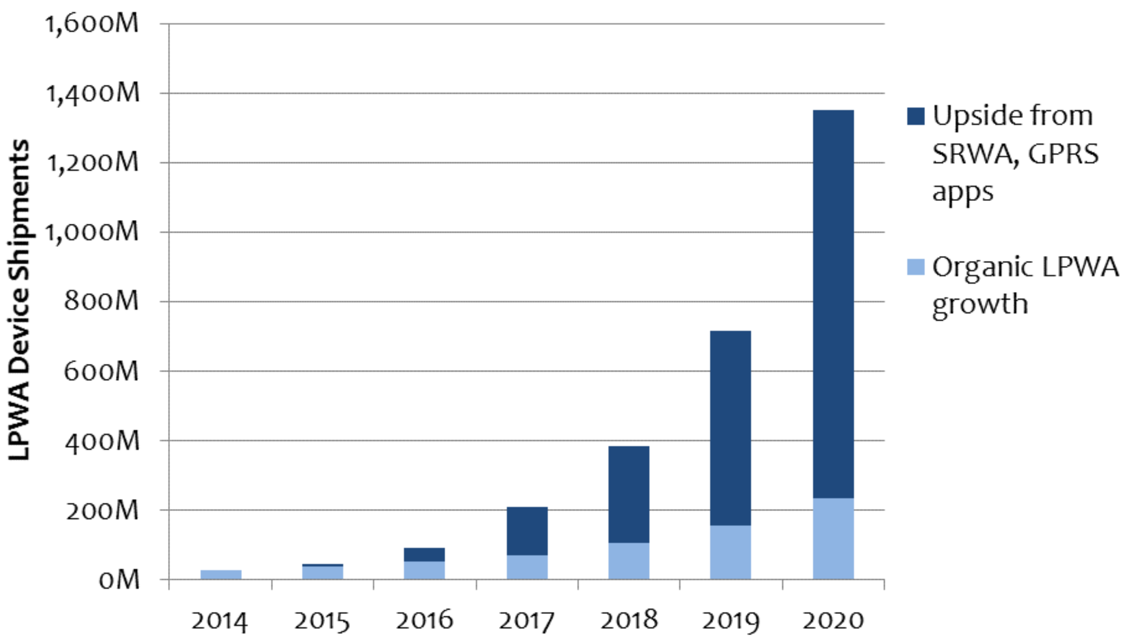

Chart 1. Global Forecast of LPWA device shipments

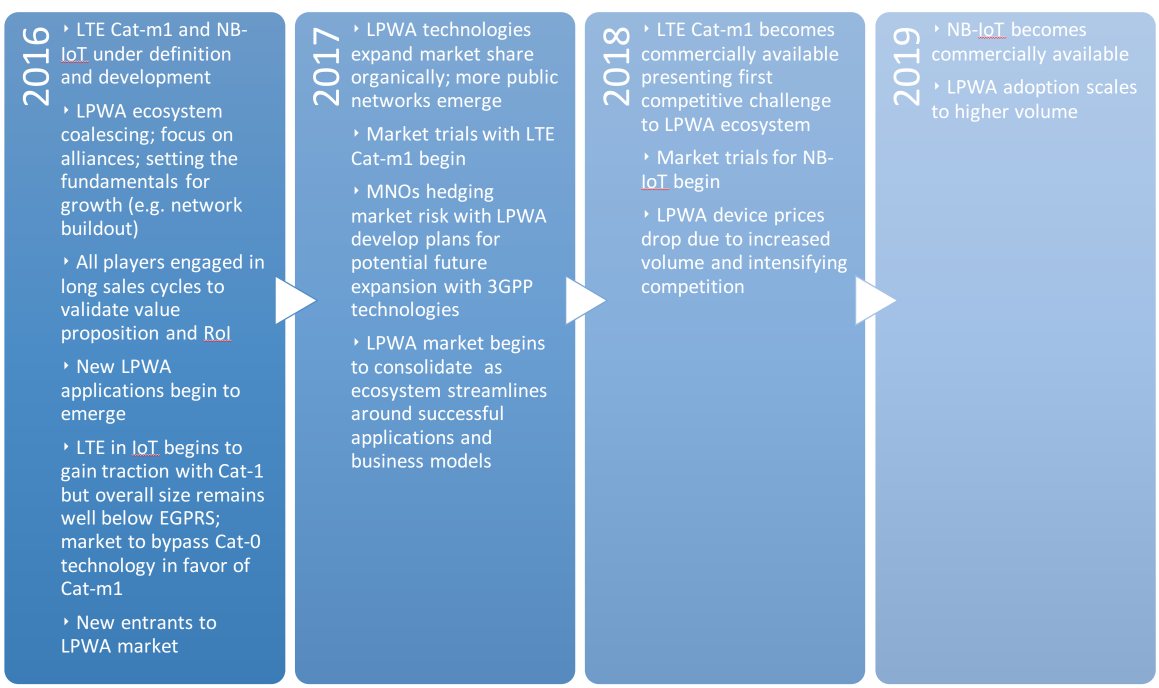

Figure 3 Market prognosis and evolution roadmap for LPWA and 3GPP IoT connectivity technologies.

