LPWAN

LOW POWER
WIDE AREA NETWORK

OVERVIEW OF EMERGING TECHNOLOGIES FOR LOW POWER WIDE AREA NETWORKS IN INTERNET OF THINGS AND M2M SCENARIOS

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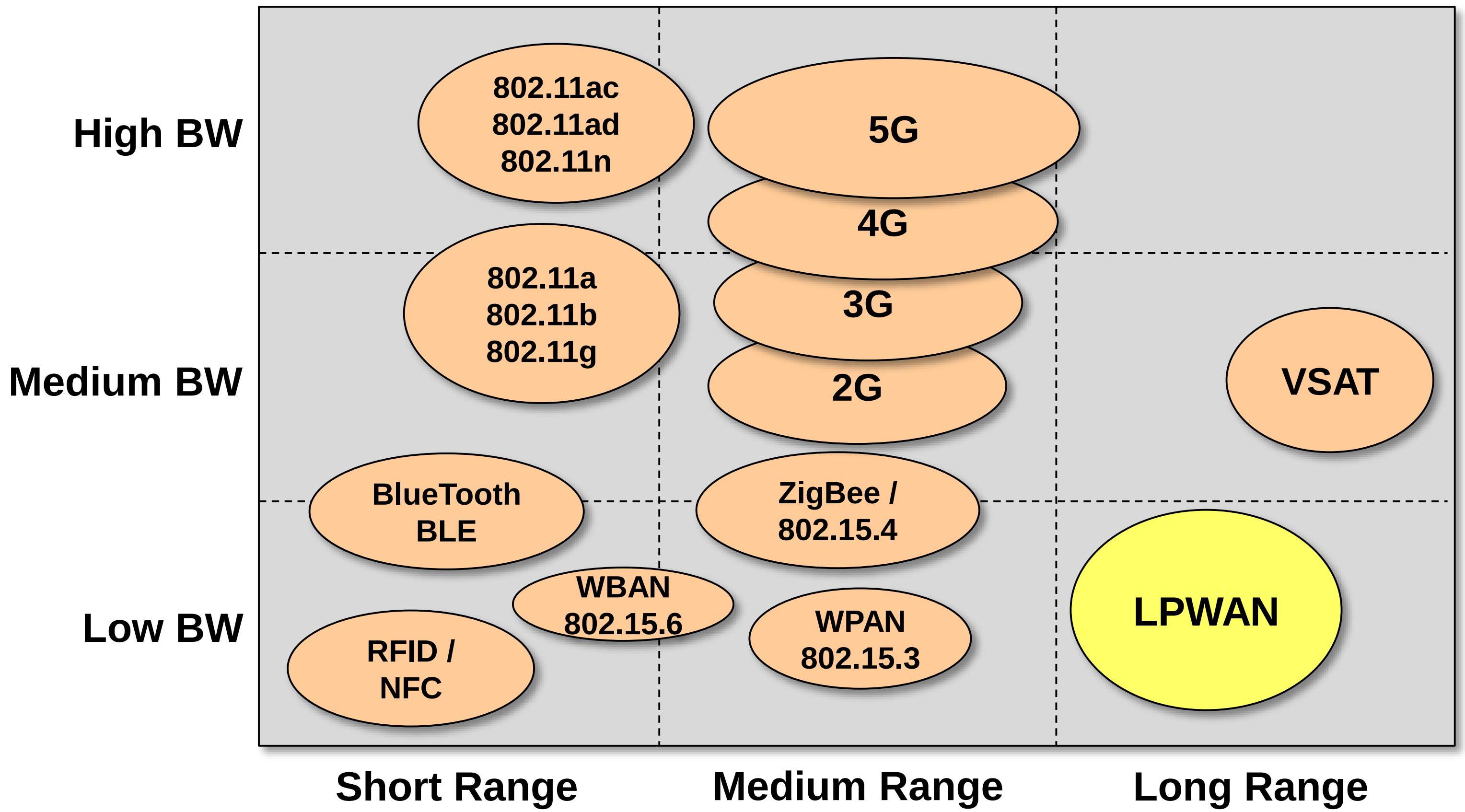
1. The sweet spot for LPWANs

Different wireless technologies cover different applications with regard to range and bandwidth. Long-range applications with low bandwidth requirements that are typical for IoT and M2M scenarios are not well supported by these existing technologies.

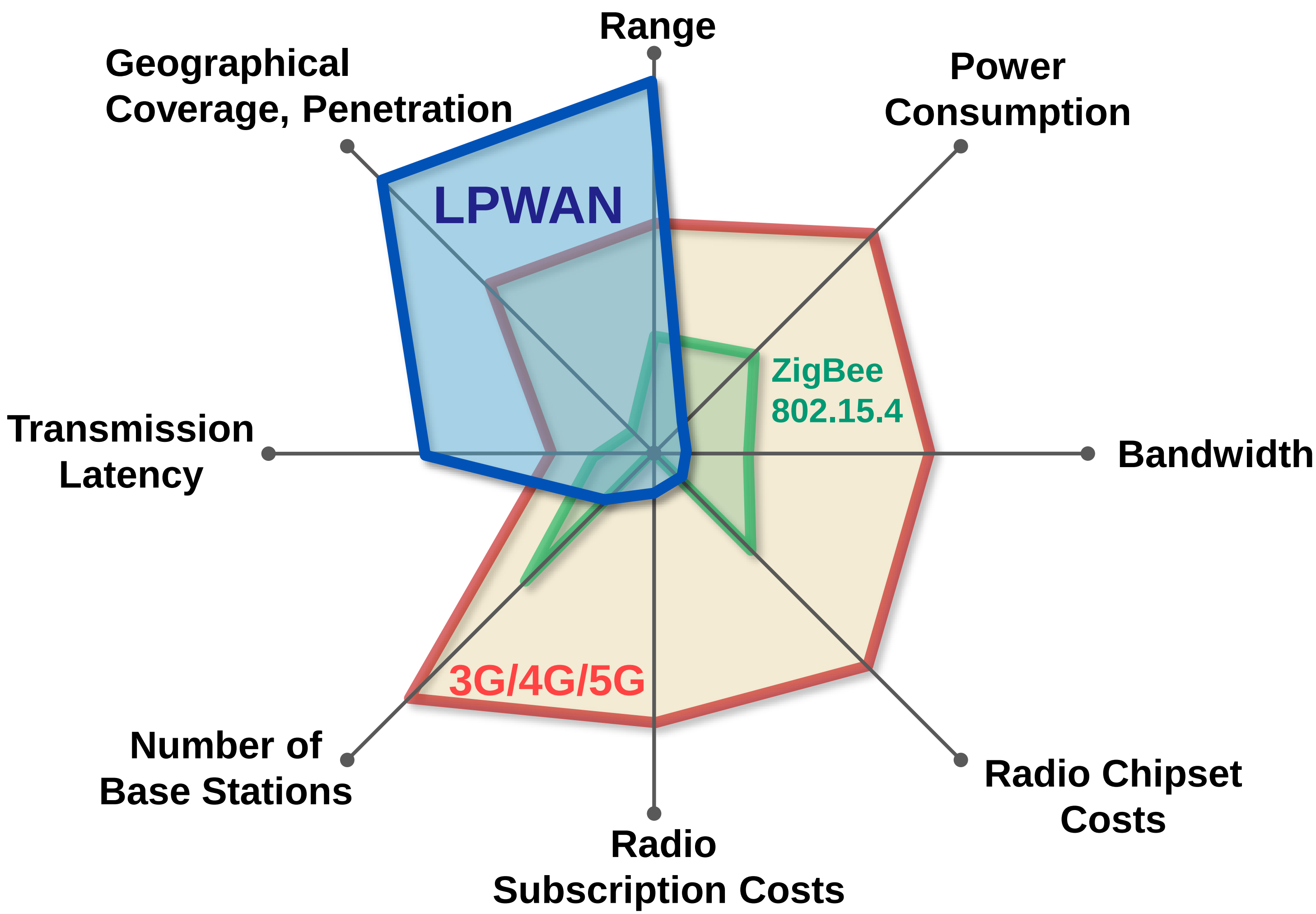
LPWAN technologies are targeted at these emerging applications and markets.



Key:
BW: Bandwitch
IoT: Internet of Things
M2M: Machine to Machine

2. LPWAN requirements and characteristics (1/2)

The needs of IoT and M2M applications pose some unique requirements on LPWAN technologies as shown in the comparison with other wireless technologies:



2. LPWAN requirements and characteristics (2/2)

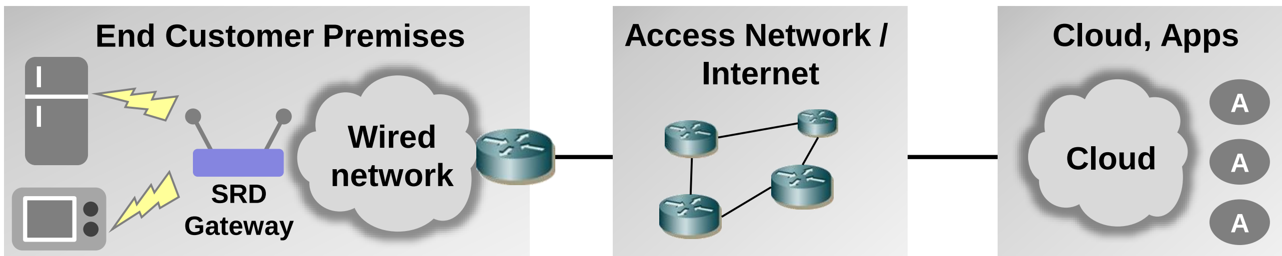
Characteristic	Target Value for LPWAN Technologies
Long range	5 – 40km in the open field
Ultra low power	Battery lifetime of 10 years
Throughput	Depends on the application, but typically a few hundred bit / s or less
Radio chipset costs	$2 or less
Radio subscription costs	$1 per device and year
Transmission latency	Not a primary requirement for LPWAN. IoT applications are typically insensitive to latency.
Required number of base stations for coverage	Very low. LPWAN base stations are able to serve thousands of devices.
Geographic coverage, penetration	Excellent coverage also in remote and rural areas. Good in-building and in-ground penetration (e.g. for reading power meters).

3. The need for long range wireless connectivity

Devices in IoT applications (the “things”) are typically installed in the field on residential premises, public places like restaurants or cafés or on industrial plant sites.

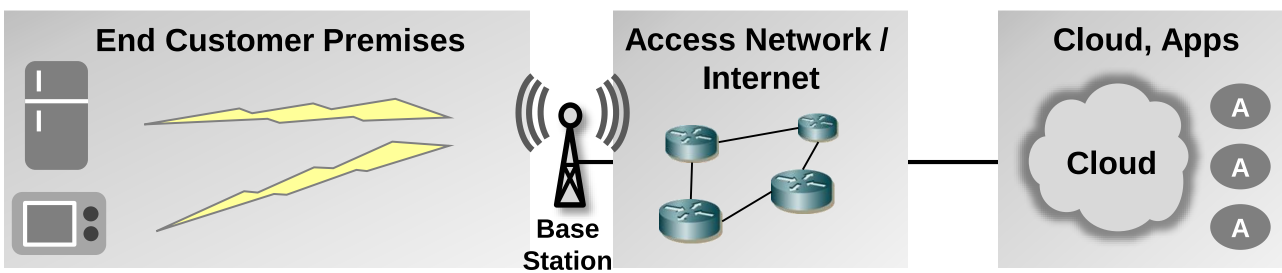
Using short range radio connectivity complicates the IoT setup due to the implications of wired on-site connectivity (firewalls, NAT, port and protocol filtering).

Short range radio connectivity for IoT devices:



- **Short range radio devices (SRD) such as ZigBee require using a gateway for long-range backhaul.**
- **The gateway is typically hooked up to some on-site wired network which is not under control of the IoT provider.**

Direct long range connectivity (LPWAN) for IoT devices:

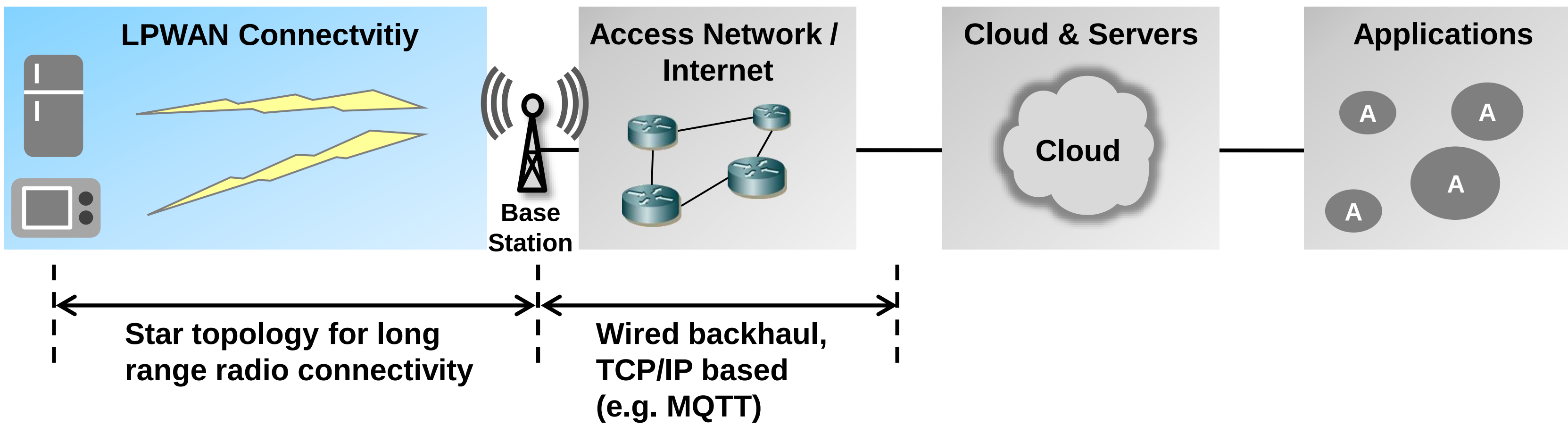


- **Long range connectivity allows direct access to the devices in the field.**
- **The base station typically serves a large number of devices thus greatly reducing costs.**

4. LPWAN network topology (1/2)

The wireless portion of LPWAN networks uses a star topology.
This obviates the need for complicated wireless mesh routing protocols which would greatly complicate the implementation of end devices and drive up power consumption.

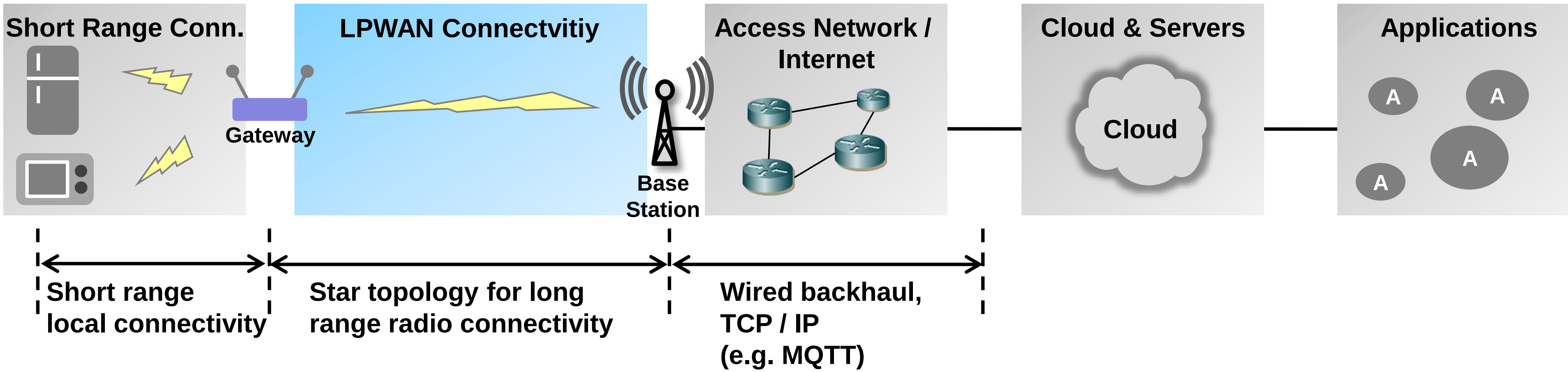
A. Direct device connectivity (base station):



- **A base station provides connectivity to a large number of devices.**
- **The traffic is backhauled to servers (cloud) through TCP/IP based networks (Internet).**
- **The base station is responsible for protocol translation from IoT protocols such as MQTT or CoAP to device application protocols.**

4. LPWAN network topology (2/2)

B. Indirect device connectivity through a LPWAN gateway:



- **In setups where devices cannot be directly reached through LPWAN, a local gateway bridges LPWAN connectivity to some short range radio (SRD) technology (e.g. ZigBee, BLE).**
- **The gateway typically runs on mains power since it serves a larger number of devices and must convert between LPWAN and SRD radio technologies and protocols.**
- **Gateways may help to improve security since more powerful security algorithms can be implemented on the gateway than is possible on the constrained devices.**

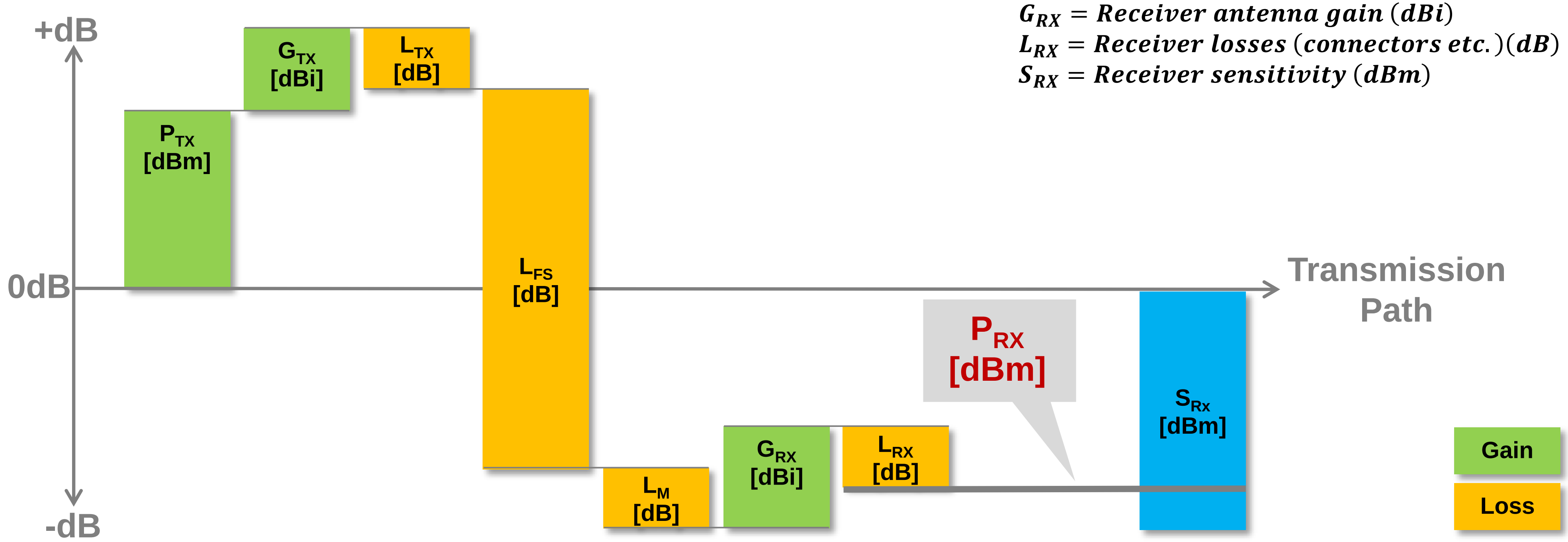
5. Link budget for LPWAN devices

Link budget:

As in most radio systems, the link budget is an important measure for power calculation. The link budget calculates the power received at the receiver and accounts for gains and losses along the transmission path.

$$P_{RX} = P_{TX} + G_{TX} - L_{TX} - L_{FS} - L_M + G_{RX} - L_{RX}$$

P_{RX} = Received power (dBm)
P_{TX} = Sender output power (dBm)
G_{TX} = Sender antenna gain (dBi)
L_{TX} = Sender losses (connectors etc.)(dB)
L_{FS} = Free space loss (dB)
L_M = Misc. losses (multipath etc.)(dB)
G_{RX} = Receiver antenna gain (dBi)
L_{RX} = Receiver losses (connectors etc.)(dB)
S_{RX} = Receiver sensitivity (dBm)



6. Receiver sensitivity for LPWAN devices

Receiver sensitivity:

The required receiver sensitivity for a LPWAN device is derived from the calculated link budget. The wireless link can be closed (communication between sender and receiver is possible) if the receiver sensitivity S_{RX} equals or is lower than (numerically in dB) the received power P_{RX}.

$$S_{RX} <= P_{RX}$$

Due to the long transmission paths that are typical for LPWAN systems, free space loss (path loss) is the dominant factor that greatly reduces the received power at the receiver.

Therefore it is essential that LPWAN receivers, particularly device nodes, have a very good receiver sensitivity (<= -140dBm), i.e. are able to receive signals levels that are 7 orders of magnitude or more smaller than the transmission level at the sender.

7. Technologies for LPWAN

In the still evolving IoT and M2M markets, a few competing radio technologies are emerging.

Common to these technologies is the use of lower frequencies than 2.4GHz or 5.8GHz to achieve better penetration into buildings or underground installations.

Work is still in progress in most of these technologies.

LPWAN Technology	Standard / Specification	Range	Spectrum
ETSI LTN	ETSI GS LTN 001 - 003	40 km in open field	Any unlicensed spectrum such as ISM (433MHz, 868MHz, 2.4GHz)
LoRaWAN	LoRa Alliance LoRaWAN	2-5km in urban areas <15km in suburban areas	Any unlicensed spectrum 868MHz (Eu) 915MHz (US) 433MHz (Asia)
Weightless-N	Weightless SIG	<5km in urban areas 20-30km in rural areas	800MHz – 1GHz (ISM)
RPMA	Proprietary (On-Ramp Wireless), planned to become an IEEE standard	<65km line of sight <20km non line of sight	2.4GHz