
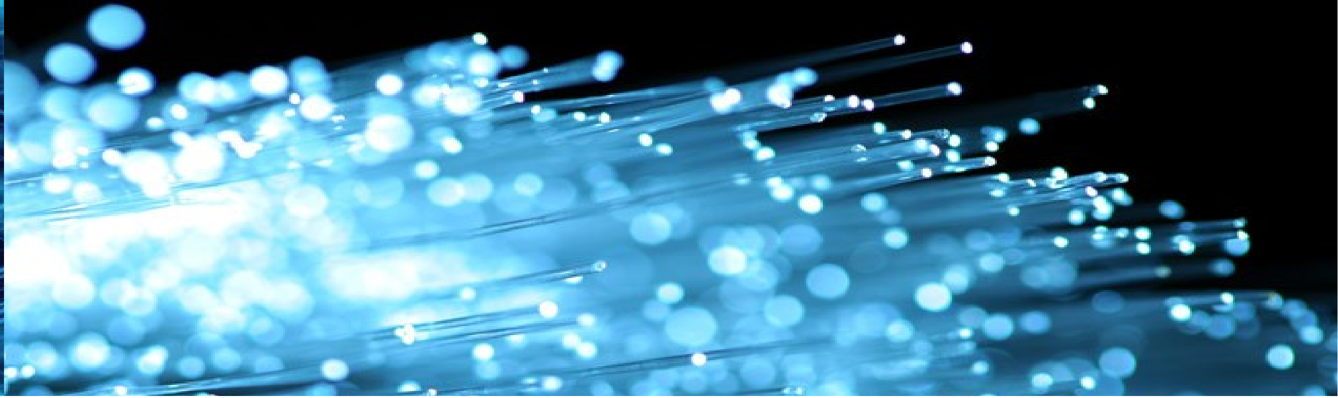

IMC-4302A Wireless Networks

Internet of Things (and cloudification)

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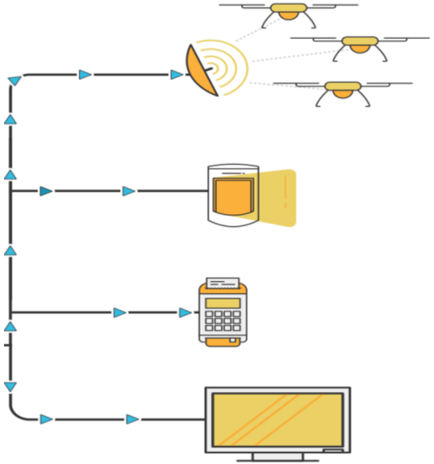
Summary

- **Definitions**
  - IoT and its different use cases
- **Transmission (OSI 1 and 2)**
  - Long range (Cellular, LoRa and SigFox)
  - Short range (Bluetooth, ZigBee, Z-Wave)
- **Networking (OSI 3 and 4)**
  - IP, IPv6
  - MQTT, CoAP
- **Application (OSI 5 to 7)**
  - Operating systems and embedded applications
  - Clouds of IoT for developers and data miners

Definitions

- Billions of applications are connected to the Internet througl Internet Protocol
  - Some with Human/Robots interaction
  - Other unmanned applications

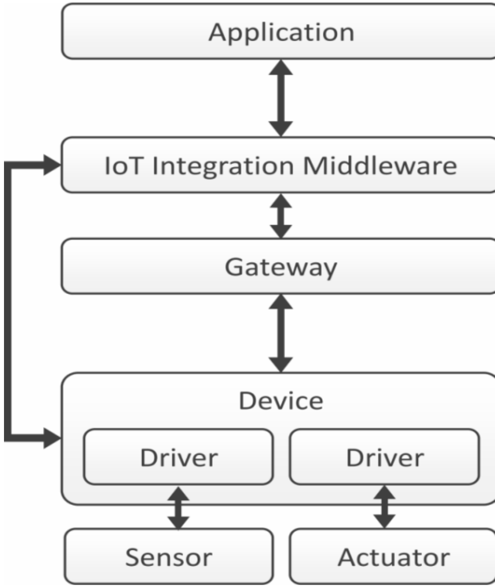
- IoT is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and network connectivity which enables these objects to connect and exchange data.



- A thing is uniquely identifiable within a bounded realm through its embedded computing system but is able to inter-operate within the existing Internet infrastructure (sometimes through a proxy).

Definitions

- **Sensor**: A hardware component. Measures parameters of its physical environment and translates them into electrical signals. Connection to the device can be wired (GPIO) or wireless.
- **Actuator**: A hardware component. Manipulates the physical environment, for example, by giving an optic or acoustic signal. Translates electrical signals into some kind of physical action.
- **Device**: A hardware component. Connected to sensors/Actuators, processes their data and controls them through drivers.
- **Gateway**: It is necessary when the Device is not capable of directly connecting to further systems, cannot communicate via a particular protocol or because of other technical limitations.
- **Middleware**: A software component responsible for receiving and processing data and provide the received data to connected *Applications*. A *Device* can communicate directly with the *IoT Integration Middleware* if it supports the transmission technology.
- **Application**: Uses the *IoT Integration Middleware* to gain insight into the physical environment by requesting *Sensor* data or to control physical actions using *Actuators*



Definitions

- Cisco made a popular estimate of 50billion IoT devices by 2020 back in 2009.
  - Some actual numbers (2016 estimates):
    - 6,4 billions (Gartner)
    - 9 billions (International Data Corporation)
    - 17,4 billions (including Smartphones and tablets, by HIS)
    - 28 Billion devices by 2021 (Ericsson)
- Popular use cases for Internet of things
  - Manufacturing, Agriculture, Transportation
  - Home, Health, Smarter Cities
  - Energy, environment

Some of Orange's Datavenue use cases

Industry

Asset Management & Smart operations

Gaz tanks monitoring

Motorway service area monitoring

Specialized services

Asset Tracking for Supply chain

Truck offload - RFID

Commercial coolers - LoRa

Automotive crates - Cellular

Generalist solutions

Healthcare

Med Techs

Glucose sensor monitoring

Medical objects

Cardiac Rhythm Management

Specialized services

Daily life & customer relationship

Boilers monitoring

Senior care

Emergency call systems

Generalist solutions

orange™

Some of Orange’s Datavenue use cases

ESIEE PARIS

Smart cities

Eco-districts | **Utilities** | **Smart offices** | **Retail**




لعقارية MSHEIREB Qatar

smartseille France

alba iulia Romania

Lubomierz Water meters in Poland

orange™ Smart building for Orange Labs

Mobile application for employees

unibail·rodamco Geo-marketing

Specialized services | Generalist solutions

Transport

Car manufacturers | **Services providers** | **Fleet Management** ocean



TESLA MOTORS

SNCB

RENAULT Passion for life

PSA GROUPE

VIASAT Usage-based Insurance

Hertz Rental by-the-hour

COTECNA

PSA GROUPE

Specialized services | Generalist solutions

More use cases

ERICSSON

ABB

Fraunhofer IPT

BOSCH

Offloading to the Edge

Ericsson smart factory (Kista)

UC1: Factory-floor collaboration between stationary and mobile robots
UC2: Interaction between the mobile robot and a human (complements UC1)
UC3: Wireless AR-based visualization of information from the factory floor

Real-time monitoring

Fraunhofer IPT shopflor (Aachen)
Using Ericsson testbed

UC4: Time-critical wireless acoustic workpiece monitoring
UC5: Versatile multi-sensor platform for digital twin of a massive number of tools / machines / workpieces

Factory of the future

Bosch semiconductor factory (Reutlingen)
With Ericsson

UC6: AGV for automated transport of production material (but Issue with AGV provider)
UC7: Time Sensitive Networking & Industrial LAN over 5G for M2M communications (to remplace legacy IEEE 802.1 technologies)

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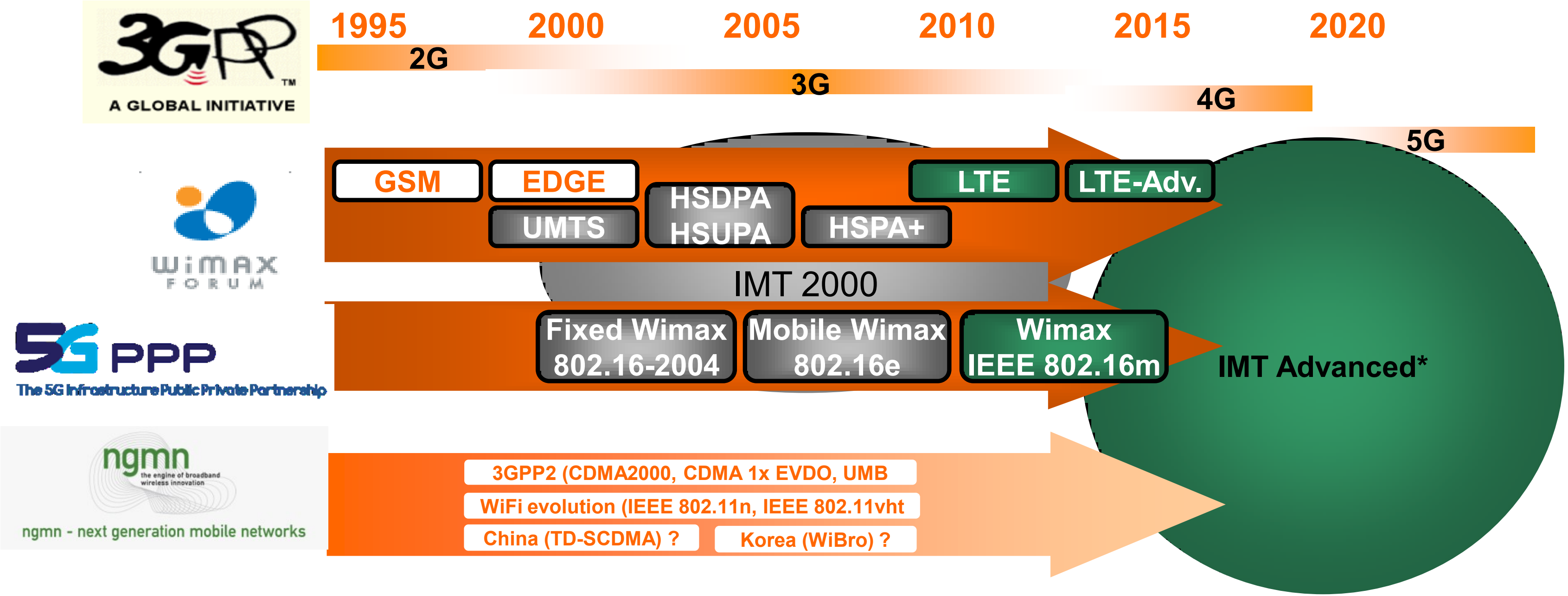
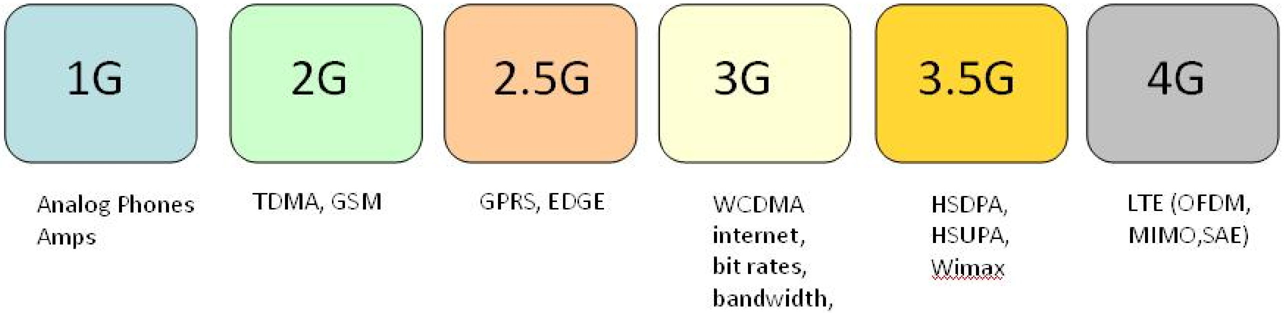
Technology and standards landscape



* **International Mobile Telecommunications-Advanced** (**IMT-Advanced Standard**) are requirements issued by the ITU-R, expected to provide a comprehensive and secure all-IP based mobile broadband solution for ultra-broadband Internet access, IP telephony, gaming services, and streamed multimedia.

Radio frequencies and coverage

- The Cellular technology is made from the **radio frequency,** the **network architecture** and the **communication protocol**



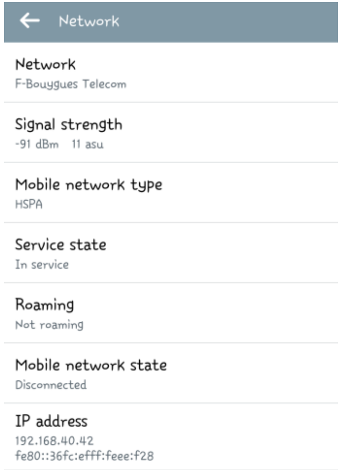
- The Frequency used **and** the transmission power **decide** of the coverage
  – Each frequency has a different rate of energy decay, **higher frequencies decaying faster**
  – This explains why the 700MHz frequency for LTE is called “the golden frequency” → better obstacle penetration and wider coverage
- Have a look at “cellmapper” and similar websites for open data about cellular coverage
  – https://www.cellmapper.net/map

Some terminology

1. Radio Access Network: the radio transmission part (includes the User Equipment and the Antenna/Base station)
   - Responsible for radio resource management

2. Core Network: the control and routing part in the operator domain
   - Responsible for user management (authentication), session management (voice and data setup), and mobility management (registration, location/routing area update)

3. User Equipment: anything the user can use to connect to the network (phone, tablet, IoT device…)
   - Responsible for authenticating the user, handling the voice/data sessions establishment and termination, <u>measuring the signal strength and reporting it</u>, and part of the handover



How it looks like on Android

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IoT applications in 2G->4G

- Machine to machine communications (M2M) or Machine-Type communications are the general used terms for IoT applications over cellular.
  - Areas of implementation are medicine, transportation, environmental monitoring, and smart grids
  - Generally used with GPRS or EDGE networks. Now migrating to 4G due to planned obsolescence of 2G

- Challenges
  - Security and privacy for health related information (any personal data that travels the network)
  - Scheduling and processing load (scalbility). This is a research area with proposals like Group-based scheduling and QoS classes of scheduling*
  - Mobility management in the transportation use case in particular

* **Machine-to-machine (M2M) Communications: Architecture, Performance and Applications**, Carles Anton-Haro and Mischa Dohler, woodhead publishing, 2015

3GPP LTE sub-standards for IoT

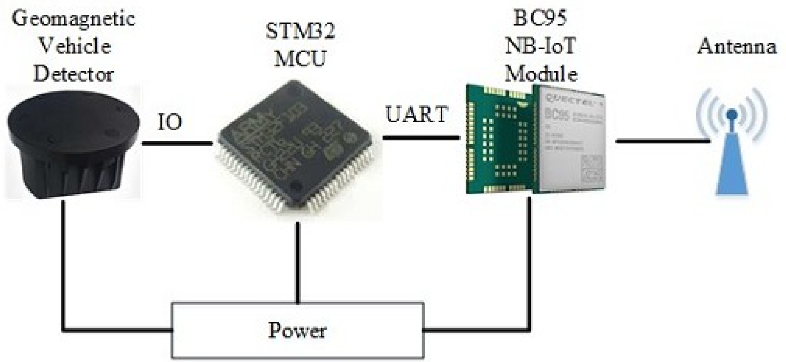
V · T · E [7][8]	LTE Cat 1	LTE-M				NB-IoT		EC-GSM-IoT
		LC-LTE/MTCe	eMTC					
		LTE Cat 0	LTE Cat M1	LTE Cat M2	non-BL	LTE Cat NB1	LTE Cat NB2	
3GPP Release	Release 8	Release 12	Release 13	Release 14	Release 14	Release 13	Release 14	Release 13
Downlink Peak Rate	10 Mbit/s	1 Mbit/s	1 Mbit/s	~4 Mbit/s	~4 Mbit/s	26 kbit/s	127 kbit/s	474 kbit/s (EDGE) 2 Mbit/s (EGPRS2B)
Uplink Peak Rate	5 Mbit/s	1 Mbit/s	1 Mbit/s	~7 Mbit/s	~7 Mbit/s	66 kbit/s (multi-tone) 16,9 kbit/s (single-tone)	159 kbit/s	474 kbit/s (EDGE) 2 Mbit/s (EGPRS2B)
Latency	50ms–100ms	not deployed	10ms–15ms			1.6s–10s		700ms–2s
Number of Antennas	2	1	1	1	1	1	1	1–2
Duplex Mode	Full Duplex	Full or Half Duplex	Full or Half Duplex	Full or Half Duplex	Full or Half Duplex	Half Duplex	Half Duplex	Half Duplex
Device Receive Bandwidth	1.4 – 20 MHz	1.4 – 20 MHz	1.4 MHz	5 MHz	5 MHz	180 kHz	180 kHz	200 kHz
Receiver Chains	2 (MIMO)	1 (SISO)	1 (SISO)	1 (SISO)	1 (SISO)	1 (SISO)	1 (SISO)	1–2
Device Transmit Power	23 dBm	23 dBm	20 / 23 dBm	20 / 23 dBm	20 / 23 dBm	20 / 23 dBm	14 / 20 / 23 dBm	23 / 33 dBm

NB-IoT: Narrowband IoT

- NB-IoT is a new cellular technology introduced in 3GPP Release 13 for wide-area coverage in IoT scenarios

- Example: a smart parking system integrated to NB-IOT (**DOI:** 10.1109/ISCIT.2017.8261235)

- NB-IoT addresses :
  - deployment flexibility,
  - low device complexity,
  - long battery lifetime,
  - support of massive numbers of devices in a cell,
  - significant coverage extension beyond existing cellular technologies



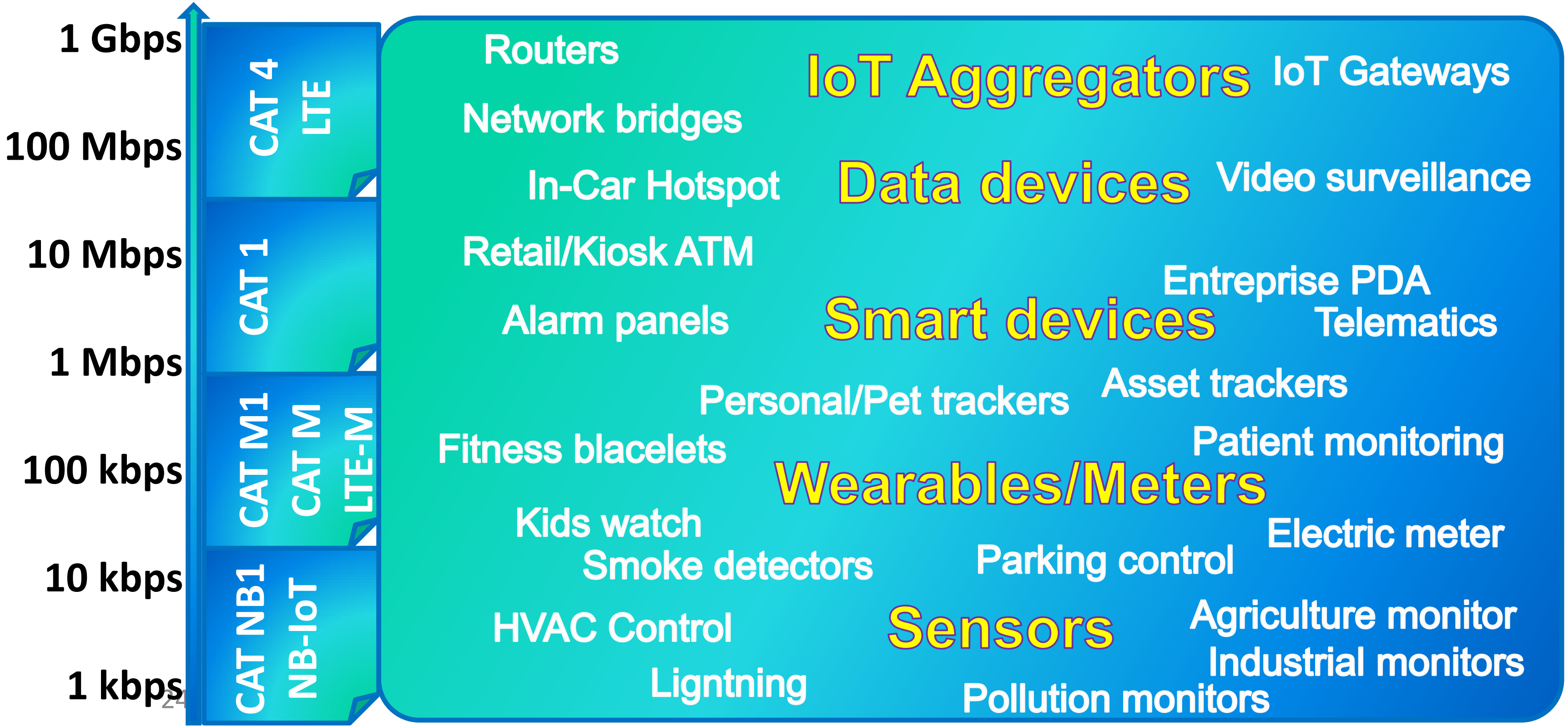
Specifications			
Parameter	***NB-IoT***		***LoRA***
	Standalone	***In band***	
Frequency	800 MHz	800 MHz	868 MHz
Channel BW	200 KHz	180 KHz	125-500 KHz
Data Rate	226.7 kbps	180 kbps	290 bps – 50 Kbps
$P_{Tx\ Base\ Station}$	40 Watt	800 mWatt	25 mWatt
S_{UE}	-120 dBm		-130 dBm

RF comparison between NB-IoT and LoRa

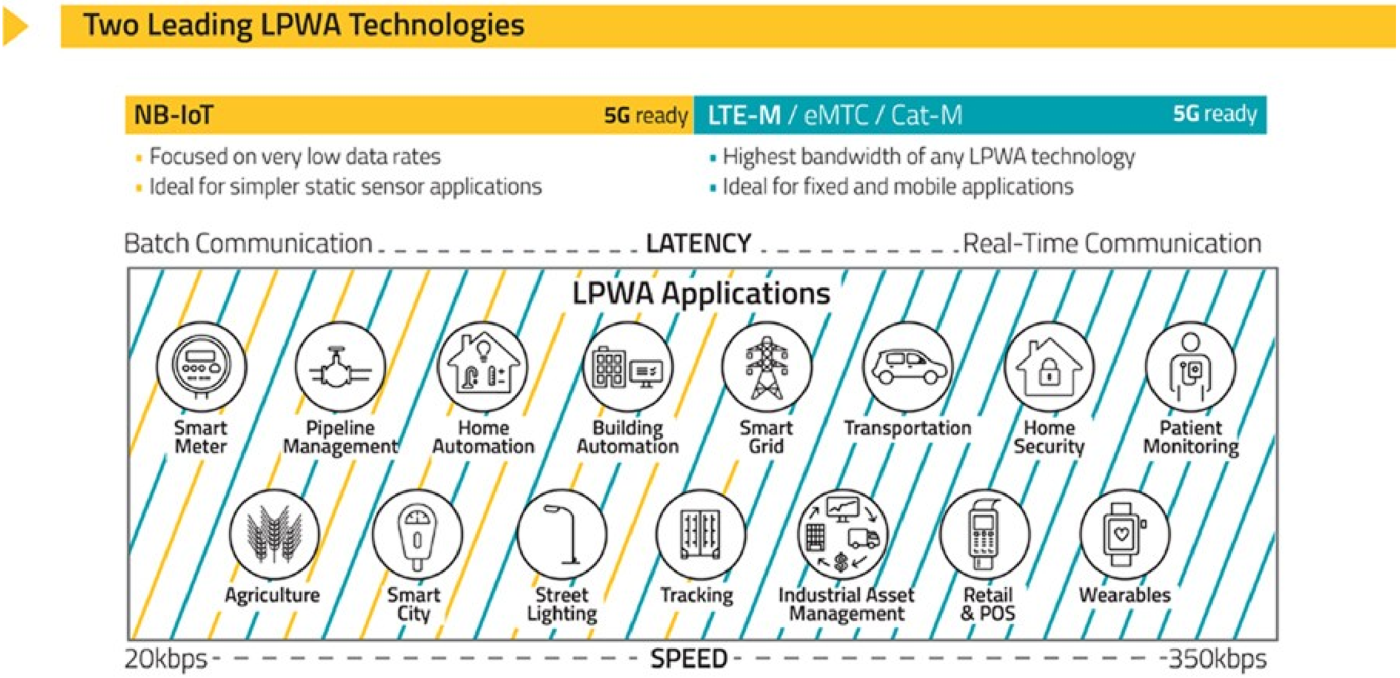
LTE-M

- LTE CAT-M1 was specified by 3GPP Release 13, which specified these design goals:
  - 10 year battery life on a 5WH battery
  - Device cost comparable to GPRS based devices
  - Extended coverage (> 156 dB MCL)
  - Variable Data Rates - to enhance coverage.
- Devices can connect to 4G networks with chips that are less expensive to make (5$), because they are half-duplex and have a narrower bandwidth
- Orange covers 98% of France with LTE-M. This is because of compatibility with existing LTE network that only requires a software patch to work

NB-IoT vs. LTE-M



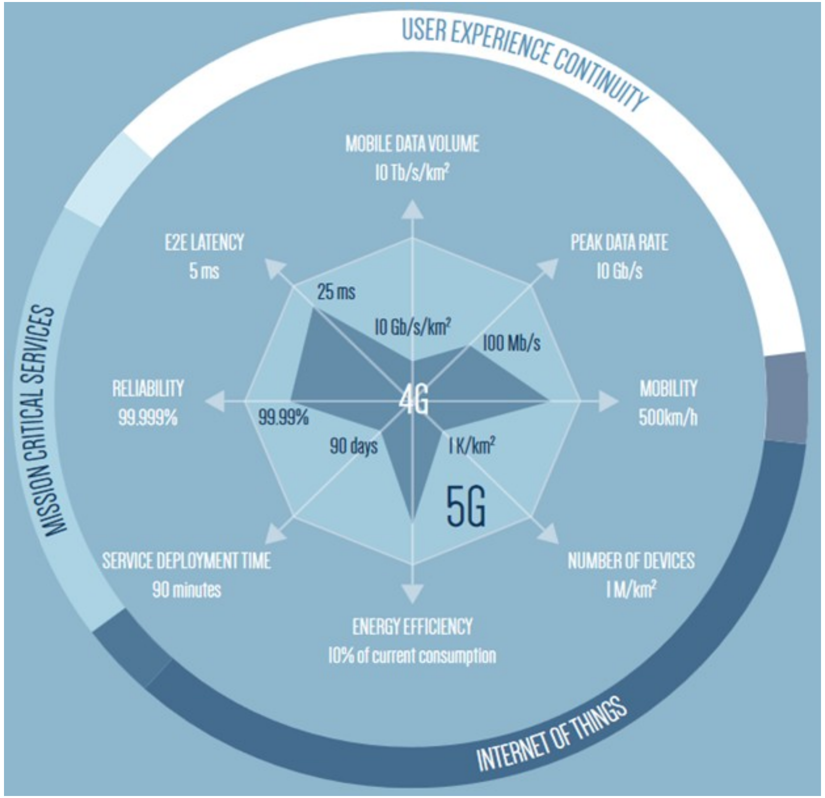
NB-IoT vs. LTE-M



IoT applications in 5G

- 5G will introduce a new concept for network operators: Slicing
  - The ability to slice the resources in the network and delegate access to over the top actors (tier-3 customers)
  - Requires to softwarize the management and control of almost every part of the network

- Challenges
  - Support a large number of devices per client. The devices can be very active (a camera) or mostly disconnected (telemetry)
  - Energy efficiency. Some of the devices will be unmanned and deployed in the “wild”. This requires control plane to be less verbose than for UEs (for example)



Radar diagram of 5G’s disruptive capabilities
(5G-Vision-Brochure-v1.pdf)

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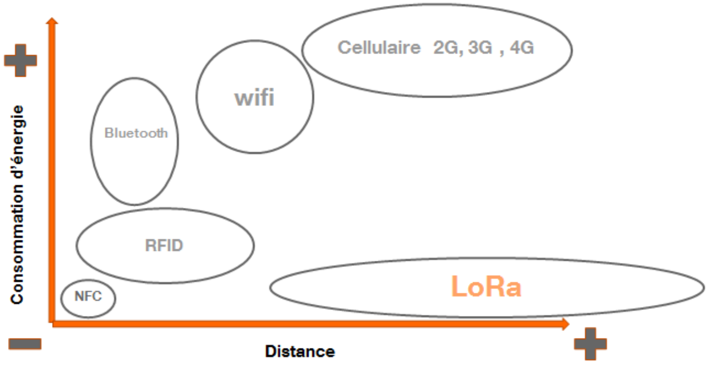
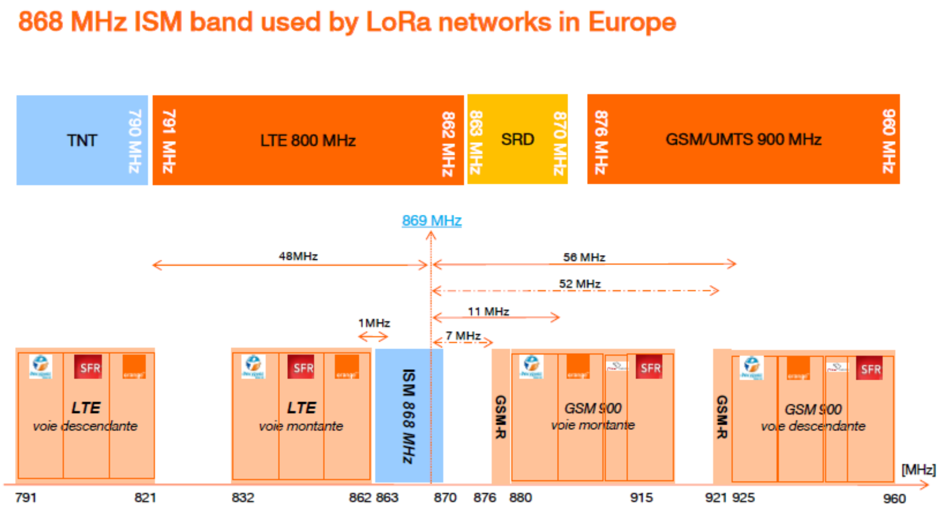
Sigfox

- Sigfox is a Network operator in the 868Mhz in Europe and 902Mhz in the US.
- A Sigfox device can send up to 140 messages with a 300bits/s per day and a payload limited to 12bytes
- Sigfox is bi-directional with a strong limitation: a device is capable of receiving only 4 messages a day at certain times
- The duty cycle restrictions of the utilized subband in the 868 MHz EU ISM band is 1%. A SigFox device may only transmit 36 seconds per hour. The time on air is 6 sec per package and thus the maximum is 6 messages per hour with a payload of 4, 8, or 12 bytes.
- Sigfox covers 85% of France's territory, and is set to cover 12 countries in 2017

	LoRa UL	LoRa DL	Sigfox UL	Sigfox DL	NB-IoT release 13 UL	NB-IoT release 13 DL	GPRS UL	GPRS DL
Spectrum [MHz]	863-870	863-870	868.1-868.3	869.425-869.625	832-862	791-821	890-915	935-960
Tx power [dBm]	14	14-27	14	27	23	37	33	37
Modulation	Chirp spread spectrum		DBPSK	GFSK	GMSK	SC-FDMA	GMSK	GMSK
Bandwidth [kHz]	125	125	0.1	0.6	180	180	200	200
Max payload [bytes]	51	51	12	8	128	85	22	22
Scheduling	Uplink initiated (class A)		Uplink initiated		Network scheduled		Network scheduled	
MCL [dB]	154	152	158	161	164	164	144	152

Long Range Wide Area (LoRa)

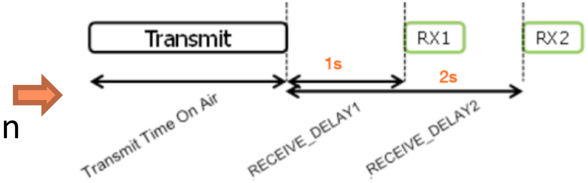




The ISM 868 MHz band used by LoRa networks is 1MHz from LTE 800 Orange uplink and 11MHz from 2G/3G 900 BYT uplink band

- LoRa is a radio technology in the unlicensed 868Mhz spectrum in EU, 915 MHz for North America,433 MHz band for Asia
- Used for short non-critical messages (telemetry), 15 - 20 km range.
- Energy-efficient and well suited to general IoT requirements
- Deployed in France and Netherlands (KPN). Swisscom and Belgacom also soon.

Uplink Transmission

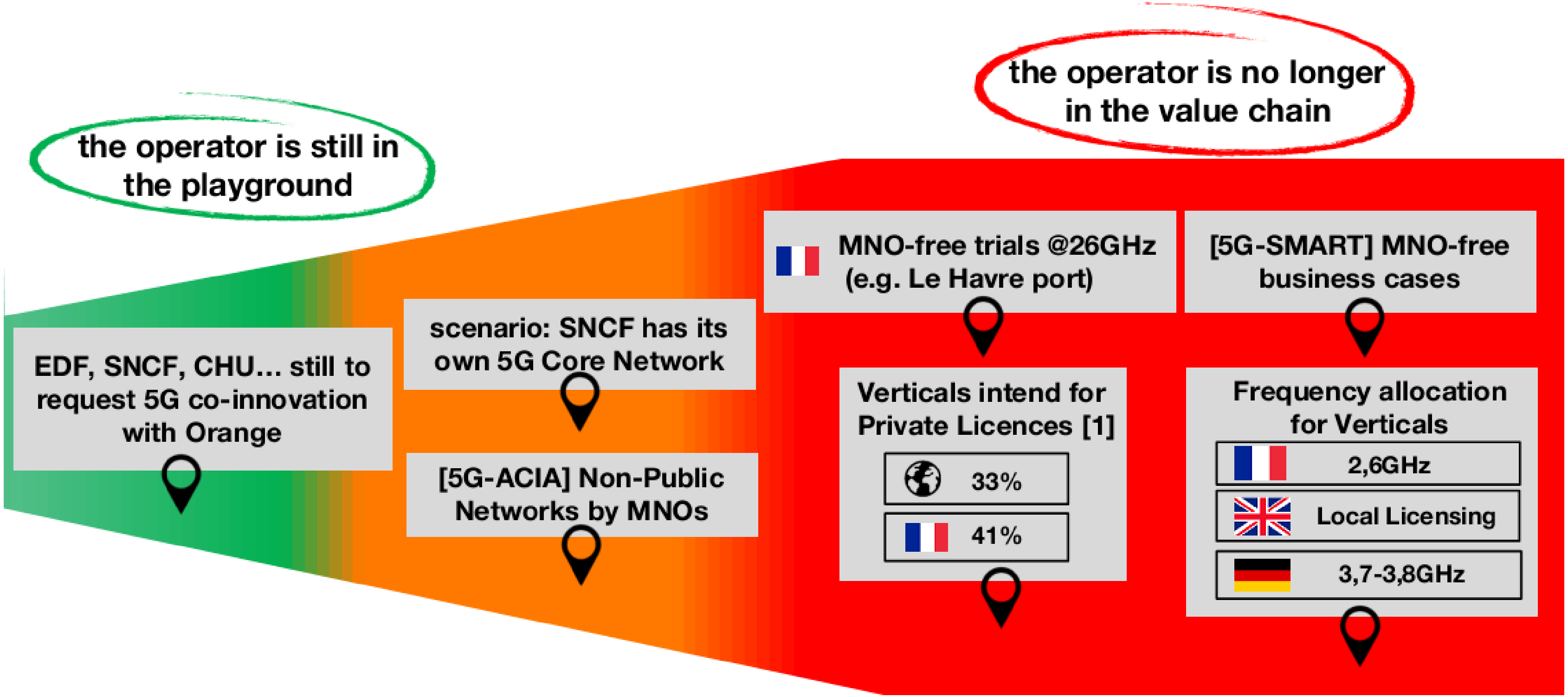


fication

LoRa vs Sigfox

	+	-
Broadband	**LoRa** Adaptive broadband from 300 bps to 5 kbps	**Sigfox** Fix & weak broadband: 100 bps
Messages size	**LoRa** 50 octets in most case, until 242 octets in best conditions	**Sigfox** Fix & limited : 12 octets
Energy consumption	**LoRa** Better efficiency due to variable & highest speed broadband than Sigfox	**Sigfox** Higher consumption due to the emission messages time which is longer than LoRa
Bi-directionnality (able to send message both in uplink & downlink)	**LoRa** Native bi-directionnality	**Sigfox** Less downlink radio efficiency than LoRa
International coverage (roaming)	**Sigfox** One single network whatever the country is, operational deployment in many countries	**LoRa** No roaming yet: specification on-going on LoRa alliance. Will require MNOs agreements
New potential service: **geolocalization**	**LoRa** Geolocalization technically available end of 2016, will depend on the network density	**Sigfox** No native geolocalization

In-depth Value Chain Transformation



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Short range communications in the 2.4Ghz unlicensed spectrum

- **Wi-Fi (IEEE 802.11)**
  - wireless LAN for supporting station mobility, transparently upper layers, mainly in the ISM 2.4 GHz band, but also in the 5GHz band.
  - Each new generation of these standards results is in a rising in throughput, speed, range, reliability without energy consumption increasing.
- **Bluetooth (IEEE 802.15.1)**
  - for short-range communications in the 2.4GHz band, provides techniques to reduce interference based on Frequency Hopping Spread Spectrum (FHSS) by avoiding the occupied channels of wireless devices near to the coverage area.
- **Zigbee (IEEE 802.15.4)**
  - Low Power Wireless Personal- Area Network with short-range and low power consumption.
  - upper layers which are based on the IEEE 802.15.4 standard, provides enhanced reliability and interoperability and supports more complicated network topologies
- **Z-Wave (proprietary)**
  - Developed by Zensys, mainly used for home automation.
  - Apparently, is also used in the ISM spectrum (868Mhz)

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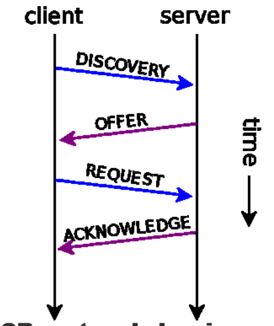
IP (basics and reminders)

- Usage : Internet, Intranet, Extranet.
  Example: 192.168.0.1
- Single IP Address for every machine.
  - Possiblity to add multiple adresses thanks to virtual interfaces (labels, dummy kernel module of linux)
- A general rule of thumb: One interface has a unique address, assigned for a certain duration.
  - The exceptions arise when you want services with failovers
- An IP address MUST be unique in a network
  - If multiple hosts have the same address it is “an address collision” or “a duplicate address”
- RFC 2131 Dynamic Host Configuration Protocol (DHCP)
  - Every IP stack (meaning every OS) is provided

DHCP options
53: 2 (DHCP Offer)
1 (subnet mask): 255.255.255.0
3 (Router): 192.168.1.1
51 (IP address lease time): 86400s (1 day)
54 (DHCP server): 192.168.1.1
6 (DNS servers): • 9.7.10.15, • 9.7.10.16, • 9.7.10.18

DHCP offer example



DHCP protocol classic exchange

Special IP addresses

- Address Block   Present Use   Reference
- ---
- 0.0.0.0/8   "This" Network   RFC 1122, Section 3.2.1.3
- 10.0.0.0/8   Private-Use Networks   RFC 1918
- 100.64.0.0/10   Shared Address Space   RFC 6598
- 127.0.0.0/8   Loopback   RFC 1122, Section 3.2.1.3
- 169.254.0.0/16   Link Local   RFC 3927
- 172.16.0.0/12   Private-Use Networks   RFC 1918
- 192.0.0.0/24   IETF Protocol Assignments   RFC 5736
- 192.0.2.0/24   TEST-NET-1   RFC 5737
- 192.88.99.0/24   6to4 Relay Anycast   RFC 3068
- 192.168.0.0/16   Private-Use Networks   RFC 1918
- 198.18.0.0/15   Network Interconnect Device Benchmark Testing   RFC 2544
- 198.51.100.0/24   TEST-NET-2   RFC 5737
- 203.0.113.0/24   TEST-NET-3   RFC 5737
- 224.0.0.0/4   Multicast   RFC 3171
- 240.0.0.0/4   Reserved for Future Use   RFC 1112, Section 4
- 255.255.255.255/32 Limited Broadcast   RFC 919, Section 7
- RFC 922, Section 7

IPv6

- Usage : Internet, Intranet, Extranet
- First drafts in 1996, called ngIP back then
- Had a lot of difficulties to become the default version due to resistance, legacy, technical problems and lack of luck
- Multiple IPv6 addresses per interface!
  - Example: 2001:0db8:85a3:0000:0000:8a2e:0370:7334
  - Can be compressed to: 2001:db8:85a3::8a2e:370:7334
- 128 bits for one address. That's a lot!

- IPv6 address scopes :
  - Local: ::1/128, fe80::/10. Associated with interfaces.
  - Unique Local addresses (ULA): fc00::/7 (globally scoped)
  - Globally scoped: e.g. 2001::/32, 2002::/16 (6to4)
- An IPv6 address MUST be unique in a network (and per interface)
  - **RFC 4861 Neighbor Discovery** is the default IPv6 addressing protocol implemented in every stack
  - **RFC 3315 Dynamic Host Configuration Protocol (DHCP) version 6**

IPv6 for IoT

- IPv6 over Low-Power Wireless Area Networks (6LoWPAN)
  - RFCs 4944 and 6282
  - IPv6 even can run on very constrained networks - including the popular IEEE 802.15.4 wireless standard, ISM (industrial, scientific, medical) band telemetry radios, and low-rate power-line communications (PLC)
- Routing Over Low-power and Lossy networks (ROLL)
  - provides a routing solution optimized for these constrained networks (IEEE 802.15.4, Bluetooth, Low Power WiFi, wired or other low power PLC)
  - RFC 6550 “RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks” for interconnection with high loss rates, low data rates, and instability

IP’s problem in the IoT context

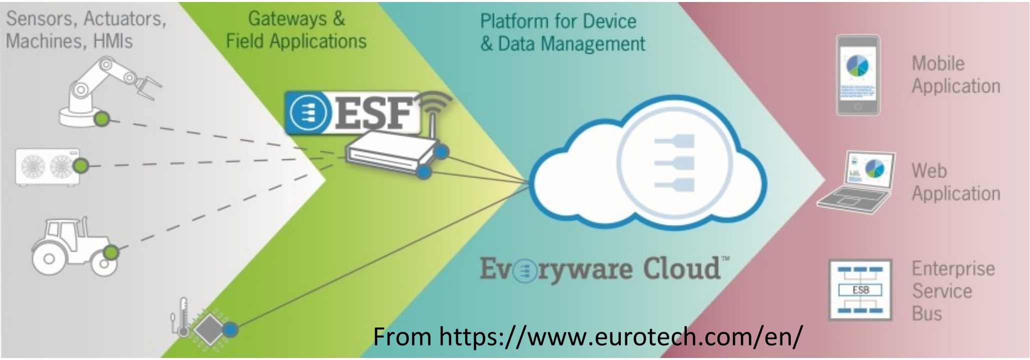
- Implementation for (very) constrained environments!
- Open source IP stacks:
  - Lightweight IP (lwIP). Designed for embedded systems, supports a large set of protocols (IP and IPv6), open source with a GPL license. Can be used with FreeRTOS OS. Uses 40KB RAM and 30KB ROM.
  - Micro IP (uIP) intended for small 8-bit and 16-bit microcontrollers. RFC1122 compliant but has some limitations. Can run on Contiki OS, uses less than 10Kb ROM and 2KB RAM
- There are other commercial stacks (ex. NetX for RTOS).

Summary

- What are the networking protocols to use for IoT ? Where are they implemented (device or elsewhere)?
- What are the differences between MQTT and CoAP ?
- Describe the publish/subscribe model and its uses

Layer 4 protocols

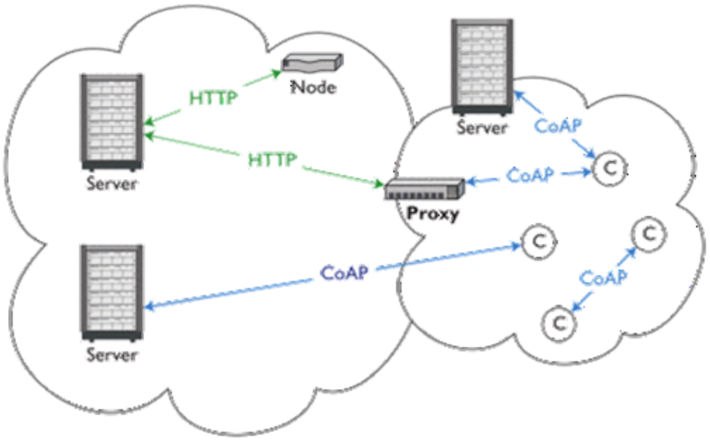
- Networking alone is not enough. Ping does not make for a business use case.
- We usually use UDP and TCP for web applications
  - TCP is the most reliable transport protocol designed for Internet but…
  - The cost is too high: packet sizes and implementation on the ROM, socket context to maintain and control plain to not tear down tcp sessions (keep alive), retransmission/congestion avoidance
  - UDP is unreliable, but comes with a lower cost. It is unfit for emergency-like applications.
    - Needs optimizations and little tweaking…
- Without modifications to TCP/IP, we need a gateway in our deployment to handle these protocols
  - This is an aggregation scenario.

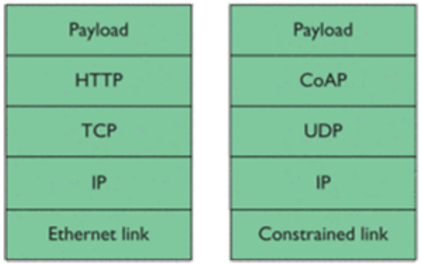


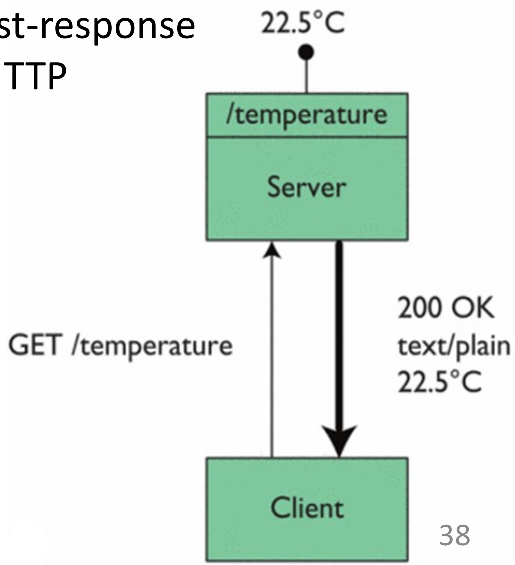
From https://www.eurotech.com/en/

Constrained Application Protocol (CoAP)

- CoAP is a transfer protocol for constrained nodes and networks
- Based on UDP, CoAP is less complex.
- Based on older and heavier HTTP, CoAP uses the REST architectural style.
  - Clients access server-controlled resources in a synchronous request-response fashion using methods such as GET, PUT, POST, and DELETE overs HTTP

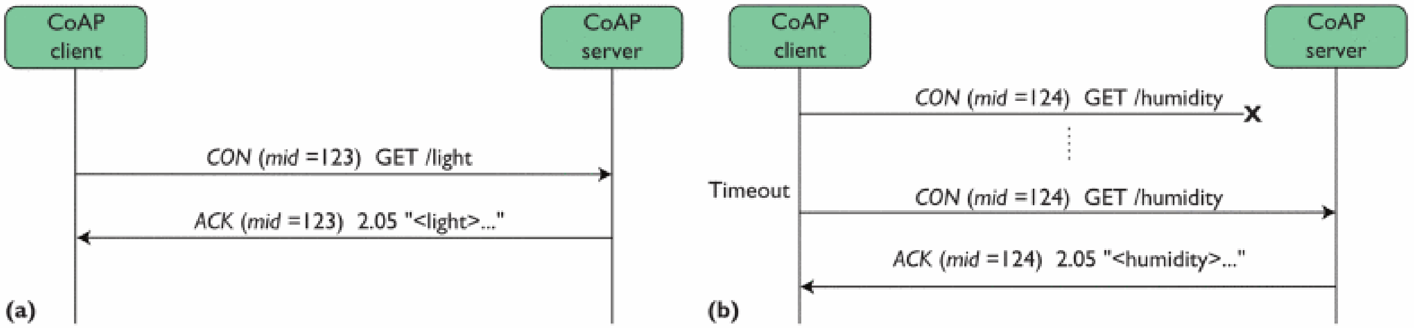






Constrained Application Protocol (CoAP)

- A central element of CoAP's reduced complexity is that, instead of TCP, it uses UDP and defines a very simple “message layer” for retransmitting lost packets
- On top of CoAP's message layer, CoAP defines the familiar four request methods, GET, PUT, POST, and DELETE. Similarly, response codes are patterned after the HTTP response codes (as in the familiar “404 not found”), but encoded in a single byte (“4.04” standing for 4∗32+04)



- CoAP implements “Observe” pattern that allows the Server to initiate a communication to a Device, it the Device has subscribed to a topic of interest by putting “observe” option in a “GET” message

Message Queuing Telemetry Transport (MQTT)

- MQTT is transfer protocol ISO/IEC PRF 20922 standard that works over TCP/IP
- Implements a publish/subscribe messaging pattern and requires a broker (event-based)
  - Publishers send messages classified in topics, to subscribers
  - Subscribers express interest in one or more topic (class of messages)
  - Subscribers and Publishers do not need to communicate directly thanks to brokers (middleware)
  - This pattern provides greater scalability and dynamic network topology
- Basic messages: Connect, Disconnect, Publish
- Clients are connected to a message broker, subscribe to a topic, from which messages are received or published to.
  - If subscribed to topics *floor1/room0/device0/temperature*, the client can access to all the temperature data from device 0 in room 0, and all messages from modules in every room in the first floor, since it is also subscribed to *floor 1/#*

Summary

- What are the networking protocols to use for IoT ? Where are they implemented (device or elsewhere)?
- What are the differences between MQTT and CoAP ?
- Describe the publish/subscribe model and its uses

MQTT vs CoAP

- MQTT is a many-to-many communication protocol passing messages through a broker.
- Decouples producer and consumer by letting clients publish and having the broker decide where to route and copy messages.
- While MQTT has some support for persistence, it does best as a communications bus for live data.
- MQTT clients make a long-lived outgoing TCP connection to a broker
- No metadata on messages

- CoAP is a one-to-one protocol for transferring state information between client and server.
- While it has support for observing resources, CoAP is best suited to a state transfer model, not purely event based.
- CoAP clients and servers both send and receive UDP packets
- CoAP has support for content negotiation and discovery

Summary

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Summary

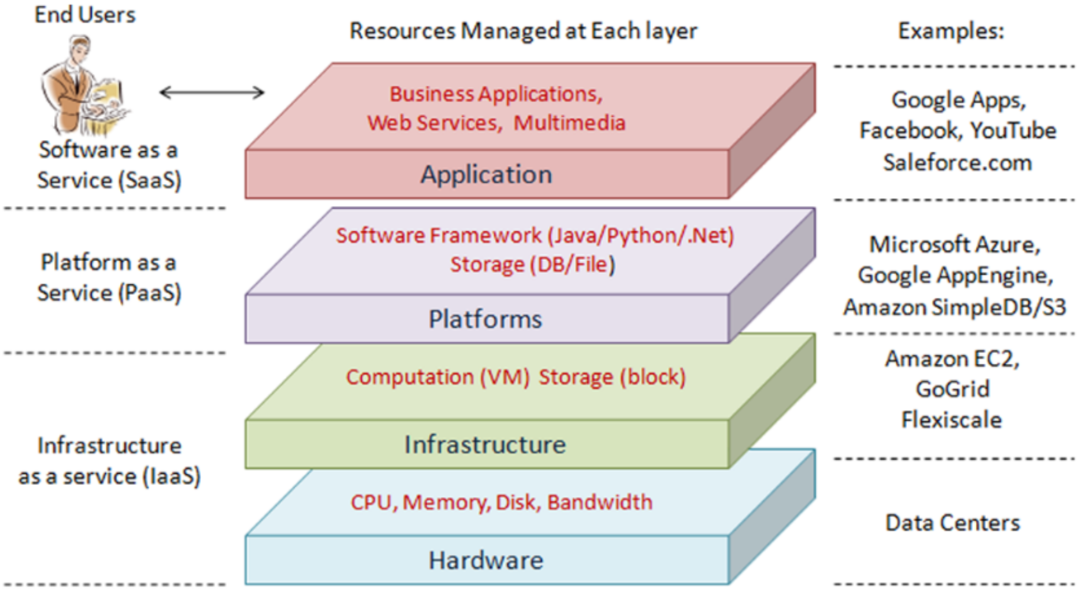
- **Definitions**
  - IoT and its different use cases
- **Transmission (OSI 1 and 2)**
  - Long range (Cellular, LoRa and SigFox)
  - Short range (Bluetooth, ZigBee, Z-Wave)
- **Networking (OSI 3 and 4)**
  - IP, IPv6
  - MQTT, CoAP
- **Application (OSI 5 to 7)**
  - Operating systems and embedded applications
  - Clouds of IoT for developers and data miners

Operating systems

- Internet of things is very broad and means different things for different people
  - There is no dominant operating system that supports all devices
- Interesting alternatives to proprietary solutions:
  - FreeRTOS
    - De-facto standard solution for microcontrollers and microprocessors
    - Reliable and feature rich. Can be combined with lwIP for connectivity.
    - The kernel is between 6K-12k bytes
  - Contiki
    - Also for microcontrollers and open source
    - Supports IPv6, 6LOWPAN, RPL, CoAP and more
    - Comes with a network simulator: Cooja.
  - Yocto
    - Not an operating system. It helps you build one.
    - A set of tools to create custom Embedded Linux distributions with Embedded GNU libc (EGLIBC)
    - You can also run the generated images with QEMU

Cloud solutions for IoT

- **Types of services**
  - Infrastructure as a Service (IaaS)
  - Platform as a Service (PaaS)
  - Software as a Service (SaaS)
- **Types of Cloud deployments**
  - Public clouds
  - Hybrid clouds
  - Private clouds
- **General common characteristics**
  - Multi-tenancy and shared pool of resources
  - Geo-distributed and ubiquitous network access
  - Dynamic resource provisioning
  - Pay-per-use pricing model

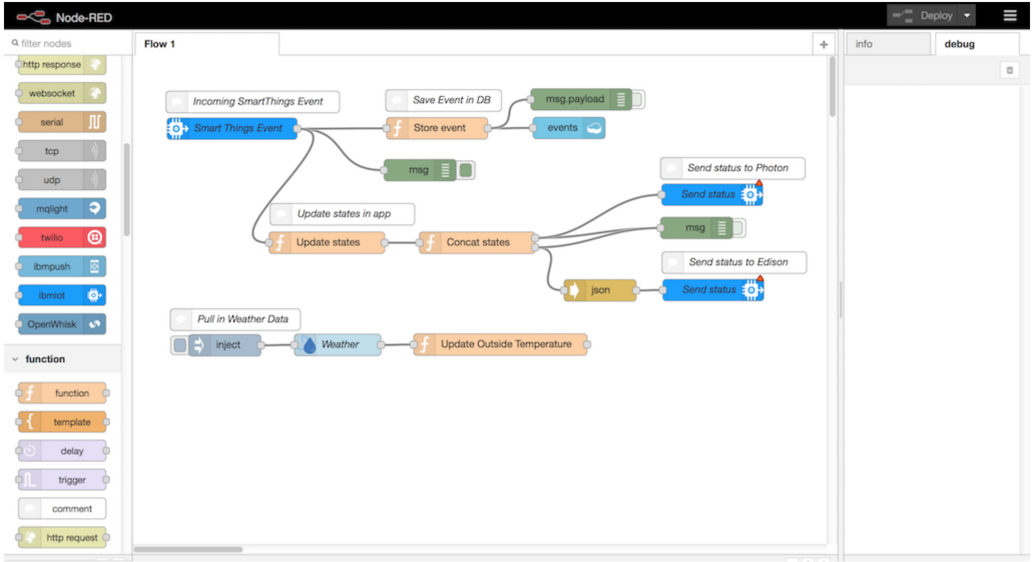


Cloud solutions for IoT

- Major cloud providers (AWS, Azure, GCP, IBM Bluemix) all propose an IoT declination of their cloud platforms
  - They handle sensing requests from different customers and manage the relevant data processing and transfer.
  - Pricing at AWS: $0.20 per GB of data processed, $0.03 per GB of processed data stored per month, $6.50 per TB of data scanned (sql queries)
- Services offered:
  - IoT management, analytics, security…
- Interesting challenges
  - Keep data consistent in applications while the IoT are rarely connected
  - Support the Over The Air firmware upgrade by providing avatar versions of the IoT device/OS

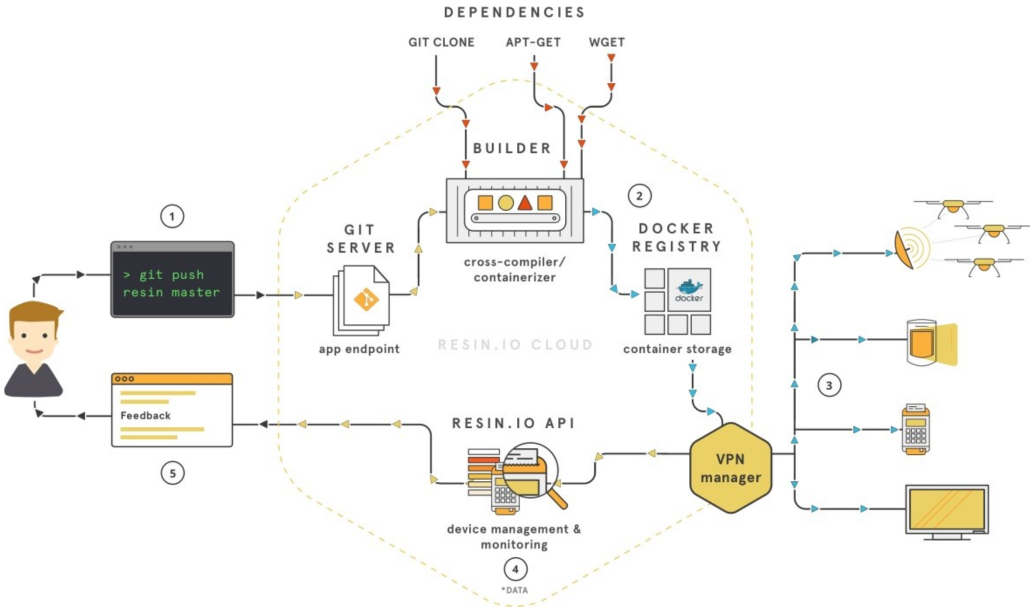
Cloud solutions for IoT

- Node-Red: Flow-based programming for the Internet of Things, proposed by IBM, supported by IBM Bluemix cloud but an opensource project
  - Also supported by Azure and AWS IoT
- Allows you to create on the fly applications through the design studio (IDE) and instantly deploy them in the cloud or locally (e.g. RPi)



Cloud solutions for IoT

- RESIN: A cloud for IoT with a focus on reproducibility
- Basically handles software updates like git for source
- Uses Yocto project for different images:
  - Rpis, Beaglebone, odroid…
  - Uses the avatar approach for updates



Summary

- What kind of applications can be implemented through cloud IoT ?
- What kind of protocols are used ?

Conclusion

- Internet of Things is a broad topic that can be addressed from different perspectives
  - Transmission:
    - Cellular vs ISM band (lora and sigfox)
    - Challenges are number of connected devices, energy efficient protocols, and scalable core networks
  - Networking:
    - Addressing and routing in particular
    - Choosing between MQTT, CoAP, HTTP and other protocols should be thought of after deciding the application
  - Application:
    - You cannot not implement the same applications in phones and constrained devices: not the same operating system or capabilities
    - Cloudification of IoT is a hot topic. Every major cloud provider has an offer to manage devices and monitor metrics
    - Pricing can be thought of for different aspects: processing, storing, querying…