Nouvelles solutions de connectivitée pour l'IoT

Journé de la Société Informatique de France : Défis informatiques de l'internet de objets

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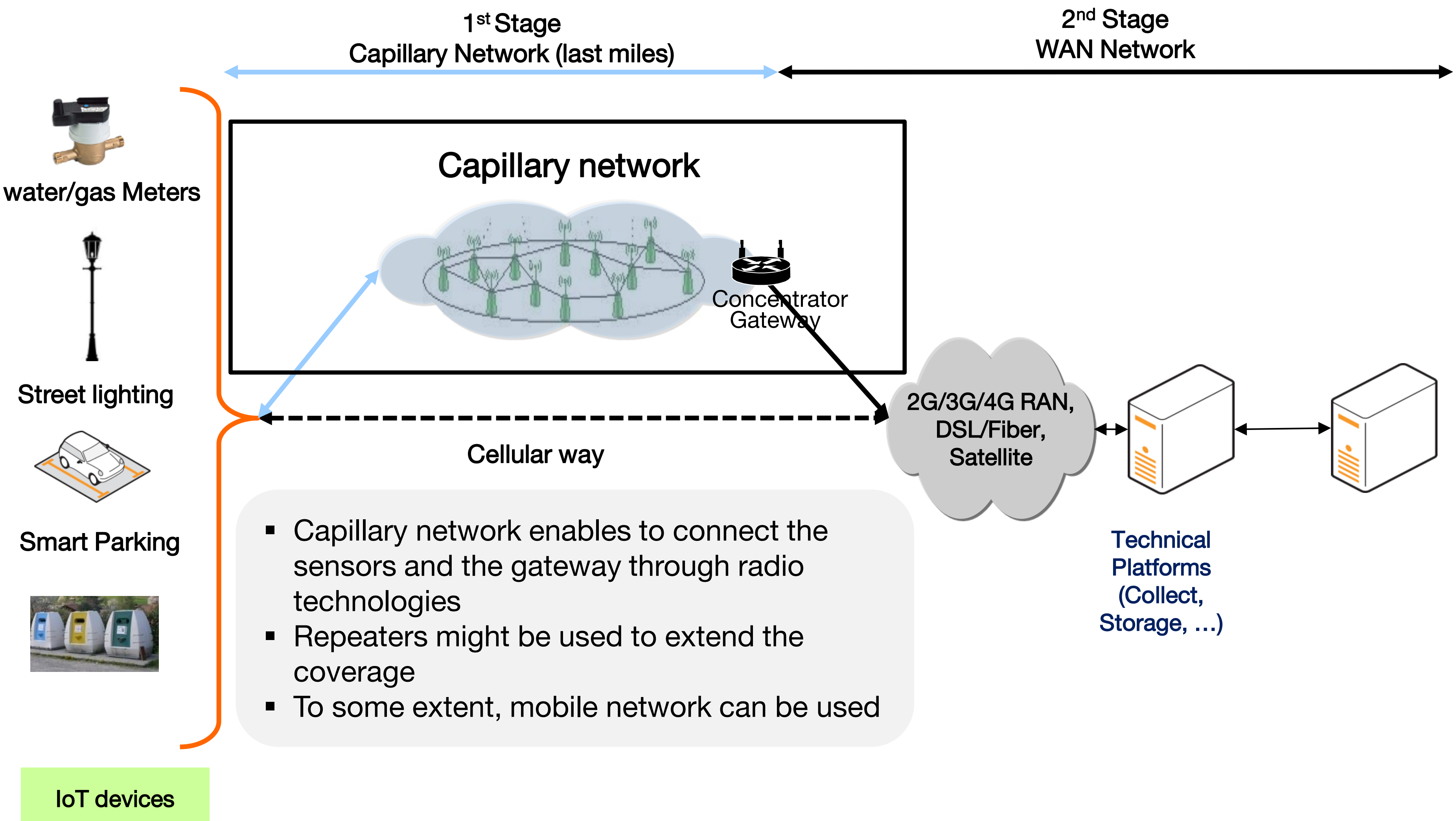
Agenda

IoT, a proliferation of new services and billions of devices

- Cisco, Ericsson, Texas Instrument and others predict there will be more than 20 billions connected devices by 2020.
- These projections are very optimistic, but even if a fraction of these projections materialize, it still represents a huge number.
- Bringing connectivity to those objects is challenge

IoT WAN Connectivity Context



- Capillary network enables to connect the sensors and the gateway through radio technologies
- Repeaters might be used to extend the coverage
- To some extent, mobile network can be used

Typical Traffic model

- Most of the IoT devices are simple sensor
  - Payload between 10 to 50 bytes, a few times per day
  - Traffic is therefore largely dominated by the uplink

Smart devices, B2C or B2B2C

- **Ultra Low power (buttons cells,** energy harvesting)
- Very small form factors
- **Low cost devices (<50€)**
- Alert-type traffic
- No real-time constraints
- Low cost of connectivity
- Easy pairing

Smart meters, smart parking

- **Low power (3V battery for 10+ years)**
- **Low cost devices (<50€)**
- Few messages /day (<100 o)
- Massively uplink
- No real-time constraints
- Static devices
- Low cost of connectivity

Env. monitoring, smart parking

- **Ultra Low power (3V battery for 10+ years)**
- **Low cost devices (<50€)**
- Periodic (ex. 1msg/h) and alert type traffic
- Massively uplink
- No strong real-time constraints
- Static devices
- Low cost of connectivity

Asset tracking, fleet management

- **Low power (3V battery for a few years)**
- High cost devices (100-1000€)
- Periodic uplink traffic
- **Possible asynchronous downlink traffic**
- RT constraints
- Mobile devices
- No constraint on connectivity price

- Most of those devices face severe energy constraint
  - Other can be addressed by the regular mobile network.
  - Signaling is usually reduced to almost nothing
  - Between two uplink, devices are in sleep mode
  - Transmit is as limited as possible (a few report per day)

- Solution for IoT connectivity have been designed accordingly

A myriad of radio communication solutions are already used to address IoT services

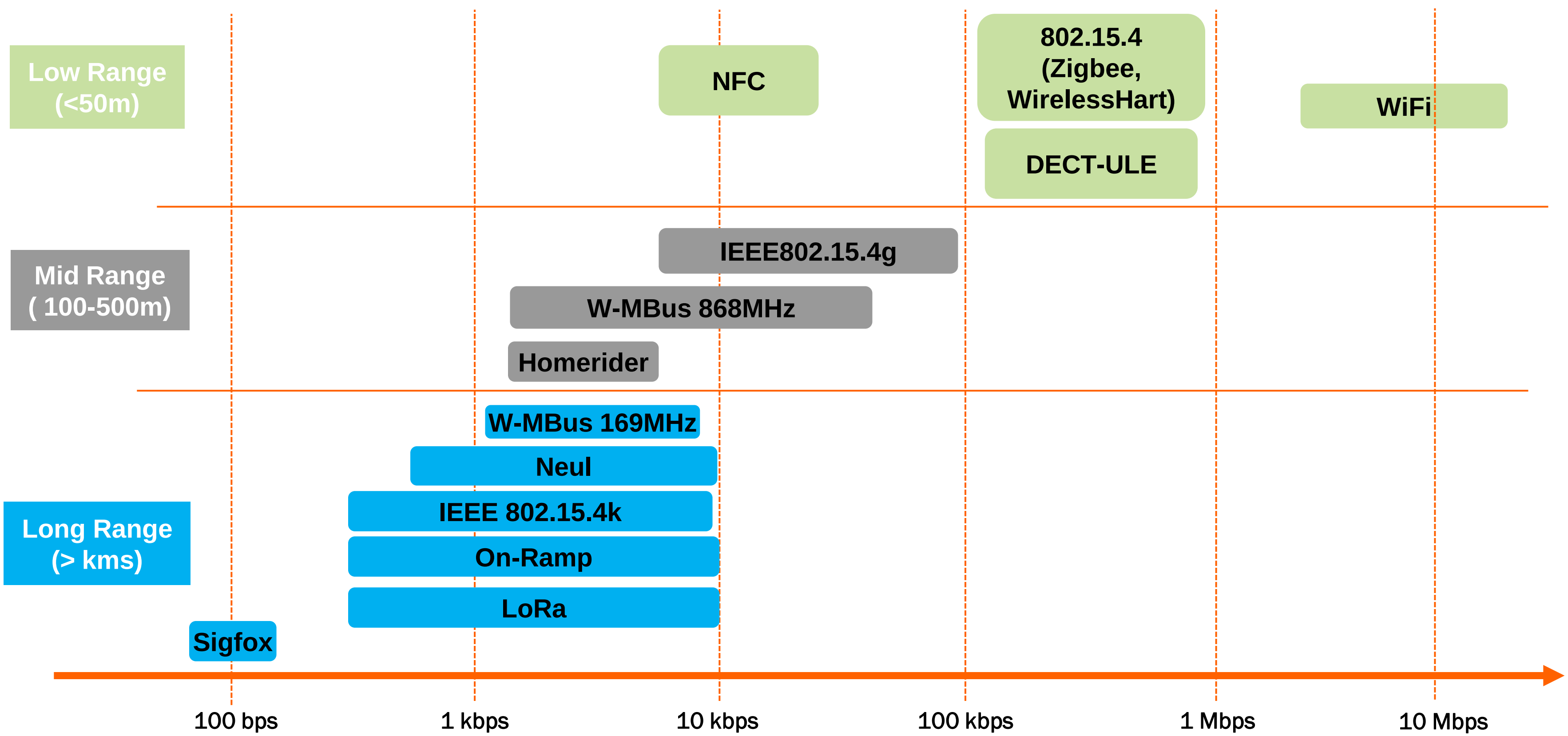
Most of them use Unlicensed Band

Some of them are standard, other are proprietary solutions

IEEE802.15.4k

Main characteristics of existing IoT technologies

- Radio based on License free bands (169/433/868/2400MHz and TV White Space)
- Low transmission power (typically: 10 to 25 mW),
- Most of the solutions are still proprietary but standardization is on going
- Data rate from 100 bit/s to 250 kbit/s
- Short/Mid/Long Range



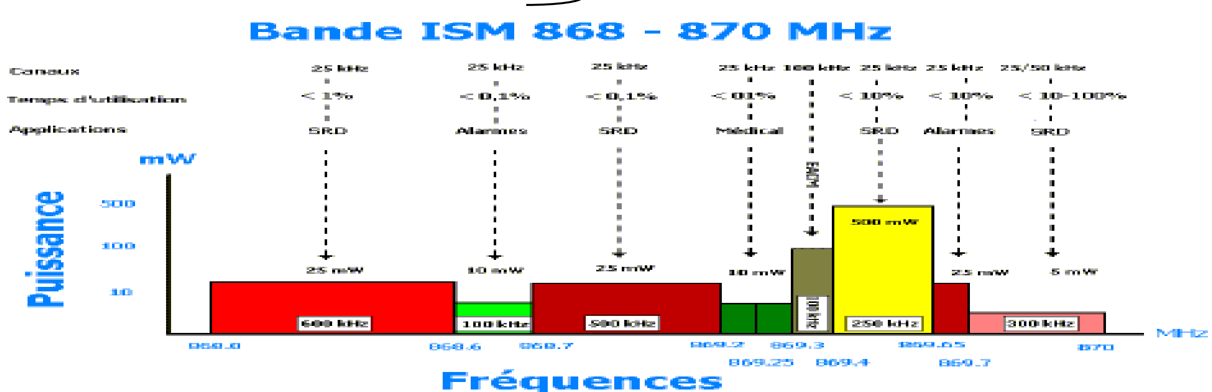
Short point on Radio Regulation

- Mobile network spectrum is licensed by national authority to MNO
  - Exclusive use is granted : access free from interference from other system warranted
  - GSM/GPRS spectrum is pretty much harmonized wordwidely
    - 2 bands in the whole Europe (900 MHz band preferred for IoT)
    - 4 bands worldwide (900 and 850 MHz band preferred for IoT
  - LTE spectrum is more complicated : 46 LTE band across the world (global roaming on 4 bands)

- SRD bands are shared by users without coordination: no warranty (access & interference)
  - IoT moslty rely on the 868 MHz Band. Legacy band plan:
    - One 600 kHz band with 1% DC and 14 dBm EIRP
    - One 500 kHz band with 0,1% de DC and 14 dBM EIRP
    - One 250 kHz band with 10% de DC et 27 dBm

    Largely used by IoT devices
  - And since 2009, some more band is available with a 14 dBm EIRP
    - 863-868 MHz avec 0,1% de DC
    - 865-868 MHz avec 1% de DC

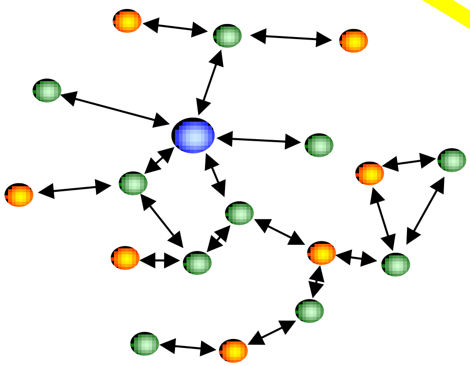
    Shared with RFID devices with 100% DC



IoT network : The coverage issue

- In addition to cost and power consumption, large coverage is a key point
  - Rural area : smart agriculture, asset tracking
  - Deep indoor / underground : smart metering, parking, building automation
- How to get such a coverage with limited EIRP and a single battery for 10 years ?

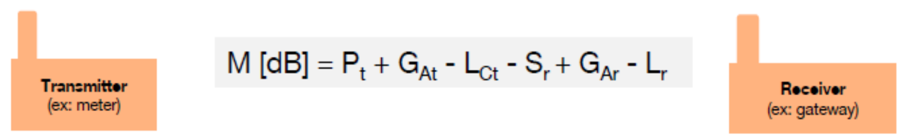
Mesh networks



Extend coverage by collaboration between nodes

- Each node relay traffic for their neighbors
- Requires enough density
- Energy efficiency can get tricky
- But each radio link is short range / high data rate

Direct Long Range Radio Link



$$M\ [dB] = P_t + G_{At} - L_{Ct} - S_r + G_{Ar} - L_r$$

Improving link budget at fixed EIRP ?

- We need to Improve RX sensitivity
- Which means increasing energy per symbol
- This will decrease symbol rate and lower noise level
- And increase transmit time.

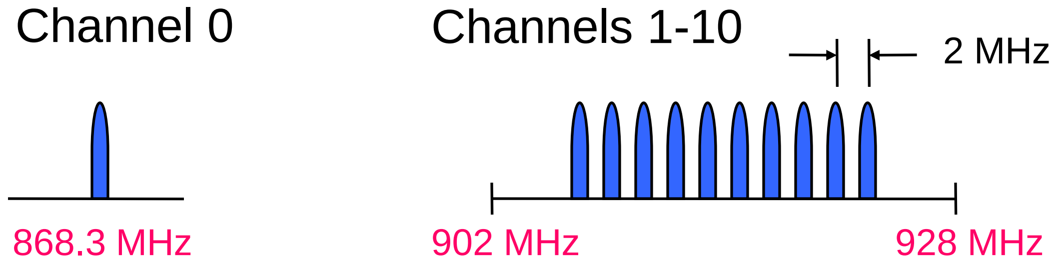
Mesh Network : IEEE 802.15.4

Mesh network can be based on proprietary radio, However,
IEEE 802.15.4 is the basis of almost every large scale initiative

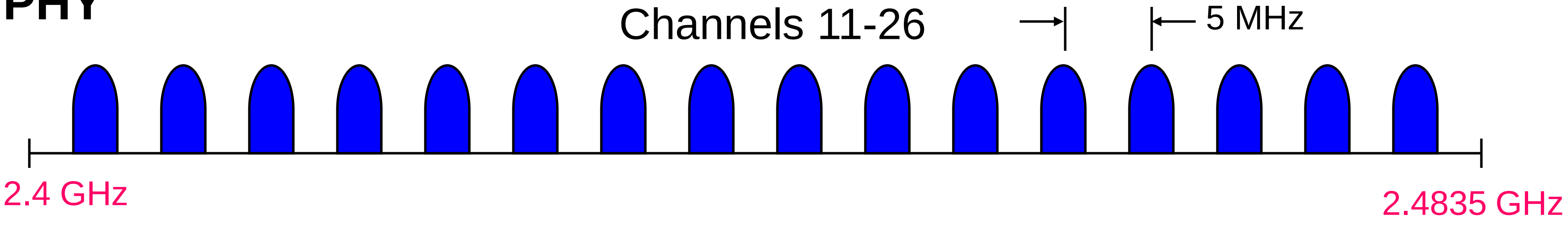
IEEE 802.15.4 PHY Overview

Operating Frequency Bands

868MHz / 915MHz PHY

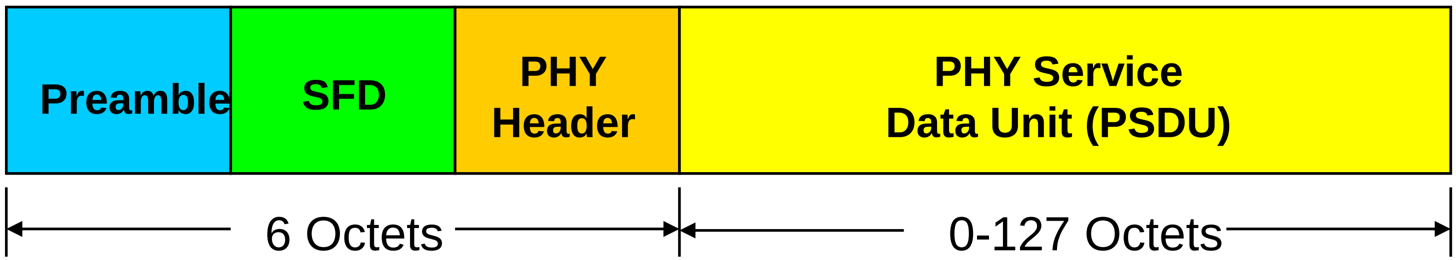


2.4 GHz PHY



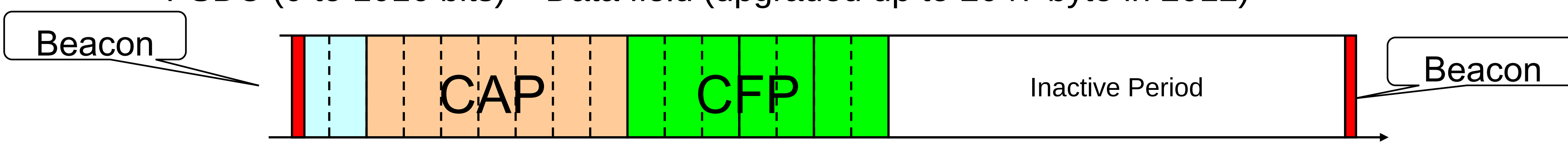
IEEE 802.15.4: a short overview

Packet Structure



PHY Packet Fields

- Preamble (32 bits) and Start of Packet Delimiter (8 bits) – synchronization
- PHY Header (8 bits) – PSDU length
- PSDU (0 to 1016 bits) – Data field (upgraded up to 2047 byte in 2012)



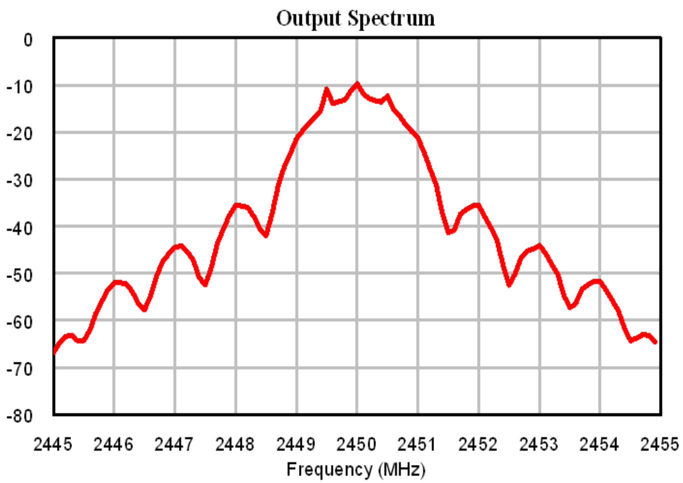
The superframe :

- Beacon : send by the coordinator, it's the borders of the superframe
- CAP : Contention acces period (CSMA-CA)
- CFP : Cotention free period (Guaranteed time-slot)
- Inactive Period : allow duty cycling

IEEE 802.15.4 PHY Overview

802.15.4-2003 Physical layers

- 2.4 GHz PHY
  - Data rate is 250 kbps (4 bits/symbol, 62.5 ksymbols/s)
  - Modulation: is 16-ary orthogonal modulation
  - 16 symbols are ~orthogonal set of 32-chip PN codes
  - Chip modulation is O-QPSK with half-sine pulse shape
  - Chip rate is 2.0 Mchip/s
  - Occupied bandwidth : 2 MHz (16 channels)
  - Max EIRP (in Europe) : 20 dBm



- 868MHz/915MHz PHY
  - Data rate is 20 kbps @ 868 MHz, 40 kbps @ 915 MHz
  - Data modulation is BPSK with differential encoding
  - Spreading code is a 15-chip m-sequence
  - Chip modulation is BPSK with raised-cosine pulse shape
  - 0.3 Mchip/s at 868 MHz (300 kHz bandwidth – 1 channel)
  - 0.6 Mchip/s at 915 MHz (600 kHz bandwidth – 10 channels)
  - Max EIRP (in Europe) : 14 dBm

IEEE 802.15.4 PHY Overview

802.15.4-2015 Physical layers

- *802.15.4g new PHY layer for Smart Utility Network (SUN)*
  - Very focused on electric smart metering and mesh network topology, which is more demanding than other applications (data rate, network capacity, latency), but do not encounter power issue.
  - Is a very generic standard, that includes not less than 3 different PHY layers (OFDM, DS-SS/PSK and FSK with slow FH) + a common signaling mode.
  - Widely promoted by the WiSun Alliance
  - But rising interest from the IT community for a full IPv6 Mesh network

PHY	Band (EU)	Data rate (kbps)	Bandwidth (kHz)	Remarks
MR-FSK	169, 430 868, 2400	2,4 – 9,6 (169) 50 – 200 (other)	12,5 (169 MHz) 200 – 400 (other)	Slow FH
OFDM	868, 2400	50 - 800	156 - 1094	Very scalable
O-QPSK	868, 2400	6,25 - 50 (868) 31,25 – 500 (2.4)	100 (868) 2000 (2400)	SF up to 32 High sensitivity

Higher Layer for a Mesh Networks

Application	Description
Zigbee	Zigbee has been designed for low powered radio system for control applications including lighting, heating and many other applications.
Wireless HART	Wireless HART is an open-standard wireless networking technology. The system uses IEEE802.15.4 for the lower layers and provides a time synchronized, self-organizing, and self-healing mesh architecture.
RF4CE	RF4CE, Radio Frequency for Consumer Electronics has amalgamated with the Zigbee alliance and aims to provide low power radio controls for audio visual applications, mainly for domestic applications such as set to boxes, televisions and the like.
MiWi	MiWi and the accompanying MiWi P2P systems are designed by Microchip Technology. They are designed for low data transmission rates and short distance, low cost networks and they are aimed at applications including industrial monitoring and control, home and building automation, remote control and automated meter reading.
ISA100.11a	This standard has been developed by ISA as an open-standard wireless networking technology for industrial automation including process control and other related applications.
6LoWPAN	IPv6 over Low power Wireless Personal Area Networks" is a system that allow to embed IPv6 packet over an IEEE 802.15.4 radio link
Thread	Thread is an IPv6-based protocol for "smart" household devices. It is based on 6LoWPAN, which in turn uses the IEEE 802.15.4 radio and mesh wireless protocol

Mesh Network summary

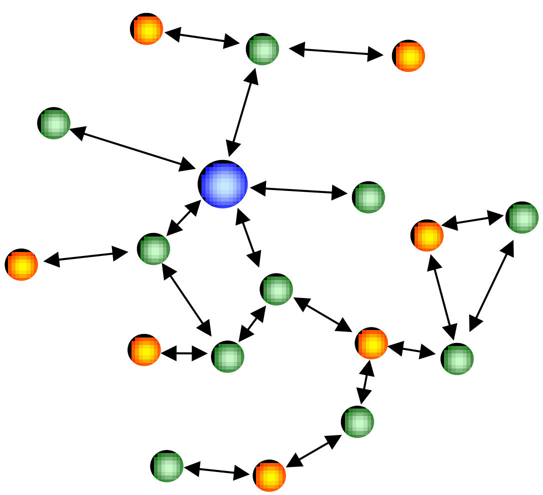
- The concept of mesh network for the IoT is promizing
  - Well suited to licence-free band (device are short range)
  - Might be robust and resilient if dense enough
  - Could be « self-deploying »
  - Un-centralized networks are in the internet spirit
  - And significant progress were made

- However:
  - Running a mesh network on battery operated device remain extremely challenging
  - As enough density is required from start, there is a chicken & eggs problem.

IoT network : The coverage issue

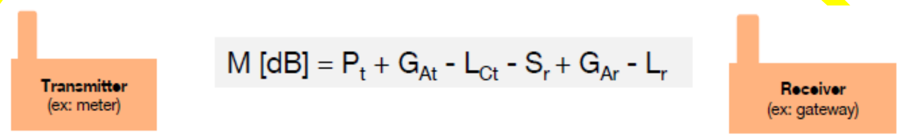
- In addition to cost and power consumption, large coverage is a key point
  - Rural area : smart agriculture, asset tracking
  - Deep indoor / underground : smart metering, parking, building automation
- How to get such a coverage with limited EIRP and a single battery for 10 years ?

Mesh networks



- Each node relay traffic for their neighbors
- Requires enough density
- Energy efficiency can get tricky
- But each radio link is short range / high data rate

Direct Long Range Radio Link



$$M\ [dB] = P_t + G_{At} - L_{Ct} - S_r + G_{Ar} - L_r$$

Improving link budget at fixed EIRP ?

- We need to Improve RX sensitivity
- Which means increasing energy per symbol
- This will decrease symbol rate and lower noise level
- And increase transmit time.

Long Range Radio Link on unlicensed band

Goal : Allow up to 150 dB path loss with 14 dBm EIRP
Consequences : RX sensitivity down to -136 dBm is needed
Fact : lowering signal bandwidth is the simplest way to increase RX sensitivity

Rational	• The lower is the bandwidth, the lower is the thermal noise	
Technics	• Ultra Narrow Band	• Spread Spectrum
Pros	• Robust to interference • Very good sensitivity • Frequency management to improve network capacity	• Robust to interference and fast fading • Very good sensitivity • Data rate flexibility
Cons	• Hardware and software complexity at the receiver side • Lack of flexibility in data rate	• Hardware complexity at the receiver side • Spectrum resource allocation • Management code
Impacts	• Data rate is around equal to the bandwidth. The lower is the bandwidth, the lower is the data rate	

LPWA : The Ultra Narrow Band approach

- Followed by companies like Sigfox, Cowisio, Plextek

- Implementation example :

	Uplink	Downlink
Bandwidth (Hz)	100	600
Symbol Rate	100	600
Modulation	BPSK	BPSK
Central Freq.	Random	depend on uplink frequency
EIRP (dBm)	14	27
Sensitivity (dBm)	< -135	< -135

- Limits:
  - At 100 bps, transmitting a 12 byte payload + header and CRC lead to almost 2 sec airtime.
  - Might conflict with duty cycle limit and channel coherency.
  - Rigid design : taking advantage of better radio condition isn't feasible
  - Downlink is limited (no paging, low capacity)

source : ETSI GS LTN 003 V1.1.1 (2014-09)

LPWA : The Spread Spectrum Approach

- Followed by companies like Semtech, OnRamp Wireless

- Implementation example :

	Uplink / Downlink
Bandwidth (kHz)	125
Chip Rate (kchip/s)	125
Data Rate (bit/s)	30 to 1000 (depending on SF)
Spreading Factor	128 to 4096
Modulation	Equiv. to DSSS
Central Freq.	band plan +/- 35 ppm
EIRP (dBm)	14
Sensitivity (dBm)	< -135 (at max. spreading)

- Limits:
  - At 100 bps, transmitting a 12 byte payload + header and CRC lead to around 1 sec airtime: Might conflict with DC limit or channel coherency.
  - Might be less spectral efficient than UNB (depending on ability to support CDMA)
  - Downlink is limited (no paging, low capacity)
  - More flexible than UNB but more complicated to optimize.

source : ETSI GS LTN 003 V1.1.1 (2014-09)

LPWA : The IEEE 802.15.4 Way (well… also DS-SS)

- *802.15.4k PHY layer to handle highly power-constrained sensors while providing long range and centralized network topology*
  - Includes a pure DS-SS PHY layer, designed for very long range and low data rate
    - RX sensitivity supposed to able to go down to -145 dBm
  - It also includes a simple but flexible FSK PHY layer, able to deliver low data rate with higher robustness than existing 15.4 FSK PHY
    - Improved FEC
    - Include symbol repetition up to 16 time to improve symbol energy
    - Able to handle at least 120 dB of path loss (10 dBm EIRP)
  - Provide frame fragmentation and relaying (virtual star network)
  - Rely on DSME MAC (cf 802.15.4e) with improved low power features
  - Standard published in end 2012.

PHY	EU Band (MHz)	Data rate (kbps)	Bandwidth (kHz)	Remarks
FSK	169, 430, 868	12,5 – 25 (169) 12,5 – 37,5 (other)	12,5 (169) 100 – 200 (other)	Spreading 1 to 16 FEC 1/2
DS-SS	868, 2400	0,003 – 6,25 (868) 0,03 – 125 (2400)	100 (868) 1000 – 2000 (2400)	Very high sensitivity SF up to 32768

Long Range Radio on unlicensed band summary

- Different technological approach's reached the same goals: Extend radio range for device operating on SRD spectrum
  - It works ! And it is already available !
  - Thanks to license fee band, deploiement is simple.
  - But at the cost of a huge throughput reduction and latency increase
  - Main existing technologies are proprietary

- Network topology : Leverage the asymmetry between devices and base station:
  - Devices are as simple as possible : complexity is reported in the base station
  - Star around the gateway / Base station (no direct link between devices)
  - And Base Stations are connected to a centralized network platform

- Downlink is largely limited compare to uplink :
  - No paging: a device isn't reachable at all time
  - Limited capacity : the base station is a device among the other and need to observe the same Duty Cycle limitation than any devices

Adapting 3GPP Mobile network to the IoT

And what about the mobile networks ?

- Mobile networks, especially GSM/GPRS (2G) is by far the most used WAN IoT network.
  - « High » data rate / QoS / Low latency…
- However, mobile network connectivity can be used only for a limited set of IoT application due to cost and power consumption
- With large scale IoT connectivity, Mobile network have to invest a new field.

In **Release-13,** 3GPP has made a major effort to address the IoT market

- The portfolio of technologies that 3GPP operators can now use to address their different market requirements includes:

  - EC-GSM-IoT EGPRS enhancements which in combination with PSM / e-DRX makes GSM/EDGE network prepared for IoT

  - eMTC Further LTE enhancements for Machine Type Communications, building on the work started in Release-12 (UE Cat 0, new power saving mode: PSM)

  - NB-IOT New radio added to the LTE platform optimized for the low end of the market

- Protocol specifications to be finalized in Q2-16

- Those technologies will be 3GPP standards, enabling interoperability and market competition

EC-GSM-IoT: Overview

- EC-GSM-IoT Objectives: *Adapt and leverage existing 2G infrastructure to provide efficient and reliable IoT connectivity over an extended GSM Coverage*

  - Long battery life: ~10 years of operation with 5 Wh battery (depending on traffic pattern and coverage extension)
  - Low device cost compared to GPRS/GSM device
  - Extended coverage (+ 20 dB compared to GSM coverage)
    - 164 dB MCL for 33 dBm UE,
    - 154 dB MCL for 23 dBm UE (will allow integrated PA)
  - Variable data rates:
    - GMSK: ~350bps to 70kbps depending on coverage extension
    - 8PSK: up to 240 kbps
  - Support for massive number of devices: ~50.000 devices per cell
  - Improved security adapted to IoT constraint.
  - Leverage on the GSM/GPRS maturity to allow fast time to market and low cost

- Deployment
  - To be deployed in existing GSM spectrum whiteout any impact on network planning.
  - EC-GSM-IoT and legacy GSM/GPRS traffic are dynamically multiplexed
  - Reuse existing GSM/GPRS base stations thanks to software upgrade

EC-GSM-IoT: Overview

- Main PHY features:
  - New “EC” logical channels designed for extended coverage
  - Repetitions to provide necessary robustness to support up to 164 dB MCL
  - Fully compatible with existing GSM hardware design (Base station and UE)
  - IoT and regular mobile traffic are share GSM time slot.

- Coverage Extension : 4 different coverage class
  - CC 2 to CC4: Variable number of blind repetitions are used
    - Burst of 4 Contiguous times slots: 4 repetition can be IQ-accumulated
    - And bursts can be recombined at soft-bit level (Chase combining)

		CC1	CC2	CC3	CC4
DownLink	MCL (dB)	149	157	161	164
	EC-CCCH	1	8	16	32
	EC-PACCH	1	4	8	16
	EC-PDTCH	1	4	8	16
Uplink	MCL (dB)	152	157	161	164
	EC-CCCH	1	4	16	48
	EC-PACCH	1	4	8	16
	EC-PDTCH	1	4	8	16

  - Beacon and Synchronization channel don’t use coverage class
    - EC-BCCH : always repeated 16 times } Mapped on Ts 1
    - EC-SCH : always repeated 28 times } Mapped on Ts 1
    - FCCH : legacy FCCH is used.
  - Device limited to +23 dBm TX power get only 10dB coverage extension

EC-GSM-IoT: Overview

- Capacity: Repetition consumes more radio resources
  - Overlaid CDMA to increase cell capacity (used for EC-PDTCH and EC-PACCH)

- Other features:
  - Support of SMS and Data, but no voice,
  - Extended DRX (up to ~52min)
  - Optimized system information (i.e. no inter-RAT support)
  - Relaxed idle mode behavior (e.g. reduced monitoring of neighbor cells)
  - 2G security enhancements (integrity protection, mutual authentication, mandate stronger ciphering algorithms)
  - NAS timer extensions to cater for very low data rate in extended coverage
  - Storing and usage of coverage level in SGSN to avoid unnecessary repetitions over the air
  - Optional mobility between GSM and EC-GSM

- Standardisation Status:
  - EC-GSM-IoT specification are expected to be completed in May 2016 (90% completion now
  - Trials have been made by operators and demonstration where shown during MWC 2016

Ehanced MTC (eMTC)

- eMTC Objectives: *define further LTE enhancements for Machine Type Communications, building on the work started in Release-12 (cat0)*
  - Long battery life: ~10 years of operation with 5 Watt Hour battery (depending on traffic and coverage needs)
  - Low device cost: comparable to that of GPRS/GSM devices
  - Extended coverage: >155.7 dB maximum coupling loss (MCL)
  - Variable rates: ~10 kbps to 1 Mbps depending on coverage extension

- Deployment
  - Can be deployed in any LTE spectrum
  - Coexist with other LTE services within the same bandwidth
  - Support FDD, TDD and half duplex (HD) modes
  - Reuse existing LTE base stations with software update

- Main PHY/RF features
  - Narrowband operation with 1.08 MHz bandwidth (1.4 MHz channel)
  - Frequency hopping with narrowband retuning for frequency diversity
  - TTI bundling/repetition to achieve large coverage enhancements
  - New UE power class of 20 dBm
  - Further cost reduction beyond Cat 0 (no wideband control channel, reduced TM support, reduced HARQ)

NB-IoT: Overview

- NB-IoT Objectives: *a New radio added to the LTE platform optimized for the low end of the market*
    - Lower cost than eMTC (same target than EC-GSM-IoT)
    - Extended coverage: 164 dB maximum coupling loss (at least for standalone)
    - Long battery life: 10 years with 5 Watt Hour battery (depending on traffic and coverage needs)
    - Support for massive number of devices: ~50.000 per cell

- Main simplification
    - Reduced data rate/bandwidth, mobility support and further protocol optimizations

- NB-IOT supports 3 modes of operation:
    - Stand-alone: utilizing stand-alone carrier, e.g. spectrum currently used by GERAN systems as a replacement of one or more GSM carriers
    - Guard band: utilizing the unused resource blocks within a LTE carrier's guard-band
    - In-band: utilizing resource blocks within a normal LTE carrier

NB-IoT: Overview

- Main PHY features
  - Narrow band support of 180 kHz (multiple PRB might be supported)
  - Supports of two modes for uplink
    - Single tone with 15 kHz and/or 3.75 kHz tone spacing
    - Multiple tone transmissions with 15 kHz tone spacing
  - No support of Turbo code for the downlink
  - Single transmission mode of SFBC for PBCH, PDSCH, PDCCH
  - New narrowband channels: NPSS, NSSS, NPBCH, NPDCCH, NPDSCH, NPUSCH, NPRACH

- Main radio protocol features
  - Single HARQ process
  - Only RLC AM mode with simplified status reporting
  - Two PDCP options:
    1) SRB 0 and 1 only. NAS security instead of AS. PDCP operating in transparent mode.
    2) SRB 0, 1, 2 and one DRB. AS security, which is cached upon RRC connection release.
  - For PDCP option 2, RRC connection suspend/resume procedures to maintain AS security context.
  - Significantly reduced broadcast system information

- Standardisation Status:
  - NB-IoT specification are expected to be completed by June 2016 (60% completion now)
  - Trials with operators are planned / on-going and demonstration where shown during MWC 2016

eMTC, NB-IOT and EC-GSM-IoT in numbers

	eMTC (LTE Cat M1)	NB-IOT		EC-GSM-IoT
Deployment	In-band LTE	In-band & Guard-band LTE, standalone		In-band GSM
Coverage*	155.7 dB	164 dB for standalone, FFS others		164 dB, with 33dBm power class 154 dB, with 23dBm power class
Downlink	OFDMA, 15 KHz tone spacing, Turbo Code, 16 QAM, 1 Rx	OFDMA, 15 KHz tone spacing, TBCC, 1 Rx		TDMA/FDMA, GMSK and 8PSK (optional), 1 Rx
Uplink	SC-FDMA, 15 KHz tone spacing Turbo code, 16 QAM	Single tone, 15 KHz and 3.75 KHz spacing SC-FDMA, 15 KHz tone spacing, Turbo code		TDMA/FDMA, GMSK and 8PSK (optional)
Bandwidth	1.08 MHz	180 KHz		200kHz per channel. Typical system bandwidth of 2.4MHz [smaller bandwidth down to 600 kHz being studied within Rel-13]
Peak rate (DL/UL)	1 Mbps for DL and UL	DL: ~250 kbps UL: ~250 for multi-tone, ~20 kbps for single tone		For DL and UL (using 4 timeslots): ~70 kbps (GMSK), ~240kbps (8PSK)
Duplexing	FD & HD (type B), FDD & TDD	HD (type B), FDD		HD, FDD
Power saving	PSM, ext. I-DRX, C-DRX	PSM, ext. I-DRX, C-DRX		PSM, ext. I-DRX
Power class	23 dBm, 20 dBm	23 dBm, others TBD		33 dBm, 23 dBm

** In terms of MCL target. Targets for different technologies are based on somewhat different link budget assumptions (see TR 36.888/45.820 for more information).*

eMTC : Target higher end of the IoT (similar price point & better connectivity than GPRS)

EC-GSM-IoT and NB-IoT: Target Low-end of the IoT, with better QoS and futureproofness than LPWA

- EC-GSM-IoT will have better worldwide overage (leverage on the large WW GSM coverage)
- EC-GSM-IoT will benefit from 2G experience : large volume, mature and well optimized technology
- NB-IoT will be well adapted for country that have large LTE coverage and/or no GSM

Main upper layer features for NB-IOT and eMTC

- UE and Network negotiate capabilities and preferences for types of NAS/core network optimizations
  - This may be used for core network selection
  - Changes in Attach procedure required

- There are two different data transfer optimization features agreed for NB-IOT and eMTC:
  - Mandatory for NB-IoT/Optional for eMTC: "CP optimization"
  - Enables Small data over NAS using encrypted NAS PDUs
  - Support for RoHC Header Compression for IP PDN connection
  - Architecture Change: MME, S-GW and P-GW may be combined in one entity (e.g. C-SGN)
  - Optional for NB-IoT and eMTC: "UP optimization"
  - User plane based with RAN context caching in idle mode to enable connection suspend/resume procedures on radio/S1 interface

- Other optional new features
  - Support for non-IP data (2 flavours: non-IP PDN via P-GW, non-IP via SCEF)
  - Attach without PDN connectivity
  - SMS transfer without combined attach
  - Storing and usage of coverage level in MME to avoid unnecessary repetitions over the air

Conclusion and Perspectives

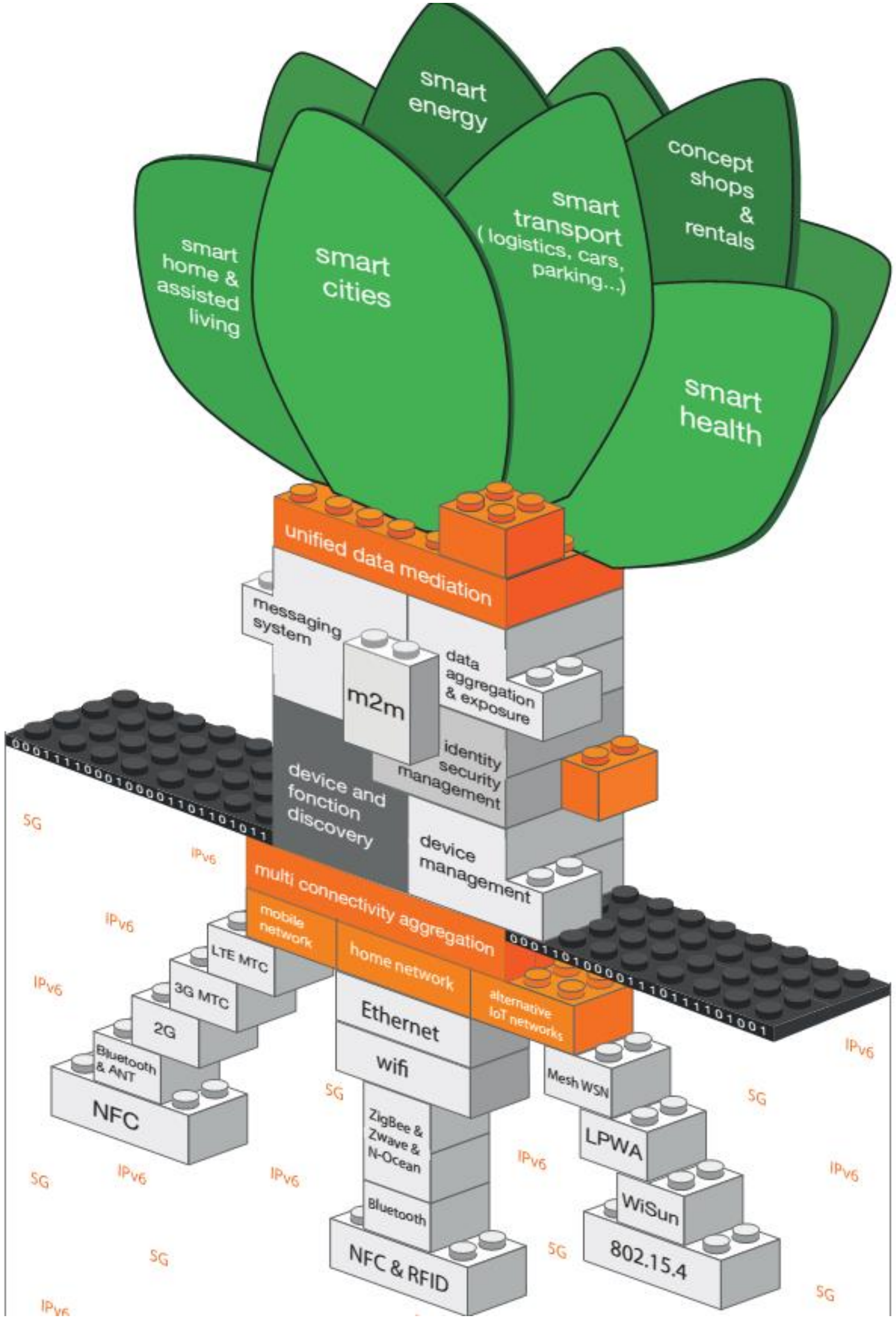
- Until recently, the lack of standard as leaded to a vertical integration of M2M services : One set of devices – One Network – One application

- But the rise of a generic IoT connectivity offer, even if still proprietary changed the situation to something more open
  - Network are operated, without a single specific purpose
  - Customer builds there own applications over it
  - And a single IoT devices can interact with several applications

- Standardization has now a key role to play to give birth to a large scale IoT
  - Enable lower cost and higher volume
  - Provide inter operability, roaming, competition , and global harmonization

- 3GPP standards are on the way : the mobile industry won't miss the IoT opportunity
  - Strong involvements from the whole industry
  - Large set of options to cover the largest possible part of the market : no leftover
  - Timing will be a key point : too late would be too late…

- Next challenge will be mainly
  - Scale with the number of IoT Devices (Spectrum, Network capacity, Devices Management
  - Adapt application protocols to the low data rate / increased latency of LPWA
  - Ensure security and reliability
  - The long term solution for IoT Connectivity wont' be a single technology.


smart energy
concept shops & rentals
smart home & assisted living
smart cities
smart transport (logistics, cars, parking...)
smart health
unified data mediation
messaging system
m2m
data aggregation & exposure
identity security management
device and fonction discovery
device management
multi connectivity aggregation
mobile network
home network
alternative IoT networks
LTE MTC
3G MTC
2G
Bluetooth & ANT
NFC
Ethernet
wifi
ZigBee & Zwave & N-Ocean
Bluetooth
NFC & RFID
Mesh WSN
LPWA
WiSun
802.15.4
5G
IPv6

Thanks