ETSI TS 103 358 V1.1.1 (2018-06)

TECHNICAL SPECIFICATION

Short range devices;
Low Throughput Networks (LTN) Architecture;
LTN Architecture

Reference
DTS/ERM-TG28-504

Keywords
architecture, interface, LTN, OSSS, radio, SRD, UNB

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The Internet of Things (IoT) presents a wide and growing range of communications requirements. Certain of these requirements are addressed by systems which are referred to as 'Low Throughput Networks' (LTN) in ETSI documents. The use cases addressed by LTN systems and the LTN systems characteristics are provided in ETSI TR 103 249 [i.1].

LTN systems may be considered to be a subset of Low Power Wide Area Networks (LPWAN), that may include other systems, already existing or developed in the future.

The present document specifies the architecture of LTN systems. It contains requirements and/or recommendations on functional blocks and interfaces that are related to the architecture (i.e. high-level description) of LTN systems.

The present document develops the work done in LTN ISG [i.2] on architecture for LTN systems.

The present document should be read in conjunction with the LTN document [i.1] and related documents, in which details of entities and interfaces are documented.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long-term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI EN 300 220-1 (V3.1.1) (02-2017): "Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 1: Technical characteristics and methods of measurement".

[2] ETSI EN 300 220-2: "Short Range Devices (SRD) operating in the frequency range 25 MHz to 1 000 MHz; Part 1: Technical characteristics and methods of measurement".

[3] IEEE EUI-64™: "Guidelines for 64-bit Global Identifier (EUI-64)".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long-term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 103 249 (V1.1.1): "Low Throughput Network (LTN); Use Cases and System Characteristics".

[i.2] ETSI GS LTN 002 (V1.1.1) (2014-09): "Low Throughput Networks (LTN); Functional Architecture".

[i.3] ETSI EN 303 204 (V2.1.2) (09-2016): "Network Based Short Range Devices (SRD); Radio equipment to be used in the 870 MHz to 876 MHz frequency range with power levels ranging up to 500 mW; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.4] PerOlof Bengtsson, Nico Lassing, Jan Bosch and Hans van Vliet: "Analysing Software Architecture for Modifiability", Research Report 11/00, Department of Software Engineering and Computer Science, University of Karlskrona/Ronneby, Sweden, ISSN 1103-1581.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

LTN family: complete solution within the scope of the LTN standard

NOTE: LTN families are not necessarily interoperable.

LTN standard: technical specifications developed by ETSI which describe architecture and protocols of LTN systems

NOTE: LTN standard comprises one or more families.

LTN system: physical instantiation of an LTN family

NOTE: The geographical deployment of an LTN system may vary on scale between local and global, including discontinuous coverage.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

BS Base Station
DA Device Application
DL DownLink
EP End-Point
IoT Internet of Things
IP Internet Protocol
LPWAN Low Power Wide Area Network
LTN Low Throughput Network
NA Network Application
RA Registration Authority
RP Relay Point
SC Service Centre
SRD Short Range Device
UL UpLink
UNB Ultra Narrow Band

4 LTN architecture description

4.1 Overall description

LTN systems comprise a radio network and a core network tailored to the connectivity of IoT devices. Figure 4-1 is the overall architecture description of any LTN system. Blue boxes and blue lines are part of the LTN system, whereas grey lines and grey boxes are application specific.

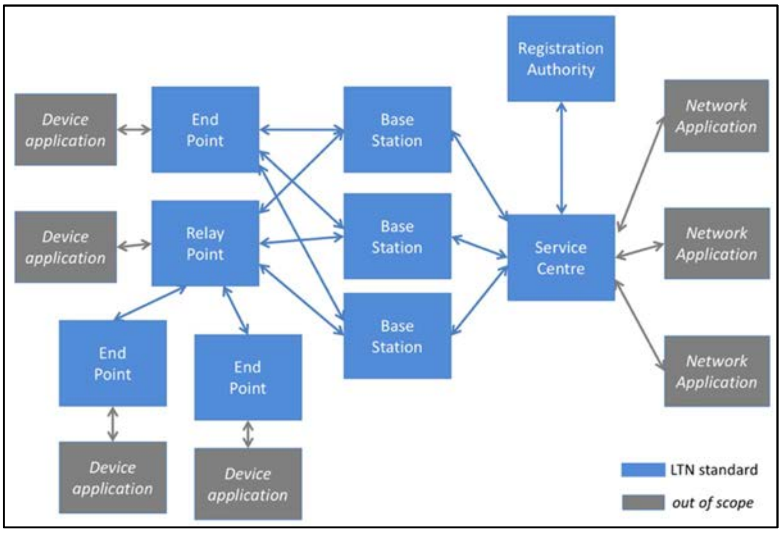

Figure 4-1: Overall architecture description of an LTN system (for information only)

In Figure 4-1, the radio access network, which consists in base stations, exhibits an optional feature where end-points and relay points are received by more than one base station at a time. This feature is named "cooperative reception" in the context of the LTN standard; it is a kind of macro-diversity (see clause 5.1 for detailed description).

4.2 LTN reference architecture

This clause gives the reference architecture as the basis for all LTN families. It is a high-level decomposition into major components with a characterization of the interaction of the components (definition derived from [i.4]). Figure 4-2 depicts the LTN reference architecture in terms of functional blocks (i.e. the components) and their interfaces (i.e. the interactions), as described in the present document.

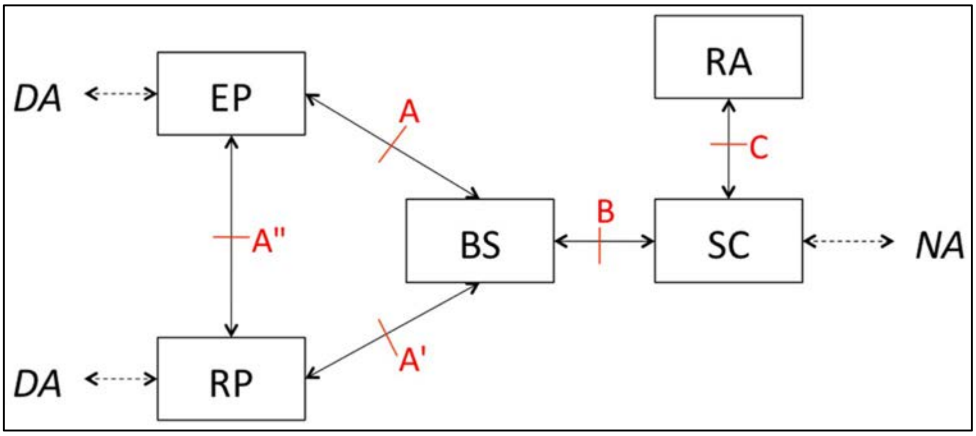

Figure 4-2: LTN reference architecture

The reference architecture depicted in the above Figure 4-2 applies to stand-alone LTN systems. If multiple LTN systems are deployed, interconnection between them may be required for the management of roaming end-points. In such case, the interface D should implement the interconnection between service centres of LTN systems (see Figure 4-3).

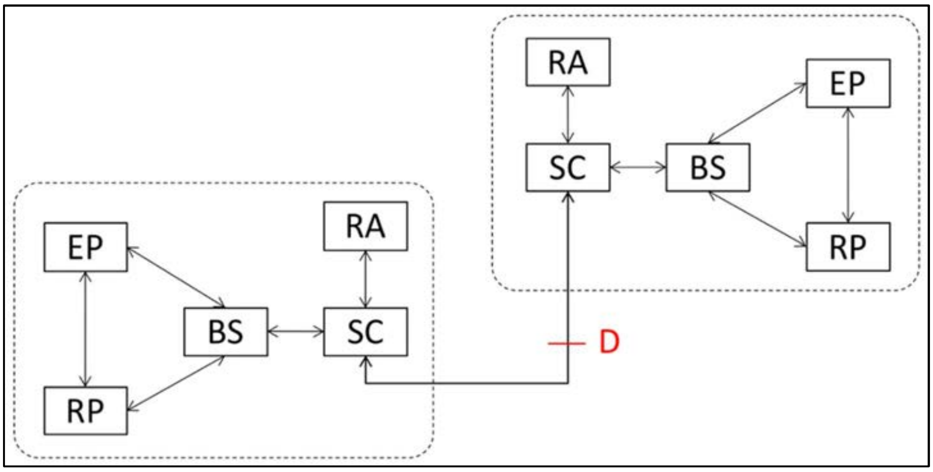

Figure 4-3: Reference architecture for interconnection of LTN systems

4.3 LTN functional blocks

4.3.1 End-point

An End-Point (EP) is a leaf node of an LTN system that communicates application data between local Device Application (DA) and Network Application (NA). It shall connect to a base station over the A interface. If relay points are supported, it shall connect to a relay point over the A" interface.

An EP shall be identified by a IEEE EUI-64™ [3] globally unique identifier.

An EP should run only one single device application and should belong to one single network application at a time.

4.3.2 Relay point

A Relay Point (RP) is an optional node in an LTN system. It shall connect to an EP over A" interface and to a base station over A' interface.

A RP may also communicate application data between local Device Application (DA) and Network Application (NA).

A RP shall be identified by a IEEE EUI-64™ globally unique identifier.

NOTE: A RP is typically a low complexity node supporting a limited number of EPs with limited support for EP mobility.

4.3.3 Base station

A Base Station (BS) is a radio hub of an LTN system. It shall connect to a single service centre over interface B. It shall connect to end-points over interface A and relay points over interface A'.

Base stations should implement provision for reduced service in case of disconnection from the SC.

4.3.4 Service centre

An LTN system shall have a single Service Centre (SC). The SC may perform the following functions:

- forwarding application data packet, both uplink and downlink;
- EP authentication, acting as either the other party of the authentication or a relay between the two authenticating parties;
- configuration and/or subscription management of end-points and relay points;

- support for cooperative reception and duplicate elimination;
- management of base stations;
- management of roaming with other service centres.

A Service Centre shall use:

- interface B for connection to base stations;
- interface C for connection to a registration authority;
- interface D for connections to other LTN system(s) for roaming purposes.

Service centre connects network applications over an Internet-based interface, which is out of scope of the present document.

4.3.5 Registration authority

An LTN system shall include the functionality of a Registration Authority (RA). The RA shall store identifiers and credentials of end-points and/or relay points. It may also store other parameters, such as:

- secret key;
- class of transmit power;
- class of EP;
- frequency capability;
- owner of the EP and/or RP;
- charge/service plan;
- etc.

The RA shall use interface C for connection to SC.

4.4 LTN interfaces

4.4.1 Interface A

Interface A is the air interface between EPs and BS. It shall be the primary air interface of any LTN system. It shall be a unidirectional or bidirectional interface between EP and BS. Interface A shall support EP mobility. It may carry signalling messages.

Interface A shall exhibit the following specific features:

- maximum coupling loss of at least 150 dB;
- random access for uplink transmission of messages;
- half duplex.

4.4.2 Interface A'

Interface A' is the air interface between RP and BS. It shall be a bidirectional or unidirectional interface.

4.4.3 Interface A''

Interface A'' is the air interface between EP and RP. It shall be a bidirectional or unidirectional interface.

4.4.4 Interface B

Interface B is the interface between a BS and the SC.

Data flow over the interface B may include decoded UL radio bursts, user packet for DL transmission, signalling and BS management messages.

Interface B shall be secured, using IP-based encryption technology or equivalent.

4.4.5 Interface C

Interface C is the interface between a SC and the RA.

Data flow over the interface C may include credentials of end-points and relay points.

4.4.6 Interface D

Interface D is the interface between two SC of the same LTN family to support roaming.

Interface D is optional; if implemented, it shall use secured IP-based links.

5 LTN key characteristics

5.1 Cooperative reception over air interfaces

Cooperative reception is the ability of a single UL transmission to be received simultaneously by several base stations. This feature is implemented with (see Figure 5-1):

- overlap of BS radio coverage, which is intentionally included in the radio design of an LTN system;
- deduplication of the received UL packets in the service centre.

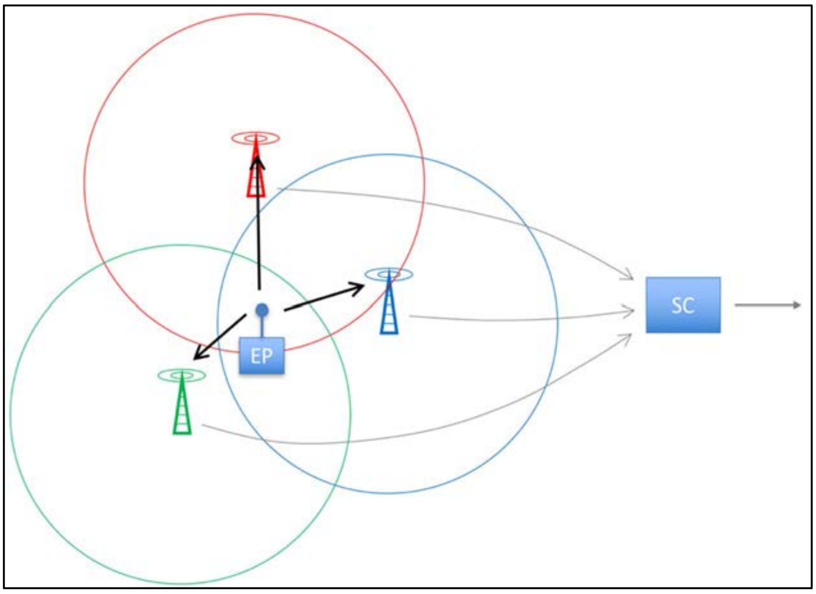

Figure 5-1: Principle of UL cooperative reception in an LTN system

In case of downlink communication, the large overlap of BS coverage allows several base stations to communicate to an end-point. BS selection in downlink is managed by the service centre on a fixed or ad'hoc basis.

As such, cooperative reception creates a spatial diversity between end-points and base stations, which helps to increase the UL and DL communication quality, especially in case of bad radio conditions.

LTN system may implement cooperative reception.

5.2 LTN politeness and coexistence

LTN systems shall implement mitigation techniques according to applicable spectrum regulations. If deployed in Europe, LTN devices shall be compliant with ETSI EN 300 220-1 [1] and ETSI EN 300 220-2 [2].

All LTN systems shall be designed to withstand interference from other systems operating in the same SRD frequency band. Various technologies may be used, such as high selectivity, frequency hopping and packet splitting, to help LTN systems coexist with LTN and non-LTN systems.

5.3 Options, profiles and families

The overall LTN architecture and the LTN functional blocks detailed in sub-clauses 4 apply to all LTN systems, irrespective of the types of application they serve. Nevertheless, flexibility in the implementation of the radio interface helps LTN to address specific requirements.

This flexibility is obtained by means of Options (for a range of parameters) described in the protocol document. A self-consistent and complete set of Options is named a Profile. Any LTN system shall conform to at least one Profile. Profiles ensure interworking of end-points, relay points and base stations (potentially coming from various manufacturers) which support the same Profile.

Family is a more general term: Families are sets of (similar) Profiles that are compatible with each other and therefore may be supported within a single LTN system. For example, two end-points which support different Profiles (in this example, the same Options *except* modulation scheme) will be compatible with a single LTN base station provided the BS supports both Profiles. Such Profiles are therefore considered to be members of a single Family.

5.4 End-point classes

An LTN system shall support one or more classes of EP as described in Table 5-1.

Table 5-1: the four classes of end-points in an LTN system

Class	Description	Purpose
Z	**UL-only:** End-point is UL-only; it does not receive DL application messages.	Application does not require DL.
A	**Pull-based:** EP receiver is only available for the reception of DL application messages for a short interval after the transmission of an UL message. (Specific duration of this interval is system-dependent.).	Application is satisfied if it can only communicate to the end-point when the end-point has just sent an uplink message. Avoids receiver battery drain between UL transmissions.
B	**Managed latency:** EP listens periodically for DL application messages. (Specific period is system-dependent, and may be configurable.)	Provides mechanism for DL communications without waiting for UL transmission. Battery drain of receiver is balanced with latency.
C	**Minimum latency:** EP listens for DL application messages whenever they may be transmitted. (Specific timing of DL transmissions is system-dependent, e.g. full duplex is not supported.)	Offers minimum system DL latency for mains-powered end-points or those where resulting battery drain can be tolerated.
NOTE 1: "always-on" end-points are class C end-points in LTN standard. NOTE 2: In class C, the experienced latency in DL links is only due to radio protocol framing and is, a priori, not seen by the network application. NOTE 3: In class B, the DL latency is mainly due to the implementation of "Power Save Mode" in the end-points. Sleep mode period may range from minutes to tens of hours; network application is designed to cope with the DL latency. NOTE 4: From a hardware implementation perspective, class C end-points may use a permanently synchronized bit clock for DL reception. Class B end-points may use synchronization mechanism upon waking up to overcome clock drift.		

Annex A (informative): LTN and other LPWAN systems

The connectivity of IoT devices is mostly based on radio links that implement very numerous radio technologies and radio architectures. Nevertheless, radio technologies for the IoT can be sorted out in four main types (see Figure A-1):

- cellular technologies optimized for the IoT;
- dedicated star networks optimized for the IoT;
- low power revisions of common Local/Personal Area Network standards;
- mesh networks covering wide area with multi-hops connectivity (these systems are named Network- Based SRDs in ETSI EN 303 204 [i.3]).

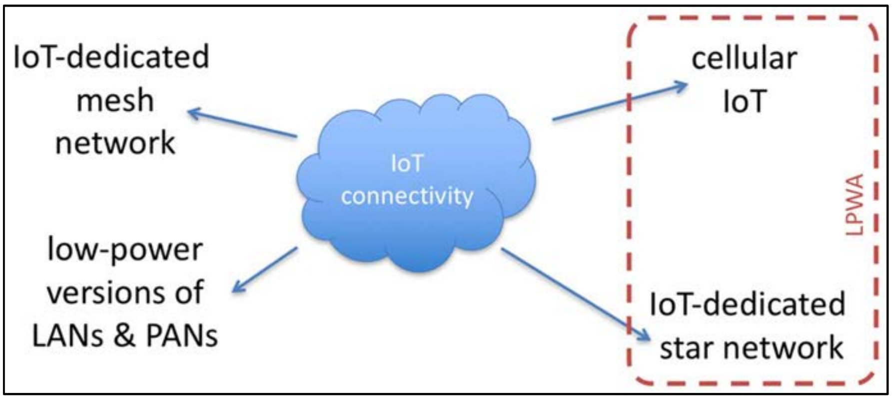

Figure A-1: The four types of IoT connectivity

Cellular IoT and IoT-dedicated star networks are named Low Power Wide Area Networks (LPWAN) by analysts. These two types of radio techniques share the common use of high sensitivity for increased radio coverage, the low power operation of radio modules in the end-points and the high capacity per base station (i.e. over one million messages per day per base station).

In addition to these characteristics, all LTN systems exhibit five specific features on their radio interface that are:

- the ability to operate in a shared spectrum environment, where spectrum occupancy is unpredictable and where polite access techniques are required by the regulation;
- a star topology for the radio access network that allows one-hop communication between end-points and base stations, thereby avoiding the need for multi-hop transmission of the same application data and associated routing overheads a random access (in time and/or in frequency) to the radio resources, that allows end-points to transmit their user data with minimal signalling overhead;
- the use of random access protocol optimized for massive number of devices;
- a half-duplex radio communication between end-points and base stations, that avoids the implementation complexity of duplexers;
- an optimization of the radio protocol for infrequent small application packets (i.e. low throughput).

These features are the core characteristics of all LTN systems; they help the design of low complexity end-points. However, LTN systems differ in their implementation, because many other features may be tuned in different ways to match the requirements of different use cases. The main variations of these features are (see Figure A-2):

- Asymmetry of UL and DL links that can go from no asymmetry to absence of DL link.
- Spectrum usage; that is mainly UNB or spread spectrum.
- Mobility of end-points that may incur various process and/or extra signalling.

- UL/DL acknowledgement that may use various approaches (i.e. from nothing to full implementation).
- Application message size that is highly related to intended application and protocol design.
- Latency in UL and DL, which strongly depends on protocol implementation.
- Link budget, which value may vary with radio technologies.
- Interference immunity, which may exhibit different values.
- Security, where threat protection level may vary.
- Geolocation, which may differ depending on radio technology and chosen algorithms.

Variations exist among these capabilities because each capability is the outcome of global trade-offs made when designing a specific LTN implementation.

As many trade-offs are possible, the LTN standard is composed of several solutions. Each solution is named an "LTN family" and is detailed in the LTN protocol document.

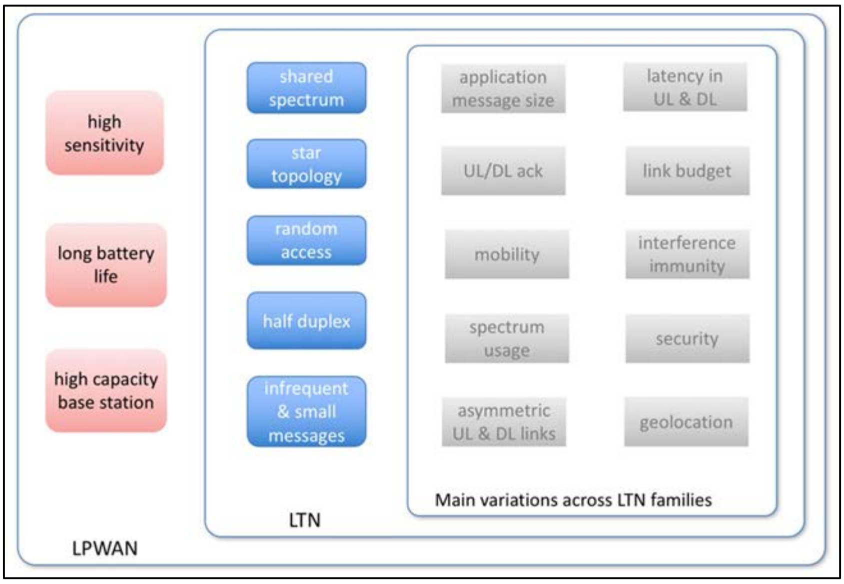

Figure A-2: LPWAN and LTN key features

History

Document history		
V1.1.1	June 2018	Publication