Connected objects,
IoT, M2M, architecture, protocols, ...

Frédéric Camps - LAAS/CNRS
fcamps@laas.fr

Agenda

IoT Definition

The internet of things (IoT) is the network of physical devices, vehicles, buildings and other items embedded with electronics, software, sensor, actuators, and network connectivity that enable these objects to collect and exchange data.

- Mobile devices
- Smart meters and objects
- Wearable devices including clothing, health care implants, smartwatches, and fitness devices
- Internet-connected automobiles
- Home automation systems, including thermostats, lighting, and home security
- Other measuring sensors for weather, traffic, ocean tides, road signals, and more

Part I

IoT Definition

Statistical data

Cyberdependance

IoT Market

IoT and market segmentation

Global architecture

IoT Architecture

System Architecture

Statistical data

Intérêt de l'IoT

- Les Français se montrent très familiers avec le principe des objets connectés : près de 6 Français sur 10 (57%) déclarent savoir précisément ce dont il s'agit.

- Les plus au fait sont les populations les plus jeunes (76% des moins de 25 ans déclarent savoir exactement ce que c'est), les CSP+ (66 %) et les hommes (63 %) . Seuls 3% des Français n'ont jamais entendu parler des objets connectés.

CSP+: catégories socio-professionnelles favorisées - https://fr.wikipedia.org/wiki/CSP%2B

Sondage IFOP du 1er décembre 2015 N°37742

# Equipement en objets connectés
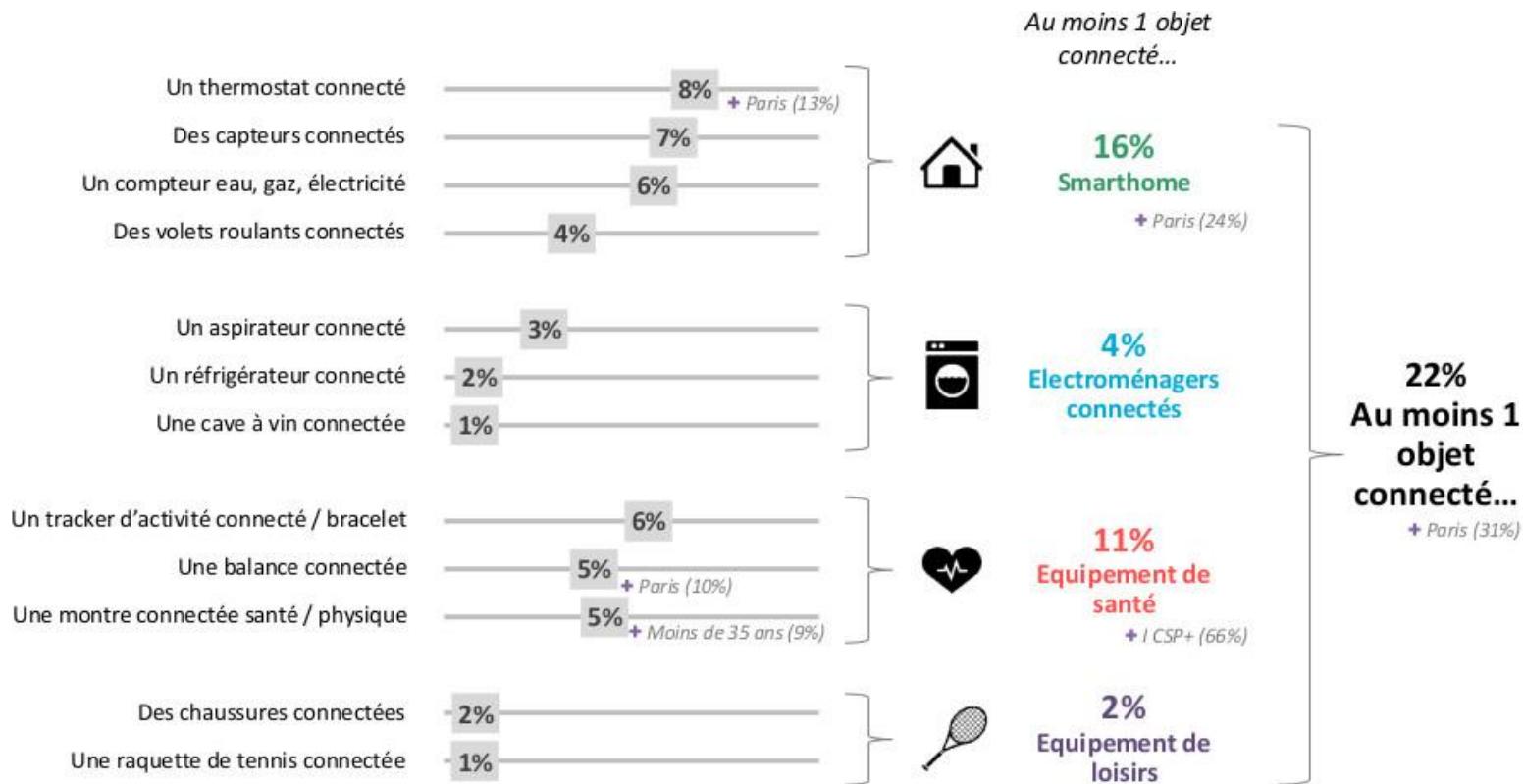
Sondage IFOP du 1er décembre 2015 N°37742

Intention d'achat d'un objet connecté
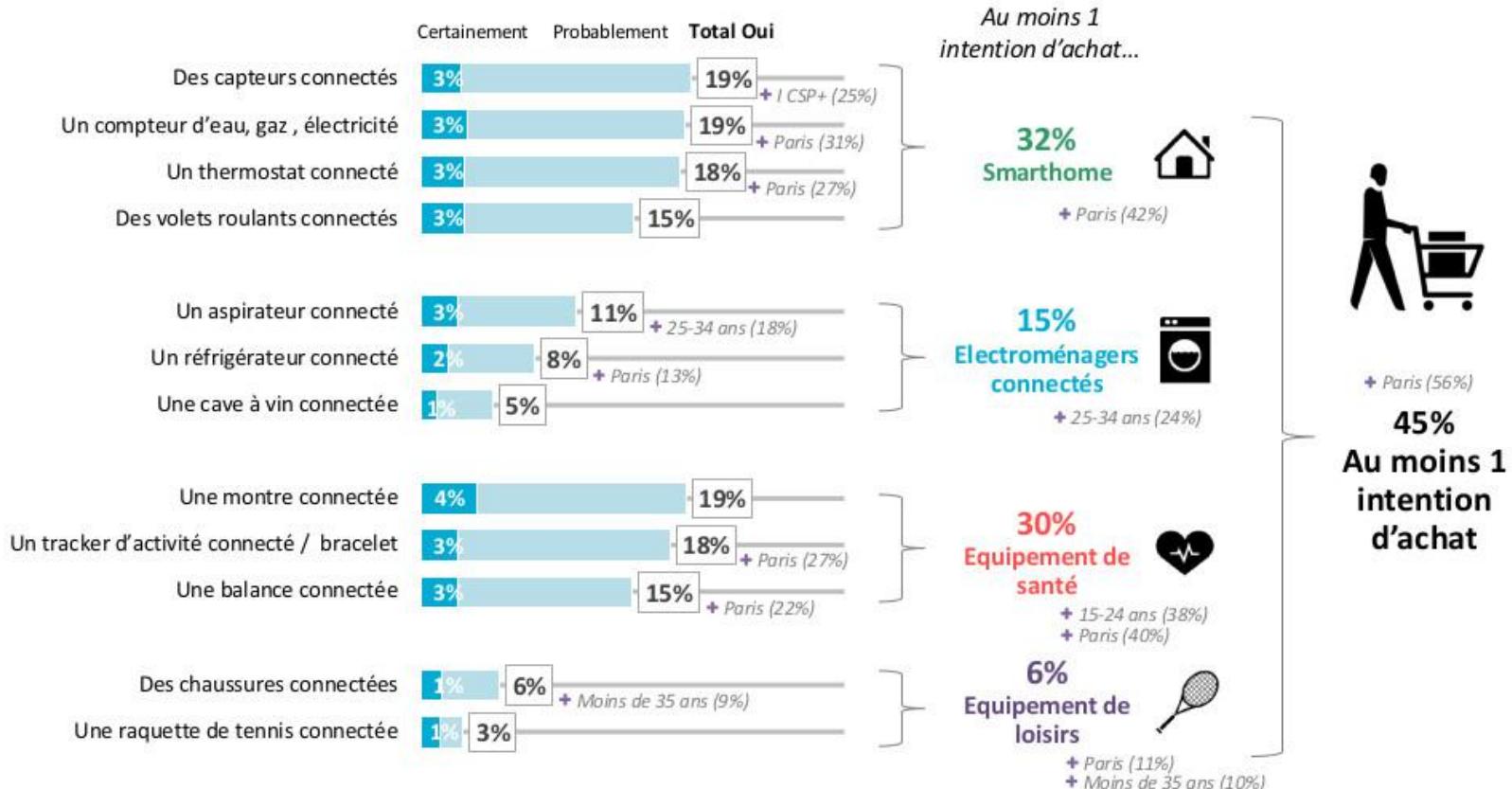
Statistical data

Intention d'achat

FRANCE	ÉTATS-UNIS	CORÉE DU SUD
50%	**58%**	**79%**

Sondage IFOP du 1er décembre 2015 N°37742

Opinions concernant les objets connectés

	Tout à fait	Plutôt	Total D'accord

Les objets connectés sont intéressants dans le cas de pratiques sportives, pour **aider à se motiver**
14% | 73%
+ 15-24 ans (83% / 26% tout à fait)

Avec les informations des objets connectés dans la santé / bien-être, on a **des choses à dire sur les réseaux sociaux**, comme montrer ses performances
4% | 32%
+ 15-24 ans (44%)
+ Moins de 35 ans (42%) / + I CSP- (39%)
+ Autres inactifs (40%) / + Paris (40%)

Les objets connectés sont **indispensables** pour **mieux connaître son corps** et **son état de santé**
4% | 31%

Les objets connectés sont **inutiles**, car mesurer son activité **ne signifie pas qu'on améliore sa santé**
17% | 58%

Les objets connectés **me font peur**, je ne veux pas qu'on **accède à des données me concernant**
14% | 50%
+ 35-49 ans (57%)
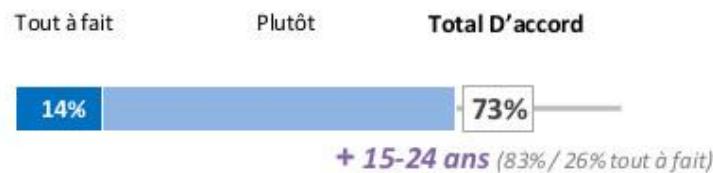
Statistical data

Cabinet GfK / Cabinet XERFI

Dynamique du marché

Cabinet GfK:

En 2015, leurs ventes auraient atteint 700 000 unités soit 120 millions d'euros.

Près de **2 milliards d'objets connectés** pourraient se vendre entre **2015 et 2020** : chaque foyer posséderait alors en moyenne 30 objets connectés.

Cabinet XERFI

Une progression régulière des dépenses qui pourraient atteindre **500 millions d'euros en 2016**.

Statistical data

Les freins à l'achat

- Parmi les individus qui ne prévoient pas d'acquérir un objet connecté, les freins sont le prix (59%), le manque d'utilité (45%), les risques liés à l'utilisation des données personnes (15%) (Source : Ifop).

- Les intentions d'achat resteraient cependant modestes, freinées par les craintes liées à:
  - la sécurité des données personnelles (68%),
  - le risque de dépendance (65%),
  - le prix (63%). (Source : Harris Interactive).

Statistical data

Impression sur la sécurité

- Le fait que les objets connectés produisent de la data est un principe plutôt clair dans les esprits (seuls 10 % des Français n'en avaient pas du tout conscience).

- Les Français semblent porter un regard inquiet sur les risques qui y sont associés : la moitié d'entre eux se dit effrayée par le risque de fuite des données personnelles, et les deux tiers (68 %) considèrent que les données sont mal protégées .

- Ce sentiment est largement partagé dans la population française, y compris auprès des "early adopters" , déjà équipés d'un ou plusieurs objets connectés.

Statistical data

Utilisation des données produites

- Les français ont en outre un **t**rès large doute sur le devenir des données produites et sur leur possesseur.

- Seul un quart des Français pense que les données appartiennent à son émetteur (18 % les attribuent à l'OS du smartphone, et 39 % ne savent pas).

- Les avis sont très partagés sur la possibilité de vendre les données produites par les objets connectés à des fins commerciales

- Seuls 16 % des Français se disent prêts à partager leurs données, mais à condition d'en tirer un avantage (assurance …).

Statistical data

Recherche sur mot clés "Internet des objets" sur 2016
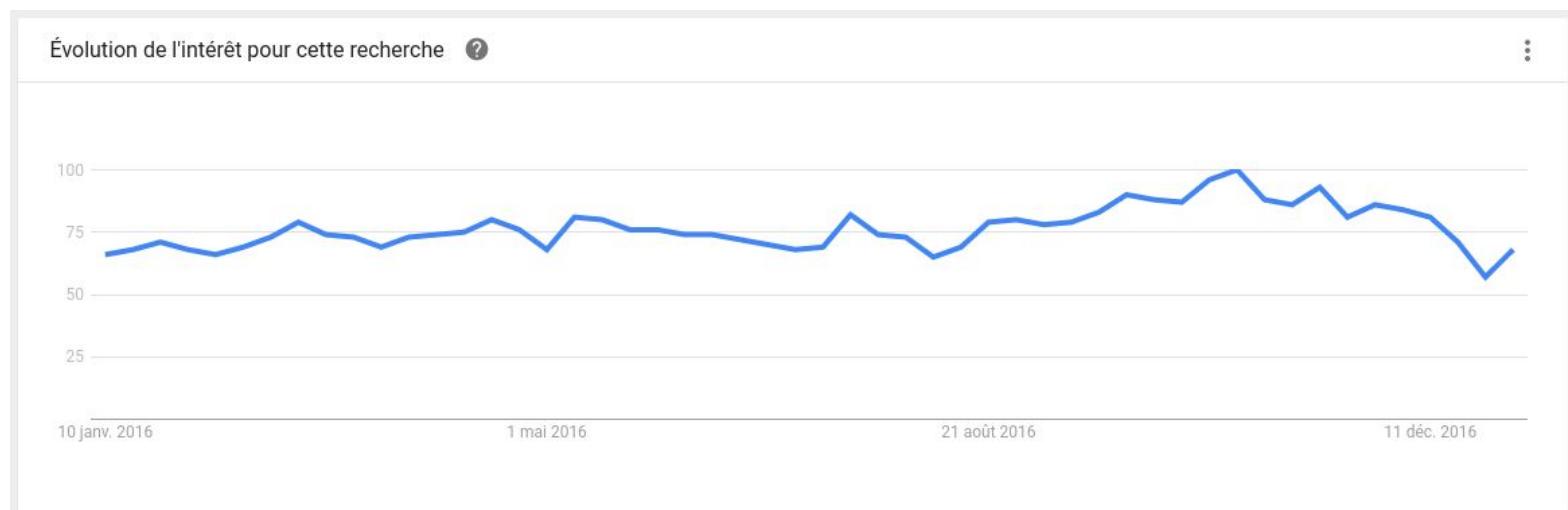
Corée du Sud (100)
Taïwan (64)
Singapour (60)
Japon Inde (52) …
France (11)

Statistical data

Pour résumer 1/2

- Un secteur en croissance,

- L'IoT est connu du public: plus de la moitié de la population connaît bien, (public plutôt jeune et CSP+),

- Des inquiétudes pour la sécurité d'utilisation,

Statistical data

Sondage IFOP du 1er décembre 2015 N°37742

Pour résumer 2/2

- Des questionnements sur l'utilisation des données,

- L'utilité est un facteur essentiel, phénomène de "gadgetisation",

- Le prix reste un facteur de blocage non négligeable,

- Le manque d'interopérabilité est un frein important.

Part I

IoT Definition

Statistical data

Cyberdependance

IoT Market

Global architecture

IoT Architecture

System Architecture

Cyberdependance

Symptômes physiologiques (Nayebi, 2007)

- Syndrome du canal carpien,

- Sécheresse des yeux,

- Négligence de l'hygiène personnelle,

- Alimentation irrégulière, repas sautés et de mauvaise qualité,

- Insomnies ou modifications dans le cycle du sommeil.

Cyberdependance

Symptômes psychologiques (Nayebi, 2007; Young, 2004)

- Sentiment de bien-être, soulagement ou euphorie pendant l'utilisation d'Internet et/ou objets connectés,

- Sentiment de vide, dépression, anxiété, irritabilité hors ligne ou quand l'accès à Internet ou au objets connectés est impossible,

- Sentiment de culpabilité ou honte face à l'utilisation d'Internet,

- Incapacité à cesser ou à diminuer l'usage d'Internet ou besoin d'augmenter le temps de connexion.

Cyberdependance

Symptômes psychologiques (Nayebi, 2007; Young, 2004)

- Diminution de l'intérêt ou du temps consacré aux autres activités «hors ligne,

- Altération du niveau de fonctionnement (difficultés relationnelles (familiales, amoureuses, professionnelles, etc.), pertes d'emploi, isolement social, etc.),

- Mensonges à propos de l'utilisation d'Internet (durée, activités en ligne, etc.)

Part I

IoT Definition
Statistical data
Cyberdependance
IoT Market
Global architecture
IoT Architecture
System Architecture

IoT Market
Market segmentation
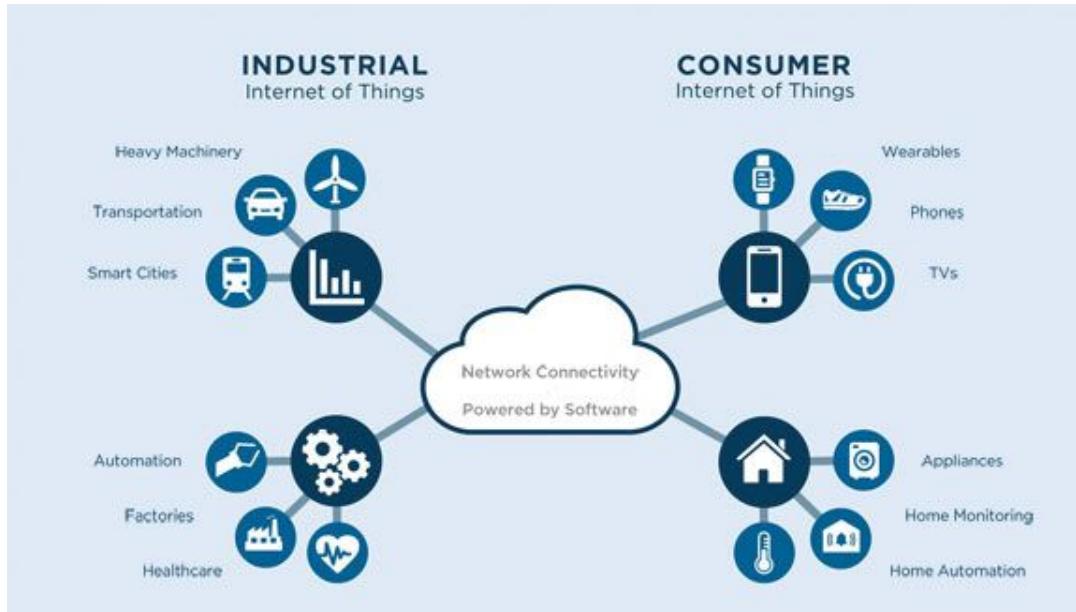
A market strongly oriented to software that plays a vital role.

IoT Market
Market segmentation

Le marché est segmenté avec des IoT aux propriétés très diverses:

- Des produits différents (industriel, consommateur …),

- Une mise en oeuvre plus ou moins complexe,

- Un niveau d'intégration très différent (embarqué réduit ou pas),

- Des niveaux de fiabilité important ou inexistant,

- Des systèmes de communication plus ou moins élaborés,

- Des infrastructures à très grande échelle ou une architecture Ad hoc ...

IoT Market

Market segmentation
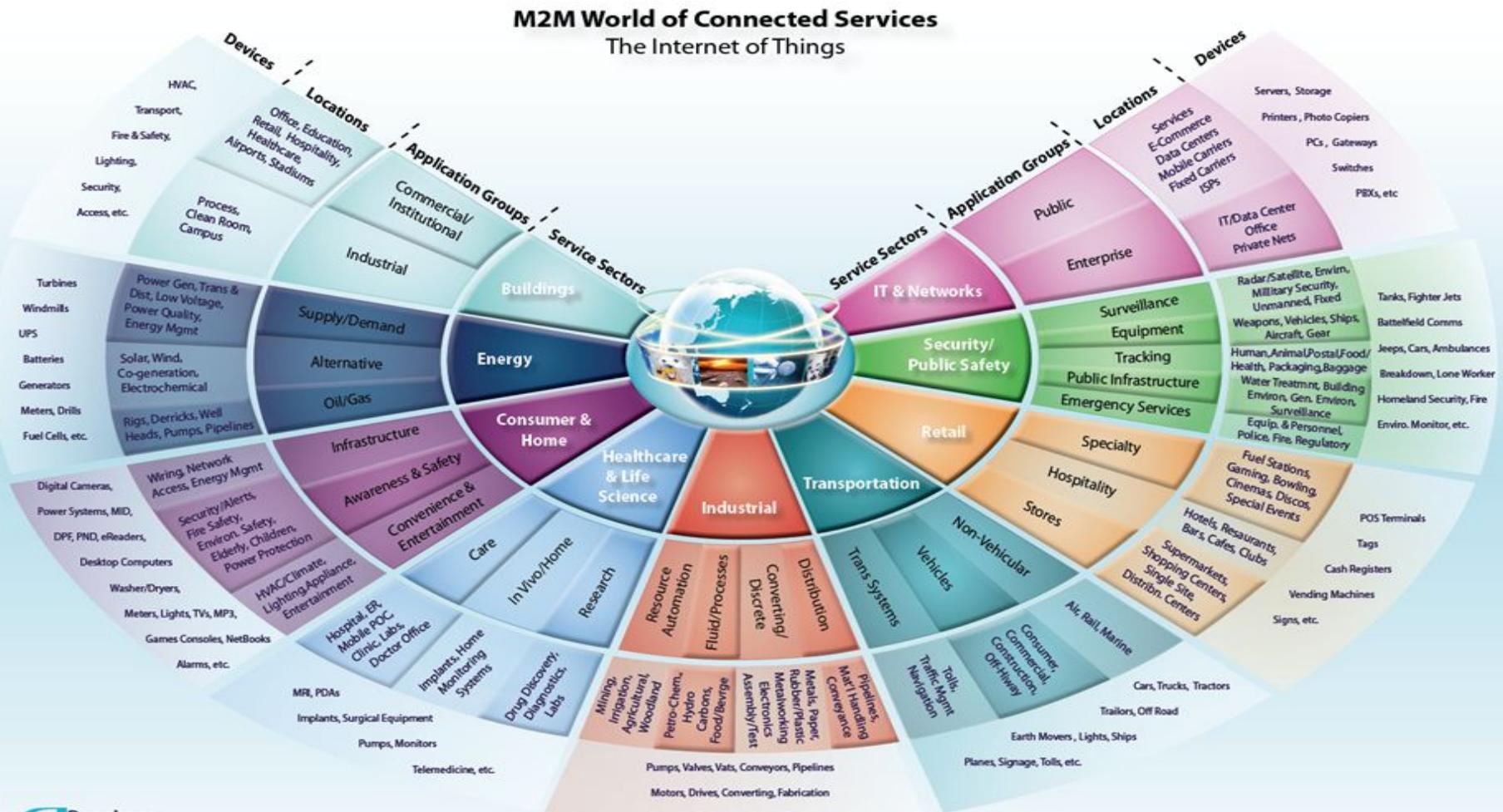
IoT Market

Market segmentation: transport
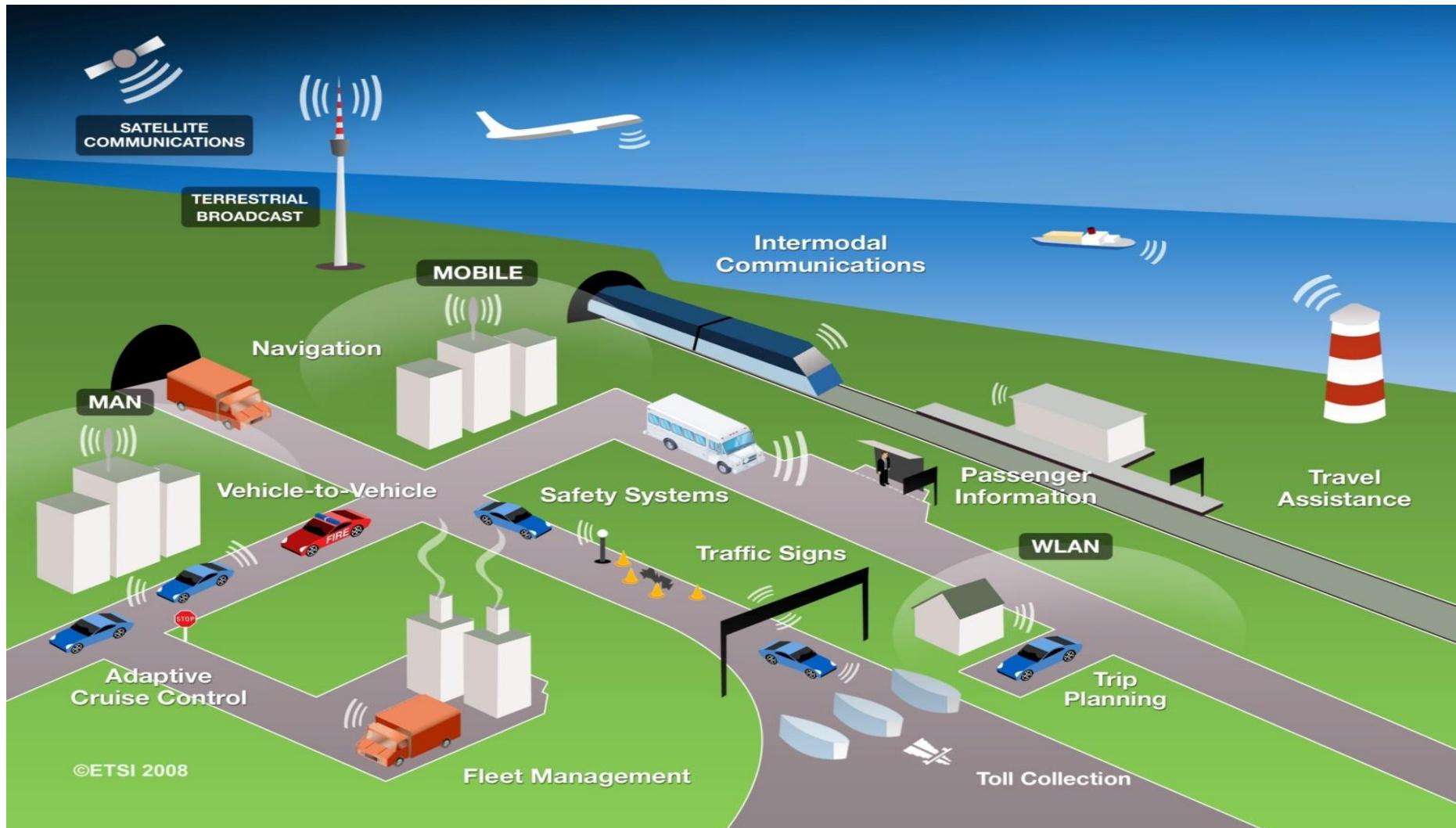
IoT Market

Market segmentation : Smart meter

Wind Turbine

Solar Panel

Light

Appliances

Temperature

Breaker

Valves

Smart Water

Smart Gas

Smart Elec.

Home displays TV, Computer

In-Home Energy Display

Meters Coms

Gateway

Wan Communication

Data Center
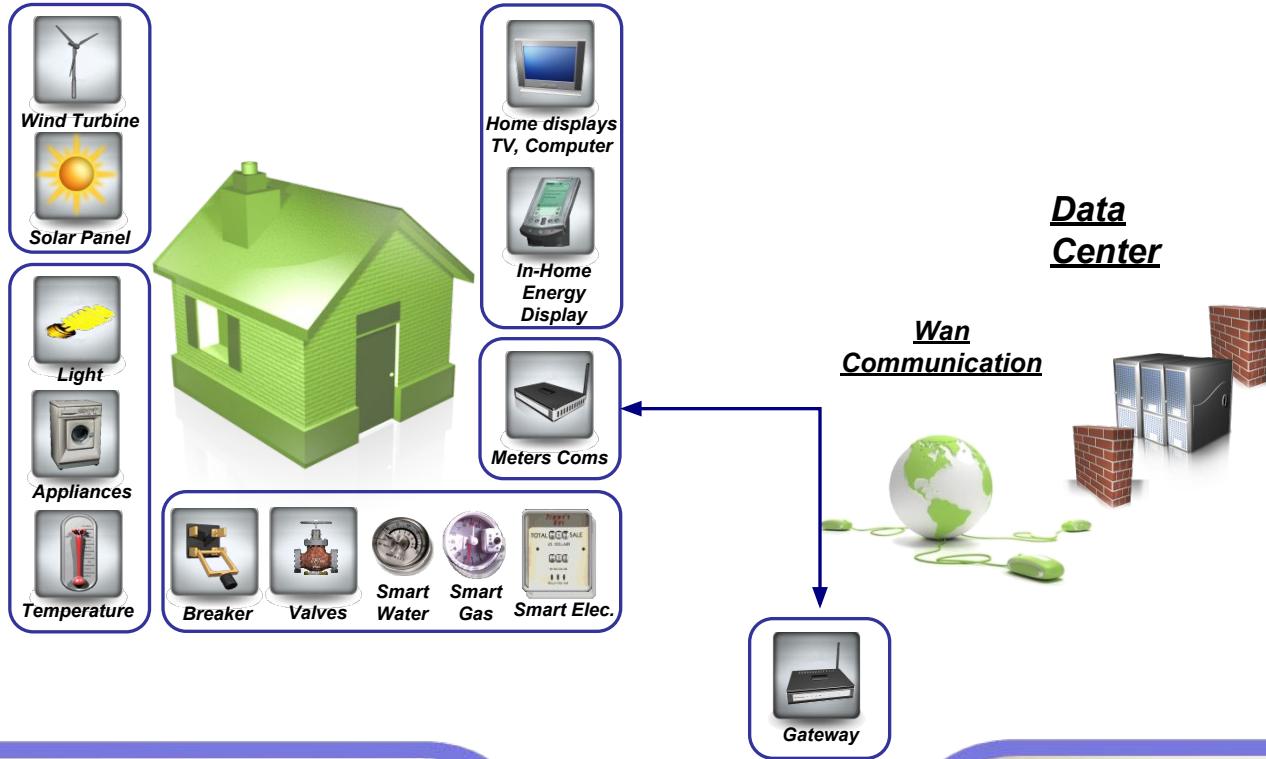
•**Consumption info**
•**Fault details**
•**Threshold management**

•**Remote Meter reading**
•**Consumption management**
•**Pricing info**

IoT Market
Market segmentation : e-Health

Disease management

Ageing independently

Personal fitness

Scheduling appointments

Lifestyle and dietary advice

Remote monitoring

Health Check

On-line health records

Part I

IoT Definition

Statistical data

Cyberdependance

IoT Market

Global architecture

IoT Architecture

System Architecture

# System Architecture
Global architecture - Cyber-Physical Systems

1- **Configuration**: A machine able to track its own health can detect failures early on and send health monitoring information to the operation level.

2- **Cognition**: In cognition level, the machine itself should take advantage of online monitoring to diagnose its own potential failures and become aware.

3- **Cyber**: This level acts as the hub for information and performs complex analytics.

4- **Conversion**: This level converts data to information using algorithms that are based on the application.

5- **Connection**: In the connection level, the data generated by connected machines.

THE 5C ARCHITECTURE FOR CYBER-PHYSICAL SYSTEMS

CPS FUNCTIONS & ATTRIBUTES

1 — CONFIGURATION LEVEL
SELF-CONFIGURE FOR RESILIENCE
SELF-ADJUST FOR VARIATION
SELF-OPTIMIZE FOR DISTURBANCE

2 — COGNITION LEVEL
INTEGRATED SIMULATION & SYNTHESIS
REMOTE VISUALIZATION FOR HUMAN INTERACTION
COLLABORATIVE DIAGNOSTICS & DECISION MAKING

3 — CYBER LEVEL
TWIN MODEL FOR COMPONENTS & MACHINES
TIME MACHINE FOR VARIATION IDENTIFICATION & MEMORY
CLUSTERING FOR SIMILARITY IN DATA MINING

4 — DATA TO INFORMATION LEVEL
SMART ANALYTICS FOR MACHINE HEALTH
MULTI-DIMENSIONAL DATA CORRELATION
DEGRADATION & PERFORMANCE PREDICTION

5 — SMART CONNECTION LEVEL
PLUG & PLAY FUNCTIONALITY
TETHER-FREE COMMUNICATION
SENSOR NETWORK

M2M architecture, IoT, network sensor.
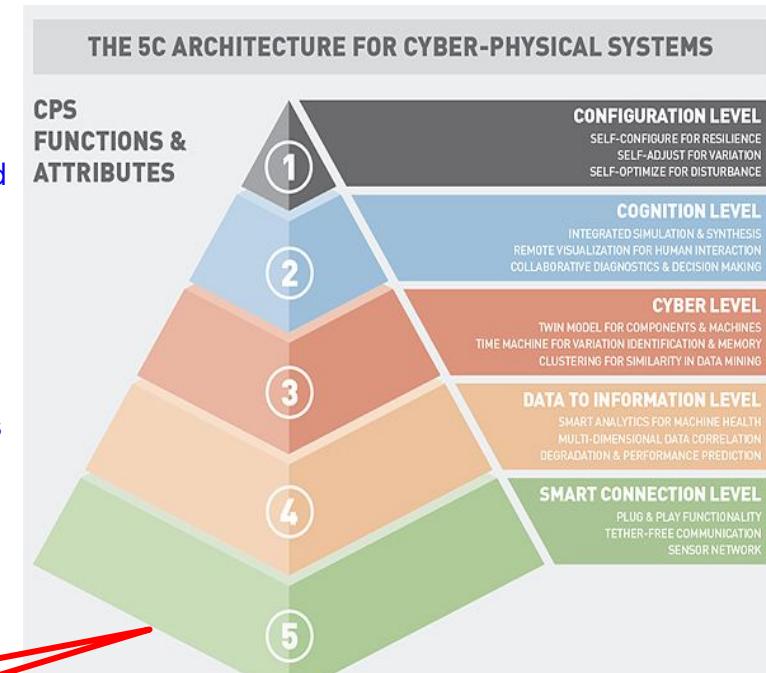
Part I

IoT Definition

Statistical data

Cyberdependance

IoT Market

Global architecture

IoT Architecture

System Architecture

IoT Architecture
Abstract Architecture Model

Communication	
Agent	
Controler	
Actuator	Sensor
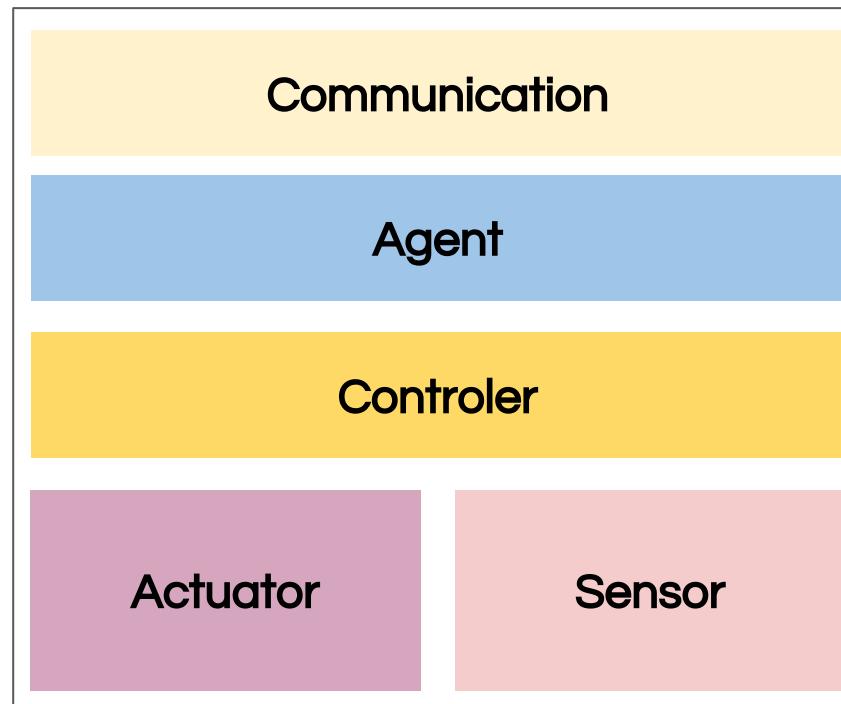
An IoT "Thing" anatomy

IoT Architecture
Abstract Architecture Model

Communication
Agent
Controler

| Actuator	Sensor

Communication layer

- Short-haul media: Wifi, Bluetooth, NFC ...

- Long-haul media: wired Ethernet, 3G, 4G, LoRa, SigFox, NB-IoT...

- Protocol: TCP/UDP/IP, HTTP, CoAP (Constrained Application Protocol) ...

IoT Architecture
Abstract Architecture Model

Communication
Agent
Controler

Actuator	Sensor
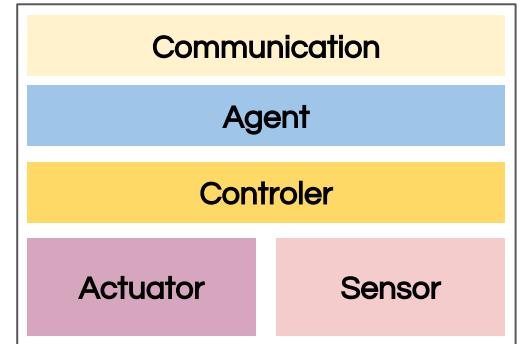
Agent

Agent is an embedded program that :

- Runs on the IoT device,
- Reports the status of an asset or environment,
- Acts as a bridge between the controller and the cloud,
- Deciding what data to send and when to send it…
- Intelligent Algorithms are located in Agent.

IoT Architecture
Abstract Architecture Model

Communication	
Agent	
Controler	
Actuator	Sensor
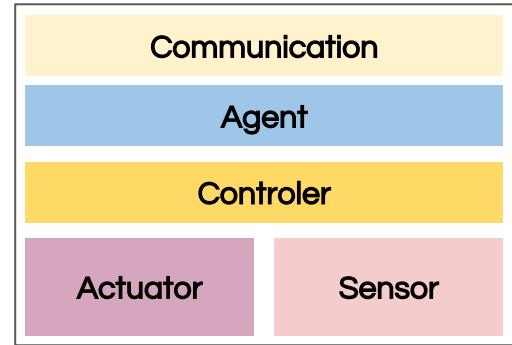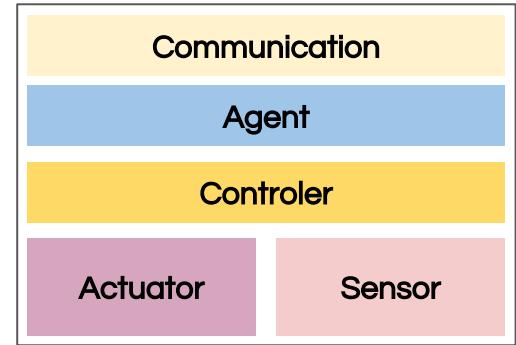
## Controler

A hardware or software component that interacts electrically or logically with sensors and actuators.

For example, a *controler* may be a simple circuit that reads an analog signal from a temperature sensor and digitizes the signal into discrete transmissions.

IoT Architecture
Abstract Architecture Model

| Communication	
Agent	
Controler	
Actuator	Sensor
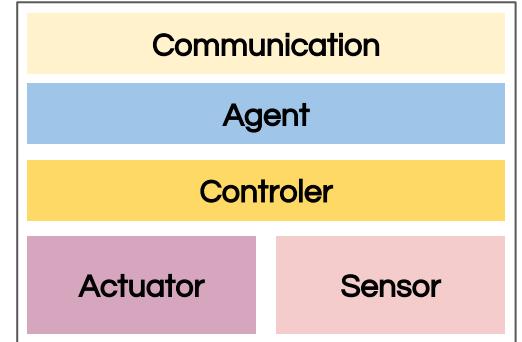
Sensors

-   Sensors read and report on the real-world status of connected products, machines, and local environments.

-   They are the eyes and ears of the system, monitoring environmental elements like:
    -   Temperature sensors,
    -   Light sensors,
    -   Moisture sensors,
    -   GPS receivers,
    -   Vehicle on-board diagnostics,
    -   Files,
    -   Product-specific data,
    -   Inertial sensor,
    -   **New!** composite sensor on Android ...

IoT Architecture
Abstract Architecture Model

Communication
Agent
Controler

| Actuator	Sensor
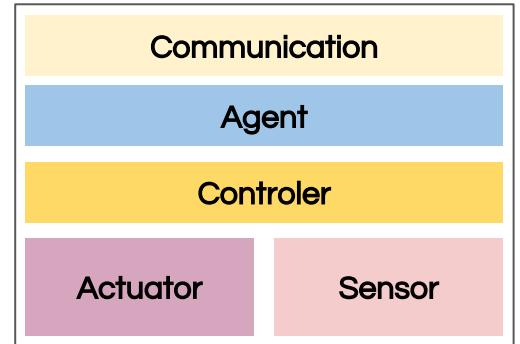
Actuators

- Actuators affect the electromechanical or logical state of a product or environment.

- They are the system's hands and feet:
    - Lights
    - Valves
    - Motors
    - Commands ("soft" actions, file distribution, firmware updates) …

IoT Architecture
Abstract Architecture Model

Composite Structure
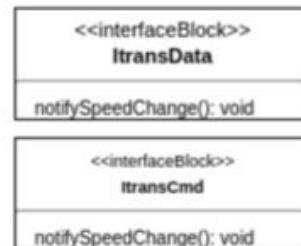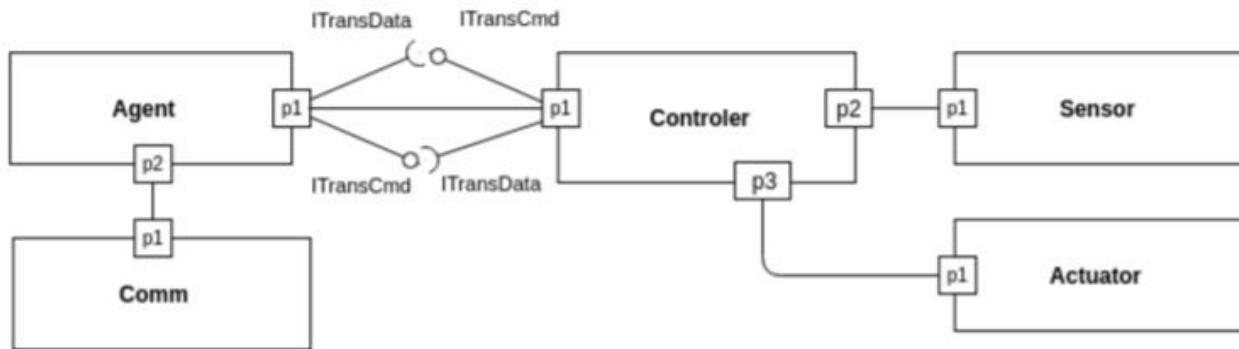
IoT Architecture
Design Pattern

Design Pattern (software + hardware)

- Solve design problems commonly encountered,

- Best practices and standards,

- Design Patterns are building blocks of architecture,

- Build an end to end solution in well specified ways,

- Provide an understanding of the use of different components of the system in a system context.

Design Pattern standard (GoF...)

| Patterns de comportement	Patterns de création	Patterns de structure
- command, - interpreter, - iterator, - mediator, - memento, - observer, - state, - strategy, - visitor.	- abstract factory, - builder, - factory method, - prototype, - singleton.	- adapter, - bridge, - composite, - decorator, - façade, - flyweight, - proxy.

IoT Architecture
Design Pattern

Example: Design Pattern standard (GoF) / Strategy

The Strategy pattern can be implemented in the context of a range of products where identical functionality is found but in a different execution context.
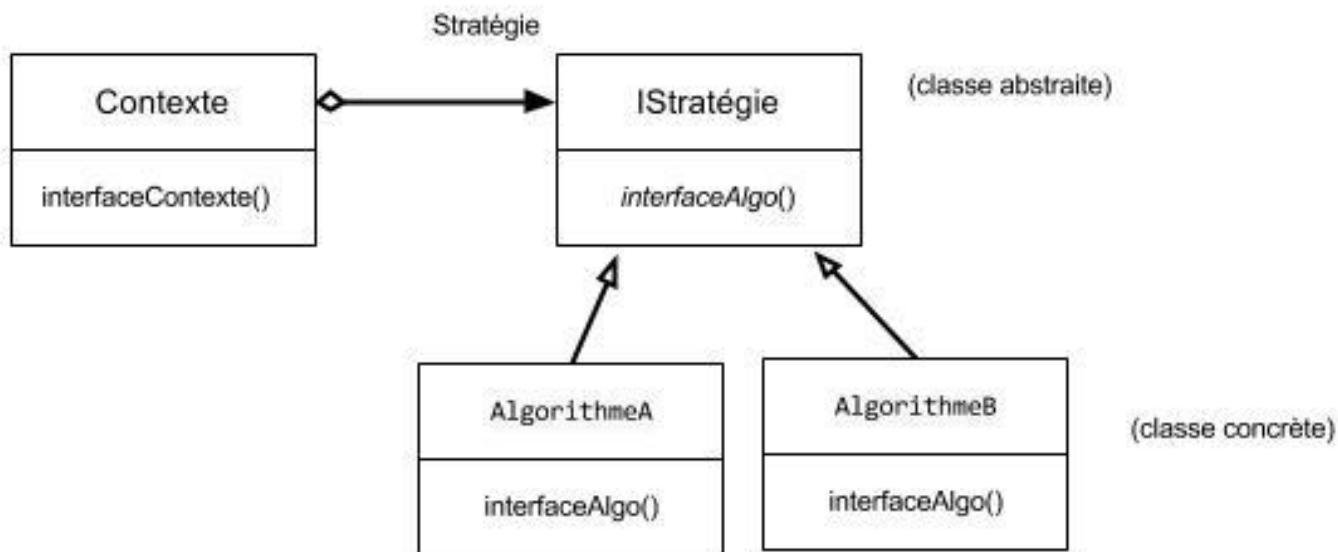
IoT Architecture
Design Pattern

Virtualization through middleware:

- Allows many applications to interact with things.

- Middleware can cache the state of the thing and minimize network traffic and power drain ...
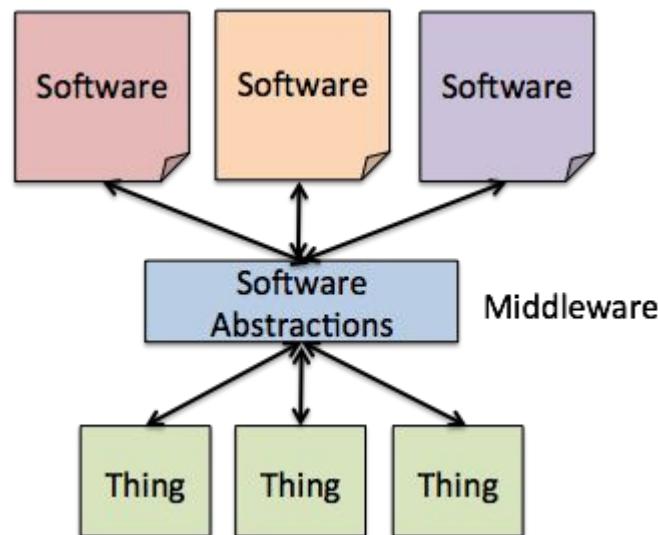
IoT Architecture
Design Pattern

Design patterns for IoT / Use Case:

- Devices talk to other devices peer-to-peer: local network connectivity enables proximal ad-hoc networking, service federation and chaining, media stream continuity.

- Personal tracking device uses smartphone as gateway: common pattern for bluetooth and WiFi connectivity.

- Smarthome local application controller and gateway: application gateway pattern ...

IoT Architecture
Design Pattern

Design patterns for IoT:

For information models
- *Structured data*: XML documents, JSON objects,
- *Web Objects*: multiple resources at a URI endpoint, object encapsulation ...

For Interaction
- *REST,*
- *Event-driven* architecture,
- *Asynchronous Events*: State updates propagate through the system as they occur,
- State Machine,
- State Externalization ...

Part I

IoT Definition

Statistical data

Cyberdependance

IoT Market

Global architecture

IoT Architecture

System Architecture

Architecture of vertical applications...

Business Application

Existing infrastructure

IoT Device

example

App Store

Wifi, Bluetooth
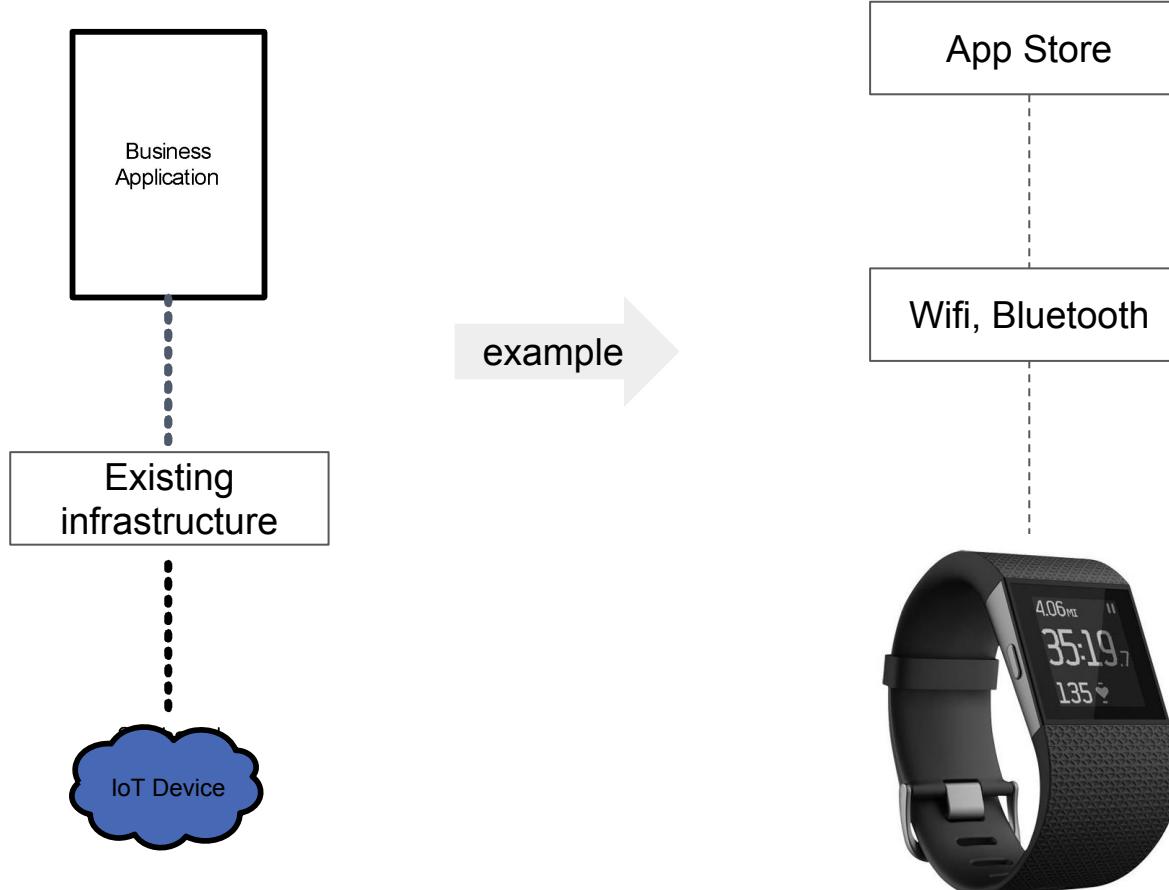
System Architecture
vertical applications

Vertical applications…
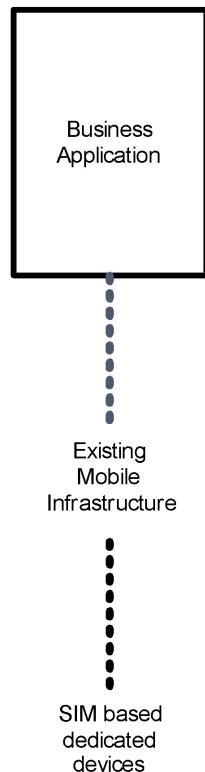
Applications don't share common infrastructure, environments and network elements

Business Application

example

Existing Mobile Infrastructure

SIM based dedicated devices

Business Application#1

Business Application#i

Business Application#N

IoT Device

IoT Device

IoT Device
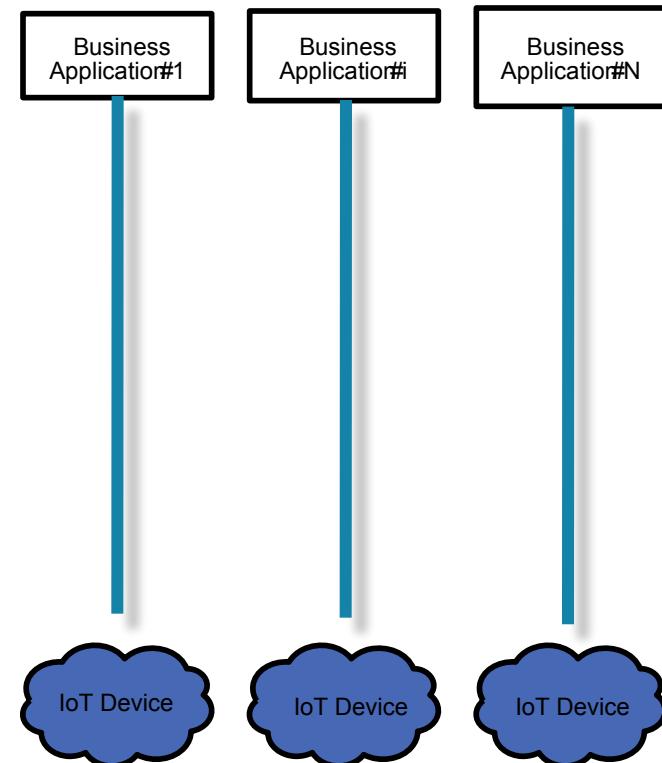
With permission of HP

System Architecture
vertical applications

Business Application
Application Infrastructure
Network Infrastructure

IoT Device
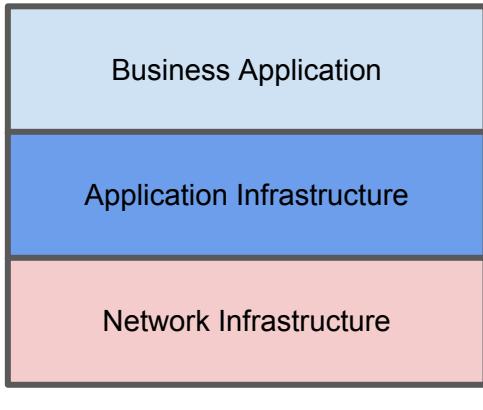
End-user application. It uses data from IoT systems. It also uses data analysis systems.

Complex decision-making algorithms are often at this level for the following reasons:
- Lack of computing capacity,
- The IoT can not have an overview ...
- The decision-making infrastructure is centralized,
- Energy consumption ...

System Architecture

vertical applications

Business Application

Application Infrastructure

Network Infrastructure

Infrastructure for applications (databases, web service, data processing ...).

IoT Device

System Architecture

vertical applications

Business Application

Application Infrastructure

Network Infrastructure

Physical interconnection (radio, wired ...), one uses several media with standard protocol IP, one calls this "IP unified".

IoT Device

System Architecture
vertical applications

Business Application
Application Infrastructure
Network Infrastructure

IoT Device

The IoT produces data and sends it to servers, local storage is possible. It also has actuators (ON / OFF system, PWM ...).

System Architecture
Horizontal applications

Pipe#1
1 Application,
1 Network
1 (or few) types of
Device

Pipe#2
1 Application,
1 Network
1 (or few) types of
Device

Pipe#N
1 Application,
1 Network
1 (or few) types of
Device

Horizontal (based on common Layer)
Applications share common infrastructure,
environments and network elements

Business Application

Business Application

Business Application

Business Application#1

Business Application#i

Business Application#N

Transport Network (mobile, fixed, Powerline ..)

Transport Network (mobile, fixed, Powerline ..)

Transport Network (mobile, fixed, Powerline ..)

Common Application Infrastructure

Transport Network 1

Transport Network 2

IP

Gateway

Gateway

Gateway

Gateway

Local NW

Local NW

Local NW

Local NW

Device

Device

Device

Device

Device

Device

Device

System Architecture

Trend in evolution of IoT
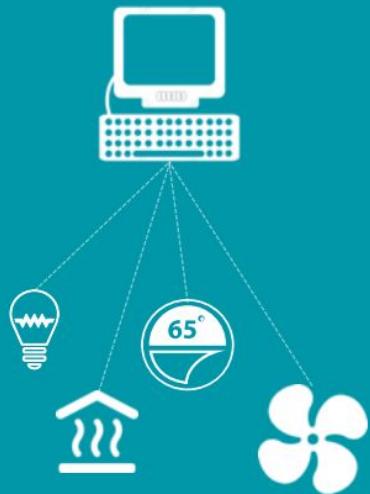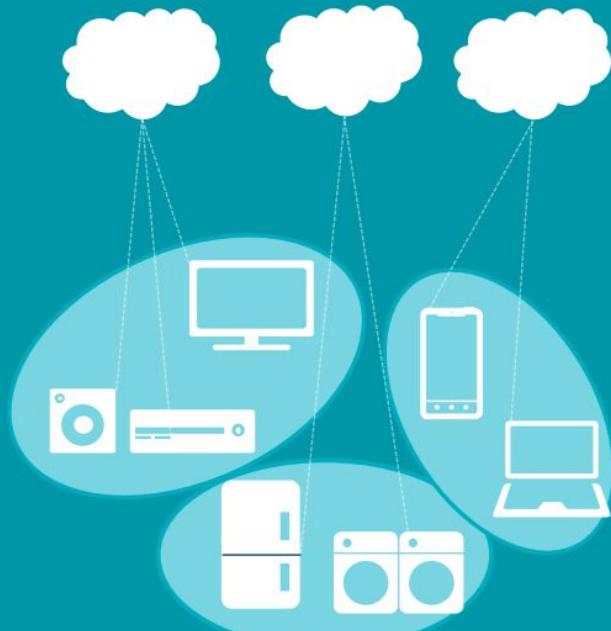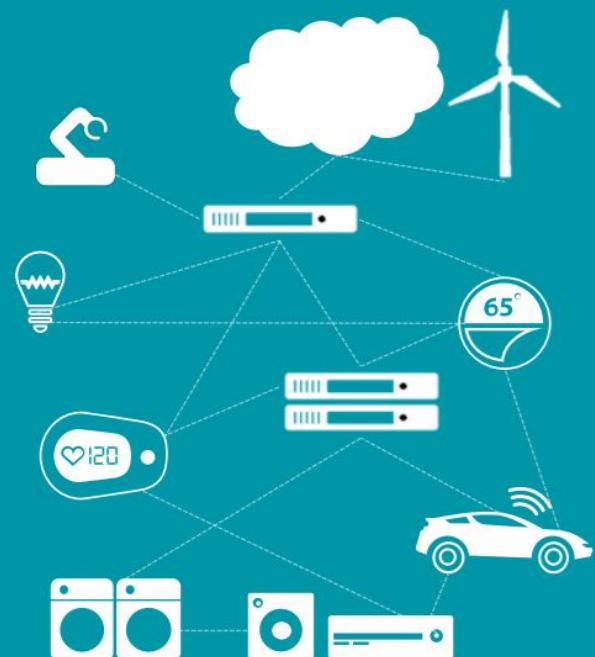
System Architecture
## Horizontal applications

Reversing the trend
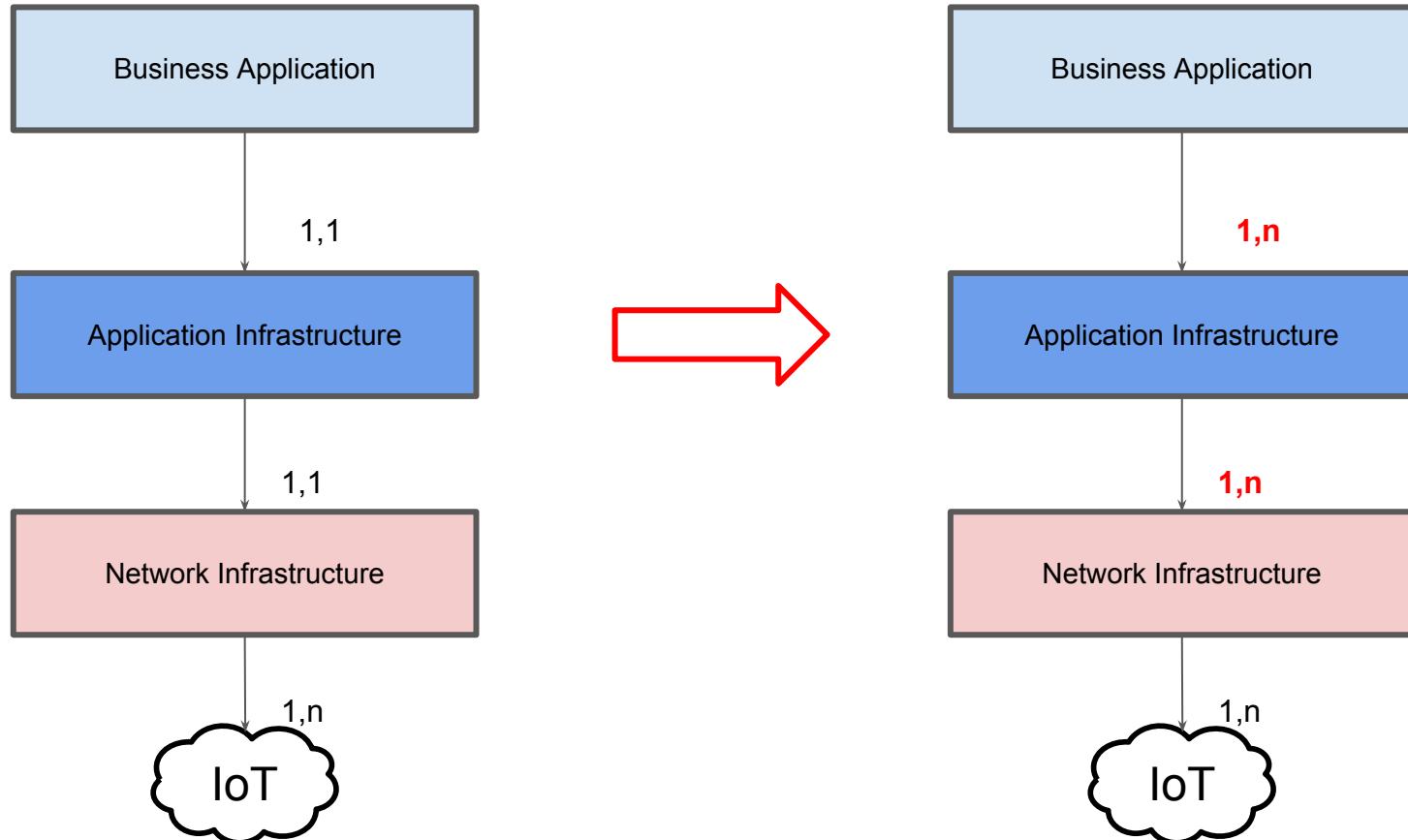
System Architecture
Classical architectures

The most classical architectures:

- It has what one carries on oneself: self
- That one has at home: home.
- What is in the city or in business.

The immaterial part of the cloud is at the crossroads of the four categories.
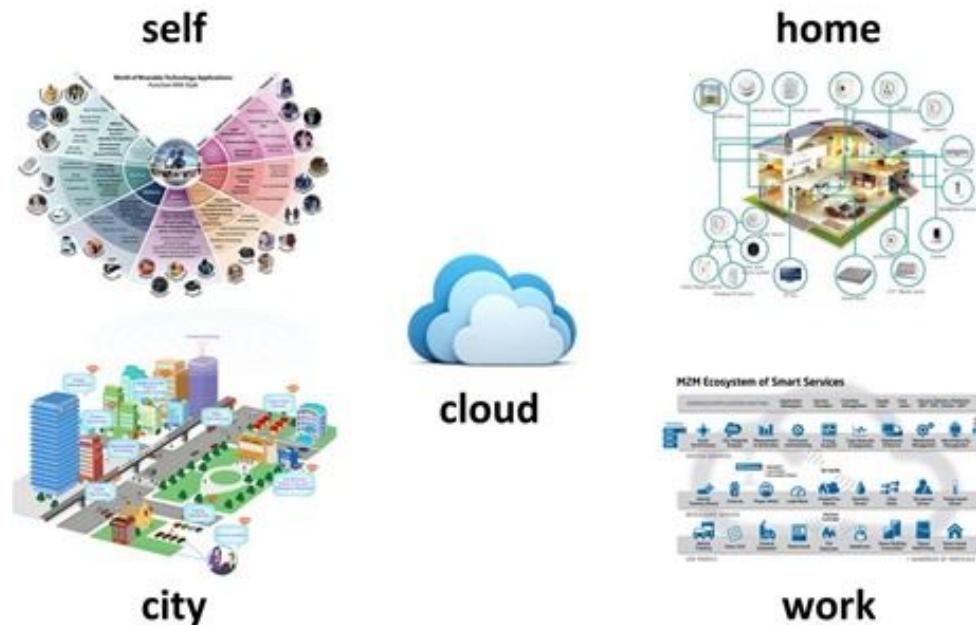
System Architecture

Network support

The iot takes as support OSI system with sometimes adaptation in order to solve problems specific to the IoT:
- management of the cost of communication,
- size of data,
- local area network,
- wireless system,
- special branch of industry ...

System Architecture
Network flows

IoT → IoT
Push data

Physical layer
protocol

System → IoT
Get data,
Actuator,
Software Update ...

Infrastructure public/private transport (radio, wired)

Internet
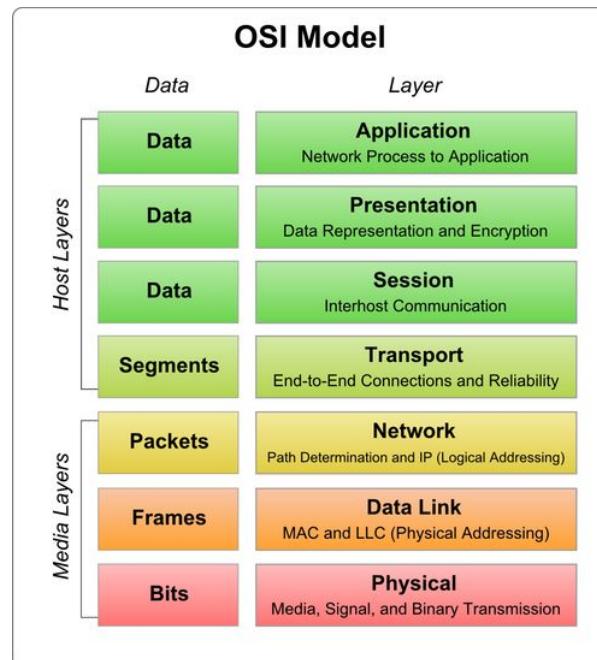
System → System
Push, Get data ...
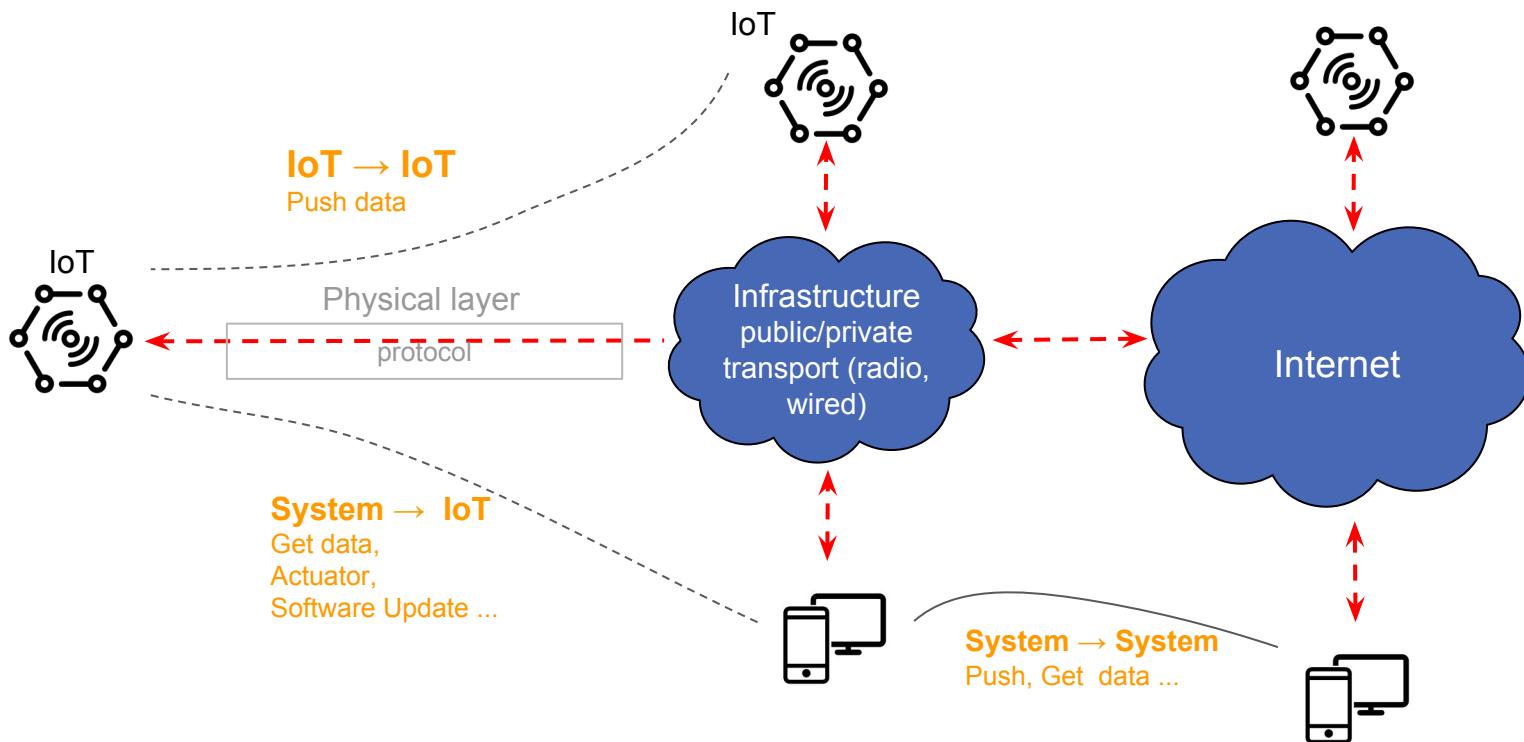
Most of the IoT devices are simple sensor:
– Payload between 10 to 50 bytes, a few times per day
– Traffic is therefore largely dominated by the uplink

http://www.societe-informatique-de-france.fr/wp-content/uploads/2015/12/IOT-Pr%C3%A9sentation-Orange.pdf

System Architecture
## Common Architecture
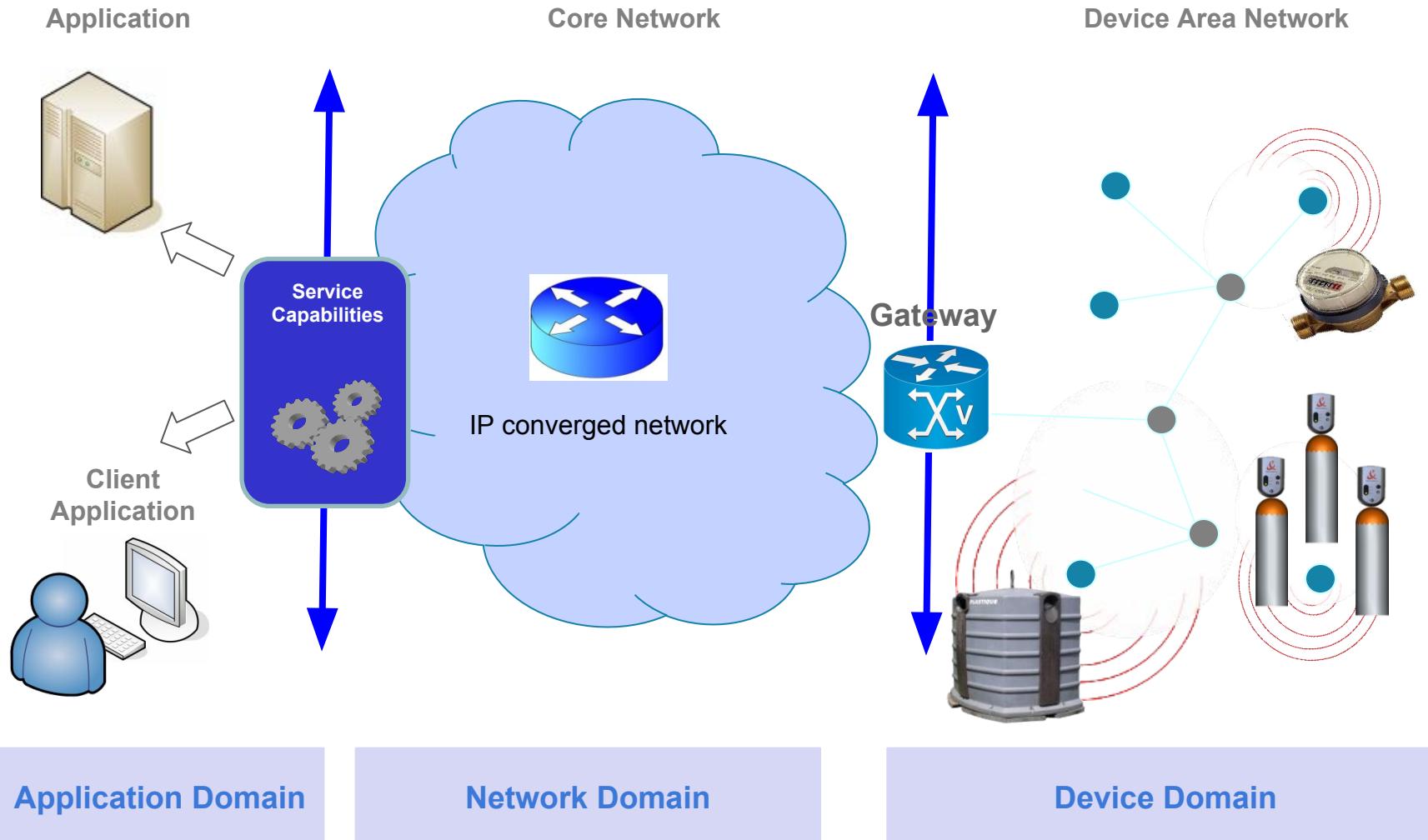
http://www.etsi.org/

Application　　　　　　　**Core Network**　　　　　　　**Device Area Network**

Service Capabilities

Gateway

IP converged network

Client Application

| Application Domain | Network Domain | Device Domain |

System Architecture

Transport protocols: Home, City
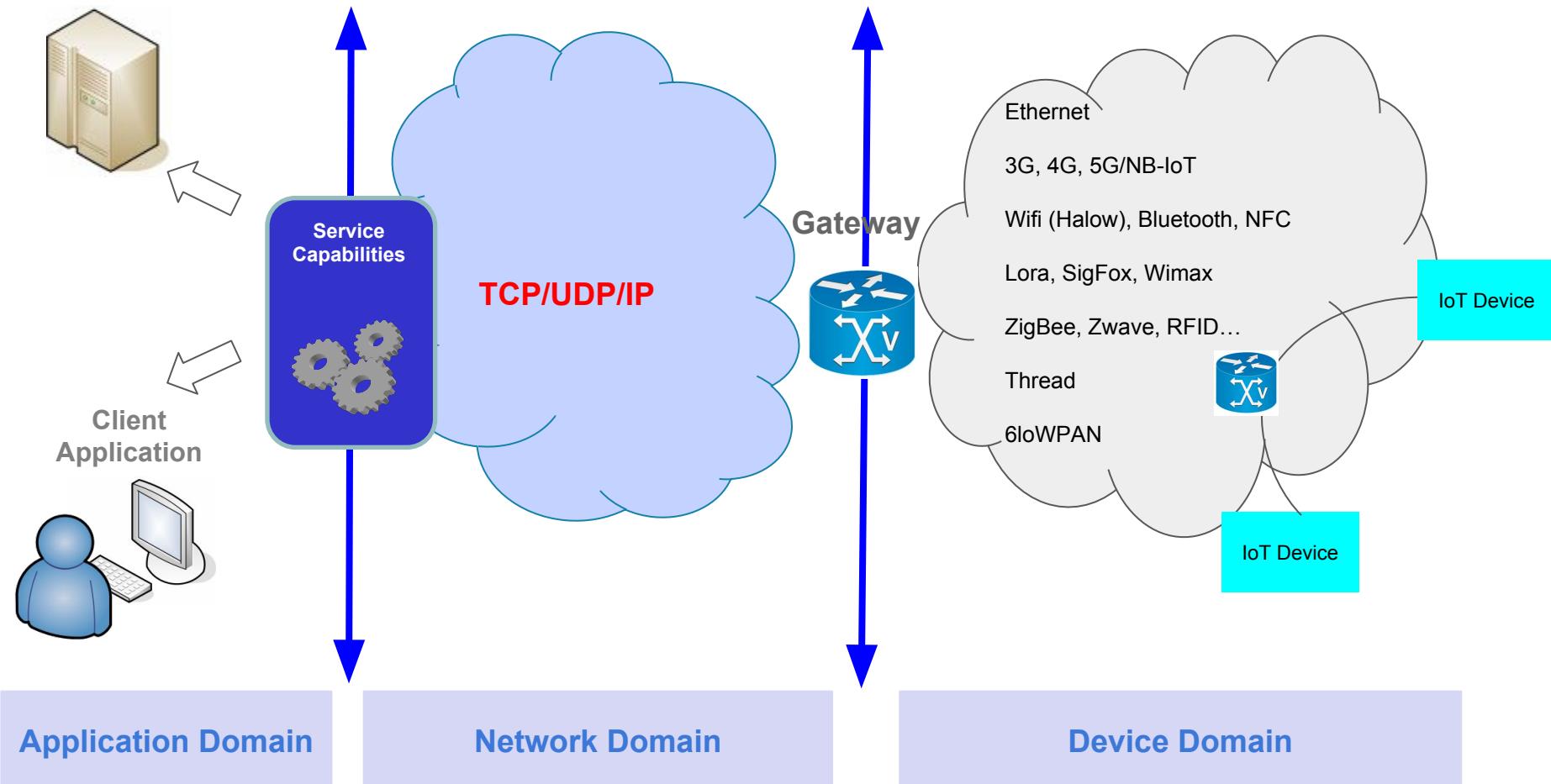
http://www.etsi.org/

Application

Core Network

Device Area Network

Service Capabilities

Gateway

TCP/UDP/IP

Ethernet

3G, 4G, 5G/NB-IoT

Wifi (Halow), Bluetooth, NFC

Lora, SigFox, Wimax

ZigBee, Zwave, RFID…

Thread

6loWPAN

IoT Device

IoT Device

Client Application

Application Domain

Network Domain

Device Domain

System Architecture

Transport protocols: Self

http://www.etsi.org/

Application

Core Network

Device Area Network

Service Capabilities

Gateway

TCP/UDP/IP

Client Application

3G, 4G, 5G/NB-IoT

Wifi (Halow), Bluetooth, NFC ...

IoT Device

Smartphone Box…
Network operator

IoT Device

Application Domain

Network Domain

Device Domain
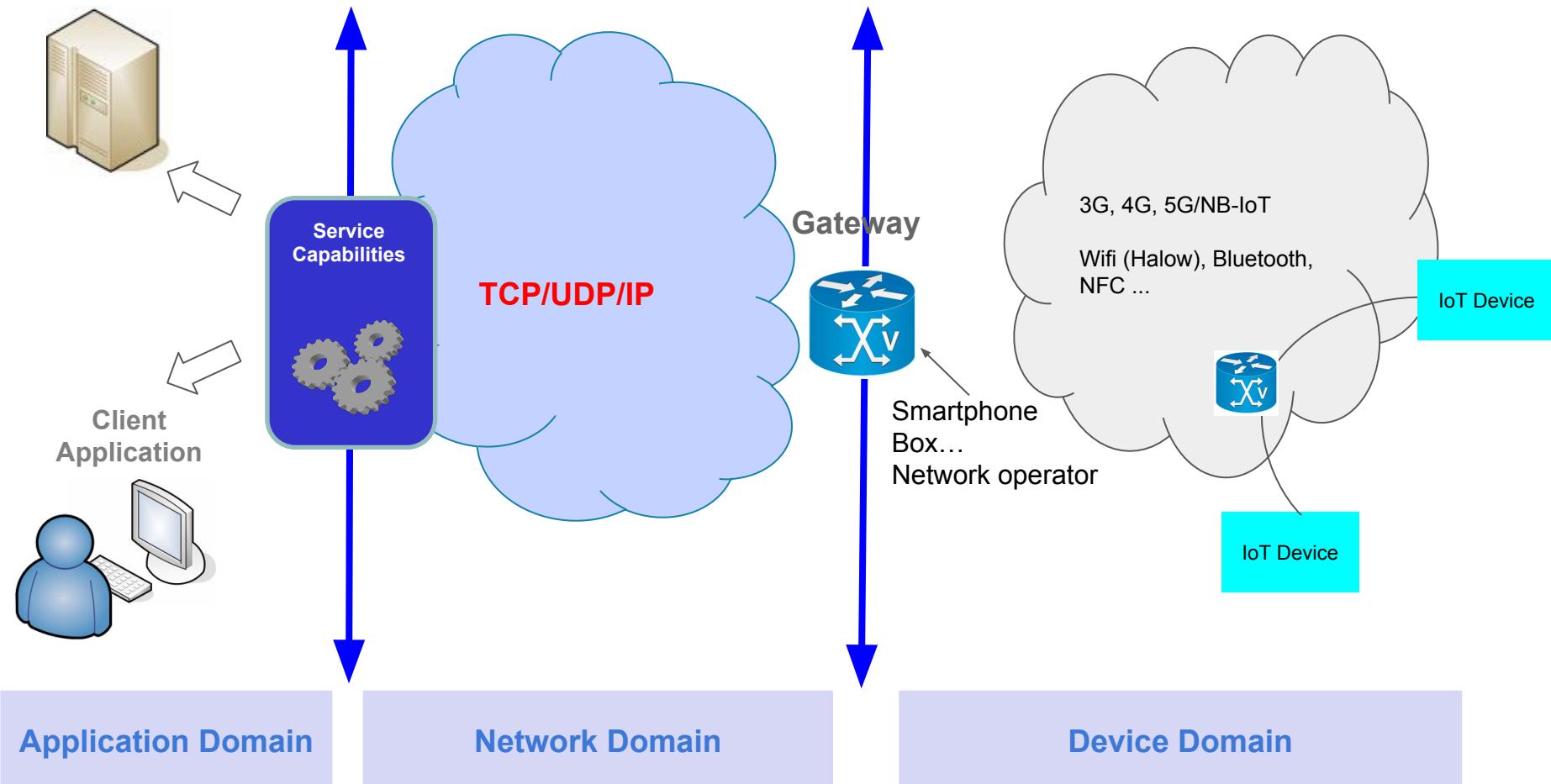
System Architecture
Gateway

- A gateway manages traffic between networks that use different protocols.

- A gateway is responsible for protocol translation and other interoperability tasks.

- An IoT gateway device is employed because some devices don't contain the network stack required for Internet connectivity, a gateway device acts as a proxy, receiving data from devices and packaging it for transmission over TCP/IP.

System Architecture
Application Domain

- End-user application,

- Ready-to-use catalog application, just a few fit for customization,

- The application uses all the capacity of the system: from the sensor to the big data:

  - Decision making,
  - Analysis,
  - Interaction with the natural environment...

System Architecture
Network Domain

- Independent of transport technologies,

- Whole IP convergence technology,

- Use of gateway system or direct access to the M2M platform,

# System Architecture
Device Domain

- Sensor and actuator system,

- Communication system,

- Performs a requested task.

System Architecture
Data Protocols for IoT - 1/2

There are several scenarios for payload transport:

- Use of TCP UDP (layer 4) and IP (layer 3) + application level (layer 7): HTTP, SOAP, MQTT, BACnet, Modbus,

Physical layer: Wifi, 4G, 5G ...

TCP UDP / IP

HTTP, SOAP,
MQTT ...
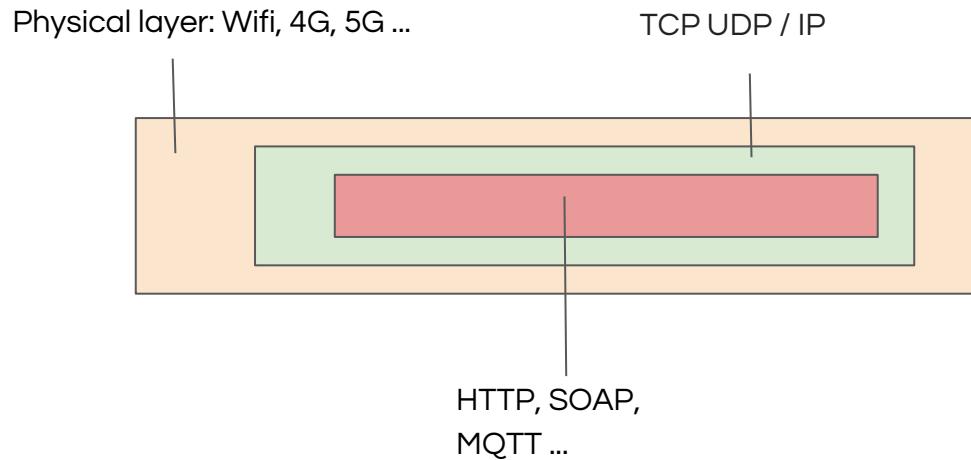
System Architecture
Data Protocols for IoT - 2/2

There are several scenarios for payload transport:

- The technology provides an end-to-end transport protocol:
    - ZigBee, LoRa, Sigfox, Bluetooth, NFC ...

- M2M / IP gateway is mandatory

Physical layer: Zigbee, LoRa ...　　　　Specific fields

Payload
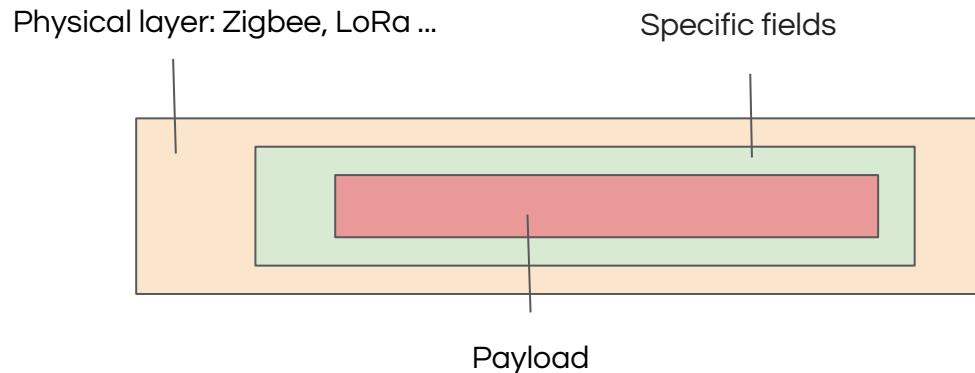
System Architecture
Transport protocols - Products

http://www.societe-informatique-de-france.fr/

A myriad of radio communication solutions are already used
to address IoT services:
- Unlicensed Band,
- Standard, other are proprietary solutions ...

Sigfox

System Architecture

Transport protocols - Long range communication

LoRa

Strong Ecosystem Enables Customized Deployment   SEMTECH

LoRa™ RF LoRaMAC | TCP/IP SSL LoRaMAC | TCP/IP SSL Secure Payload

AES Secured Payload Application Data

HW | GW | Software & Complete Solutions | Development

Embit Eolane Nemeus Invisible Systems Aduenis

MultiTech Systems, MICROCHIP, Laird, imst

MultiTech Systems, CISCO, imst, kerlink

IBM, actility, Stream & Orbiwise

IBM, senet, ARM mbed, MPLAB X

LoRa | **IP**
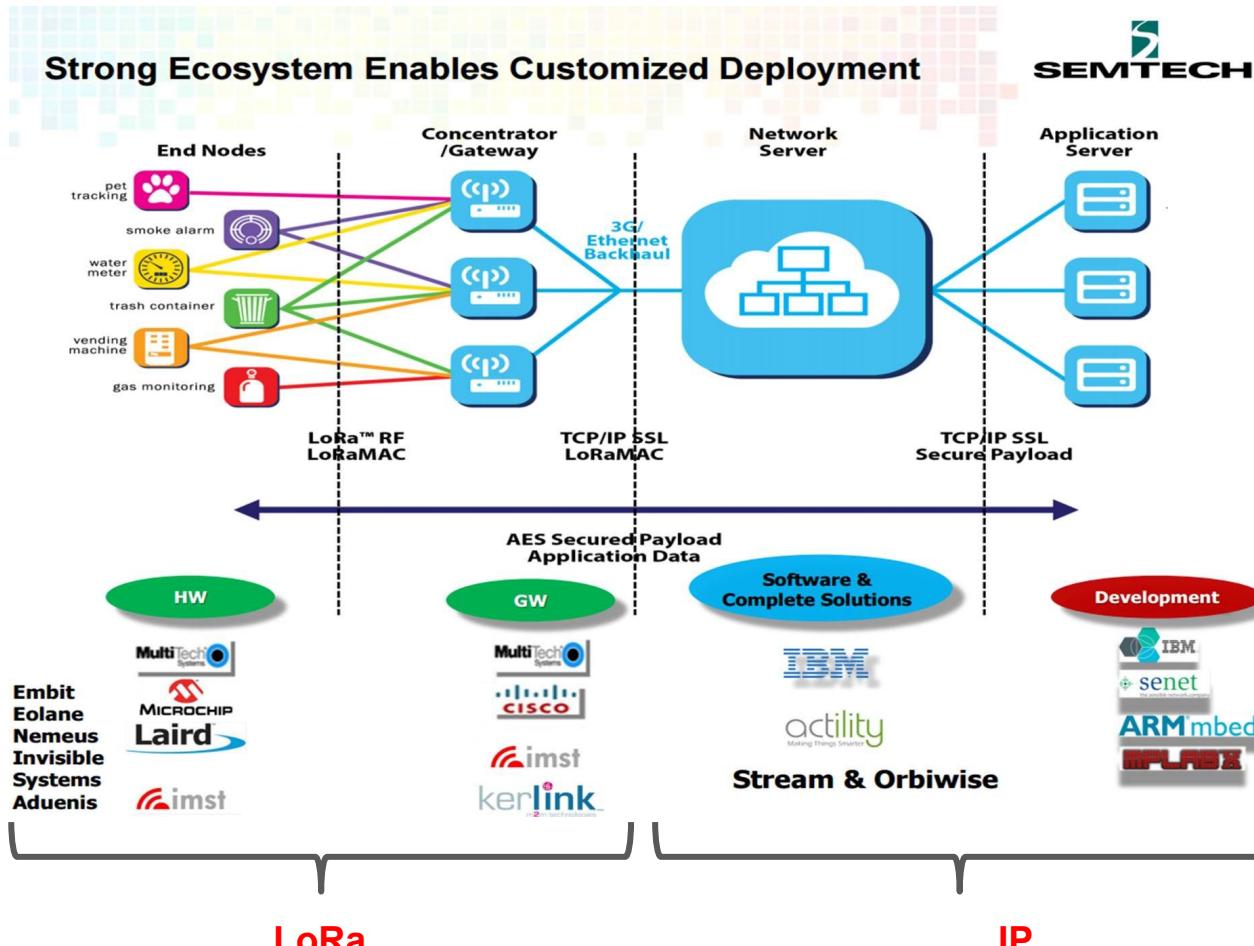
Transport protocols - mesh - 6loWPAN - Principle

https://tools.ietf.org/html/rfc6282
https://en.wikipedia.org/wiki/IEEE_802.15.4

6LoWPAN - IETF RFC 6282

("IPv6 over Low-Power Wireless Personal Area Networks")

- IEEE 802.15.4 in the 2.4-GHz band,

- Ethernet, Wi-Fi,

- Low-power wireless mesh network.

6LoWPAN stack example

| HTTP, COAP, MOTT, Websocket, etc. |
| UDP, TCP (Security TLS/DTLS) |
| IPv6, RPL |
| 6LoWPAN |
| IEEE 802.15.4 MAC |
| IEEE 802.15.4 |
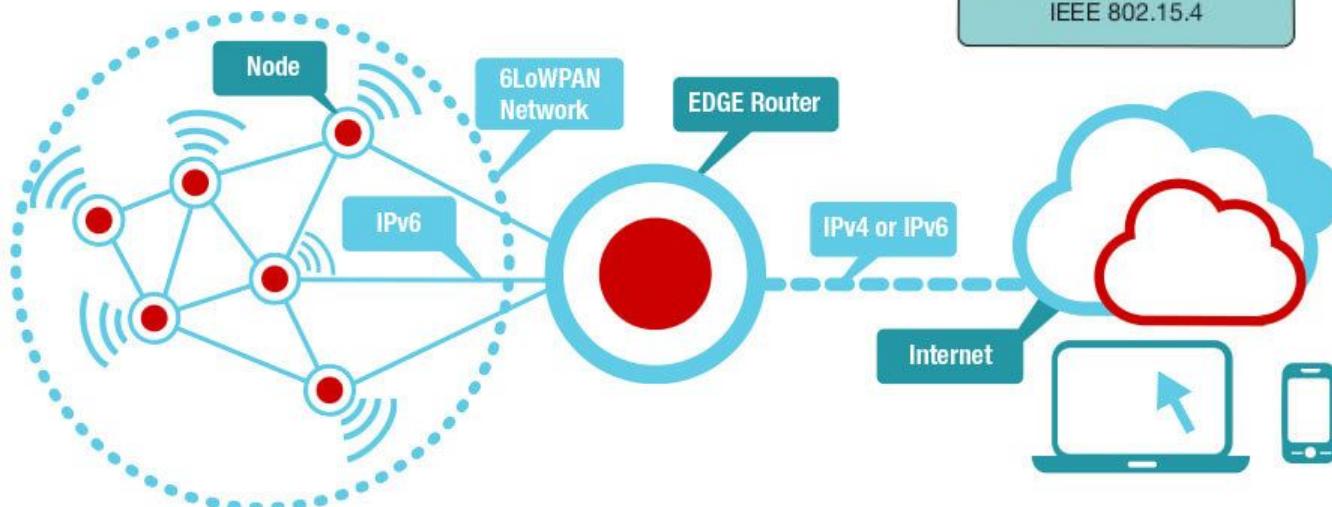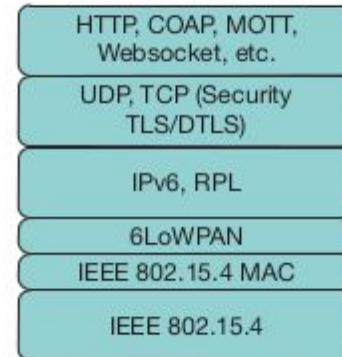
System Architecture
Transport protocols - mesh - 6loWPAN - Limitation

https://tools.ietf.org/html/rfc6282
https://en.wikipedia.org/wiki/IEEE_802.15.4

- Limited throughput network (up to 250 kbit/s),

- IPv6 only (due to IPv6 compression),

- Limited payload size (33 bytes over UDP, 21 bytes over TCP),

- The packet size constraints imposed by IPv6 and 802.15.4 result in an excessive fragmentation / reassembly problem.

System Architecture
Transport protocols - mesh - Thread

http://threadgroup.org
https://en.wikipedia.org/wiki/Thread_(network_protocol)

**Thread** - Closed-documentation

-   Use existing infrastructure with a software update,
-   Based on IEEE802.15.4 and 6LowPAN,
-   Up to 250 nodes with high levels of authentication and encryption,
-   IPv6-based, UPD + DTLS,
-   Designed for very low power.
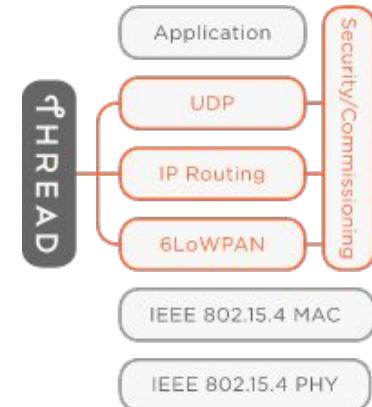
OpenThread - BSD license (allowing anyone to reuse, modify or redistribute it in source or binary form)

-   https://github.com/openthread/openthread)

-   https://github.com/ARMmbed/nanostack-border-router

End Device Router Eligible
Thread Router
Leader
Border Router
Thread Link
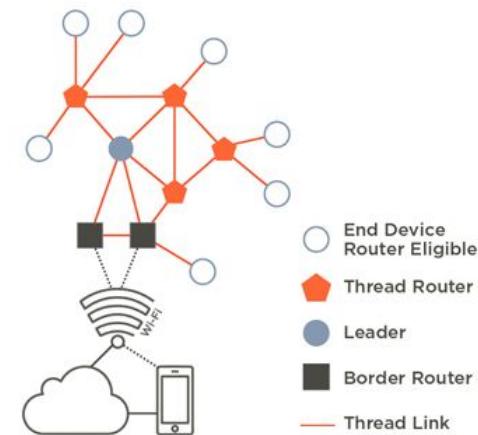
(thread Leader is a device responsible for managing router ID assignment)

System Architecture
Transport protocols - mesh - Zwave

z-wavealliance.org
https://en.wikipedia.org/wiki/Z-Wave

Z-Wave Alliance ZAD12837 / ITU-T G.9959 - open protocol / proprietary technology

- Receipt acknowledgment,

- Each component is both receiver and transmitter,

- Z-Wave gateway for Ip an Internet access,

- The throughput is 9.6/40/100kbit/s ,

- Enabling control of up to 232 devices,

- The only maker of chips is Sigma Designs,

Open source: http://www.openzwave.com/ - to incorporate Z-Wave functionality into applications.

Contrôleur Z-Wave Plus dongle USB - 40€

System Architecture

Transport protocols - mesh - ZigBee

http://www.zigbee.org
https://en.wikipedia.org/wiki/ZigBee

ZigBee - IEEE 802.15.4-2003 - ZigBee Alliance

- The nodes are designed to work for several months (up to ten years for the less consuming),

- Data rate : 250 Kb/s (up to),

- Ready Profile: Home Automation , Personal Home & Hospital Care, Smart Energy ...

System Architecture
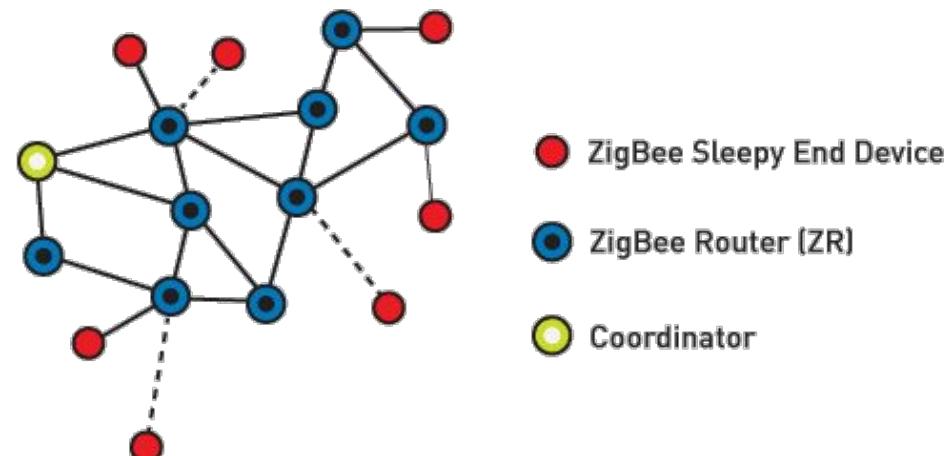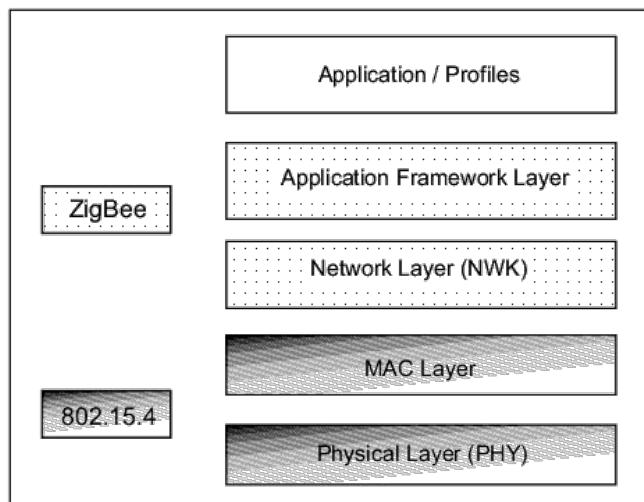
https://www.enocean.com
https://en.wikipedia.org/wiki/EnOcean

EnoCean - ISO/IEC 14543-3-10

- Ultra low power radio applications,

- Batteryless wireless communications with piezo generators,

- AES algorithm with a 128-bit key,

- 125 kilobits per second, 50 µWs for a single telegram,

- 868 MHz for Europe,

- Unique 32-bit identification number (ID),

- Gateway: WiFi, Ethernet/IP, KNX, BACnet,

- Raspberry Pi board with the EnOcean Developer Kit.

IP gateway

System Architecture
Transport protocols - 5G/NB-IoT

Narrow Band* IoT (NB-IoT) - 3GPP Release 13

- LTE (Long Term Evolution),
- Ubiquitous coverage,
- Low Power Wide Area Network (LPWAN),
- Low range communication,
- Low cost, long battery life,
- **Managed quality of service** (QoS),
- End-to-end security,
- Availability 2017.

- **Specification**:
    - Downlink Peak Rate: 250 kbps,
    - Uplink Peak Rate: 250 kbps (multi-tone), 20 kbps (single-tone),
    - Duplex Mode : Half Duplex,
   - Device Transmit Power: 23 dBm or 20 dBm

*NarrowBand: bande étroite, https://en.wikipedia.org/wiki/Narrowband

System Architecture
Transport protocols - 5G/NB-IoT

http://www.3gpp.org/
https://en.wikipedia.org/wiki/NarrowBand_IOT
http://www.3gpp.org/news-events/3gpp-news/1785-nb_iot_complete

Smart Metering
Gas Metering
Water Metering

Smart Cities
Streetlights
Parking
Waste Management

Consumer
White Goods
People Tracking

Smart Buildings
Alarm Systems
HVAC
Access Control

Agriculture / Environment
Land / Environment Monitoring
Pollution Monitoring
Animal Tracking

https://www.u-blox.com/en/product/sara-n2-series
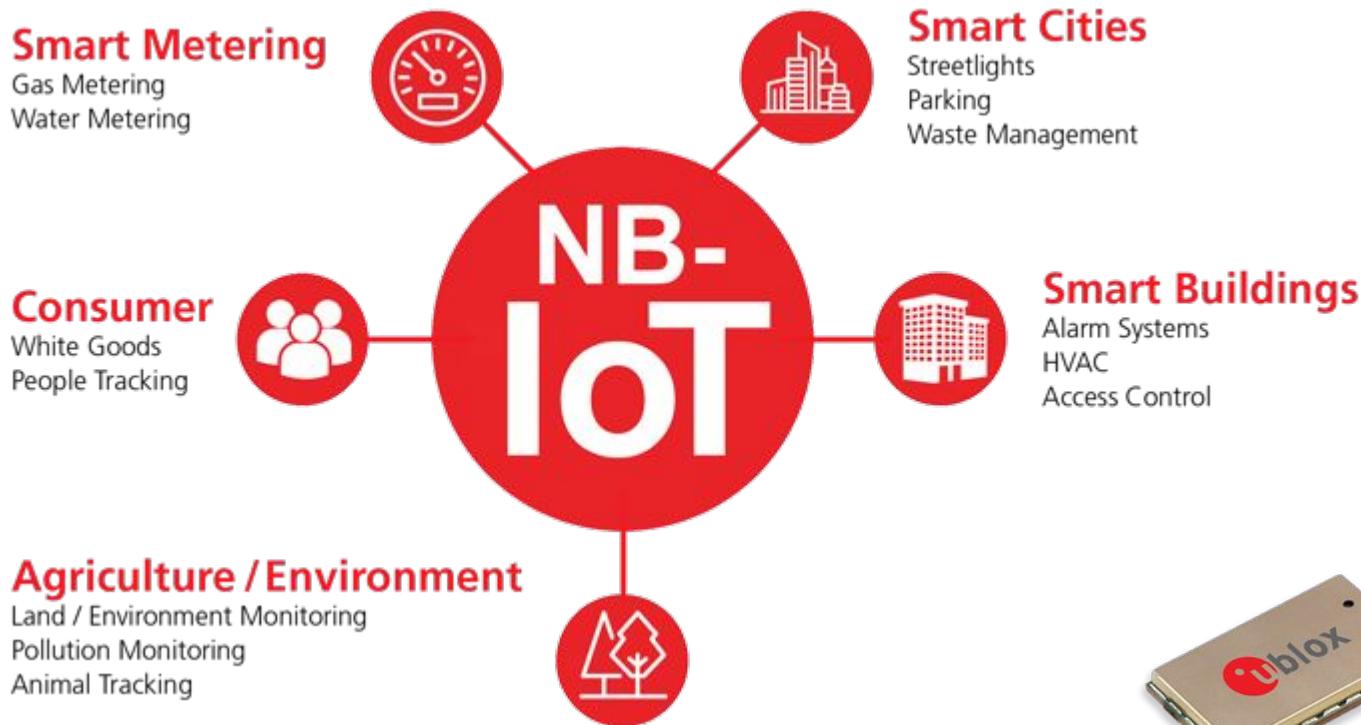
System Architecture

Transport protocols- Wifi Halow

http://standards.ieee.org/findstds/standard/802.11ah-2016.html
https://en.wikipedia.org/wiki/IEEE_802.11ah

Wifi Halow - IEEE 802.11ah (2016)

- Spectrum of 900 MHz without a license (863 MHz - 868 MHz in Europe), today 2.4 GHz or 5 GHz,

- Devices operating on batteries,

- Data rates up to 347 Mbit/s,

- Signal is less attenuate when it goes through objects (wall, ground) , the equipment does not consume as much power,

- **Double the range** of wifi current standards,

- A standby mode.

System Architecture
Transport protocols - RFID

http://standards.ieee.org/findstds/standard/802.11ah-2016.html
https://en.wikipedia.org/wiki/IEEE_802.11ah

## RFID - Radio-frequency identification

- Invented in 1948 by Harry Stockman
- Identification of objects
- Dedicated for short range communication
- Data: read, write
- Tag**:**
    - Active: internal battery (2 → 4 years), greater range, higher date trans. rates
    - Passive: without battery, unlimited life,
- Component:
    - Tag: chip , antenna
    - Reader: RF module, antenna
    - Host computer : middleware
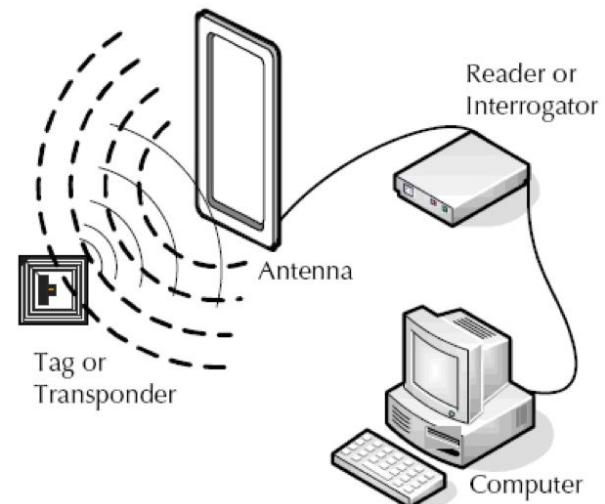
System Architecture

Transport protocols: Work, City

http://www.etsi.org/

Application

Core Network

Device Area Network

Service Capabilities

TCP/UDP/IP

Gateway

BacNet ModBus KNX M-Bus

IP

IoT Device

Client Application

Client Application

IoT Device

Application Domain

Network Domain

Device Domain
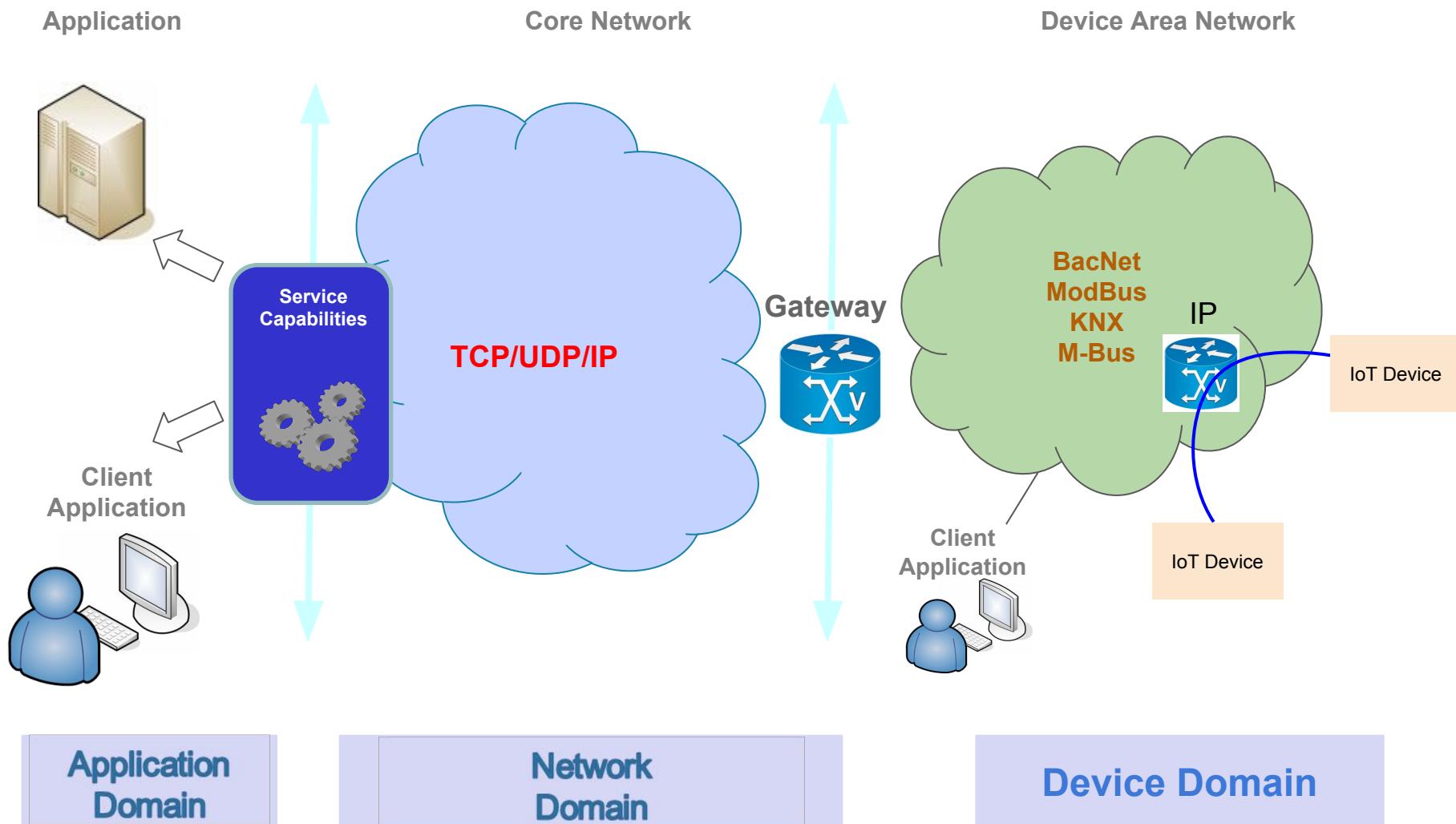
System Architecture
Protocol BACnet: City, Building

http://www.iso.org/iso/fr/catalogue_detail?csnumber=63753
https://en.wikipedia.org/wiki/BACnet

BACnet is a communications protocol for Building Automation and Control (BAC) networks. It is an ASHRAE, ANSI, and ISO 16484-5 standard protocol.

- Control systems for applications such as heating, ventilating, and air-conditioning control (HVAC), lighting control, access control, and fire detection systems and their associated equipment.
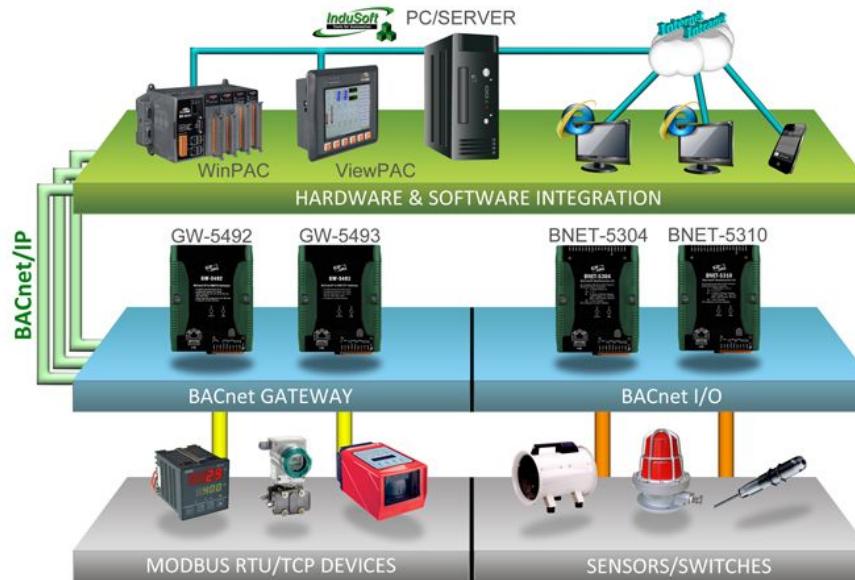
http://www.icpdas.com/root/product/solutions/industrial_communication/fieldbus/bacnet_ip/bacnet_ip_intro.html

System Architecture

Protocol ModBus: City

ModBus is a serial communications protocol originally published by Schneider Electric.

- For use with its programmable logic controllers (PLCs).

- De facto standard communication protocol.
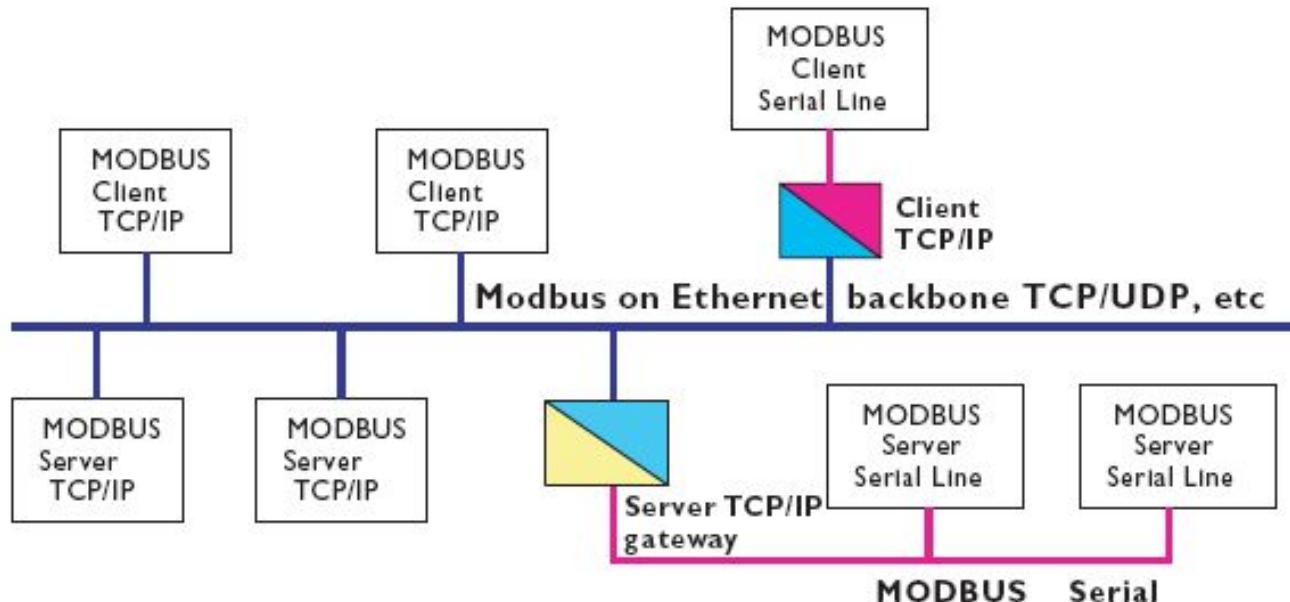
System Architecture

Protocol ModBus - Open source library

http://www.modbus.org/

http://libmodbus.org/ - Linux

- LGPL v2.1+
- Library is written in C
- Supports RTU (serial) and TCP (Ethernet) communications.

http://jamod.sourceforge.net/

- Library is written in Java ...

System Architecture
Protocol KNX: City, Home

KNX is a standardized (EN 50090, ISO/IEC 14543), OSI-based network communications protocol for building automation. KNX is the successor to, and convergence of, three previous standards: the European Home Systems Protocol (EHS), BatiBUS, and the European Installation Bus (EIB or Instabus). The KNX standard is administered by the KNX Association
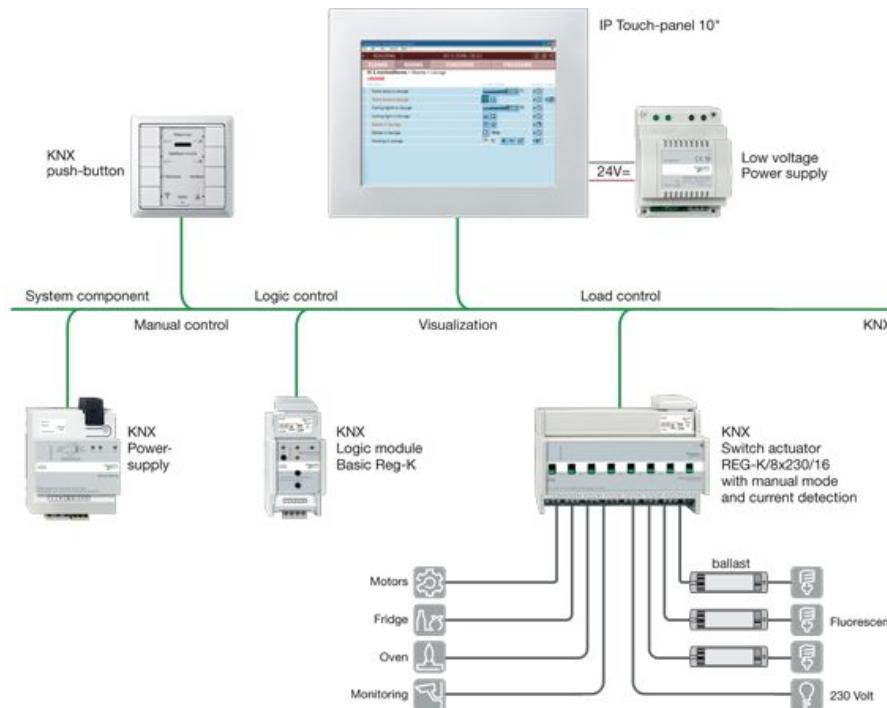
System Architecture

Protocol M-Bus: City

M-Bus (Meter-Bus) is a European standard (EN 13757-2 physical and link layer, EN 13757-3 application layer).

- For the remote reading of gas or electricity meters,

- For communication on two wires, making it very cost effective.

- A radio variant of M-Bus (Wireless M-Bus) is also specified in EN 13757-4.

M-Bus remotely meter reading system
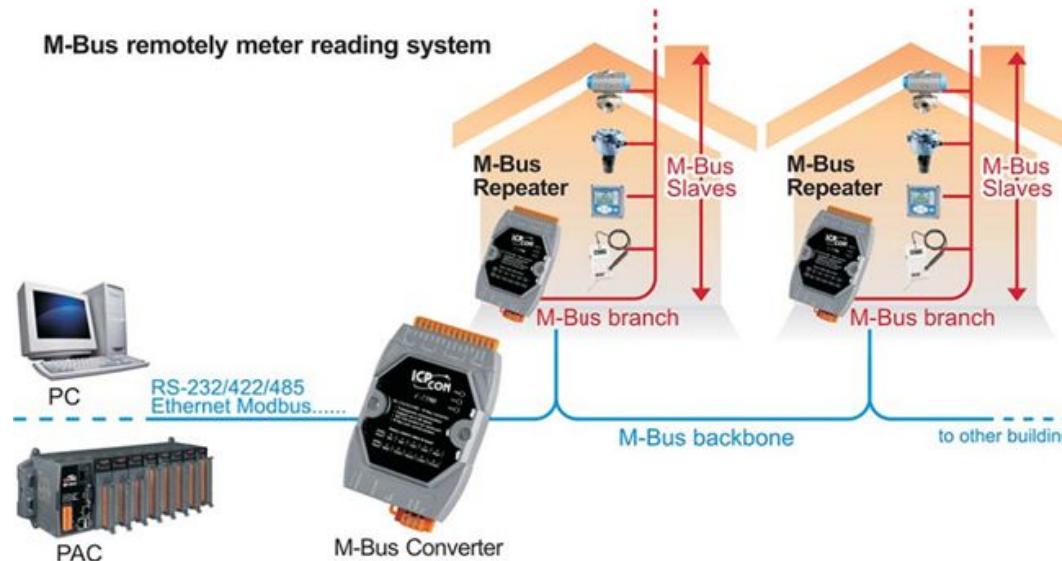
System Architecture
Data Protocols for IoT - REST

https://www.w3.org/2001/sw/wiki/REST
https://en.wikipedia.org/wiki/Representational_state_transfer

REST (Representational state transfer)

- Providing interoperability between computer systems on the Internet,

- Predefined set of stateless operations,
    - Each request contains necessary to service the request,
    - No client context being stored on the server between requests.

- The message inside: elicits a response that may be in XML, HTML, JSON or some other defined format,

- WWW REST protocol: HTTP verbs GET, POST, PUT, DELETE.

System Architecture

http://www.iso.org/iso/catalogue_detail.htm?csnumber=69466
https://en.wikipedia.org/wiki/MQTT

MQTT (Message Queuing TelemetryTransport) - ISO/IEC PRF 20922 :

- Designed for lightweight machine-to-machine communications.

- The message inside: JSON, HTML, CSV, or even a proprietary binary format.

All three clients open TCP connections with the broker. Clients B and C subscribe to the topic speed.
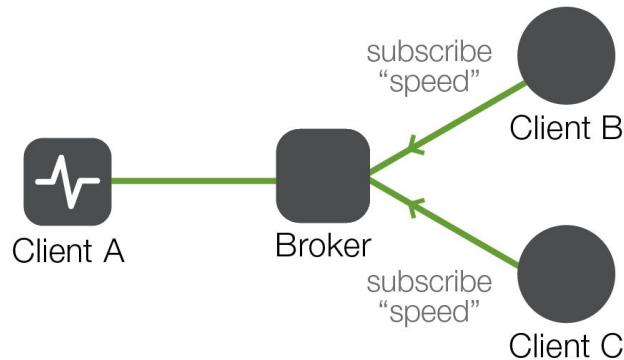
At a later time, Client A publishes a value of 15mph for topic speed. The broker forwards the message to all subscribed clients.

System Architecture

Data Protocols for IoT - "subscribe and publish" - XMPP
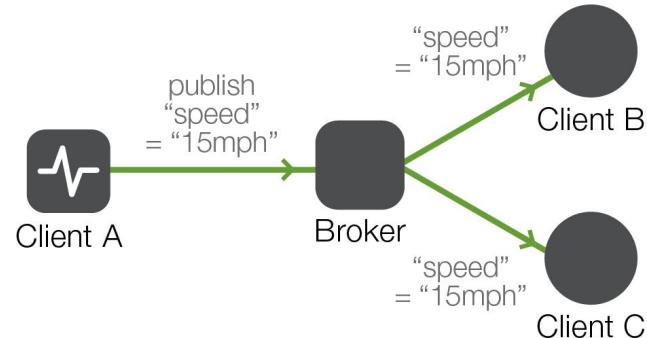
https://tools.ietf.org/html/rfc6120
http://xmpp.org
https://en.wikipedia.org/wiki/XMPP

XMPP (Extensible Messaging and Presence Protocol) - IETF 6120, 3920, 3921

- Communication between machines in many different scenarios:
    - Request/Response, Asynchronous Messaging, and Publish/Subscribe

- Standard bi-directional socket connections,

- Presence (broadcast, probes, directed …),

- The message inside: XML over Http/WebSocket, binary data must be first base64,

- Extension for "Provisioning*" (XEP-0324) and "Discovery" (XEP-347),

- XMPP provisioning server,

- XMPP provides "Global Identities," which helps identify an unlimited number of devices by their unique XMPP addresses …

XEPs: XMPP extension for IoT

*Provisioning: enables IoT devices to delegate trust to more capable servers, defines how provisioning, the management of access privileges, etc., can be efficiently and easily implemented.

System Architecture

Data Protocols for IoT - "subscribe and publish" - CoAP

CoAP (Constrained Application Protocol) - IETF RFC 7252

- REST architecture,
- Use UDP/IP (with loss recover mechanism),
- Observation mechanism (like subscribe and publish),
- Coap Resource Directory,
- The message inside: text, binary.

Navigateur Web / Applications M2M				
HTTP		CoAP		Application
TCP		UDP		Transport
IPv4 / IPv6			IPv6	Réseau
			6LoWPAN	
UMTS / GPRS	802.3 Ethernet	802.11 Wifi	802.15.4 LoWPAN	Physique et Liaison de Données
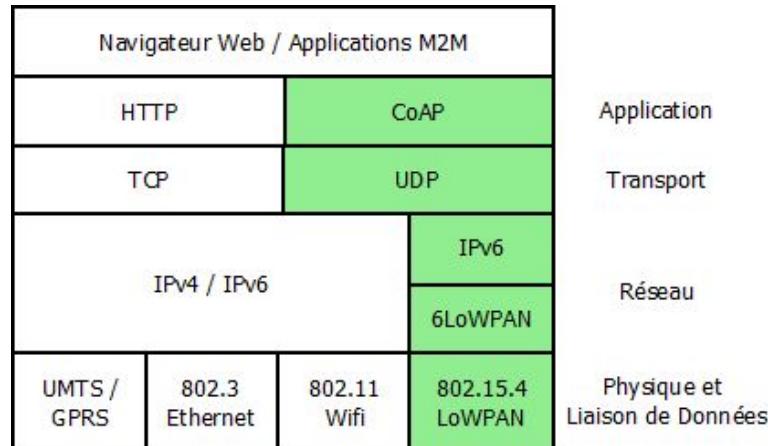
System Architecture
Data Protocols for IoT - Websocket

https://tools.ietf.org/html/rfc6455
https://en.wikipedia.org/wiki/WebSocket

Websocket - IETF RFC 6455 - W3C

- Bidirectional communication technology for web browsers and web servers,

- Browser-side: JavaScript interface in HTML 5,

- Use TCP/HTTP (http for protocol handshake),

- Transport Layer Security (TLS),

- The message inside: plain text messages, binary data or images,

- Web Socket transport layer: XMPP, STOMP, AMQP ...

System Architecture
Data Protocols for IoT - AMQP

AMQP (Advanced Message Queuing Protocol) - ISO/IEC 19464:2014

- Connecting different systems to talks to each other (client , broker*),

- Create cross-platform messaging applications,

- **Avoids using gateway** between evolving systems,

- Message acknowledgements,

- The message inside: the payload of messages are not defined by the AMQP,

- Uses TCP/IP.

*Broker (Server): An application - implementing the AMQP model - that accepts connections from clients for message routing, queuing etc

System Architecture
IoT discovery - mDNS

https://tools.ietf.org/html/rfc6762
https://en.wikipedia.org/wiki/Multicast_DNS

mDNS (multicast Domain Name System) - IETF RFC 6762

- Name resolution without a server (MDNS records are stored locally on each machine),

- MDNS is based on the principle of multicast (IPv4 224.0.0.251, IPv6 FF02::FB),

- UDP port 5353.

System Architecture

IoT identification

https://en.wikipedia.org/wiki/Electronic_Product_Code
https://en.wikipedia.org/wiki/Ucode_system

Hardware:

- Maxim DS1990A (1-Wire®): Unique Factory-Lasered 64-Bit Registration,

- Processor Unique ID,

  → http://www.mouser.fr/Search/Refine.aspx?Keyword=Serial+number+ic

Software:

- **EPC** (Electronic Product Code)

- **uCode**: Structure and Resolution mechanism (ucode resolution server and ucode information server …)

System Architecture
IoT management - TR-069

https://www.broadband-forum.org/
https://en.wikipedia.org/wiki/TR-069

TR-069 CWMP - Broadband Forum

- Addresses modems, routers, gateways, as well as end-user devices,

- The TR-069 standard was developed for automatic configuration and management,

- As a bidirectional SOAP/HTTP-based protocol,

- Security and authentication mechanism, data model …

EasyCwmp: a GPLv2 open source implementation of the TR069

System Architecture
IoT management - OMA-DM

http://www.openmobilealliance.org/
https://en.wikipedia.org/wiki/OMA_LWM2M

OMA-DM - Open Mobile Alliance

- **Provisioning**: Configuration of the device, enabling and disabling features,

- **Device Configuration:** Allow changes to settings and parameters of the device,

- **Software Upgrades** ,

- **Fault Management** – Report errors from the device,

- OMA DM protocol uses XML for data exchange,

- Transport : USB, RS-232, wireless media:GSM, CDMA, IrDA, or Bluetooth),

- Transport layers: WSP (WAP), HTTP, or OBEX or similar transports.

System Architecture

Data Protocols for IoT - Synthesis

Infrastructure (ex: 6LowPAN, IPv4/IPv6)

Identification (ex: EPC, uCode, IPv6, URIs)

Comms / Transport (ex: Wifi, Bluetooth, LPWAN)

Discovery (ex: Physical Web, mDNS, DNS-SD)

**Data Protocols** (ex: MQTT, CoAP, AMQP, Websocket)

Device Management (ex: TR-069, OMA-DM)

Semantic (ex: JSON, Web Thing Model)

next → **Multi-layer Frameworks** (ex: OneM2M, Fiware, Alljoyn, IoTivity, Weave, Homekit)

System Architecture
Data Protocols for IoT - Synthesis for IP layered
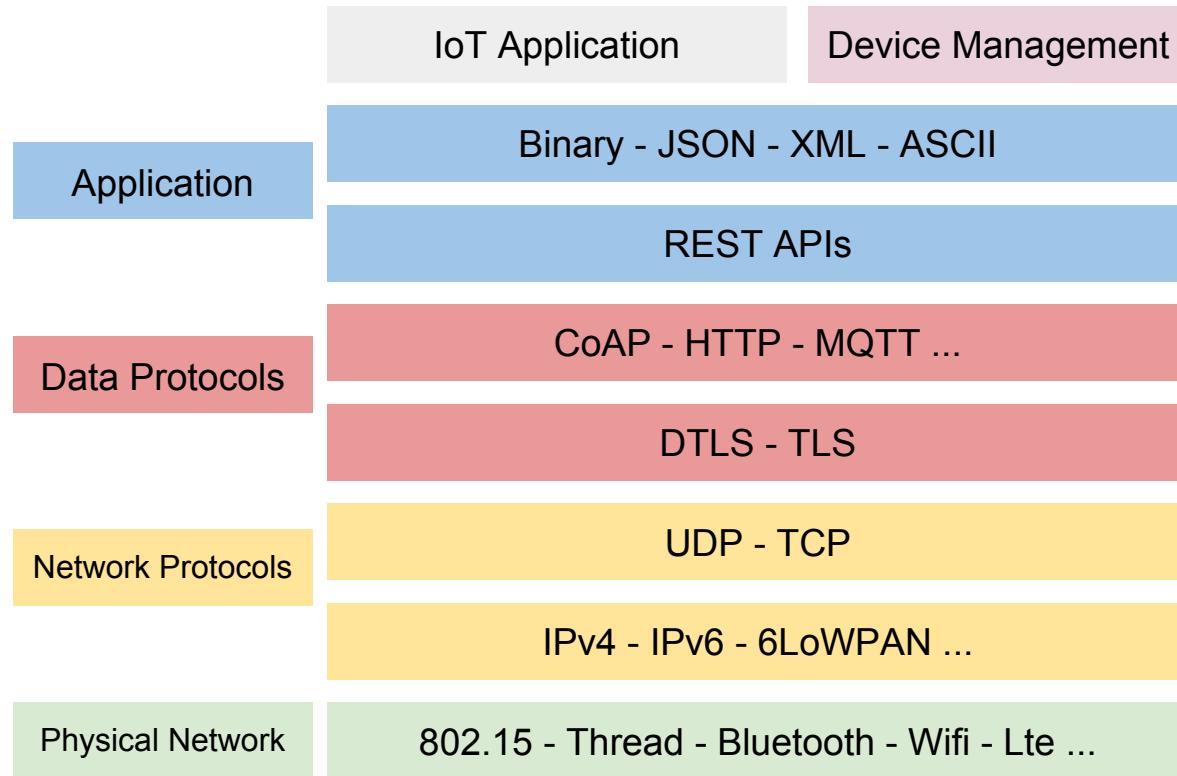
	IoT Application	Device Management

	Binary - JSON - XML - ASCII
Application	REST APIs

	CoAP - HTTP - MQTT ...
Data Protocols	DTLS - TLS

	UDP - TCP
Network Protocols	IPv4 - IPv6 - 6LoWPAN ...

	802.15 - Thread - Bluetooth - Wifi - Lte ...
Physical Network	

System Architecture
Architecture and Protocols

http://www.journaldunet.com/ebusiness/telecoms-fai/1181267-les-reseaux-iot/
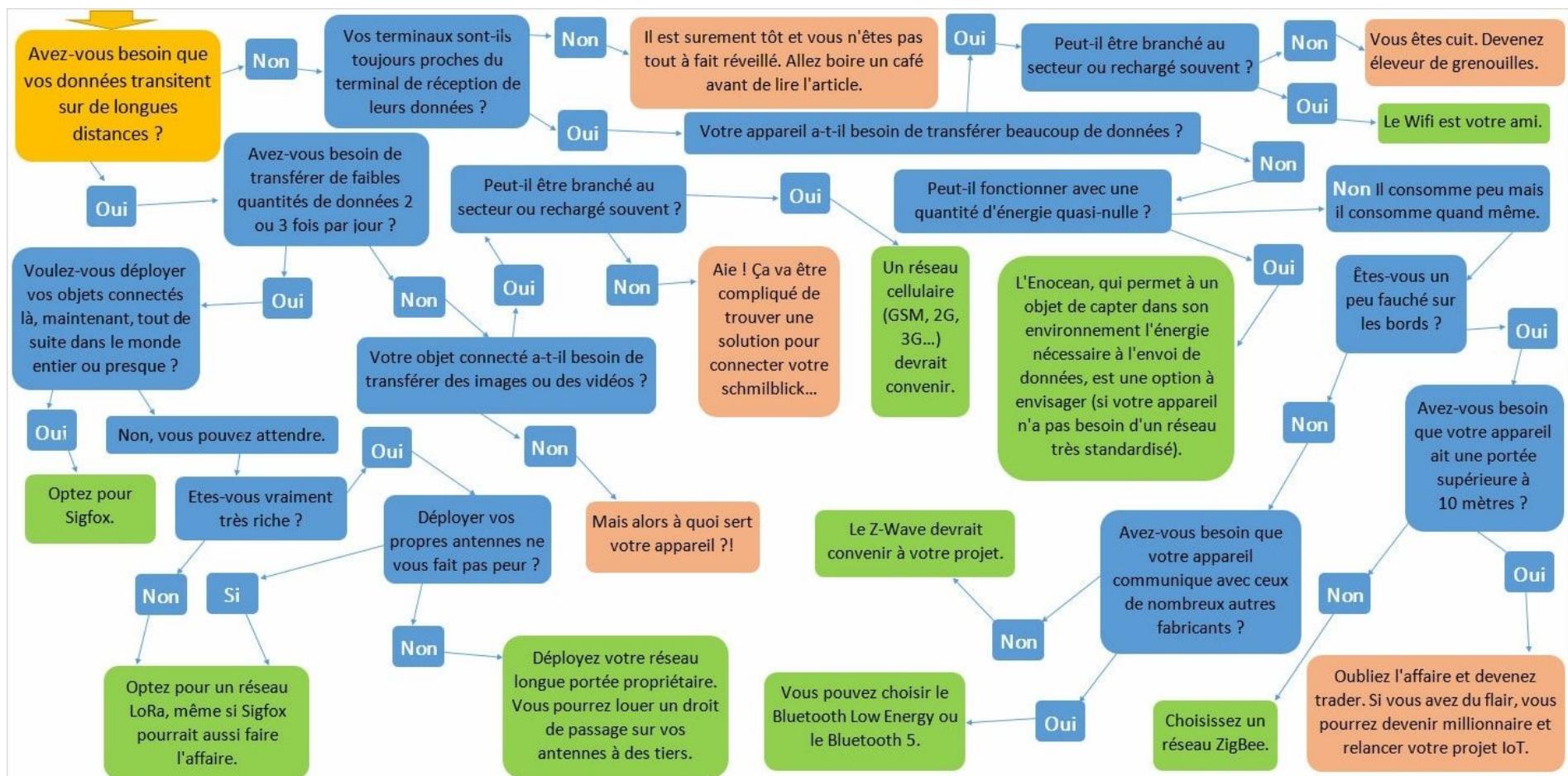
System Architecture

Architecture and Protocols: Cost effective ?

IoT cost is negligible (?):

- Communication systems,

- Infrastructure (Data storage, web service ...),

- Service (Maintenance, upgrade, troubleshooting ...),

- ...

Part II

M2M System - Definition

M2M System - Global architecture

M2M System - Communication example

M2M System - Standards

M2M Open platform

Lightweight M2M

M2M impact for IoT

Big data

IoT and digital hub

M2M System
Motivation

Motivation 1:

- Enabling **interoperability** of systems,

- Machine-to-machine **communication without human** intervention,

- Since systems are increasingly complex, many use cases can not be adapted or require **complex logistics** that could be **dedicated directly to IoTs**,

- Providing large and small-scale **Integration Infrastructure**.

M2M System

Motivation 2:

- Standardization of data access,

- Define standard infrastructures,

- Defining Development Patterns ..

M2M System
Motivation

Motivation 3:

- Enabling application developers to focus on functionality (not lower task : routing, authentication …),

- Enabling any application to read or control any sensor, under control of a horizontal security framework,

- Providing network-based service, such as data publication and subscription.

Motivation 4:

- Reliability by
    - Robustness and fault tolerance
    - Redundancy

- Platform-independence,

- Internet and firewalls,

- Security and access control ...

https://fr.wikipedia.org/wiki/Machine_to_machine

M2M (Machine To Machine)

"Le Machine to Machine ou M2M est la combinaison des technologies de l'information et de la communication (TIC), avec des objets intelligents et communicants, permettant à ces derniers d'interagir entre eux sans intervention humaine"

- Uses telecommunications and computing to enable communication between machines (without human),

- A communication from a machine or network of machines to a server,

- Requests for data contained in device or capable of transmitting data ...

https://fr.wikipedia.org/wiki/Machine_to_machine

M2M (Machine To Machine)

- The data can be updated, deleted inside IoT...

- Discovery System,

- Registers the system status ...

M2M System
Definition 3/3

M2M platform act as a concentrator of many technologies.

→ M2M is a support for IoT as a **low level layer**,
→ IoT platform can use M2M support.
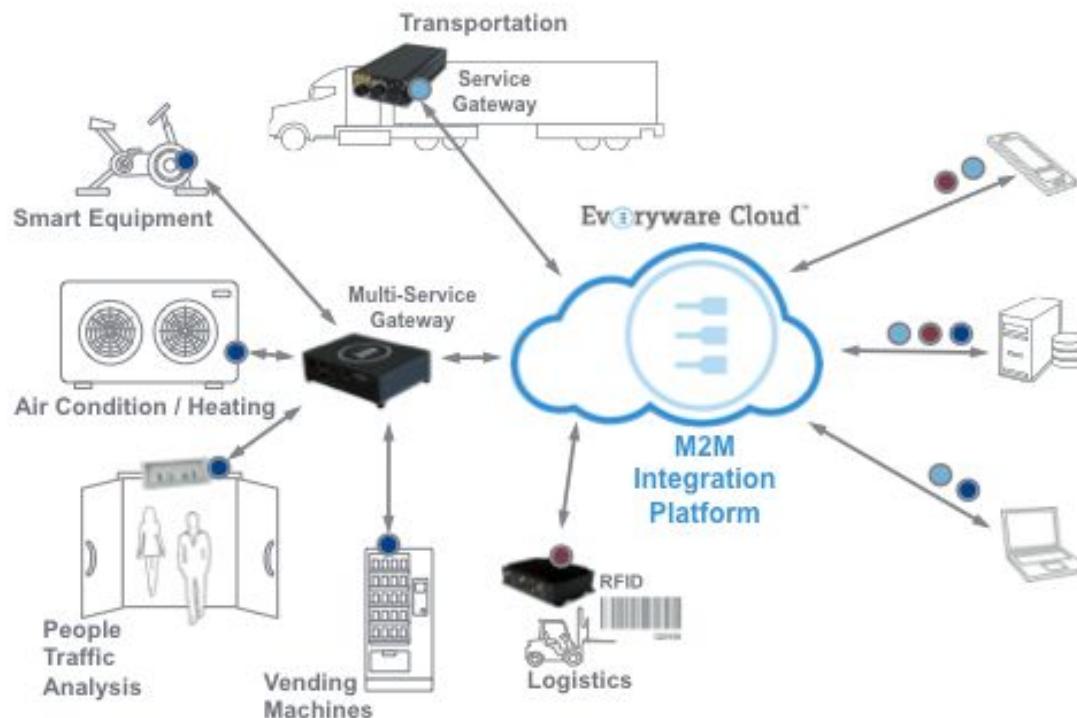
Part II

M2M System - Definition

M2M System - Global architecture

M2M System - Communication example

M2M System - Standards

M2M Open platform

Lightweight M2M

M2M impact for IoT

Big data

IoT and digital hub

M2M System
Global Architecture (ETSI)

http://www.etsi.org/

M2M Application

M2M Platform

Core Network
(converged IP)

IP connectivity
IP interworking proxy
(M2M)

Device

Ethernet

3G, 4G, 5G/NB-IoT

Wifi (Halow), Bluetooth, NFC

M2M or
native
protocol

Lora, SigFox, Wimax

ZigBee, Zwave, RFID...

Thread

6loWPAN

M2M Device

IP interworking
proxy (M2M)

Service
Capabilities

M2M
Platform

TCP/UDP/IP

Gateway

BacNet
ModBus
KNX
M-Bus

Device

IP interworking
proxy (M2M)

M2M
Platform

IP connectivity
IP interworking proxy
(M2M)

Client
Application

M2M
Platform

M2M Device

Application Domain

Network Domain

Device Domain

M2M System
Global Architecture (ETSI)

Graphic: Sensinode: Zach Shelby:
http://www.slideshare.net/zdshelby/standards-drive-the-internet-of-things
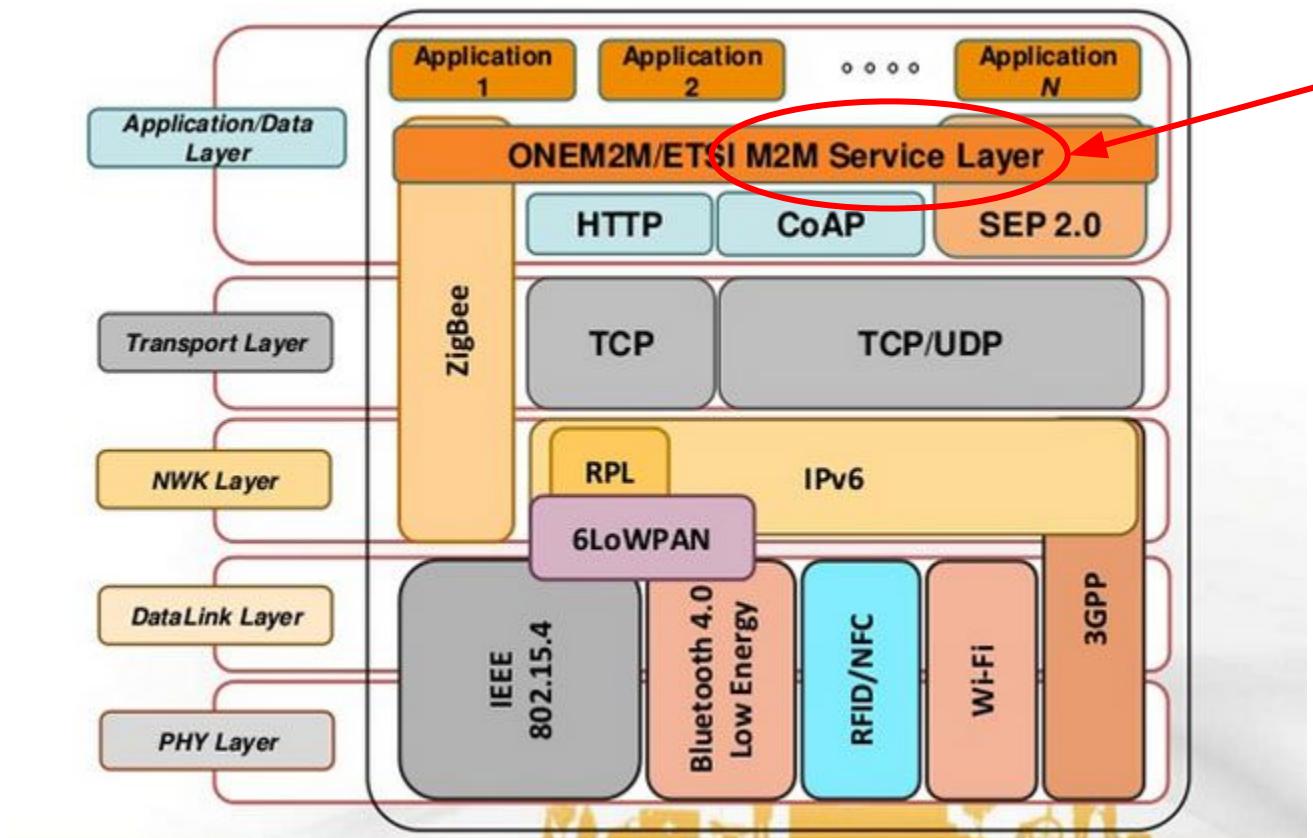
M2M System
Global Architecture (ETSI)

Configuration 1

M2M exchange protocol between M2M enable equipment.
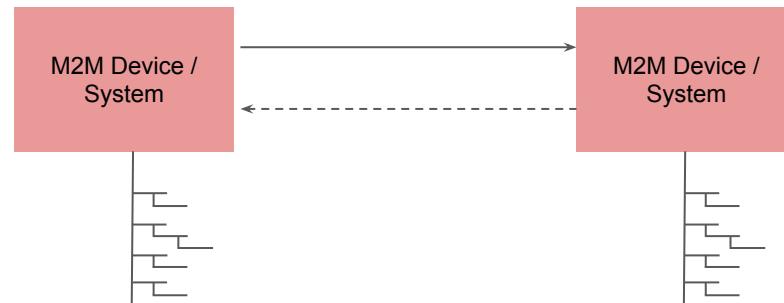
M2M System

Configuration 2

Recover system information and configuration from standard device to M2M device. This configuration allows limited communication to retrieve basic information.
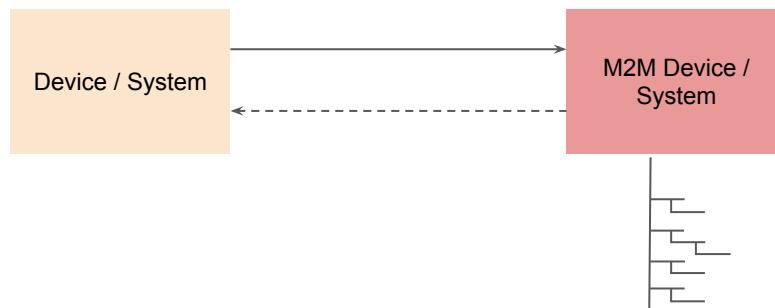
M2M System
Global Architecture (ETSI)

Configuration 3

M2M exchange between equipment through a gateway, because the device/system is not M2M enable.
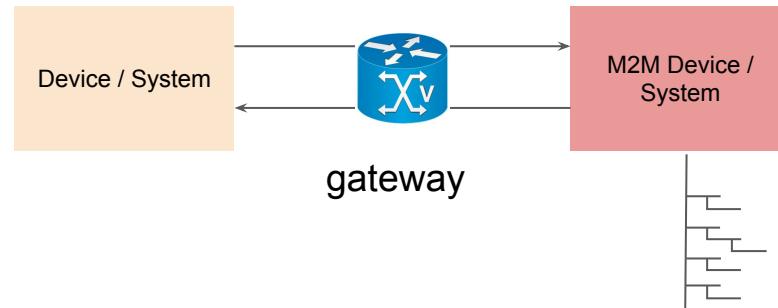
gateway

Configuration 3 - Example

M2M application

M2M Gateway
Zigbee/IP
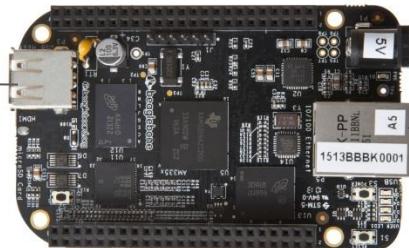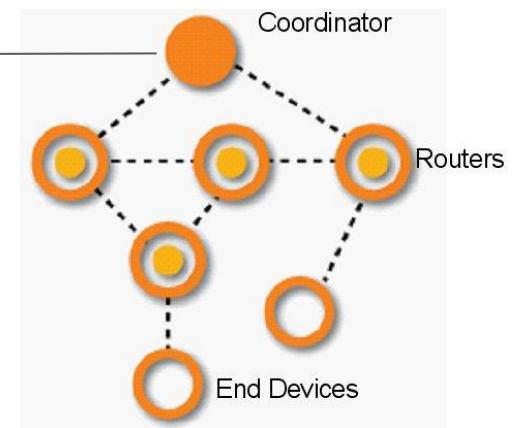
Réseau
IP

USB

Coordinator

Routers

End Devices

Part II

M2M System - Definition

M2M System - Global architecture

M2M System - Communication example

M2M System - Standards

M2M Open platform

Lightweight M2M

M2M impact for IoT

Big data

IoT and digital hub

System Architecture
## ETSI M2M communication example

M2M smart Metering Example 1

| Device Application | DA |

| Network Application | NA |

interfaces

dIa

mIa

DSCL

NSCL

ElectMeterDSCL

Device Service
Capability Layer

Applications

Scls

SmartMeteringNCSL

Network Service
Capability Layer

Applications

Scls

ETSI Service
Capability Layer

mId

Smart
Meter
Device

Smart
Metering
Server
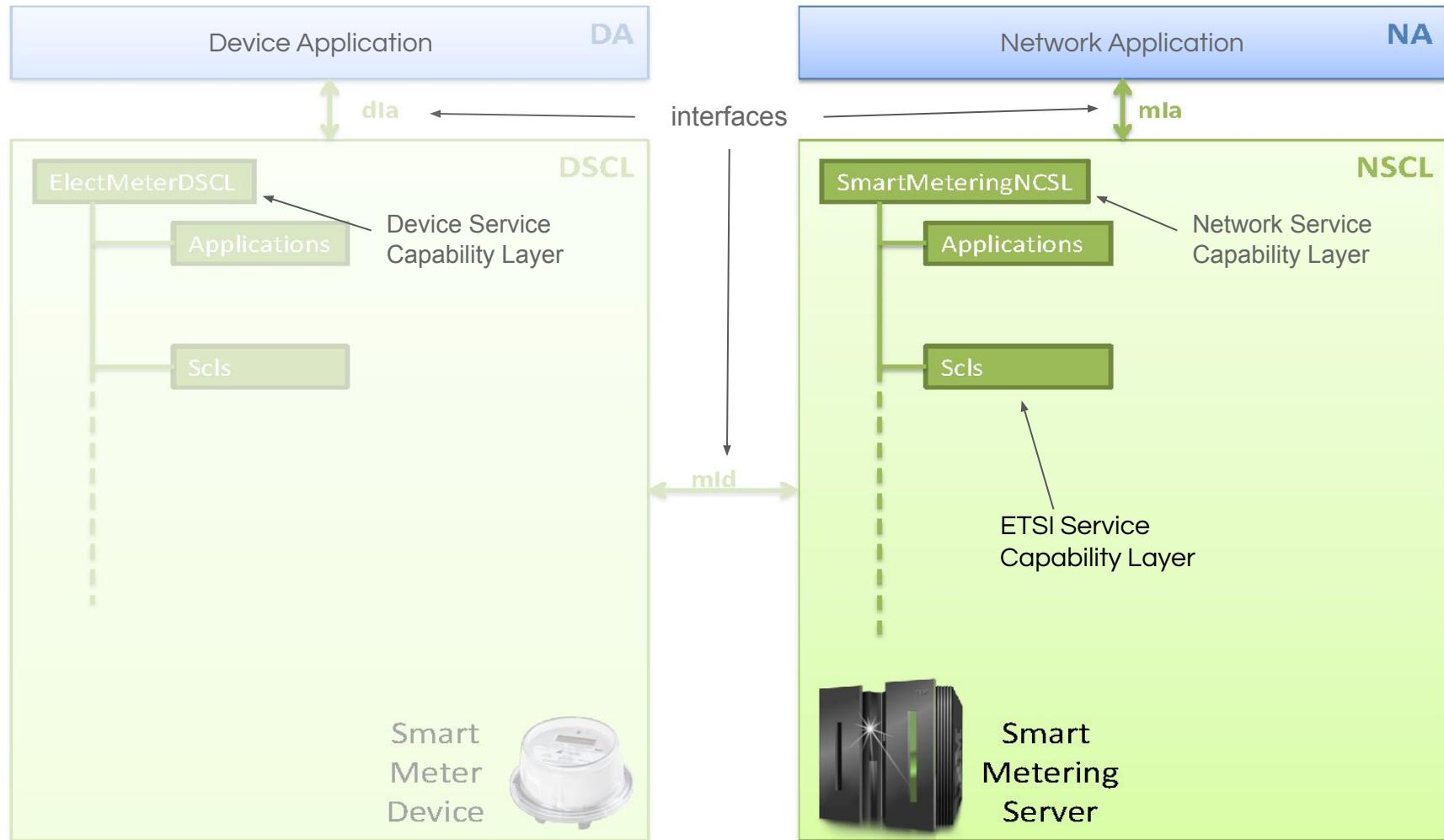
A representation of the NSCL and DSCL along with their corresponding resource structure.

System Architecture
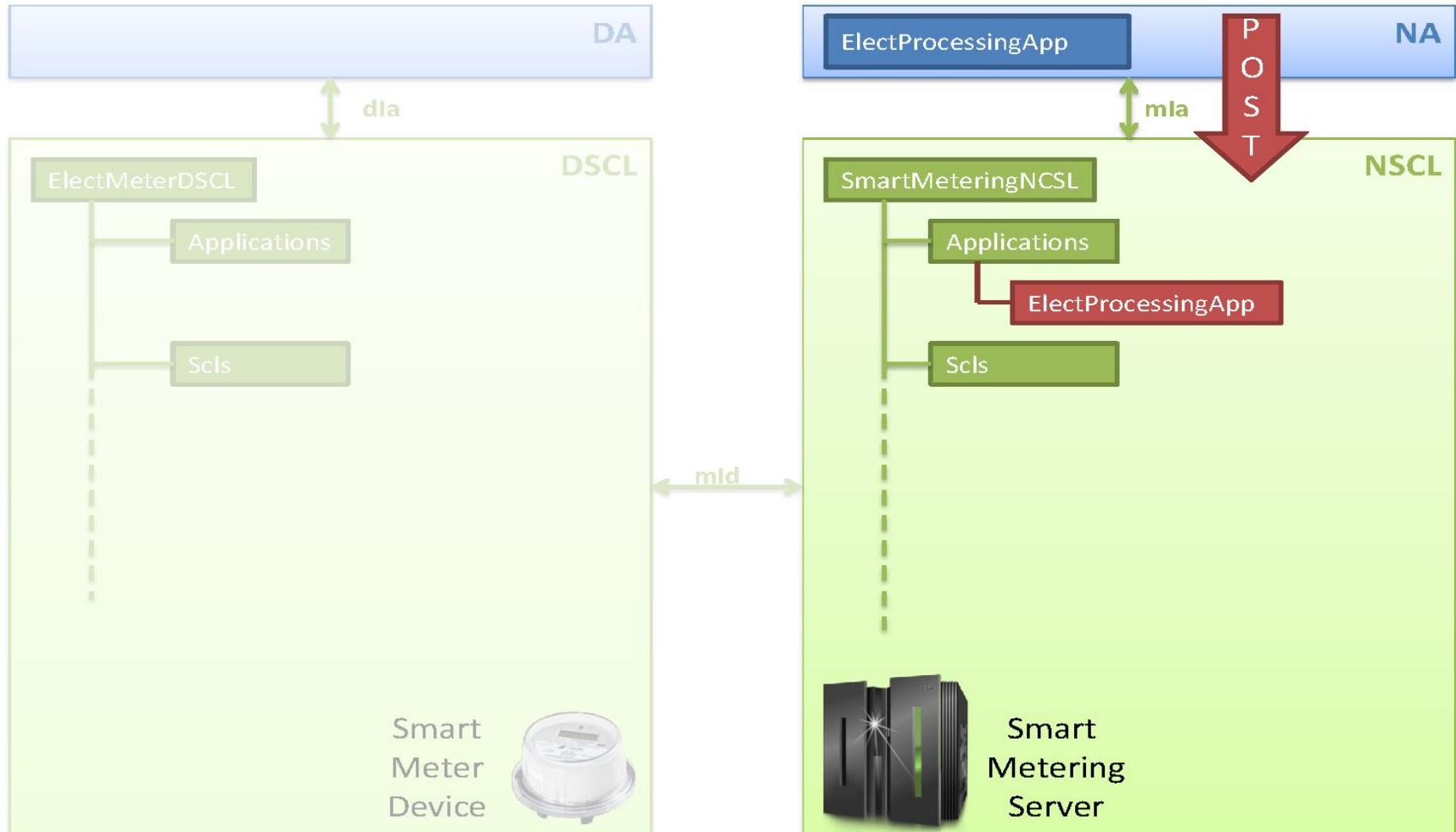
M2M smart Metering Example 1

Step 1- Network Application Registers to the NSCL

System Architecture

ETSI M2M communication example

M2M smart Metering Example 1

DA

NA

ElectProcessingApp

dIa

mIa

DSCL

NSCL

ElectMeterDSCL

SmartMeteringNCSL

Applications

Applications

ElectProcessingApp

Scls

Scls

SmartMeteringNSCL

ElectMeterDCSL

mId

POST

Smart
Meter
Device

Smart
Metering
Server

Step 3- The Smart Meter Registers to the NSCL

System Architecture
## ETSI M2M communication example

M2M smart Metering Example 1

Step 3- Device Application Registers to the DSCL

System Architecture
## ETSI M2M communication example

M2M smart Metering Example 1

ElectMeterApp | DA

P O S T

dIa

ElectProcessingApp | NA

mIa

DSCL

ElectMeterDSCL

Applications

MeterDataApp

Containers

ElectData

Scls

SmartMeteringNSCL

Smart Meter Device

NSCL

SmartMeteringNCSL

Applications

ElectProcessingApp

Scls

ElectMeterDCSL

Smart Metering Server

mId
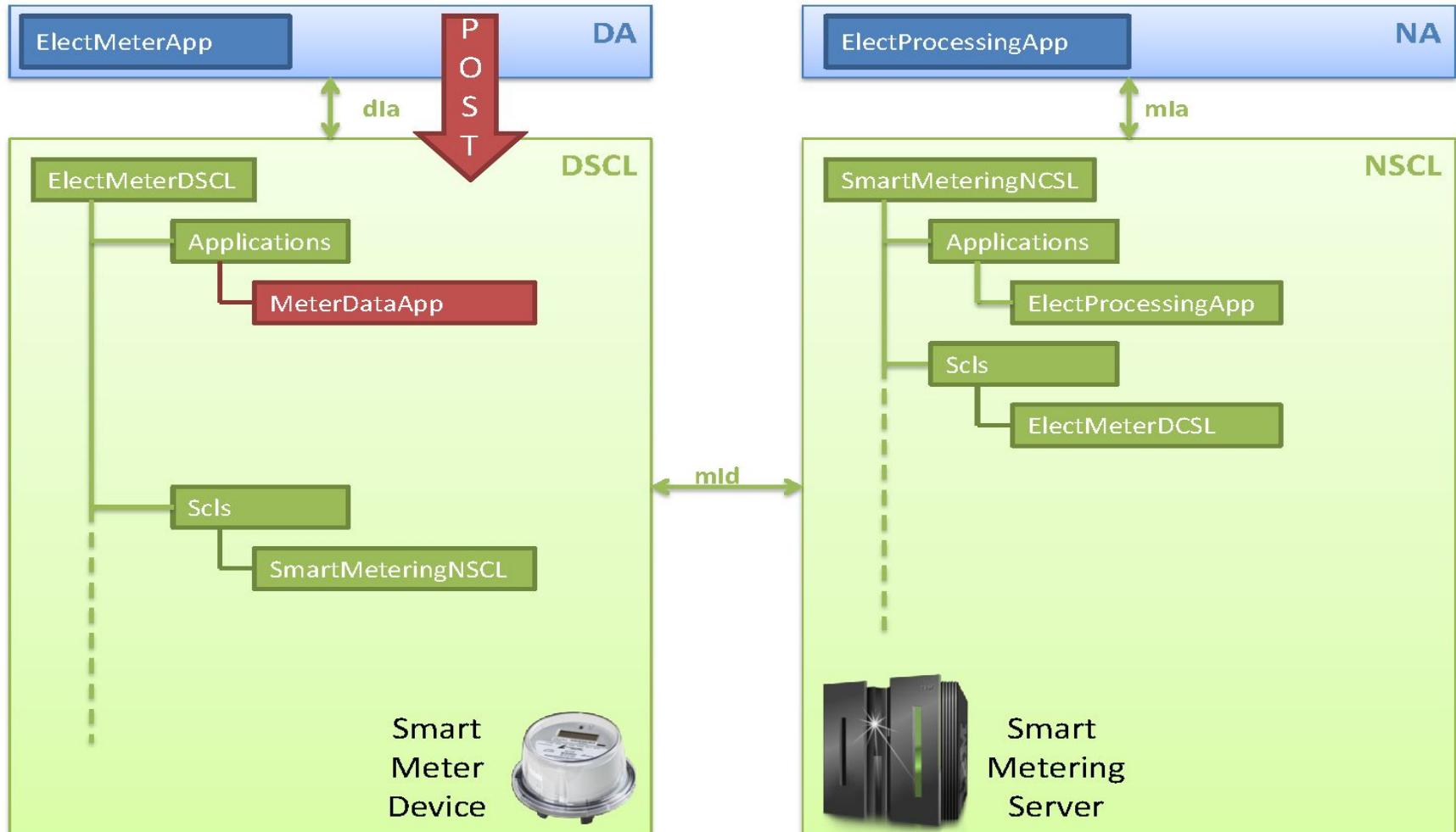
Step 4- Device Application Creates An ElectData container
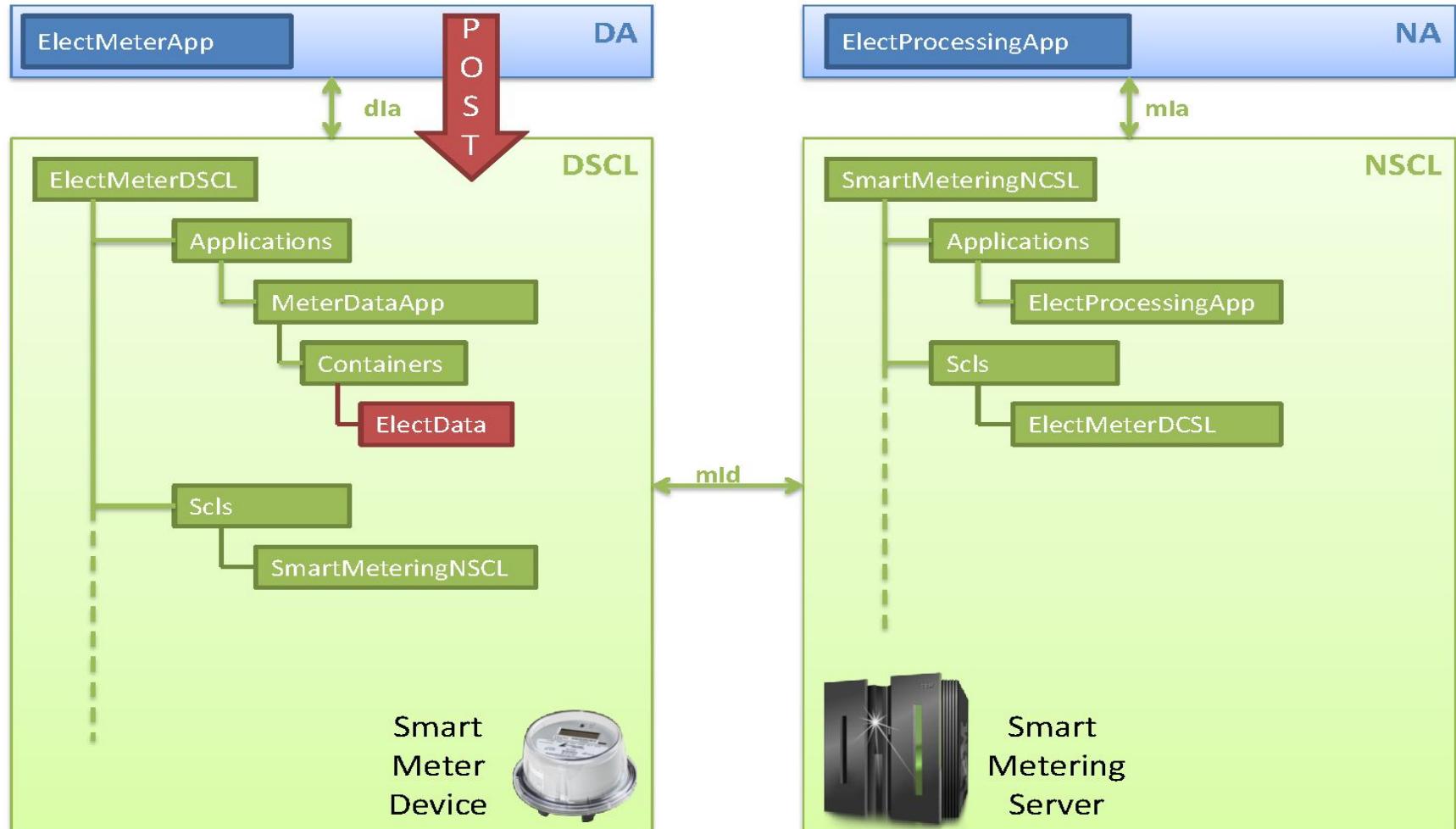
# System Architecture

M2M smart Metering Example 1
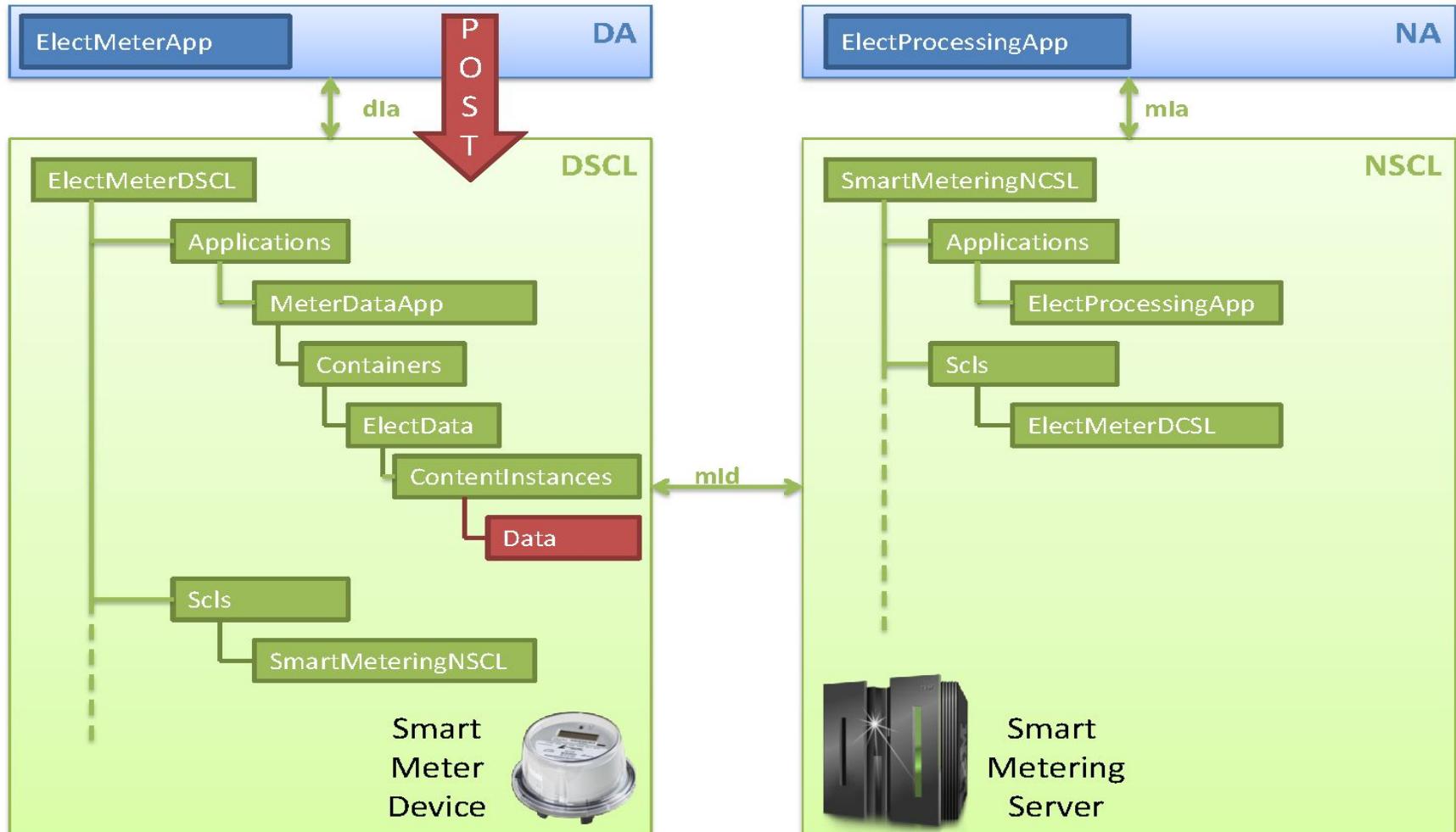
Step 5- Device Application Creates a Data contentInstane

System Architecture
## ETSI M2M communication example

M2M smart Metering Example 1

ElectMeterApp — DA

ElectProcessingApp — NA

GET

dIa

mIa

DSCL

ElectMeterDSCL

Applications

MeterDataApp

Containers

ElectData

ContentInstances

Data

Scls

SmartMeteringNSCL

mId

GET

NSCL

SmartMeteringNCSL

Applications

ElectProcessingApp

Scls

ElectMeterDCSL

Smart Meter Device

Smart Metering Server

Step 5- Network Application Read Data content Instance

System Architecture

ETSI M2M communication example

## M2M smart Metering Example 1
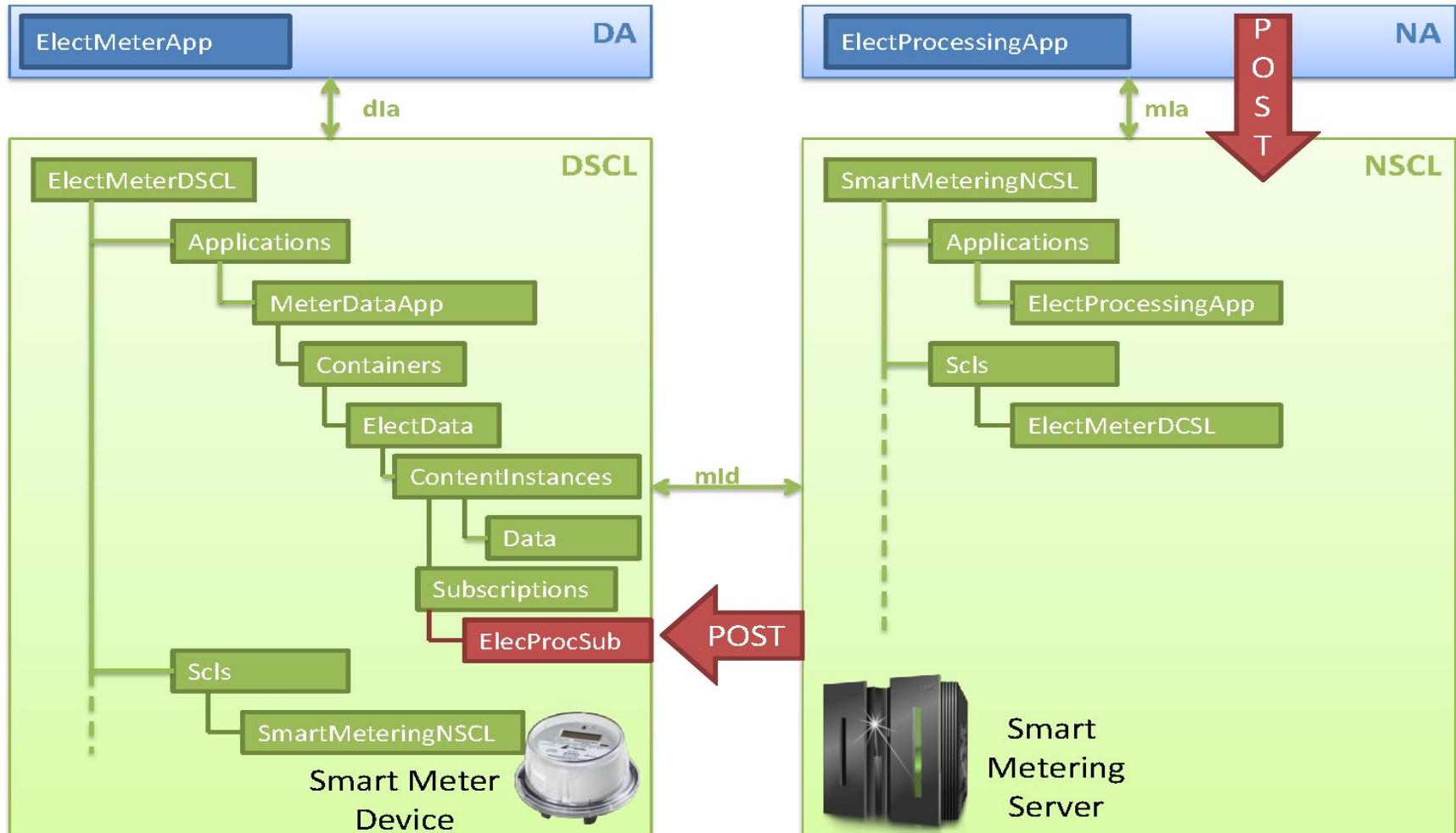
Step 5'- Network Application Create Subscription on ElectData contetnInstances

System Architecture
ETSI M2M communication example

M2M smart Metering Example 1
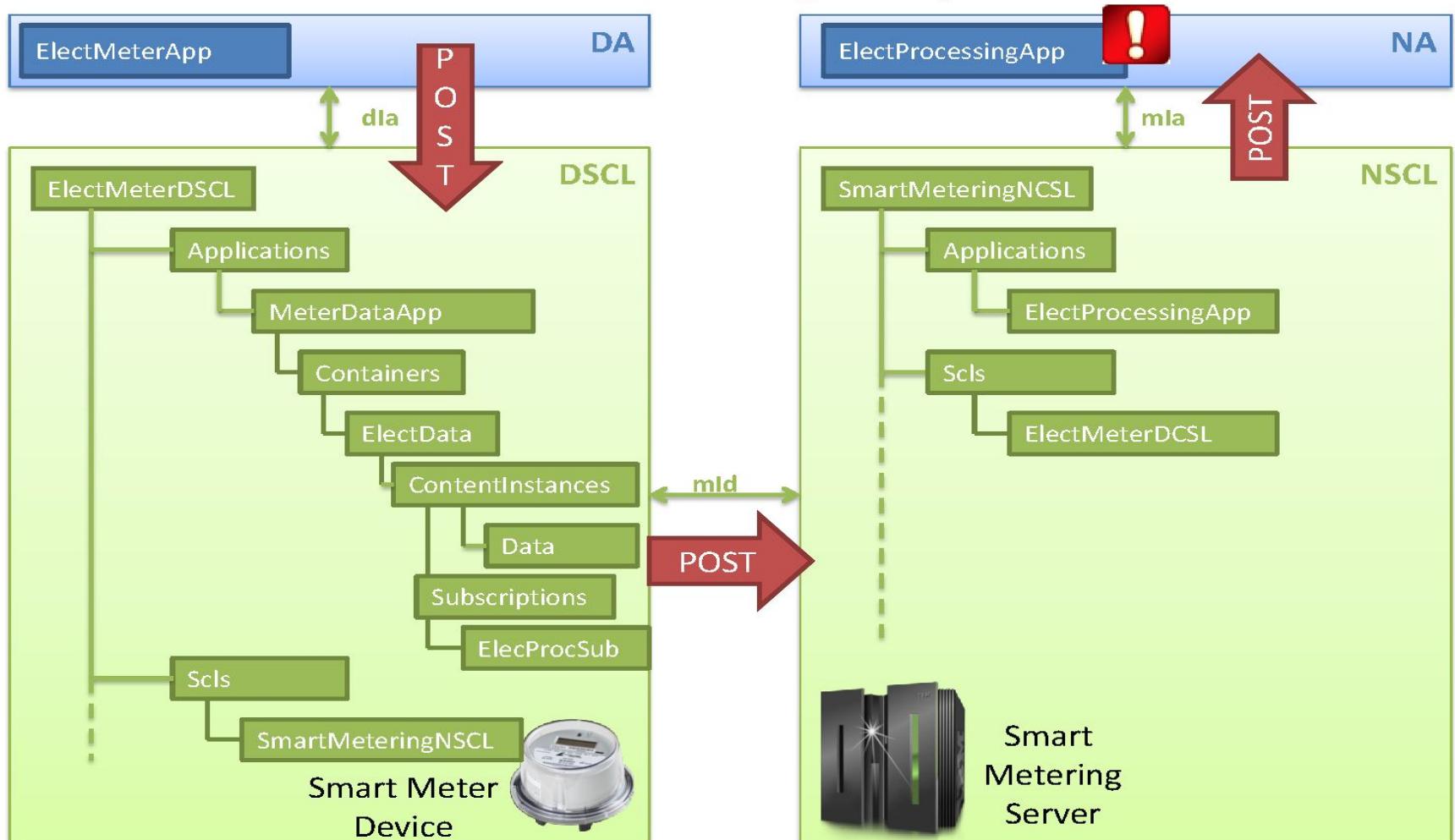
Step 6'- Network Application receives notification

M2M smart Metering Example 2

DA		NA

dIa   mIa

DSCL
- ElectMeterDSCL
  - Applications
  - Scls

NSCL
- SmartMeteringNCSL
  - Applications
  - Scls

mId

Smart Meter Device
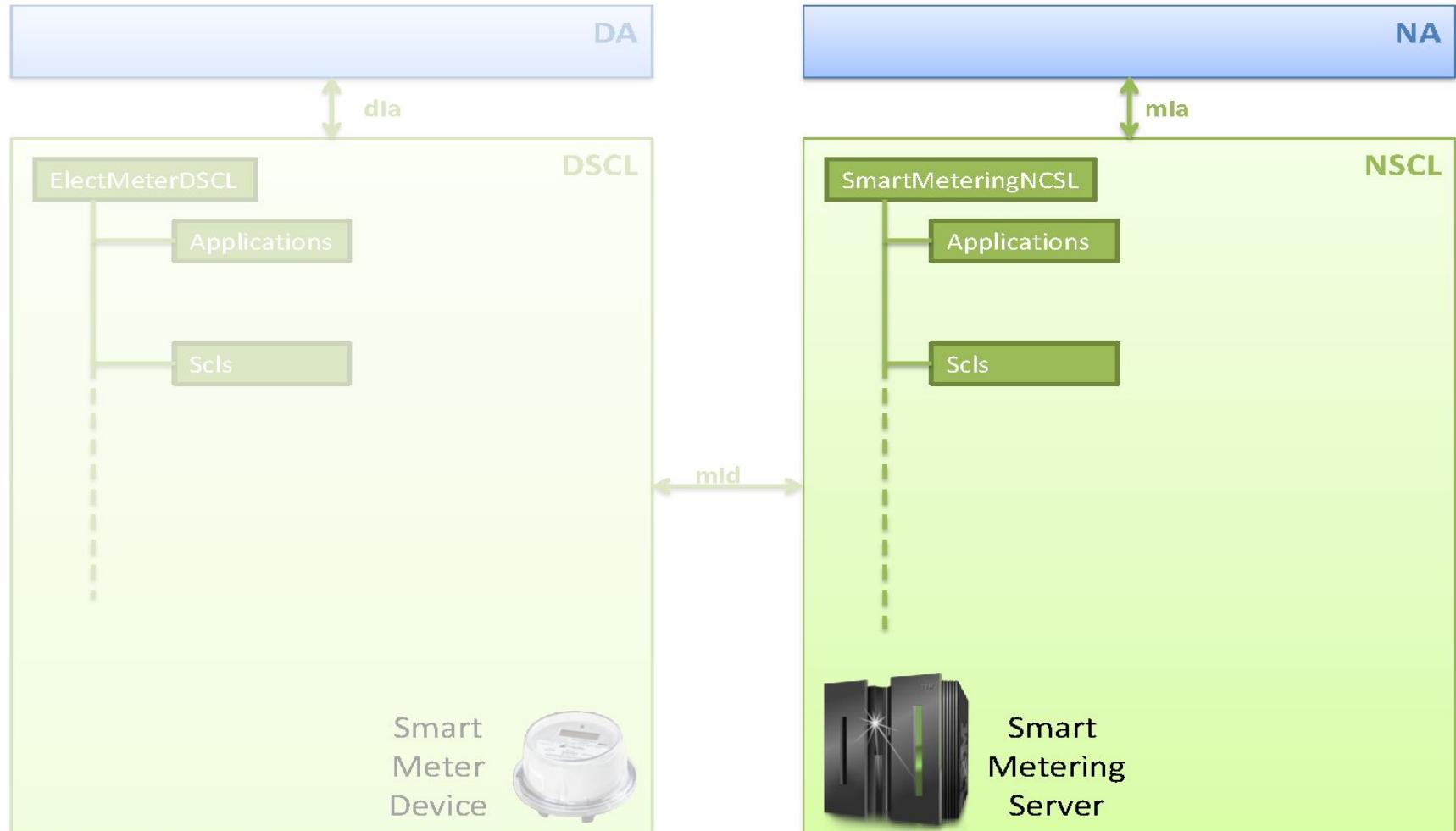
Smart Metering Server

A representation of the NSCL and DSCL along with their corresponding resource structure.
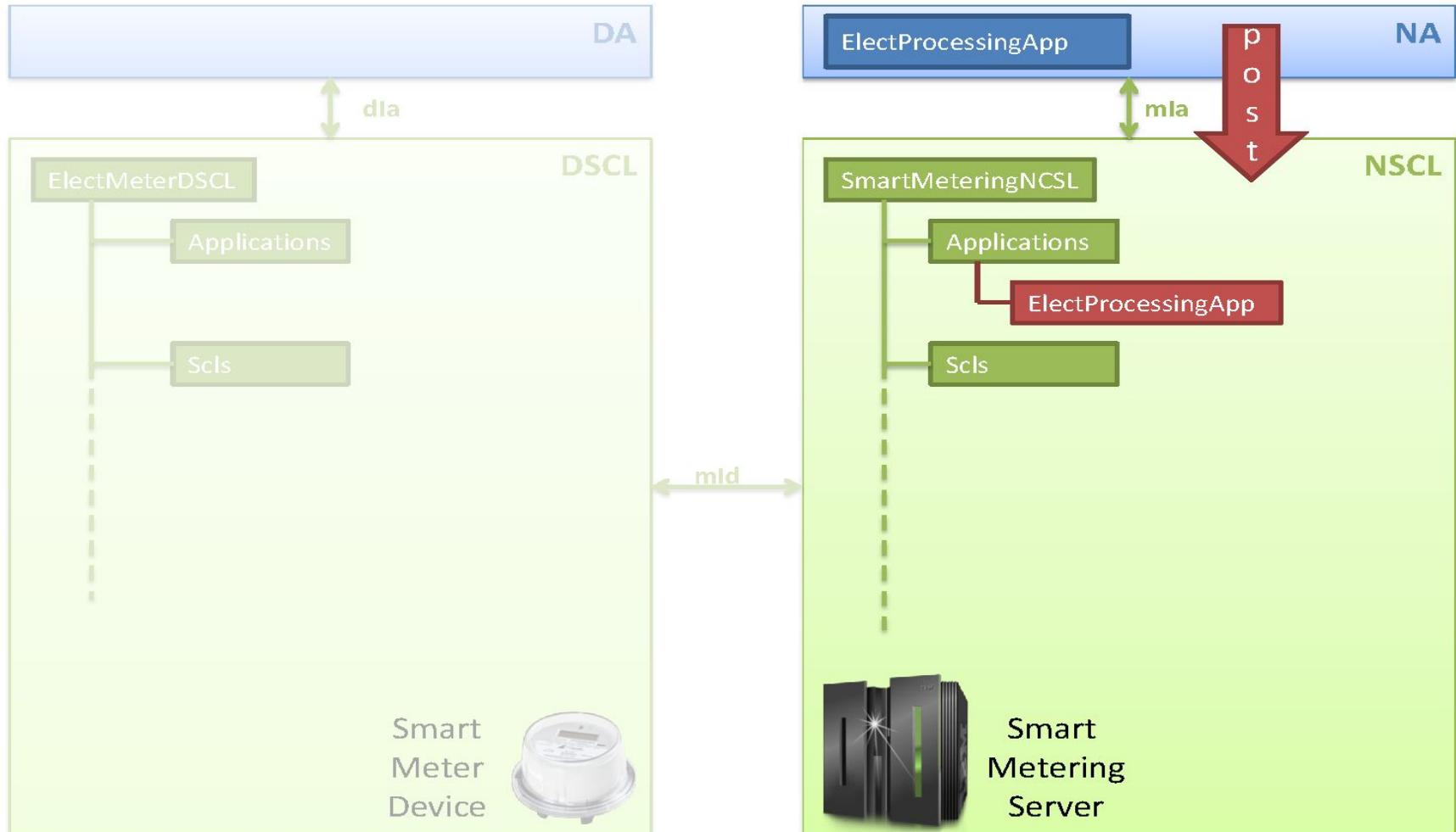
M2M smart Metering Example 2

Step 1- Network Application Registration to the NSCL

M2M smart Metering Example 2
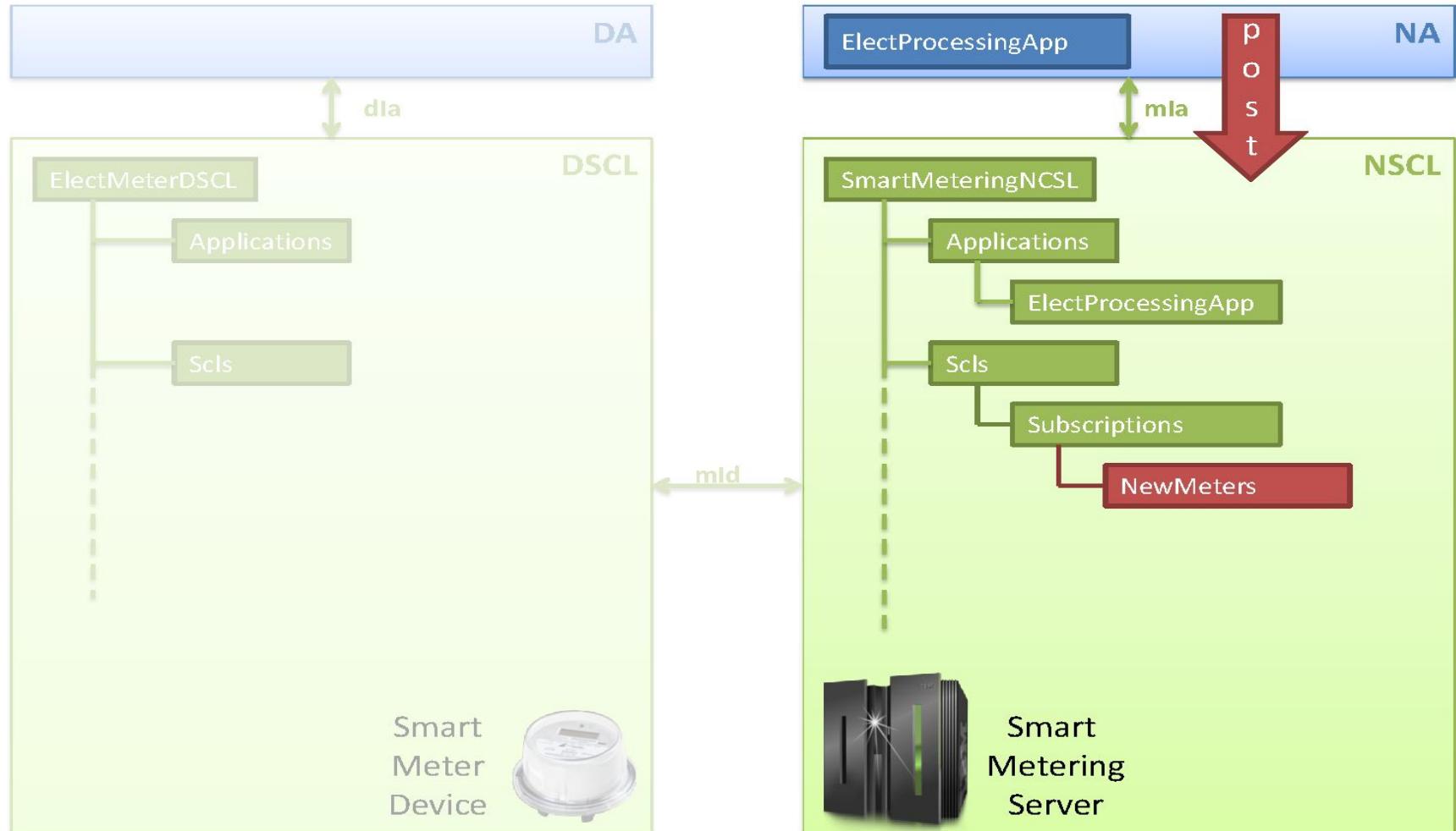
Step2- NA Subscribes for Registering Smart Meters

System Architecture
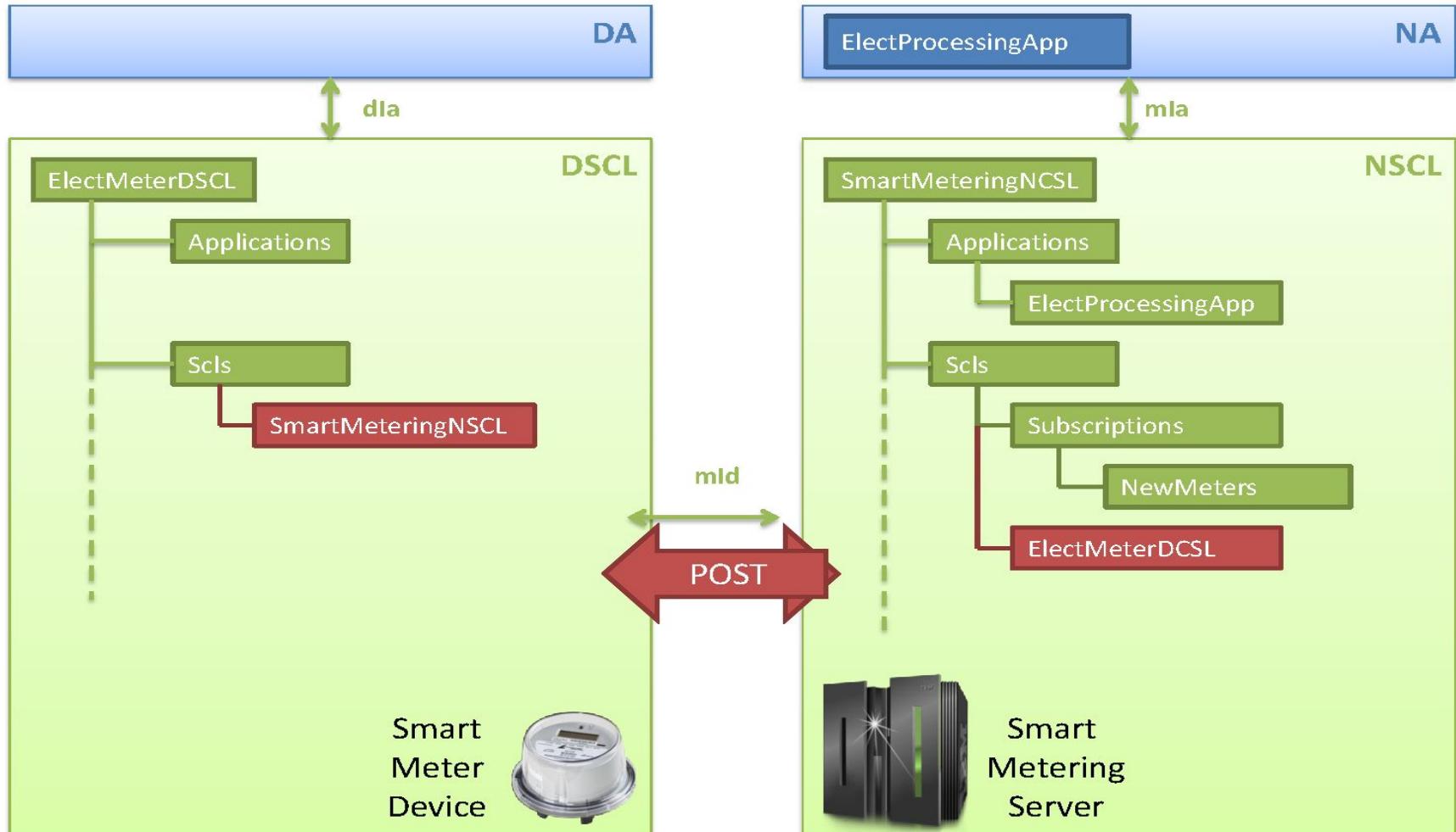
ETSI M2M communication example

M2M smart Metering Example 2

Step 3- The Smart Meter Registers to the NSCL

System Architecture
ETSI M2M communication example

M2M smart Metering Example 2

DA

ElectProcessingApp

NA

dIa

POST

mIa

DSCL

ElectMeterDSCL

Applications

Scls

SmartMeteringNSCL

NSCL

SmartMeteringNCSL

Applications

ElectProcessingApp

Scls

Subscriptions

NewMeters

ElectMeterDCSL

mId

Smart Meter Device

Smart Metering Server
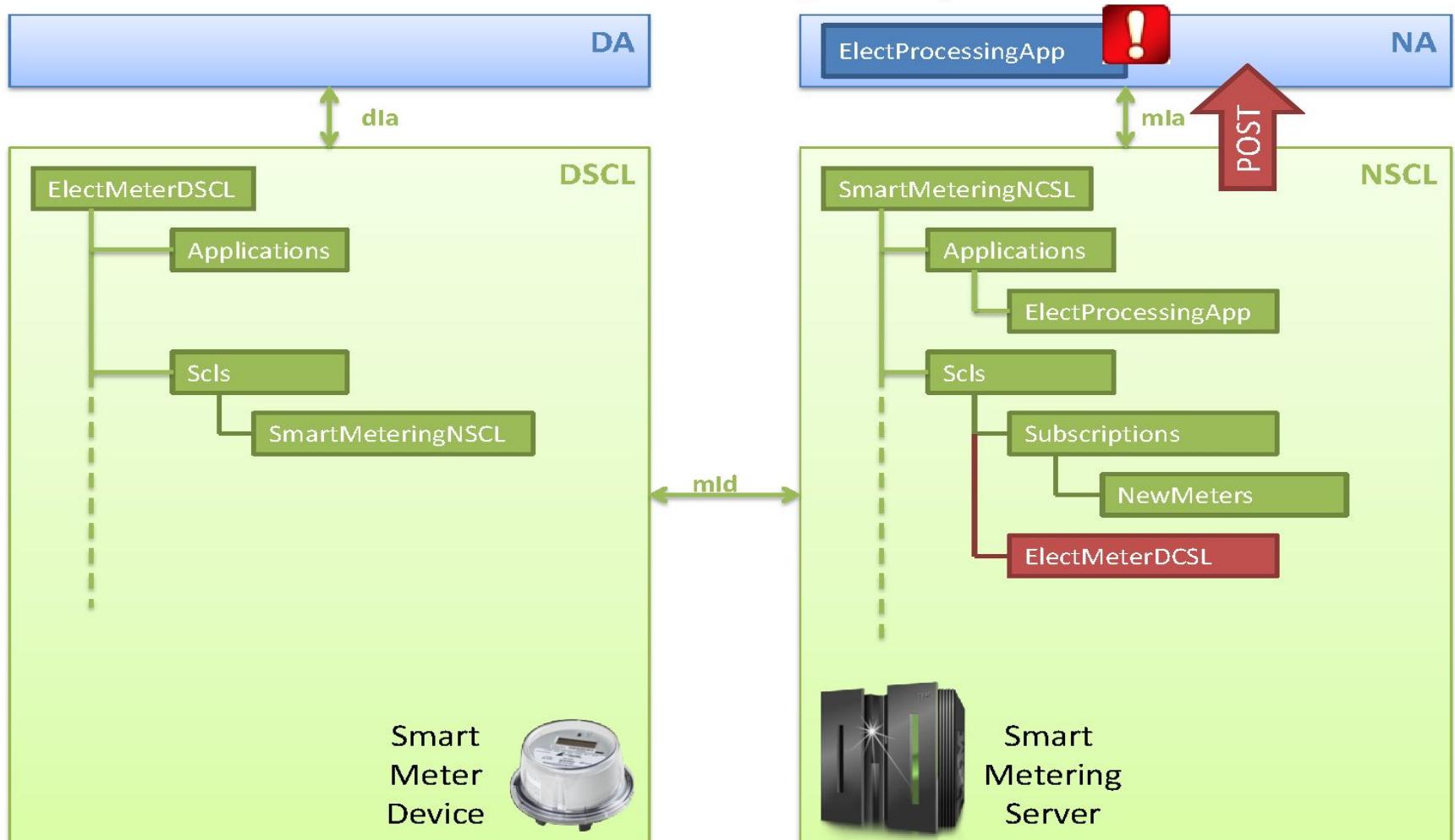
Step 4- Notifying the Network Application about a Registered Smart Meter

System Architecture
ETSI M2M communication example


M2M smart Metering Example 2
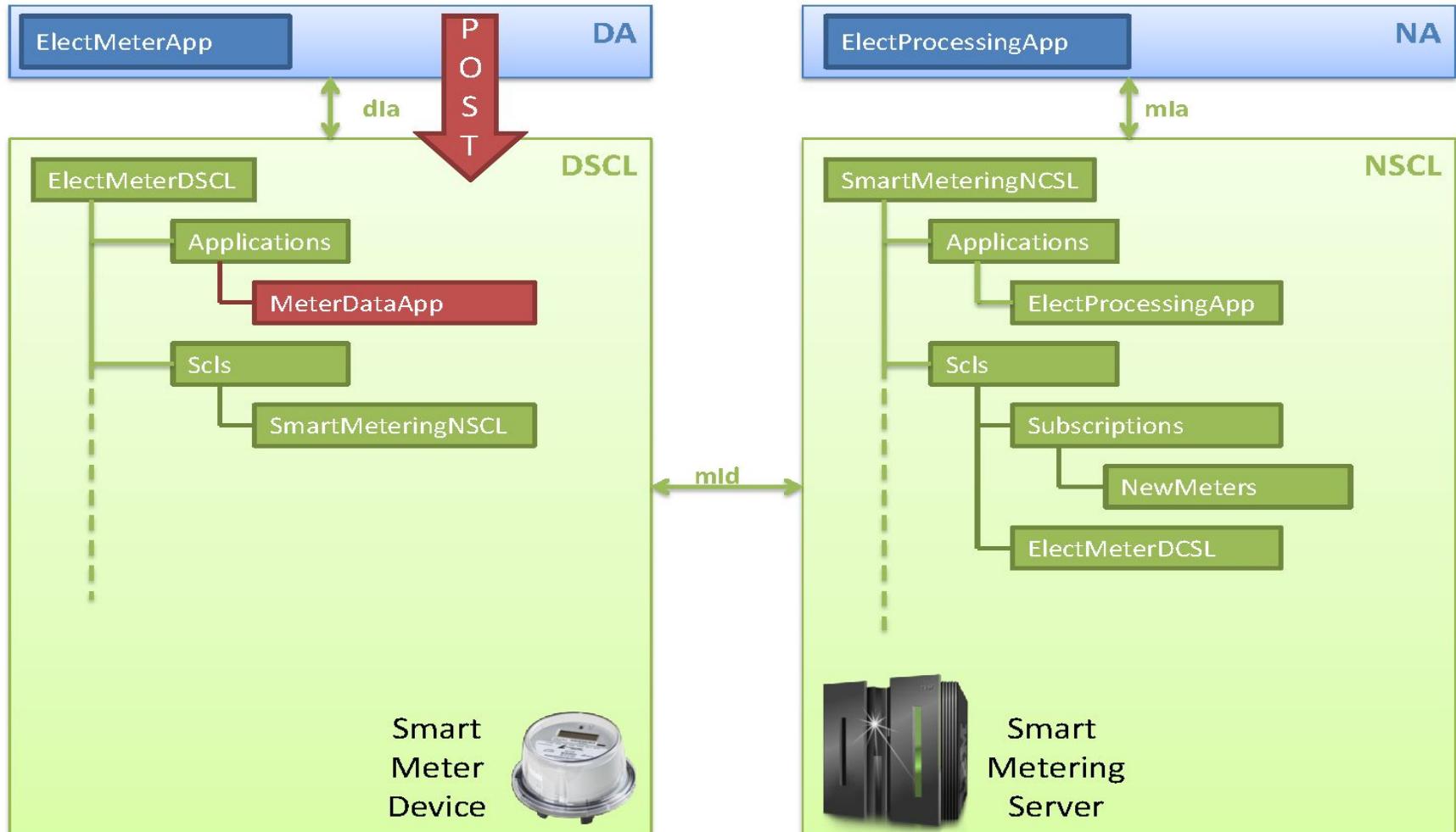
Step 5- Device Application Registration to the DSCL

System Architecture
ETSI M2M communication example

M2M smart Metering Example 2
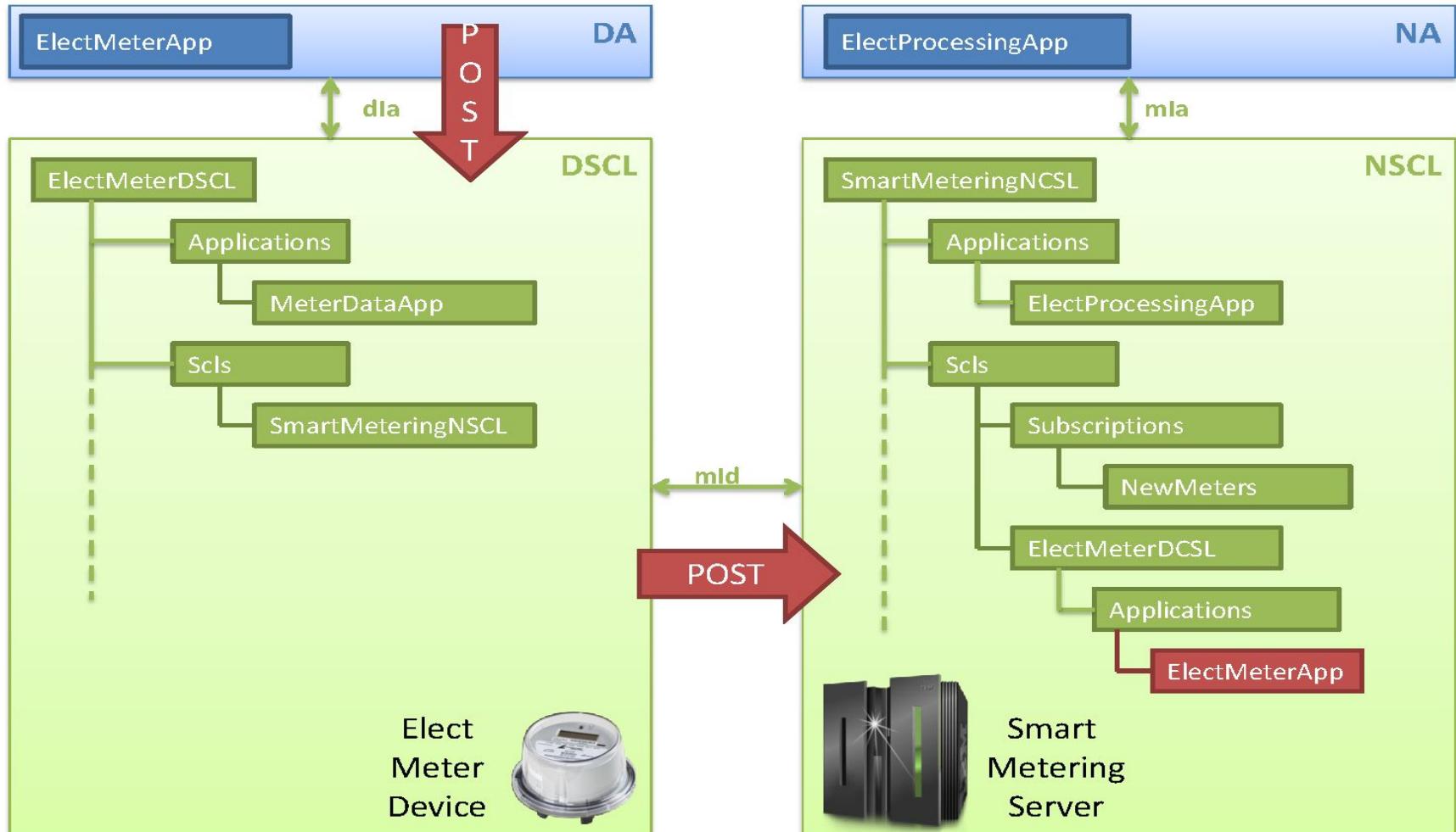
Step 6- Announcing a Registered DA to the NSCL

M2M smart Metering Example 2
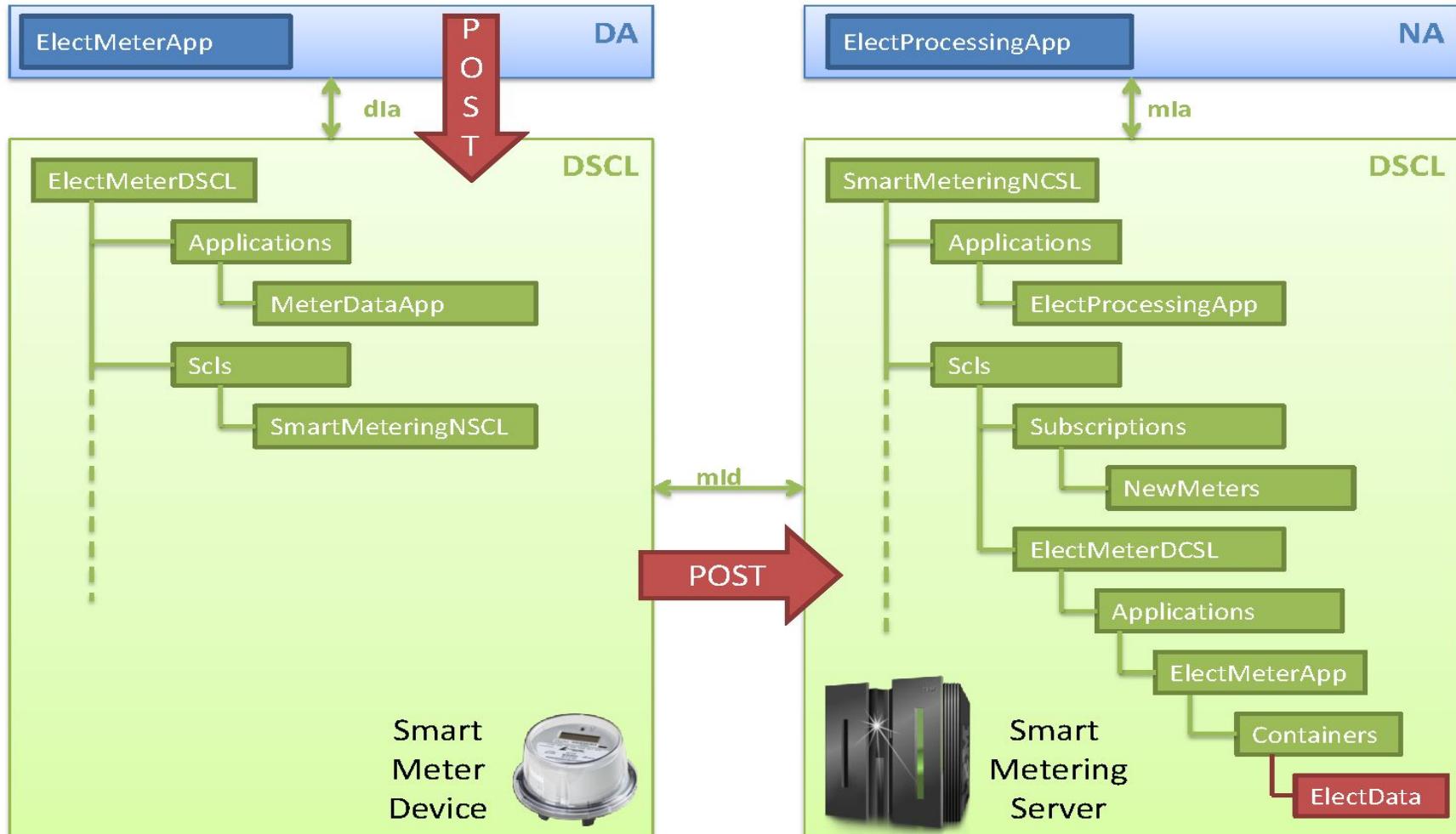
Step 7- Reporting Meter Data through the Use of Container Resource

Part II

M2M System - Definition

M2M System - Global architecture

M2M System - Communication example

M2M System - Standards

M2M Open platform

Lightweight M2M

M2M impact for IoT

Big data

IoT and digital hub

M2M System
M2M Standards

https://en.wikipedia.org/wiki/Standards_organization

How are M2M standards organized?

- **De facto** standard (Google, Yahoo, others industrials …): no compatibility with other systems,

- **SDO** (Standard Development Organisation: ETSI, ANSI …,): Standard but no implementation,

- **Open Source** Projects: many projects with little standardization, sometimes absorbed by the SDO,

- **Alliance** (industrials + SDO): Participation of manufacturers in the development and implementation of standards.

M2M System
M2M Standards - ETSI

European Telecommunications Standards Institute (ETSI)

- Independent, not-for-profit, standardization organization in the telecommunications industry,

- Headquartered in Sophia-Antipolis, France,

- ETSI inspired the creation of OneM2M with 3GPP.

- Full member
- Associate member
- Observers

M2M System
M2M Standards - 3GPP "Organizational Partners" - OneM2M

(http://www.3gpp.org/)
http://www.3gpp.org/images/presentations/2016_11_3gpp_Standards_for_IoT.pdf

---

The **3rd Generation Partnership Project** (3GPP) unites telecommunications standard development organizations acts as an "Organizational Partners", example for OneM2M :

- **ARIB**: Association of Radio Industries and Businesses, Japan
- **ATIS**: Alliance for Telecommunications Industry Solutions, US
- **CCSA**: China Communications Standards Association
- **ETSI**: European Telecommunications Standards Institute
- **TSDSI**: Telecommunications Standards Development Society, India
- **TTA**: Telecommunications Technology Association (TTA), Korea
- **TTC**: Telecommunication Technology Committee, Japan

Alliance: industrial + SDO*

- Participation of manufacturers in the development and implementation of standards,

- **Very active structures** that develop operational products for the industry (compatibility testing, …),

- Permanent Industrial lobbying.

*(Standard Development Organisation)

Today OneM2M is the most representative standard.

M2M / ETSI:

- Initiates Advanced Specifications for M2M Systems,

- Proposes with the 3GPP a merger of the international M2M specifications to guarantee the interoperability of M2M systems worldwide.

OneM2M / 3GPP:

- Participation of SDOs from several countries to propose an international standard for M2M systems,

- The impact of the standard M2M ETSI is very important because far ahead of other sdo.

M2M System
M2M Standards - M2M - OneM2M

Today OneM2M is the most representative standard.

(http://www.3gpp.org/)

The oneM2M standardization work is split in 5 **W**ork **G**roup:

- **WG1:** Requirements,

- **WG2:** Architecture,

- **WG3:** Protocols,

- **WG4:** Security,

- **WG5:** Management, Abstraction and Semantics.

M2M System
M2M Standards

What M2M standard does not offer ?

- M2M standard are not always compatible with each other, but can offer gateways (data representation, architecture ...),

- All the transport protocols are not all taken into account, it depends on the implementation,

- A standard can have several different implementations with more or less successful integration levels,

- There are implementations specific to certain environments (industrial electronics, real time ...) ...

M2M System

M2M Standards

OneM2M
Fiware
BUTLER
OpenIoT
IoT-A

AllJoyn
OneM2M

OneM2M
AllJoyn
OPEN INTERCONNECT

M2M System

Main criterias for choosing an M2M system:

- Standard (Europe, USA, Asia …),

- M2M interoperability,

- Scalability,

- Security,

- Small memory footprint for embedded systems,

- Open platform: turnkey infrastructure, which does not follow standard but offers plugin.

- Data mining …

M2M System

M2M Standards - Platform

Open Plateforme

OpenIoT

Fiware

OpenInterconnect

IoT-A

AllJoyn

Universaal

OneM2M

Architecture
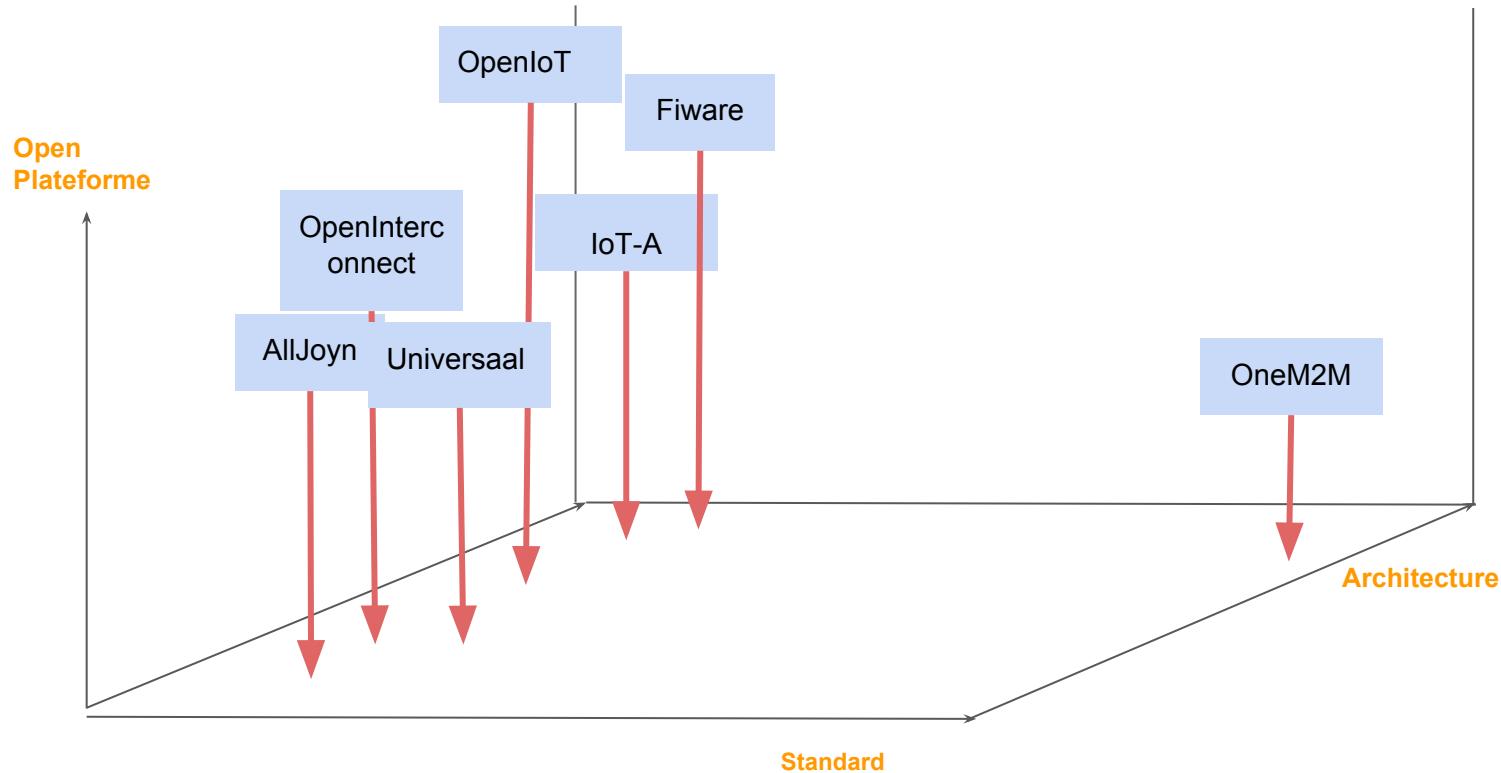
Standard

KAA Mango Nimbits Butler ...

M2M System
M2M Standards - ETSI M2M specification

`http://www.etsi.org/technologies-clusters/technologies/internet-of-things`

Machine-to-Machine communications: **Functional architecture**: ETSI TS 102 690 V1.1.1 (2011-10)


The M2M Service Capabilities are both at **network level** (M2M Service Capabilities in the Network Domain) and at **local level** (M2M Service Capabilities in the **M2M Gateway** and in the M2M Device).

Reference points

ETSI TS 102 690 V1.1.1 (2011-10) - P79

Data <scl>

```
        <scl>
1 |   m
  |         "attribute"
  |   1
  |         containers
  |   1
  |         groups
  |   1
  |         applications
  |   1
  |         accessRights
  |   1
  |         subscriptions
  |   1
  |         mgmtObjs
  |   1
  |         notificationChannels
  |   1
  |         m2mPocs
  |   1
  |         deviceInstances
```
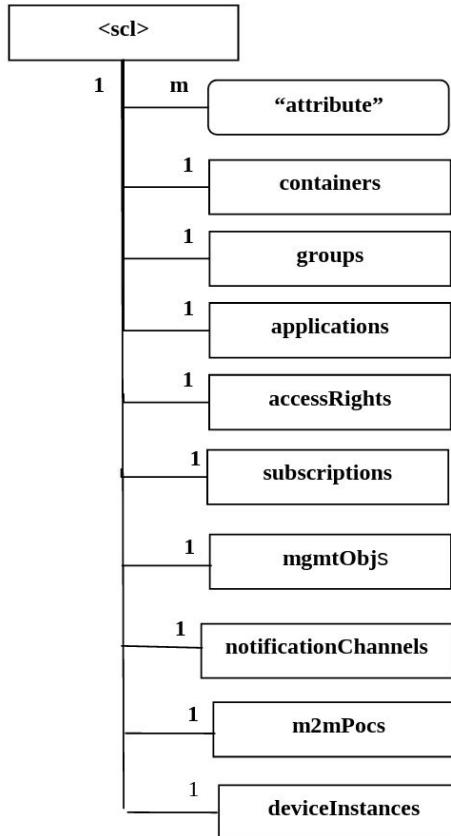
"An <scl> resource shall represent a remote SCL that is registered to the containing <sclBase> . This means that each remote SCL that is registered with the <sclBase> shall be represented by an <scl> resource in that <sclBase> (the registered remote SCL). "

M2M System

M2M Standards - OneM2M (ETSI implementation)

http://www.onem2m.org/technical/developers-corner/tools/open-source-projects

- OCEAN, open alliance for IoT standard,

- IOTDM,

- **OM2M**, hosted by the Eclipse Foundation (LAAS/CNRS),

- ATIS,

- OASIS SI...

M2M System
M2M Standards - OneM2M interoperability

http://www.onem2m.org/technical/published-documents

oneM2M enable interconnection across devices and applications:

OneM2M platform

| OPC UA | AllSeen | OCF | OMA LightWeightM2M |
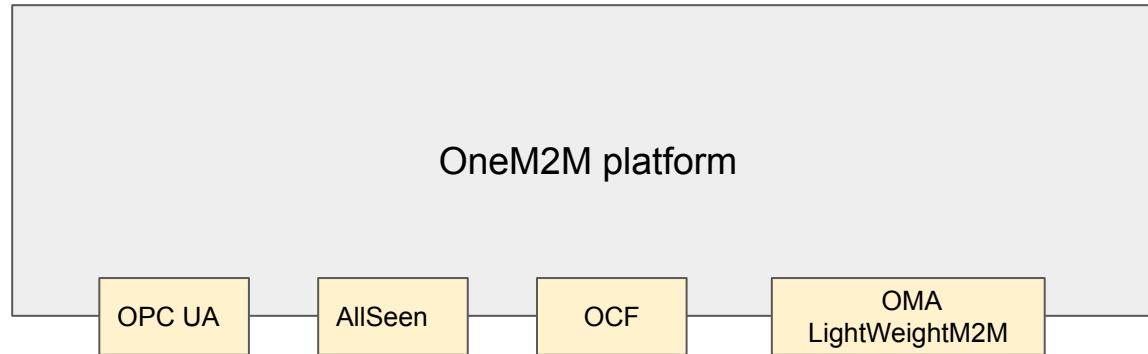
M2M System
M2M Standards - IEEE M2M

IEEE P2413

"This standard defines an architectural framework for the Internet of Things (IoT), including descriptions of various IoT domains, definitions of IoT domain abstractions, and identification of commonalities between different IoT domains."

Part II

M2M System - Definition

M2M System - Global architecture

M2M System - Communication example

M2M System - Standards

M2M Open platform

Lightweight M2M

M2M impact for IoT

Big data

IoT and digital hub

M2M System
Open platform

- Open platforms are open source projects,

- Can use M2M standards or not,

- Open platforms can be installed as public, private,

- Open platforms can offer a vertical architecture and M2M behaviour,

M2M System

Open platform - Service and implementation

- Open platforms offer more integrated services (data analysis, data storage, security ...),

- Most open platforms are not true standards (depending on the implementation),

- Open platforms can provide gateways to other M2M systems.

M2M System
Open platform - Fiware

https://www.fiware.org/

European project Fiware:

- M2M or simple IoT with transport protocol,

- Integrated services (big data, data analysis),

- Uses Docker components,

- Private or public platform ...

- Plugin to other M2M systems such as OneM2M,

- Easy to use for testing...

M2M System

Open platform - Fiware
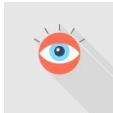
Orion Context Broker allows you to model, manage and gather context information at large scale enabling context-aware applications.

Real time processing of Context Events

Publication of Context Information as Open Data

Creating Application Dashboards

Real time processing of Media Streams
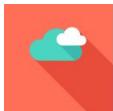
Hosting your Application on a FIWARE Cloud

M2M System

Open platform - Fiware

Big Data Analysis of Historic Context Information

Connection to the Internet of Things

Handling Authorization & Access Control to APIS

M2M System
Open platform - Fiware

Tools
- CDE Manager
- GEI Catalogue
- IDE pugins
- eLearning System
- SoPeCo
- PROSA
- Trace Analyzer
- UFT Framework
- USDL editor

Applications and Services
- Future Internet applications
- Services

Security
- Access Control
- Identity Management
- Data Handl.
- DB Anonym
- Monitoring
- Android Flow
- Content-based Security
- Context-based Security
- Malware Detection
- Secure Storage

Apps / Business Framework
- Application Mashup
- Store
- Service Mashup
- LightSem Comp.
- BEMES
- Marketplace
- Service Composition
- Registry
- RSS
- Repository
- Mediation

Data
- PubSub Broker
- BigData Analysis
- Metadata pre-processing
- Query Broker
- Semantic Annotation
- Comp. Video Analysis
- CEP
- Location Platform
- Semantic App Support

IoT
- (B) Device Management
- (GW) Device Management
- (B) Configuration Management
- (GW)Protocol Adapter
- (B) IoT Broker
- (GW)Data Handl

Cloud
- DataCenter Mngmt
- Service Mngmt
- Edgelets Mngmt
- Job Scheduler
- VM provisioning
- Monitoring
- CloudProxy (I2ND)
- Object Storage

Advanced Middleware & Web UI
- 2D-UI
- 3D-UI
- Synchronization
- Real/Virtual Interaction
- 2D/3D Capture
- GIS Data Provider
- Interface Designer
- Virtual Characters
- POI Data Provider
- Middleware
- Augmented Reality
- Cloud Rendering

I2ND
- Connected Device
- Network Inf&Cntrl
- Service, Cap Conn & Contr
- CloudProxy (I2ND)

Infrastructure
- Transport Networks
- End User Devices
- Devices (IoT)
- Application Server
- Access Networks
- Machines (e.g. virtual)

Premise (existing Backend Systems)
- Charging
- Monitoring
- Payment
- Booking & OrderMngt

Actors:
- customer
- customer
- value-added service provider
- domain experts
- developer
- service/content provider
- marketplace provider
- network infrastructure provider
- platform infra. provider

Legend
- FI-WARE GE v3
- FI-WARE GE v2
- FI-WARE GE v1
- actor
- External component or artifact

155

M2M System

M2M Standards - Dimension for IoT interoperability

Northbound: back-end apps, Analytics ...

Eastbound: cloud and big data

Southbound: Devices, gateways
and access technologies

# M2M System
Open platform - Fiware

M2M System
Open platform - Fiware

sensor/actuator

M2M System
Open platform - Fiware

https://forge.fiware.org/

This scenario stands for a simple integration of IoT devices into the Data chapter ContextBroker.

M2M System
Open platform - Fiware

https://forge.fiware.org/

This scenario describes a use case where IoT end nodes or at least intermediate Gateways implement the NGSI protocol.
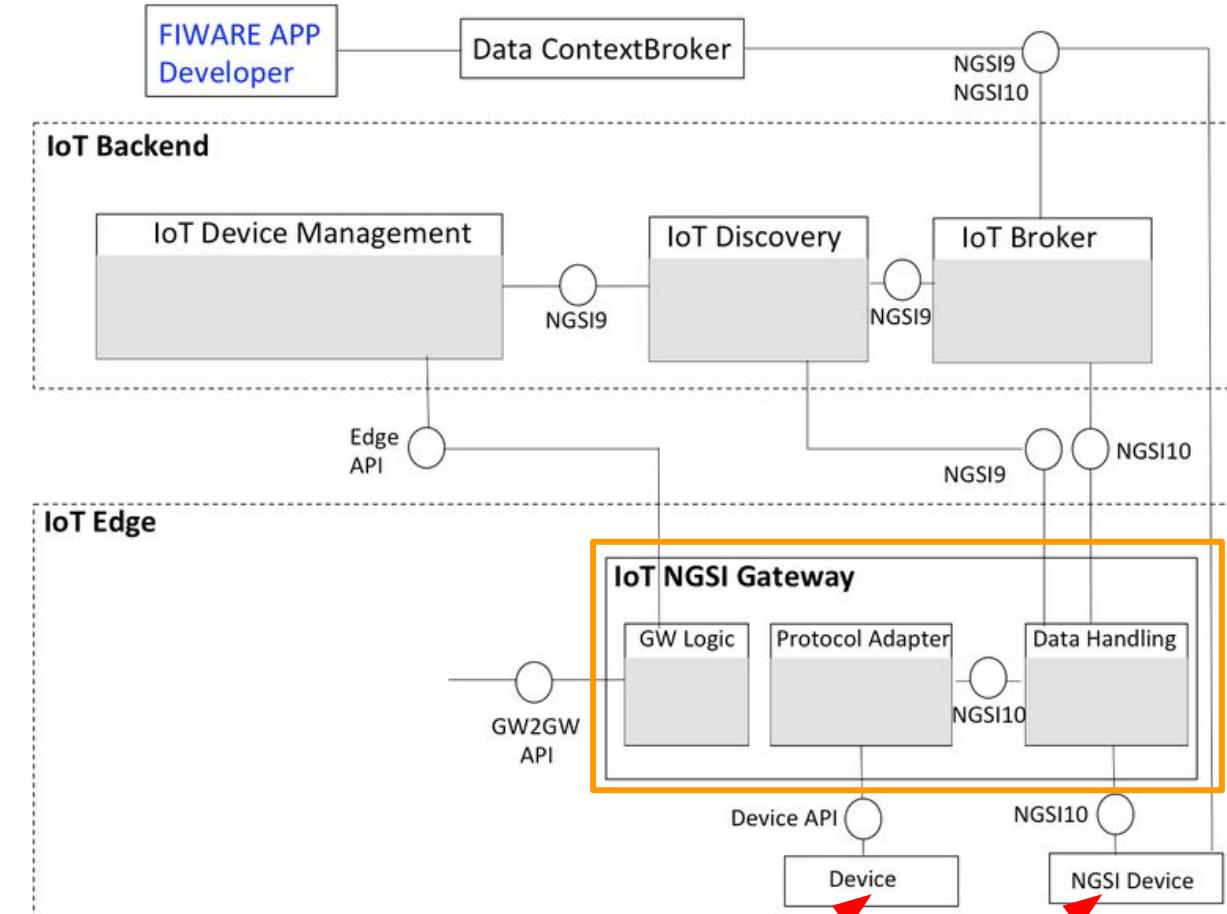
M2M System
Open platform - Fiware

Context Availability Management component

//{serverRoot}/NGSI9

Resources for Convenience Operations

- /contextEntities
  - /{EntityID}
    - /attributes
      - /{attributeName}
    - /attributeDomains
      - /{attributeDomainName}
- /contextEntityTypes
  - /{typeName}
    - /attributes
      - /{attributeName}
    - /attributeDomains
      - /{attributeDomainName}
- /contextAvailabilitySubscriptions
  - /{subscriptionID}

Resources for NGSI-9 Operations

- /registerContext
- /discoverContextAvailability
- /subscribeContextAvailability
- /updateContextAvailabilitySubscription
- /unsubscribeContextAvailability

The intelligent IoT embeds an API that makes the object "smarter". **The object has a database** that allows to store data and to restore them, to discover other services ...

https://forge.fiware.org/plugins/mediawiki/wiki/fiware/index.php/FI-WARE_NGSI-9_Open_RESTful_API_Specification

https://forge.fiware.org/plugins/mediawiki/wiki/fiware/index.php/FI-WARE_NGSI-10_Open_RESTful_API_Specification

M2M System
Open platform - Fiware

Step 1 : Create an "IDAS" Service

Step 2: Register your IoT device

Step 3: Send Observations related to your IoT device

Step 4: Reading measurements sent by your IoT device

Step 1:

```
POST http://130.206.80.40:5371/iot/services

Headers:

{
  'Content-Type':       'application/json',
  'X-Auth-Token' :      '[TOKEN]',
  'Fiware-Service':     'openiot',
  'Fiware-ServicePath': '/'
}

Payload:

{
  "services": [
    {
      "apikey":      "4jggokgpepnvsb2uv4s40d59ov",
      "cbroker":     "http://0.0.0.0:1026",
      "entity_type": "thing",
      "resource":    "/iot/d"
    }
  ]
}
```

M2M System
Open platform - **High level App**

- Future Internet business = models to calculate revenue and cost,

- Future Internet Applications run on top of platform,

- Business Model based on ontology,

- Business Modeler = page web application created in HTML5, CSS3 and JavaScript,

- Ontology = XMI and UML metadata languages to describe a business model,

M2M System

Open platform - High level App - Ontology

```
https://forge.fiware.org/plugins/mediawiki/wiki/fiware/index.php
/FIWARE.ArchitectureDescription.Apps.BusinessModeller
```
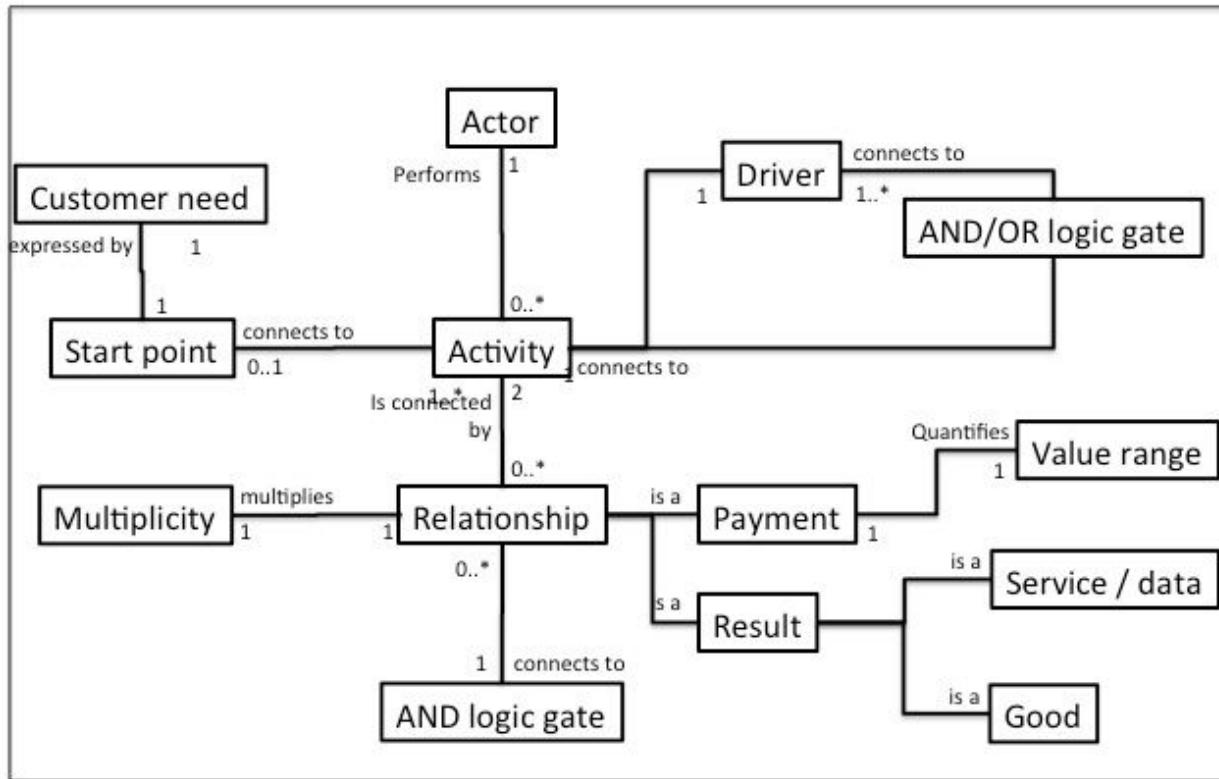
M2M System
Open platform - Fiware - high level App catalogue
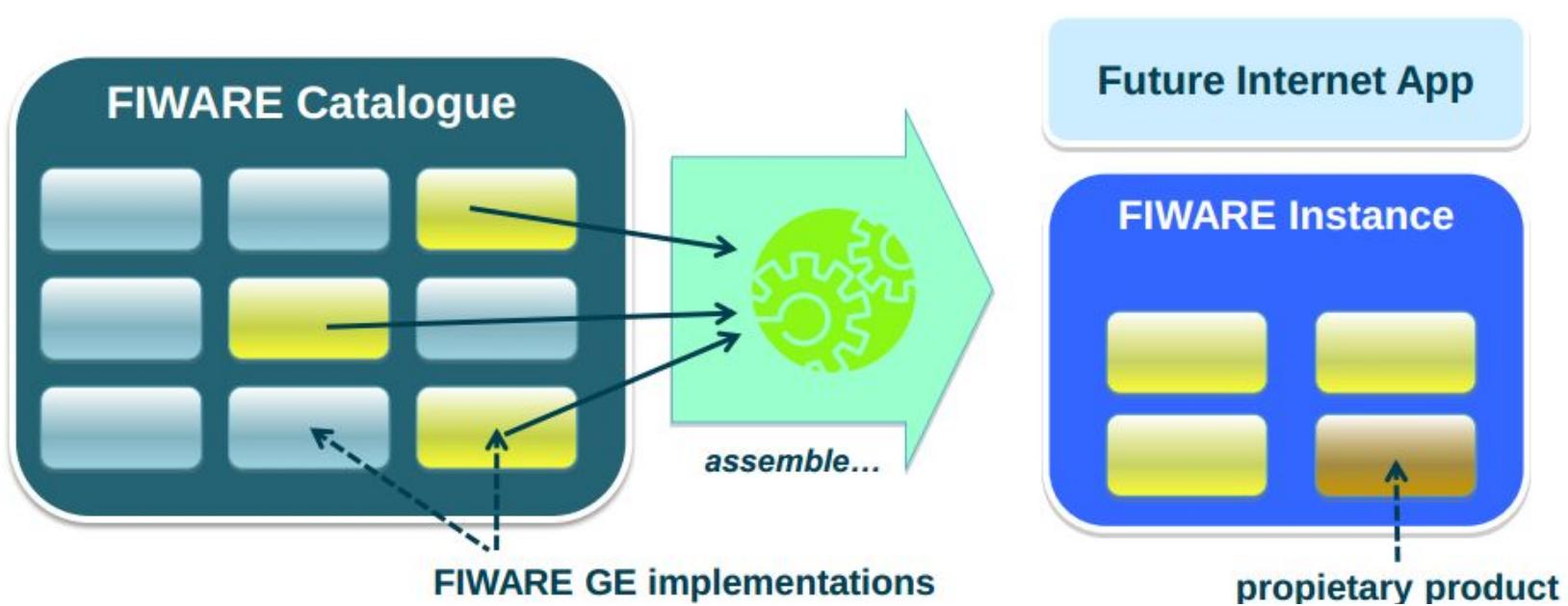
http://www.businessoulu.com/media/tiedostot/fiche/fi-ware-presen
tation.pdf

M2M System

Open platform - Fiware - high level App - City model

`http://smartcityapphack.com/fiware/`

M2M System

Open platform - Fiware - high level App - City model

http://smartcityapphack.com/fiware/

- Smart city platform as a Data/Knowledge Hub

- Non-intrusive, open to third parties
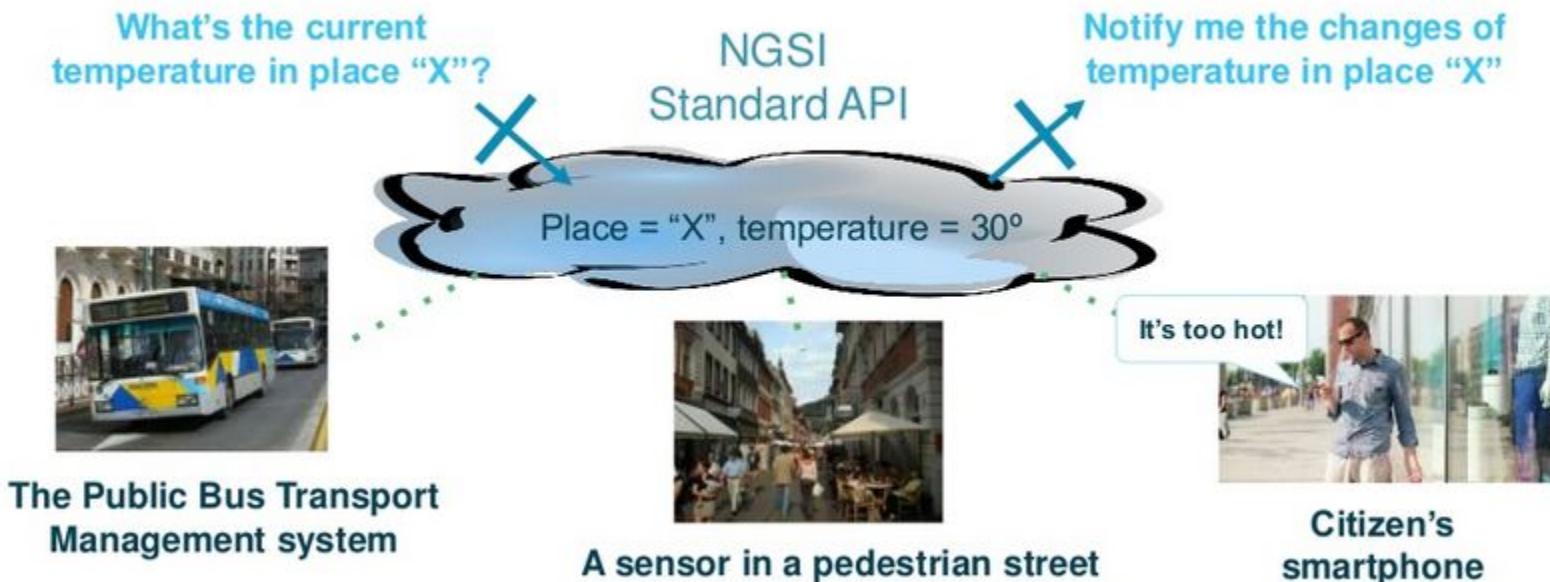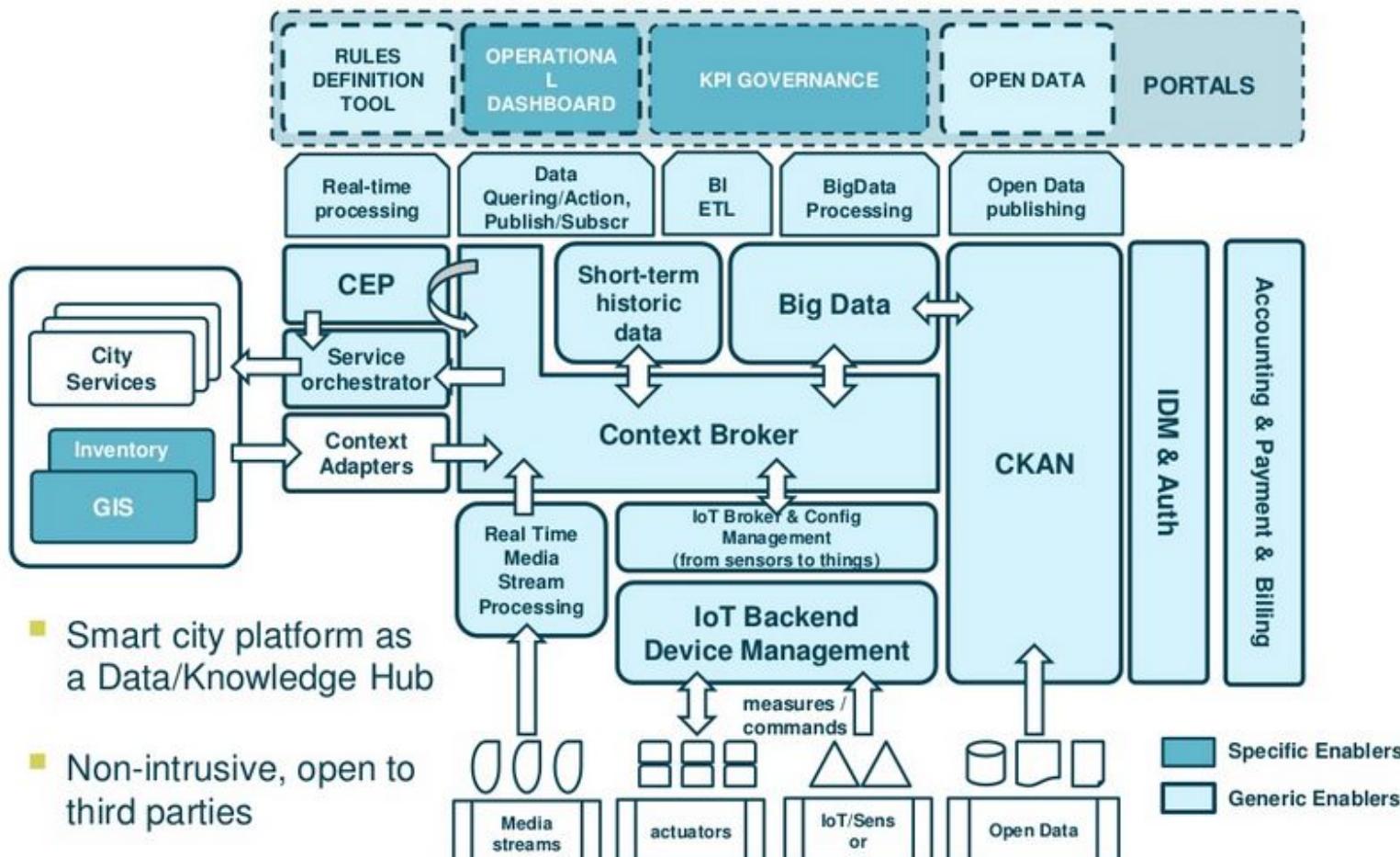
M2M System

Open platform - Fiware - docker

```
https://forge.fiware.org/plugins/mediawiki/wiki/fiware/index.php
/FIWARE.OpenSpecification.Cloud.Docker
```


Multi-Tenant Docker hosting on FIWARE Remotely Managed by Docker Client
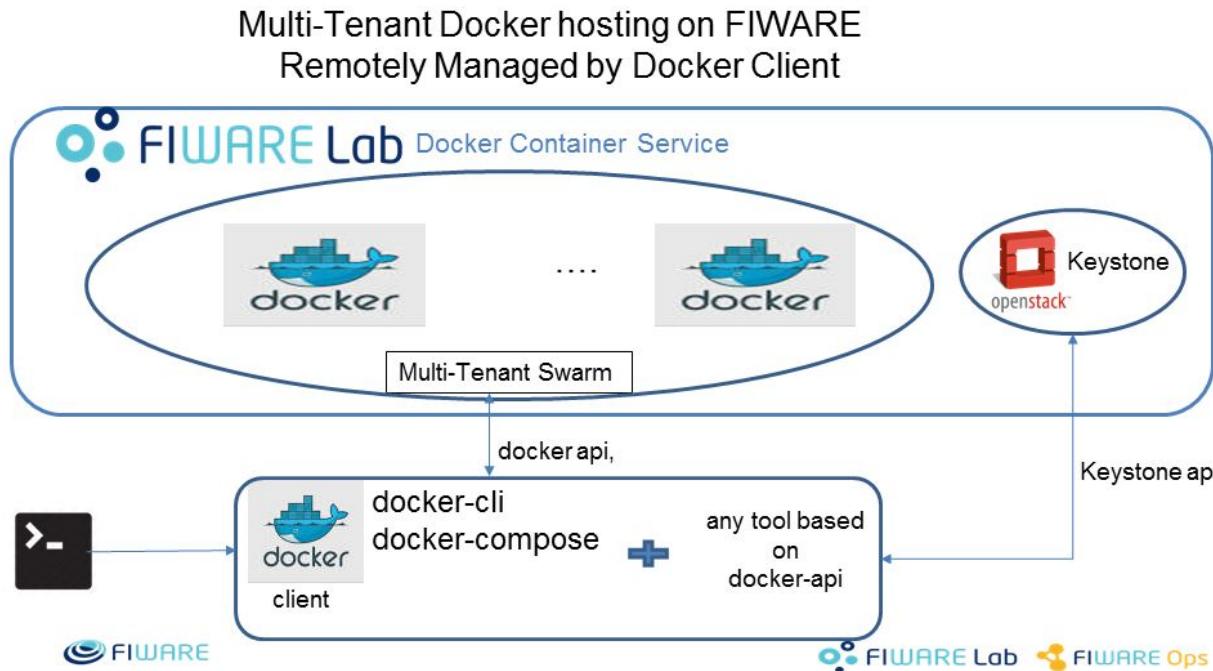
M2M System
Open platform - IoTivity (US)

- A collaborative open source software framework (AllJoyn + Linux Fondation),

- Apache 2.0 license,

- Sponsored by the Open Connectivity Foundation (OCF), a group of industry leaders,

- Development in C, C++ and Java,

- Android, Tizen, Ubuntu (Linux), and Windows.

M2M System
Open platform - AllSeen (US)

https://allseenalliance.org/
https://allseenalliance.org/framework/documentation/learn/core/standard-core
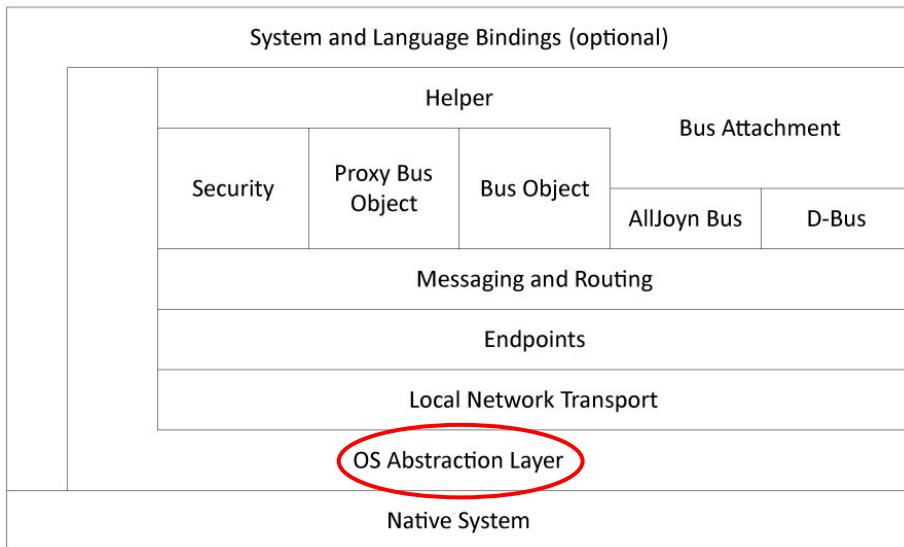
Basic client, service, or peer architecture
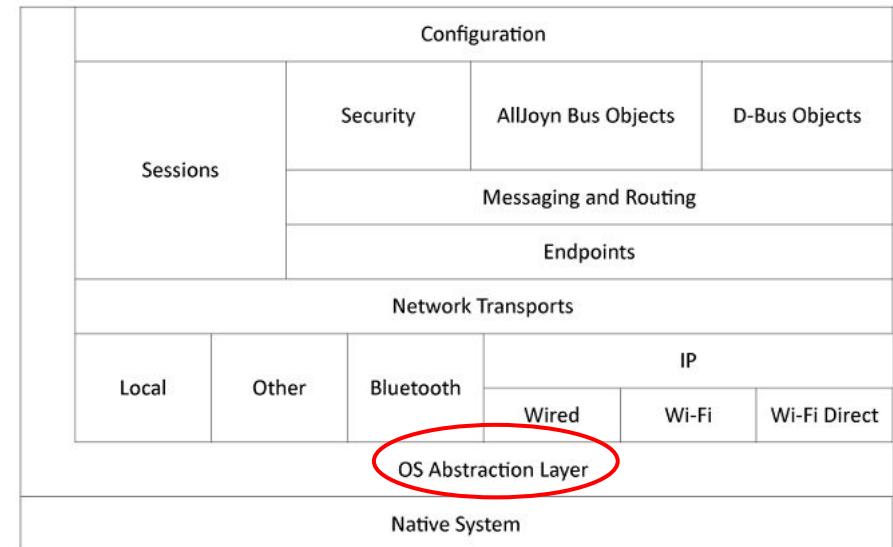
Basic router architecture

M2M System

http://www.onem2m.org/news-events/onem2m-deployment-announcements

http://www.nec.com/en/press/201412/global_20141215_02.html

- NEC is the first company in the world to deploy the new oneM2M service layer standard in a live smart city control center deployment

- Fiware + OneM2M plugin

Partie II

M2M System - Definition

M2M System - Global architecture

M2M System - Communication example

M2M System - Standards

M2M Open platform

Lightweight M2M

M2M impact for IoT

Big data

IoT and digital hub

M2M System
Lightweight M2M

- The above solutions are possible on large systems,

- Some industrial equipment requires **very light M2M** system,

- Lightweight M2M behavior should be similar to the large systems,

- Interoperability with other M2M systems.

M2M System
Lightweight M2M - OPC-UA

https://opcfoundation.org/about/what-is-opc/
https://www.unified-automation.com/
http://open62541.org/

- OPC is an interoperability standard industrial automation,

- Standardized in the IEC 6254,

- Asynchronous protocol built upon TCP, HTTP or SOAP,

- Its purpose was to abstract specific protocols (such as Modbus, Profibus, etc.).

M2M System
Lightweight M2M - OPC-UA - Structure

https://opcfoundation.org/about/what-is-opc/
https://www.unified-automation.com/
http://open62541.org/
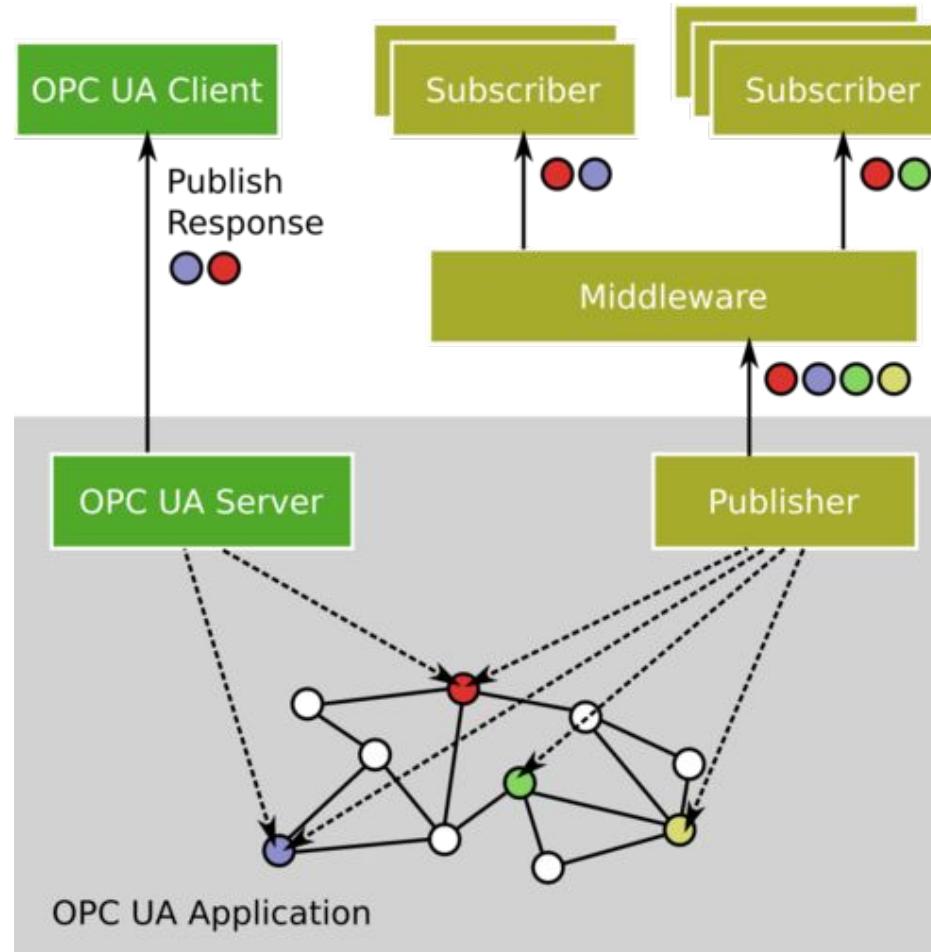
M2M System
Lightweight M2M - OPC-UA - M2M Functions

```
https://opcfoundation.org/about/what-is-opc/
https://www.unified-automation.com/
http://open62541.org/
```

- **Discovery**: find the availability of OPC Servers on local PCs and/or networks,

- **Address space**: all data is represented hierarchically,

- **On-demand**: read and write data/information based on access-permissions,

- **Subscriptions**: monitor data/information and report-by-exception when values change based on a client's criteria,

- **Events**: notify important information based on client's criteria,

- **Methods**: clients can execute programs, etc. based on methods defined on the server.

M2M System
Lightweight M2M - OPC-UA - Platform Independence

```
https://opcfoundation.org/about/what-is-opc/
https://www.unified-automation.com/
http://open62541.org/
```

- **Hardware platforms**: traditional PC hardware, cloud-based servers, PLCs, micro-controllers (ARM etc.)

- **Operating Systems**: Microsoft Windows, Apple OSX, Android, or any distribution of Linux, etc.

```
https://opcfoundation.org/about/what-is-opc/
https://www.unified-automation.com/
http://open62541.org/
```

- Open62541 (http://open62541.org) - LGPL : C

- Unified-automation.com : Java, .NET, C++, ANSI C

- https://github.com/FreeOpcUa/freeopcua : C++

M2M System

Lightweight M2M - OPC-UA - Implementation open62541 (server)

http://open62541.org/doc/current/tutorial_server_firstSteps.html

```c
#include <signal.h>
#include "open62541.h"

UA_Boolean running = true;
static void stopHandler(int sig) {
    running = false;
}

int main(void) {
    signal(SIGINT,  stopHandler);
    signal(SIGTERM, stopHandler);

    UA_ServerConfig config = UA_ServerConfig_standard;
    UA_ServerNetworkLayer nl;
    nl = UA_ServerNetworkLayerTCP(UA_ConnectionConfig_standard, 16664);
    config.networkLayers = &nl;
    config.networkLayersSize = 1;
    UA_Server *server = UA_Server_new(config);

    UA_Server_run(server, &running);
    UA_Server_delete(server);
    nl.deleteMembers(&nl);
    return 0;
}
```

M2M System
Lightweight M2M - OMA - Implementation

```
http://openmobilealliance.org
https://en.wikipedia.org/wiki/OMA_LWM2M
```

- OMA Lightweight M2M is a protocol from the Open Mobile Alliance for M2M or IoT,

- Communication protocol between a LWM2M Server / Client,

- Architectural design based on REST,

- Simple Object based resource model:
    - Resource operations of creation/retrieval/update/deletion/configuration of attribute,
    - Resource observation/notification,
    - TLV/JSON/Plain Text/Opaque data format support.

M2M System

Lightweight M2M - OMA - Implementation

http://openmobilealliance.org

the ARM mbed platform,

Microsoft's Azure platform,

Nokia's IMPACT IoT Platform,

Ericsson's Device Connection Platform,

IoTerop's IOWA LwM2M commercial stack,

Sierra Wireless' modules,

gateways and IoT platform ...

Part II

M2M System - Definition

M2M System - Global architecture

M2M System - Communication example

M2M System - Standards

M2M Open platform

Lightweight M2M

M2M impact for IoT

Big data

IoT and digital hub

M2M System

Impact on IoT

- M2M behavior:
    - Gateway
    - IoT only
- Platform (Linux, Android …)
- Data structure,
- M2M compatibility,
- Remote setup,
- New protocol,
- Update procedure.
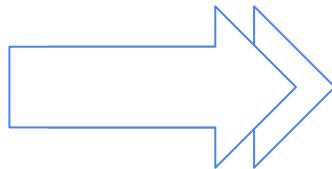
- Memory
- CPU
- Communication medium

- Fleet management
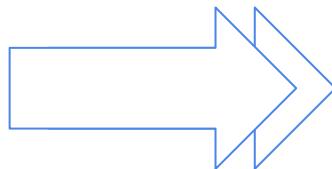
Part II

M2M System - Definition

M2M System - Global architecture

M2M System - Communication example

M2M System - Standards

M2M Open platform

Lightweight M2M

M2M impact for IoT

Big data

IoT and digital hub

M2M System
Big data - Sharing the data
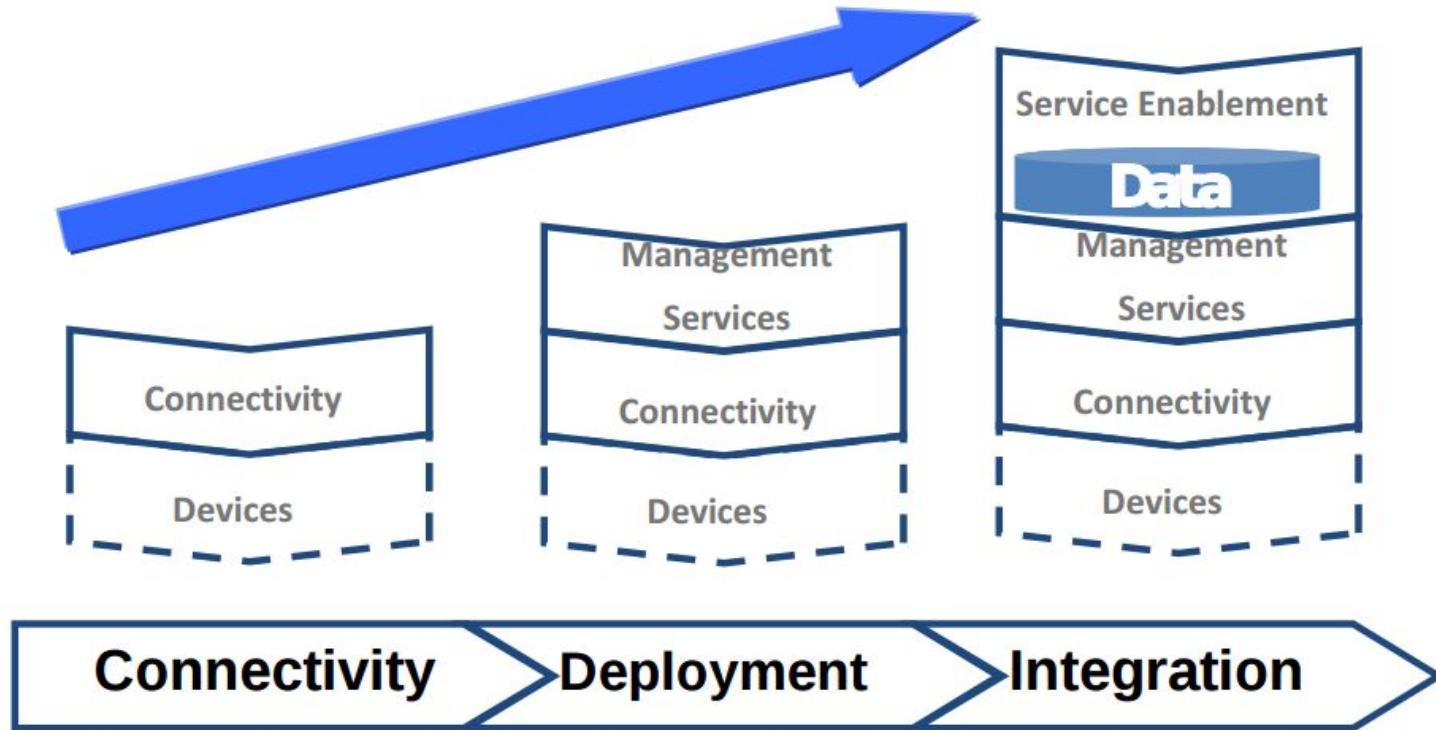
M2M is based on a "Store and Share" paradigm
- The data may be made available in the platform to the other applications, interested application are notified by means of subscription
- Privacy is ensured by a strict Access Rights Management...

M2M System
Big data - Sharing the data

- Taming the data deluge,

- Challenges:
    - Data storage and management,
    - De-centralized/multi-server architectures,
    - Performance bottlenecks,
    - Increasing hardware requirements.

- Example: Hadoop project

http://www.fromdev.com/2015/03/hadoop-alternatives.html
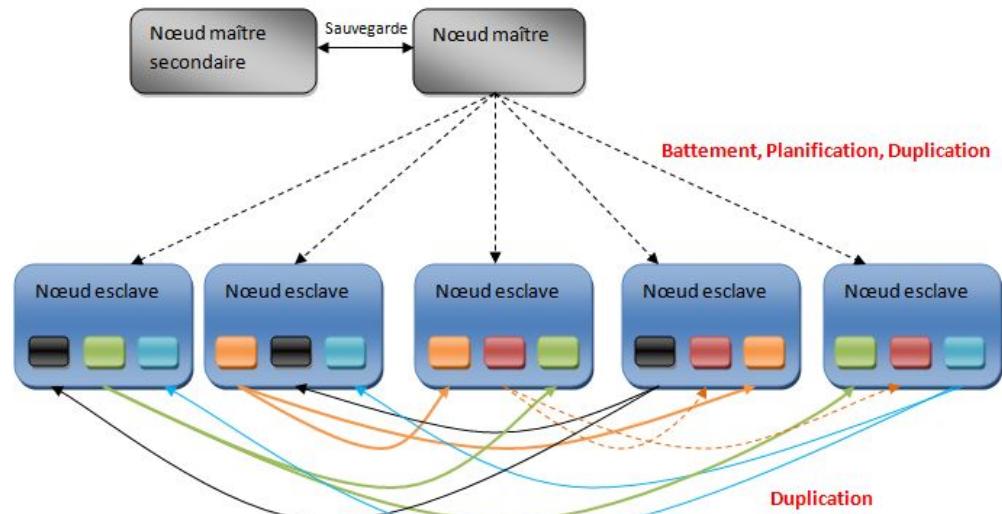
"Hadoop dans les nuages"

- Hadoop can be deployed in a data center (Microsoft, Amazon, IBM et Google) ,

- Alternative:
    - Disco project: http://discoproject.org/
    - Misco
    - Cloud MapReduce
    - ...

Part II

M2M System - Definition

M2M System - Global architecture

M2M System - Communication example

M2M System - Standards

M2M Open platform

Lightweight M2M

M2M impact for IoT

Big data

IoT and digital hub

IoT hub

IoT and digital hub - Cyber-Physical Systems

http://www.designworldonline.com/big-future-for-cyber-physical-manufacturing-systems/
https://en.wikipedia.org/wiki/Internet_of_things
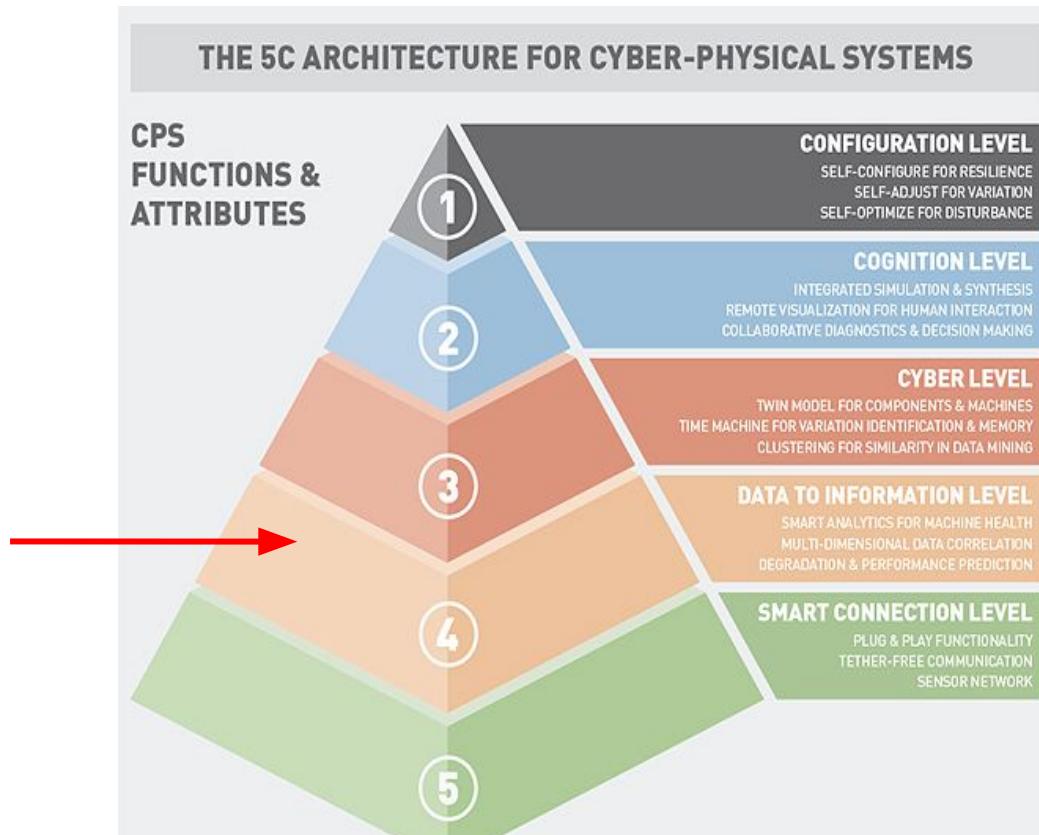
IoT hub
IoT and digital hub

- Offer an all-in-one product to manufacturers and developers of connected objects

- Use a virtualized platform with standard (s) and protocols,

- Pay an overall cost,

- Trust the provider ...

Example: http://www.hubnumeriquedelaposte.fr/
http://www.ibm.com/internet-of-things/

IoT and digital hub

Example:

Amazone, ThingSpeak, dweet.io, open.sen.se, SMQ IoT LED Control ,
Kaa , Beebotte ...

IoT hub
IoT and digital hub

A modern IoT platform architecture consists of 8 elements:

1- **Connectivity and standardization:** brings different protocols and different data formats into a single "software" interface ensuring accurate data transmission and interaction with all devices.

2- **Device management:** ensures that the connected "objects" work correctly, allows to distribute patches and updates for software and applications running on systems and gateways.

3- **Database:** Scalable data storage provides requirements for databases in the cloud.

IoT hub
IoT and digital hub

A modern IoT platform architecture consists of 8 elements:

4- **Management Processing & Action**: Dynamic data analysis triggers events and gives meaning to mass storage.

5- **Analytical processing**: more complex analysis of data and learning systems. The analysis becomes predictive and makes it possible to extract the useful data from the mass of the data.

6- **Visualization**: Reading by humans analysis of data, graphic, dashboard.

IoT hub
IoT and digital hub

A modern IoT platform architecture consists of 8 elements:

7- **Additional tools**: Enable prototyping, testing, ecosystem creation, IoT management and control.

8- **External interface**: Provide development APIs, Software Developments Kits (SDKs), gateways between different technologies.

IoT hub
IoT and digital hub

https://iot-analytics.com/5-things-know-about-iot-platform
/

Database
Repository that stores the important data sets

External interfaces
APIs, SDKs and gateways that act as interfaces for 3rd party systems (e.g., ERP, CRM)

Analytics
Algorithms for advanced calculations and machine learning

Additional tools
Further development tools (e.g., app prototyping, access management, reporting)

Data visualization
Graphical depiction of (real-time) sensor data

Processing & action management
Rule engine that allows for (real-time) actions based on incoming sensor & device data

Device management
Backend tool for the management of device status, remote software deployment and updates

Connectivity & Normalization
Agents and libraries that ensure constant object connectivity and harmonized data formats

IoT hub
IoT and digital hub - Example: Google

https://developers.google.com/weave/guides/overview/what-is-weave
https://cloud.google.com/
https://cloud.google.com/speech/

Weave

- Convert audio to text by applying powerful neural network models,
- Recognizes over 80 languages and variants,
- Context-aware recognition …
- Batch prediction services ...

IoT hub
IoT and digital hub - Example: Google

https://developers.google.com/weave/guides/overview/what-is-weave
https://cloud.google.com/
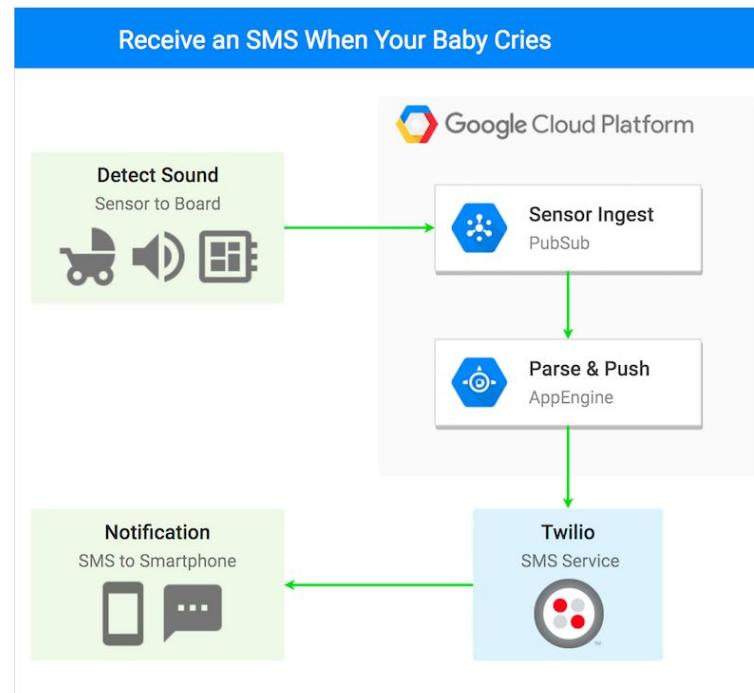
Weave
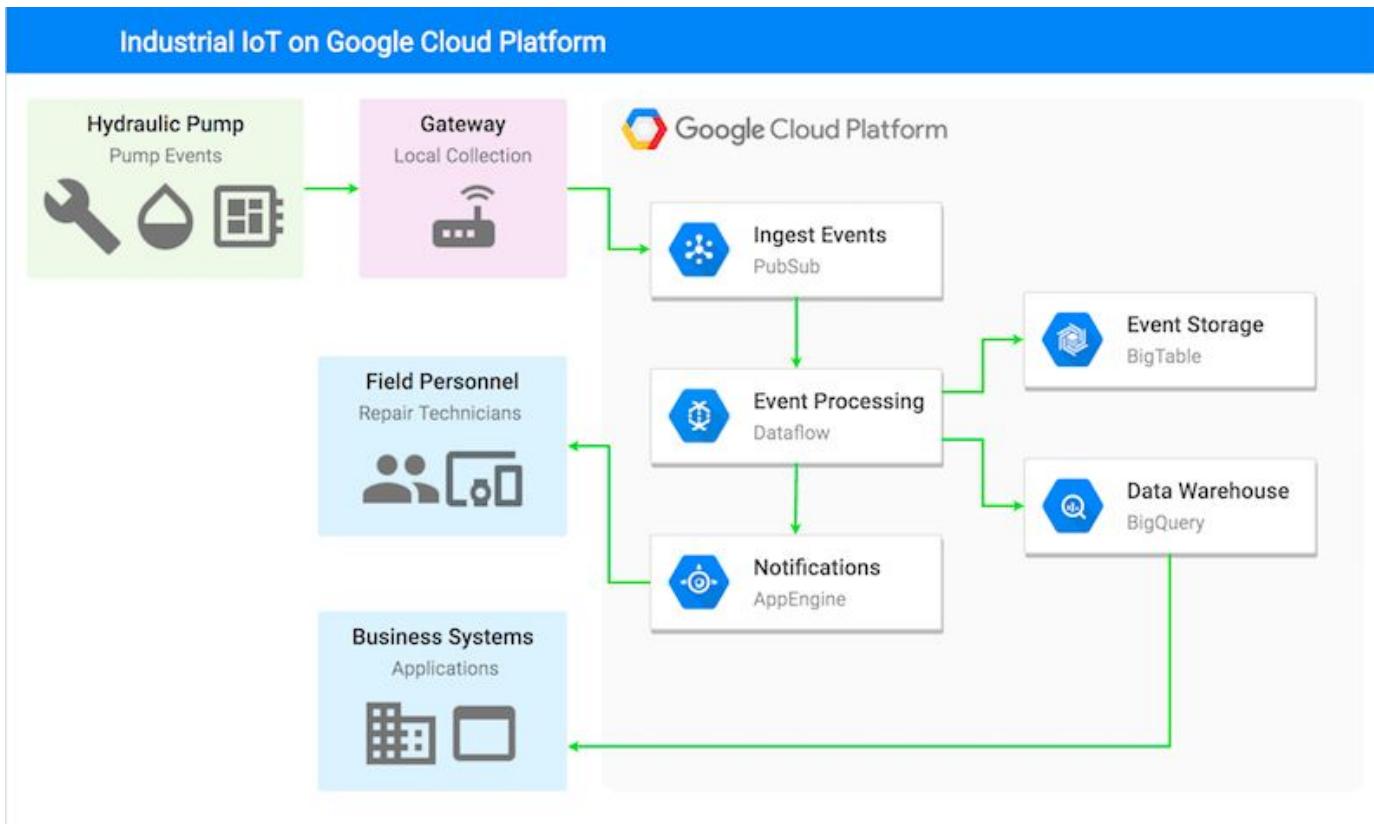
Partie III

Concept of IoT data model

Use case and automatic generation

Developing an IoT

M2M System
Concept of IoT data model

http://www.eclipse.org/vorto/news/index.html

Objectives:

- Accelerate the integration of IoT into the platform,
- Search device characteristics and device functionality,
- Use a code generator for devices ...

Example: Bosch M2M with the ThingWorx® IoT platform.

M2M System
Concept of IoT data model

http://www.eclipse.org/vorto/documentation/overview/introduction.html
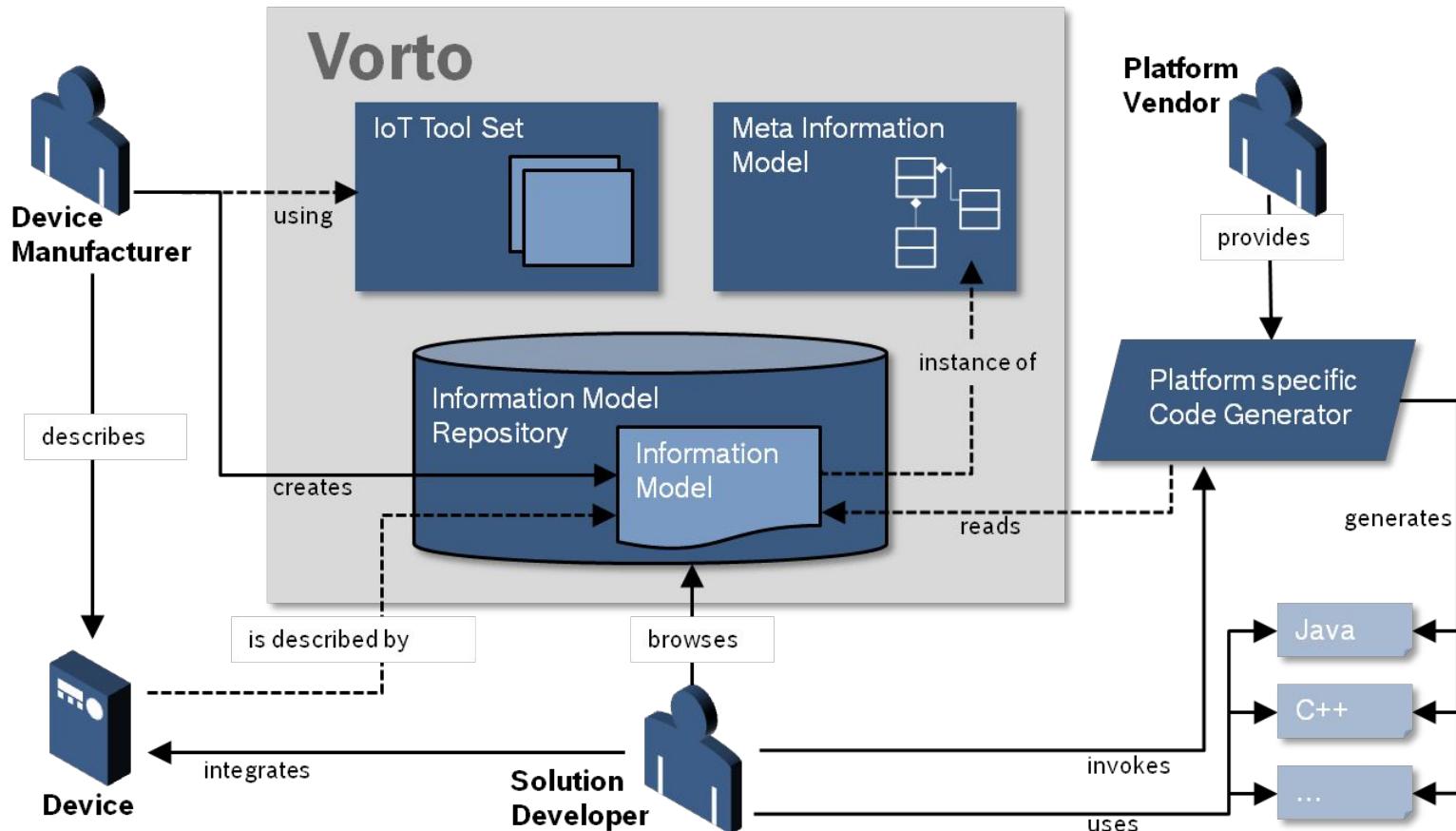
M2M System

Concept of IoT data model

- The system describes itself,
- The system describes its own UCs and disseminates them under control,
- The system executes the UCs.
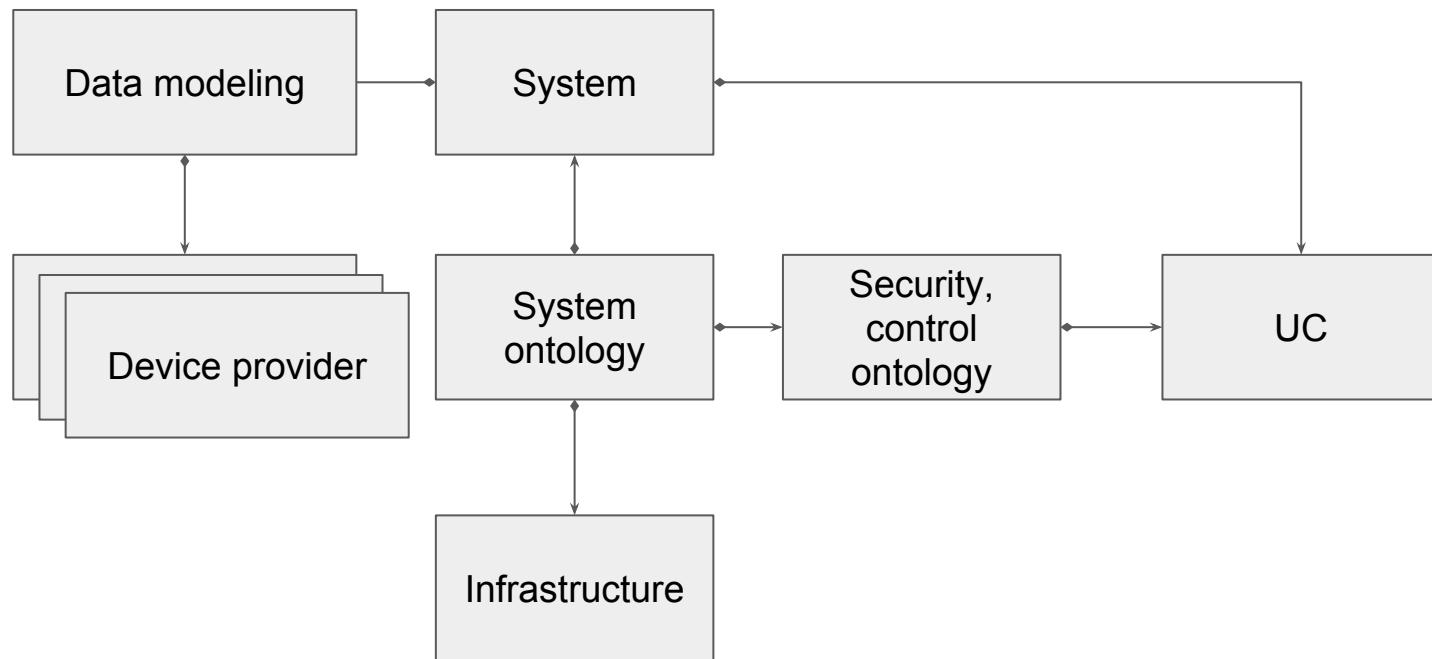
M2M System
Concept of IoT data model - Language design

- AADL: The Architecture Analysis & Design Language

- AADL is used to model the software and hardware architecture of an embedded

```
system Complete
end Complete;

system implementation Complete.PBA_speed_control
  subcomponents
    speed_sensor: device sensor.speed;
    throttle: device actuator.speed;
    speed_control: process control.speed;
    interface_unit: device interface.pilot;
  connections
    DC1: port speed_sensor.sensor_data ->
         speed_control.sensor_data;
    DC2: port speed_control.command_data -> throttle.cmd;
    DC3: port interface_unit.set_speed ->
         speed_control.set_speed;
    EC4: port interface_unit.disengage ->
         speed_control.disengage;
end Complete.PBA_speed_control;
```
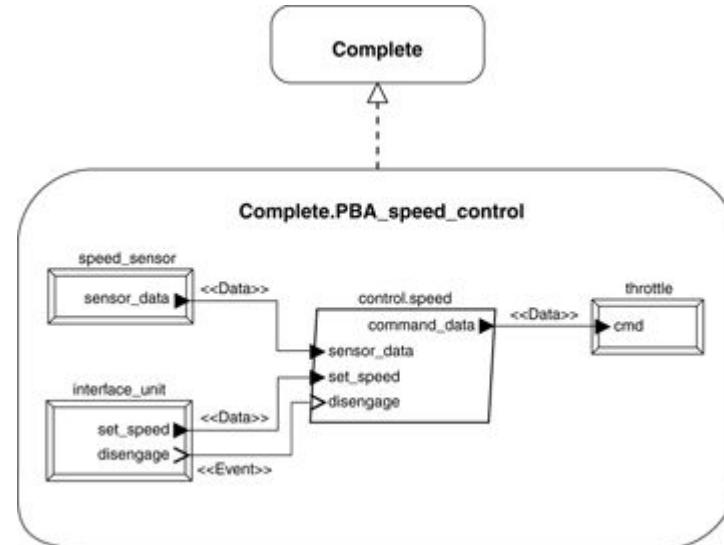
Part III

Concept of IoT data model

Use case and automatic generation

Developing an IoT

Constat:

- L'équipement est aujourd'hui relativement bas coût car cela permet une grande diffusion, c'est l'objectif de l'IoT !

- La valeur ajoutée "apparente" pour le client se situe plus dans les services offerts par le système, le matériel est complètement abstrait.

- Les cas d'utilisation ou Use Case permettent de démontrer une utilisation particulière d'un système:

    - gestion de la température,
    - alarme
    - ...

Qu'est ce qu'un USE CASE ?:

- Caractériser l'utilisation d'un système dans un contexte donné,

- Mettre en évidence les aspects fonctionnels (quels sont les fonctions/services que l'utilisateur pourra mettre en oeuvre),

- Décrire les aspects fonctionnels optionnels ou non,

- Présenter les interactions entre les acteurs humains et non humains,

- Mettre en évidence un fonctionnement nominal et non nominal.
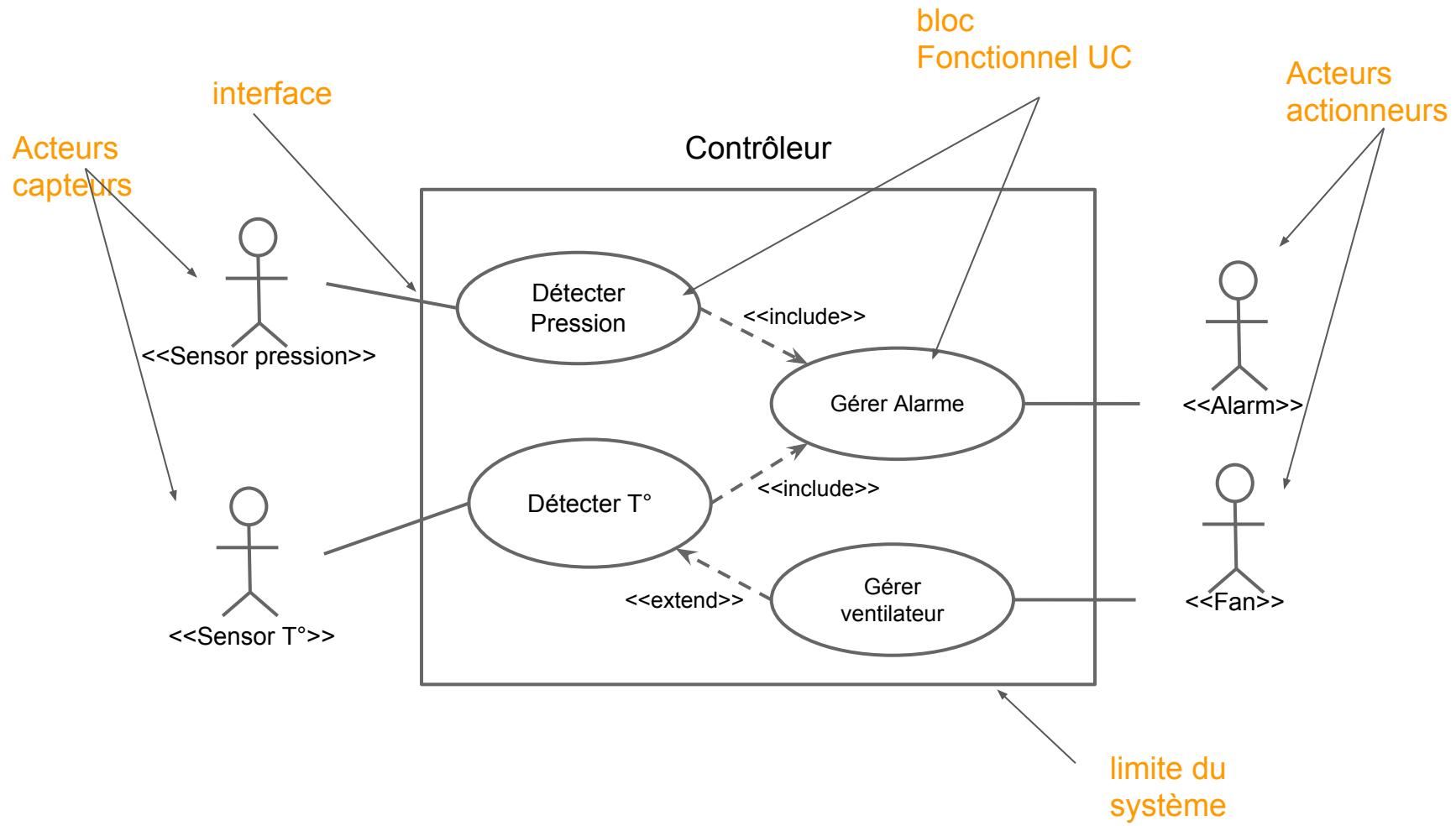
Création d'un UC

- En principe les équipements sont livrés dans un contexte de Use Case qui permet d'utiliser le système avec des paramètres de configurations modifiables, mais on reste dans le cadre du Use Case:

    - Un système d'alarme reste un système d'alarme,

    - Un système de gestion de température sera toujours utilisé pour gérer des températures.

    On voit bien ici que le système est figé dans son utilisation et qu'il n'y a pas de possibilité de modifier le cadre du UC !

IoT
Use Case

Modification fonctionnel UC
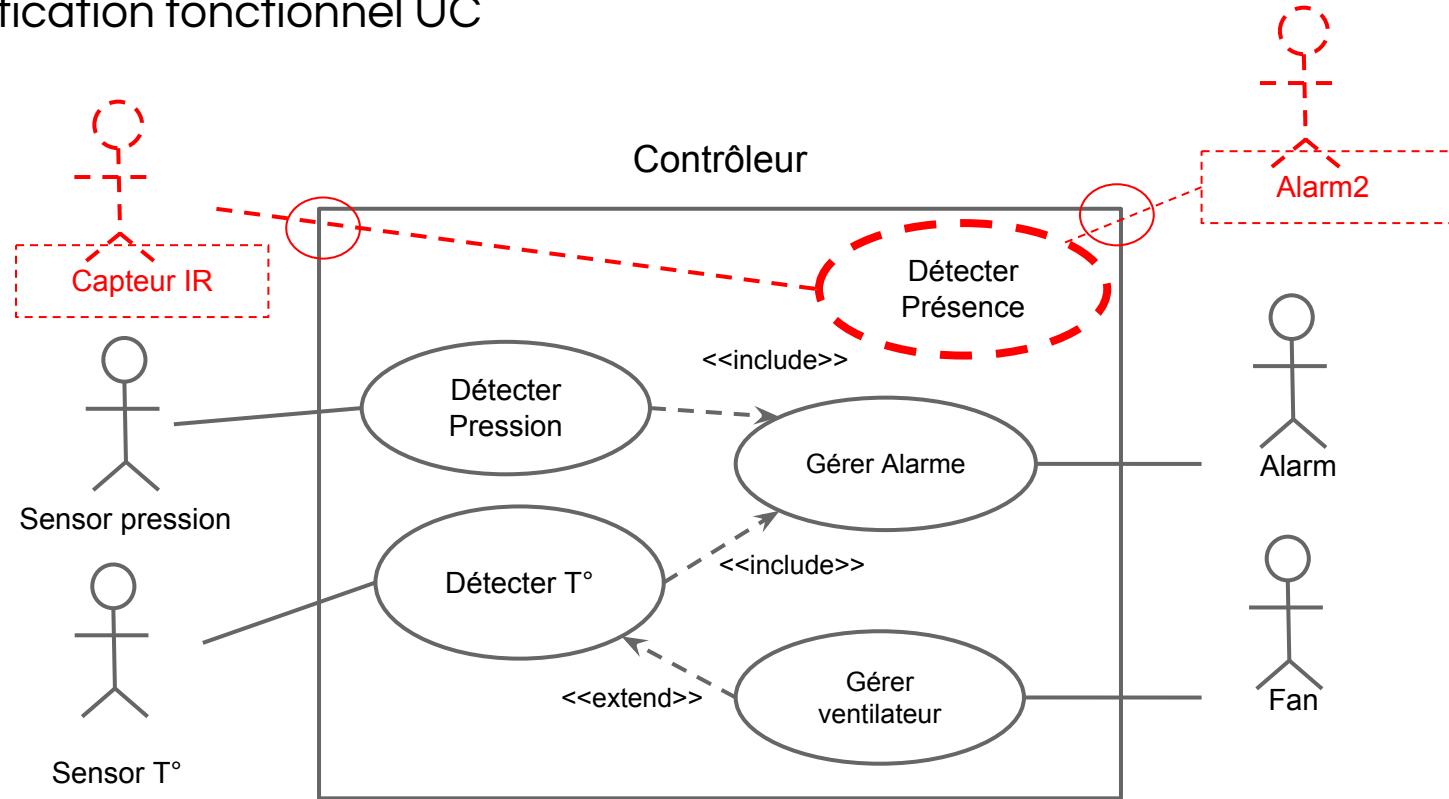
Une modification fonctionnelle implique ici un capteur IR + une alarme. Il faut prévoir deux interfaces supplémentaires, les traitements associés … il faut réaliser une fusion des modèles (éventuellement à partir d'une banque de modèle) ...

IoT
Use Case

IoT
Use Case

Use Cases [Stage 0]

TR 102 691
Smart
Metering

TR 102 732
eHealth

TR 102 857
Connected
consumer

TR 102 898
Automotive

TR 102 897
City
automation

TR 102 935
Smart Grid
impacts on
M2M

Stage 1 — **TS 102 689** M2M Service Requirements

TR 102 725
M2M
Definitions

TR 102 167
Threat analysis &
counter measures to
M2M service layer

TR 102 966
Interworking
with M2M Area
Networks

Stage 2 — **TS 102 690** M2M Functional Architecture

TS 101 404
OMA DM
compatible
Management
Objects

Stage 3 — **TS 102 921** M2M Communications; mIa, dIa and mId interfaces

TS 101 405
BBF TR-069
compatible
Management
Objects

TR 101 584
Semantic
support for
M2M Data

Les uses case complexes:

- Utilisation du cloud,

- Fusion de modèle (Use case …),

- Définition de Use Case en fonction du hub numérique (plateforme IoT),

- Intelligence artificielle (capacité à raisonner …),

- Ontologie (description du système),

IoT
Use Case

Les uses case complexes:

- Machine learning, auto apprentissage (deep learning),

- Autonomic (self-Configuration, self-Healing ...)

- Gestion des écosystèmes urbains et non urbains,

- Gestion des systèmes de systèmes (SoS) ...

IoT
IoT Use Case - Use Case bank

- Many use case are listed:
    - Health,
    - Transportation,
    - Energy management,
    - Security …

- These use cases are described very precisely
    - Actor,
    - Sensor,
    - Architecture (software, hardware),
    - Limits …

- These Use Case can be purchased …

IoT
IoT Use Case - Use Case bank

http://www.iotone.com/usecases

IoT
IoT Use Case - Use Case bank

https://nodered.org

- "visual tool for wiring the Internet of Things"

Nodes
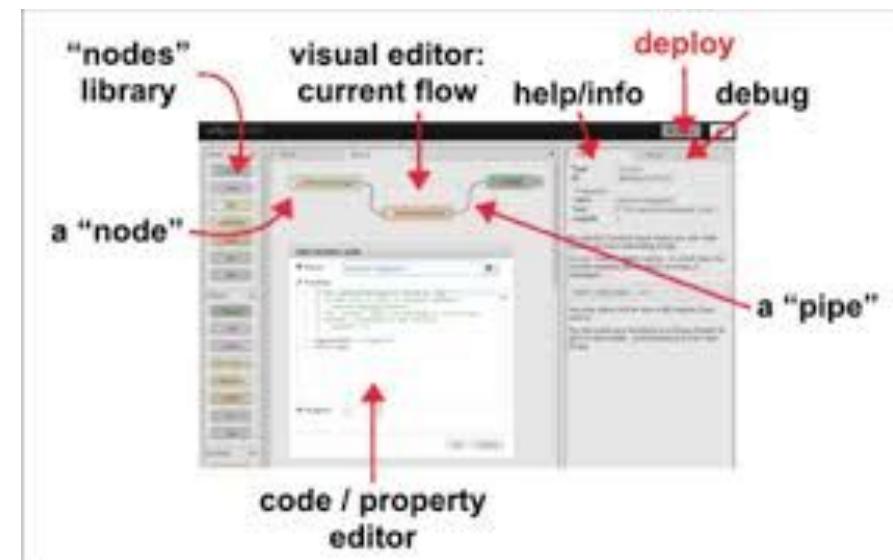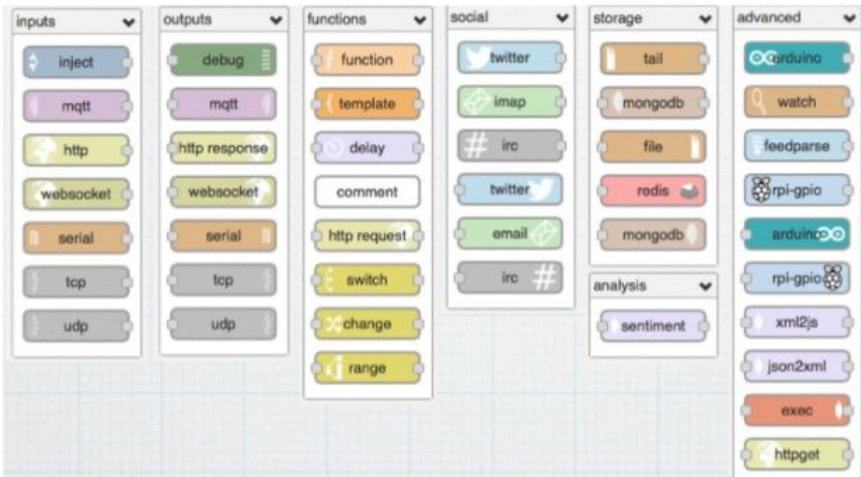
Part III

Concept of IoT data model

Use case and automatic generation

Developing an IoT

Developing an IoT
New Concept ?

Nouvelle approche (?):

- IoT très basse consommation,
- Sans OS ou micro OS, RT OS,
- Intégration d'une/plusieurs architectures d'intégration,
- Niveau de sécurité élevé,
- Comportement générique du système,
- OS clé en main ...

Developing an IoT
New Concept ?

OS spécialisé "clé en main"

- mbed IoT
    - compilateur en ligne,
    - grand choix de carte, composant …
    - mini OS, très léger ...
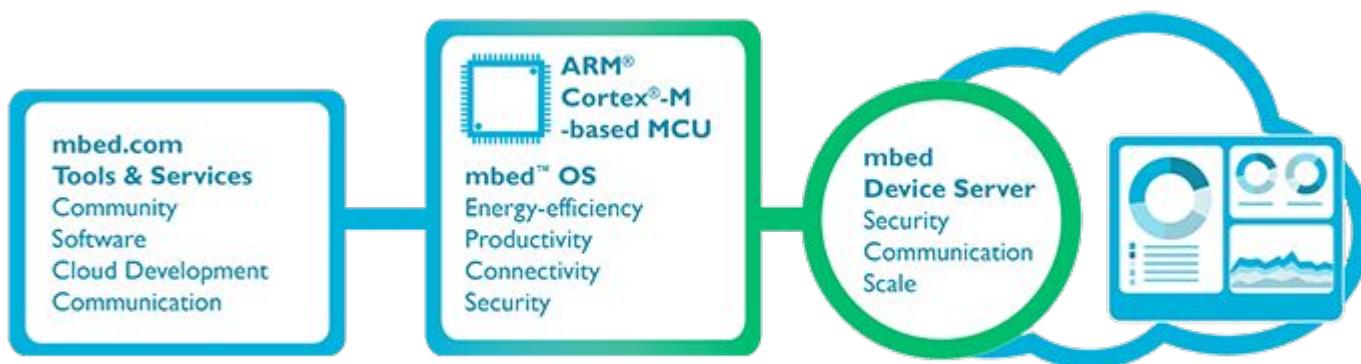
mbed ⇒ OS spécialisé "clé en main" + API

Featured applications

Smart Home Featured Applications

Smart Metering
- Energy meter
- Gas/Water meter

Heating & Energy Control
- Smart Plug
- Heating cost allocator
- Electronic thermostat

Security & Surveillance
- Lighting Control
- Security & Access Control
- Remote monitoring
- Alarm, Presence & Fire Detection
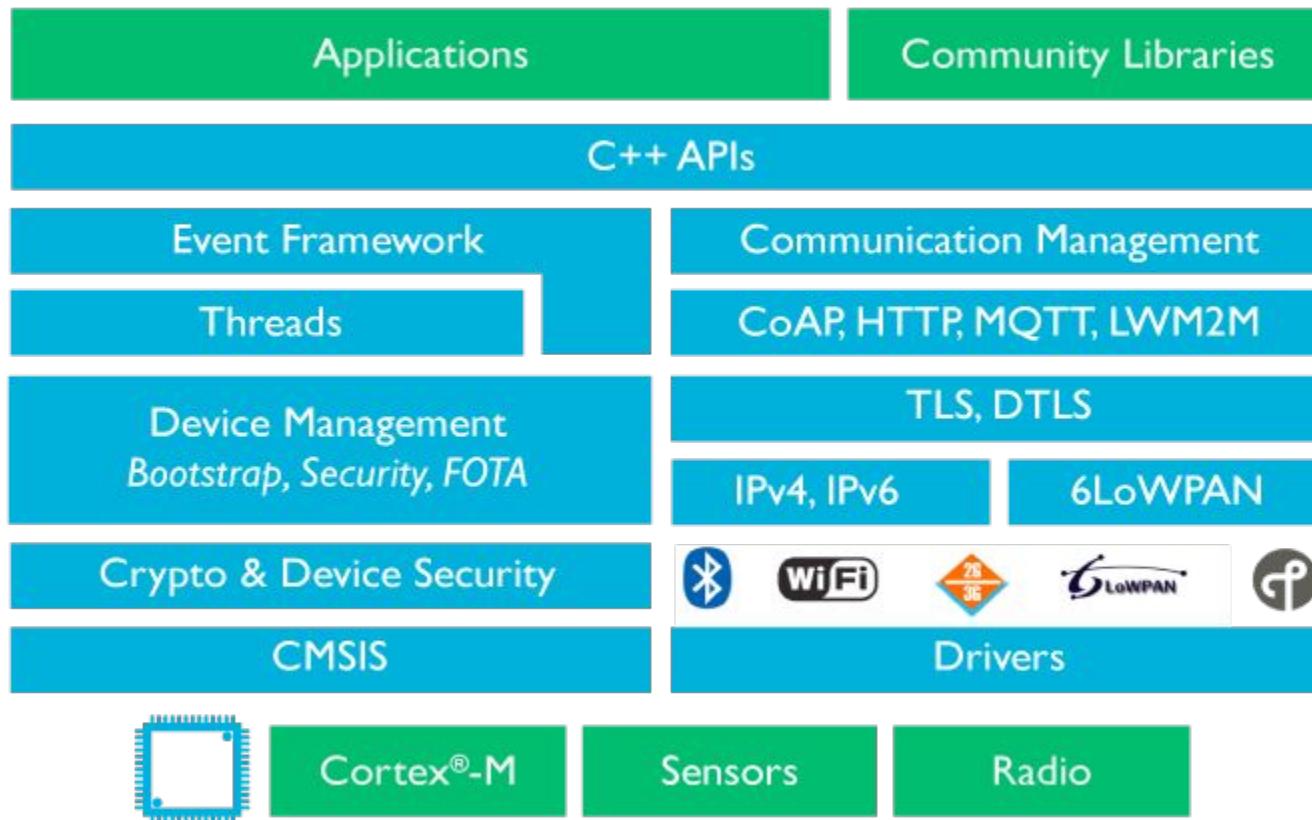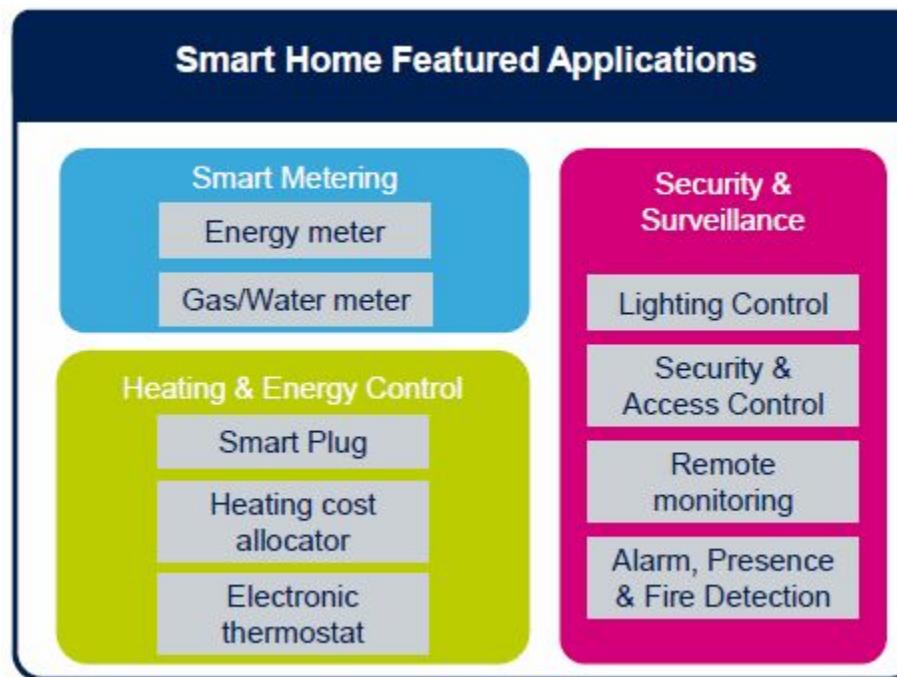
Developing an IoT
New Concept ?

androidthings

- Android Things (formerly known as Brillo),
- Android and certified hardware,
- Android APIs, Google services, and Android developer tools,
- Google BSP: The Board Support Package (BSP) is managed by Google …

Apps

Java API Framework | Google Services | Things Support Library

Native C/C++ Libraries

Hardware Abstraction Layer (HAL)

Linux Kernel
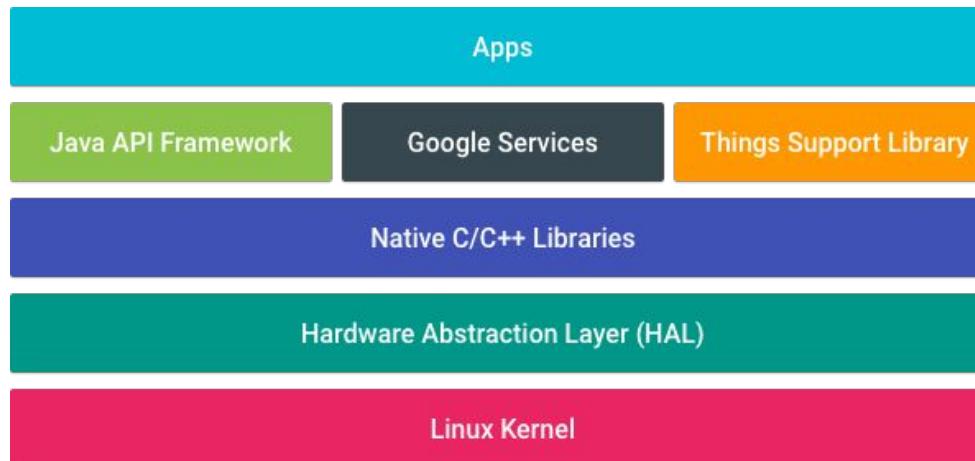
Developing an IoT
New Concept ? - Module multi-standard

http://www.ti.com/lsds/ti/wireless-connectivity/multi-standard/products.page

SimpleLink™ CC26xx wireless MCU

Copyright © 2016, Texas Instruments Incorporated

Éléments clés pour le développement IOT

Quels sont les comportements et besoins des utilisateurs ?

Où sont les manques des solutions existantes ?

Quels sont les potentiels technologiques à exploiter ?

Quels sont les standards à utiliser ?

Comment rendre une solution innovante simple à mettre en œuvre et à utiliser ?

Developing an IoT
Pattern Development

Éléments clés pour le développement IOT

Comment utiliser un maximum de capteur, de système de réseau ?

Quelle valeur ajoutée propose le produit (action cognitive et impact sur l'humain) ?

Quelle interaction cognitive (type de valeur ajoutée) ?

Quel est l'écosystème du produit ?

Puissance de la plateforme qui analyse les données (lien producteur < == >

consommateur via une plateforme) ?

System Architecture
Global architecture - Cyber-Physical Systems

http://www.designworldonline.com/big-future-for-cyber-physical-manufacturing-systems/
https://en.wikipedia.org/wiki/Internet_of_things

Niveau de la création de la valeur ajoutée
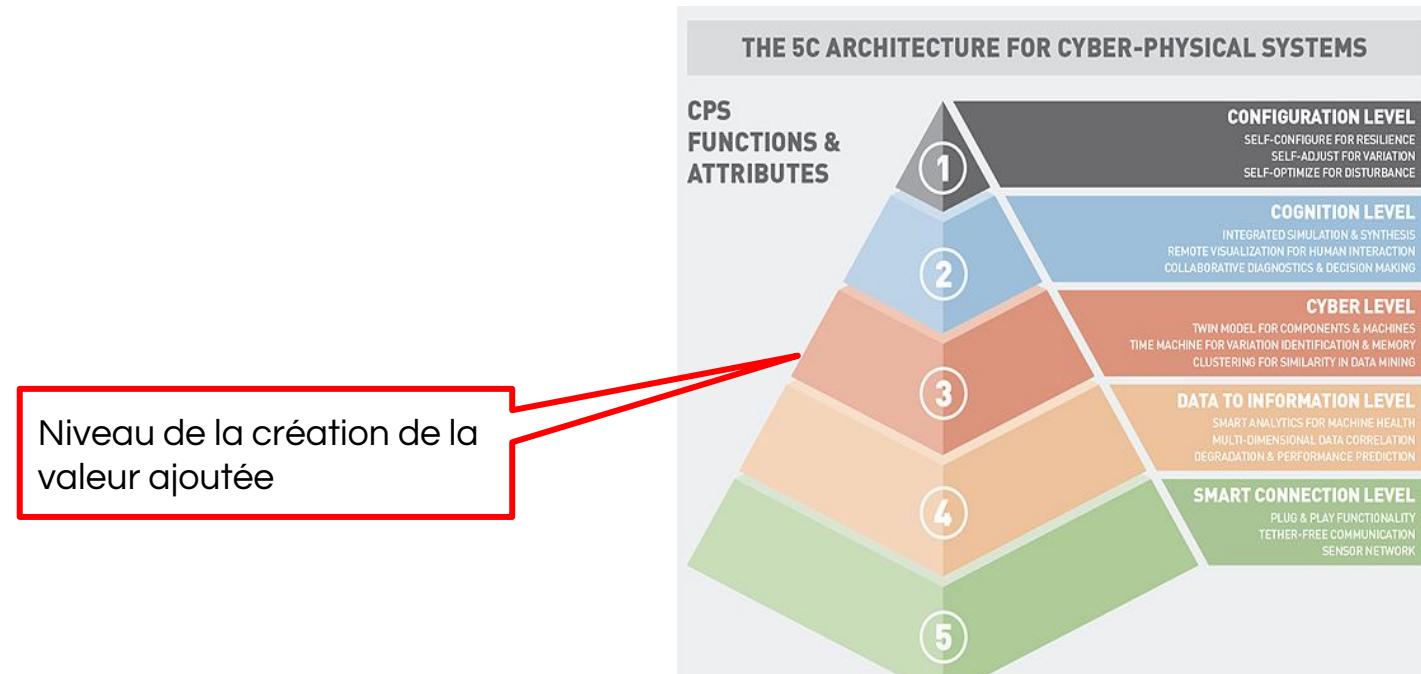
System Architecture
Global architecture - Cyber-Physical Systems

https://en.wikipedia.org/wiki/Minimum_viable_product

Analyse en sens inverse pour trouver la véritable valeur ajoutée du produit MVP (Minimal Viable Product). On définit la cognition utile puis on trouve le produit associé !

Ici on oublie l'approche "capteur" …

L'industrie du digital (GAFA) permet de donner de l'intelligence aux objets !

THE 5C ARCHITECTURE FOR CYBER-PHYSICAL SYSTEMS

CPS FUNCTIONS & ATTRIBUTES

1. **CONFIGURATION LEVEL**
   SELF-CONFIGURE FOR RESILIENCE
   SELF-ADJUST FOR VARIATION
   SELF-OPTIMIZE FOR DISTURBANCE

2. **COGNITION LEVEL**
   INTEGRATED SIMULATION & SYNTHESIS
   REMOTE VISUALIZATION FOR HUMAN INTERACTION
   COLLABORATIVE DIAGNOSTICS & DECISION MAKING

3. **CYBER LEVEL**
   TWIN MODEL FOR COMPONENTS & MACHINES
   TIME MACHINE FOR VARIATION IDENTIFICATION & MEMORY
   CLUSTERING FOR SIMILARITY IN DATA MINING

4. **DATA TO INFORMATION LEVEL**
   SMART ANALYTICS FOR MACHINE HEALTH
   MULTI-DIMENSIONAL DATA CORRELATION
   DEGRADATION & PERFORMANCE PREDICTION

5. **SMART CONNECTION LEVEL**
   PLUG & PLAY FUNCTIONALITY
   TETHER-FREE COMMUNICATION
   SENSOR NETWORK

Developing an IoT
Pattern Development

Développeurs

    Qui construit le système: ingénieur, designer, client ?

    Qui réalise la veille technologique ? Quels sont vos axes stratégiques ?

Clients

    Qui achètent la solution, et qui l'utilisent ?

Produit, service, cycle de vie ?

    Est ce que la solution est un produit et/ou un service ? Est-ce que le cycle est long, court ?

Rythme

    Savoir le concevoir, prototyper et fabriquer rapidement !

    Savoir développer du logiciel et maîtriser une chaîne de valeur (du capteur au cloud)

Developing an IoT
Pattern Development

A éviter pour le développement IoT

- Mono-usage,

- Mono-fonction,

- Mono-logiciel,

- Mono-support (utiliser le smartphone et le Web …)

- Technologie complètement banalisée,

- Aucune mise à jour,

- Système vertical,

- Manque de sécurité, trop de sécurité,

- Peu de visibilité sur les données (production et traitement) …

- Système sans diagnostique …

Références

https://www.fiware.org

https://www.xively.com/

http://www.intel.com/content/www/us/en/internet-of-things/infographics/iot-platform-infographic.html

https://iot-analytics.com

https://www.thingworx.com/platforms/

https://www.oracle.com/solutions/internet-of-things/

http://www.ibm.com/internet-of-things/iot-solutions/watson-iot-platform/

https://cloud.google.com/solutions/iot/

https://cloud.google.com/docs/

http://www.st.com/en/applications/internet-of-things-iot/smart-home.html

http://www.ifop.com/?option=com_publication&type=poll&id=3250

http://www.ifop.com/media/poll/2946-1-study_file.pdf

http://www.objetconnecte.com/1-francais-sur-2-objet-connecte-6-mois/

http://www.stuffi.fr/etude-harris-ebg-objets-connectes/

http://www.objetconnecte.net/objets-connectes-opportunites-limites/