IoT Technologies

Internet of Things A.Y. 18-19

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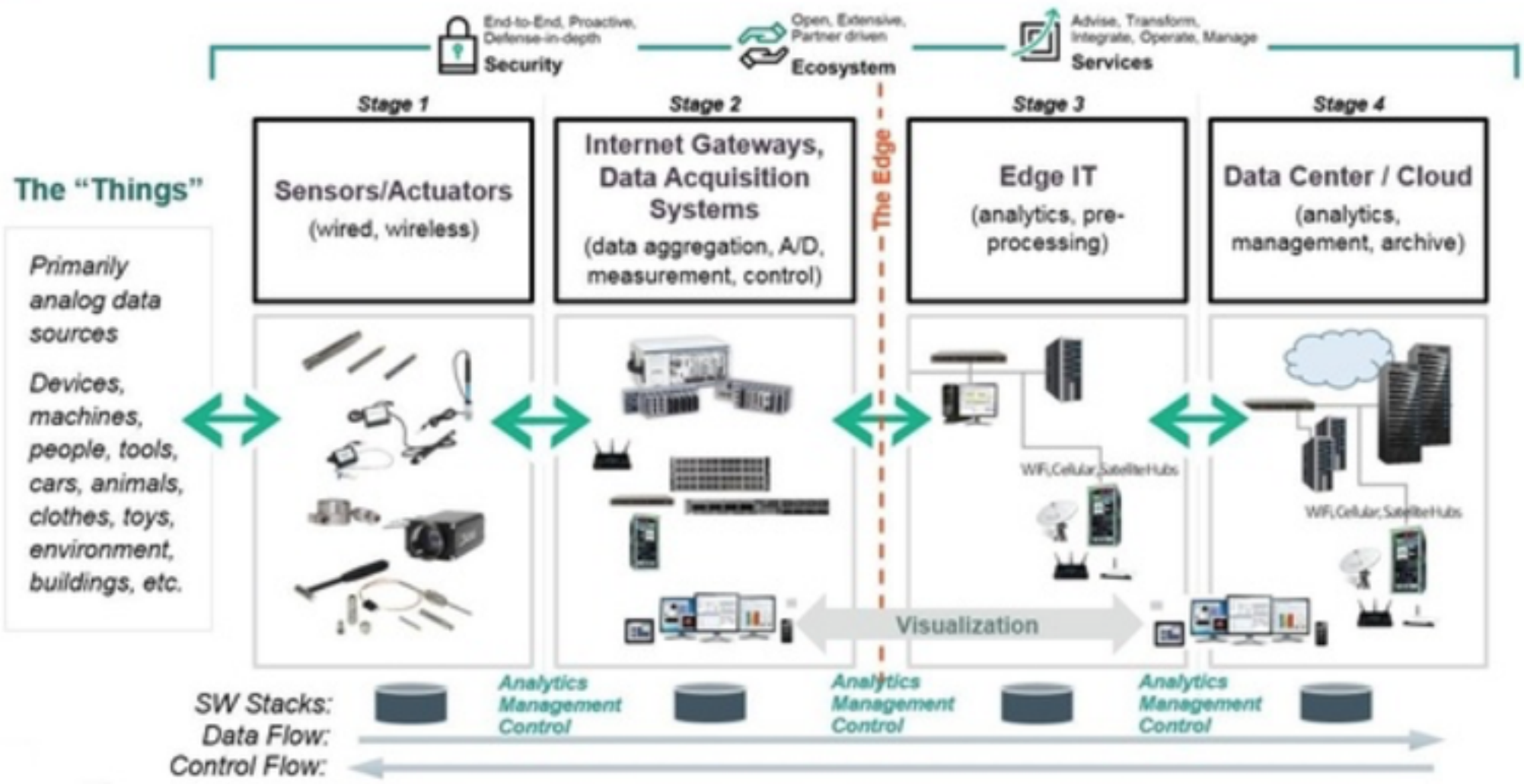
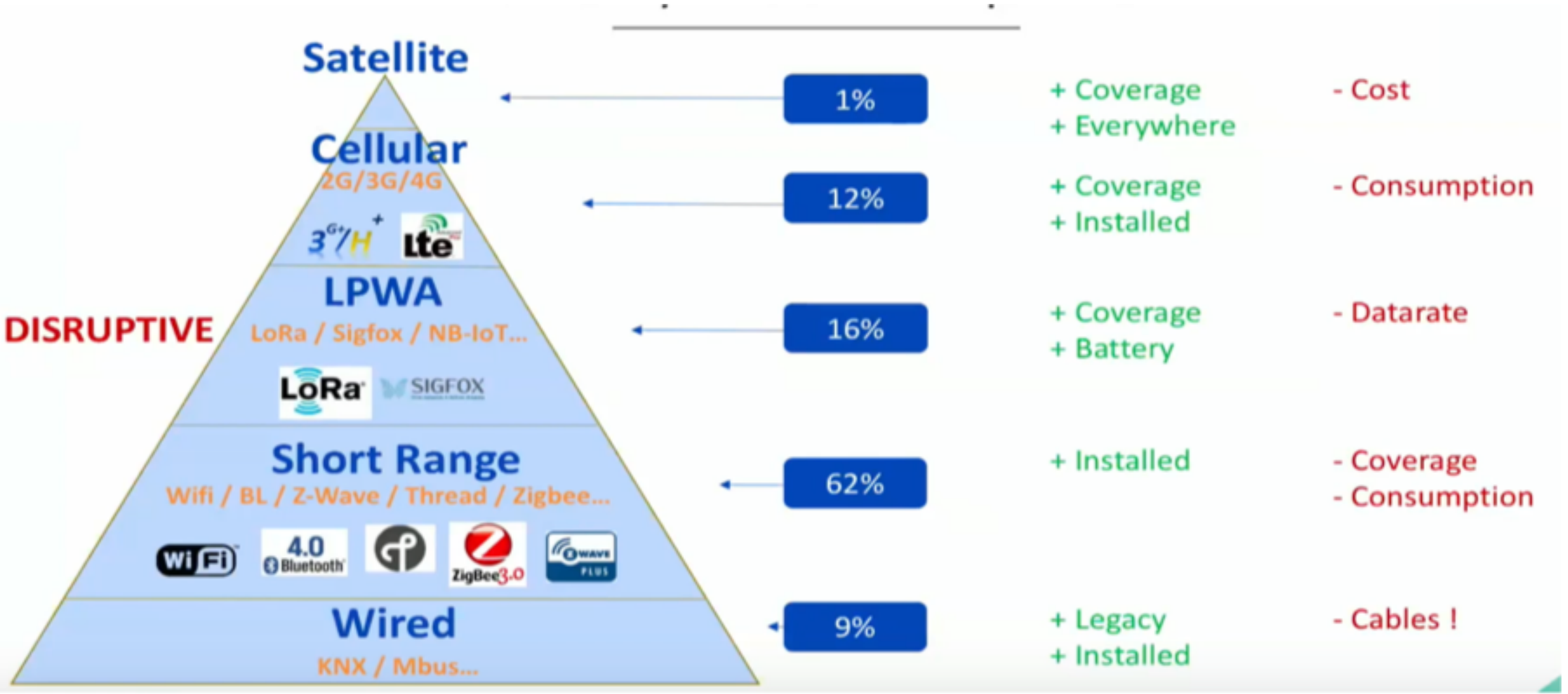
PART I

Architecture of an IoT system

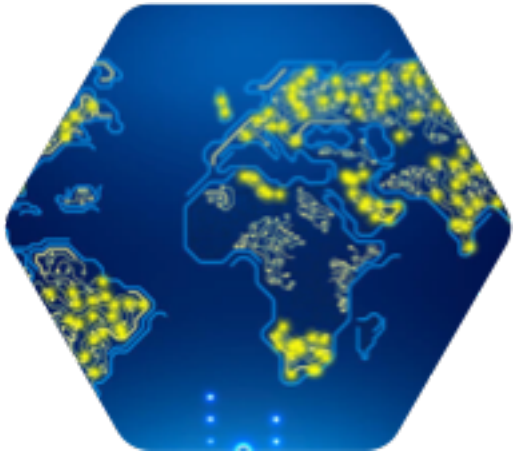


IoT Comm. Technologies



IoT techs

- KNX http://knx.fi/doc/esitteet/KNX-Basics_en.pdf
- M-Bus protocol
- Wireless M-Bus http://pages.silabs.com/rs/634-SLU-379/images/introduction-to-wireless-mbus.pdf
- https://download.beckhoff.com/download/document/Application_Notes/DK9322-0810-0036.pdf



M-BUS (Meter Bus)

- It is a single-master bus technology , in which the master requests and picks up the data from devices acting as slaves.
- M-BUS is used as a standardized system for reading energy and consumption meters or other end devices or actuators. Through serial data transmission a M-Bus master can read up to 250 energy and consumption meters.
- Signals are transferred serially from the connected slaves (measuring devices) to a master via a reverse polarity protected two-wire line. The field devices can be powered via the bus cable.
- The master queries the meters by modulating the supply voltage: 1 corresponds to a signal level of 36 V DC, a logical 0 is represented by 24 V DC. The slave responds to the master by modulating its current consumption: 1.5 mA corresponds to logical 1, logical 0 is detected between 11 and 20 mA. Data transfer rates of 300 to 9,600 baud are possible. Broadcasting and unicasting both supported.
- Data and command structure can depend on manufacturer. Devices of different manufacturers can share the same bus.

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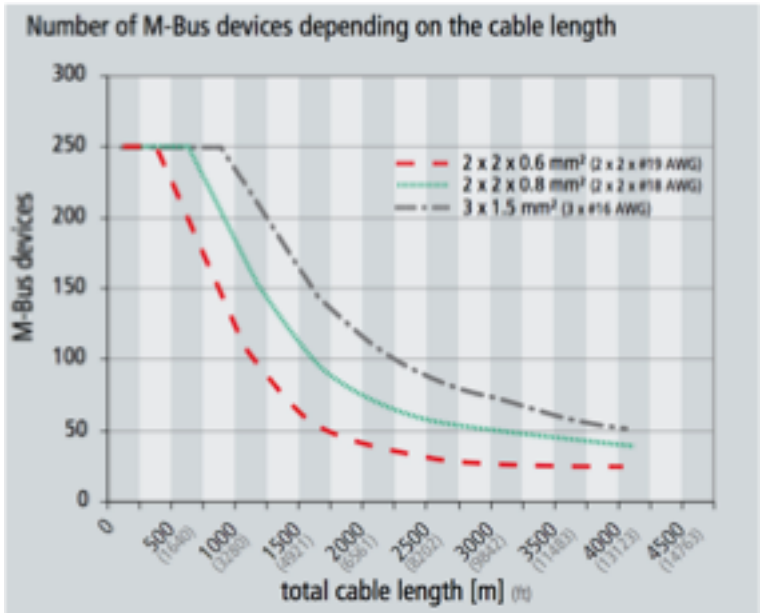
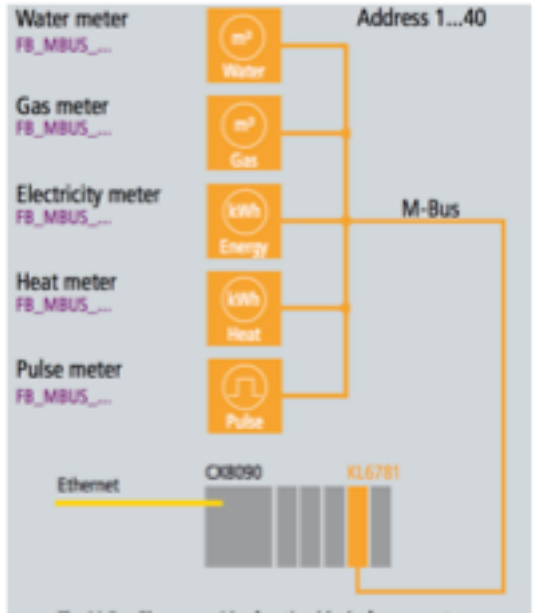
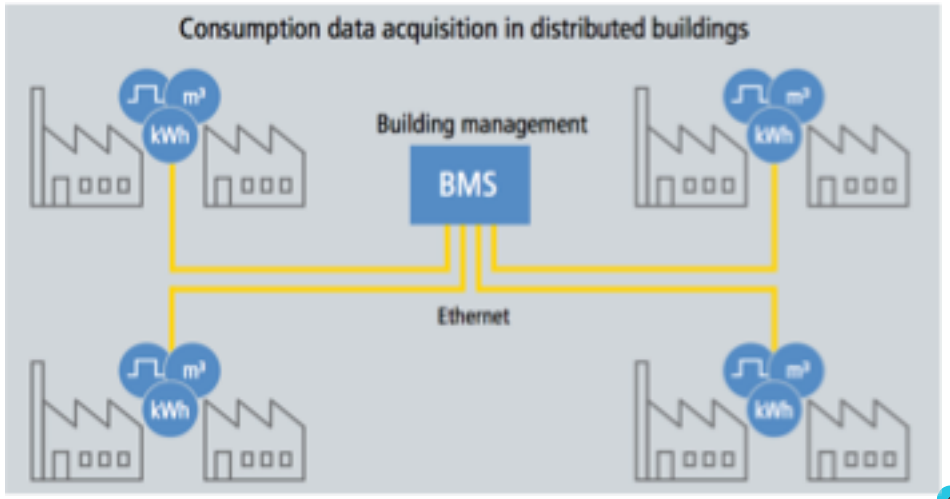
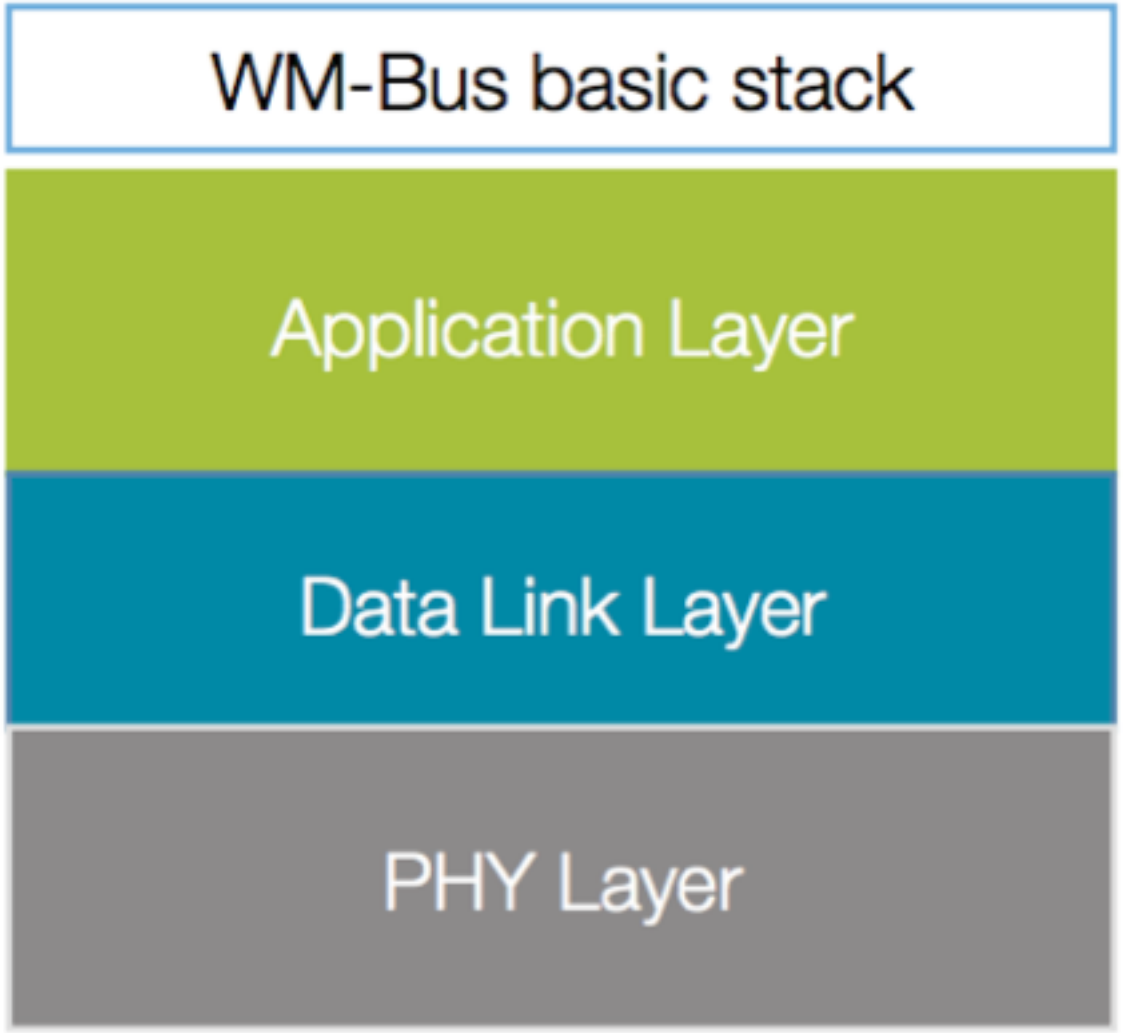






Wireless M-BUS

- Wireless M-Bus: 868MHz, 433MHz and 169MHz.
- Star Network, not IP or mesh networking enabled
- MAC: Aloha with listen before talk



KNX Bus technology

- The KNX system is a widely adopted bus system for building control. All devices in a KNX system use the same transmission method and exchange data via a common bus network. (problems: access control; need to explicitly address devices).
- All sensors and actuators in the building are connected by a “data cable” (typically twisted pair bus) enabling them to share information with each other. Each device can communicate with every other device (no centralized structure).
- The transmitter creates the AC voltage corresponding to the logical zero by only sending a half-wave, which it does by lowering the voltage on the pair of cores in the data cable by around 5 V. After approximately half a bit period, the sender cancels this voltage drop again.
- The control field defines the priority of the telegram (PDU) and whether or not transmission of the telegram was repeated. The address field specifies the Individual Address of the sender and the destination address of the receiver. The data field, which can be up to 16 bytes long, contains the telegram’s payload. The checksum field is used for parity checks. A variant of CSMA/CA medium access control is adopted.
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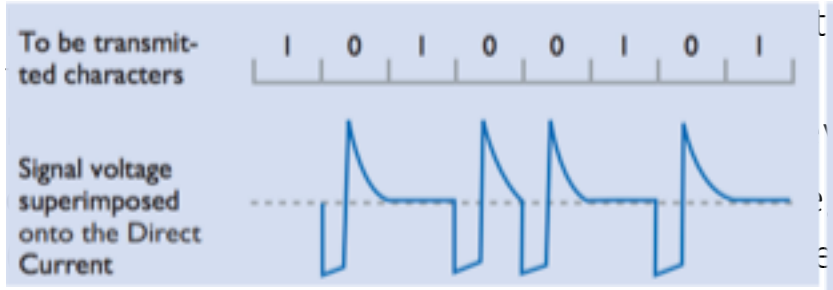
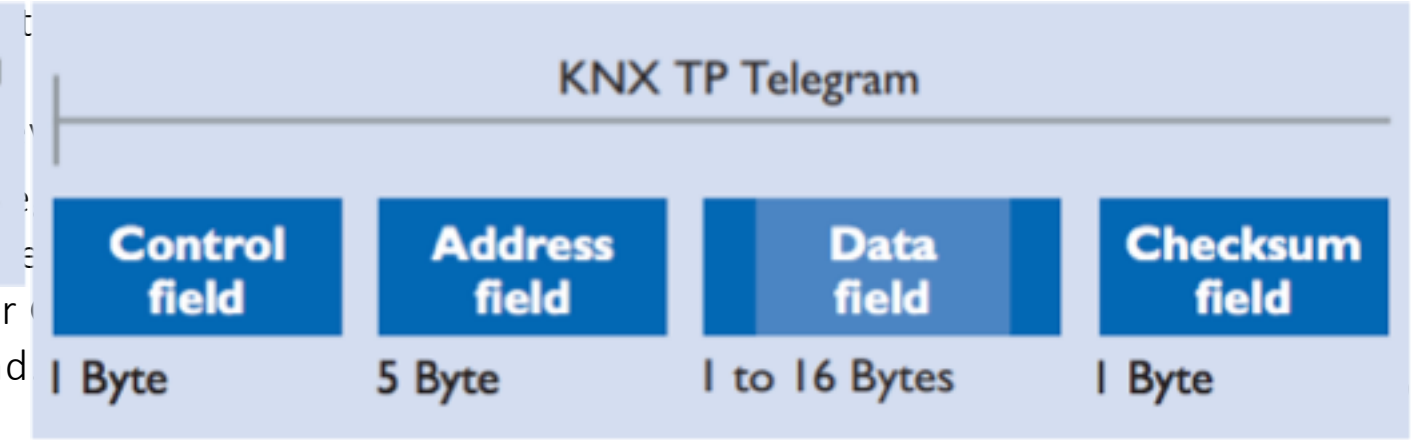
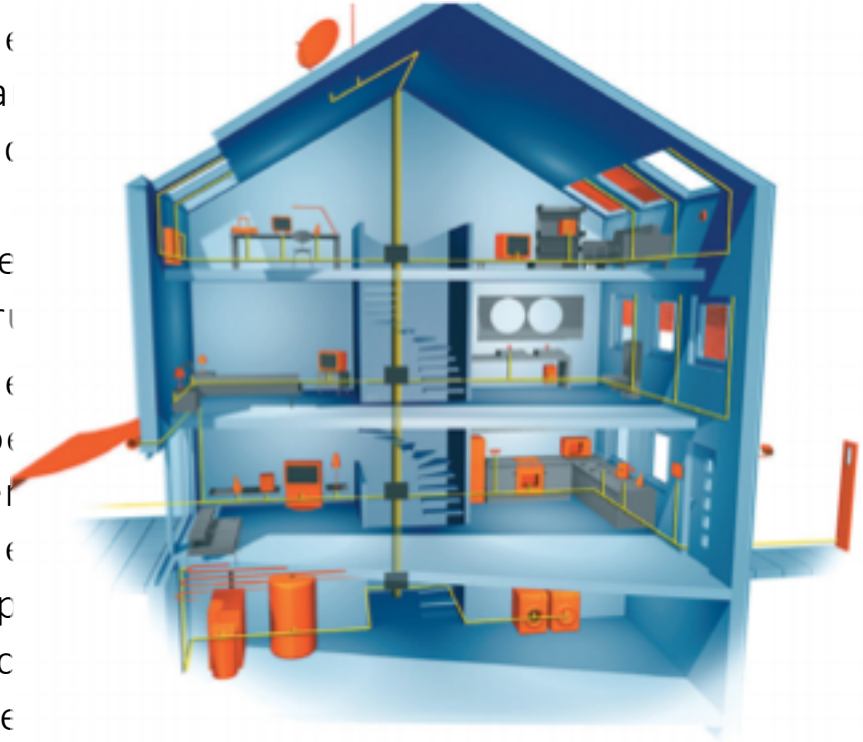
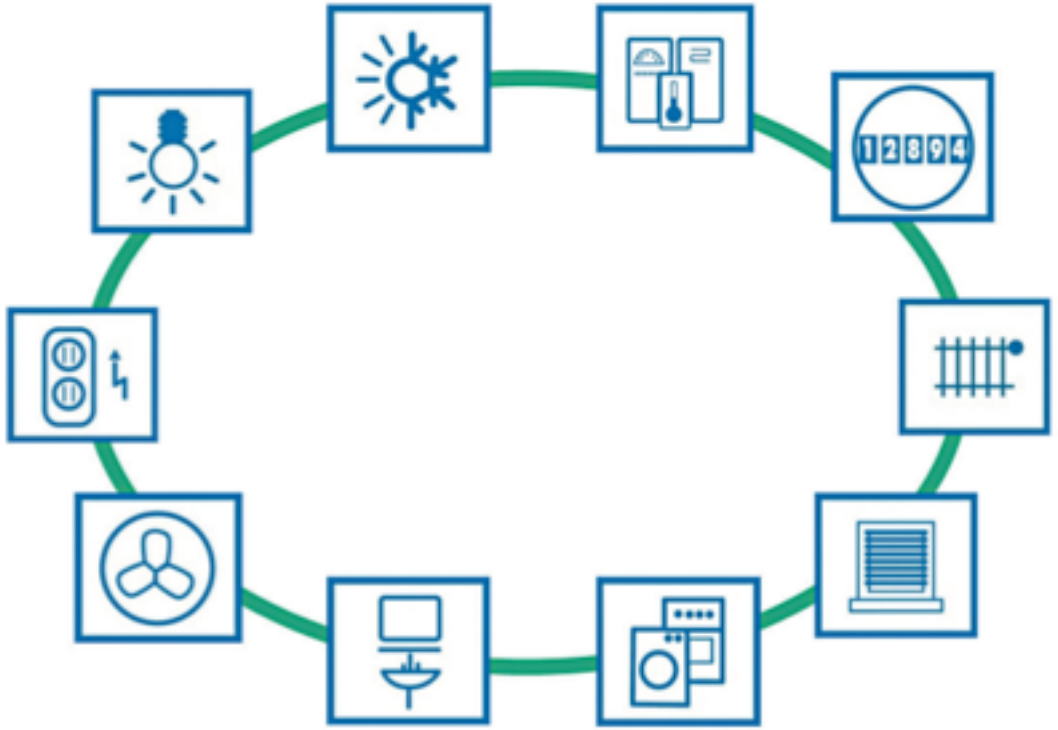


-
destination address (Individual Address or
byteslong, contains the telegram’s payload



KNX Bus Technology





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- All … …necte… the… …devi… …ized str…
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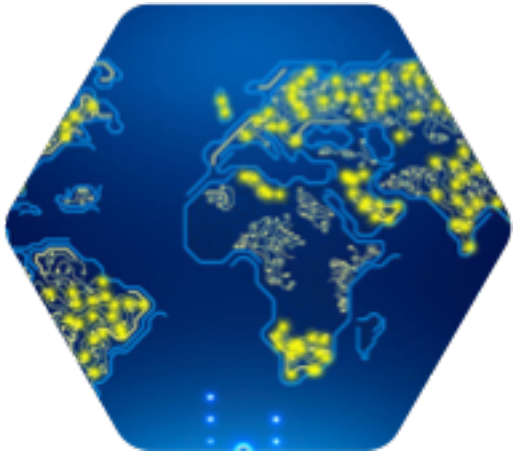
- The … …ram (… …vas rep… …ual Ac… rec… …ytes l… …d is use… …dium
- KNX supports also communication using other types of media: Powerline (lower bit rate, FSK, slightly different format, CSMA); RF; Ethernet.
- RF version (one hop): 868Mhz, typically devices can only tx information or they have to duty cycle (<1%) The control field defines the priority of the telegram and whether or not transmission of the telegram was repeated (if the receiver did not respond). The address field specifies the Individual Address of the sender and the destination address (Individual Address or Group Address) of the receiver. The data field, which can be up to 16 byteslong, contains the telegram's payload. The checksum field is used for parity checks.

IoT techs

- BLE https://eu.industrial.panasonic.com/sites/default/pidseu/files/downloads/files/pan150148_whitepaper_bluetooth.pdf
- Thread https://www.silabs.com/products/wireless/mesh-networking/thread
- ZigBee 3.0

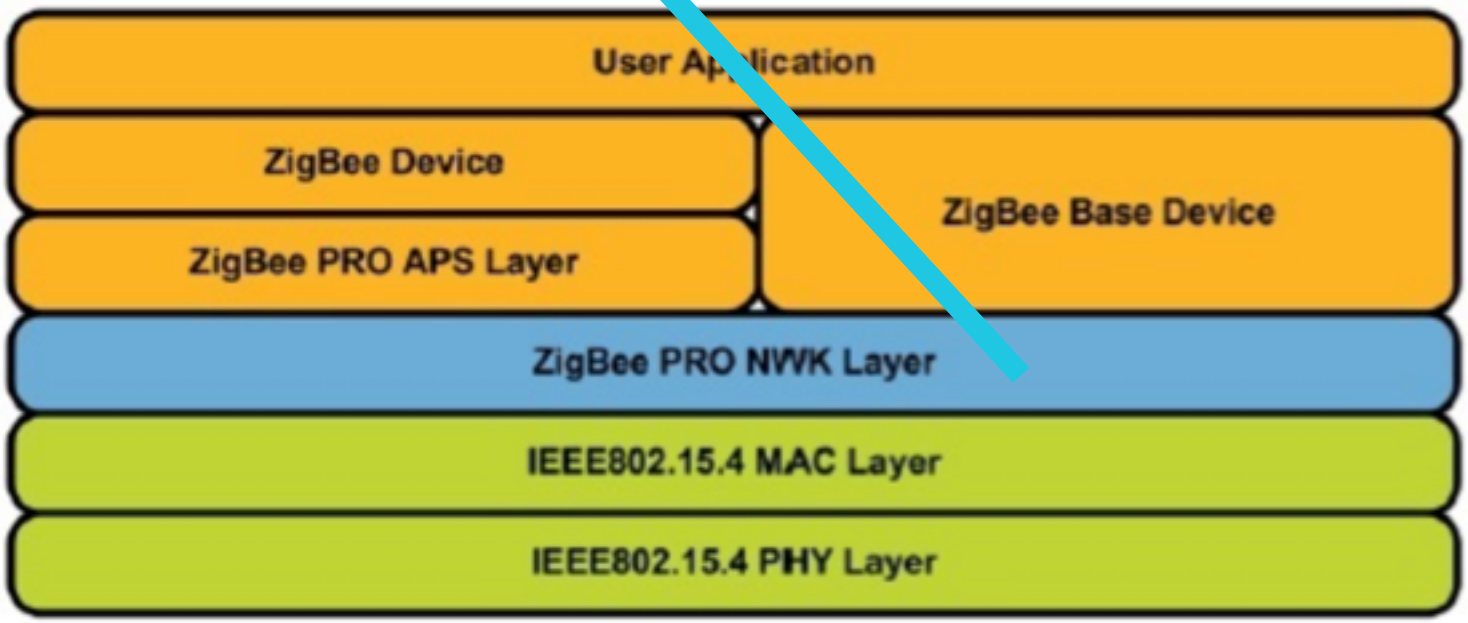
https://www.zigbee.org/zigbee-for-developers/zigbee-3-0/

- Z-wave https://z-wavealliance.org/ (legacy)



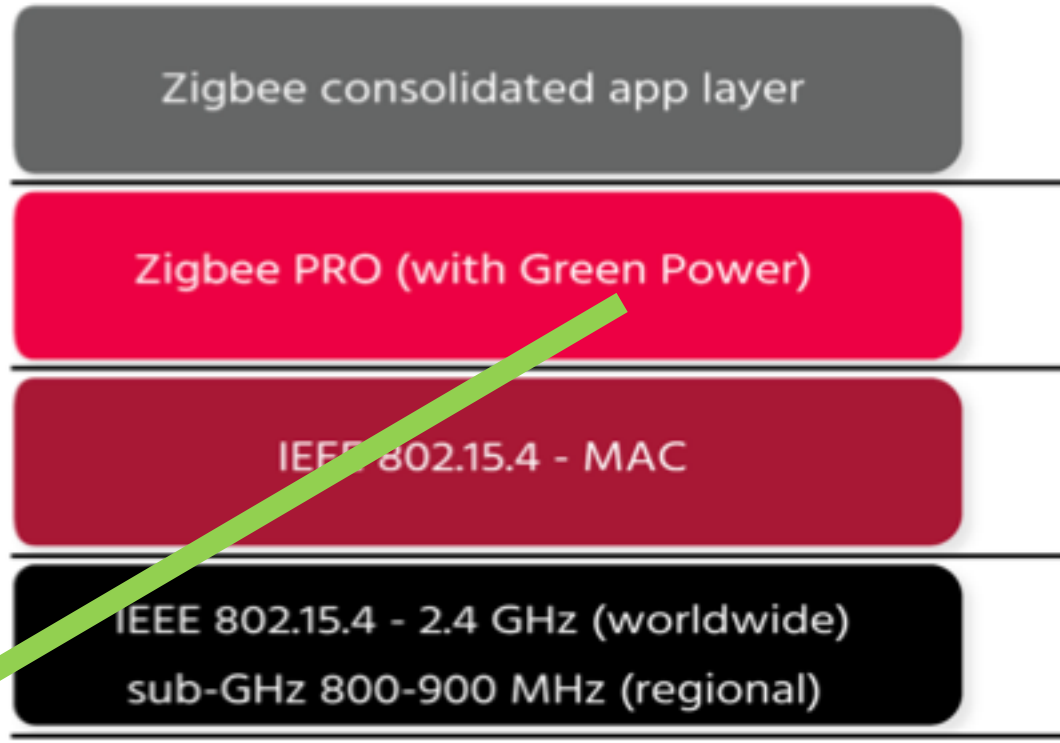
ZigBee

AODV, extended with a ETX like metric



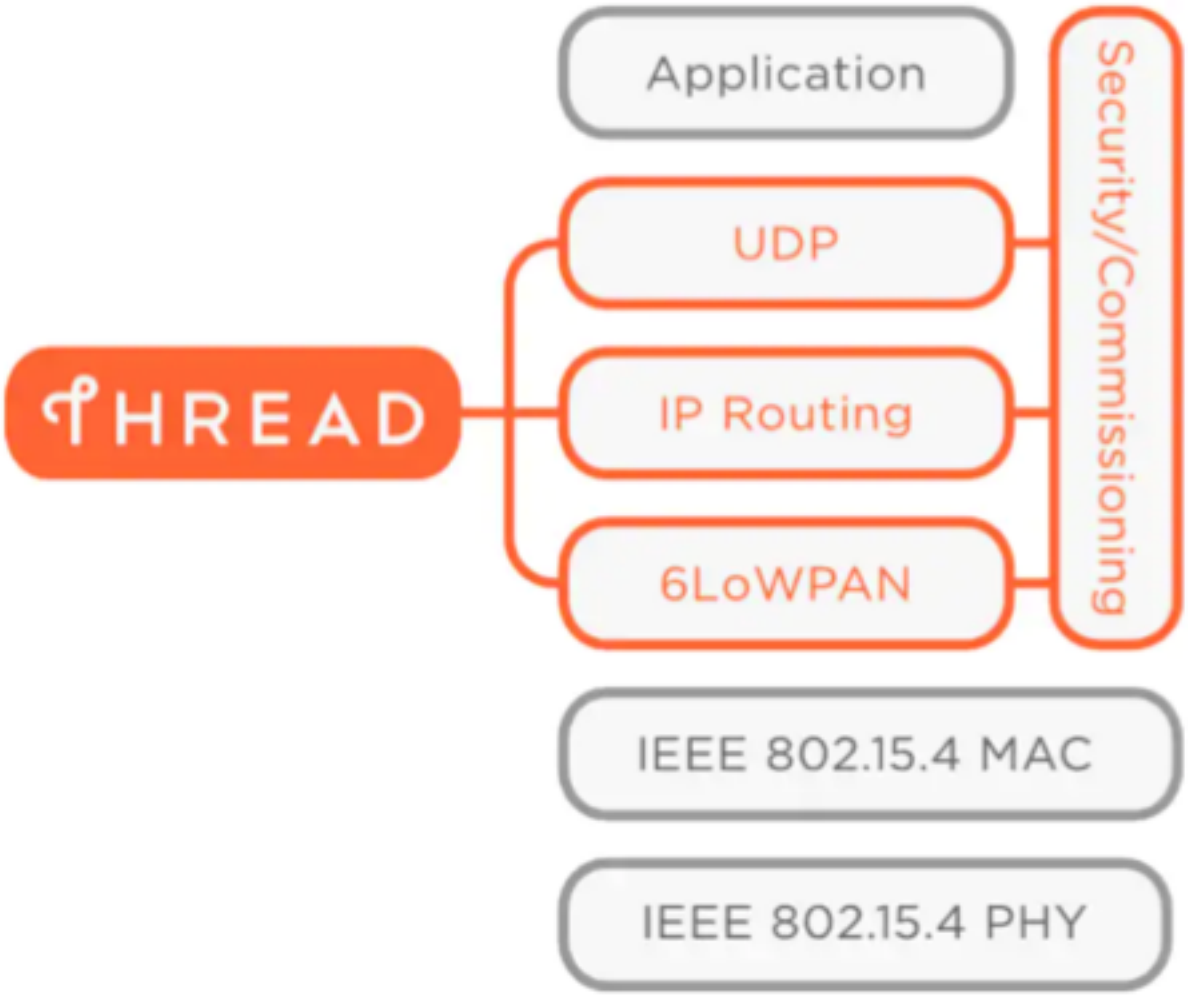
Zigbee 3.0 Protocol Stack

zigbee



Started in 2017, battery-less devices
Now supported

Thread



Traditional distance vector (RIPng)

Bluetooth Low Energy

- Faster device discovery (over a limited number of channels, not overlapping with WiFi)
- Overcomes the limits (existing in Bluetooth Basic) of the 7 slaves per piconet → a master can have associated even thousands of slaves
- Separates channels used for discovery/affiliation and for data transmission. Uses frequency hopping and polling as in the basic Bluetooth.
- Everything from physical design to use models is designed to keep power consumption at a minimum.
- To reduce power consumption, a BLE device is kept in sleep mode most of the time. Maximum/peak power consumption is less than 15 mA and the average power consumption is about 1 µA. The active power consumption is reduced to a tenth of the energy consumption of classic Bluetooth.

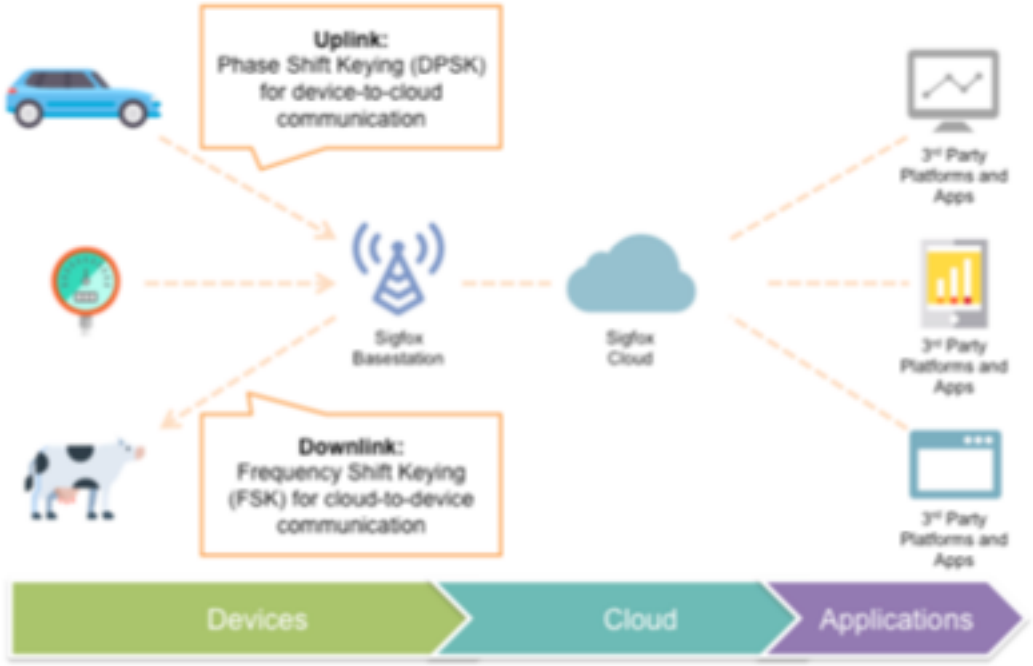
Emerging IoT techs

Long range IoT technologies

- SigFox
- LoRa

SigFox

- Sigfox network provides a networking infrastructure for supporting IoT devices with low data rate needs. It is a long range IoT technology.



- Connected devices can send messages with a payload of 1 to 12 bytes and receive messages of 8 bytes. Devices are limited by a network policy to a maximum of 140 transmitted messages per day and up to 4 received messages.

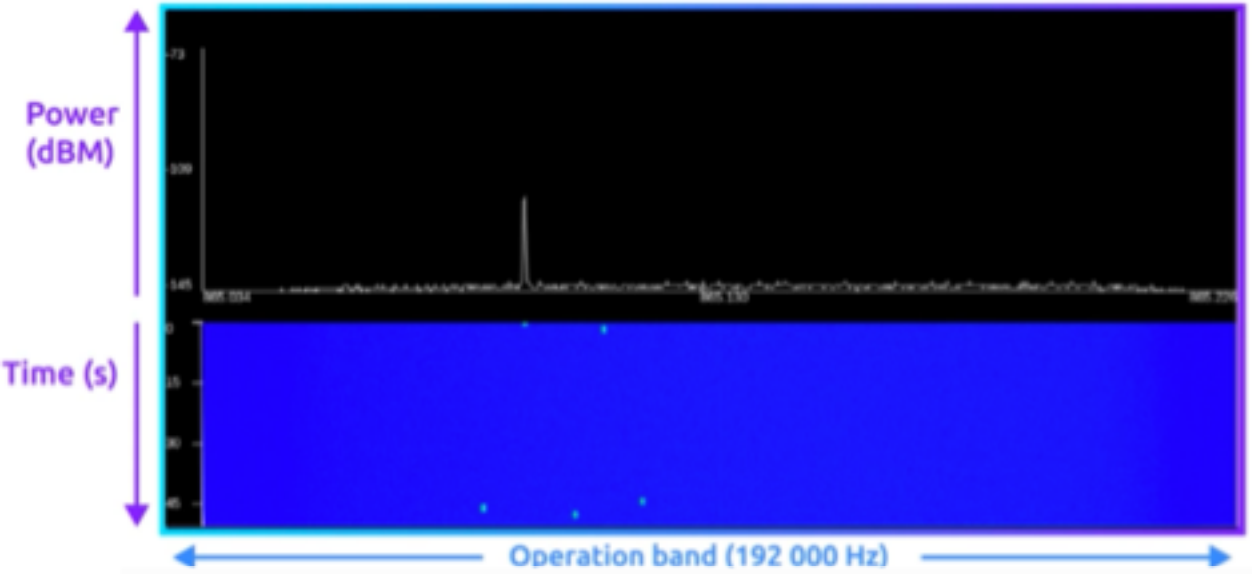
SigFox

Architecture

One base station (BS) can manage 1Mln messages a day, 1000 BS used to cover France

High sensitivity receivers

SigFox



D-BPSK modulation

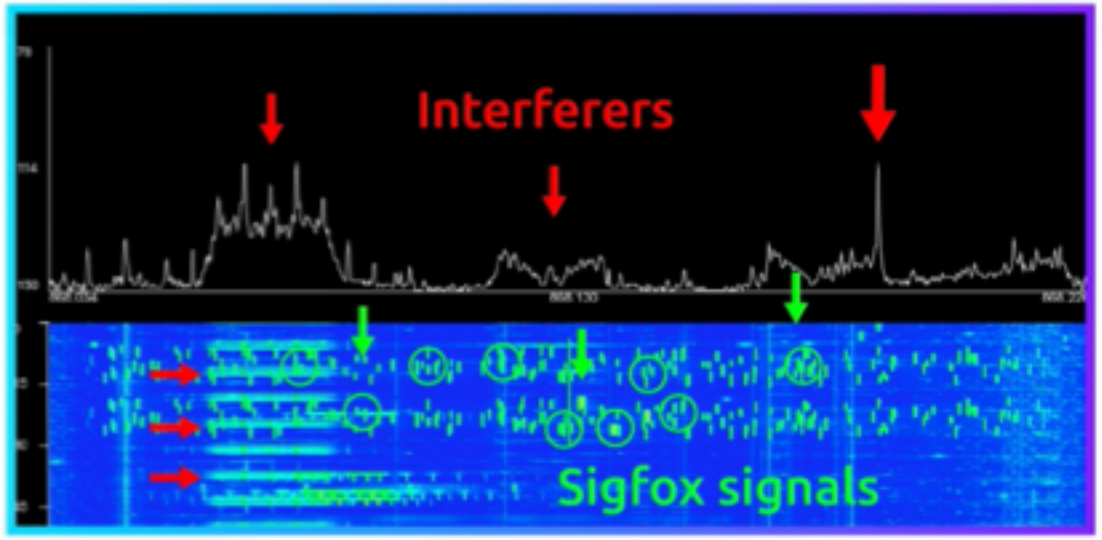
↓

High spectral efficiency

1 bit/s = 1 Hz

↓

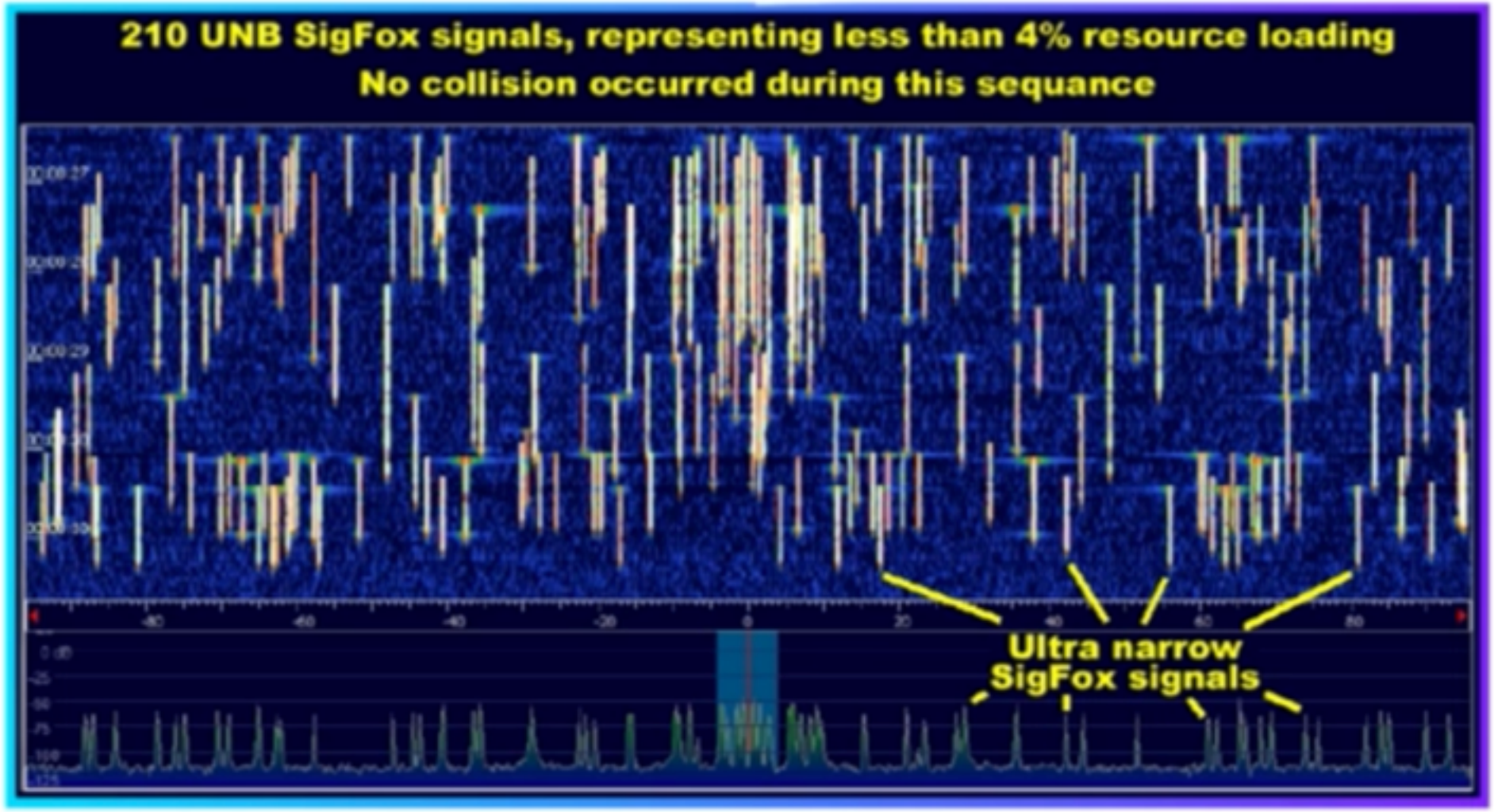
100 Hz transmission bandwidth at 100 bps



- Sigfox operates in the 868-868.6MHz band (unlicenced). It uses Ultra Narrow Band (UNB) signals coupled with Duty Cycle, 100 bps D-BPSK data modulation in uplink →low power; long range; better resilience to unexpected or largely unpredictable interferences

SigFox

- A pseudorandom phy channel assignment policy allows to deal with more than 300 simultaneous uplink messages.



SigFox

- Transmitted packets:

Uplink transmissions

0 > 12 bytes

Max: 140 messages/day

Downlink transmissions

0 to 8 Bytes

4 messages per day

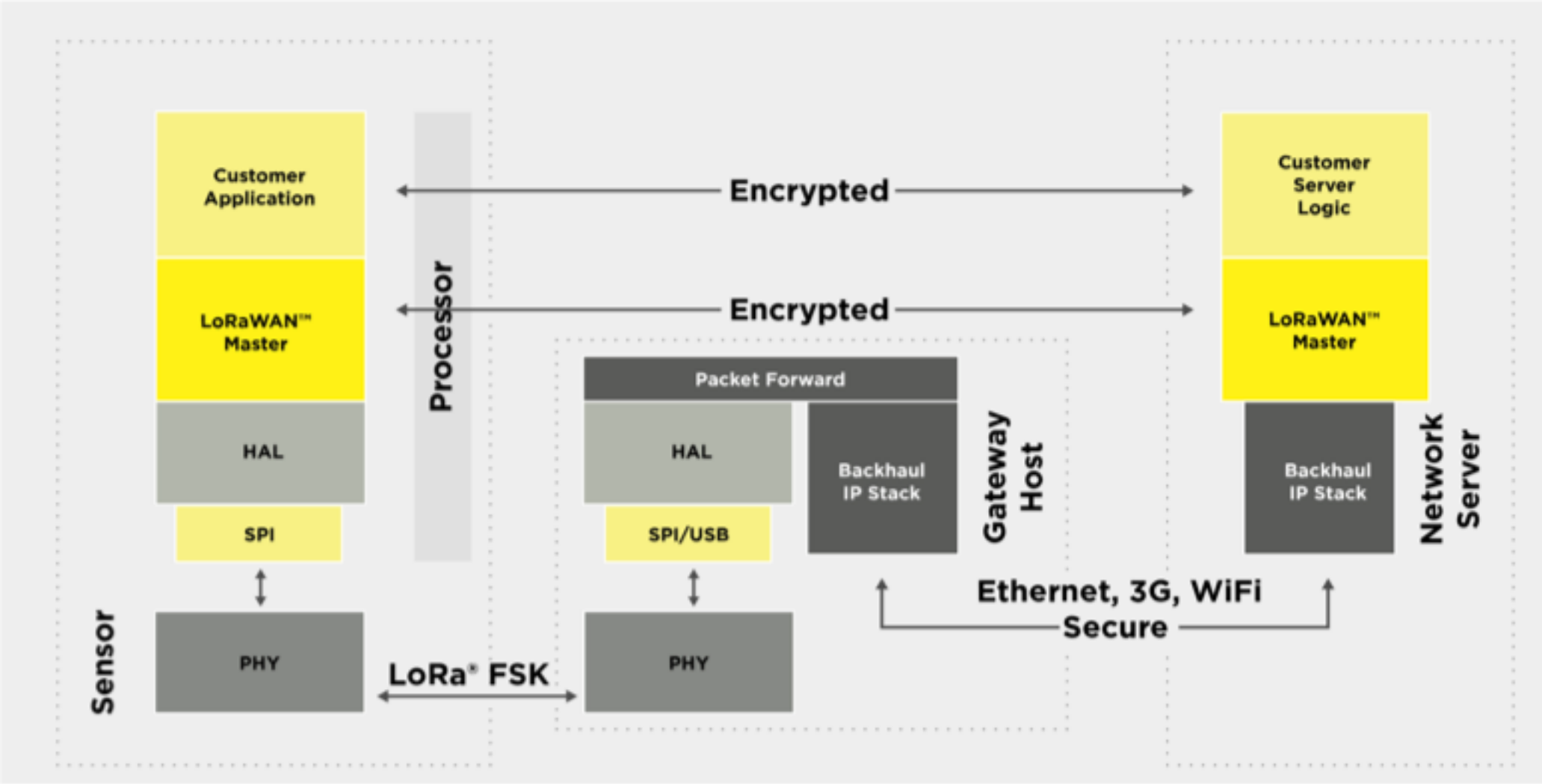
LoRaWAN

- Low Power narrow IoT technology
- Standardization Body: LoRaWAN Alliance
- Standard: https://lora-alliance.org/resource-hub/what-lorawantm

LoRaWAN – Key Features

- Network based on star-of-stars topology in which gateways relay messages between end-devices and a central Network Server; the Network Server routes the packets from each device of the network to the associated Application Server
- To secure radio transmissions the LoRaWAN protocol relies on symmetric cryptography using session keys derived from the device's root keys. In the backend the storage of the device's root keys and the associated key derivation operations are insured by a Join Server.
- Gateways are connected to the Network Server via secured standard IP connections while end-devices use single-hop LoRa™ or FSK communication to one or many gateways. LoRa is a proprietary phy by Semtech.
- communication is generally bi-directional, although uplink communication from an end-device to the Network Server is expected to be the predominant traffic
- Communication between end-devices and gateways is spread out on different frequency channels and data rates. LoRa data rates range from 0.3 kbps to 50 kbps according to an adaptive data rate (ADR) scheme
- End-device changes channel in a pseudo-random fashion for every transmission. The end-device respects the maximum transmit duty cycle and max transmit duration relative to the sub-band used and local regulations.

LoRaWAN – Network elements



LoRaWAN - Coverage

100
Network Operators

68
Alliance Member Operators

51
Countries operating in

100
Countries with LoRaWAN Deployments

Alliance Member Public Networks
Other LoRaWAN Deployment

LoRa By the Numbers

500,000+
LoRa-based gateways to be deployed worldwide by 2020

140 million
LoRa-based end-nodes to be deployed worldwide on private and public networks by the end of 2020

100+
LoRaWAN®-based network operators in 51 countries

40%
of all LPWANs are predicted to run on LoRa by 2019 (IHS MarketInsider, Sept 17)

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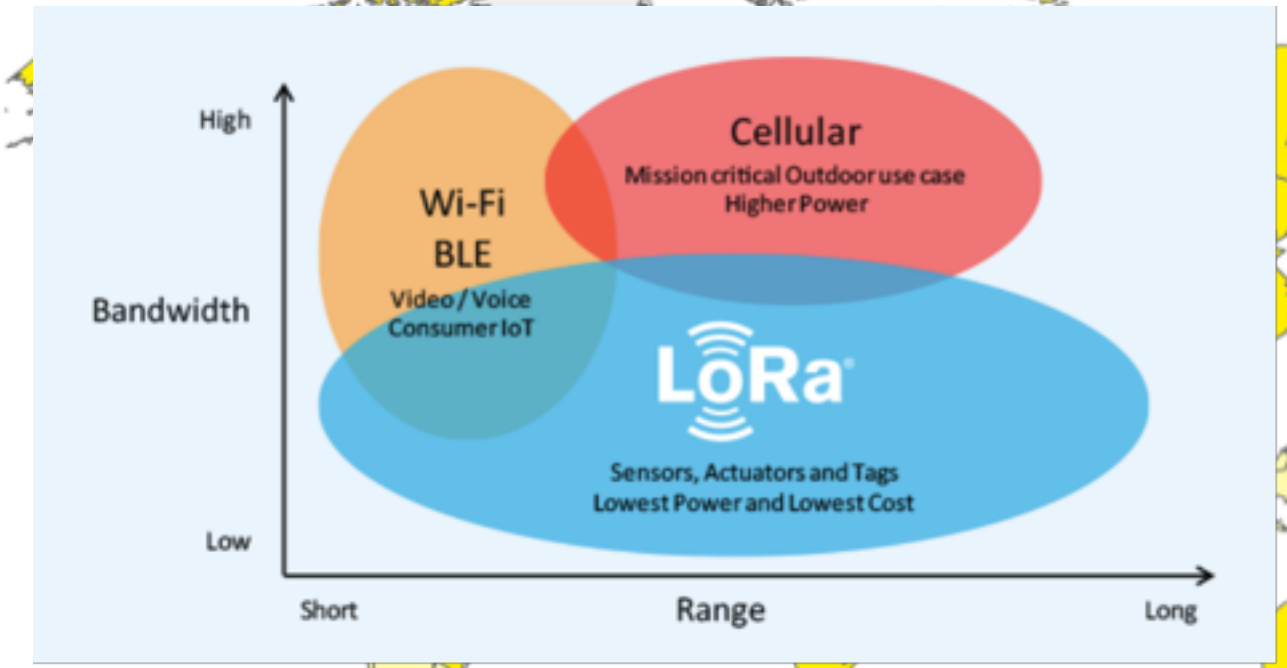

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Other LoRaWAN Deployment

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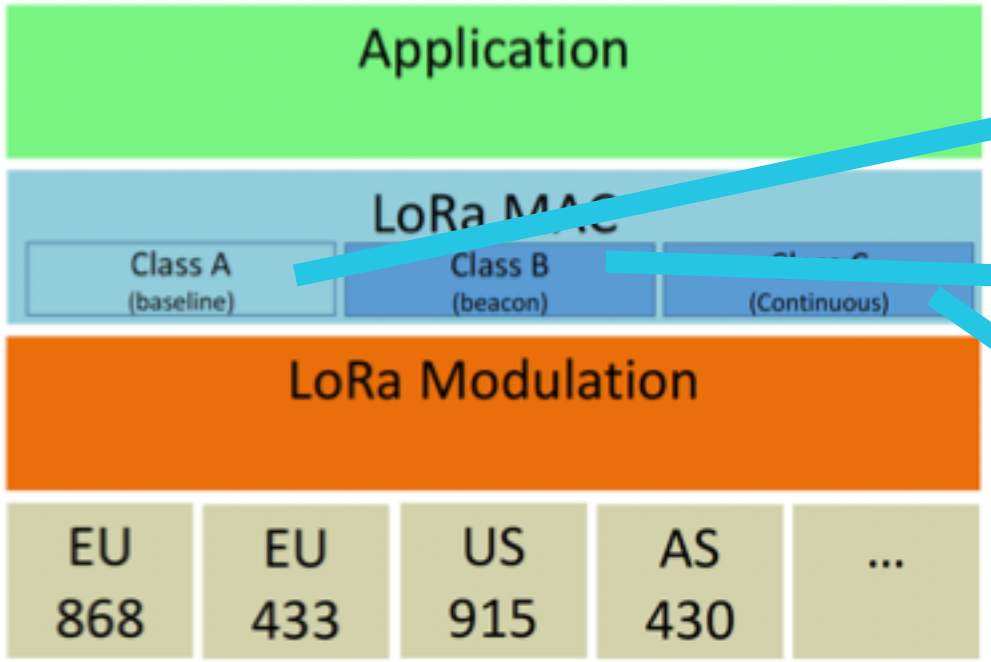

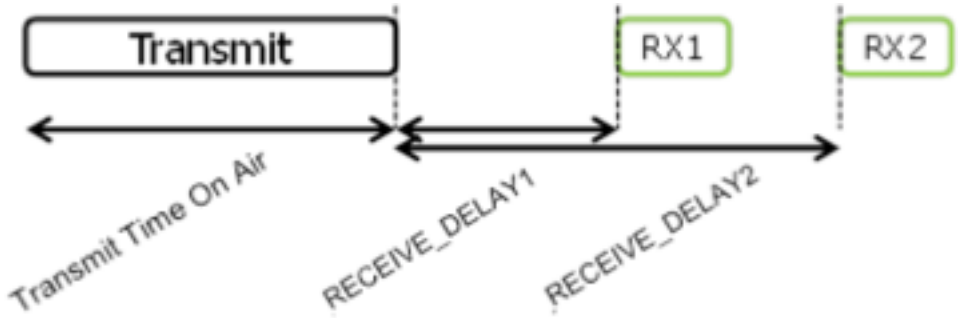

- End-devices of Class A allow for bi-directional communications whereby each end-device's uplink transmission is followed by two short downlink receive windows.
- Bi-directional end-devices with scheduled receive slots (Class B): End-devices of Class B allow for more receive slots. In addition to the Class A random receive windows, Class B devices open extra receive windows at scheduled times.
- Bi-directional end-devices with maximal receive slots (Class C): End-devices of Class C have nearly continuously open receive windows, only closed when transmitting.

Feature	LoRaWAN	Narrow-Band	LTE Cat-1 2016 (Rel12)	LTE Cat-M 2018 (Rel13)	NB-LTE 2019(Rel13+)
Modulation	SS Chirp	UNB / GFSK/BPSK	OFDMA	OFDMA	OFDMA
Rx bandwidth	500 - 125 KHz	100 Hz	20 MHz	20 - 1.4 MHz	200 KHz
Data Rate	290bps - 50Kbps	100 bit/sec 12 / 8 bytes Max	10 Mbit/sec	200kbps – 1Mbps	~20K bit/sec
Max. # Msgs/day	Unlimited	UL: 140 msgs/day	Unlimited	Unlimited	Unlimited
Max Output Power	20 dBm	20 dBm	23 - 46 dBm	23/30 dBm	20 dBm
Link Budget	154 dB	151 dB	130 dB+	146 dB	150 dB
Batery lifetime - 2000mAh	105 months	90 months		18 months	
Power Efficiency	Very High	Very High	Low	Medium	Med high
Interference immunity	Very high	Low	Medium	Medium	Low
Coexistence	Yes	No	Yes	Yes	No
Security	Yes	No	Yes	Yes	Yes
Mobility / localization	Yes	Limited mobility, No loc	Mobility	Mobility	Limited Mobility No Loc

Questions?