White Paper
Smart Cities

Sterlite Tech

LoRa network advantageous as key IOT enabling technology

Abstract: As cities move toward efficiency, smart city technologies such as IoT and LoRa can provide new solutions for smarter and improved city services.

LoRa (Low Range)
Long rage is a key factor for large-scale communication networks typically required in Smart-City applications and IoT. Recently, narrowband and spread-spectrum technologies surfaced as cost-effective candidate technologies to fulfil low throughput and long-range communication.

LoRa is a spread-spectrum modulation scheme that uses wideband linear frequency modulated pulses whose frequency increases or decreases over a certain amount of time to encode information. The main advantages of this approach are twofold: a substantial increase in receiver sensitivity due to the processing gain of the spread spectrum technique and a high tolerance to TX and RX frequencies misalign.

- LoRa is a Semtech technology for IoT
- Provides long range and low power wireless technology to connect low-cost, battery operated sensors over long distances (10 miles range and > 10 years battery life)
- The LoRa Alliance was formed in February 2015. Release 1.0 of LoRaWAN specification was released to public on June 16, 2015
- Applications: smart city, sensor networks, industrial automation application

Important Factors in LORA network
The most critical factors in a LORA are:
- Network architecture
- Communication range
- Battery lifetime or low power
- Robustness to interference
- Network capacity (maximum number of nodes in a network)

• Network security
• One-way vs. two-way communication
• Variety of applications served

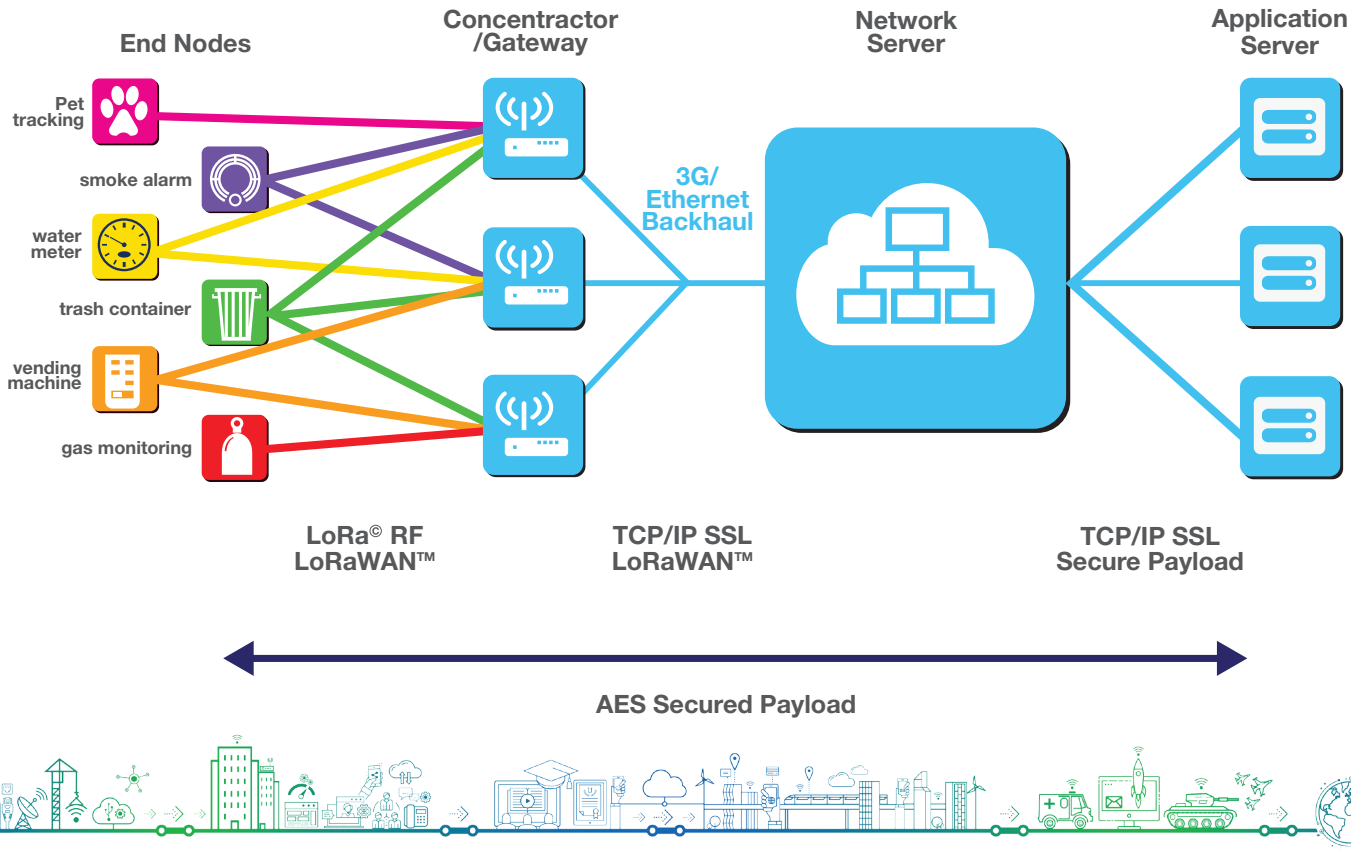
What is LORAWAN?
LoRaWAN™ defines the communication protocol and system architecture for the network while the LoRa® physical layer enables the long-range communication link. The protocol and network architecture have the most influence in determining the battery lifetime of a node, the network capacity, the quality of service, the security, and the variety of applications served by the network.

Network Architecture
Many existing deployed networks utilise mesh network architecture. In a mesh network, the individual end-nodes forward the information of other nodes to increase the communication range and cell size of the network. While this increases the range, it also adds complexity, reduces network capacity, and reduces battery lifetime as nodes receive and forward information from other nodes that is likely irrelevant for them. Long range star architecture makes the most sense for preserving battery lifetime when long-range connectivity can be achieved.

Network Infrastructure:
The LoRaWAN protocol was defined specifically for LPWAN applications, keeping security, scalable capacity, cost, and ease of deployment in mind. 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 processingcomplexity is shifted up the chain so that network management functions and any tasks that require significant processing power are handled in the server layer. The gateways typically act as packet forwarders and send packets to a network server 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 cost-effective. 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.

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 costsavings can be gained when cities implement smart street lighting infrastructure, where lights are automatically dimmed or even switched off during low traffic. This is just one example of a smart city use case enabled by LoRa's long-range capability. LoRaenabled 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.

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 synchronised.

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 utilisation 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, optimise 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.

Wide area networks
Technology Trade-offs

There is a lot of activity in the IoT sector comparing LORA options both from a technical comparison but also from a business model perspective. LORA networks are being deployed now because there is a strong business case to support immediate deployment, and the cost to deploy the network in unlicensed bands requires much less capital than even a 3G software upgrade. The questions that should be answered to compare different LORA technologies are:

- Flexibility to target a large variety of applications
- Is the communication protocol secure?
- Technical aspects – range, capacity, two-way communication, robustness to interference
- Cost of network deployment, cost of end-node BOM, cost of battery (largest BOM contributor)
- Ecosystem of solutions providers for flexible business models
- Availability of end-products to ensure ROI of network deployment
- Strength of ecosystem to ensure quality and longevity of the solution

SIGFOX	LORA	3G
Pros:	**Pros:**	**Pros:**
• Long range	• Long range	• Well -established standards
• Long battery life (up to 20 years)	• Long battery life (>10 years)	• Long rage
• Low cost	• Low cost	• High data rate
	• Uses cellular network as backhaul	• Very wide coverage
		• Licensed band (except LTE-U)
Cons:	**Cons:**	**Cons:**
• New standard	• New standard	• Not optimised for IoT
• Unlicensed band interference	• Unlicensed band interference	• Battery life
• Can't run on existing cellular network – needs a dedicated SIGFOX network	• Very low data rate can only be used for IoT	• Cost
• Very low data rate can only be used for IoT		

WHY LoRa IS A GAME CHANGER FOR SMART CITY APPLICATIONS

LoRa Technology offers both technical and business benefits for smart city applications.

Technical Benefits

• Low asset deployment cost due to:
– Great indoor penetration: One gateway operates in a star network with sensors communicating directly to the gateway from a range of up to 20 kilometers. Sensors can be located indoors or outdoors. There is no need for complex coverage analysis as is required for mesh network solutions.

– Ease of installation: Battery-operated sensors are capable of lasting up to 20 years depending on the application being used. This means there is no need for power source wiring for sensors as opposed to existing solutions such as GSM, LTE or Wi-Fi.

• Secure: AES-128 encryption is built in.
• Open standard: The LoRaWAN™ specification is supported and maintained by the LoRa Alliance™ allowing seamless and easy scalability.
• Geolocation: LoRa Technology utilises a GPS-free geolocation technology that does not require additional power.
• Low connection costs: LoRa Technology operates in the unlicensed ISM band, which means no or very low spectrum costs (there may be a very low connection fee if using an external service provider).

Business Benefits

• Available today for public and private deployments.
• Low deployment and operational costs when compared to emerging cellular-based solutions like LTE-M and NB-IoT.
• Open network: – Cities have the capability of choosing from multiple and competing network service providers, helping to drive down prices. OR – Cities can deploy their own local municipal network, which can host multiple applications. The cost can be minimized by leasing bandwidth to companies within the city who want to run their own applications.
• Leverage deployed assets: LoRa Technology's robust signalling can penetrate buildings for wide ranging coverage even in dense urban areas. This allows one LoRa-based gateway to potentially cover multiple buildings within a range of 2+ kilometers.
• Growing ecosystem: The fast-growing LoRa Alliance™ currently comprises over 400 companies that are creating solutions using the LoRaWAN specification. The LoRa Alliance™ includes major industry players and many other start-ups and network operators. Combined, this ecosystem offers multiple sources of supply from communications ICs to networks to server-based application platforms. The LoRa Alliance also certifies sensors and other devices for interoperability.

Conclusion

As cities move toward efficiency, smart city technologies can provide new solutions for smarter and improved city services. A scalable and low cost IoT network is the cornerstone of a Smart City program, and LoRa-based devices and the LoRaWAN specification provide high-capacity, low power networks that form the basis of successful smart city solutions.

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