



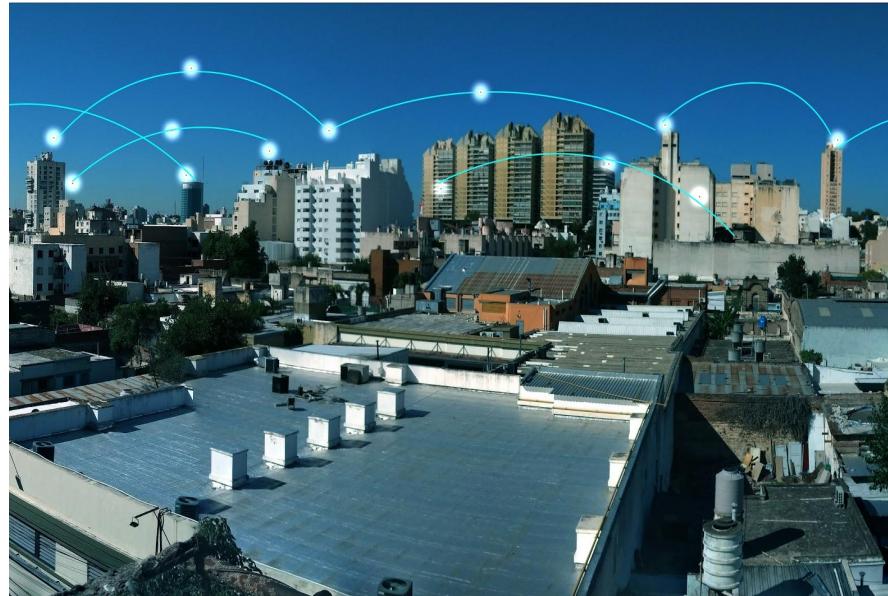
INTERNET OF
THINGS (IoT)

Communicate

Jorge Finochietto
Horacio Mendoza

IoT Connectivity decisions

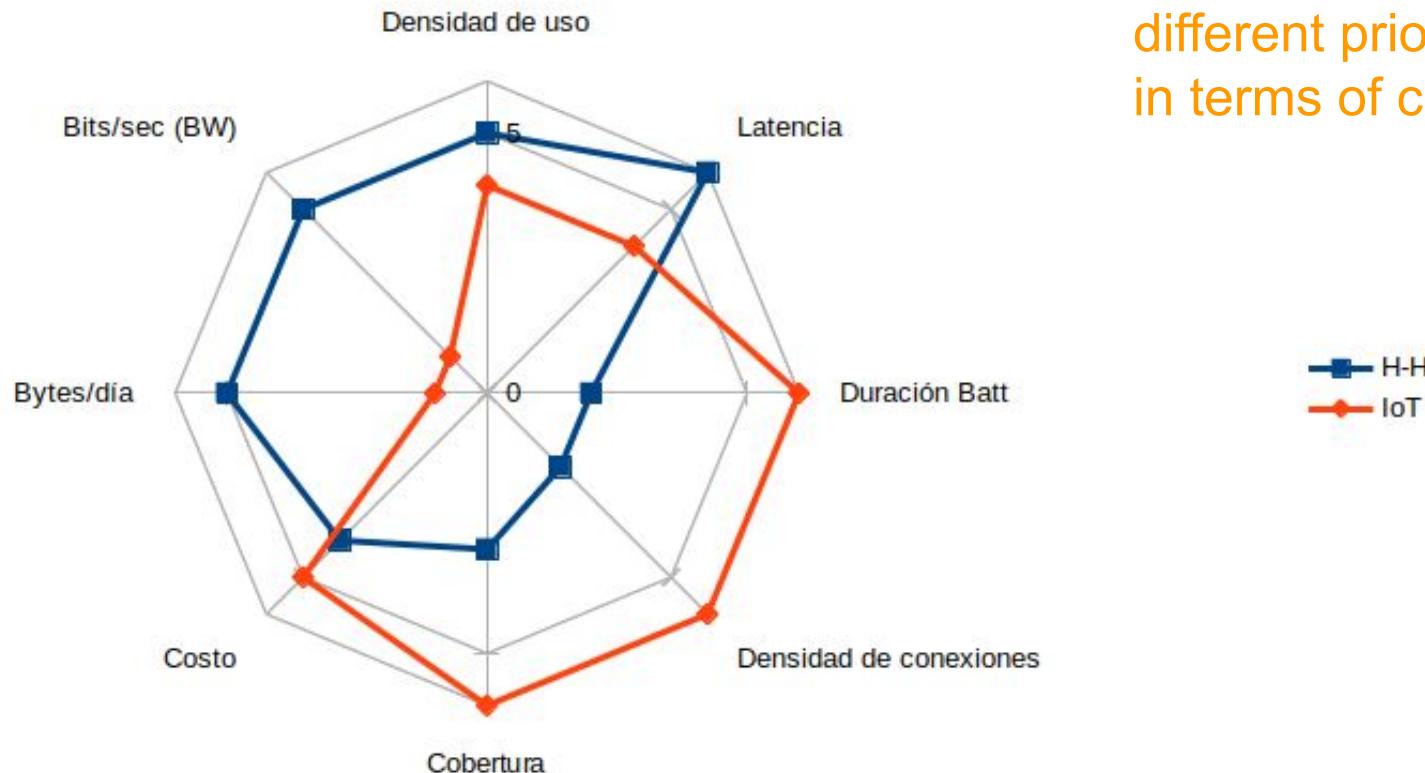
- Wired or Wireless.
- Short / Long distance.
- Mobile / Static / Nomadic nodes.
- Licensed/ Unlicensed Spectrum-band



Usually this decisions will lead a trade-off situation with power consumption, coverage and cost.

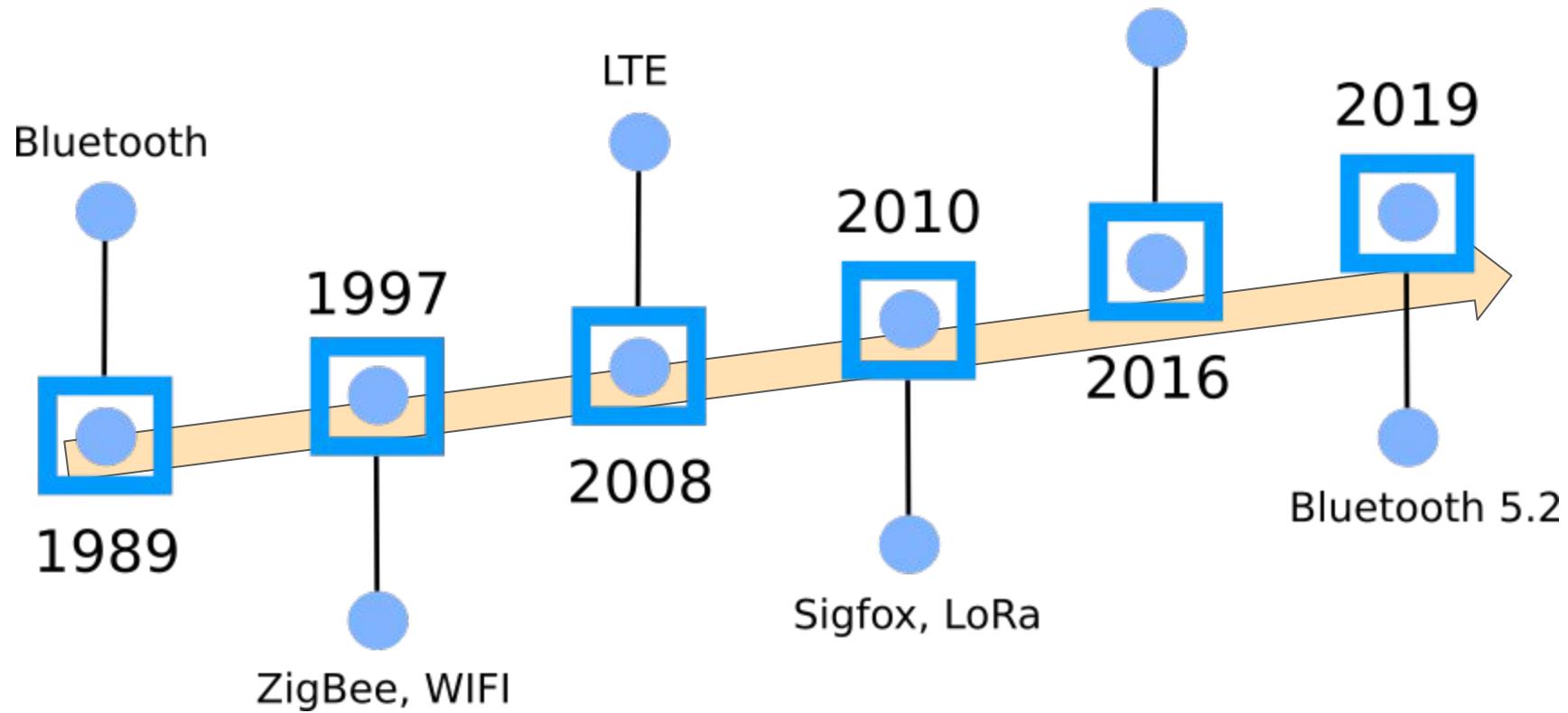
IoT Connectivity

Human vs Machine

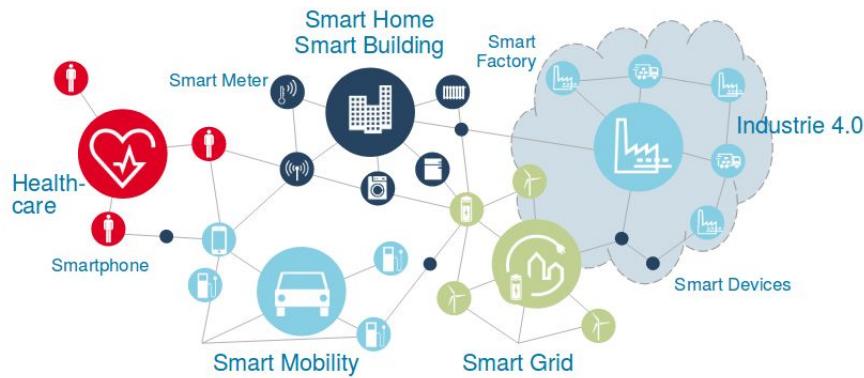


Human and machine have different priority perceptions in terms of connectivity.

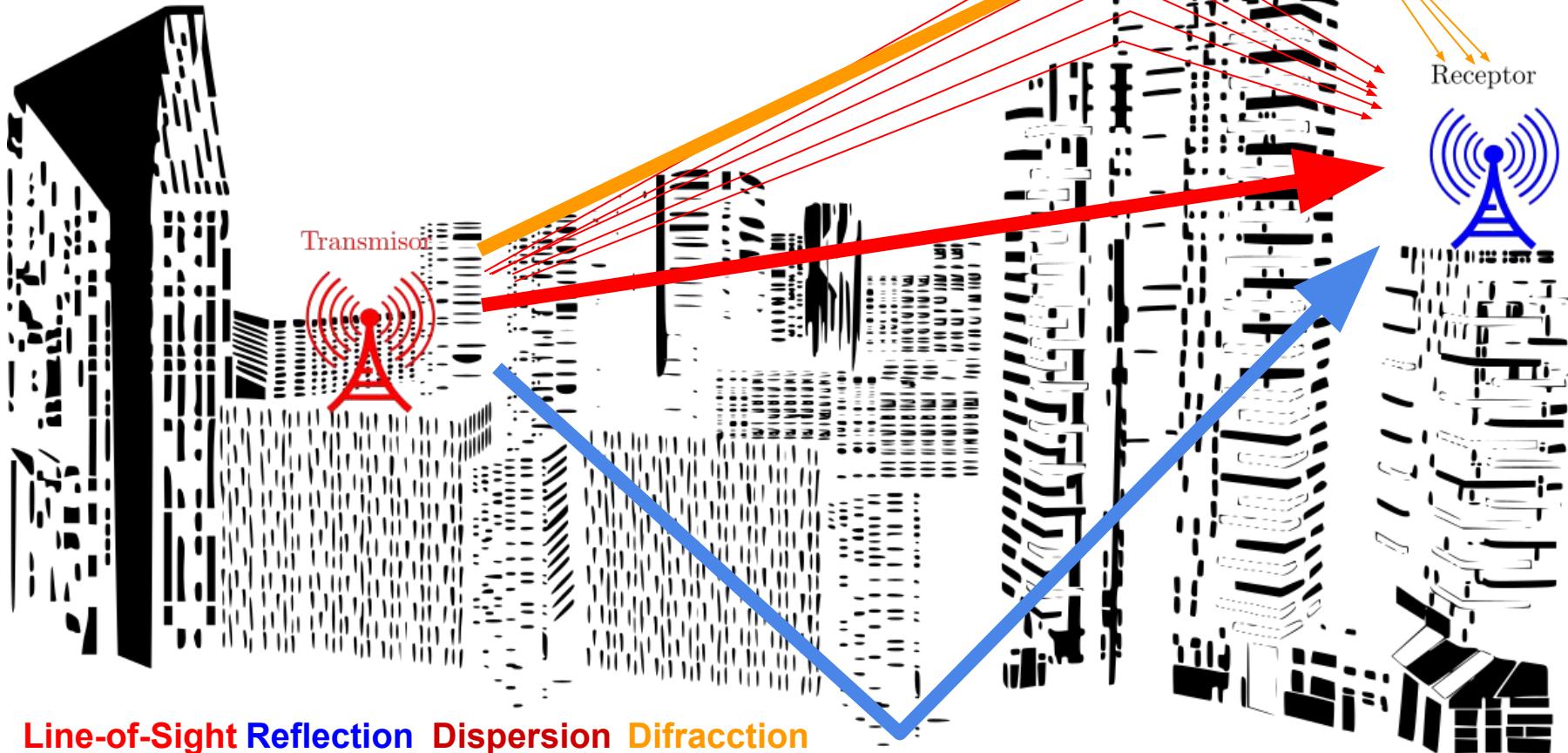
IoT Connectivity



Wireless Propagation Mechanisms



Wireless Propagation Mechanisms

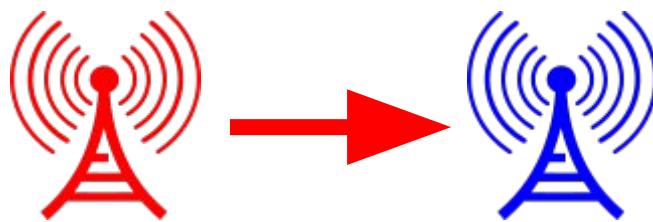




Same mechanisms
operate on indoor
spaces

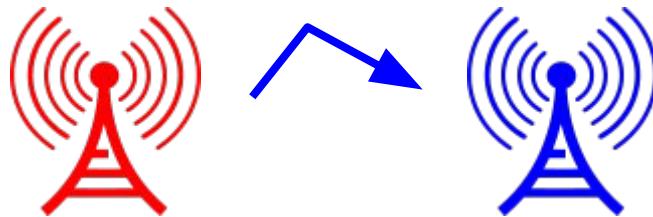
Distancias relativas entre Tx Rx y el entorno es menor

Line-of-Sight
LoS



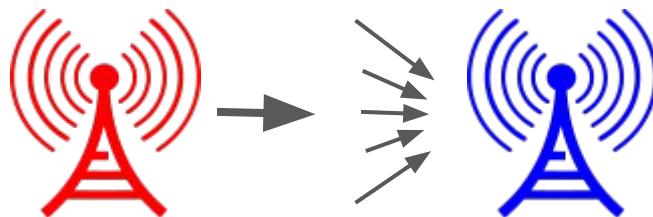
main effect

Reflection



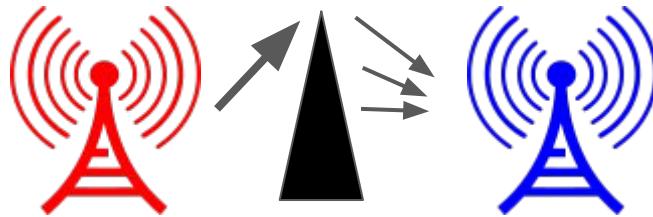
Fading

Dispersion



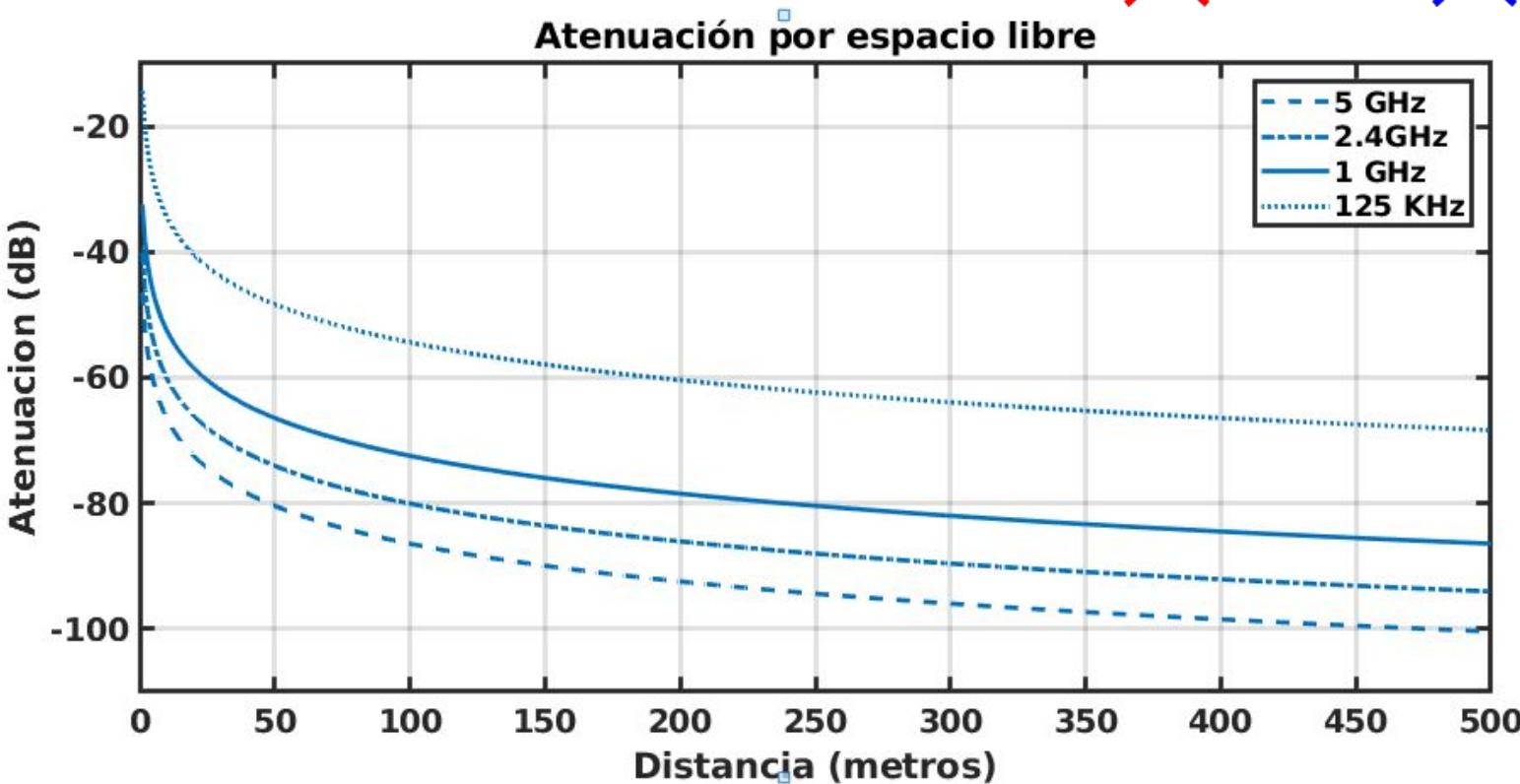
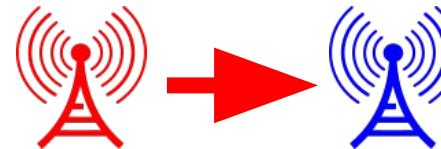
Fading

Difracction

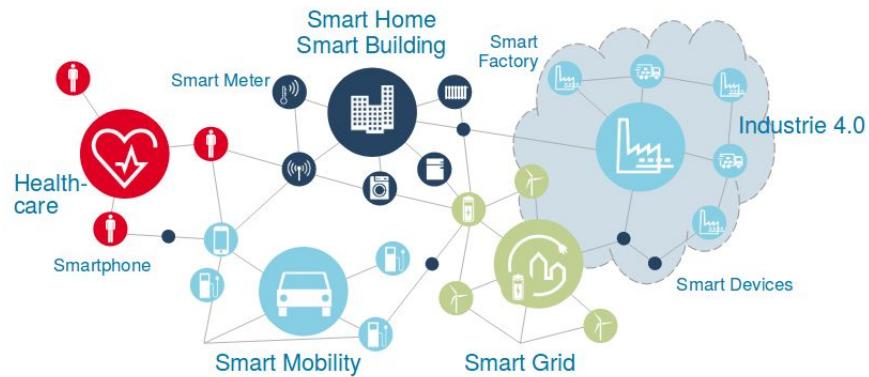


Obstacles

Los attenuation



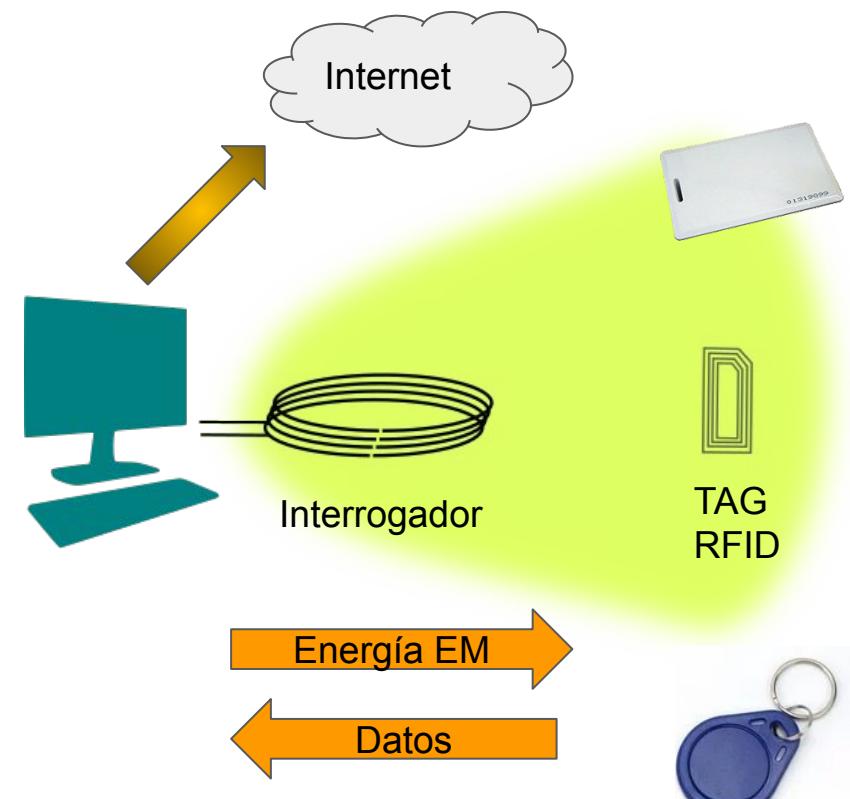
Short-Range Wireless Communication



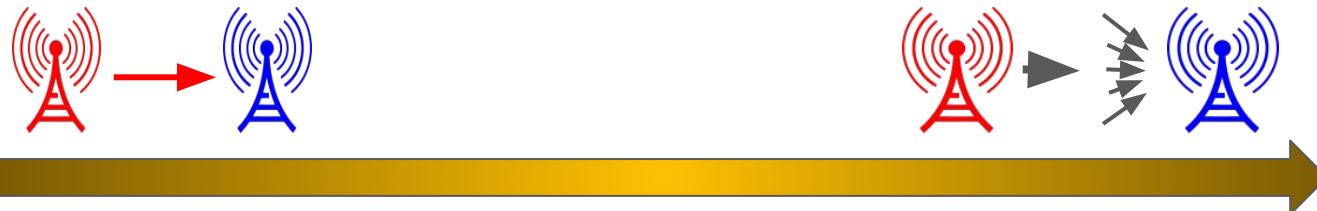
RFID Radio Frequency IDentification

Tecnología de presencia/identificación

- Opera en 125 kHz /
- Tags de código único y programables.
- Lecturas múltiples
- Distancias de hasta 10 m
- Control de acceso
- Control de Stock
- Localización de objetos



RFID Radio Frequency IDentification



125-131 kHz	6.8 MHz	13.56 MHz	433 MHz	915 MHz	2.45 GHz
LF	DF	HF	UHF	UHF	UHF

- Penetración de materiales
- Sensible a ruidos industriales
- Baja transferencia de datos y bajo alcance.
- Menos sensible a piezas Metálicas.
- Mayor alcance y mayor transferencia de datos.
- Sensible a piezas metálicas.
- Menor penetración de materiales



Redes de Sensores a batería

Pensado para dispositivos de bajo costo y operados a batería.

- IEEE 802.15.4-2011
- Frecuencia: 2.4GHz
- Alcance: 10-100m indoor.
Max 300m Los.
- Velocidad de transferencia:
250 kbps
- Aplicaciones Domóticas e
industriales

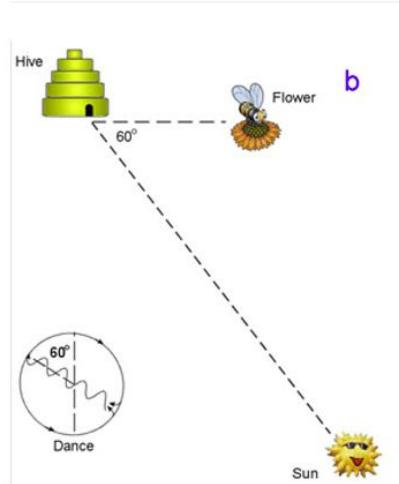
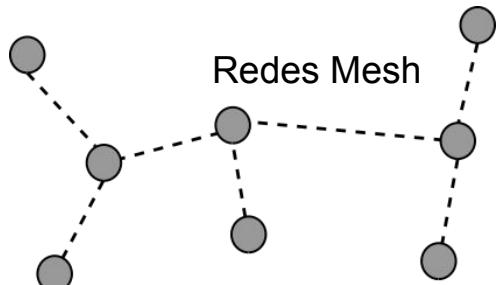


Photo: Bill Tietjen, Bellarmine University



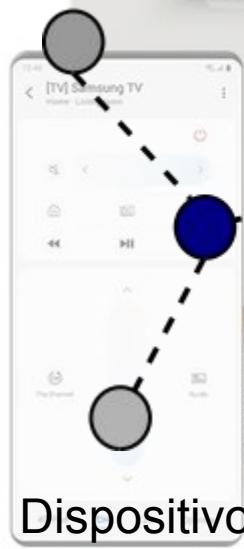
Foto de [Tiger Lily](#) en [Pexels](#)



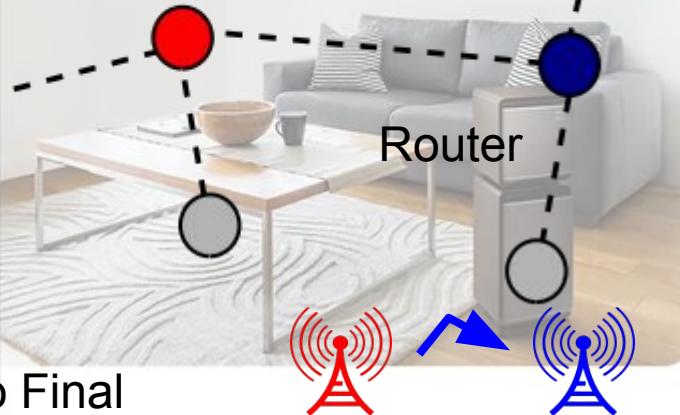
Redes de Sensores a batería



Redes Mesh



Coordinador (Hub)



Dispositivo Final

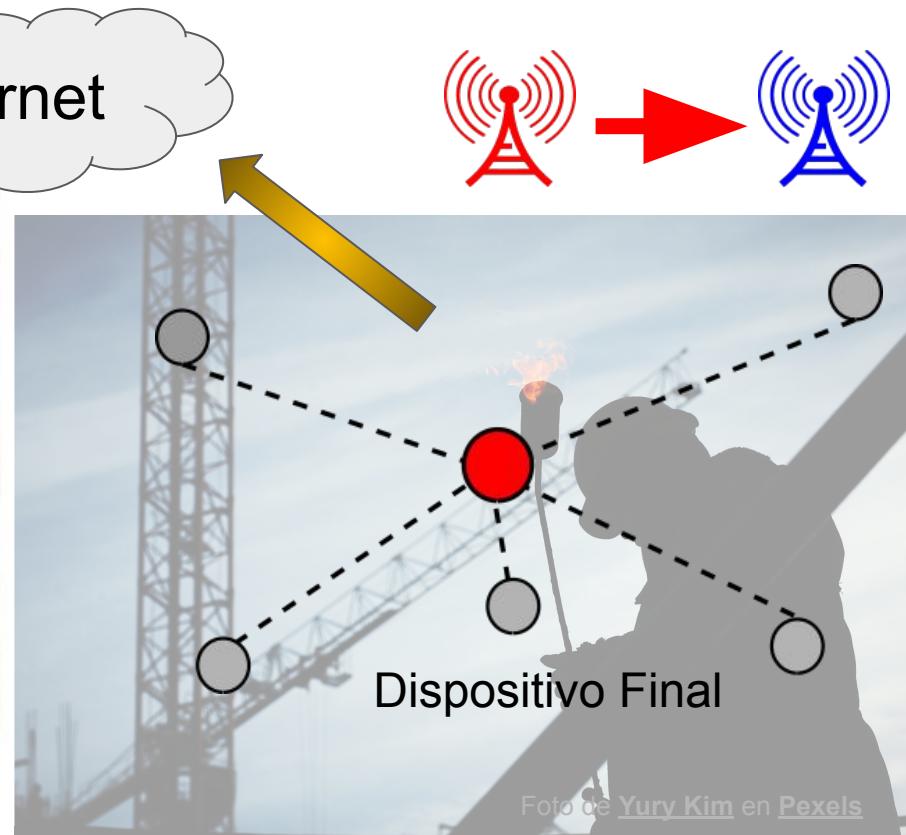


Foto de [Yury Kim](#) en [Pexels](#)



Bluetooth®

Comunicando dispositivos de área personal

Pensado para dispositivos cercanos a la persona.

- **Classic (v4)**

- Special Interest Group (SIG)
- Frecuencia: 2.4GHz
- Alcance: 10m indoor. Max. 100 m Los.
- Velocidad de transferencia: 1 Mbps - 3 Mbps
- Aplicaciones comunicaciones personales
- Topología: P2P

- **Low Energy (v5)**

- Special Interest Group (SIG)
- Frecuencia: 2.4GHz
- Alcance: 10-100m indoor. Max. 1000 m Los.
- Velocidad de transferencia: 125 kbps - 2 Mbps
- Aplicaciones: Domótica y biomédica.
- Topología: Mesh, P2P, Broadcast

Harald Blåtand

www.bluetooth.com





Bluetooth®

Comunicando dispositivos de área personal

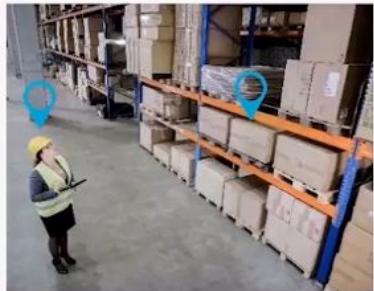


Magnetómetros
Acelerómetros
Giróscopos
Conectados
mediante chips
Bluetooth LE



Direction Finding – use cases

Asset tracking



Wayfinding



Point of interest



Item finding



Real-Time Location
Systems (RTLS)

Indoor positioning

Proximity marketing

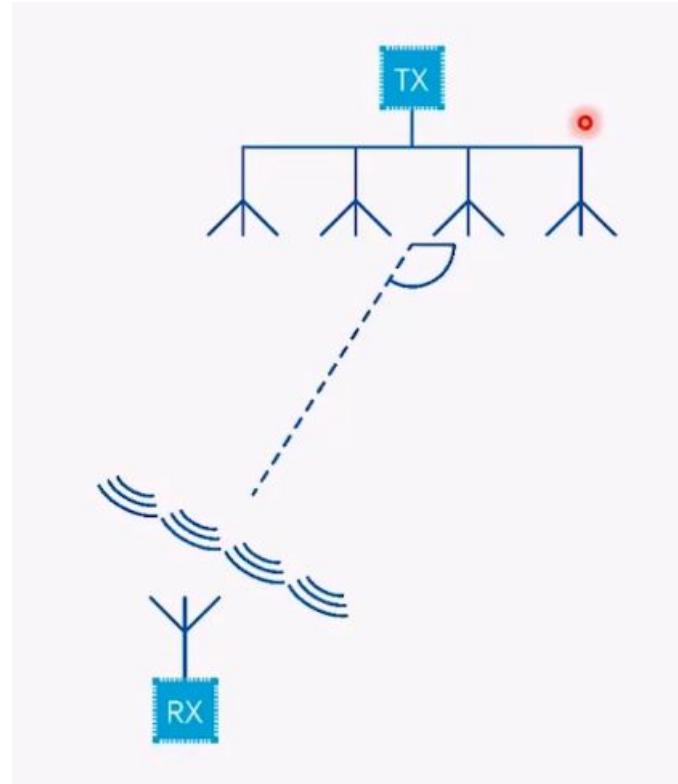
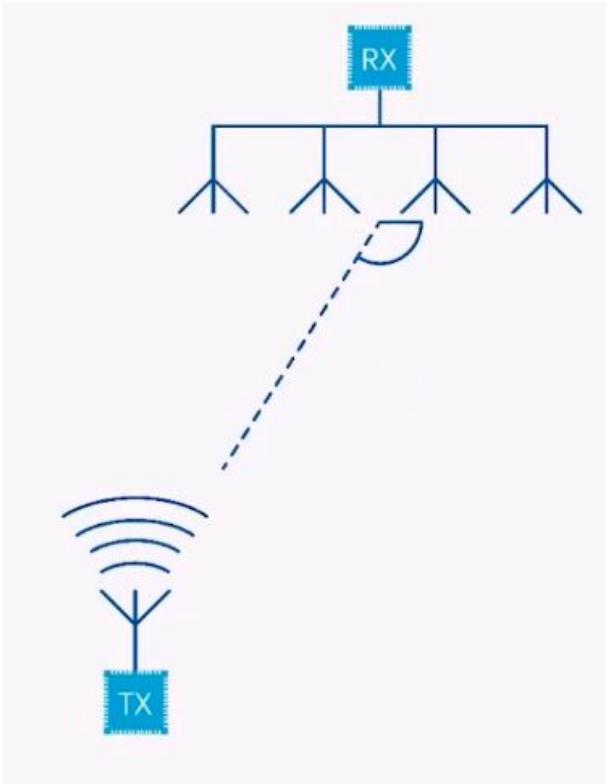
More advanced item
finding solutions

Positioning systems

Proximity solutions

Direction finding

Angle of Departure - Angle of Arrival





Comunicando dispositivos de área personal

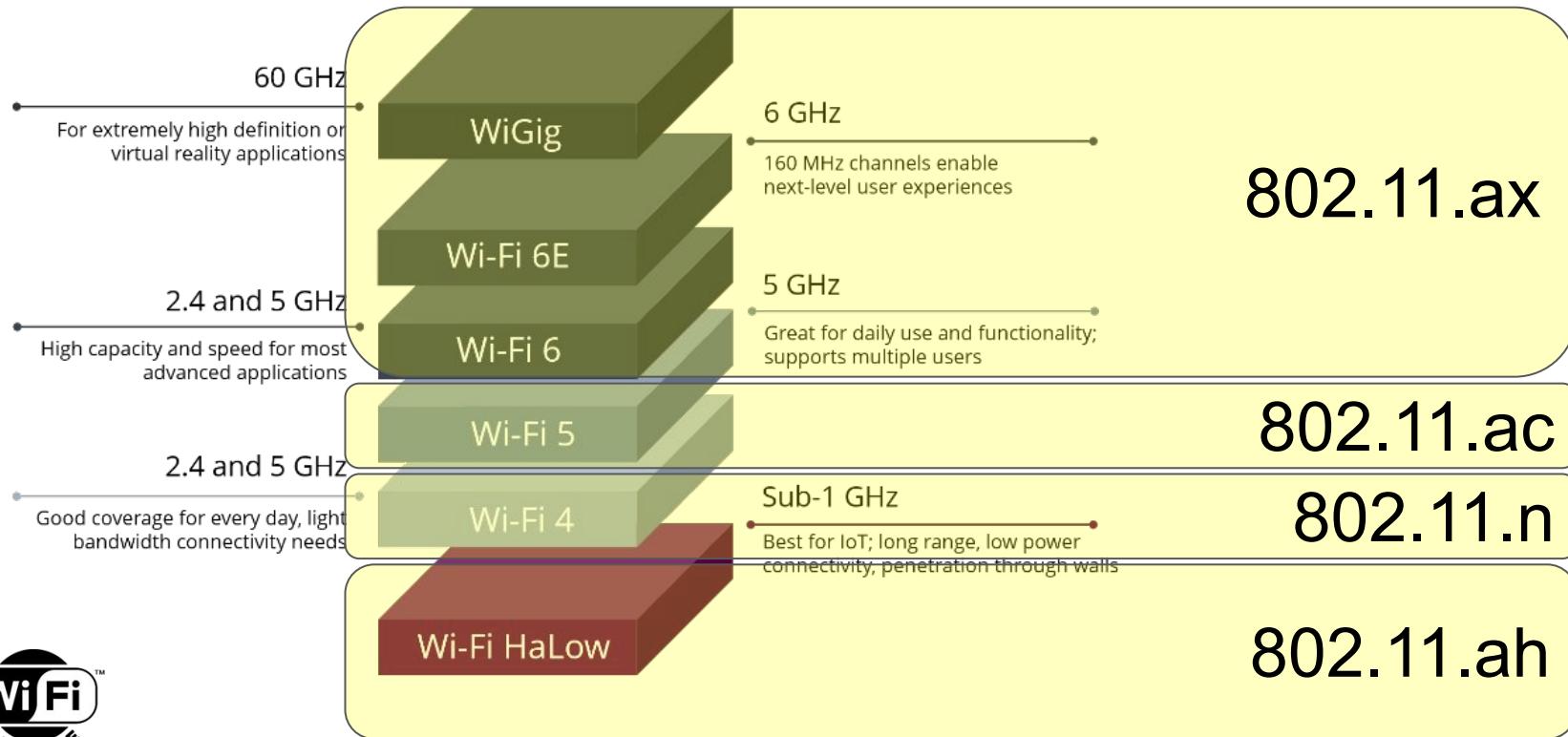
Bluetooth 5's long range is enabling beacons to track assets



2 Mbps
1 Mbps
113 kbps

Bluetooth 5 ignites beacons

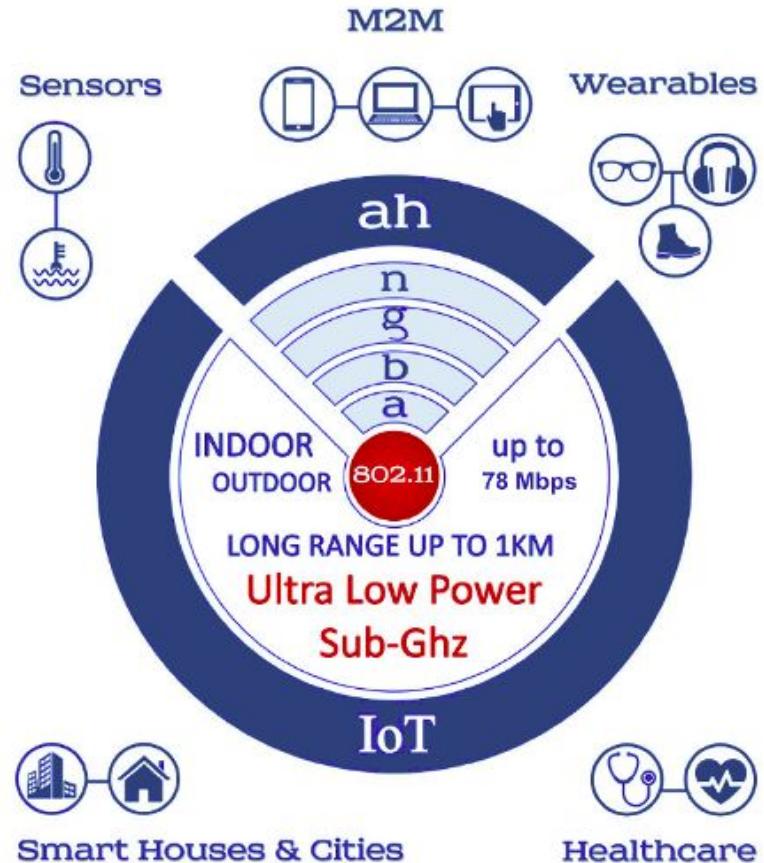
IEEE 802.11 - WI-FI



WI-FI HaLow

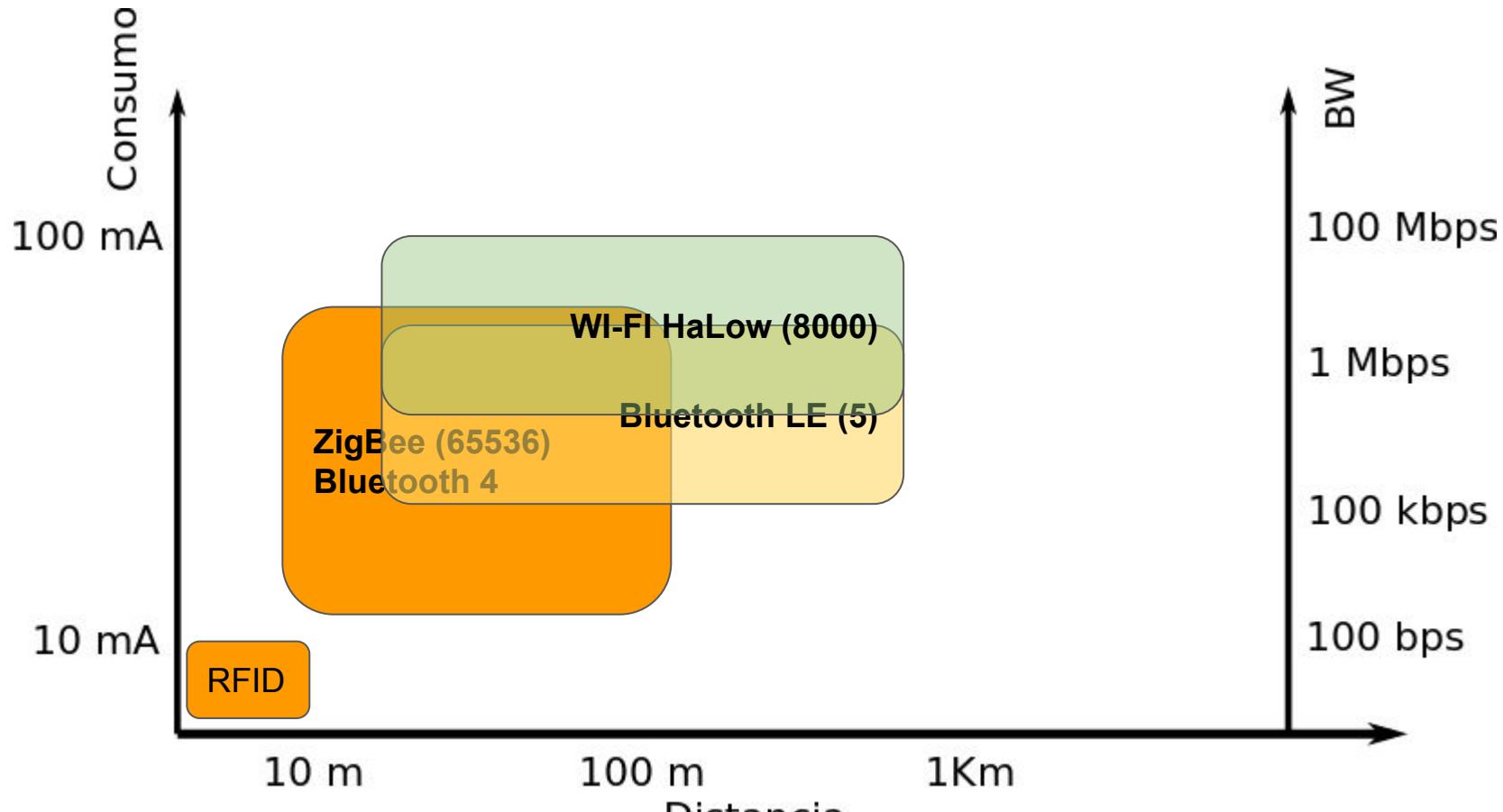
Hacia dispositivos IoT

- IEEE 802.11.ah
- Frecuencia: 750 - 900 MHz
- Alcance: 10-100m indoor. Max. 1000 m Los.
- IP nativo.
- Pensado para operar a batería
- Velocidad de transferencia: 150 kbps en adelante
- Aplicaciones: conectar dispositivos IoT en entornos industriales y rurales.



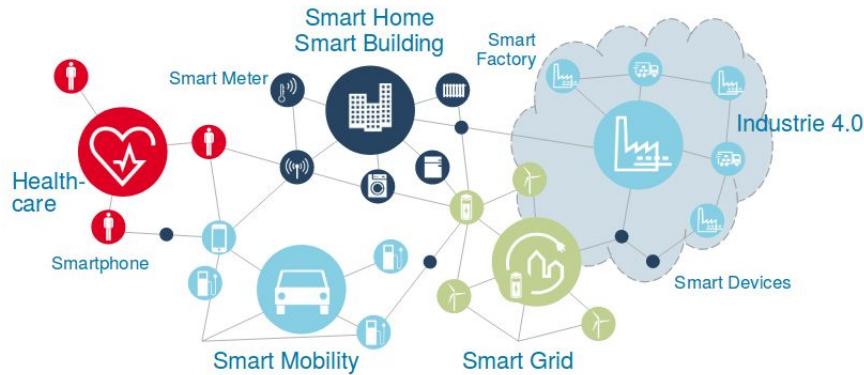
Comparativa

Tecnologías comunicaciones de corto alcance IoT



Mid-Range Wireless Communication

LPWAN : Low Power Wide Area Network



LPWAN : Low Power Wide Area Network

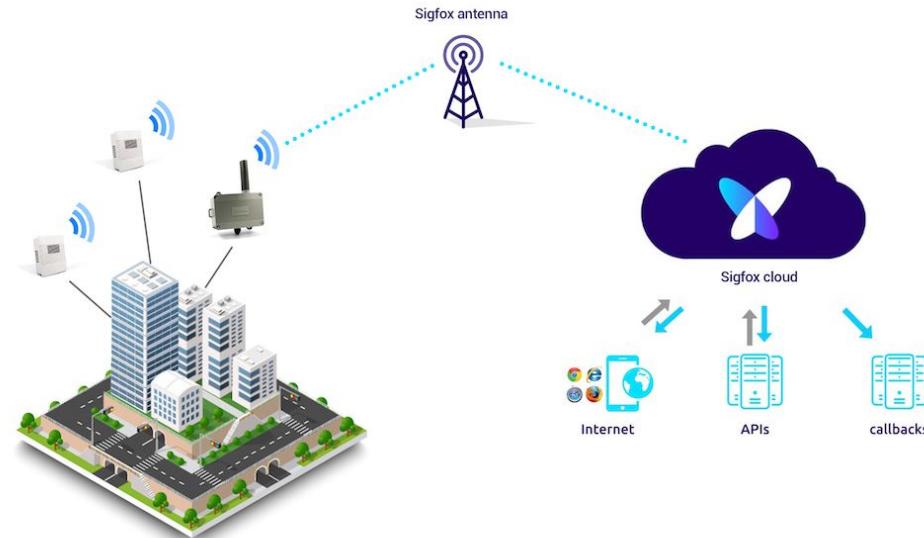


SigFox



Low Power and Long Distance

- Tecnología Propietaria Ultra Narrow Band
- Banda: 900 MHz
- Alcance: 1-10 Km Los.
- Random FTMA. Evita gestión de acceso al medio.
- Ancho de banda estrecho 100 ~ 600 Hz
- Baja tasa de transferencia: 100~600 bps.
- Limitación de 12 bytes por packet y hasta 140 msj diarios.
- Aplicaciones: conectar dispositivos IoT en entornos urbanos, industriales y rurales.



En Argentina:

<https://www.sigfox.com/en/coverage>

<https://www.grupodatco.com/0g-networks/>



Low Power and Long Distance

- Acceso por operadoras
- Bandas licenciadas
- Alcance: 15 Km Los.
- Random FTMA. Evita gestión de acceso al medio.
- Ancho de banda estrecho 200 KHz
- Baja tasa de transferencia: 30~60 kbps.
- No Soporta movilidad.
- Aplicaciones: conectar dispositivos IoT en entornos urbanos, industriales y rurales.



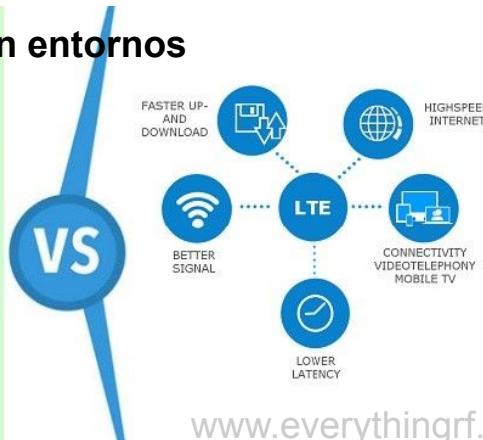
<https://www.claro.com.ar/empresas/lte-m-nb-iot>

CLARO NB-IOT	
Vida Útil de la Batería	< 10 años
Velocidad de Conexión	< 64 Kbps
Movilidad	No
Tipo de Conectividad	Eventual



Low Power and Long Distance

- Acceso por operadoras
- Bandas licenciadas
- Alcance: 12 Km Los.
- Random FTMA. Evita gestión de acceso al medio.
- Ancho de banda estrecho 1.4 MHz
- Tasa de transferencia: 600 kbps.
- Soporta movilidad.
- Aplicaciones: conectar dispositivos IoT en entornos urbanos, industriales y rurales



CLARO LTE-M
Vida Útil de la Batería
< 5 años
Velocidad de Conexión
< 1 Mbps
Movilidad
Sí
Tipo de Conectividad
Frecuente



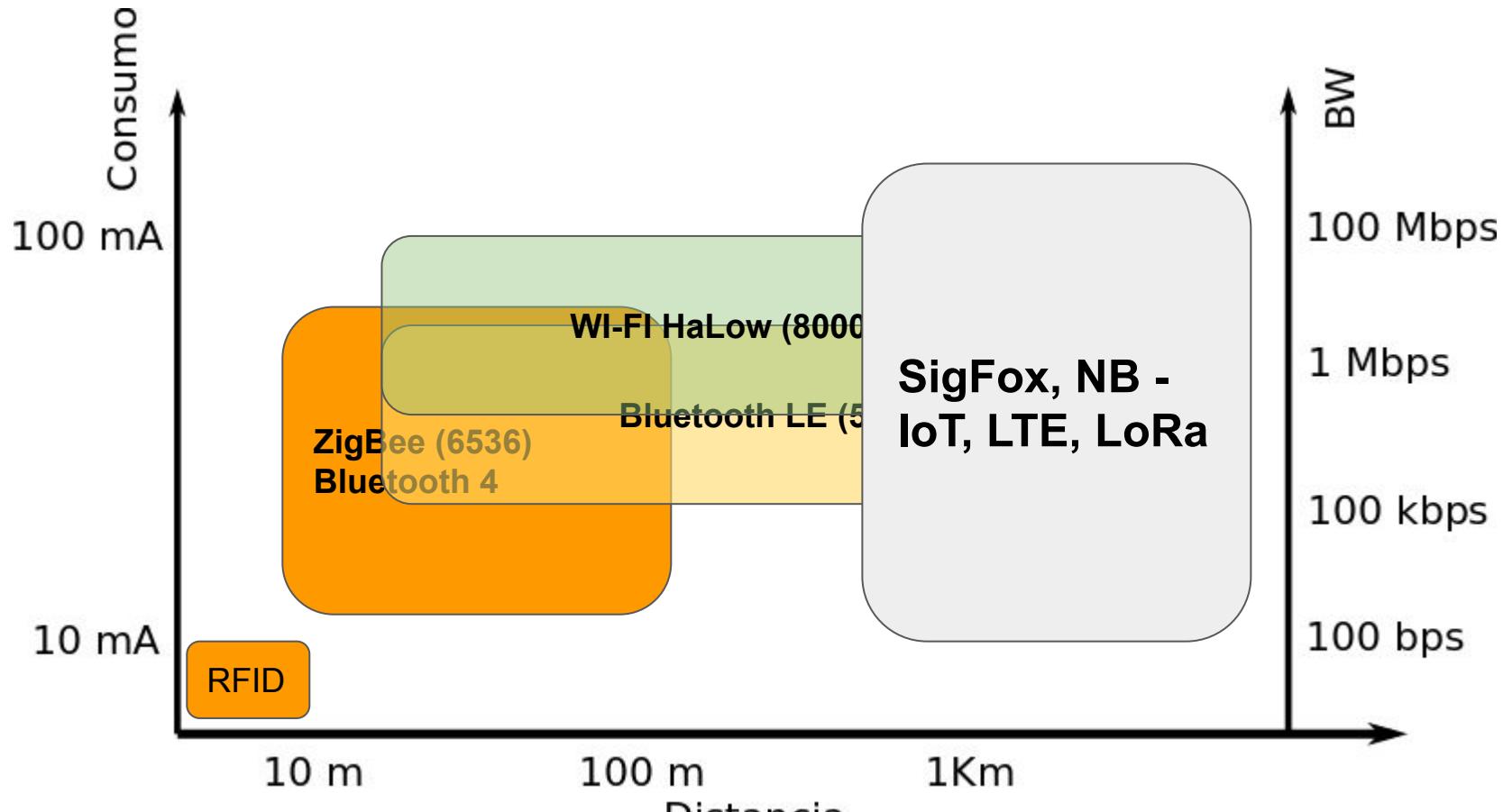
Low Power and Long Distance

- Tecnología propietaria de Seamtech Inc.
- Banda: 900 MHz
- Alcance: 10 -15Km con Los.
- Acceso al medio mediante
- Tasas de transferencia: 300 bps - 50 kbps.
- Tamaño de Paquetes definidos por usuario
- Aplicaciones: conectar dispositivos IoT en entornos urbanos, industriales y rurales.



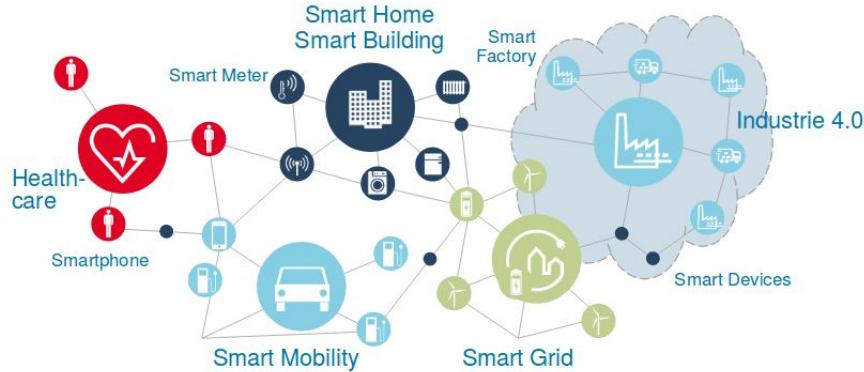
Comparativa

Tecnologías comunicaciones de corto y largo alcance IoT



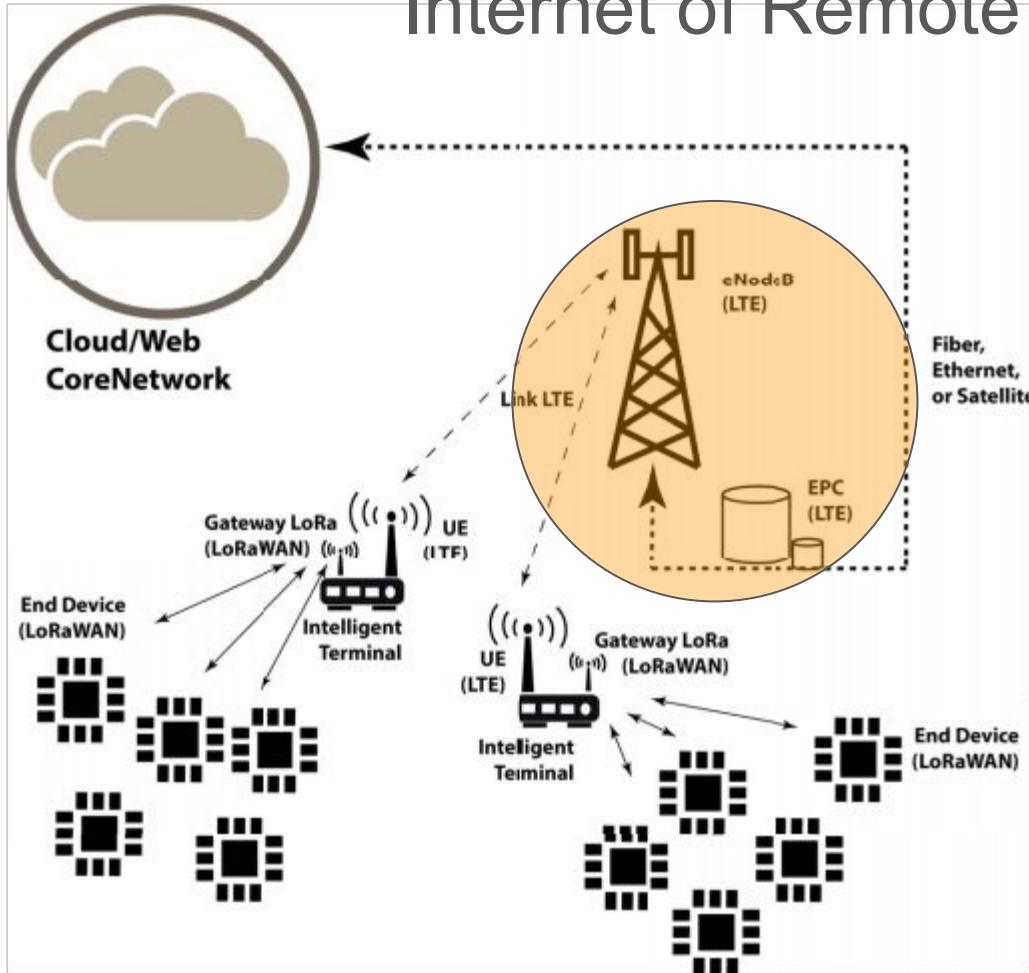
Long-Range Wireless Communication

Internet of Remote Things



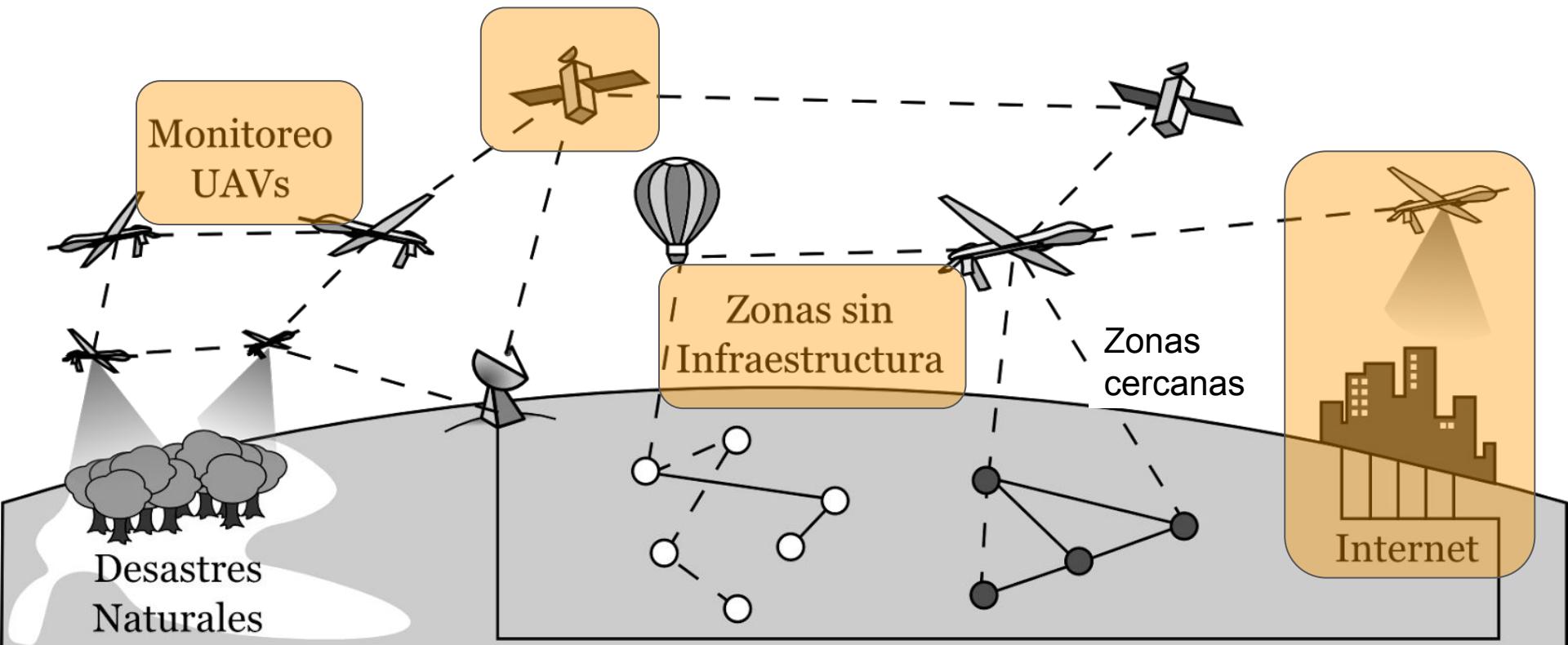
Horacio A. Mendoza

Internet of Remote Things

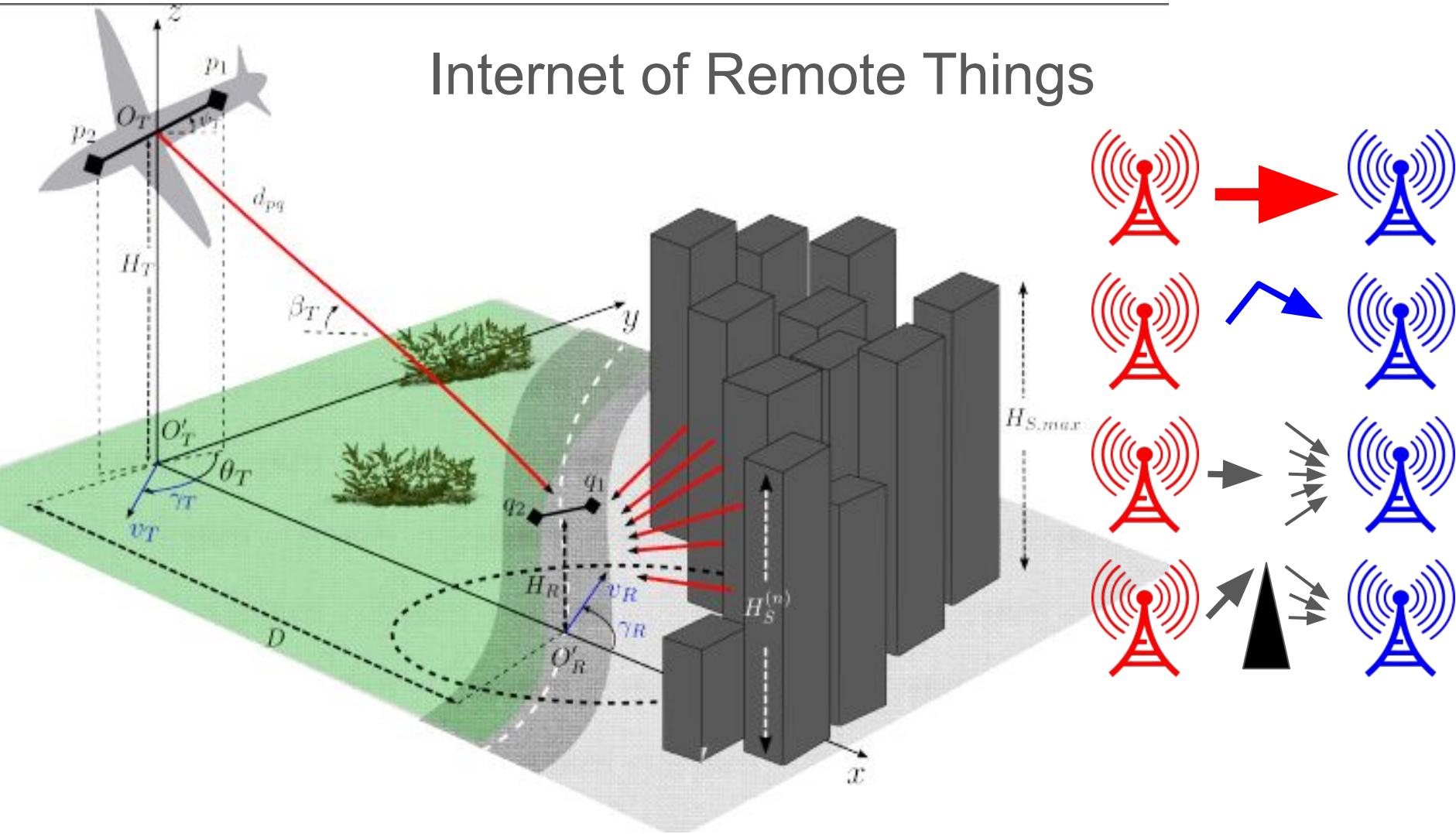


What if we don't have access to cellular infrastructure?

Internet of Remote Things



Internet of Remote Things

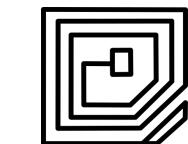


Challenges

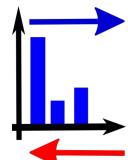
- Identificar la tecnología de comunicaciones apropiada.
- Identificar la disponibilidad de sensores en la red.
- Identificar problemas operativos por falta de conectividad.

Desde la perspectiva de la transformación digital

- Desafíos estructural de recursos.
- Adquisición de datos mediante sensores.
- Disponibilidad del dato para procesar.



IDENTIFICACIÓN



SENSADO Y CONTROL



COMUNICACIÓN



COMPUTACIÓN



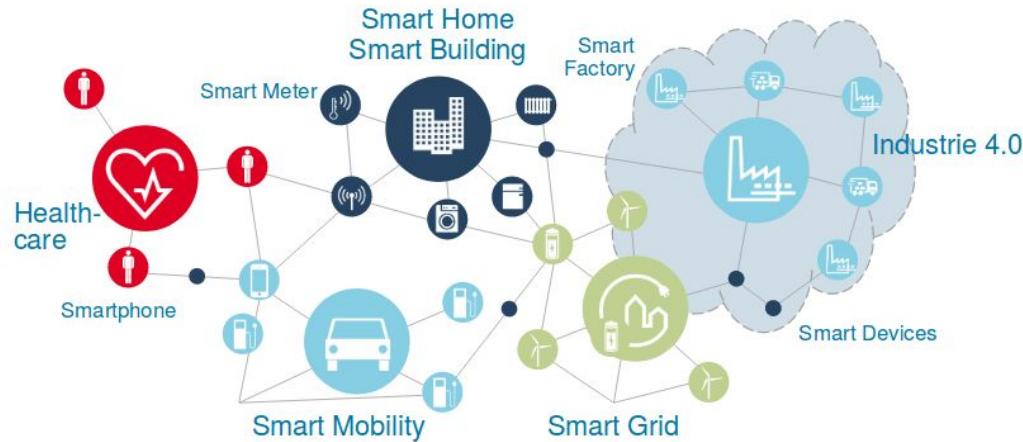
SERVICIOS



SEMÁNTICA

“A smart thing is only smart if it can communicate”

CloudRF



IoT Connectivity Technologies

Attribute	Bluetooth® Low Energy Technology	Wi-Fi	Z-Wave	IEEE 802.15.4 (Zigbee, Thread)	LTE-M	NB-IoT	Sigfox	LoRaWAN
Range	10 m – 1.5 km	15 m – 100 m	30 m - 50 m	30 m – 100 m	1 km – 10 km	1 km – 10 km	3 km – 50 km	2 km – 20 km
Throughput	125 kbps – 2 Mbps	54 Mbps – 1.3 Gbps	10 kbps – 100 kbps	20 kbps – 250 kbps	Up to 1 Mbps	Up to 200 kbps	Up to 100 bps	10 kbps – 50 kbps
Power Consumption	Low	Medium	Low	Low	Medium	Low	Low	Low
Ongoing Cost	One-time	One-time	One-time	One-time	Recurring	Recurring	Recurring	One-time
Module Cost	Under \$5	Under \$10	Under \$10	\$8-\$15	\$8-\$20	\$8-\$20	Under \$5	\$8-\$15
Topology	P2P, Star, Mesh, Broadcast	Star, Mesh	Mesh	Mesh	Star	Star	Star	Star
Shipments in 2019 (millions)	~3,500	~3,200	~120	~420	~7	~16	~10	~45

IoT Connectivity Technologies

Low Power WAN
(LPWAN)

Attribute	Bluetooth® Low Energy Technology	Wi-Fi	Z-Wave	IEEE 802.15.4 (Zigbee, Thread)	LTE-M	NB-IoT	Sigfox	LoRaWAN
Range	10 m – 1.5 km	15 m – 100 m	30 m - 50 m	30 m – 100 m	1 km – 10 km	1 km – 10 km	3 km – 50 km	2 km – 20 km
Throughput	125 kbps – 2 Mbps	54 Mbps – 1.3 Gbps	10 kbps – 100 kbps	20 kbps – 250 kbps	Up to 1 Mbps	Up to 200 kbps	Up to 100 bps	10 kbps – 50 kbps
Power Consumption	Low	Medium	Low	Low	Medium	Low	Low	Low
Ongoing Cost	One-time	One-time	One-time	One-time	Recurring	Recurring	Recurring	One-time
Module Cost	Under \$5	Under \$10	Under \$10	\$8-\$15	\$8-\$20	\$8-\$20	Under \$5	\$8-\$15
Topology	P2P, Star, Mesh, Broadcast	Star, Mesh	Mesh	Mesh	Star	Star	Star	Star
Shipments in 2019 (millions)	~3,500	~3,200	~120	~420	~7	~16	~10	~45

Distance, Rate & Power Tradeoff

If distance increases,
then either the rate decreases or the power increases

If the rate increases,
then either the distance decreases or the power increases

If the power decreases,
then either the rate or distance decreases

IoT Platforms

IoT Devices need to be connected to IoT platforms where data can be stored, visualized, analyzed and actions can be taken

Besides these platforms deal with device management and access control

Several IoT platforms exist which provide all these functionalities:

- [Thingsboard](#)
- [Tago.io](#)
- [Thingspeak](#)
- [Wolkabout](#)
- [Allthingstalk](#)

Device Management

Devices can be connected directly to IoT platforms using communication protocols such as HTTPS or MQTT (more later)

Typically HTTPS (POST/GET) is used to connect devices directly to the IoT Platforms when IP connectivity is also supported by the device

However, LPWAN (low power - wide area) devices such those using LoRaWAN technology instead connect to the IoT platform through gateways. Hence, instead of connecting single devices, a network of devices is connected to the platform