element14 Essentials: IoT II

element14 Learning Center

IoT II: LoRaWAN for IoT Applications *Sponsored by* MICROCHIP

Featuring: Arduino, Microelektronica, The Things Network, ST Microelectronics, Laird Technologies, & Pycom

1. Introduction

As the Internet-of-Things (IoT) becomes more mainstream, one of the issues to consider has been how to send tiny bits of information from miniscule sensors over long distances using extremely low power. The general class of a network capable of wide area connection using low power is called a Low Power Wide Area Network (LPWAN). Among LPWAN technologies, Long Range Wide Area Network or LoRaWAN is proving to be an extremely effective solution with practical applicability to IoT applications. In this Learning Module, we take a close look at LoRaWAN technology.

2. Objectives

Upon completion of this module, you will be able to:

- Define LoRaWAN technology
- Describe what LoRaWAN can be used for
- Explain how LoRaWAN works
- Compare LoRaWAN to other LPWAN technologies

3. What is LoRaWAN?

LoRaWAN is the name for a network technology protocol stack that is based on the LoRa chipset. LoRaWAN is maintained by the LoRa Alliance, which includes among its membership companies such as Cisco, IBM, Semtech, HP, Orange, Proximus, ARM, Microchip, NEC, and many others. (See full list.)

LoRaWAN is ideally suited for IoT applications that require sensing at long ranges (2-15 km; 1-9 miles). LoRaWANs are characterized by a star-of-stars topology. LoRaWAN finds applications in Smart grid, Smart cities, industrial automation, farming, and much more.

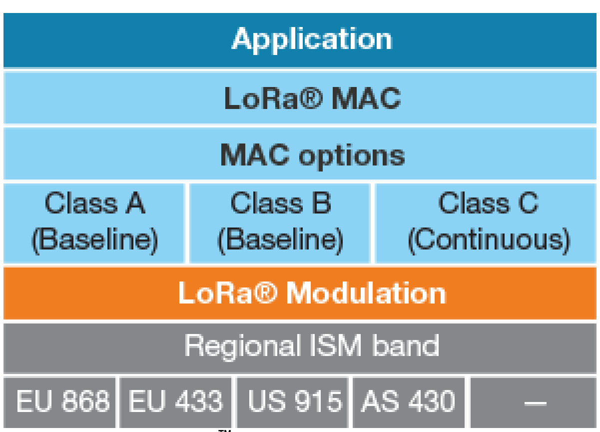


Figure 1: LoRaWAN™ is a standard that defines the communication protocol for LPWAN technology based on the LoRa chipset. It allows low-powered devices to communicate with Internet-enabled applications across long range wireless connections.

4. What Can LoRaWAN Be Used For?

For wireless connectivity, many different technologies are available. However, technologies such as WiFi, Bluetooth, and ZigBee are all most suited to shorter range communications. For communication over long distances, these technologies cannot be used at all, or if they can be used, the cost-benefit in terms of high power consumption per bit of information transmitted makes their use unfeasible (See Figure 2).

	LoRa	Zigbee	Bluetooth	WiFi
Topology	Star of Stars	Mesh, Star	Star	Star
Battery life	Decades	Years	Days	Hours
Maximum Data Rate	50 kbps	250 Kbps	1 Mbps	54Mbps
Coverage	5-15 kilometers	70-300 meters	100 meters	50-100 meters

Table 1: Comparison of WiFi, Bluetooth and Zigbee to LoRa

For many IoT applications, the actual amount of data to be transmitted is relatively small, so the higher data rate of some unlicensed band technologies (WiFi/Bluetooth) is not required. Here a special class of technologies is being designed under the broad umbrella of Low Power Wide Area Network (LPWAN), that have the characteristics of being low data rate, low power consumption, and long range. LoRaWAN belongs to the LPWAN set. Other technologies in the LPWAN domain include NB-IoT (Narrow Band IoT), SigFox, Random Phase Multiple Access (RPMA), Weightless, and more. LPWANs are usually characterized by long range, low power consumption, a capacity to support a large number of nodes, and robustness to interference. LoRaWAN is particularly suited to low-cost, high-volume applications that require primarily uplink capabilities. But LoRaWAN having a downlink capability is beneficial in certain situations, as compared to a technology like SigFox that has no downlink capability. In the next section, we will be looking at how the uplink/downlink combination comes into play with different classes of LoRaWAN service.

- 4.1 LoRaWAN Applications

Application areas for LoRaWAN include industrial automation, manufacturing, precision farming, smart grid, pipeline monitoring, environment monitoring, smart cities, and healthcare. It is usually suited to applications in which data has to be gathered and aggregated from a number of remote locations. The star of stars topology of LoRaWAN makes it suited to the aggregating function, and the relatively long range (up to 5 km urban and 15 km rural) makes it suitable for applications such as precision farming, smart grid, or smart cities, where data has to be gathered from a localized area but one that nonetheless can stretch for a few miles or kilometers.

Smart City

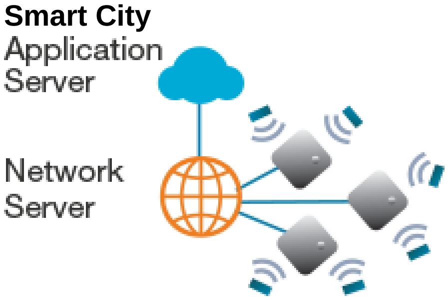


Figure 2: The Things Network Architecture

When the LoRaWAN network was initially set up by The Things Network for the city of Amsterdam, it was able to cover the whole city using only 10 Gateways. The entire network was setup by academics, researchers, and volunteers in a matter of weeks. It is free for use by anyone in the city. (As of writing this module, the Amsterdam LoRaWAN network has grown to 51 gateways with 120 contributors.)

Livestock Monitoring

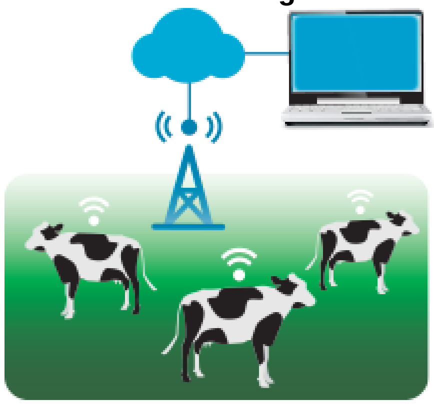


Figure 3: LoRa Livestock Monitoring System

Cattle feed lots can lose billions of dollars each year from sick cows. One way to combat this problem is for the rancher to be more aware of the livestock's health. This can be done by using LoRa-enabled cattle tags that can measure the cow's body temperature, head movement, and mobility. Cattle health data can be gathered in an application server, with reduced mobility and body temperature as key indicators of sickness. Once a sick cow is identified, a rancher would remotely video conference with a veterinarian, who can then check the cow's vitals and other biometric data. This system can get faster care to the sick cow while preventing the sickness from spreading throughout the herd.

Radiation Leak Detection

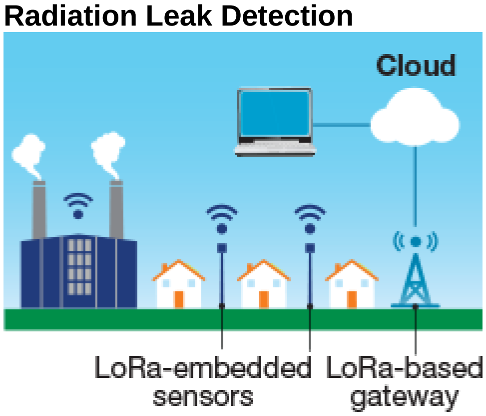


Figure 4: Lora Radiation Leak Detection and Alert System

Another example of a LoRaWAN application is radiation leak detection. In America, many people live within 10 miles of a nuclear power plant. As such, this circumstance can pose a potential safety hazard. One way to limit the safety risk is to place radiation leak detectors throughout the plant and the adjacent community, so radiation can be monitored. Radiation leak detectors can be made of sensors and gateways embedded with LoRa technology. Radiation level data is collected by LoRa-enabled sensors. Data is regularly sent to a LoRa gateway, which in turn sends the information to the network server where it gets analyzed. An application server can send alerts to the plant manager and/or community via mobile device, computer, or other media.

5. How Does LoRaWAN Work?

We will consider 3 planes when discussing LoRaWAN operation. The first one is the topological plane in which we will look at how a LoRaWAN network is set up and how data is aggregated. In the second, we will look at the classes of operation for LoRaWAN; you can also think of these as modes. Finally, we will look at some of the specific radio technology aspects of LoRaWAN.

- 5.1 Topology

LoRaWAN topology is a star of stars. The ultimate information gatherers are the nodes, which are often called "motes" as a carryover from sensor network terminology. Typically, motes sense information and send it to a localized gateway that is within range. This is the lower level of the star of stars. Each gateway that is connected to motes in its local region forms a star.

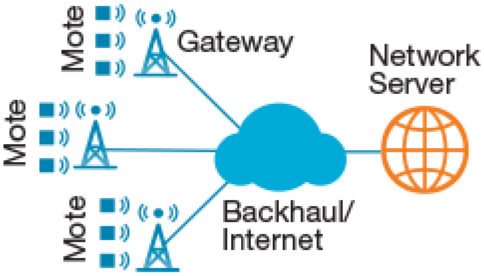


Figure 5. A typical LoRaWAN network architecture (Source: Experimental Performance Evaluation of LoRaWAN: A Case Study in Bangkok/IEEE).

Gateways are connected to an aggregating server using a separate backhaul technology (i.e. traditional internet connectivity, not using LoRaWAN). Gateways connecting to the server then form the upper level of the star of stars. (See Figure 5).

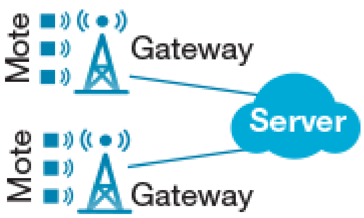


Figure 6: Mote to Gateway is a One Hop Transmission

Note how the motes have very limited capability; they do not perform any routing function. The transmission from mote to gateway is simply a one-hop transmission in range. It is conceivable that a mote may be within the range of more than one gateway. If more than one gateway were to pick up the same information/message, the server is capable of detecting that, and in terms of Acknowledgements (ACKs), the server designates one of the gateways to be the responder/acknowledger.

All motes on a LoRaWAN are provided with a 32-bit dynamic address. Each device has a unique 64-bit identifier. Thus, they are similar to MAC addresses used in many other networking technologies.

- 5.2 Classes

LoRaWAN has 3 operational modes or classes of operation. In this section, we will discuss each class:
Class A: Class A is the basic mode and all LoRaWAN nodes must support this mode. The mote looking to uplink to the gateway looks to see if the channel is free. If free, it can transmit information to the gateway. Thereafter, the mote waits two *receive* time slots in which it is expecting communication from the gateway. Typically, this is when the gateway would send an Acknowledgement (ACK) indicating that it received the uplink message from the mote correctly. This is also the time when the gateway can send other information using one of the two downlink slots (but not both).

Class A: Class A operation is completely asynchronous, so the mote only tries to transmit when it has something to transmit, and then stays “on” for the duration of the communication. The rest of the time the mote can save power by being in a power-save mode in which the radio and associated circuitry can be turned off. Class A is essentially an ALOHA-like uplink protocol, which means that even though power consumption is low, the efficiency of channel utilization is low and it may take several attempts to get reliable communication.

Class B: Class B is also called a Beacon mode. This mode extends the operation of Class A by scheduling time slots for downlink transmission. A periodic Beacon message is sent out by the Gateway. As is typical with Beacon messages, this Beacon is used to synchronize clocks between the Gateway and the motes (to correct for clock drift); additionally, the Beacon also specifies specific time slots or time windows during which it wishes to send information to specific motes. Having this information from the Beacon, the associated mote then can "come alive" during those time slots to receive the required communication.

A device can still do class A operation at any time if it is ready to transmit information, provided it works with the time framing as specified by the Beacon. Obviously, the power consumption in this mode is higher because the device has to be alive when the Beacon is expected, and in additional listening slots if so specified by the Gateway.

Class C: Class C is a fully synchronous mode in which the mote, when it is not transmitting, is always listening for communications from the Gateway. Not surprisingly, this mode is called the "Continuously Listening" mode. Class C would require a continuous or frequently changeable power source and is likely to not be used frequently in practice (because if there is a power infrastructure available, then there may also be other networking capabilities available).

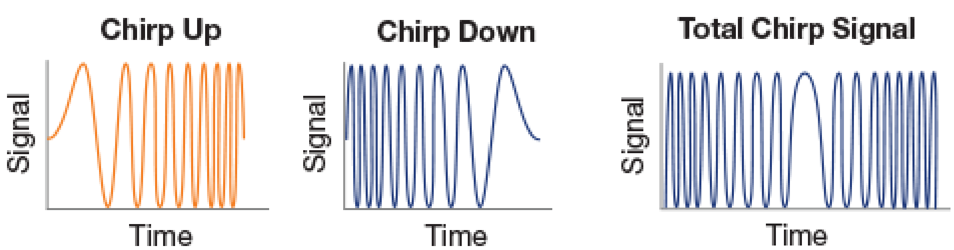
Both Class B and Class C can be used to multicast messages from the Gateway to motes, i.e. all motes can receive the same message from the Gateway simultaneously.

Over-the-air (OTA) updates (ex: firmware updates) to motes are unfeasible in Class B and even Class C because packet sizes in LoRaWAN need to be small. If packet sizes are increased, this would have an effect on the reliability of the transmission and would in turn reduce the range of transmission.

- 5.3 Radio Technology

As we have mentioned before, there is LoRa and there is LoRaWAN. It is essential to understand the difference between the two terms. LoRa refers to the radio chipset or wireless technology that is used for the devices. Semtech is the original manufacturer of this technology. (Microchip and STMicroelectronics are now able to manufacture chipsets under license.) But LoRaWAN refers to the protocol stack used for communication and utilizes the LoRa physical layer. As we saw before, LoRaWAN is maintained by the LoRa Alliance. We may think of LoRa as referring to the Physical (PHY) layer of the LoRaWAN protocol stack.

- 5.4 Chirp Spread Spectrum Technology



(a) **(b)** **(c)**

Figure 7: Chirp modulation uses sinusoidal waveforms whose instantaneous frequency increases (a) or decreases (b) over time. LoRaWAN transmissions work by chirping, that is, separating the chirps in various places relative to time and frequency to encode information (c).

LoRa uses Chirp Spread Spectrum (CSS) technology. CSS is a wideband Spread Spectrum technology. In layman's terms, CSS spreads the transmission over a wide bandwidth. CSS was originally developed as an alternative to Ultra Wide Band (UWB, sometimes called wireless USB). It is distinguished from more traditional Spread Spectrum (SS) such as Direct Sequence (DSSS; used in CDMA and WiFi) and Frequency Hopping (FHSS; used in WiFi and cordless phones) in that it does not add any pseudo-random elements to help distinguish the signal from noise on the channel; instead, it relies on the predictability of the Chirp signal for that purpose. CSS is also more resistant to multipath fading and Doppler shifts.

LoRaWAN signals are resistant to noise at low power. The signal level actually appears below the noise floor. [The noise floor in a communication network is the amount of ambient noise detected at a certain spectrum band.] The predictable properties of the signal and wide band make it distinguishable from the noise floor. LoRa uses CSS with Spreading Factors (SF) ranging from SF7-SF12. Typically, increasing SF means reducing the data rate while making the signal more robust to noise. In LoRaWAN, the mote is allowed to select the SF to optimize for power consumption and range.

- 5.5 Frequency Bands

One of the advantages of a technology like LoRaWAN is that it has been designed to work in an unlicensed band. Thus, devices and applications can be easily deployed without having to go through an extensive approval process with the FCC (or other regional communications regulatory body). However, one of the disadvantages of LoRaWAN is that in the sub-GHz spectrum different bands are available in different regions of the world. Thus, we have the following regional bands of operation for LoRaWAN, making it less portable from one region to another (although there is some overlap in the 900 MHz ISM bands):

- United States: 902-928 MHz ISM
- European Union: 863-870 MHz and 433 MHz
- China: 779-787 MHz ISM; 433.575 MHz
- Australia: 915-928 MHz ISM
- Asia: 923 MHz ISM
- South Korea: 920-923 MHz ISM
- India: 865-867 MHz ISM

- 5.6 Other Details

We have already discussed that ACKs are used to confirm message transmission. This improves the reliability of the communication while sacrificing some of the channel capacity; although by now you will have observed that with typical packet sizes in the 10s of bytes with a data rate of up to 50 kbps, a large number of messages can still be transmitted. In an ALOHA like (i.e., random access protocol developed at the University of Hawaii) broadcast situation with no synchronization, the probability of packet collision is fairly high and so ACKs are desirable to know whether or not your transmission succeeded.

Security is provided through AES-128 (substitution permutation network (SPN) block cipher algorithm). There are 3 distinct keys:

- **AppKey:** An application key known to the device and the application: this is used for Over-the-Air (OTA) Authentication (OTAA); on session activation, the other two keys are generated.
- **NwkSkey: A Network Session Key (Public):** this is used to do a Message Integrity Code (MIC) check to ensure that messages are not tampered with in transition.
- **AppSkey: Application Session Key (Private):** this is used to encrypt the message payload.

6. Comparison of LoRaWAN to Other LPWAN Technologies

As you can see in table 2 below, LoRa is somewhat similar in many respects to other LPWAN technologies. The question arises then: why should one choose LoRa over any of the others? The best way to answer that question is to examine some key factors. Of course, the choice of the specific technology is definitely dependent on the application. For example, the 50 Kbps speed may not be sufficient for certain applications. In IoT applications, power and range—a suitable combination of power range—is extremely important. With LoRa technology at a medium cost, one can get a good range (up to 15 km rural) while having the kind of power consumption that enables motes to keep going for years, even decades (estimates of 20 years on a single battery are common). And for that decent power/range combination you also get a pretty good speed of up to 50 Kbps in both uplink and downlink.

On top of that, there are two features that make LoRa technology attractive for IoT applications. One is the security, which is robust, and the second is the fact that there is flexibility of application through the use of the 3 classes of operation. Other attractive features include the fact that the standard is maintained by an Alliance and is not proprietary, and even though the chipset technology is proprietary, Semtech, the manufacturer, is sharing that with other manufacturers such that there is going to be a range of LoRaWAN offerings in the marketplace. Finally, the use of an unlicensed band is always attractive in terms of time-to-market for new LoRa device manufacturers and Spectrum Regulatory compliance (although this may be less relevant to the end user, it does have an impact, as we have observed a wide range of devices in unlicensed bands).

Of the cons for LoRaWAN technology, the chief one is the fact that, although working in an unlicensed band, the band itself is not consistent in different regions of the world. The bands used in North America, Europe, and Asia are different, and this puts a burden on the manufacturer looking to sell applications in expanded markets. This is not that much of a concern for the DIY end user, however.

	LoRaWAN	**SigFox**	**NB-IoT**	**LTE-M**	**RPMA**	**Weightless-P**	**LinkLabs Symphony Link**
Model	Alliance	Proprietary	Open	Open	**Proprietary**	Open	**Proprietary**
Frequency Band	Sub-GHz, variable	868 MHz, 902 MHz	LTE	Various	2.4 GHz	Sub-GHz	150 MHz - 1 GHz
Spectrum	Unlicensed	Unlicensed	Licensed	Licensed	Unlicensed	Unlicensed	Unlicensed
Range (km)	urban: 2-5 rural: 15	urban: 3-10 rural: 30-50	urban: 1-5 rural: 10-15	urban: 2-5	urban: 1-3 rural: 25-50	urban: 2	urban: 2-5 rural: 15
Speed (up/down)	50 kbps/50 kbps	300 bps/-	250 kbps/250 kbps	1 Mbps/1 Mbps	634 kbps/156 kbps	100 kbps/100 kbps	100 kbps/100 kbps
Power consumption	Low	High	High	Low	Medium	High	Medium
Cost Estimate	Medium	Low	Medium	High	High	Low	Medium

Table 2: Comparison of LoRaWAN to other LPWAN Technologies

**The longer range in rural environments is due to Line-of-Sight communications being possible. The max range is always possible when there is direct line of sight. Rural environments are also less likely to have obstructions that absorb the signal, such as buildings. (Note that trees can still be a factor.) The terrain in applications such as farming is also expected to be relatively flat, once again making for better communication.*

*** It's clear that a lot of LPWAN technologies use sub-GHz spectrum. The reason for this is that the radio characteristics are favorable in this frequency range, providing longer range at lower power.*

7. Getting Started with LoRaWAN

The best way to get started with LoRaWAN is to get started with an evaluation kit. In the LoRa development boards' page of this learning module, we provide additional information about a wide array of LoRA development boards and kits, for makers to professional users, including Arduino, Microchip, The Things Network, Laird Technologies, Mikroelektronica, ST Microelectronics, and Pycom.
oRa Development Boards for element14 Essentials: IoT II

8. LoRa Development Boards

If you are just getting started with LoRaWAN, the best way to do it is with an evaluation kit. What follows is a summary of some of the LoRa development boards, available from a variety of suppliers, that can be used to experiment with LoRa wireless connectivity, make your first LoRaWAN project, or design a new product with LoRa.

Arduino

Arduino MKR WAN 1300 (LORA Connectivity)
Buy Now

If you are working with Arduino boards already, and are familiar with the Arduino Software (IDE) for code development and programming, then Arduino's MKR WAN 1300 is a great board to start experimenting with LoRa connectivity. It combines the functionality of the MKR Zero and LoRa connectivity. It's a convenient tool for makers who want to design IoT projects but don't have much experience with networking or LoRa connectivity. It's based on the Atmel SAMD21 and a Murata CMWX1ZZABZ Lo-Ra module.

Microelektronica

LoRa Click Board
Buy Now

Another quick way to build a LoRaWAN is with Microelektronika's click boards. The LoRa click carries Microchip's RN2483 fully certified LoRa Sub-GHz, 433/868 MHz European R&TTE Directive Assessed Radio Modem. It is designed to use either a 3.3V or a 5V power supply. It communicates with the target microcontroller over a UART interface (TXD, RXD, CTS) with the addition of a Reset pin (RST). The US version of the LoRa Click Shield can be found here.

To use the LoRa click board, you need a base board such as the EasyPIC V7 Development Kit or you can use the Raspberry Pi, where all you need is a Click Shield, which plugs into the Pi and the click board plugs into the Shield. Note: there are different versions of the Click Shield: Pi1 Click Shield, Pi2 Click Shield, and Pi3 Click Shield.

The Things Network

LoRaWAN Sensor Node
Buy Now

LoRaWAN Network Gateway
Buy Now

The Things Network has taken the world by storm with its community-based, public IoT networks based upon LoRa connectivity. What's nice about The Things Network is that the price of entry is low and there's a support network for you to get help and collaborate.

To participate in The Things Network, other than signing up, you need a Things node and a Things gateway. The Things Node is a based on the SparkFun Pro Micro and has an added Microchip LoRaWAN module along with an embedded antenna. It contains a temperature sensor, digital accelerometer, light sensor, button and RGB LED. All this is packaged in a matchbox sized waterproof casing.

To connect to the Things Network server, you'll need a Things Network Gateway/Base station that enables devices such as sensors and embedded computers to connect to the Internet.

TTN-UN-915LoRaWAN Single Board Computer
Buy Now

If you want to use The Things Network to deploy your own IoT prototypes using LoRa connectivity, you should check out The Things Uno. You can use it to make one of your existing projects wireless up to 10km range by simply swapping your current Arduino board with the Things Uno.

The Things Uno is an Arduino Leonardo based embedded SBC solution with an integrated Microchip LoRaWAN (Long Range WAN) RN2483 module and on-board antenna. It is completely compatible with the Arduino IDE and Shields and can simply replace your current Arduino UNO board to add long range wireless capabilities to your projects. An optional external antenna can be added to maximize the range.

Microchip

Sub-GHz 915 MHz long range LoRa Module
Buy Now

Microchip's RN2903 Low-Power Long Range LoRa Technology Transceiver 915 MHZ module provides an easy to use, low-power solution for long range wireless data Transmission for North America. The RN2903 module complies with the LoRaWAN Class A protocol specifications. It integrates RF, a baseband controller, command Application Programming Interface (API) processor, making it a complete long range solution. The RN2903 module is suitable for simple long range sensor applications with external host MCU.

In Europe, the equivalent LoRa module is the RN2483A-I/RM103 Low-Power LoRa Technology Transceiver, which works at 868 MHz.

Microchip LoRa Technology Kit - 900
Buy Now

If you are a professional user or a tech entrepreneur who would like a full set of building blocks to design a LoRaWAN from scratch, Microchip's LoRa® Network Evaluation Kits should be at the top of your wish list. The Microchip LoRa Technology Kit - 900 (NA version) includes an 8-Channel 915-MHz LoRaWAN Network Gateway along with 2 LoRaWAN motes and local LoRaWAN Network/Application Server. In other words, it contains everything necessary to setup a minimal LoRaWAN network. The package also comes with the

Software Development Suite so that you can develop and deploy your prototype application. The Things Network has a great article on step-by-step setup of a test deployment.
The 915 MHz product range is applicable in the United States. The 900 Evaluation Kit discussed above works at 915 MHz. The RN 2903 module is the basis for the RN 2903 motes that are included for the 900 Evaluation kit. Additional motes or RN 2903 modules can be purchased to expand the capabilities of your test deployment. Standalone RN 2903 modules can be used in conjunction with a compatible PICtail/PICtail-Plus Board.

In Europe, the equivalent Evaluation kit is the Microchip LoRa Technology Evaluation Kit - 800, which works at 868 MHz. The RN 2483 product range of modules and motes is applicable in this band. Even though the evaluation kit is for the 868 MHz range, the RN 2483 Transceiver also works at the 433 MHz band.

Development Board, RN2903 915 MHz LoRa Technology Mote
Buy Now

The RN2903 LoRa® Mote is a LoRaWAN™ Class A end-device based on the RN2903 LoRa modem. As a standalone battery-powered node, the Mote provides a convenient platform to quickly demonstrate the long-range capabilities of the modem, as well as to verify inter-operability when connecting to LoRaWAN v1.0 compliant gateways and infrastructure.

The Mote includes light and temperature sensors to generate data, which are transmitted either on a fixed schedule or initiated by a button-press. An LCD display provides feedback on connection status, sensor values, and downlink data or acknowledgements. A standard USB interface is provided for connection to a host computer, providing a bridge to the UART interface of the RN2903 modem.

In Europe, the equivalent LoRa® Mote is the RN2483 LoRa® Mote, which works at 868 MHz.

RN2903 LoRa® Technology PICtail™/PICtail Plus Daughter Board
Buy Now

The RN2903 LoRa® Technology PICtail™/PICtail Plus Daughter Board is a development board for the Microchip RN2903 Low-Power Long Range, LoRa® Technology Transceiver Module.

Development of a LoRa system with the RN2903 connected to Microchip's PIC MCU line is possible on PIC18 Explorer boards via the 28-pin PICtail connector, or on Explorer 16 boards using the 30-pin card edge PICtail Plus connector.

The PICtail board also has an on-board PIC18 MCU available for custom user functions. It is pre-programmed to provide a simple USB-to-UART serial bridge enabling easy serial connection.

In Europe, the equivalent LoRa® Technology PICtail™/PICtail Plus Daughter Board is the RN-2483-PICtail, which works at 868 MHz.

ST Microelectronics

Discovery Kit, LoRa® Low Power Wireless Module
Buy Now

Designed by ST Microelectronics The B-L072Z-LRWAN1 is a low power wireless STM32L0 LoRa Discovery kit This kit is for LoRaWAN and LPWAN protocols with STM32L0 It is a development tool to learn and develop solutions based on LoRa and FSK/OOK technologies It features an all-in-one open module CMWX1ZZABZ-091(by Murata The module is powered by an STM32L072CZ and an SX1276 transceiver The transceiver features the LoRa long-range modem providing ultra long range spread spectrum communication and high interference immunity minimizing current consumption The LoRaWAN stack is certified class A and C compliant

I-NUCLEO-LRWAN1 - LoRa LPWAN Expansion Board
Buy Now

If you are familiar with ST Microelectronics's Nucleo and Discovery evaluation platforms, then you may want to start your next LoRa-enabled IoT project with ST's Nucleo expansion board or the LoRa Discovery kit. Called the LoRa® expansion board for STM32 Nucleo (I-NUCLEO-LRWAN1), this third party board is an integrated solution allowing anyone to learn and develop solutions using LoRa® and/or FSK/OOK technologies. The I-NUCLEO-LRWAN1 features the USI®LoRaWAN™ technology module, addressing low-power wide area network (LPWAN) and comes with embedded AT-commands stack pre-loaded. The I-NUCLEO-LRWAN1 can be controlled from an external host such as a NUCLEO-L053 board, running the I-CUBE-LRWAN embedded software. The I-NUCLEO-LRWAN1 is LoRaWAN™ class A certified and sustains the class C.

Note: The I-NUCLEO-LRWAN1 is supplied by a third party not affiliated with ST. For the latest information, refer to the third party's GitHub page.

Laird Technologies

RM191-SM LoRa/BLE Combination Module
Buy Now

The RM191-SM is a LoRa/BLE module (915MHz LoRa for US/Canada) featuring smartBASIC. It offers a solution for long range enterprise IoT deployments. It combines Bluetooth v4.0 with LoRaWAN into one module. The module aggregates and transmits data from Bluetooth smart (BLE) devices and sensors over LoRa to gateways as far as 15Km (~10 miles) away. This bridges the personal area network to the wide area network. The RM191-SM is LoRa alliance and Bluetooth SIG certified and fully interoperable with any LoRaWAN adherent gateway.

Pycom

LOPY4 - IoT Dev Board with Sigfox/LoRa/WiFi/Bluetooth
Buy Now

The LoPy4 is a quadruple bearer MicroPython-enabled development board (LoRa, Sigfox, WiFi, and Bluetooth). Using the Espressif chipset, the LoPy4 combines power, friendliness, and flexibility. It has a Semtech LoRa transceiver SX1276 with a LoRaWAN stack and is compliant to Class A and C devices.

Test Your Knowledge

Are you ready to demonstrate your LoRaWAN for IoT Applications knowledge? **Then take a quick 15-question multiple choice quiz to see how much you've learned from this LoRaWAN for IoT Applications Learning Module.**

To earn the LoRaWAN for IoT Badge, read through the module to learn all about LoRaWAN for IoT Applications, attain 100% in the quiz at the bottom, leave us some feedback in the comments section, and give the module a star rating.

Take Quiz