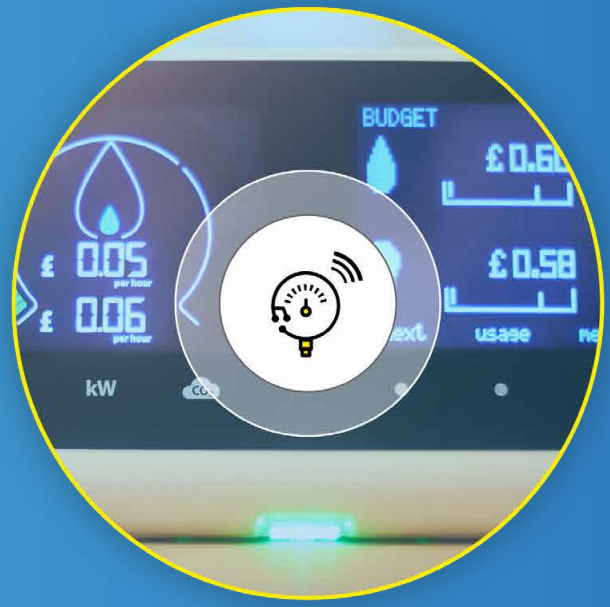
Briefing for IoT Solution Specialists:
Using LoRaWAN® in Smart Buildings, Cities & Utilities



LoRa Alliance®

beecham research

Shaping the IoT future

Introduction

This briefing provides an introduction particularly for Solution Providers (SPs) and System Integrators (SIs), who specialise in Smart Buildings, Smart Cities or Smart Utilities, on what LoRaWAN® is and its significance in the IoT market.

SPs and SIs help to streamline the assimilation process and enable solutions in these sectors to run smoothly. As systems become more complex this is an increasingly important role. Beecham's recent research has indicated that the influence of specialist SPs and SIs in the buying process is high, in view of their sector expertise, but that awareness of LoRaWAN may be low. We hope this briefing is useful. Further information can be gained from the LoRa Alliance® as detailed on the final page.

LoRaWAN has come a long way in a short time, with the specification only being introduced to the market in February 2015, when the LoRa Alliance was formed. In that time, it has already become the leading LPWAN technology for IoT applications by some margin – as also detailed in this briefing.

LoRaWAN was invented to address the utility market, with the ability to penetrate concrete and steel and provide connectivity underground with low power usage.

As a result, an estimated 35-40% of all LoRaWAN deployments are in utilities at this time. These attributes are also well-suited to the Buildings and Smart Cities sectors, where LoRaWAN deployments are now increasing rapidly.

Following a brief introduction to what LoRa and LoRaWAN are and how they differ, this briefing has three parts:

Part 1.

An Overview of LoRaWAN in the IoT market and its future prospects. This includes a market forecast of expected shipments, analyst views and quotes from interviews with IoT solution providers regarding use of LoRaWAN. In addition, more detailed interviews with leading system integrators are included on why they are now focusing on LoRaWAN for their projects.

Part 2.

LoRaWAN Key Features – how it works, its key properties and security by design.

Part 3.

Key Sectors. Use of LoRaWAN in Smart Buildings, Smart Cities and Smart Utilities. A summary of why LoRaWAN is particularly suitable for use in these three sectors, together with a variety of case studies to illustrate its inherent flexibility.

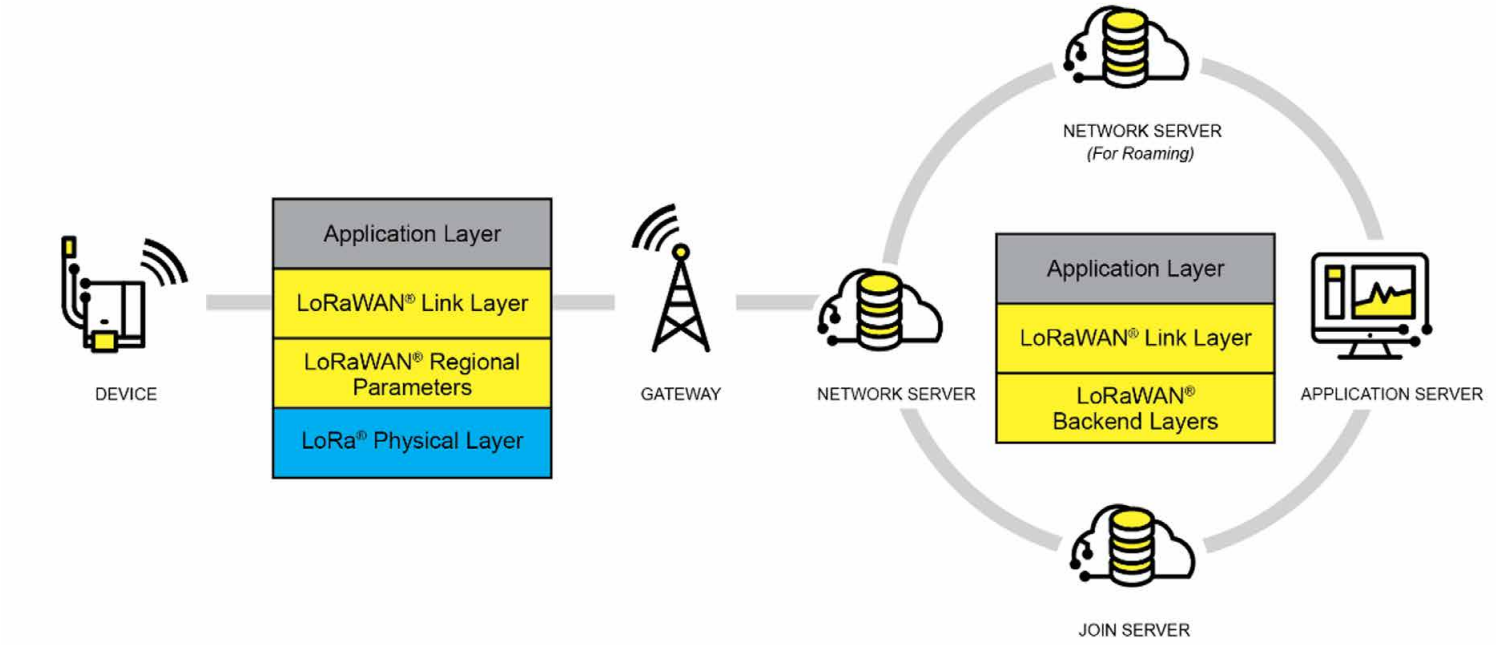
What is LoRa® and LoRaWAN®

LoRa (standing for Long Range) is a wireless technology that is built for long range and low power use. LoRa is a proprietary radio modulation technology owned by Semtech and deals with only the stack's physical layer. LoRa technology uses a proprietary Chirp Spread Spectrum (CSS) modulation technology, which has low power characteristics like FSK modulation and is used for long-range communications.. Semtech has licensed its LoRa intellectual property (IP) to other chip manufacturers.

In contrast, LoRaWAN (standing for Long Range Low Power Wide Area Network) is the communication protocol and system architecture. LoRaWAN deals with the link layer of the protocol stack. It is open-source and managed by the LoRa Alliance®.

LoRaWAN is an official ITU-T Y.4480 standard of the International Telecommunication Union (ITU).

Initially, the link layer protocol was called "LoRaMAC" and, among other things, specified the message formats and security layers for a proper networking protocol. In February 2015, the LoRa Alliance® was founded and now has more than 500 member companies. The networking protocol was renamed "LoRaWAN." While LoRa was invented by Cycleo, prior to being acquired by Semtech, LoRaWAN was invented by Semtech, IBM and Actility. Keeling made the first LoRaWAN outdoor gateway, followed by Multitech with the Conduit. The LoRa Alliance® was an initiative from Semtech, Kerlink, IBM and Actility. The LoRa Alliance's goals were, and still are, to "support and promote the global adoption of the LoRaWAN standard by ensuring the interoperability of all LoRaWAN products and technologies."



LoRaWAN® offers multiple network deployment models to solve different IoT business applications globally. Deployment options include Private, Public, Hybrid and Community networks, as follows:

Private LoRaWAN Networks

Private LoRaWAN networks give customers the freedom to deploy their own gateways, provide their own backhaul, and deploy sensors in range of those gateways.

LoRaWAN Private networks are often used by large enterprises because:

- They can be placed where wanted
- They can be built when wanted
- There is no need to share with other users, offering complete control of traffic
- They are not constrained by network operator limitations, such as applications that use a large number of downlinks.

Public LoRaWAN Networks

Public networks allow a customer to pay a network operator to connect its sensors without deploying gateways with backhaul in-house.

LoRaWAN Public Networks are a convenient solution for many LPWAN IoT use cases because customers can simply use a network that already exists.

There are currently over 180 LoRaWAN public network operators worldwide and many private networks providing connectivity in more than 190 countries.

Hybrid LoRaWAN Networks

Hybrid networks allow a customer to move between public and private networks, which is useful especially in use cases involving asset tracking where a connected device often moves out of range of one private network while traveling towards another.

Community LoRaWAN Networks

Community networks are decentralized networks comprised of components hosted by individuals that offer connectivity to the public.

Overview of LoRaWAN® in the IoT Market

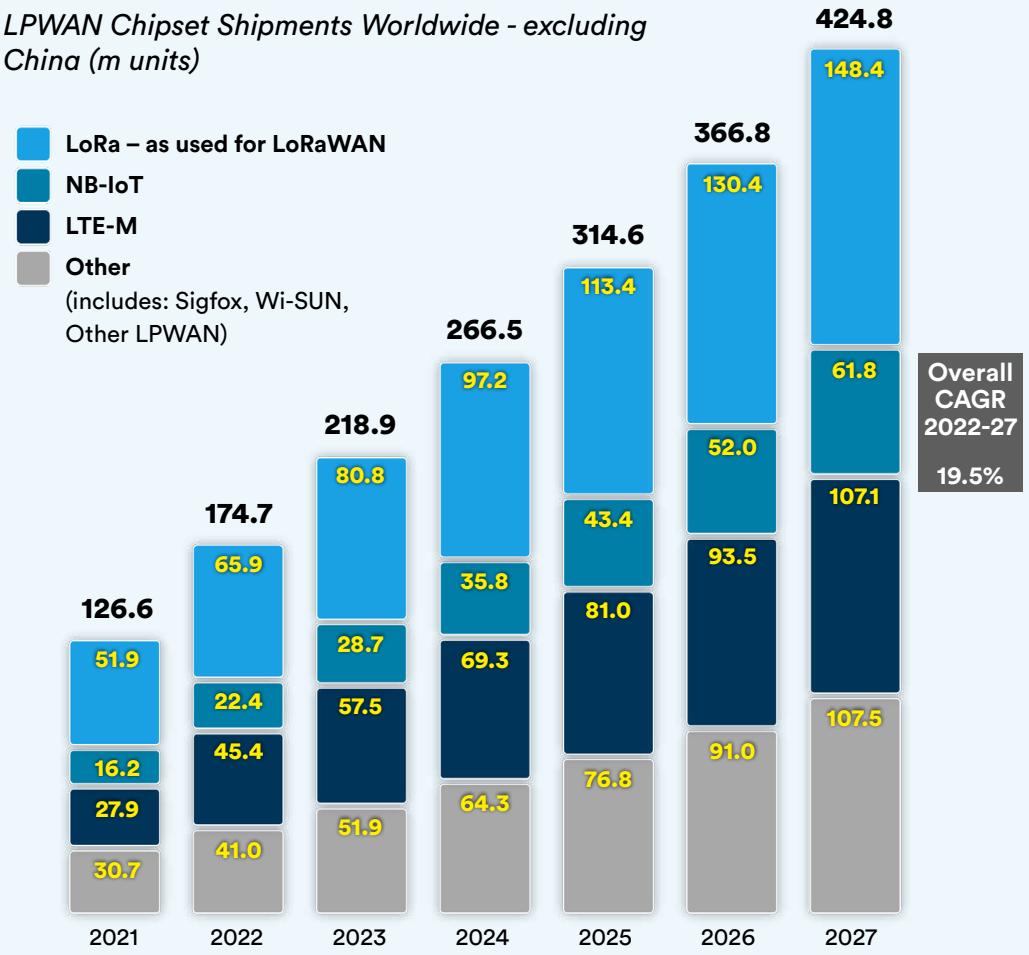
LPWAN Chipset Shipments

LPWAN (Low Power Wide Area Network) is now seen as the key technology area for mass volume IoT (Massive IoT) applications, which will make up over 80% of IoT applications by 2026. This covers sensor-based and many other low data rate applications that have not been cost effective for other connectivity technologies to address.

Although there are others, chief among the LPWAN connectivity technologies are: LoRaWAN®, LTE-M and NB-IoT. NB-IoT has been pursued by the Chinese government as a standard for Massive IoT applications in the country and, as a result, is offered by all mobile network operators (MNOs) in China. Everywhere else, there is a mixture of LTE-M and NB-IoT offered by MNOs. As a consequence, chipset shipments forecasted for these three technologies in the period 2022-27 excluding China gives a clearer picture of what is really happening in the rest of the world.

It is clear from this that shipments of LPWAN chipsets are growing strongly at nearly 20% per annum to 2027, with LoRa vs NB-IoT at the rate of 2:1 outside China. This is often not recognised in the IoT market – that **LoRaWAN is already the leading LPWAN technology for IoT applications by some margin.**

LPWAN Chipset Shipments Worldwide - excluding China (m units)



Source: Beecham Research 2023

The Market View of LoRaWAN®

1. Omdia LPWAN Market Report 2022

According to analyst house Omdia, the number of low-power wide-area (LPWA) IoT network connections will grow at a compound annual rate (CAGR) of 23 percent in the period to 2028, driven mostly by growth in NB-IoT and LoRaWAN technologies. NB-IoT and LoRa will account for 87 percent of all LPWA-style IoT connections in 2028.

Omdia calculates these two technologies own 85 percent of global LPWA-IoT connections. The analyst said cellular-based NB-IoT and non-cellular LoRaWAN, more than LTE-M and Sigfox, their traditional rivals respectively, are in the “sweet spot for mid-range IoT applications”.

The NB-IoT story remains a parochial one, mostly restricted to China, where more than 90 percent of global NB-IoT connections resided at the end of 2022 – and commonly deployed for stationary use cases like utility metering and smart-city monitoring. Omdia commented: “Outside of China, the adoption of the NB-IoT has been slow. China will continue to be the main driver of NB-IoT adoption in the foreseeable future.”

Omdia concludes: “LoRaWAN has had several years of unchallenged growth, building momentum, and gaining maturity. Its success in the future remains as it has differentiated offerings and a value that NB-IoT cannot easily match. LoRa has unmatched accessibility for companies deploying IoT applications. This accessibility has made LoRaWAN one of the favourites of small developers, the maker community, and over-the-top IoT networks.”

2. RCR Wireless News: James Blackman July 27 2023

LoRa Alliance claims large numbers of sensors added in Asia

The LoRa Alliance has claimed “millions of sensors” have been added in the region in the first half of 2023 on the backs of “large projects” in China, Japan, Korea, and India. It highlighted deployments by Tata Communications in the Middle East (300,000 end nodes) and India (250,000) and by advanced metering infrastructure (AMI) provider Leotek in South Korea (250,000 sensors), plus a number of others variously in sub-50,000 volumes, as examples.

The alliance said: “The continued evolution of LoRaWAN networks is increasing accessibility [and] further accelerating growth.” Its Tokyo conference in October reflects growing interest in LoRaWAN in the region; in China, in particular, LoRaWAN has fallen some way behind cellular-based LPWAN solutions, based mostly on NB-IoT – as a consequence of government initiatives via big operator firms.

The LoRa Alliance said support for the technology in the wider region has been strong, and getting stronger; it is considered an option, as elsewhere, for battery-powered water and gas metering, management, and leak detection, plus for environmental monitoring and for street lighting and related public safety applications. Sigfox-owner Unabiz, newly-part of the alliance, has had some success in Japan, via a long-time tie-up with KDDI-owned Soracom and a headline deal with Japanese gas utility NICIGAS.

For reference, the alliance has listed the following deployments to underline LoRaWAN®'s credentials in the Asia Pacific region:

- Tata Communications has scaled two significant deployments; the first enables a connected worker solution covering more than 250,000 end nodes; the second for more than 300,000 end nodes across India and the Middle East
- Packetworx and Actility are deploying a nationwide public LoRaWAN network in the Philippines with over 6,000 gateways.
- Semtech is a partner in a water metering deployment of 250,000 sensors in Korea.
- Milesight has completed multiple deployments across China, with approximately 50,000 LoRaWAN devices deployed.
- iWOW Technology [has] installed a network of over 400 TEKTELIC LoRaWAN gateways to service over 25,000 sensors for smart metering and emergency response services.
- IoT Ventures is deploying more than 8,000 sensors to support its LoRaWAN end-to-end solutions in agriculture
- One of the largest subway companies in Japan [has] introduced Yokogawa Electric Corporation's Sushi Sensors to monitor hundreds of ventilators and air conditioning equipment units located in its stations and tunnels.
- SenRa [has] collaborated with a large building management system (BMS) company in India to optimize and expand its LoRaWAN deployment covering a 65-acre site and leveraging more than 250 sensors in the initial phases of the project.
- Kiwi Technology has launched two significant IoT FOT deployments; the first supports LNG gas metering and leverages a third-party network control unit that uses LoRaWAN with Class B to connect and monitor gas meters in real-time and potentially reduce gas leaks. The second harnesses LoRaWAN for smart temperature management solutions across food retail and cold chain.
- Semtech [has] supported Aeon Delight in equipping 90 administrative facilities in Japan with solar panel-driven LoRaWAN sensors.

3. Beecham Research primary research interviews

Beecham Research has recently conducted a wide range of 1 on 1 interviews of IoT solution providers. Quotes from these relevant to LoRaWAN® as follows:

LoRaWAN power consumption and range

"In smart metering, LoRaWAN is extremely suitable because the power consumption is very low with a very long range and indoor penetration capabilities reaching gas/water meter sensors that are located underground."

"Asset tracking is a promising one for LoRaWAN. Smart city applications are starting to pick up, so street lighting for instance, waste management, smart parking, smoke sensors etc."

"LoRaWAN lines-up nicely from a cost perspective. You have the ability to roll-out a fully private network that is actually cellular like."

"If a city deploys a LoRaWAN network you can use it for a variety of applications. You can make use of networks for several applications."

"Europe is probably the most advanced in the use of LoRaWAN."

Comparing LoRaWAN other LPWAN for IoT

"Industrial IoT will be split between the cellular world, LTE/M and NB-IoT, and LoRaWAN."

"NB IoT is a compromise on battery life, but it is still less efficient than LoRaWAN."

"The barrier of entry to LoRaWAN systems is very low. If you contrast that with the ecosystem of NB-IoT or LTE/M, the barrier of entry is much higher and therefore, you not seeing as much innovation from the types of solutions that we are seeing in the marketplace around LoRaWAN."

"The LoRaWAN technology has been developed to allow wider coverage than other radio technology such Wi-Fi, Bluetooth, Zigbee. LoRaWAN allows a good coverage in buildings where dense indoor coverage is requirement, you can reach 2-3kms. In non-dense areas LoRaWAN can reach up to 15-20kms for example in agriculture."

The System Integrator View of LoRaWAN®

Question 1. How significant is LoRaWAN in the IoT market?

According to Bob Blanchard, Manager of Business Development for the Americas at system integrator Klika Tech Inc., *"LoRaWAN is huge. The biggest problem with IoT in general is the requirement for gateway devices and the additional infrastructure to make it all work. LoRaWAN reduces that to a minimum".*

"Firstly, indoors. In general, there's a lot of interference of radio frequencies indoors. The 2.4 GHz band is often saturated with Wi-Fi, Bluetooth, ZigBee and many others. LoRaWAN in US operates at 915 MHz so completely outside of that band, so does not have interference issues."

"Secondly, because it operates at such a low frequency it actually penetrates walls and infrastructure far better than those higher frequencies do. LoRaWAN is ideal for sending small amounts of data over very long distances, through infrastructure and avoiding interference from other technologies."

"Unlike other technologies, we can put one LoRaWAN gateway per property – two at the most – and get all the LoRaWAN devices to work with that. Every gateway requires a network cable to be pulled to it, requires power, requires a switch port in a wiring closet somewhere. That is all significant in cost and man hours to deploy. LoRaWAN saves a lot of that cost."

Patrick Parodi is Managing Director of PwC's Connected Solutions, a group that manages and deploys IOT solutions for the large enterprise. *"I think LoRaWAN's share of voice is much smaller than its share of market value. The wireless industry is dominated by licensed public spectrum technologies and is less interested in unlicensed private networks" he says.*

"The usual "field of dreams" approach to deploying wireless networks is not going to be the same as we enter this new era of connected things. For low power sensors and networks, you should invest based on where the demand is and grow from there."

According to Parodi " LoRaWAN becomes even more valuable when used alongside other emerging technologies like computer vision or ambient BLE and WiFi signals being detected. For instance, PwC Connected Solutions has a small low power camera that we put on utility meters – both alphanumeric meters for electricity, gas and water as well as analog ones with needles. The camera takes a picture, then we have an inexpensive chip that is powerful enough to turn that picture into data that can be sent back via LoRaWAN. This is computing at the edge and when combined with LoRaWAN turns any old, antiquated meter into a smart meter."

> ***"LoRaWAN is huge. The biggest problem with IoT in general is the requirement for gateway devices and the additional infrastructure to make it all work. LoRaWAN reduces that to a minimum"***

> ***"LoRaWAN's share of voice is much smaller than its share of market value"***

Question 2. What are the key benefits that LoRaWAN provides?

Again, according to Parodi *"The cost benefit analysis is very strong. The cost of deploying and managing the network is not only reasonable in terms of the cost of the sensors and gateways but also in terms of battery life and ongoing operational expense. LoRaWAN is great for deploying private, secure low-cost sensors allowing us to get new environmental data from difficult to reach places."*

"There is a misconception in the market that LoRaWAN is best for outdoors, because of its long-range capability. In fact, LoRaWAN is particularly good for getting data in difficult to reach places underground and behind large structures – for temperature, humidity, light, sound and so forth. LoRaWAN has an important role to play inside large buildings, warehouses, and manufacturing facilities."

"The other part of the value proposition is the ease at which you can deploy a private LoRaWAN network. You can build your own network – you don't need to be dependent on third party infrastructure. It also sits over the top so you don't necessarily need to get the IT Department involved. "

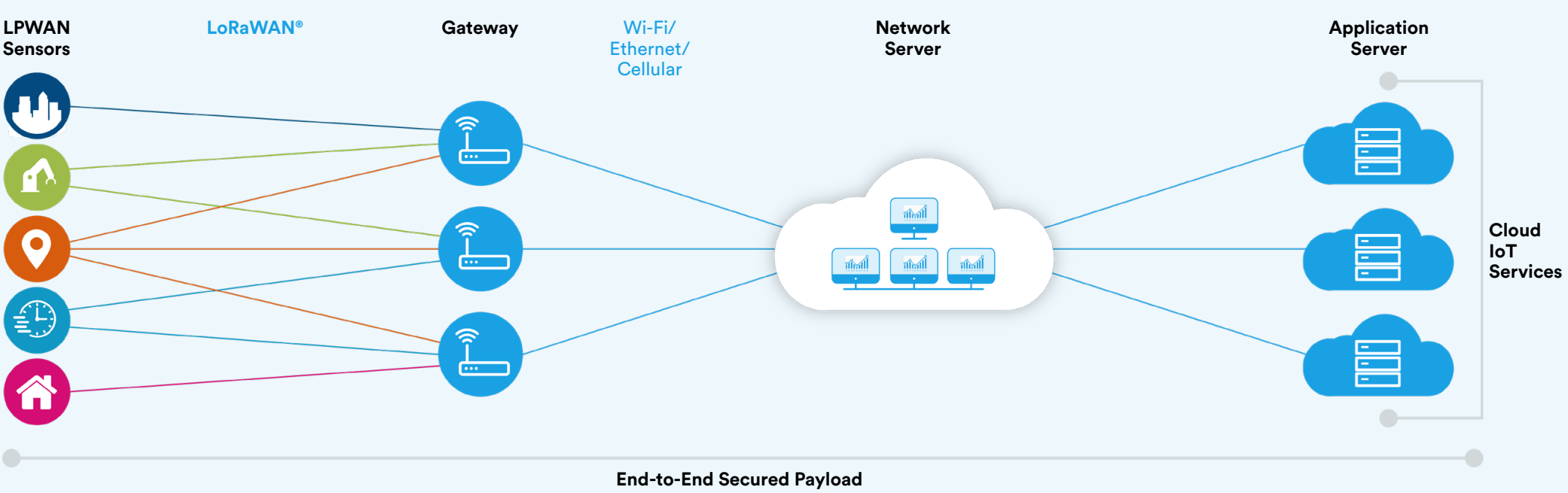
"Once you have a LoRaWAN network you can easily add new sensors for new applications. These are generating new 'operational" data streams that are proprietary and are going to feed the new AI models for the enterprise that will be essential to compete in the future."

> ***"LoRaWAN is particularly good for getting data in difficult to reach places underground and behind large structures"***

LoRaWAN® Key Features

How LoRaWAN Works

In a LoRaWAN network, there are LoRaWAN end-devices, gateways, network servers and application servers. The LoRaWAN network architecture is deployed in a star and point to point communication topology.

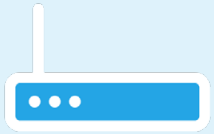


A LoRaWAN® end-device consists of 2 parts:

- **A radio module with an antenna.**
- **A microprocessor to process the sensor data and transmit it to the gateway.**

End-devices are often battery-powered. Because they are configured to send data periodically, an end-device broadcasts its data to every gateway in its vicinity. The devices will wake up and transmit data and then go back to sleep. They are never turned on for 24×7.

LoRaWAN gateways capture data from the end-devices and channel the data to a network server.



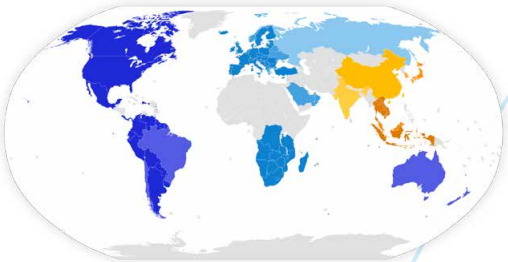
A LoRaWAN gateway consists of 3 parts:

- **A radio module with an antenna for LoRaWAN communication**
- **A microprocessor to process the received sensor data**
- **An Internet connectivity technology such as Wi-Fi, Ethernet, or Cellular Network to transfer the data to the Network Server.**

LoRaWAN gateways are mains powered as they work 24×7. The gateways can listen to multiple frequencies simultaneously, in every spread factor at each frequency. Gateways do not store any data – they are packet forwarders. The communication between the end node and gateway is bidirectional, which means the end node can send data to the gateway, as well as receive data from the gateway. See also section on Security.

The Network server acts as the LoRaWAN manager. It is responsible for scanning and rejecting duplicate data received by multiple gateways and serving the Application server. In addition, the network server performs network management functions like over-the-air activation, dynamic frame routing, adaptive rate control, traffic management, and administration.

LoRaWAN® Frequency Use



LoRaWAN operates via the LoRa® chipset or end device in the unlicensed ISM band in the sub-Giga Hertz frequency. This means a license is not needed to transmit data via the LoRa technology in this band. The actual frequency of this sub-Giga Hertz ISM band for LoRaWAN varies from country to country, as listed in this table. For example, in the USA it is 902-928 MHz, in UK 863-870 MHz and 433 MHz, in India 865-867 MHz.

The range between LoRaWAN end-device and gateway sender and receiver depends on the environment of the equipment where it operates. Indoor coverage largely depends on the type of building material used. In urban areas, the range is 2-5 km, in rural areas 5-15 km, and if there is Direct Line Of Sight between the Gateway and the LoRaWAN end-devices end Nodes it can be more than 15 km.

In contrast, NB-IoT operates where there is mobile network coverage and typically offers up to 1km from a cell tower in urban areas, 5-10 km in rural areas.

Some exceptional ranges have been recorded for LoRaWAN connectivity. For example, LoRaWAN has been shown to work at a range of 702km. (Source: Telkamp and Slats 2017). This was achieved by launching a LoRaWAN end-device Node in the sky using a helium balloon.

Key LoRaWAN® Specifications

The LoRaWAN Regional Parameters specification guides the adaptation of the LoRaWAN Link Layer specification to comply with the various regulations enforced throughout the world on the use of the various frequency bands of unlicensed spectrum which are available. It defines default values for Link Layer parameters and channel plans. Each of the regional channel plans can be broadly characterized as dynamic channel plans, with a small number of default channels, or fixed channel plans, where all channels are defined then selectively activated by the network. Regional parameters are defined for a vast majority of countries in the world, using 9 main channel plans, and support for additional countries is regularly added.

The LoRaWAN Regional Parameters specification is a companion document to the LoRaWAN Link Layer specification, both of which are maintained by the Technical Committee of the LoRa Alliance®. While the LoRaWAN Link Layer specification defines the air interface between a compliant end-device (sensor, actuator, tracker, etc.) and a compliant network core, the LoRaWAN Regional Parameters specification defines the adaptation of the LoRaWAN Link Layer specification to comply with the various regulations enforced throughout the world on the use of various frequency bands of unlicensed spectrum which are available. A quick cross reference table is included in the LoRaWAN Regional Parameters specification to help implementers identify the relevant frequency bands and LoRaWAN channel plans which are available, by country.

One of the primary goals of the LoRa Alliance Regional Parameters Working Group, which maintains the specification, is to create the smallest number of regional channel plans which cover the largest possible number of regulatory regions. In doing so, the group minimizes the complexity to implementers as well as the certification cost, as end-device certification is enumerated by Link Layer revision and Regional Parameters revision and channel plan.

Regardless of the parameters specified or configured, LoRaWAN equipment must not operate in a manner contrary to the prevailing local rules and regulations where it is operating. It is the responsibility of the LoRaWAN end-device or gateway to ensure compliance is maintained.

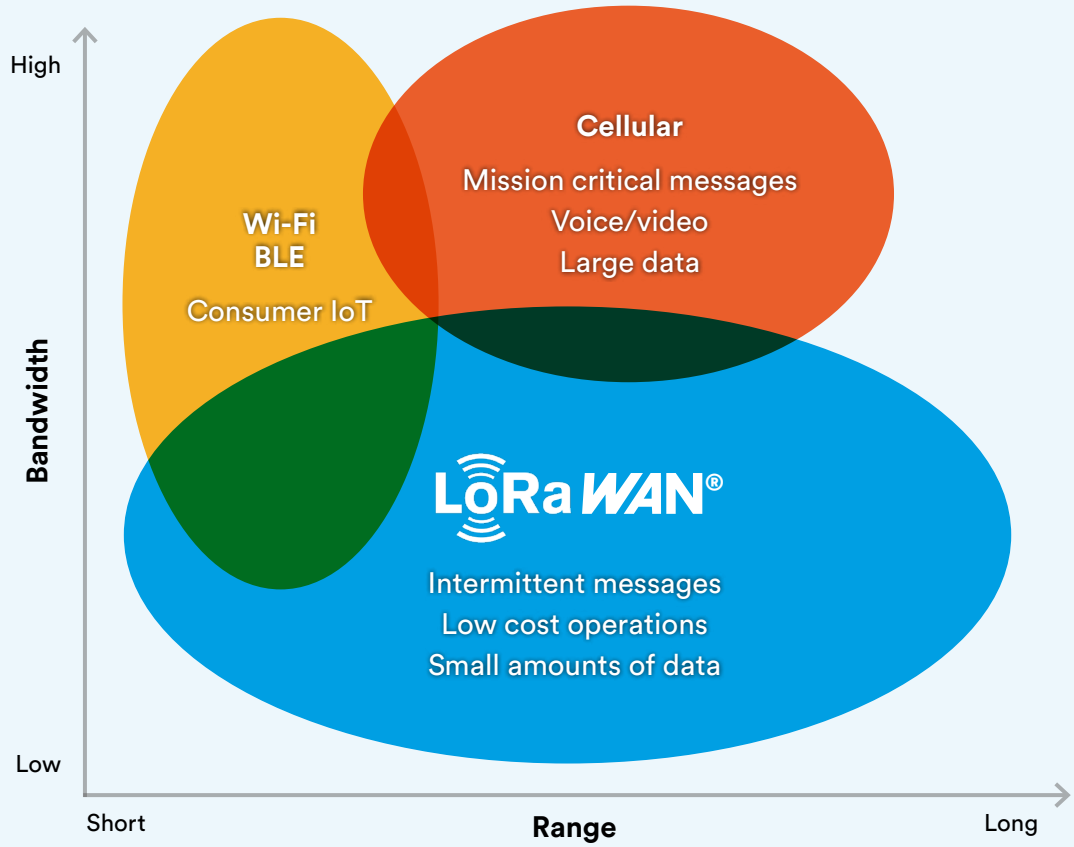
[1] https://resources.lora-alliance.org/technical-specifications/rp002-1-0-4-regional-parameters

[2] https://lora-alliance.org/wp-content/uploads/2021/11/LoRaWAN-Link-Layer-Specification-v1.0.4.pdf

Bandwidth vs Range: Where LoRaWAN® Fits

LoRaWAN enables data communication over long distances while using very little power. When connected to a non-cellular LoRaWAN network, LoRa devices can support a very wide range of IoT applications by transmitting packets with important information. LoRaWAN networks fill the technology gap of Cellular and Wi-Fi/BLE based networks that require either high bandwidth or high power, or have a limited range or inability to penetrate deep indoor environments.

LoRaWAN is flexible for rural or indoor use cases in smart cities, smart homes and buildings, smart agriculture, smart metering, and smart supply chain and logistics.



LoRaWAN® Secure by Design

Security is a fundamental need in all IoT applications and has been designed into the LoRaWAN specification from the beginning. However, the topic of security encompasses multiple properties and, in particular, the cryptographic mechanisms used to implement security in LoRaWAN need careful explanation. This section aims to present the security of the current LoRaWAN specification. Firstly, this presents the security properties embodied in the LoRaWAN specifications. Secondly, provides details of its implementation and thirdly, some explanations about LoRaWAN security design.

Properties of LoRaWAN Security

LoRaWAN security is designed to fit the general LoRaWAN design criteria: low power consumption, low implementation complexity, low cost and high scalability. As devices are deployed in the field for long periods of time (years), security must be future-proof. The LoRaWAN security design adheres to state-of-the-art principles: use of standard, well-vetted algorithms, and end-to-end security. Later, this section describes the fundamental properties that are supported in LoRaWAN security: mutual authentication, integrity protection and confidentiality.

Mutual authentication is established between a LoRaWAN end-device and the LoRaWAN network as part of the network join procedure. This ensures that only genuine and authorized devices will be joined to genuine and authentic networks. LoRaWAN MAC and application messaging are origin authenticated, integrity protected, replay protected, and encrypted. This protection, combined with mutual authentication, ensures that network traffic has not been altered, is coming from a legitimate device, is not comprehensible to eavesdroppers and has not been captured and replayed by rogue actors.

LoRaWAN security further implements end-to-end encryption for application payloads exchanged between the end-devices and application servers.

In some traditional cellular networks, the traffic is encrypted via over-the-air interface, but it is transported as plain text in the operator's core network. Consequently, cellular end users are burdened by selecting, deploying and managing an additional security layer (generally implemented by some type of VPN or application layer encryption security such as TLS). This approach is not suited in LPWANs where over-the-top security layers add considerable additional power consumption, complexity and cost.

Security Implementation

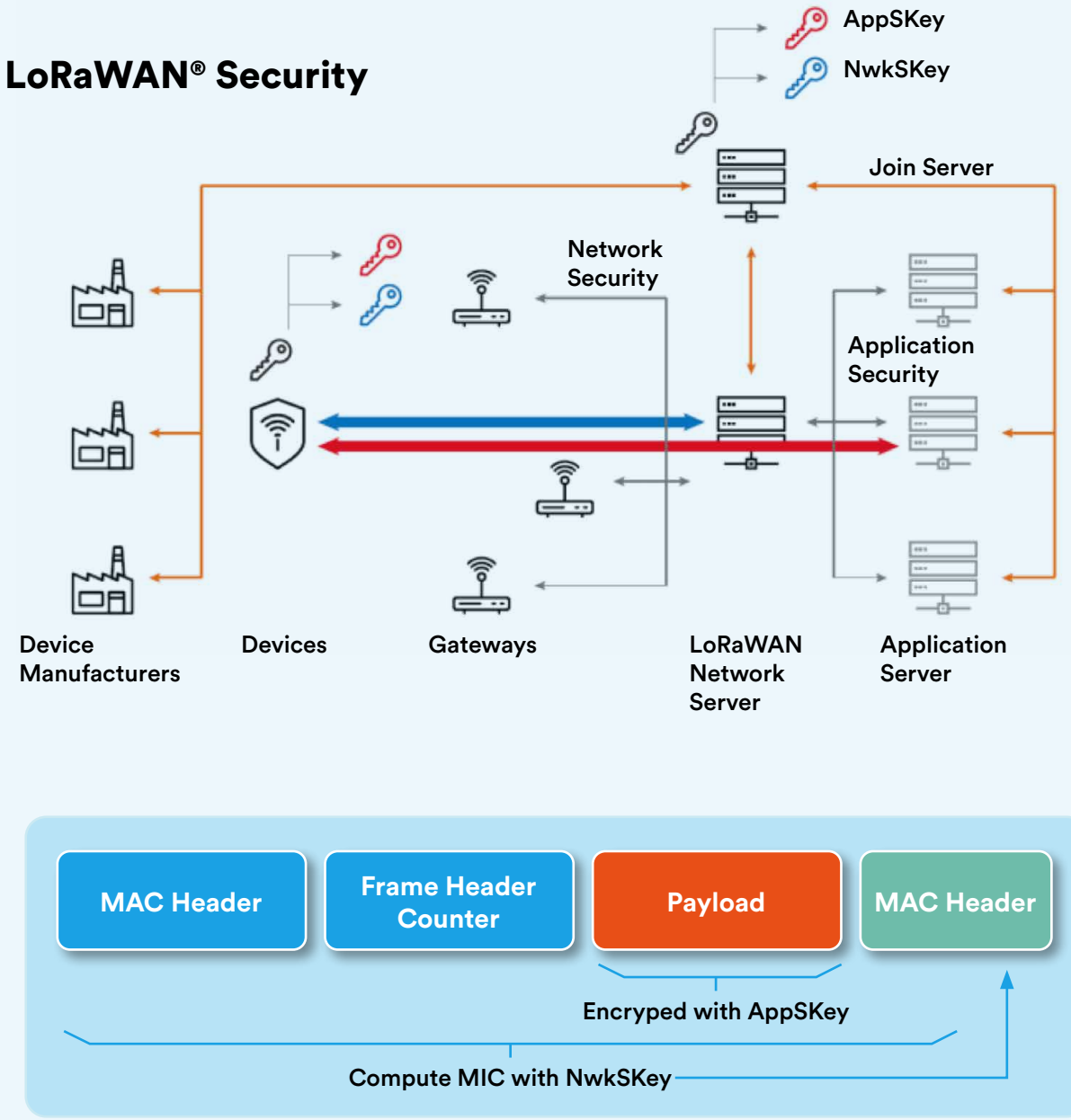
The security mechanisms rely on the well-tested and standardized AES (1) cryptographic algorithms. These algorithms have been analysed by the cryptographic community for many years, are NIST approved and widely adopted as a best security practice for constrained nodes and networks. LoRaWAN security uses the AES cryptographic primitive combined with several modes of operation: CMAC (2) for integrity protection and CTR (3) for encryption. Each LoRaWAN device is personalized with a unique 128 bit AES key (called AppKey) and a globally unique identifier (EUI-64-based DevEUI), both of which are used during the device authentication process. Allocation of EUI-64 identifiers require the assignor to have an Organizationally Unique Identifier (OUI) from the IEEE Registration Authority. Similarly, LoRaWAN networks are identified by a 24-bit globally unique identifier assigned by the LoRa Alliance.

Securing Application Payloads

LoRaWAN application payloads are always encrypted end-to-end between the end-device and the application server. Integrity protection is provided in a hop-by-hop nature: one hop over the air through the integrity protection provided by LoRaWAN protocol and the other hop between the network and application server by using secure transport solutions such as HTTPS and VPNs.

Mutual Authentication
The Over-the-Air Activation (also known as Join Procedure) proves that both the end device and the network have the knowledge of the AppKey. This proof is made by computing an AES-CMAC (4) (using the AppKey) on the device's join request and by the backend receiver. Two session keys are then derived, one for providing integrity protection and encryption of the LoRaWAN MAC commands and application payload (the NwkSKey), and one for end-to-end encryption of application payload (the AppSKey). The NwkSKey is distributed to the LoRaWAN® network in order to prove/verify the packets authenticity and integrity. The AppSKey is distributed to the application server in order to encrypt/decrypt the application payload. AppKey and AppSKey can be hidden from the network operator so that it is not able to decrypt the application payloads.

Data Integrity and Confidentiality Protection
All LoRaWAN traffic is protected using the two session keys. Each payload is encrypted by AES-CTR and carries a frame counter (to avoid packet replay) and a Message Integrity Code (MIC) computed with AES-CMAC (to avoid packet tampering). Diagram shows the structure of a LoRaWAN packet and its protection:



Additional Points to Note:

Physical security of a LoRaWAN device
AppKey and the derived session keys are persistently stored on a LoRa Alliance device and their protection depends on the device physical security. If the device is subject to physical threats, keys can be protected in tamper resistant storage (also known as Secure Element), where they will be extremely difficult to extract.

Cryptography
Some sources claim that LoRaWAN cryptography only uses XOR and not AES. In fact, as already mentioned, AES is used in the standardised CTR mode which makes use of XOR crypto operations (as many other modes like CBC (5)). This strengthens the AES algorithm by using a unique AES key for each block cipher.

Session key distribution
As AppSKey and NwkSKey are generated from the same AppKey, one could argue that if the LoRaWAN operator has the AppKey, it is able to derive the AppSKey and hence to decrypt the traffic. In order to avoid this situation, the server managing the AppKey storage, mutual authentication and key derivation can be run by an entity outside the control of the operator. In order to give operators additional flexibility, the LoRaWAN specification (1.1) defines two independent master keys: one for the network (NwkKey) and one for the applications (AppKey).

Backend interfaces security
The backend interfaces involve control and data signalling among network and application servers. HTTPS and VPN technologies are used for securing the communication among these critical infrastructure elements, much the same way as done in other telecom systems.

Implementation and deployment security
The LoRa Alliance works towards ensuring its protocol and architecture specifications are secure, while recognizing that the overall security of the solution also depends on the specific implementation and deployment. Implementation security issues need to be taken up by the relevant manufacturers and deployment issues need to be taken up by the relevant network operators. These two types of issues are not specific to the LoRaWAN technology and usually equally applicable to any radio technology implemented on the same platforms/networks.

Footnotes:
(1) AES - Advanced Encryption Standard. It is a public encryption algorithm based on symmetric secret keys, allowing message encryption and authentication.
(2) CMAC - Cipher-based Message Authentication Code.
(3) CTR - Counter Mode Encryption. It is a mode of operation of AES algorithm relying on a counter to encrypt streams of data.
(4) AES-CMAC - Cipher-based Message Authentication Code using AES encryption algorithm to provide message integrity and authenticity.
(5) CBC is a mode of operation of AES algorithm relying on an initialization vector and the previous data block to encrypt streams of data.

IPv6 Over LoRaWAN®

In addition to IPv4, LoRaWAN now seamlessly supports Internet Protocol version 6 (IPv6) from end-to-end. By expanding the breadth of device-to-application solutions with IPv6, LoRaWAN's addressable IoT market is also broadened to include internet based standards required in smart electricity metering and new applications in smart buildings, industries, logistics, and homes.

The IPv6 adaptation layer facilitates and accelerates development of secure and interoperable applications over LoRaWAN and builds on the LoRa Alliance's commitment to ease of use. IP-based solutions, commonly found in enterprise and industrial solutions, among many others, can be transmitted over LoRaWAN, and easily integrated with cloud infrastructures. This allows developers to quickly enable internet-based applications, while significantly reducing time-to-market and total cost of ownership.

The successful development of IPv6 Over LoRaWAN is credited to the active collaboration of LoRa Alliance members in the Internet Engineering Task Force (IETF) to specify the Static Context Header Compression (SCHC) and fragmentation techniques, which makes transport of the IP packets over LoRaWAN very efficient.

The LoRa Alliance IPv6 over LoRaWAN Task Force then took the SCHC specification (RFC 90111) and integrated it into the body of the LoRaWAN standard. LoRa Alliance member company, Acklio, made significant contributions to enable IPv6 over LoRaWAN and was integral to the development of the SCHC technology for LoRaWAN.

The first application to leverage SCHC for IPv6 over LoRaWAN is DLMS/COSEM for smart metering. It was developed as part of the liaison between the LoRa Alliance and DLMS User Association to address electric utilities requirement for the use of IP-based standards. There are many additional applications for IPv6 over LoRaWAN, including monitoring internet networking equipment, reading RFID labels, and IP-based smart home applications.

Relay Feature to Extend Coverage

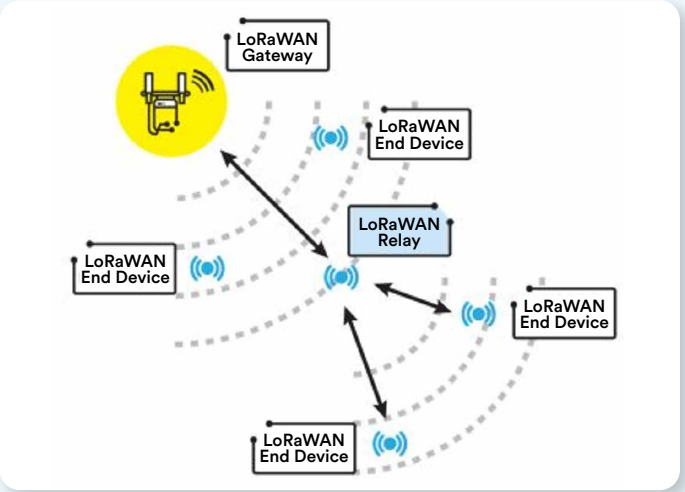
This feature expands the LoRaWAN link-layer standard with the addition of a relay specification. Relay allows for battery-operated, easy-to-deploy network coverage extensions at low cost in use cases requiring deep indoor or underground coverage, or relaying data on satellite connected LoRaWAN devices.

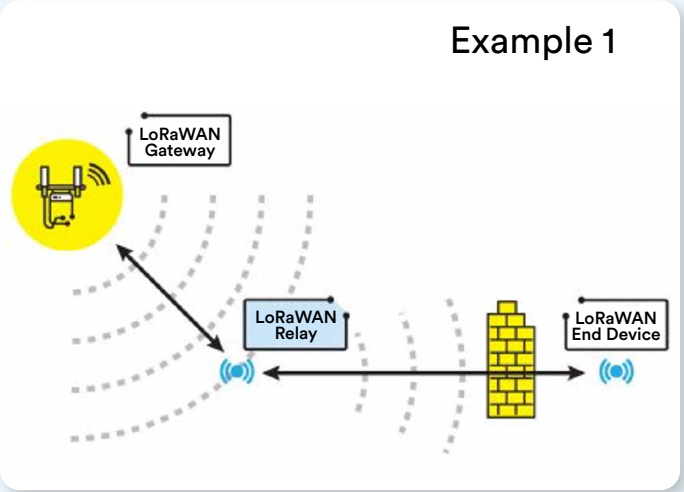
This provides a standardized solution for full end-to-end communications in extremely challenging underground, metal and concrete environments where sensor signals need a boost or redirect to reach either the gateway or end-device.

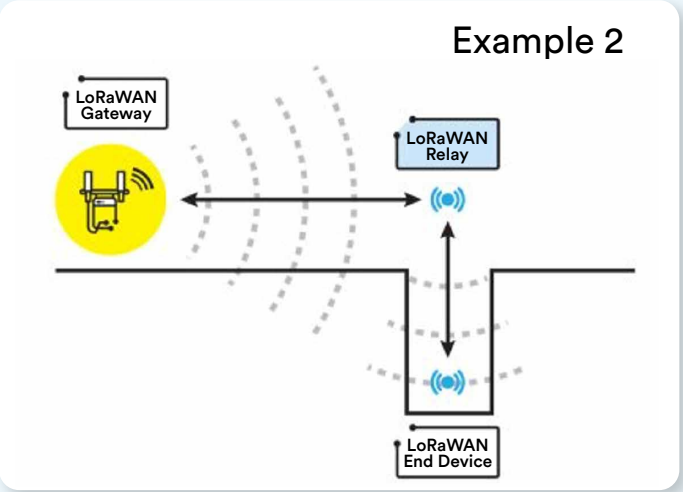
A key use for relay is metering in the utilities sector. Adding relay to the LoRaWAN standard to achieve coverage for even the most difficult cases (for example meters inside metal closets) significantly strengthens LoRaWAN's offer in metering and utilities, and more broadly across key verticals including smart cities and buildings, and industrial IoT.

The LoRaWAN Relay Specification document describes the relaying mechanism used to transport LoRaWAN frames bi-directionally between an end-device and gateway/ network server via a battery-operated node. By enabling relay, the device can transfer LoRaWAN frames between an end-device and network when there is insufficient coverage from the gateway.

This specification enables Network coverage extension through battery operated relay and maintains compatibility with the LoRaWAN Link-Layer standard in terms of protocol and security. The new relay nodes are battery-powered and can be installed anywhere. This makes them a very easy to deploy, low cost and low power way to extend network coverage, without needing to add additional gateways. Relay end points allow LoRaWAN to provide coverage of all devices with only a nominal cost of installation.







LoRa Alliance®: Maintaining Regulatory Compliance

Regulation is the cornerstone of the LoRaWAN ecosystem and working with policy makers and regulators is considered crucial for the success and growth of the LoRaWAN technology and its adoption globally.

Activities of the LoRa Alliance in these areas include the following:

Spectrum Regulation: The radio frequencies used by the LoRaWAN protocol fall under different regulatory domains in different countries. To ensure the efficient and interference-free operation of LoRaWAN networks, the LoRa Alliance closely monitors each region decision about spectrum in order to:

- Secure appropriate spectrum allocation
- Ensure compliance with spectrum regulations
- Maintain a harmful-interference-free environment
- Anticipate future LoRaWAN network deployments, for example LPWAN IoT satellite.

Legal Compliance: IoT technologies, including LoRaWAN, are subject to various regulatory and legal requirements, such as data protection, security and privacy laws. The LoRa Alliance collaborates with regulators to ensure that the technology and ecosystem meet these requirements to safeguard user data and privacy, gain public trust, and avoid potential legal issues.

Interoperability and Global Adoption: The LoRa Alliance aims to foster global interoperability and standardization of LoRaWAN devices and networks. Engaging with regulators in different regions helps ensure that regulatory frameworks align with the Alliance's goals and that LoRaWAN technology can be deployed seamlessly across borders, promoting wider adoption and larger markets such as smart utilities using LoRaWAN-enabled devices and services.

Support for New Applications: As the IoT landscape evolves, new use cases and applications emerge, many of which have unique requirements and may operate in specialized regulatory environments. By working closely with regulators, the LoRa Alliance can understand the needs of different industries and verticals and adapt the LoRaWAN technology to cater to these specific requirements, expanding the potential applications of LoRaWAN.

Policy Advocacy: Engaging with regulators allows the LoRa Alliance to advocate for policies that promote IoT adoption and innovation. By participating in discussions and sharing insights with regulatory bodies, the Alliance can help shape favourable policies that encourage investment in IoT infrastructure and technologies, benefiting the entire IoT ecosystem. It also anticipates future deployments such LoRaWAN satellites in the ISM bands.

In summary, maintaining positive and collaborative relationships with regulators is crucial for the LoRa Alliance to address regulatory challenges, ensure legal compliance, support global adoption, and advocate for policies that foster IoT growth. By doing so, the Alliance can extend its members' benefits with for example access to information on regulatory threats/opportunities and drive the expansion of LoRaWAN technology and its applications across various industries and regions.

LoRaWAN® Certification

A LoRaWAN Certified^{CM} mark indicates that a LoRaWAN device has been tested, de-bugged, and will function on any LoRaWAN-compliant network.

Interoperability between OEMs products is critical to growing the LoRaWAN market. LoRaWAN Certification helps to ensure devices made by different OEM's operate correctly with each other once they are deployed in the field. LoRaWAN Certification of end-node devices is also critical to an efficient and reliable LoRaWAN network deployment. Devices which misbehave can degrade network capacity and in extreme cases, make a network unusable. Bad behavior can be revealed by LoRaWAN Certification.

The LoRa Alliance certifies LoRaWAN end-nodes that are compliant with LoRaWAN standards and is aggressively working to bring additional, value-added certification programs to its members. Providing Certification of LoRaWAN features above Layer 2 is regularly deployed. Features like SCHC and FUOTA are already available.

Pre-certification testing with the LoRAWAN Certification Test Tool (LCTT) conveniently takes place at the OEM's facility. Certification testing then takes place at the LoRa Alliance Authorized Test Lab (ATL). Each ATL selected by the LoRa Alliance has met the requirements for ISO/IEC10725 and is recognized by international accreditation bodies. The LCTT was developed by the LoRa Alliance to automate testing of LoRaWAN end devices. The LCTT is provided to members who wish to pre-test and troubleshoot their devices prior to submitting them to an ATL for certification testing.

The RF Performance of a device is critical for the successful deployment of LoRaWAN networks to maximize the use of the radio spectrum available to the device. New optional extended RF tests will provide a full 3D radiated power scan, and a sensitivity figure of the devices ability to receive LoRaWAN packets. The ability to demonstrate a satisfactory level of RF performance is important as most operators require a minimum RF performance for the devices they allow onto their networks.

Public operators have experienced a large amount of issues with devices on both the LoRaWAN communication protocol (MAC layer) and the RF emission properties. These two aspects are crucial for a successful IoT application. Incompatibilities of the device with the LoRaWAN protocol could result in unwanted behavior on the network and inefficient energy management. Due to suboptimal antenna designs and sizes, insufficient RF emission power will cause the device to only use a small part of the network's full coverage, causing the coverage to seem a lot worse than it really is.

To ensure adequate performance of a device on a LoRaWAN network, each network operator distributes their own device qualification trademark after testing the applied hardware. Currently a hardware manufacturer must follow separate approval procedures at every public operator to obtain these network specific qualification trademarks. Therefore, many LoRaWAN public operators have agreed to use a common qualification process to approve devices on their networks. This process clarifies what must be done for a device to perform on a public network. The decision to approve a device remains with each network operator itself.

Key Properties of LoRaWAN®

Long Range

Connects devices up to 30 miles apart in rural areas and penetrates dense urban or deep indoor environments

Low Power

Requires minimal energy, with a prolonged battery lifetime of up to 10 years, minimizing battery replacement costs

Secure

Features end-to-end AES128 encryption, mutual authentication, integrity protection, and confidentiality

Standardized

Internationally recognised standard offers device interoperability and global availability of LoRaWAN networks for speedy deployment of IoT applications anywhere

Geolocation

Enables GPS-free tracking applications, offering unique low power benefits untouched by other technologies

Mobile

Maintains communication with devices in motion without strain on power consumption

High Capacity

Supports millions of messages per base station, meeting the needs of public network operators serving large markets

Low Cost

Reduces infrastructure investment, battery replacement expense, and ultimately operating expenses

Key Sectors

LoRaWAN® in Smart Buildings

Key Trends

- **There is an increasing emphasis on worker safety and comfort in workplaces post-Covid. Climate change is also priority, with sustainability reporting and associated monitoring**
- **Making workplaces more comfortable, ensuring clean air, avoiding overcrowding and extremes of temperature**
- **Encouraging workers to return to their offices**
- **The major increase in energy costs following the pandemic and war in Ukraine.**

Managing commercial properties has become increasingly challenging, between the conflicting needs of owners to keep costs down and renters wanting a safe and comfortable experience. In addition there are the escalating costs across all input areas, from energy to insurance.

Many buildings already use building management systems (BMS), which are most often hardwired systems installed during construction that automate building management with limited functions. LoRaWAN is a low-power, long range networking technology that complements BMS by providing critical information on building health and tenant usage, making it easy and cost effective to add-on IoT functionality in buildings without connecting into current BSM or IT infrastructures. Data can be transmitted through concrete, metal and underground, where other networking solutions struggle.

LoRaWAN-connected devices can be used to monitor and manage power, heat, cooling, gas, water, air quality and lighting-related energy consumption more efficiently – and provide real-time data on leaks, energy usage, occupancy patterns, security and environmental conditions. Additionally, LoRaWAN is an open standard backed by a large ecosystem of vendors, giving building managers a wide variety of solutions that can be tailored to meet their specific needs. It also means that building managers do not need to worry about being “locked-in” to a single source vendor, ensuring flexibility
over the building’s lifetime.

The number of applications that LoRaWAN can make “smart” in a building is extensive. Some of the widest adoption to date has been for:

- **HVAC and Climate Control**
- **Lighting & Signage Management**
- **Energy Management, incl. Power Mgt, Metering**
- **Air Quality Monitoring**
- **Occupancy Monitoring**
- **Smart Parking.**
- **Sustainability Monitoring**
- **Health Monitoring/Smart Hygiene**
- **Predictive Maintenance**
- **Asset Management**
- **Structural Health Monitoring (Vibration, Stress, Dampness)**
- **Water Management, Monitoring (Leak Control)**

By implementing LoRaWAN, managers have real time access to data, which offers insight they need to optimize conditions, prevent catastrophic damage and better utilize space and maintenance resources. The following are examples of the return on investment (ROI) being achieved by deploying LoRaWAN:

Water and gas leak detection. Insurance costs have increased by more than 300% since 2017, so any steps a building manager can take to improve monitoring not only prevent millions in damages but can also drive down insurance costs due to reduced risk. Kairos is a LoRa Alliance member who has seen strong results in this space delivering customers ROI in just 6 months by preventing property loss.

Gas leaks also present a huge risk to buildings and their users, which has led many local governments to mandate increased monitoring. Alliance member ProSentry recently showcased one of its many LoRaWAN monitoring solutions that saves lives and property by alerting staff to the exact location and severity of gas leaks within seconds, allowing them to address a gas leak up to 10 times faster than unmonitored situations.

Energy conservation is another application that affords a rapid and high ROI when LoRaWAN is used to collect and use data to optimize heating, ventilation and air conditioning systems. Nordic Propeye, also a LoRa Alliance member, has successfully achieved up to 30% energy reduction across its properties and ROI within a year in buildings equipped with LoRaWAN.

Real-time access to data enables buildings to be truly smart. Using technologies like LoRaWAN that are fit-for-purpose – meaning they meet the unique networking challenges of buildings – and are open standards allow building managers and owners to save costs and improve the experience of building occupants.

Some example case studies are as follows:

LoRaWAN® Enables SOFREL IoT Sensors to Lower Heating Expenses of Large Buildings (p27)

Building Owner Reduces Energy Consumption with LoRaWAN®-Enabled Sensors from ELSYS (p28)

Protecting New York City Condominiums from Water Damage with LoRaWAN® (p29)

LoRaWAN® Enables SOFREL IoT Sensors to Lower Heating Expenses of Large Buildings

Challenge

Each year, large buildings waste thousands of dollars and countless kilowatts in energy due to inefficient heating systems. The issue is often down to a lack of data. Without extremely accurate information on internal and external temperatures, it is not possible for building managers to setup heating systems efficiently.

Working in collaboration with several large facility management companies in France, LACROIX Group developed LoRaWAN-enabled SOFREL IoT Sensors to solve the issue. Placed inside the building and on the external facades, the sensors provide exact real-time temperature readings. In addition, interior motion sensors detect when people are inside the building. This enables the building manager to adjust heating to suit interior and exterior conditions in order to maximize efficiency and minimize costs.

Solution

The solution is used by facility management companies across France on a range of large buildings, including offices, apartment blocks, schools, and hospitals. Once deployed, the SOFREL IoT Sensors wirelessly transfer data and create a complete temperature map of a building. With this, a building manager can track temperatures on a smartphone or PC and design heating schedules to match the exact requirements of the users inside – and the temperatures outside.

LACROIX Group's SOFREL IoT Sensors are fully certified to meet the functional requirements of the LoRaWAN specification. This is important especially for facility management companies that deploy their own private LoRaWAN networks. Certification gives them peace of mind that a device will function smoothly on their network. The sensors also include cybersecurity features to protect sensitive company data.

Benefits

One key benefit of heat mapping is the elimination of 'blast heating'. On large buildings, one of the highest heating costs occurs when outside temperatures drop quickly, as rapid blast heating is required to bring internal temperatures up. With accurate, real-time temperature data, building managers can gently increase heat as soon as the outside temperature drops, lowering costs for the building operator, but also reducing strain on energy providers. By optimizing heating cycles, energy use is reduced which in turn reduces energy bills and minimizes carbon emissions from heating systems.

LACROIX

Building Owner Reduces Energy Consumption with LoRaWAN®-Enabled Sensors from ELSYS

Challenge

As one of the largest property rental firms in Sweden, Stockholmshem owns numerous residential buildings, providing homes for almost 60,000 tenants. Stockholmshem controls the heating in each apartment centrally – and heating is the company's single largest operating expense.

Previously, Stockholmshem adjusted heating based on the outdoor temperature. However, this often resulted in individual apartments being either too hot or too cold. Stockholmshem's solution was to install ELSYS's LoRaWAN-enabled ERS2 Lite sensors in all of its 22,000 apartments.

Solution

Placed in the hallway of each apartment, the ERS2 Lite sensor measures temperature and humidity. This data is transferred via a nearby LoRaWAN gateway to Stockholmshem's building operations system. Using this data, Stockholmshem can then adjust heating to ensure a steady indoor climate of around 20°C in each apartment.

The solution has significantly improved indoor conditions for Stockholmshem's tenants. Importantly, it has also reduced Stockholmshem's heating costs by around 6% per year.

Stockholmshem chose ERS2 Lite sensors from ELSYS as they are discreet and small (just 76×76×23mm), making them ideal to install in many apartments. Importantly, the sensors are also LoRaWAN-enabled, which gives Stockholmshem two key benefits:

- LoRaWAN ensures excellent penetration through building materials so no wires are required and the sensors are fast to install
- LoRaWAN is low power, extending sensor battery life (10+ years) which lowers maintenance costs

Benefits

Stockholmshem wants to become carbon neutral by 2030 and is striving to reduce carbon emissions across its operations. The LoRaWAN-enabled temperature monitoring system is a key measure in this work.

With the sensor system, Stockholmshem has estimated a reduction of energy consumption from building heating by over 8,000 MWh per year, the equivalent of heating 1,200 fewer apartments.

ELSYS.se

Protecting New York City Condominiums from Water Damage with LoRaWAN®

Challenge
Water-related losses in buildings have exponentially increased, leading insurance premiums to rise and resident dissatisfaction to grow when they incur costly losses and displacement. Many building management teams are choosing to install leak detection systems. One residential condominium in New York City discovered (the hard way) what can go wrong when each apartment installs a different system.

Six years into the condo's leak detection efforts, the residents, the board, and the building's management team noticed several challenges:

Notifications. Each resident's leak detection system notified the super of a leak in a different manner. Sometimes via constant texts until a valve was shut-off; sometimes with a phone call, or an unintelligible robocall.

Investment. Some residents invested significant amounts of money into technology created by businesses that then failed. Once the businesses were gone, their proprietary leak detection systems were no longer functional. Many of the systems were expensive.

Wi-Fi. Many residents' leak detection systems relied upon Wi-Fi for connectivity; however, Wi-Fi proved unreliable, frequently requiring that the network and leak detection system be reset and the monitors receive replacement batteries.

Water damage. The systems were unreliable, allowing water damage to occur in some instances.

Solution
The condo wanted a system that was consistent, easy to use and understand, could be customized to their needs, and would not interfere with the building's Wi-Fi.

ProSentry's LoRaWAN leak detection solution readily meets these needs. LoRaWAN can easily and affordably create IoT connectivity for an entire building and lay the groundwork for a holistic solution. Retrofitting a building to use LoRaWAN does not require a complex installation and LoRaWAN does not interfere with Wi-Fi. Because the LoRaWAN standard is an open protocol, sensors from different vendors can work together.

Benefits
This feature, as well as the breadth of the ecosystem, allows for a wide variety of solutions beyond water leak detection, such as gas leaks, mechanical malfunctions and environmental monitoring.

The ProSentry platform is fully customizable and provides an all-in-one wireless sensing solution. It provides modular monitoring, integrated insights, and instant notifications, which are also customizable according to the end user's desires.

ProSentry

LoRaWAN® in Smart Cities

A smart city is a city that uses advanced technology to improve the quality of life for its residents and make the city more efficient and sustainable.

Key Trends

- **Number of smart city projects is developing quickly worldwide. Recent reports suggest annual spend on related technologiesof $120bn worldwide in 2023, growing 10% per annum over the next decade**
- **The major increase in energy costs following the pandemic and war in Ukraine**
- **Cities finding that smart city projects are increasing in complexity with more partners needed to make them work**
- **Requirements that extend beyond the boundaries of their traditional projects, in particular environment-related**
- **Regulations taking on higher importance thanks to climate change and carbon reduction imperatives.**

LoRaWAN provides many benefits for smart cities, including:

Long-range connectivity: LoRaWAN's long-range connectivity allows IoT devices to be deployed over large areas, providing comprehensive coverage of the city. This makes it possible to monitor and control various aspects of the city's infrastructure and services, including street lights, traffic, air quality, waste management, and more.

Low-power consumption: LoRaWAN's low-power consumption enables IoT devices to operate for long periods on a single battery charge. This reduces maintenance costs and makes it easier to deploy and manage large numbers of IoT devices throughout the city.

Cost-effectiveness: LoRaWAN operates on unlicensed frequencies, which makes it a cost-effective solution for IoT applications that require wide area coverage. This reduces infrastructure costs and enables cities to deploy a large number of IoT devices without incurring significant expenses.

Scalability: LoRaWAN's star-of-stars network topology enables it to support large-scale networks with millions of devices. This makes it possible to connect a wide range of IoT devices throughout the city, enabling real-time monitoring and control of city infrastructure and services.

Security: LoRaWAN includes advanced security features, including end-to-end encryption, to ensure the privacy and security of data transmitted over the network. This protects the city's infrastructure and services from cyber-attacks and other security threats.

IoT applications most suitable for LoRaWAN®:

- **Energy management including detecting overuse of heating and lighting**
- **Environmental Sensing - Indoor air quality management, fire risk management; outdoor air pollution**
- **HVAC Heating, Ventilation, Air Conditioning in large public buildings – changes expected with climate change**
- **Public services including waste collection and disposal, street cleaning, City wayfinding systems**
- **Smart parking (public spaces)**
- **Smart roads infrastructure**
- **Street Lighting management**
- **Sustainability Monitoring**
- **Vertical transportation – smart elevators**
- **Water Management – supply for buildings and public areas, floods management**

Some example case studies are as follows:

Optimization of waste management, Saumur Val de Loire Agglomération (France) (p32)

LoRaWAN® Partners Unite to Solve Parking Issues (p33)

A Creative Way to Enable Smart City IoT with LoRaWAN® For Street Lights (p44)

Buildings | **Cities** | Utilities

Optimization of waste management, Saumur Val de Loire Agglomération (France)

Challenge

Saumur Val de Loire Agglomération was searching for a sensor and they asked Heyliot to equip a dozen voluntary drop-off points. Why use a sensor? When containers are full, people often leave their garbage outside, near the drop-off point. Saumur Val de Loire Agglomération wanted to avoid these overflows by being alerted as soon as a container is full. On the contrary, some points are also located on the outskirts of towns, and the Heyliot solution could also be used to optimize collections.

Solution

Deploy 15 sensors on above-ground and underground drop-off points previously identified as problematic.

- Thanks to its universal fixing system, the sensor can be installed on all types of waste containers
- In order to send their measurements, the sensors use the Orange public network dedicated to connected objects (LiveObjects).

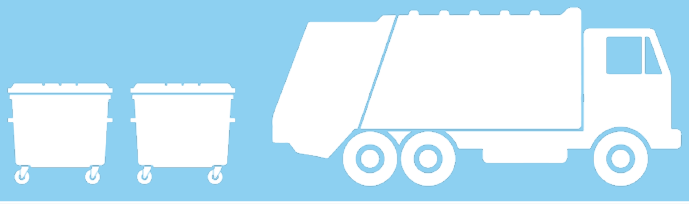
Benefits

- A better understanding of the activity of the container fleet
- An increased reactivity
- No more cleanliness problems

Customer Testimonial

After a few weeks of receiving feedback, we can make several observations: the data is proving to be most useful for the two most distant drop-off points being tested in order to optimize movements and adapt collection frequencies. For the voluntary drop-off points located in the center of Saumur, the sensor is able to detect bags that are stuck in the trash chute. We receive a notification indicating that the column is full and by analyzing the curve, we can very quickly realize that it is an obstruction. Our maintenance team intervenes to unblock the chute and thus avoids the illegal dumping of waste around the drop-off point. The hour-by-hour visualization of the filling rate is also useful in terms of operation, to better understand how the drop-off points are being used by the population. The Heyliot team knows how to make itself available and helped us throughout the deployment and use of the product, with regular feedback to best meet our needs.

Alice DESVALLON, Operations Manager



heyliot

LoRaWAN® Partners Unite to Solve Parking Issues

Challenge

Anyone who spends a lot of time driving knows that parking can be a time consuming and frustrating chore. With increasing congestion, parking restrictions and fewer stopping routes, drivers are finding it increasingly more difficult to find available spots. Adding to this difficulty is the challenge of paying the parking fee after a spot is finally secured. In some areas, meters are not easy to find, require coins or sometimes are even broken, all leaving the parker with even more frustration. It was all these challenges that the City of Huntington Park set forth to tackle in developing a new easy to use parking application for its citizens.

Nobel did their own homework on the gateways in the field. They needed the solution to be reliable in outdoor conditions, waterproof and airtight. The MultiTech gateway fit the bill. It also had a high LoRaWAN range. In a site survey of the gateway range, MultiTech's gateways had a much higher range for communication that would lessen the number of gateways required, reducing the expense for the City. If they had opted for another vendor, they would have needed more gateways. In the end, Nobel Parking decided, like the City of Huntington concluded, that the MultiTech Conduit® IP67 was their first choice.

Solution

Nobel's vision was a system that utilized sensors that would send sensor data to users via a user-friendly application. The city at the onset suggested utilizing LoRaWAN®, a Low Power Wide Area (LPWA) networking protocol designed to wirelessly connect battery operated 'things' to the internet, and services that support it. They also had specific wireless and gateway provider recommendations. Early in the process, it was determined that the Helium Network, the largest, public LoRaWAN network in the world, would be their choice for the wireless network and MultiTech as its ideal gateway provider.

Benefits

Utilizing LoRaWAN enables the City of Huntington Park to most cost-effectively connect a large number of parking space IoT sensors to the cloud. In addition, the now established LoRaWAN network allows additional services to easily be added to the network in the future, adding additional sensors if necessary. Alternative parking solutions reviewed required more infrastructure, such as dedicated RF network antennas and wiring to deploy such large applications.

Looking forward to the future, Nobel intends to develop additional solutions that utilize the MultiTech Conduit IP67 Base Station with Helium in new markets such as water utilities and health and sewer monitoring, to name a few. "It has really given us the ability to easily setup a LoRaWAN network with minimal configuration and the possibilities for innovation utilizing this combined solution are endless."

MULTITECH®

A Creative Way to Enable Smart City IoT with LoRaWAN® For Street Lights

Challenge

Smart city infrastructure requires a holistic approach that considers the inter-dependencies among different sectors and stakeholders.

It also requires a robust data infrastructure that enables the collection, analysis, and sharing of data across various platforms. By investing in smart city infrastructure development and monitoring, cities can leverage technology to address their most pressing challenges while also enhancing their sustainability and resilience.

When it comes to implementing gateways for LoRaWAN in smart city street lighting, one of the main challenges for cities is how to ensure reliable and cost-effective connectivity for a wide range of applications.

Another challenge is how to manage smart city IoT solutions. Cities need a platform that can enable remote monitoring, device control, data analytics, and data visualization.

Solution

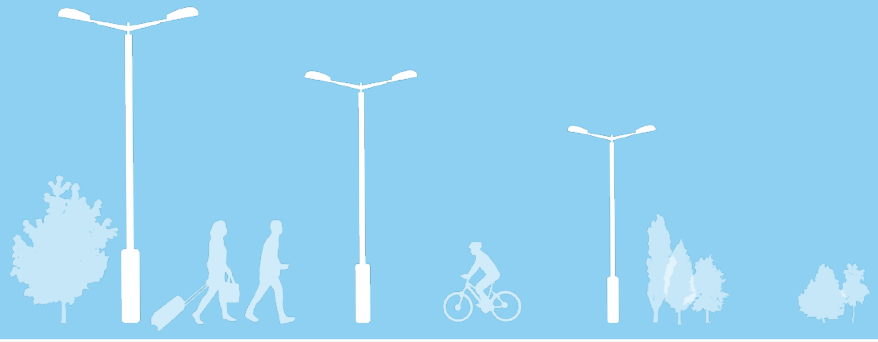
Felicity and TEKTELIC Communications have partnered to deploy TEKTELIC's KONA Micro Gateways into available streetlighting fixtures. The solution utilizes LoRaWAN® coverage to ensure data can be gathered cost-effectively and optimally when needed.

KONA Micro Gateways provide reliable 'always on' connectivity thanks to an integrated battery backup. This reassures Felicity and its clients that data will continue to be collected, even in the event of a power outage. The gateways are also designed to help customers achieve the lowest total cost of ownership with carrier-grade performance and high scalability.

Benefits

Deploying gateways for LoRaWAN in street lighting infrastructure provides a dense 2-km network radius of coverage, with simple and cost-efficient deployment.

The KONA Micro Gateways also provide deep penetration coverage characteristics, which allows for smooth data transfer in dense urban areas.



TEKTELIC communications

LoRaWAN® in Smart Utilities

Key Trends - Water

- Climate change causing global water shortage crisis
- IoT enables leak detection in underground pipes using high-tech acoustic loggers and electronic sensors
- Older utilities lose a great deal of water through leaks
- Water metering offers visibility into water usage, supply and demand and assists in forecasting
- Water treatment (releasing into rivers and sea) meeting strong regulatory pressures from multiple sources.

Key Trends - Gas

- Climate change now taken seriously across business and industry
- Utilities like gas highly regulated. Must continually prove they are making efforts to reduce Carbon footprint
- Necessitates better monitoring and control systems to optimise efficiency and safety.
- Protecting the health and safety of workers also increasingly mandatory
- Production facilities increasingly obliged to reduce pollutants emanating from their operations
- The major increase in energy costs following the pandemic and war in Ukraine, particularly affecting gas and the greater drive for smart metering as a result.

Utilities of all types have a need to improve control and measurement of the commodities they supply in order to bill consumption accurately, reduce wastage, cut operational costs and give a better customer experience.

Whether supplying water, gas or electricity, utilities need to supply reliable and safe services, while also doing so economically to ensure value for money for customers and continued revenue for the company. With the effect of climate change and population demanding more resources, utilities companies are also looking for ways to drive down waste, optimise the use of available resources and integrate the renewable resources.

Efficient metering is central to these goals. Reliable, easy to access data on water and gas volumes and flow rates is essential to managing distribution network such as optimizing the cost of energy used for pumping water at the right pressure level, or dosing better the water treatment process, while granularity of data on electricity consumption patterns is vital to capacity planning for smart grids.

They can do this by regularly collecting data from meters, monitoring all types of sensors and controlling remote valves or actuators in almost real time. The key to this is connectivity.

LoRaWAN is an ideal connectivity technology for utilities because it combines extremely long range, measured in miles, with deep underground and indoor penetration.

It also offers very long battery lifetimes of up to two decades, making maintenance less of a burden.

As a simple and efficient way to connect IoT devices, LoRaWAN has already proven its capabilities in numerous deployments for smart water and smart gas metering, with millions of water meters and gas meters deployed across the globe.

There are currently 181 LoRaWAN public networks and many private networks providing connectivity in more than 200 countries. With a large ecosystem of developers, suppliers and providers, utilities and their customers have a greater choice of applications and a greater number of device makers that can incorporate more widely deployed technologies into their device.

The technology is also an open protocol recognized by the ITU-T and supports OMS for M-Bus and DLMS with IPv6 adaptation layer among major international metering standards. The utilities require these key standards for ensuring interoperability and reliability of smart meters. The same standard can also be operated over different communication media, thus a smart meter can have dual connectivity interface to ensure the maximum coverage and uptime across different networks. Additionally, the same LoRaWAN network can support multi-metering applications, and support other IoT devices offering new benefits and revenues such as sensors for remote monitoring of pressure, water quality or detectors for gas or water leaks.

A new opportunity for IoT to play a key role in the digitization of utilities is with the management of infrastructure. Smart utilities can benefit from LoRaWAN sensors improving the resilience of their smart grid. With easier and lower cost of integration and deployment, sensors connected with LoRaWAN help utilities to identify and locate short-circuits and line faults faster, improving the uptime of the infrastructure. Industrial standards for smart grid such as IEC61850 and IEC 60870-5-104 can be supported for cost-effective monitoring. For the integration of new renewable energy (such as solar panels) in residential markets through support of IEEE2030.5, LoRaWAN is also likely to see increased adoption.

LoRaWAN supports flexibility in network models, as networks can be public, private, hybrid or community based and support roaming.

By enabling easy connectivity of smart IoT devices to a network, allowing data to be readily converted into insights and thus actionable decisions, LoRaWAN can help utilities cut costs, improve safety, reduce waste and improve customer satisfaction while still being compliant with different standards required by smart utilities.

Some example case studies are as follows:

LoRaWAN®-enabled Flowserve solution helps Anglian Water Reduce Costs and Downtime (p37)

Providing a Low Power, Low Cost, 100% Coverage Solution with LEO IoT Satellites (p38)

French utility to digitise 70% of water meters (p39)

Ensuring Reliable Gas Supply and Increasing Infrastructure Safety (p40)

LoRaWAN®-enabled Flowserve solution helps Anglian Water Reduce Costs and Downtime

Challenge

Anglian Water, one of the largest water utility providers in the UK, was facing increasing pressure to improve the reliability of its equipment. To address this challenge, the company implemented RedRaven, a Predictive Maintenance (PdM) service from Flowserve. The service includes Condition-Based Monitoring (CBM), which incorporates LoRaWAN wireless technology.

With RedRaven, Anglian Water was able to increase the efficiency of its predictive maintenance to avoid unscheduled shutdown, while also lowering costs and downtime.

Solution

RedRaven combines wireless LoRaWAN-enabled sensors with an advanced insight visualization portal (Insight Portal) to help utilities proactively identify and address issues before they cause downtime and disruptions.

Placed on a range of equipment, the sensors collect vibration, temperature, and pressure data. The data is transferred securely via LoRaWAN to the Insight Portal, where it can be monitored by the utility's technicians. Importantly, RedRaven's Monitoring Center also uses the data to provide technical insights and recommendations that help operators make more informed decisions to improve plant efficiency, productivity, and reliability.

Benefits

After successfully proving the RedRaven solution at four sites, Anglian Water implemented a full CBM Framework solution across all its clean water monitoring and recycled water operations – for up to 900 assets over a five-year period. With RedRaven, Anglian Water is:

- Changing its culture around predictive maintenance to reduce unexpected downtime
- Using valuable operational insights to increase efficiency
- Saving time, expenses, and work hours through better maintenance planning

For large water utilities, understanding the performance of their equipment and assets is essential. With the correct knowledge, the utility can avoid unplanned maintenance or breakdown stoppages, ensuring a consistent supply of water to end-users and avoiding any potential fines.

This requires a Condition-Based Monitoring solution that can:

- Be easily implemented wirelessly across wide distances
- Deliver 24/7 remote monitoring
- Enable immediate alert/alarm notifications
- Enable trend analysis insights

REDRAVEN FLOWSERVE

Buildings | Cities | **Utilities**

Providing a Low Power, Low Cost, 100% Coverage Solution with LEO IoT Satellites

Challenge

A major utility in the Middle East, in charge of managing approximately two million smart meters, wanted to improve the visibility of all its meters and assets to deliver better quality services to its customers. The utility faced challenges in capturing data from some meters and other fixed assets, especially when they were outside the cellular network range, due to the:

- expensive and unreliable cellular connectivity - local area network limited distance and the need for ongoing power supply - often inaccurate manual readings, time-consuming and costly truck rolls and site visits.

Solution

Wyld Networks have developed a new sensor-to-satellite module suite with LoRaWAN® that allows IoT sensors and devices to communicate directly with the cloud, using Low Earth Orbiting (LEO) satellites. Wyld's low-power, low-cost LoRaWAN solution enables data to be sent via Wyld Connect, using just 2 x AA batteries or a small solar cell, with an expected battery life of up to several years. It provides 100% coverage of any water and electricity metering and infrastructure monitoring for any location. Operators can access the data via the Wyld Fusion cloud-based platform.

Benefits

By gaining 100% visibility on all meters and assets, the utility can now enable a predictive and preventive strategy to monitor its networks for leak, level and pressure sensors, water levels and pressure sensors, transmission lines, substations, and solar power stations.

Wyld's LEO IoT satellites provide uninterrupted 100% global connectivity so that the utility can meet its commercial and sustainability targets and deliver economic opportunities to drive development, growth and new jobs. Using Wyld Connect and Wyld Fusion, the utility can enhance its operational efficiency and effectiveness and promote preventive maintenance, including planning, production, transmission and distribution.

Wyld

French utility to digitise 70% of water meters

Challenge
Veolia and its subsidiary Birdz have selected Orange Business Services to digitise its water services.

The two will digitise their water metering by connecting over 3 million water meters using a LoRa network over the next ten years.

The goal to read more than 70% of the meters remotely by 2027 follows a suceessful 12-month pilot in Toulese.

Solution
Birdz has chosen Orange Business Services to help it make a strategic shift from a technology requiring deployment of a radio network infrastructure to a solution that is open, interoperable and reversible and also a solution which meets the needs of our customers.

The network currently covers 30,000 municipalities and 95% of the population of Metropolitan France.

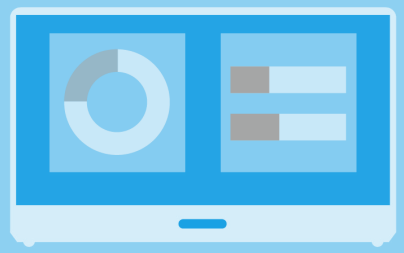
The smart water meters project will help reduce consumer bills by giving them access to real-time water usage data which they can use to identify potentials to enhance water efficiency.

For Veolia and Birdz, the project will help improve water management to ensure sustainable management of water resources and to enhance revenue collection and reduce non-revenue water through quick detection of water leaks and fraud.

Benefits
The LoRa network will allow Birdz to focus on their core business and develop new services.

Birdz will also rely on Live Objects, the object and data management platform of Orange Business Services, to collect the mass of information from the meters.

Frédéric Van Heems, CEO of Veolia Water France, stated: “This project with Orange Business Services illustrates Veolia’s goal to digitalize our businesses and services. It is a true growth driver that will allow us to optimise our methods and performance, and also to propose new services to our customers, in line with their expectations for efficiency, interoperability, and transparency.”



VEOLIA

Ensuring Reliable Gas Supply and Increasing Infrastructure Safety

Challenge
With the demand for natural gas on the rise and millions of miles of aging distribution infrastructure needing to be maintained, utilities are looking to the Internet of Things (IoT) to digitally transform the industry. The evolution to Advanced Metering Infrastructure (AMI) initiatives is producing accurate and timely invoicing, improving customer satisfaction and encouraging waste reduction by consumers. Additionally, real-time and historical data from smart gas meters enable gas utility companies to efficiently manage their operations, including energy production, distribution and delivery, while reducing costs and optimizing resource allocation.

Solution
Vestitel researched different connectivity options and selected Semtech's LoRa devices and the LoRaWAN® standard.

"We chose LoRa® because it is a proven technology that has emerged as the global standard for LPWAN connectivity. The long range performance and low power consumption of LoRaWAN and amazing battery life of LoRa-enabled devices are ideal for smart metering and smart infrastructure applications."
- Valentin Velichkov, CEO at Vestitel

Devices integrated with LoRa and the LoRaWAN standard aredifferentiated by an open ecosystem, strong security specifications, bidirectional communication, optimization for mobility, and scalability for capacity. The architecture of the LoRaWAN standard is a fault tolerant and redundant platform designed to connect hundreds of thousands of low cost, battery-operated sensors over long distances and harsh environments that have been too challenging or cost prohibitive for cellular or local area network(LAN) technologies.

The success of LoRa in LPWAN-based IoT applications speaks for itself: IoT networks based on the LoRaWAN standard are currently deployed in 173 countries with an ecosystem supported by hundreds of contributing members of the LoRa Alliance®, an open, nonprofit association with the mission to support and promote the global adoption of the LoRaWAN standard.

Benefits
Vestitel leveraged members of the LoRa Alliance to build its state-of-the-art LoRaWAN network, supporting M-Bus and DLMS metering standards, across the entire territory of Bulgaria and Greece. A strategic partnership with OrbiWise, a leading provider of advanced technologies for the IoT industry, is responsible for connecting and deploying several hundred gateways and 100,000 gas meters manufactured by GoldCard through the end of 2025.

Vestitel has already deployed smart metering in Sofia, the capital of the Balkan nation of Bulgaria with a population 1.7 million, and six other cities across Bulgaria and Greece, including Thessaloniki, the second largest city in Greece. The use case will serve as the blueprint for the Balkan region. In addition to smart metering, LoRa is providing critical measurements for gas pressure and temperature throughout Sofia, as well as leak detection and malfunction notifications. When an anomaly appears, Overgas can shut off valves remotely then send technicians to evaluate and repair equipment.

vestitel SEMTECH

For Further Information on LoRaWAN®

See LoRa Alliance site at: https://lora-alliance.org/

Contact LoRa Alliance at: https://lora-alliance.org/contact/

Upcoming Events

The LoRa Alliance will also have a large booth with many members at:
Smart Cities Expo World Congress in Barcelona. 7-9 November 2023
ENLIT Europe in Paris. 28-30 November 2023

LoRa Alliance®

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Shaping the IoT future