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Wireless communication for Smart Buildings

Kortrijk, 07/04/2017

citc
contactless technologies.EuroRFID

Smart Buildings: What for ?

- Access control
- Smart HVAC management
- Smart light management
- Indoor location
- Room management (occupancy / reservation / …)
- Energy / water consumption monitoring
- Indoor air quality monitoring
- …

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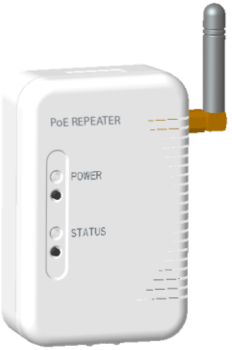
Smart Buildings: How ?

With a lot of different equipments:

- Automation & control equipments
- Actuators
- Sensors, a lot of



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Smart Buildings & Wireless technologies

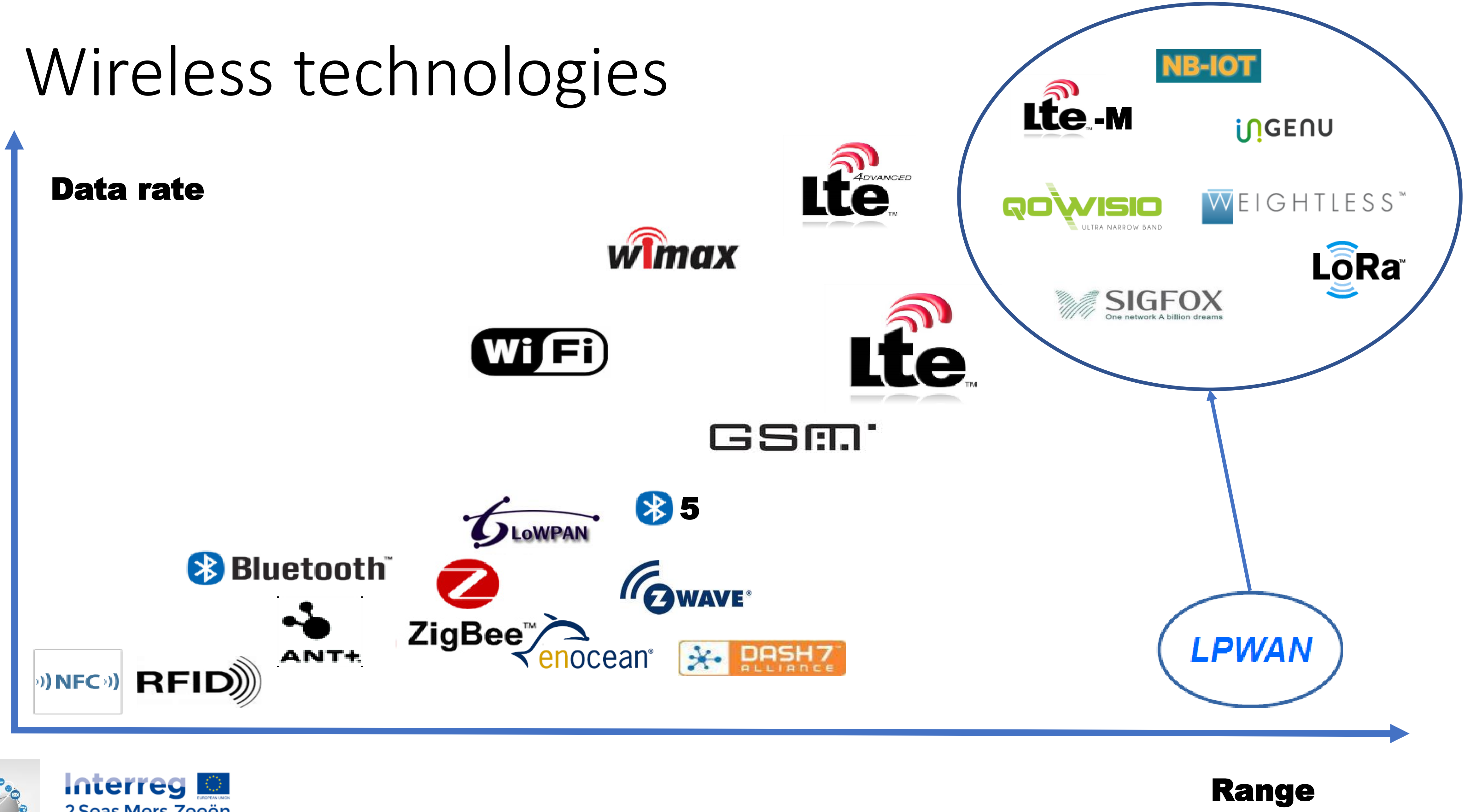
Why wireless technologies ?

- Because of costs of course, deployment costs
  - Especially for existing buildings
- Verstatility also

The goal: **Zero Wire devices**

- communicating wirelessly and
- running on battery for years or harvesting energy from environment

Wireless technologies



Wireless technologies & Smart Buildings

A lot of different already technologies

- But which one are relevant for the Smart building ?
  - You may find most of them in Smart buildings already
  - But some are more appropriate while others may disappear quickly
  - Smart Home vs. Smart Building
- Which characteristics are important for Smart building use cases ?
  - Cost
  - Power consumption
  - **Indoor range**
  - Ease of deployment
  - Durability
  - Data rate almost never important

The link budget: principles

Received Power = Transmitted Power + Gains – Losses

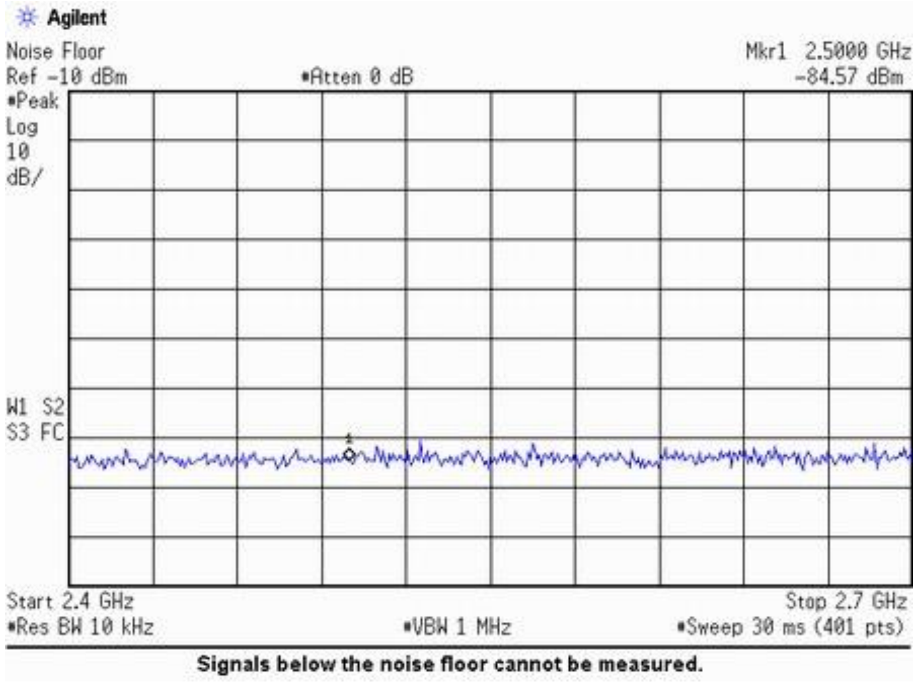
- The transmitter sends a message with a certain power
- The receiver receive a noisy signal with a certain power
- Received power must be greater than receiver **sensitivty**

Sensitivity of the receiver is the ability to extract the transmitted message from the received noisy signal

The link budget: principles

Receiver Sensitivity depends on

- The quality of receiver (its signal processing electronic)
- The bandwith of the signal
- The temperature



The **noise floor** is the physical limit of sensitivity

$$\mathbf{P_{dBm} = -174 + 10 \log_{10}(BW)}$$

Bandwith	Noise floor
1 MHz	- 114 dBm
125 kHz	- 123 dBm
200 Hz	- 151 dBm

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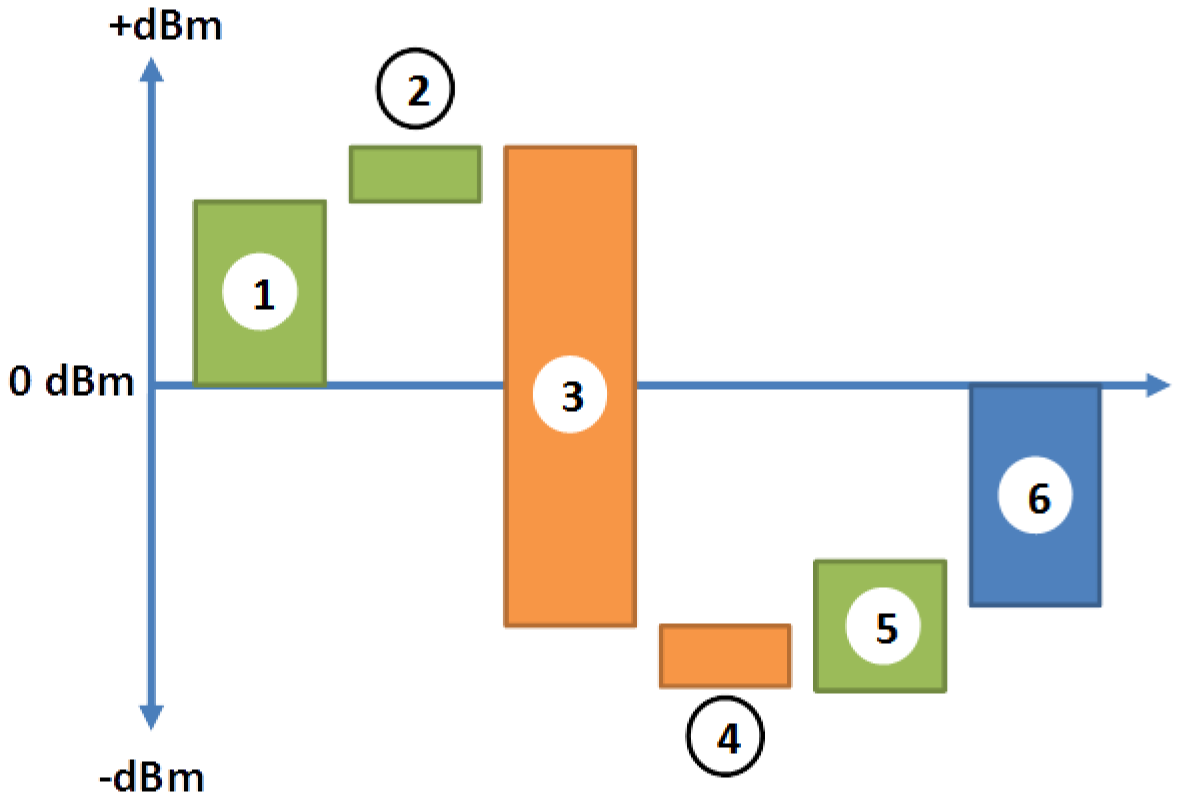
The link budget: principles

Typical Receiver Sensitivity

Sensitivity		Receiver
- 96 dBm	$2.5.10^{-10}$ mW	STM300 ENOCEAN ASK
- 97 dBm	2.10^{-10} mW	TI CC2640R2
- 98 dBm	$1.6.10^{-10}$ mW	STM300 ENOCEAN GFSK
- 103 dBm	5.10^{-11} mW	TI CC2640R2 @125kbps / Z-Wave @9.6kbps
-137 dBm	2.10^{-14} mW	RN2483 LoRa@0.25kbps / ATIM Sigfox

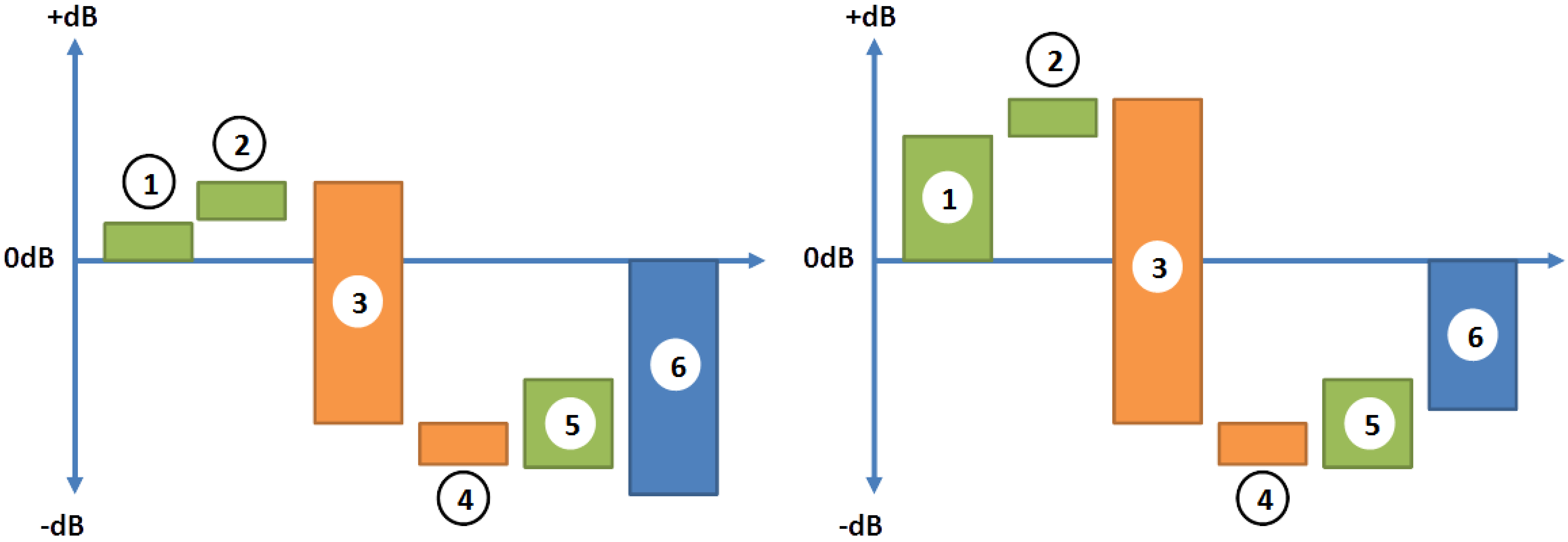
The link budget: principles



1. Transmitter output power
2. Transmitter antenna gain
3. Path loss (free space or indoor)
4. Miscellaneous losses
5. Receiver antenna gain
6. Receiver sensitivity

Maximum link budget = Max Output power – Receiver sensitivity

The link budget: principles

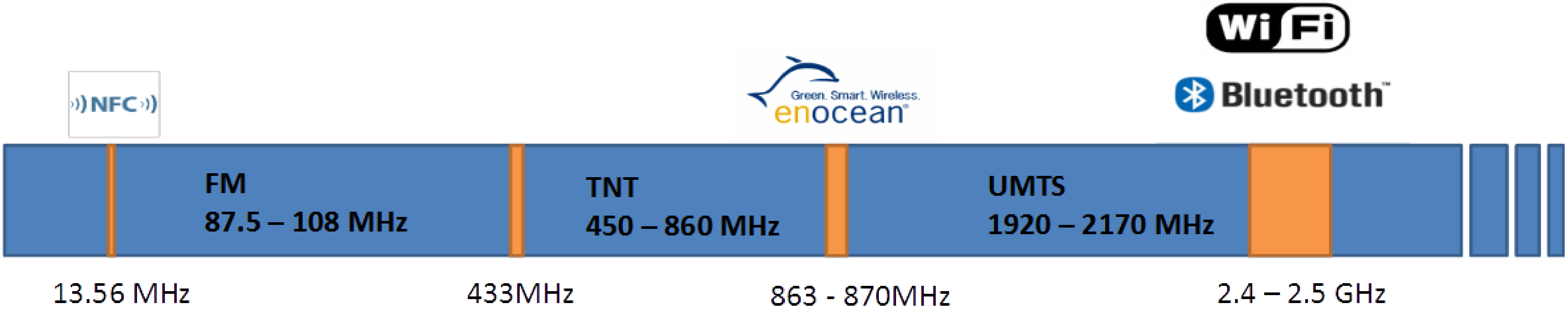


The link budget: Transmit power

Increasing transmit power

- ISM rules / health norms
- Power consumption

Transmit power (mW)	Transmit power (dBm)	Standard
2 mW	4 dBm	Z-Wave
3 mW	5 dBm	Bluetooth
5 mW	7 dBm	EnOcean
25 mW	14 dBm	LoRa & Sigfox
39 mW	16 dBm	Wi-Fi



The link budget: max link budget

Typical maximum link budget

- Path loss has to be lower

Standard	Max link budget
Z-Wave (9.6 kb/s)	107 dBm
Bluetooth (125 kb/s)	108 dBm
EnOcean	103 dBm
LoRa (0.25 kb/s)	151 dBm
Sigfox	151 dBm

The link budget: path loss

Free space loss

- The attenuation of the signal in free space
- **FSL = 20 $\log_{10}$(d) + 20 $\log_{10}$(f) – 147.55**

Distance	Frequency	Attenuation
10 m	2.4 GHz	60 dBm
100 m	2.4 GHz	80 dBm
1 km	2.4 GHz	100 dBm
1.6 km	2.4 GHz	104 dBm
10 km	868 MHz	111 dBm
960 km	868 MHz	150 dBm

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SIGFOX
One network A billion dreams

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The link budget: path loss

Indoor path loss

- ITU indoor propagation model
- $\mathbf{IPL = N \log_{10}(d) + P_f(n) + 20 \log_{10}(f) - 147.55}$

N: distance power loss coefficient

n: number of floors

$P_f(n)$: floor loss penetration factor

Factors and coefficents depends on building type

- residential / office /commercial / …

The link budget: path loss

Free space vs. Indoor path loss

Distance	Frequency	Free space Attenuation	Residential, one floor	Office, two floors
10 m	2.4 GHz	60 dBm	72 dBm	89 dBm
20 m	2.4 GHz	66 dBm	80 dBm	98 dBm
40 m	2.4 GHz	72 dBm	89 dBm	107 dBm
100 m	2.4 GHz	100 dBm	100 dBm	119 dBm
100 m	868 MHz	71 dBm	-	110 dBm
200 m	868 MHz	77 dBm	-	119 dBm

LoRa

- Originally developped by Semtech - promoted by LoRa Alliance
- Frequency – ISM 868 MHz

Cost	Intermediate, but should decrease rapidly (<12$ for SoC)
Power consumption	Several months to several years on battery (msg / day)
Indoor range	Best solution, several hundred meters, even with 5+ floors
Ease of deployment	Best solution for large buildings, no infrastructure except a base station
Durability	New technology, but very fast growing ecosystem. However, currently relies on one silicon vendor only

Wi-Fi

- Standard 802.11
- Frequency – ISM 2,4 GHz and 5 GHz

Cost	Very cheap (< 2$ for a SoC)
Power consumption	Only days on battery, needs external power
Indoor range	~ 40 meters indoor
Ease of deployment	Depends on whether a local wlan infrastructure may be used
Durability	Mature technology and large ecosystem

BLE 5.X

- Originally developed by Nokia, now Bluetooth Special Interest Group
- ISM 2,4GHz

Cost	Very cheap (< 2$ for SoC)
Power consumption	Several months to years on battery or energy harvesting
Indoor range	~ 40 meters indoor
Ease of deployment	Ok for smaller & residential buildings otherwise needs complementary infrastructure
Durability	Mature technology and very large ecosystem (mobile), but new for the building

EnOcean

enocean® alliance

No Wires. No Batteries. No Limits.

enocean®

- Originally developed by an offspring of Siemens
- Frequency - ISM (868 MHz Europe)

Cost	Quite expensive (<25$ for a SoC)
Power consumption	Several months to years on battery or energy harvesting
Indoor range	~ 40 meters indoor
Ease of deployment	Very simple for smaller & residential buildings. Use repeaters and gateways for larger buildings
Durability	Growing ecosystem, a lot of equipments already. BLE 5 is a serious challenger. One silicon vendor only.

Z-Wave

- Developed by Danish company Zen-Sys
- Frequency - ISM (868 MHz Europe)

Cost	Intermediate (<10$ for a SoC)
Power consumption	Several months on battery (mesh networks)
Indoor range	~ 40 meters indoor
Ease of deployment	Simple for smaller & residential buildings. Complexity of mesh networks
Durability	Well established ecosystem, a lot of equipments already, but BLE 5 and EnOcean are serious challengers

Summary

- Zero wire devices is the ultimate goal
- Deployment and maintenance costs are paramount
- LoRa & BLE 5 are new to the building sector, but are also the most promising technologies in two different sub-markets (residential & small building vs. large buildings)