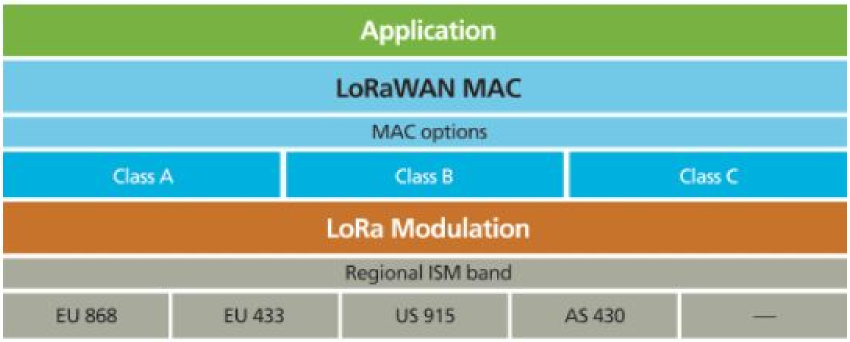
LoRa

What is LoRa®?

LoRa (short for long range) is a spread spectrum modulation technique derived from chirp spread spectrum (CSS) technology. Semtech's LoRa devices and wireless radio frequency technology is a long range, low power wireless platform that has become the de facto technology for Internet of Things (IoT) networks worldwide. LoRa devices and the open LoRaWAN® protocol enable smart IoT applications that solve some of the biggest challenges facing our planet: energy management, natural resource reduction, pollution control, infrastructure efficiency, disaster prevention, and more. Semtech's LoRa devices and the LoRaWAN protocol have amassed several hundred known uses cases for smart cities, smart homes and buildings, smart agriculture, smart metering, smart supply chain and logistics, and more. With over 158 million devices connected to networks in 92 countries and growing, LoRa devices are creating a Smarter Planet.

What is LoRaWAN®?

The LoRaWAN open specification is a low power, wide area networking (LPWAN) protocol based on LoRa Technology. Designed to wirelessly connect battery operated things to the Internet in regional, national or global networks, the LoRaWAN protocol leverages the unlicensed radio spectrum in the Industrial, Scientific and Medical (ISM) band. The specification defines the device-to-infrastructure of LoRa physical layer parameters and the LoRaWAN protocol, and provides seamless interoperability between devices. While Semtech provides the LoRa radio chips, the LoRa Alliance®, a non-profit association and the fastest growing technology alliance, drives the standardization and global harmonization of the LoRaWAN protocol.

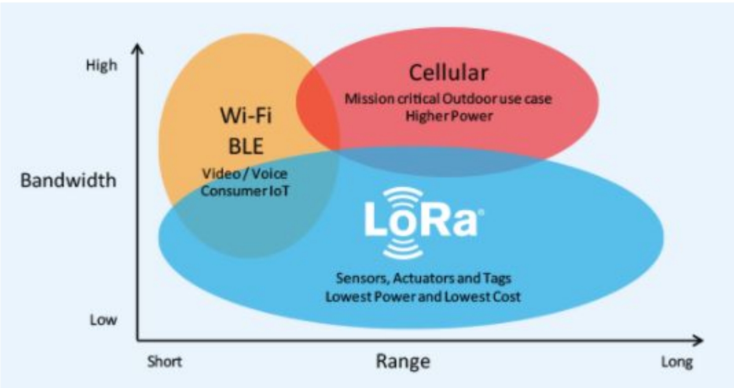


The first layer is the physical layer. LoRa, is the physical layer or the (wireless) modularization which creates the long range communication link. LoRaWAN is about the communication protocol and system architecture for the network as the LoRa Alliance puts it. Or even simpler: LoRaWAN is the network *(WAN = Wide Area Network)*.

Why LoRa®?

Unlike other disruptive technologies that can be slow to gain global adoption, Semtech's LoRa Technology is not a promise of a future potential, but is available today all around the globe. With over several hundred known use cases (and growing), and more than 158 million devices deployed on every inhabited continent, Semtech's LoRa devices and the LoRaWAN® protocol are creating a Smart Planet. Industry analyst IHS Market projects that 43% of all LPWAN connections will be based on LoRa by 2023. LoRa Technology is realizing the potential of the Internet of Things (IoT).

LoRa Technology has revolutionized IoT by enabling data communication over a long range while using very little power. When connected to a non-cellular LoRaWAN network, LoRa devices accommodate a vast range of IoT applications by transmitting packets with important information. LoRaWAN fills 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. In effect, LoRa Technology 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.



Filling the 5G Gap

While 5G was designed to bring faster speeds and connectivity, LoRa devices and the LoRaWAN protocol serve distinct use cases where devices need to be battery-operated and last in the field extended periods of time. The LoRaWAN protocol has a communication range reaching more than six miles, which is further than 5G's mmWave variant. While 5G may be optimal for video calls or ultra-low latency applications, LoRaWAN is ideal for water and gas metering, asset tracking and many more applications where low power consumption and long range are required. In addition to LoRa devices' long range capabilities, it has the power to penetrate physical structures where 5G signals cannot.

LoRa Complements Wi-Fi, Bluetooth and Cellular

Like Wi-Fi, LoRaWAN operates in the unlicensed band and supports indoor applications; like Cellular, LoRa Technology is highly secure from end devices to the application server, and is suitable for outdoor applications. LoRa devices and the LoRaWAN protocol combine these features of Wi-Fi and Cellular networks to offer an efficient, flexible and economical connectivity solution ideal for IoT applications whether indoor or outdoor and installed in public, private or hybrid networks. Simple sensor data can fuel analytics platforms, such as those for artificial intelligence and machine learning. These require data diversity which is made possible by low-cost LoRa-enabled sensors.

Fun Facts:

The patented LoRa wireless radio frequency technology stands for the physical layer protocol while LoRaWAN, developed by the LoRa Alliance, stands for the media access control layer protocol, which leverages and includes the physical LoRa modulation of Semtech. LoRaWAN networks, using the LoRaWAN protocol, are offered by over 70 network operators and there are LoRaWAN IoT deployments in more than 100 countries (private ones included)

The LoRa® Ecosystem

LoRa Technology is bolstered by a diverse global ecosystem of hardware manufacturers, software designers, network providers, and industry associations. Learn more about each of these providers below, and explore featured solutions. To shop for a specific product or service to support a LoRa-based device design or LoRaWAN® network deployment, search Semtech's catalog of LoRa-based products and services found in the LoRa Developer Portal. (Link)

LoRa Alliance

Established in 2015, the LoRa Alliance is an open, non-profit association dedicated to the standardization of low power wide area networks (LPWAN) and the global promotion of the LoRaWAN® open standard. The LoRa Alliance mission is to support and promote global adoption of the LoRaWAN standard by ensuring interoperability of all LoRaWAN products and technologies, enabling the Internet of Things (IoT) to deliver a sustainable future.

Gateways

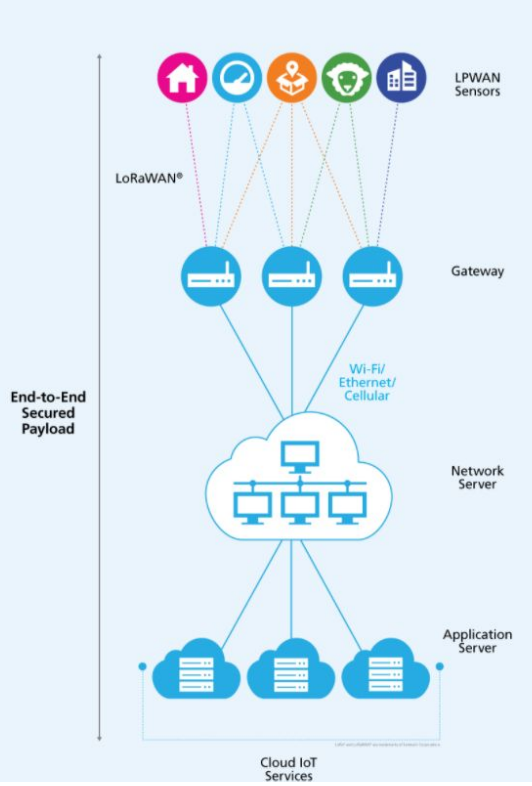
One of the first steps to creating a LoRa-based project is selecting the right hardware. From starter kits to gateways and modules, there is an expansive catalog of hardware available to support Internet of Things (IoT) projects for any end-market application. Find the right LoRaWAN gateway for your solution by exploring featured gateway providers. (Link)

Software

To deploy an IoT solution based on LoRa Technology, the right selections of application and network server software will need to be in place. Several IoT development platforms support LoRa Technology to help simplify deployment of LoRa-based systems.(Link)

Networks

Bring LoRa-enabled devices to life by connecting to a public or private LoRaWAN network. With coverage on six continents, a LoRaWAN network is available in over 100 countries around the world. Discover featured networks and access a global coverage map. (Link)



LoRa Devices: Connected Everywhere

Designed for IoT communications, LoRa devices and the LoRaWAN protocol enable the connection between remote point-of-use devices and LPWANs for delivery to analytics applications.

Devices

LoRa Modulation: Semtech's LoRa is the physical (PHY) silicon layer, or wireless modulation, used to create the long range communication link.

Transceivers & End-Nodes: Transceivers configured with LoRa devices are embedded into end-nodes, or sensor devices, designed for a multitude of industry applications.

Picocells & Gateways: Sensors capture and transmit data to gateways over distances near and far, indoor and outdoor, with minimal power requirement.

Networks

Network Server: Gateways send information via Wi-Fi, Ethernet or Cellular to the network server, which is responsible for network management functions like over-the-air activation, data de-duplication, dynamic frame routing, adaptive rate control, traffic management, and administration.

Applications

Application Servers & Cloud IoT Services: Applications interpret the data collected by LoRa-based devices, applying techniques like machine learning and artificial intelligence to solve business problems for a Smarter Planet.

Key Features of LoRa Technology

Long Range

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

Geolocation

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

Low Power

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

Mobile

Maintains communication with devices in motion without strain on power consumption

Secure

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

High Capacity

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

Standardized

Offers device interoperability and global availability of LoRaWAN networks for speedy deployment of IoT applications anywhere

Low Cost

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

Understanding LoRa Technology

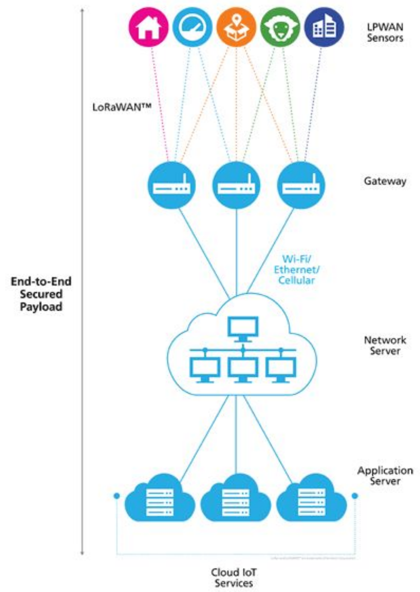
In any typical **IoT solution** provided for warehouse management or field monitoring, there will hundreds of Sensors nodes deployed on the field which will monitor the vital parameters and send it to the could for processing. But these sensors should be wireless and should operate on a small battery so that it is portable. Wireless solutions like RF can send data to long distance but requires more power to do so thus cannot be battery operated, while BLE on the other hand can work with very little power but cannot send data to long distance. So this is what brings in the need for LoRa.

In LoRa we can achieve high distance communication without using much power, thus overcoming the drawback of Wi-Fi and BLE communication. But how is it possible? If that is the case why do BLE and RF still exist?

That is because **LoRa comes with its own drawbacks**. In order to achieve high distance with Low power LoRa compromises on Bandwidth, **it operates on very low bandwidth**. The maximum bandwidth for Lora is around 5.5 kbps, this means that you will be able to send only small amount of data through LoRa. So, you cannot send Audio or Video through this technology, it works great only for transmitting less information like sensor values.

Many people compare LoRa with Wi-Fi or Bluetooth, but these two do not stand anywhere near LoRa. Bluetooth is used to transfer information between two Bluetooth devices and Wi-Fi is used to transfer information between an Access Point (Router) and Station (Mobile). But LoRa technology was primarily not invented to transmit data between two LoRa modules.

You can think of LoRa to be more like cellular communication. Signal from one **LoRa Node** reaches another Node through a **LoRa Gateway** as shown in the image below.



These Gateways then take the information to the internet and finally to the end user through an application interface. Similarly the **data from the user will also reach the node through the network server and the Gateway**.

A LoRa Node usually operates on a Battery and consists of a Radio Module and Microprocessor. The Microprocessor is used to read the data from the senor and send it in the air through the Radio module which will then be picked up by a LoRa Gateway. The LoRa Gateway also has a Radio Module and a Microprocessor but is normally operated over AC mains since they require more power. **A single LoRa Gateway could listen to multiple LoRa nodes, while a single LoRa node could also send information to multiple gateways**, this way the information from the node will be picked up gateway without it being lost. **When information id is sent from the node to the gateway it is called as uplink and when it is sent from gateway to node it is called as down link.**

LoRa falls under the category of LPWAN, where LPWAN stands for Low Power Wide Area Network. It is not just LoRa that can operate on LPWAN, but we also have other technologies like Narrow Band IoT (NB-IOT), Sigfox etc. which are capable of operating in the same LPWAN. Once the technology of LoRa was introduced, it needed certain set of protocols to be followed by all manufactures, so the LoRa alliance was formed which then introduced the LoRaWAN. LoRaWAN is a modified form of LPWAN which specifies the protocol on how LoRa in a physical layer should be used to send and receive data among the nodes, gateways and to the internet.

Conclusion

The whole idea for the project at hand is to make sure the device has the capability of reading data from other LoRa Nodes. LoRa Nodes are the physical layer as mentioned multiple times This means they are responsible for collecting the data from a sensor and transfer it through other nodes and gateways. Gateways are the stations that listen to the data transferred from nodes and send it to the end-user through different networks like WiFi.

BBGW can be set up as a gateway and be able to read data from different nodes with different frequencies. How can we make the BBGW a Gateway?

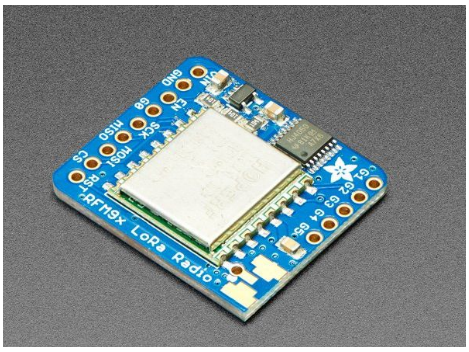
Before going in deep with the gateway idea, it should be noted that this is not the only approach that we can have in here. In LoRa Mesh Network with BeagleBone Black, They made their BBB into a node rather and gateway and had multiple of them in order to communicate and transfer the data. Nodes are limited in terms of frequency and number nodes they can connect simultaneously.

Buy

For being able to implement LoRa feature for BeagleBone we need to make the BBGW a node that only receives data or Gateway. Therefore, we need transceiver or gateway module

RFM95W - LoRa Radio Transceiver Breakout - 868 MHz (2x)

This module can help us in receiving or sending data at frequency of 868 MHz, which is allowed by EU.(US: 915 MHz)



Pros

1. Cheap Solution
2. Adafruit library supports the module
3. Both SPI and I2C are available

https://www.adafruit.com/product/3072

digitec (Not exactly this device)

RHF0M301 LoRaWAN Module

This module can create a Solid gateway as it can support all the available frequencies allowed in different countries. However this solution is expensive and proper libraries are not currently available for Adafruit. RHF0M301 & Features

Next step is to have a proper LoRa sensor to make sure we can test the implementation. Instructions and possible design are explained for each of the above configurations.

RFM95W

These modules enable BBGW to utilize radio frequency modulation of LoRa to transfer the data from one transceiver to another. However, this module does not have LoRaWan protocol and it is not able to communicate with all commercial LoRaWan sensors(All Commercial Sensors) . Therefore, BBGW is not a Gateway but a LoRa node that can receive data from another node, which transfers data through LoRa technology without LoRaWan protocol.

Scenario: Another microcontroller like BBGW or Arduino should be set to be a LoRa node that reads data from any sensor and sends it to the Receiver node, which is BBGW. Therefore another RFM95W is required to fulfill this requirement.

Proving Concepts: it is possible to utilize long range data transfer capability of the LoRA network and if the arduino involved on the sensor node (sender), we can also prove the low power consumption.

RHF0M301 LoRaWAN Module

First point is that gateways translate LoRa air modulations to proper IP protocols to communicate with other devices.With This module we can now communicate with LoRaWan with any commercial sensor that uses this protocol. There are many different sensors available on the market. Devices

The process of connecting the module to a node is not very well clear at this moment for me as people usually upload the code to the sensors as well to make sure they will be connected to the correct gateway. This requires testing sessions with sensors and a commercial gateway to make sure the process is well cleared.

There is no python code available to upload code to the RHF0M301 or send data. However, I speculate that it can be done (but need to be tested) through SPI protocol that is available for the Module.

Barriers To Building Private Networks With LoRaWAN

LoRaWAN works well for some applications, but it's not the best fit for **customer-deployed (also known as private network) solutions.** The main reasons for that are:

The coexistence of multiple gateways allows for interference. With LoRaWAN, all gateways—no matter who owns or operates them—are tuned to the same frequencies. That means your LoRaWAN network sees all my traffic and vice versa. It's better to have only one network operating in a single area in order to avoid collision problems.
However, it is possible to work through the LoRa Alliance to have specific channels set aside for specific uses. It is also possible for network operators to limit the amount of downlink in their networks from the server side to ensure low priority endpoints don't "clog" the network with downlink traffic.

It does not guarantee message receipt. LoRaWAN is an asynchronous, ALOHA-based protocol where packet error rates (PER) of more than 50 percent are common. This is fine for some meter-reading applications, but for industrial or enterprise sensor networks or control systems, 0 percent PER is a requirement. The "spray-and-pray" method of message delivery is not appropriate for most industrial use cases, which is why LoRaWAN is best suited for uplink-focused networks.

It requires a fair amount of development work. Another challenge our customers have faced is that LoRaWAN is primarily a data link (MAC) layer (OSI Layer 2), with only some elements of a network layer (OSI Layer 3). As of today, no vendor provides an end-to-end LoRaWAN solution. Instead, you need to work with multiple vendors to acquire nodes, gateways, a backend server, and every other part of the ecosystem separately. While this allows for a lot of flexibility in applications, it leaves application developers with a good amount of work to produce a complete product offering. This includes packetization, downlink control, multicast, etc.

There are duty cycle limitations. There are some limitations inherent with 868 MHz bands in public networks. In Europe, the main limitation is the one percent duty cycle (in most cases). This means if you measure the average length of time the gateway is transmitting over time, it cannot exceed one percent. Because of this, the gateway is pretty limited in how much it can transmit. In the U.S., FCC regulations for the ISM band have no such limitation.

It has a variable maximum transmission unit (MTU) payload size. Another big limitation of LoRaWAN is that the MTU payload size is variable based on the spreading factor the network assigns to the node. In other words—if you're far away from the gateway the number of bytes you can transmit is small, but if you're close it's much bigger; you simply can't know that ahead of time. Therefore, the node firmware or application has to be able to accommodate changes in the payload side at the application layer, which is very challenging when you're developing firmware.

Most developers solve this problem by selecting the smallest available MTU at the highest spreading factor the network could assign, which in most cases is very small, often less than 12 bytes. So LoRaWAN nodes that need to send larger amounts of data, for example 300 bytes, would have to send it in 30 10-byte messages because they may face a situation where they are assigned a small MTU. As a result, those nodes transmit much more than necessary due to the complex software alterations that would be required to handle these changing MTU values.

LoRaWAN is fine if you want to build on carrier-owned and operated public networks. There are many hardware and network server providers competing in this space, so there is a lot of choice. And for simple applications, where you don't have a lot of nodes and don't need a lot of acknowledgement, LoRaWAN works. But if your needs are more complex, you will inevitably hit serious roadblocks. Many LoRaWAN users haven't experienced those roadblocks yet simply because their networks are still fairly small. Try using LoRaWAN to operate a public network with thousands of users doing different things, and the difficulties will most certainly skyrocket.

Also, developing and deploying a system around LoRaWAN is a complex process. One of the reasons we wrote this article is because we have customers approach us who are under the impression that LoRaWAN "works out of the box" like some WiFi or cellular modems might. You'll want to be sure you understand all the architecture and have a good grasp on how the system works before you decide it's the best route for you.