WHITEPAPER

LoRa Technology: Ecosystem, Applications and Benefits

SEMTECH

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Introduction

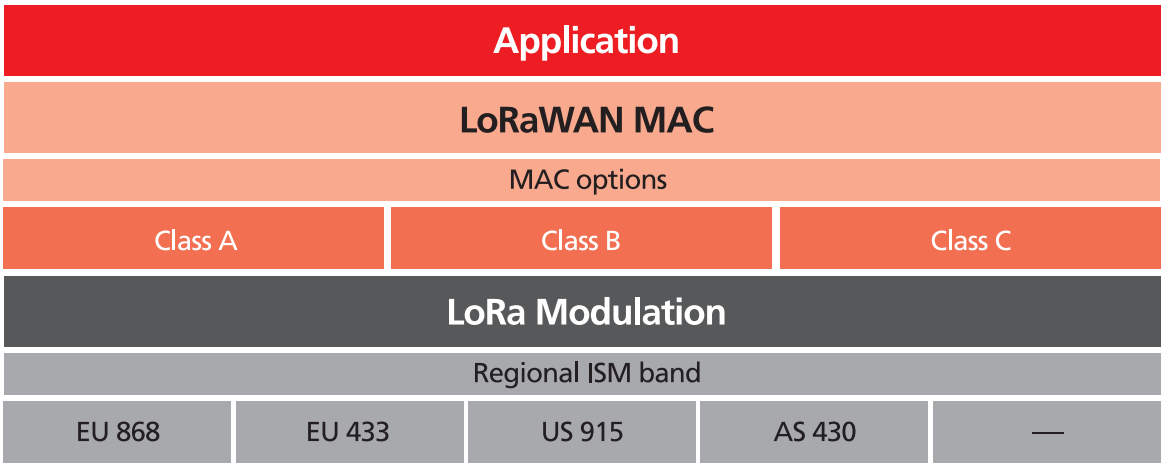
Low Power Wide Area Network (LPWAN) technologies have emerged to enable a large share of the growing Internet of Things (IoT) market. Machina Research estimates that there will be 27 billion IoT connections in 2025 and industry revenue opportunity will reach $3 trillion. While short-range wireless technologies, such as Wi-Fi, Bluetooth, and in-building power line communications (PLC) will continue to account for about 72 percent of all IoT connections in 2025, Machina Research estimates that 11 percent of IoT connections will use LPWAN technologies, such as LoRa®, and 3GPP-defined technologies like LTE Cat M1 and narrowband IoT (NB-IoT). Given the large market opportunity and benefits to businesses and consumers, there is significant interest in IoT and multiple approaches to addressing the market.

The LPWAN market is often viewed as a technology battleground from which one solution will emerge as the winner and de facto standard. But in reality, LPWAN use cases are so varied that no one technology will meet all requirements, as some LPWAN technologies are better suited for certain applications than others. Given the size of the market and varied nature of applications, there is room and, in fact, a place for multiple complementary options.

This paper focuses on LoRa wireless technology for IoT, specifically addressing LPWAN applications from Semtech Corporation operating in unlicensed spectrum with a large ecosystem of adopters. The following sections cover the value proposition of LoRa, the applications for which the technology is best suited, and the ecosystem of technology adopters.

LoRa Technology & LoRaWAN

LoRaWAN™, based on Semtech's LoRa wireless RF IC, is the open MAC layer protocol defined and standardized by the LoRa Alliance™. It operates in unlicensed spectrum, enables long-range, bidirectional communication and is deployed in a star-of-stars network architecture whereby end nodes are not associated with a specific gateway, but transmit data to multiple gateways within its range. Each gateway can independently support tens of thousands of sensor nodes. LoRaWAN data rates are scalable and follow an adaptive data rate algorithm to optimize power consumption and network capacity.



Source: Semtech Corporation

The Power of the Ecosystem

The LoRa Alliance has attracted more than 450 members since it launched in early 2015. Its members include mobile network operators, sensor and gateway manufacturers, chipset and module manufacturers, large enterprises, network management services, and application software providers. Member companies recognize the benefits of LoRa technology and the open standard LoRaWAN specification in the areas of low power, long range, scalable network capacity, open business model, and extremely fast deployment time.

While the LoRa Alliance defines the LoRaWAN specification and certifies products, it does not dictate how service providers should deploy LoRaWAN networks and price services. This open ecosystem approach creates flexibility for service providers and enables a variety of business models to flourish. For example, service providers currently offer LoRa-enabled connectivity services based on monthly subscriptions for network server use, number of messages sent, number of devices connected, or according to time of day usage.

LPWAN Advantage for Network Operators & Service Providers

Network operators and service providers are aggressively moving beyond offering connectivity, which may have limited revenue per user in IoT applications, such as metering and smart city infrastructure. Offering value-added services to capture recurring revenue based on LPWAN technology provides a much better return on investment and moves the network operators and service providers up the value chain as they offer deep integration and deliver fast, flexible services to their subscribers.

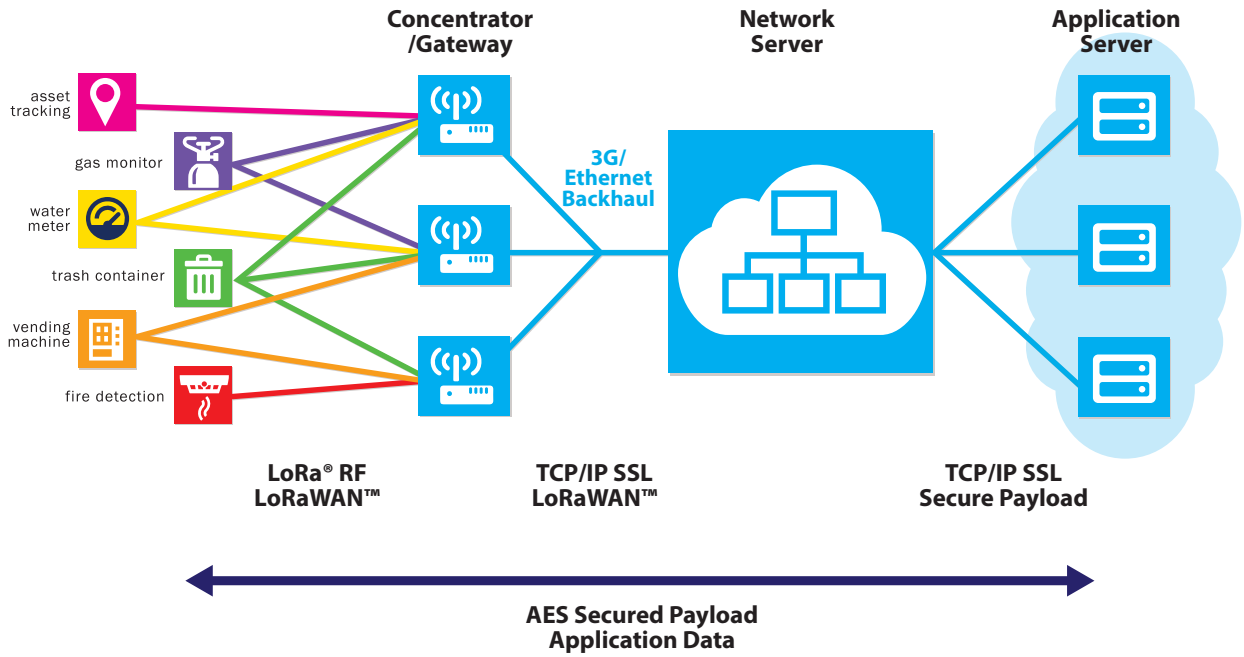
Existing cellular technology is not suitable for LPWAN applications that require long battery lifetime and low cost of connectivity. Alternative LPWAN technologies, such as LoRa, are addressing this market need by enabling fast, low-cost network deployment for different types of network operators, including mobile network operators, which rely on cellular technology for their primary business models.

Mobile network operators deploying LoRaWAN public networks plan to use a hybrid approach to LPWAN by combining LoRa technology with, for example, one of the emerging cellular technologies to cater to different use cases. In this example clear differentiation such as very low latency communication, higher quality of service and higher data throughput can be required for specific use cases. Typically, LoRaWAN is preferred for its low power, native geolocation, low network deployment and module cost, and mobility. Immediate and global availability of commercial LoRa-enabled sensors and gateways is an added benefit and does not require an operator to own or use expensive LTE licenses. By combining the feature sets of multiple technology options, network operators can deliver a wider variety of IoT connectivity services and thus capture more market share.

Other types of network operators, such as large enterprises that do not own traditional mobile network assets, are also deploying LoRaWAN networks and offering IoT services to their customers. Another deployment model is viral deployment, which has created a new breed of crowd-sourced LoRaWAN infrastructure where anyone can easily setup gateways and allow sensors in their range to connect to the network.

LoRaWAN Network

Network Infrastructure: The LoRaWAN protocol was defined specifically for LPWAN applications, keeping security, scalable capacity, cost, and ease of deployment in mind. Several manufacturers offer LoRaWAN gateways or base stations that support scalable LoRaWAN network deployments. LoRaWAN gateways enable public and private network deployments and are designed for outdoor or indoor use. The gateways support bidirectional communication and can simultaneously process messages from many LoRa-based sensor nodes. To keep hardware infrastructure costs low, most of the processing complexity is shifted up the chain so that network management functions and any tasks that require significant processing power are handled in the Cloud. The gateways typically act as packet forwarders and send packets to a network server that resides in the Cloud via a backhaul connection that may use Ethernet, Wi-Fi, 3G, or 4G/LTE. Due to the low cost of gateways compared to cellular base stations, increasing the capacity of a LoRaWAN network by adding additional gateways is fairly easy and inexpensive. Each sensor message is picked up by all the gateways within its range and each gateway can support between eight to 64 channels, which allows millions of messages per day to be processed by a network.



Source: Semtech Corporation

Network Server: The network server resides in the Cloud, and it processes packets from multiple gateways, directing them to an application server. Thanks to innovative features in the network server, many service providers have been able to create unique IoT offerings. Companies offer LoRaWAN network servers with value-added features ranging from free initial connections, to verified support for several gateways, to multiple IoT platforms that manage sensor nodes and integration with other backend services.

Application Server: The network server sends packets to the appropriate application server, which handles the customer application and presents data that is relevant. This helps users to monitor and track assets, cost savings and operational efficiency gains. Additionally, the user may set up rules to take action on specific events or a combination of events via a web-based application dashboard. There are highly-integrated application servers and dashboards available which make setting up and managing a LoRaWAN network fast. As most business owners and end users are looking for ease of use and reliable data that they can take action on, the IoT applications on smartphones and computers are designed to have easy configuration with a simple visual interface. These applications also offer integration with large Cloud service providers such as Amazon Web Services and Microsoft Azure.

Features of LoRa Technology

Low Power: LoRaWAN was designed to reduce the power consumption and extend the battery lifetime of connected sensors. In the lowest power mode, it uses an asynchronous communication method so the nodes only "wake up" when they have data to send, and then go back into power-saving "sleep mode" directly or once the transmission is acknowledged. LoRaWAN systems also use intelligent, Adaptive Data Rate (ADR) algorithms that enable the nodes to adjust data rates to best suit the environment. If a node is close to a gateway, then it will use less power, less time on air and higher data rates. Conversely, nodes located at the furthest possible points would use higher power and lower data rate. This is in contrast to cellular-based technologies that constantly ping the network to sync and to competing LPWAN technologies that do not support ADR and use a constant data rate regardless of the environment.

LoRaWAN sleep mode currents are in the nano amp-range while active receive and transmit currents are in the low milliamps, enabling some applications such as smart meters to last 20 years on a single battery. LoRaWAN also supports a "beaconing mode" named Class-B and a "continuous receive mode" named Class-C for applications at the expense of slightly higher power consumption.

LoRaWAN's low power feature extends battery life in sensors and makes it a good fit for smart building applications where sensors may be located in hard-to-reach places, such as behind walls, in elevator shafts or in basements. Smart building applications can prevent property damage, minimize time spent manually monitoring premises, reduce insurance premiums, as well as improve response times to problems, such as water leaks or heating outages.

Robust Long-Range Coverage: Depending on the environment and the presence of any obstructions, LoRaWAN can cover distances up to 30 miles in rural areas and more than 2 miles in dense urban environments with link budgets ranging from 158 dB to 168 dB. This coverage distance can compete with existing cellular-based technologies, and it is enabled by LoRa's unique spread-spectrum modulation scheme. Moreover, spread-spectrum techniques are more robust than narrowband schemes in noisy channel conditions and better at mitigating interference.

LoRa's long-range capability, in addition to its native geolocation, low-cost and low-power characteristics, makes it ideally suited for a range of smart city applications. A successful trial in street lighting showed that a single LoRaWAN gateway could cover up to 20,000 streetlights with the farthest streetlight being 10 miles away from the gateway. Significant energy and cost savings can be gained when cities implement smart street lighting infrastructure, where lights are automatically dimmed or even switched off during low traffic. According to UK Green Investment Bank, the United Kingdom has 7.4 million streets lights and spends over £300 million per year to power them. If the UK implemented smart lighting infrastructure that utilized traffic data to automatically turn street lights on and off, wasteful energy use will be reduced and money will be saved.

This is just one example of a smart city use case enabled by LoRa's long-range capability. LoRa-enabled smart sensors can monitor a variety of municipal infrastructure, such as bridges, tollbooths, parking lots, manhole covers, historic buildings, trash containers, water reservoirs, and help to reduce traffic congestion, lower operational costs, and schedule preventive or repair maintenance work.

Low Cost: LoRaWAN sensors and gateways (base stations) typically cost less than competing LPWAN technologies for a number of reasons. First, there are no wireless spectrum license fees because they operate in unlicensed spectrum, and the LoRa Alliance ensures that the protocol is royalty free. Next, LoRaWAN's long-range star network architecture allows a mix of in-building and outdoor gateways and sensors that can be flexibly deployed to minimize capital expenditure (CAPEX) and operating expenditure (OPEX) for network operators. Finally, the LoRa Alliance ecosystem allows for competition on every level in the value chain that creates more cost-effective solutions for consumers and business owners.

Cellular-based technologies, in contrast, operate in licensed spectrum and incur intellectual property (IP) royalties due to 3GPP heritage. Even if these technologies are expected to be deployed on existing LTE base stations, where the existing hardware supports it, licenses will apply. And, LTE primarily covers urban areas using the expensive LTE frequency spectrum. The required software upgrades, which would incur an investment for the cellular operators, often require hardware upgrades of the gateways incurring additional cost.

LoRaWAN's cost efficiency makes it particularly suited for utility companies. Utility companies were among the first adopters of LPWAN technology because their battery-powered meters are located in underground, difficult to reach places, and they were looking for more efficient ways to monitor energy, water and gas usage. This required a connectivity solution with very low power and long-range capability that is also at a low cost, which LoRa technology, operating in an unlicensed industrial, scientific and medical (ISM) radio frequency band, could provide.

Beyond meter reading, utility companies can also use LoRa technology to monitor large pipelines for costly and wasteful leaks or faults. According to the American Society of Civil Engineers, old leaky pipes lose seven billion gallons of drinking water every day in the U.S. In developing countries, the World Bank estimates that 45 million cubic meters of drinking water is lost daily at a cost of $3 billion annually. Saving just half of the losses in developing countries would provide water for 90 million people.

Geolocation: LoRaWAN provides secure geolocation data for outdoor fixed and mobile assets without using expensive, power-hungry Global Positioning System (GPS) on the sensor nodes. LoRa uses Differential Time of Arrival and other hybrid techniques to determine location without using extra processing power and without added cost to the end node. Location is estimated by algorithms in the Cloud using a packet's time of arrival from a sensor node to multiple gateways that are precisely time synchronized.

LoRaWAN's modulation and bandwidth are also suitable for connecting fast moving objects, unlike narrowband solutions that offer limited mobility support. In use cases where movement is involved, geolocation capability becomes necessary to track assets and optimize operations. LoRa enables location determination ranging from 65 to 650+ feet, which can be further enhanced through machine learning and Big Data analytics. If the power consumption allows for the use of Wi-Fi, BLE, GPS, then other technologies' hybrid end node designs will support use cases that require enhanced location accuracy.

Today, the LoRa geolocation solution helps improve asset utilization and reduce operational expenses by up to 50% in some cases. Smart sensors enable logistics companies to track the location of containers as well as their condition by monitoring vibrations, opening/closing of container doors, and temperature or humidity. This helps logistics companies better manage inventory levels, optimize land use and improve efficiency. In agriculture, geolocation provides valuable input to determine where to irrigate to achieve an increased yield. For example, potatoes grow 20% better when properly irrigated. Moreover cattle location and status information increase operational efficiencies and drive down mortality of cows and their calves.

Conclusion

There are several LPWAN technology options available today and several that may emerge in the future. Given the variety of LPWAN applications, the market is more likely to evolve and converge on a few complementary technologies rather than weed out all but one technology winner. Cellular technologies will re-use some of the existing cellular infrastructure and will serve a specific section of the LPWAN market, while low-cost, unlicensed spectrum options such as LoRaWAN will continue to serve applications that require low-cost, multi-year battery operation, long-range connectivity, and geolocation. The technical benefits of LoRa technology, its ease of deployment and its open business model have attracted a global and growing ecosystem of suppliers and network operators in over 100 countries. The LoRa Alliance members are already delivering LoRaWAN-based IoT services for smart building, agriculture, utility companies, supply chain managers, and a wide range of other segments.

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