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SIGFOX System Description
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Abstract

This document presents an overview of the network architecture and system characteristics of a typical SIGFOX Low Power Wide Area Network (LPWAN), which is in line with the terminology and specifications being defined by the ETSI ERM TG28 LTN group. It is intended to be used as background information by the IETF LPWAN group when defining system requirements of different LPWAN technologies that are suitable to support common IP services.

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[1.](#) Introduction

This document presents an overview of the network architecture and system characteristics of a typical SIGFOX LPWAN, which is in line with the terminology and specifications being defined by the ETSI ERM TG28 Low Throughput Networks (LTN) group [[etsi ltn](#)]. It is intended to be used as background information by the IETF LPWAN group when defining system requirements of different LPWANs that are suitable to support common IP services.

LPWAN technologies are a subset of IoT systems which specifically enable long range data transport (e.g. distances up to 50 km in open field), are capable to communicate with underground equipment, and require minimal power consumption. Low throughput transmissions combined with advanced signal processing techniques provide highly effective protection against interference.

Because of these characteristics, LPWAN systems are particularly well adapted for low throughput IoT traffic. SIGFOX LPWAN autonomous battery-operated devices send only a few bytes per day, week or month in an asynchronous manner and without the need for central coordination, which allows them to remain on a single battery for up to 10-15 years.

2. Terminology

The following terms used in this document are in accordance to the ones defined by ETSI ERM TG28 Low Throughput Networks (LTN) [[etsi_ltn](#)]:

Base Station (BS) - A Base Station is a radio hub of an LTN system.

Device Application (DA) - An application running on the End Point or device.

End Point (EP) - An End Point is a leaf node (aka device) of an LTN system that communicates application data between the local device application and the network application.

Low Throughput Networks (LTN) - Terminology used in ETSI to define Low Power Wide Area (LPWA) networks.

Network Application (NA) - An application running in the network at the opposite extreme of the device.

Registration Authority (RA) - The Registration Authority is a central entity that contains all allocated and authorized End Point IDs.

Service Center (SC) - Each LTN system has a single service centre. The SC performs the following functions:

- * EPs and BSs management
- * EP authentication
- * Application data packets forwarding
- * Cooperative reception support

3. System Architecture

Figure 1 depicts the different elements of the system architecture:

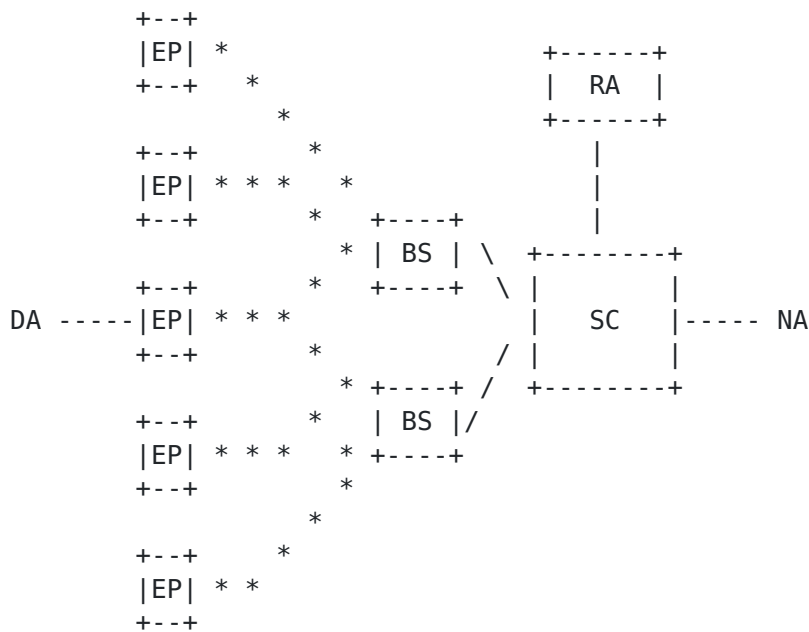


Figure 1: ETSI LTN architecture

The architecture consists of a single core network, which allows global connectivity with minimal impact on the end device and radio access network. The core network elements are the Service Center (SC) and the Registration Authority (RA). The SC is in charge of the data connectivity between the Base Station (BS) and the Internet, as well as the control and management of the BSs and End Points. The RA is in charge of the End Point network access authorization.

The radio access network is comprised of several BSs connected directly to the SC. Each BS performs complex L1/L2 functions, leaving some L2 and L3 functionalities to the SC.

The devices or End Points (EPs) are the objects that communicate application data between local device applications (DAs) and network applications (NAs).

EPs (or devices) can be static or nomadic, as they associate with the SC and they do not attach to a specific BS. Hence, they can communicate with the SC through one or many BSs.

Due to constraints in the complexity of the EP, it is assumed that EPs host only one or very few device applications, which communicate to one single network application at a time.

4. Radio Spectrum

The radio interface is compliant with the following regulations:

Spectrum allocation in the USA [[fcc_ref](#)],

Spectrum allocation in Europe [[etsi_ref](#)],

Spectrum allocation in Japan [[arib_ref](#)].

At present, the SIGFOX LTN radio interface is also compliant with the local regulations of the following countries: Australia, Brazil, Canada, Kenya, Lebanon, Mauritius, Mexico, New Zealand, Oman, Peru, Singapore, South Africa, South Korea, and Thailand.

5. Radio Protocol

The radio interface is based on Ultra Narrow Band (UNB) communications, which allow an increased transmission range by spending a limited amount of energy at the device. Moreover, UNB allows a large number of devices to coexist in a given cell without significantly increasing the spectrum interference.

Both uplink and downlink communications are possible with the UNB solution. Due to spectrum optimizations, different uplink and downlink frames and time synchronization methods are needed.

5.1. Uplink

5.1.1. Uplink Physical Layer

The main radio characteristics of the UNB uplink transmission are:

- o Occupied bandwidth: 100 Hz in Europe, 600 Hz in the USA
- o Uplink baud rate: 100 baud in Europe, 600 baud in the USA
- o Modulation scheme: DBPSK
- o Uplink transmission power: compliant with local regulation
- o Link budget: 155 dB (or better)
- o Central frequency accuracy: not relevant, provided there is no significant frequency drift within an uplink packet

In Europe, the UNB uplink frequency band is limited to 868,00 to 868,60 MHz, with a maximum output power of 25 mW and a maximum mean transmission time of 1%.

5.1.2. Uplink MAC Layer

The format of the uplink frame is the following:

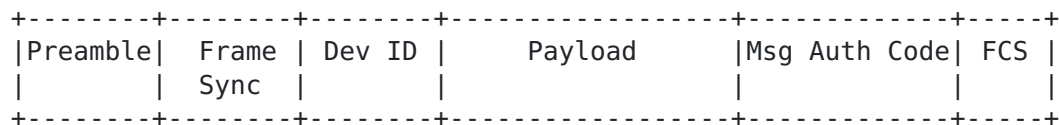


Figure 2: Uplink Frame Format

The uplink frame is composed of the following fields:

- o Preamble: 19 bits
- o Frame sync and header: 29 bits
- o Device ID: 32 bits
- o Payload: 0-96 bits
- o Authentication: 16-40 bits
- o Frame check sequence: 16 bits (CRC)

5.2. Downlink

5.2.1. Downlink Physical Layer

The main radio characteristics of the UNB downlink transmission are:

- o Occupied bandwidth: 1.5 kHz
- o Downlink baud rate: 600 baud
- o Modulation scheme: GFSK
- o Downlink transmission power: 500 mW in Europe, 4W in the USA
- o Link budget: 153 dB (or better)

- o Central frequency accuracy: Centre frequency of downlink transmission are set by the network according to the corresponding uplink transmission.

In Europe, the UNB downlink frequency band is limited to 869,40 to 869,65 MHz, with a maximum output power of 500 mW with 10% duty cycle.

5.2.2. Downlink MAC Layer

The format of the downlink frame is the following:

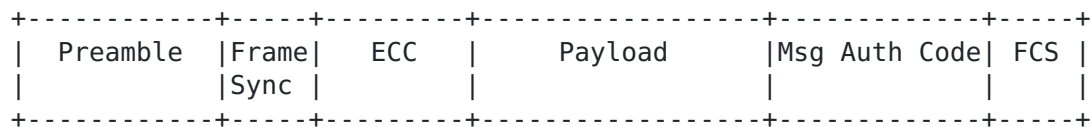


Figure 3: Downlink Frame Format

The downlink frame is composed of the following fields:

- o Preamble: 91 bits
- o Frame sync and header: 13 bits
- o Error Correcting Code (ECC): 32 bits
- o Payload: 0-64 bits
- o Authentication: 16 bits
- o Frame check sequence: 8 bits (CRC)

5.3. Synchronization between Uplink and Downlink

The radio interface is optimized for uplink transmissions, which are asynchronous. Downlink communications are achieved by querying the network for existing data from the device.

A device willing to receive downlink messages opens a fixed window for reception after sending an uplink transmission. The delay and duration of this window have fixed values. The LTN network transmits the downlink message for a given device during the reception window.

The LTN network selects the BS for transmitting the corresponding downlink message.

Uplink and downlink transmissions are unbalanced due to the regulatory constraints on the ISM bands. Under the strictest regulations, the system can allow a maximum of 140 uplink messages and 4 downlink messages per device. These restrictions can be slightly relaxed depending on system conditions and the specific regulatory domain of operation.

6. ETSI LTN

The ETSI TC EMC and Radio Spectrum Matters (ERM) group has multiple work items dealing with LTN. The objective is to define use cases, system architecture and radio protocols for LTN (or LPWAN), using shared spectrum bands, allowing to offer very low cost subscriptions per device.

According to ETSI TG28, LTN is particularly well suited for low throughput machine to machine communication where data volume is limited and low latency is not a strong requirement. Some foreseen applications include remote measurement for agriculture and environment, smart metering for utilities, smart cities applications such as air pollution monitoring or public lighting, etc.

LTN could also cooperate with cellular networks to address use cases where redundancy, complementary or alternative connectivity is needed. Low power, very low throughput, very long battery life, simple, effective and robust radio communication principles are the key features of ETSI LTN systems.

7. Network Deployment

As of March 2017, SIGFOX's network has been fully deployed in 6 countries, with ongoing deployments on 26 other countries. The one-contract one-network model allows devices to connect in any country, without any notion of roaming.

The vast majority of the current applications are sensor-based, requiring solely uplink communications, followed by actuator-based applications, which make use of bidirectional (i.e. uplink and downlink) communications.

Similar to other LPWAN/LTN technologies, the sectors that currently benefit from the low-cost, low-maintenance and long battery life are agricultural and environment, public sector (smart cities, education, security, etc.), industry, utilities, retail, home and lifestyle, health and automotive.

8. IANA Considerations

N/A.

9. Security Considerations

The radio protocol provides mechanisms to authenticate and ensure integrity of the message. This is achieved by using a unique device ID and a message authentication code, which allow ensuring that the message has been generated and sent by the device with the ID claimed in the message.

Security keys are independent for each device. These keys are associated with the device ID and they are pre-provisioned. Application data can be encrypted by the application provider.

10. Acknowledgments

The authors would like to thank Olivier Peyrusse for the useful inputs and discussions about ETSI LTN.

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