### [Low Power Wide Area Networking Technologies](#_bookmark2)

#### [LPWAN Network Topologies](#_bookmark2)

LPWAN has two network topologies:

1. Direct device connectivity (base station)
2. Indirect device connectivity through an LPWAN gateway

###### [**Direct Device Connectivity Topology of LPWAN**](#_bookmark2)

* The base station that is present in the network provides connectivity to many devices.
* The traffic is sent to servers (cloud) through TCP or IP-based networks (Internet).
* The base station is responsible for translation of protocol from IoT protocols such as MQTT or CoAP to specific device application protocols.

A picture containing diagram

Description automatically generatedLPWAN connectivity

Access network

Cloud and servers

Applications

Base station

Star topology for long-range radio connectivity

Wired backhaul, TCP/IP-based (e.g., MQTT)

**Direct device connectivity topology of LPWAN.**

###### [**Indirect Device Connectivity through an LPWAN Gateway**](#_bookmark2)

* where it is not possible to connect devices directly to LPWAN, a **local gateway** is used for short range radio like ZigBee or BLE.
* The gateway runs on **mains power** as it has to support a large number of devices.
* The gateway has a capability to perform protocol conversion from **SRD (software defined) radio technologies to LPWAN technology.**
* Gateways provide more security to IoT ecosystem using powerful security algorithms.

#### [Sigfox](#_bookmark2)

Sigfox is very popular in the LPWAN industry. It has partnership with a lot of vendors in the radio space such as Texas Instruments, Silicon Labs, and Axom. Sigfox does not support bidirectional networks and offers support for uplink only sensor applications. This imposes a restriction on the end user to transfer only 15 bytes of traffic at a time with an average of only 10 messages per day. This limits the usability of this technology only for very simple devices.

Sigfox uses antennas that are set up on towers in order to receive data from devices such as parking sensors and water sensors. Data transmissions using Sigfox technology happen in 868 or 915 MHz frequency bands.

Shape, rectangle

Description automatically generatedShort-range communication

Gateway

LPWAN

connectivity

Base station

Access network

Cloud and servers

Applications

Short range local connectivity

Star topology for long range radio connectivity

Wired backhaul,

TCP/IP (e.g., MQTT)

**Indirect device connectivity through an LPWAN gateway.**

Sigfox’s wireless systems send data in very small quantities very slowly using a mobile technol- ogy called binary phase shift keying (BPSK). Data transmissions for long ranges are done with the help of long and short messages.

###### [Binary Phase Shift Keying](#_bookmark2)

Phase-shift keying (PSK) is a modulation technique that transmits data by changing the phase of the reference signal, which is called carrier wave. This technique is widely used for data transmis- sion RFIDs, wireless LANs, and Bluetooth. Binary phase shift keying (BPSK) is the simplest form of PSK. It uses two phases that are separated by an angle of 180°. Since there are two phases, this technique is also called 2-PSK.

Sigfox is widely used for applications that send small, infrequent bursts of data. Some examples of application domains are alarm systems, location monitoring systems, and simple metering sys- tems. In these systems, signal data are sent few times to ensure that the data gets transmitted. The downside of this approach is shorter battery life for battery powered applications.

#### [Weightless](#_bookmark2)

*Weightless* is an open LPWAN standard. It operates in sub-1 GHz unlicensed spectrum. Weightless has three open standards:

* Weightless-P
* Weightless-N
* Weightless-W

###### [Weightless-P](#_bookmark2)

This standard offers bidirectional communication. It uses a narrow band modulation scheme in order to provide bidirectional communications capability. This standard provides very high qual- ity of service (QoS) parameter that is the best in class offered in the IoT sector.

Weightless-P will offer the committed performance rate, network reliability, and security parameters that are given by 3GPP carrier grade solutions. This standard also provides substantially lower costs when compared to other LPWAN technologies. This standard has less than 100 uW power consumption in an idle state. This power consumption rate is low when compared to 3 mW, which is used by other best cellular technologies that are available in the market.

###### [Weightless-N](#_bookmark2)

This standard offers one-way communication. They have a long battery life of about 10 years and have a low network cost. The Weightless-N standard uses star network architecture. It works in sub-GHz spectrum using ultra narrow band (UNB) technology. This standard offers a range of several kilometers even in urban environments. This standard offers very low power consumption, which in turn provides a long battery life for devices. This standard requires small conventional cells, minimal hardware, and incurs less network costs. This standard uses differential binary phase shift keying (DBPSK) digital modulation scheme to transmit using narrow frequency bands. This standard uses a frequency hopping algorithm in order to reduce interference.

This standard provides support for encryption and implicit authentication using a shared secret key regime in order to encode transmitted information via a 128-bit AES algorithm. This standard offers support for mobility as the network can automatically route terminal messages to the correct destination. Using this standard, multiple networks that are operated by different companies are enabled and can be colocated as well. Each base station that operates using this standard queries a central database in order to determine which network the terminal is registered to in order to decode and route data correctly.

###### [Weightless-W](#_bookmark2)

This standard is the most extensively used option as it runs in the unused TV spectrum. Data rates from 1 Kbit/s to 10 Mbit/s are possible based on the link budget with the size of data packets starting from 10 bytes. There is no upper bound on packet size. The overhead is extremely low, for example, 50 byte packets have less than 20% overhead. Both acknowledged and unacknowledged

message transmission modes are supported. The multicast call feature allows messages to be sent to

multiple devices. Interrupt feature supported by this standard allows devices to raise alarms in order to notify specific events that need attention such as power outage.

Service provision layering features provide worldwide contracts and automated change of net- work provider capabilities. Terminals can run multiple applications at the same time, and the mobility is fully supported. This standard provides an ultra secure 128-bit encryption and authen- tication model, which is based on a shared secret key. This standard has an extremely low com- plexity architecture. This type of architecture facilitates low-cost implementation using minimal memory and processor power in order to further extend battery life.

At the network level, careful scheduling features enable transmissions to be planned well ahead of time. The capability to plan ahead of time provides very high loading efficiency. The frequency hopping and intelligent frequency planning features help to maximize throughput on congested networks.

This standard offers wide range of modulation schemes and spreading factors, which in turn offers flexibility in network design. The range is about 5 km in indoor terminals. The entire core network runs as a software service that enables cloud hosting of this service.

#### [LoRa](#_bookmark2)

LoRa Alliance12 promotes use of an open standard for LoRa-based networks called LoRaWAN. This standard was developed by Semtech, IBM research, and Actility. Following are the main features of LoRaWAN:

* They have three open standards that provide various types of options for end users.
* Since it is an open ecosystem, there are a lot of software and vendors that are available in the market for supporting this standard.
* This standard lacks many features like support for roaming, packetization, firmware upgrades over air, and so on.
* In order to use this standard, the network server software should be run in the cloud that mandates subscription from a network server vendor.
* Semtech is the only vendor that manufactures the chips that may impact the scale of produc- tion and adoption of this standard.