ITU Regional Forum on Emergent Technologies
Tunis - Tunisia, 23-24 April 2019

Internet of Things: advances, perspectives and challenges in significant technical areas including standards

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Outline

- Internet of Things - the role of standardization
- Advances, perspectives and challenges in some significant technical areas (ITU-T standardization oriented view)
  - Architectures and Platforms
  - Smart Cities and other IoT application domains (selected list)
  - As backup information: Horizontal capabilities and technologies (selected list)

The IoT is fundamentally changing the business and drives convergence between ICT and industries

Products	**Smarter Products**	• *Embedded and enhanced processing power* • *Greater data capabilities* • *Bi-directional communications*
Isolated	**Connected**	• *Pervasive coverage and greater bandwidth* • *Multiple technologies* • *Real time communications*
Operational Technology	**OT + IT Convergence**	• *Applications and data* • *Integrated/advanced analytics* • *Shift in traditional product design*
Service Innovation	**"Servitisation"**	• *Products designed with integrated services* • ***New business models***

Competitive Advantage

Source: Machina Research

IoT is driving a profound transformation of the industries, the digitalization impacting products, processes, business models and ecosystems, social life

"Ultimately, digitalization is connecting all industries into a giant ecosystem" [source: Harvard webinar]

IoT and leading technologies

The IoT is expected to benefit from integration of a number of leading technologies and their advances, including those for

- Machine to Machine Communications
- Advanced sensing and actuation
- Cloud Computing (and distributed computing)
- Softwarization (incl. Software Defined Networking, Network Functions Virtualization)
- Autonomic Networking and other network features (e.g. IMT2020/5G advances such as network slicing)
- Big Data processing, management and governance
- Semantics and ontologies support
- Distributed Ledgers (Blockchain)
- Machine Learning and Artificial Intelligence
- Security, Privacy and Trust (data, infrastructure, applications)

It is hoped that the IoT international standardization reuses as much as possible the standards developed in the different technology areas,
but that it also addresses lacks and issues coming from their integration as well as from the specific needs of IoT ecosystems' stakeholders

IoT interoperability and the role of standardization

Market research: "nearly 40% of economic impact of the IoT requires interoperability between IoT systems"

IoT value will come solving interoperability issues within/across IoT domains (different interoperability dimensions)

Key issue with IoT interoperability is current diversity =>> international SDOs have a key role in promoting standards convergence and harmonization (ITU-T as key actor)

Open innovation systems move fast =>> Standardization needs to cope - process, collaboration

Landscape in continuous evolution

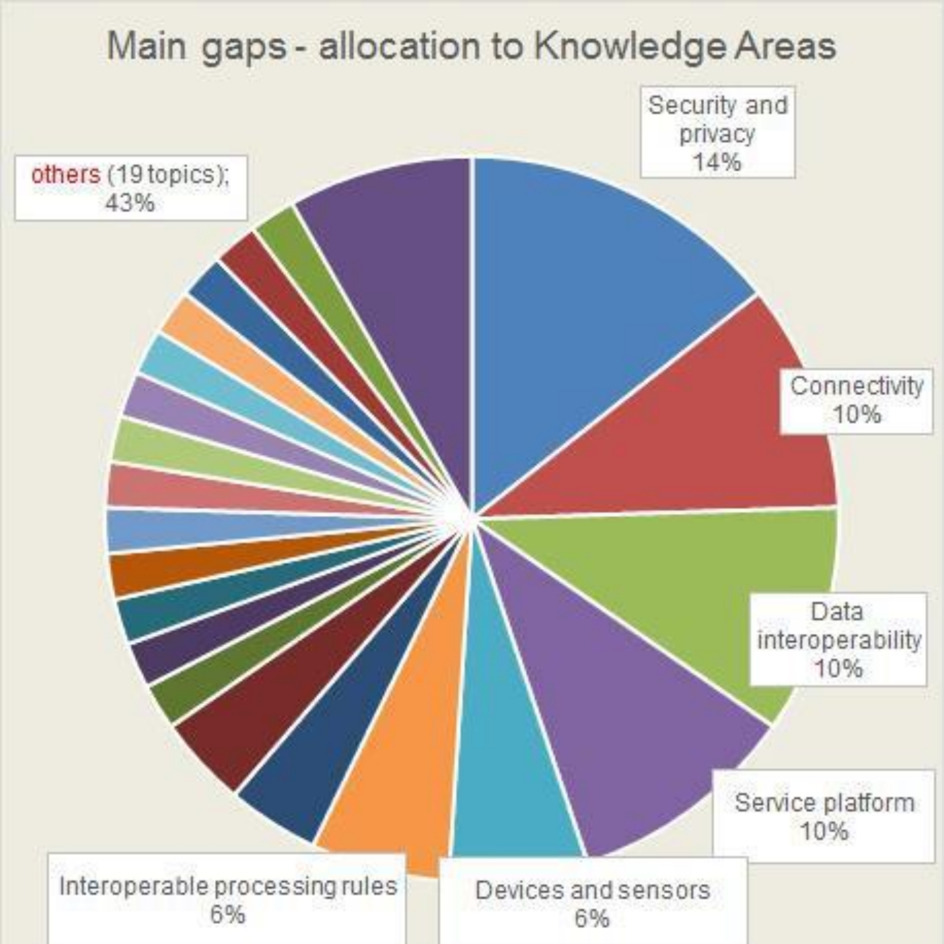
Source: AIOTI WG3 (IoT Standardisation) – Release 2.8

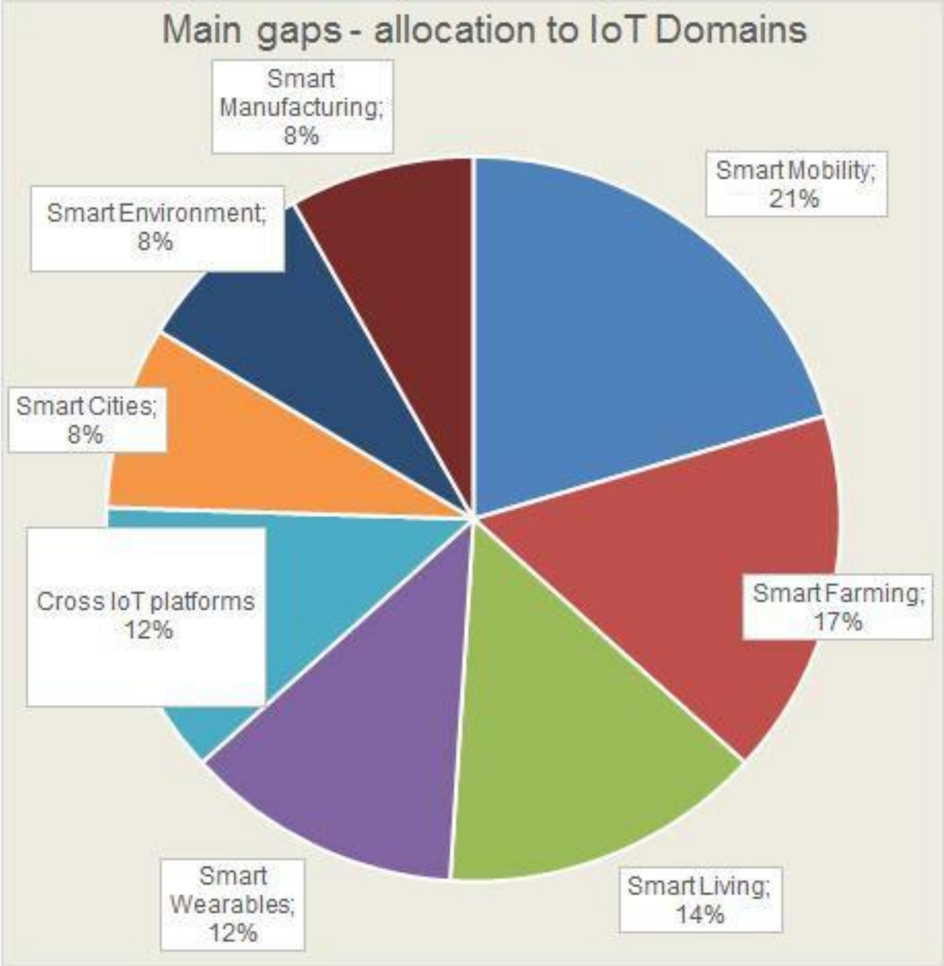
The standardization journey of IoT is ongoing: standards gaps (technical, but also business and societal)

Consolidated view of 49 main gaps

[extract from AIOTI WG03-EC workshop, Feb 2017 (results published as ETSI TR) (*)]

Standards gaps in terms of both missing and competing standards

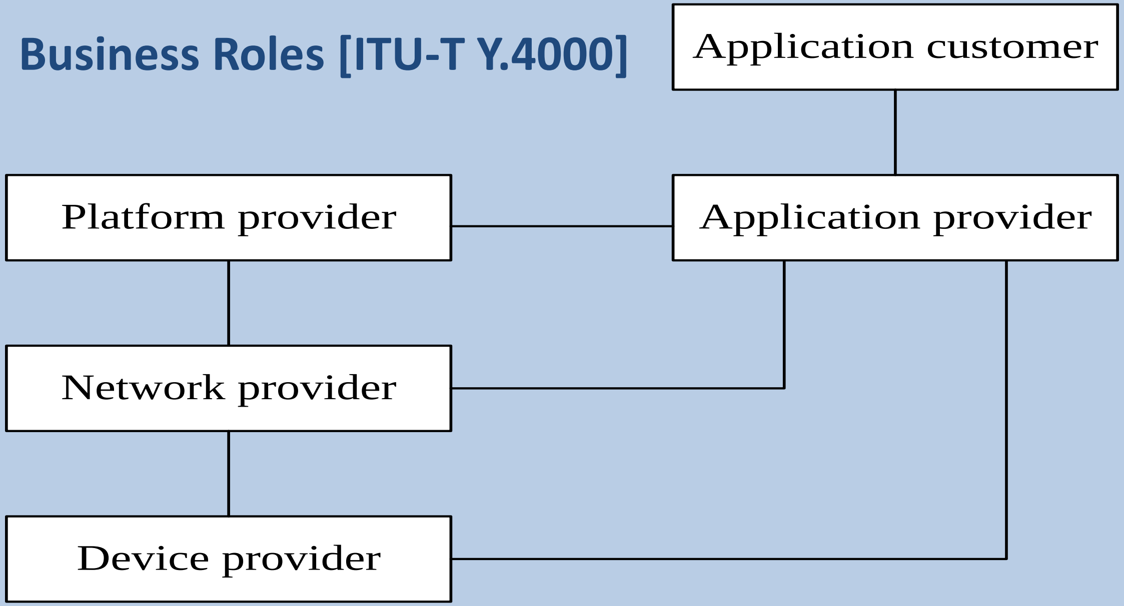




(*) A renewed study on standards gaps has been started in 2H 2018

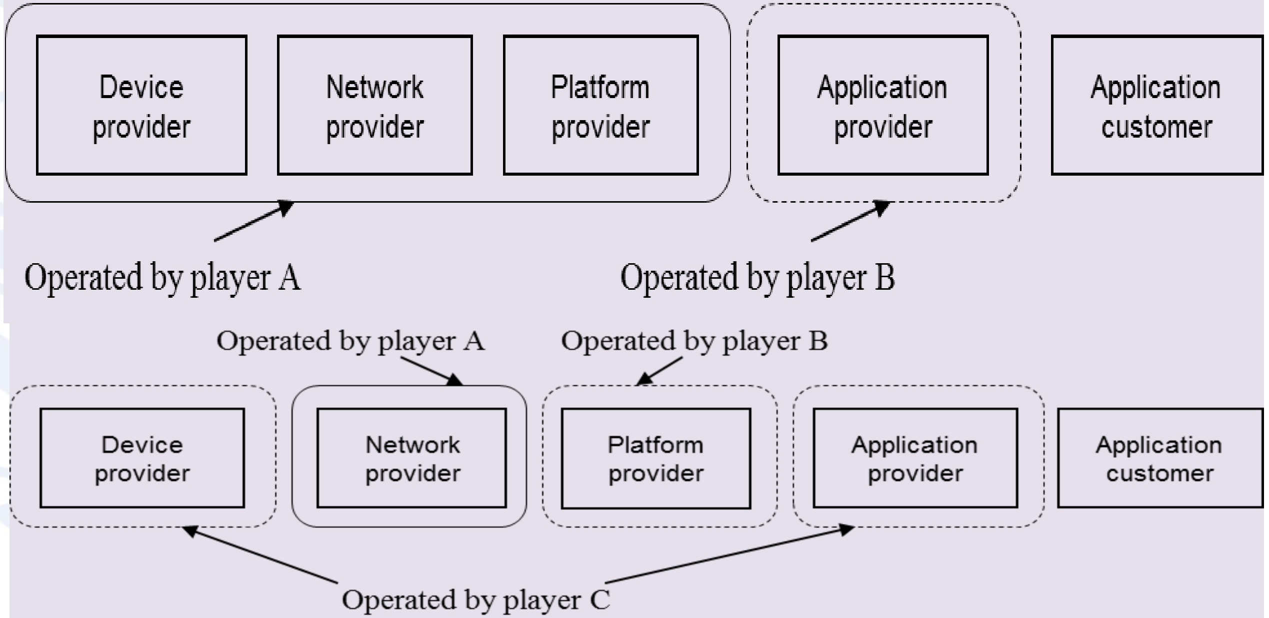
The complexity of IoT ecosystems needs to be taken into consideration also from the standards development perspective

Business Roles [ITU-T Y.4000]



Simplified view of business relationships
(not representing all what can be found across the huge number of real IoT business deployments)

Business models – one of the examples described in Y.4000



Main objective of Y.4000 analysis: building a proactive linkage between real deployments and technical standardization (requirements, capabilities and functions, open interfaces)

This exercise has been later adopted in numerous domain-specific studies s (e.g. e-health, wearables, Big Data), investigating stakeholders of those ecosystems and related requirements to support in standards development

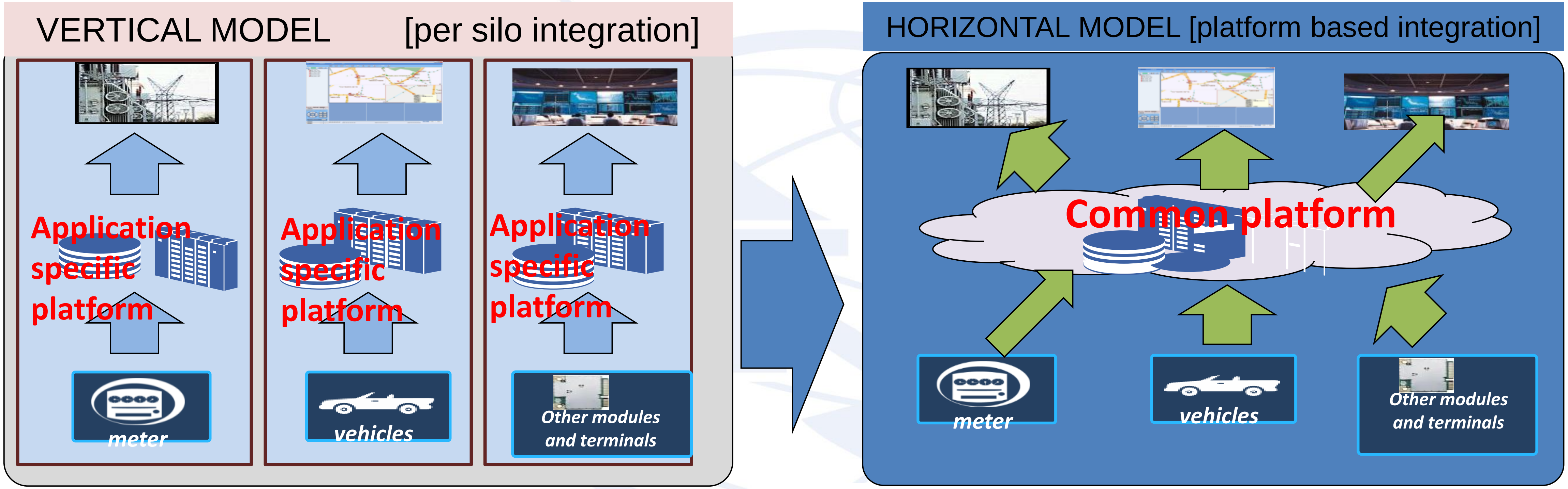
Advances, perspectives and challenges in some significant technical areas

Architectures and Platforms

NOTE – “Platform” is an abused term

From vertical to horizontal approach (common platform)

The situation of technology separation among IoT application domains produces market separation



Platform configured per vertical application (application domain)

Horizontal platform supporting multiple vertical apps
(with common components and application-specific components)

Deployment reality: different (domain) platforms will continue to co-exist and need to interoperate

Per silo integration *does not scale and limits the evolution possibilities*

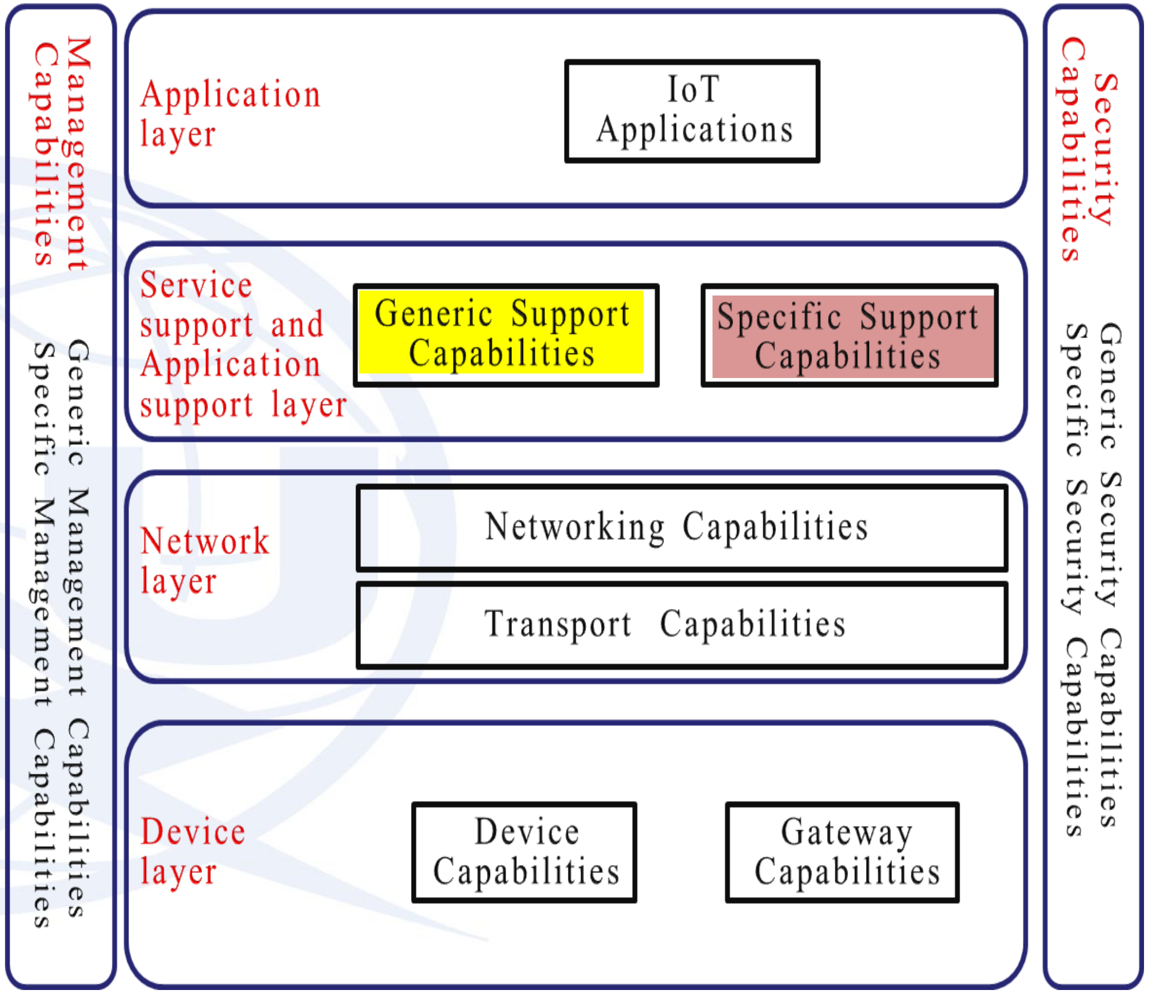
Platform based integration is needed *with the key role of open standards and open source*

A basic reference - the IoT Reference Model defined by ITU-T

Capability view of IoT infrastructure

- Application capabilities
- Service Support and Application Support capabilities
- Network capabilities
- Device and Gateway capabilities
- Cross-layer Management Capabilities
- Cross-layer Security Capabilities

Source: Y.4000/Y.2060 "Overview of the Internet of things" (2012)

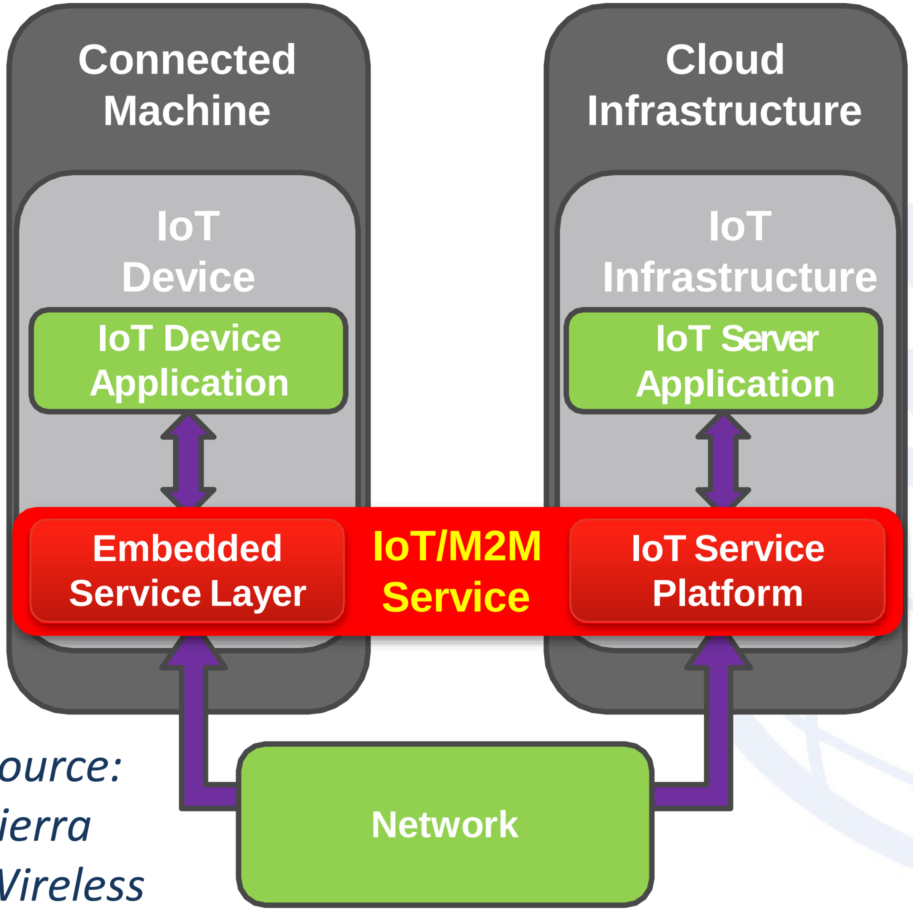


Other foundational ITU-T Recommendations on IoT include:

Y.4100 Common requirements of the Internet of things

Y.4401 Functional framework and capabilities of the Internet of things

The oneM2M Architecture and its common Service Layer



Source: Sierra Wireless

oneM2M Architecture layers

Application Layer

Software "framework" that sits between IoT applications and communication networking components

Service Layer

Provides horizontal services that IoT applications across different industry segments commonly need (e.g. data management, security, etc.)

Network Layer

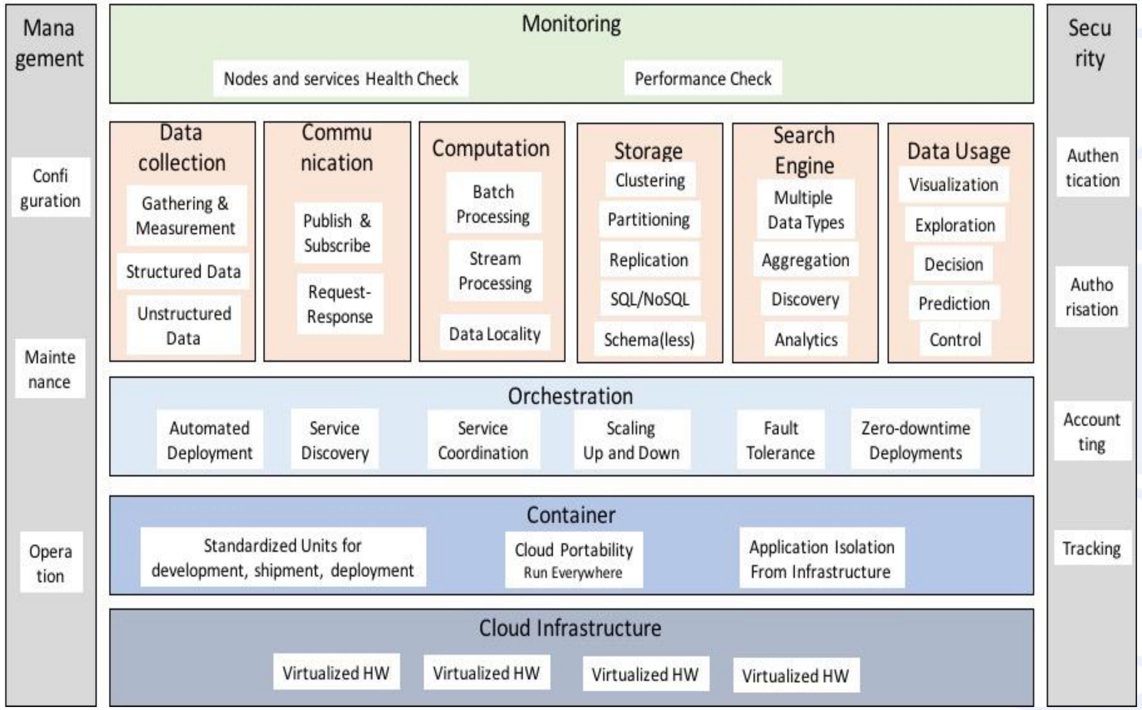
Can be deployed on devices, gateways and servers in highly distributed deployments

Via ITU-T collaboration with oneM2M, various oneM2M specifications have been adopted as ITU-T Recs/Supplements since Sept 2017 (incl. oneM2M Functional Architecture Y.4500.1)

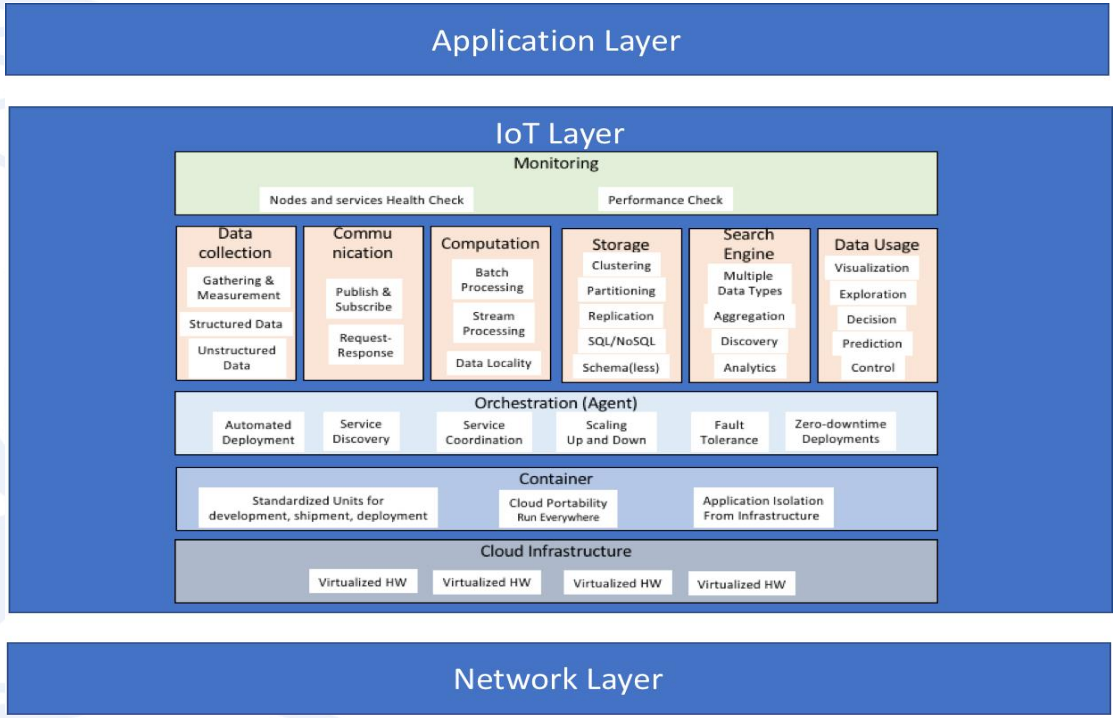
Further ITU-T collaborations are expected (incl. with ISO/IEC JTC1 SC41 and its published IoT Ref. Architecture)

The studies on IoT Architectures continue …

Example: microservices-based architectural approach for virtualization of IoT infrastructure



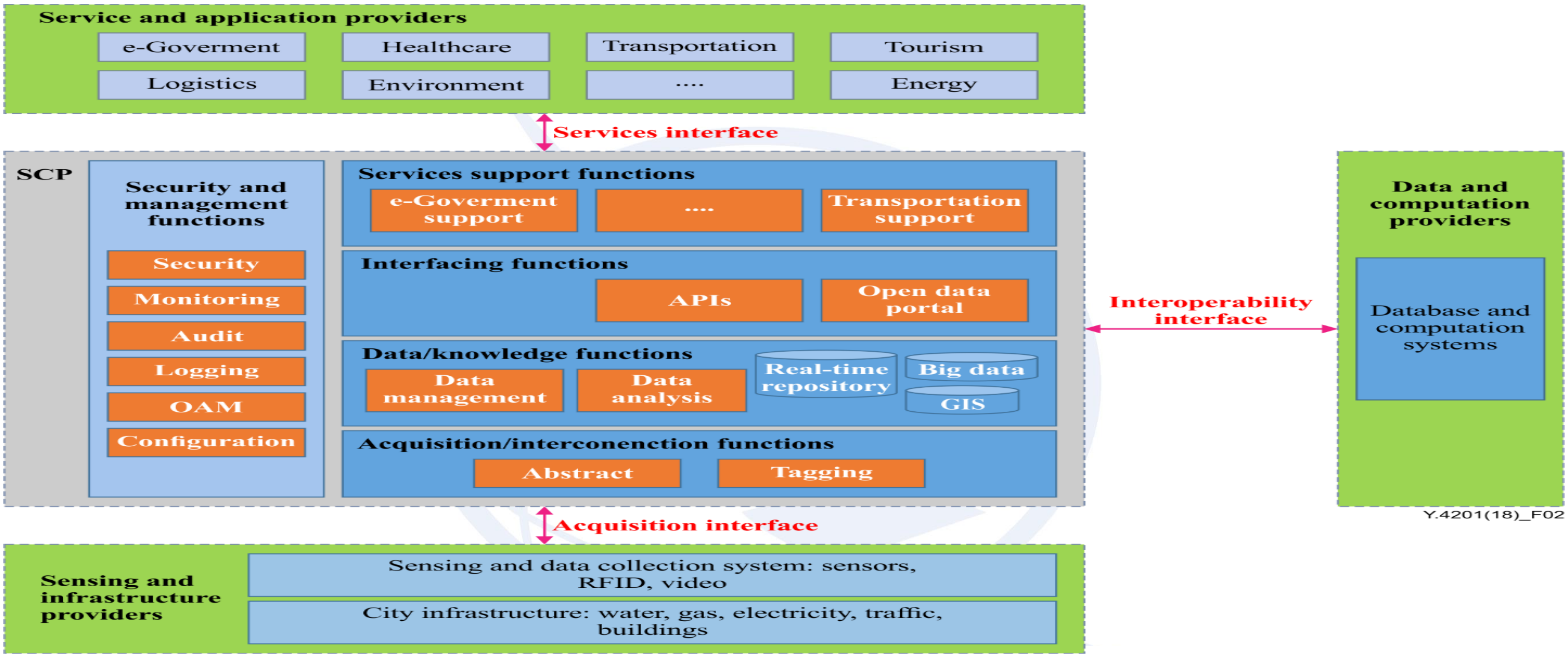
Example of microservices-based functional architecture for IoT Virtualisation



Mapping of microservices-based functional architecture on AIOTI High Level Architecture

Source: AIOTI High Level Architecture Rel. 4.0 (June 2018)

Framework of Smart City Platform [Y.4200/Y.4201]



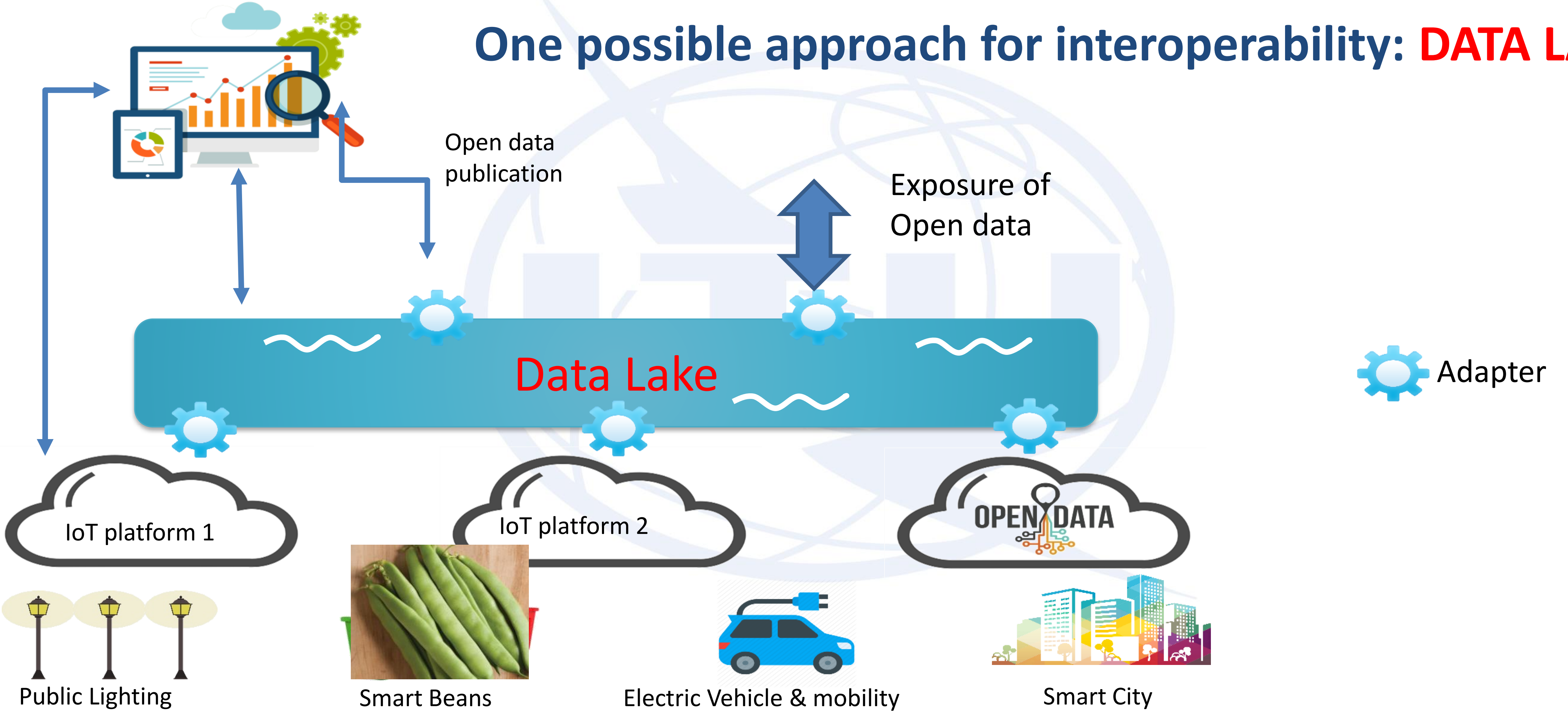
Reference framework of Smart City Platform (SCP)

Y.4200 Requirements for the interoperability of Smart City Platforms

Y.4201 High-level requirements and reference framework of smart city platforms

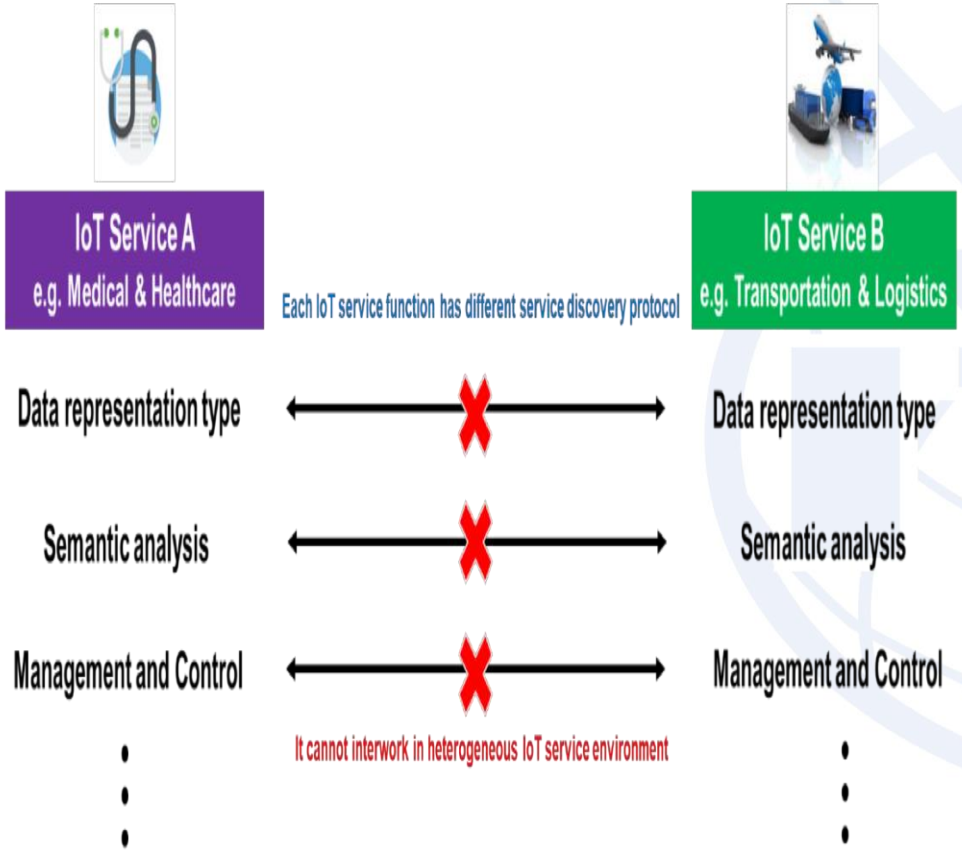
Interoperability among heterogenous platforms is critical

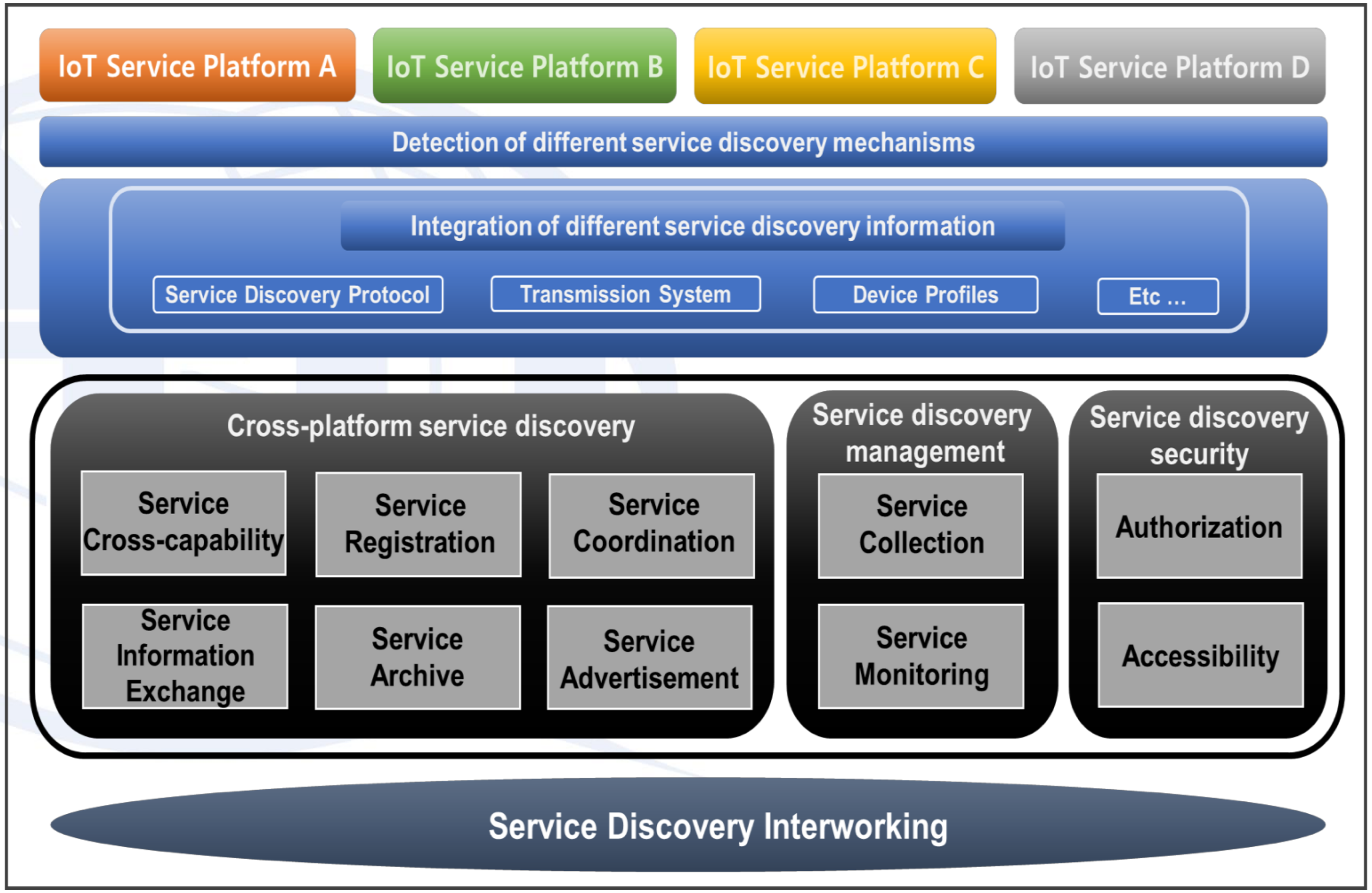
One possible approach for interoperability: DATA LAKE



Source: ongoing studies in EC H2020 project and AIOTI WG3 High Level Architecture team

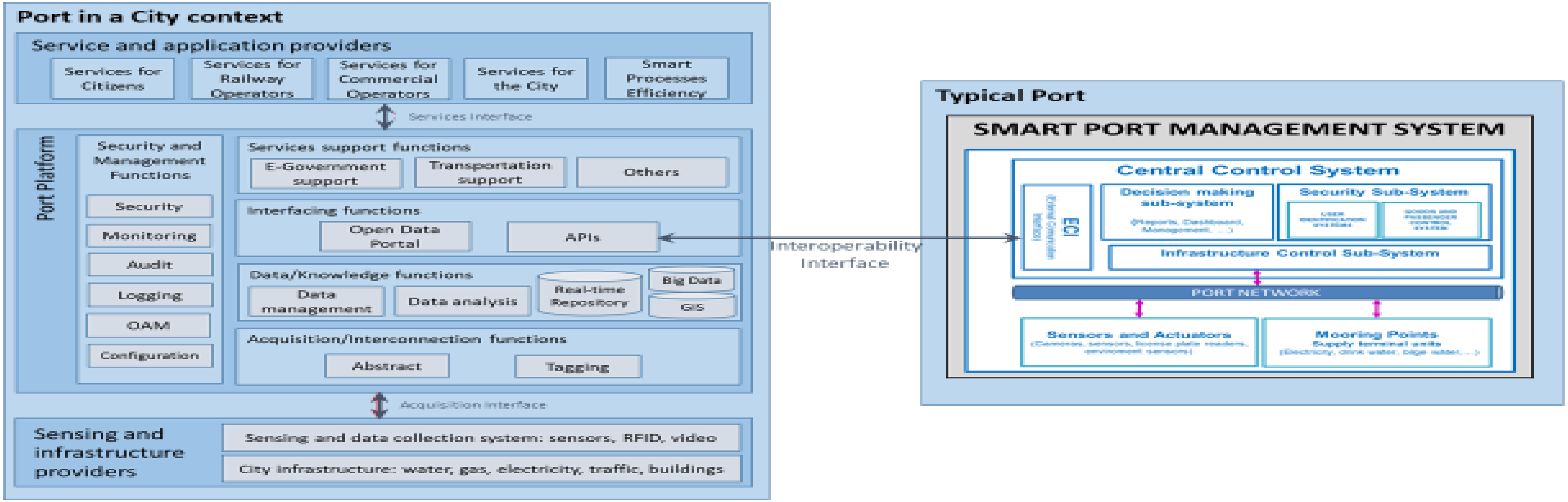
Cross-platform service discovery for platform interoperability (ongoing Y.IoT-SD-Arch)





Smart Port [ongoing ITU-T Y.smartport]

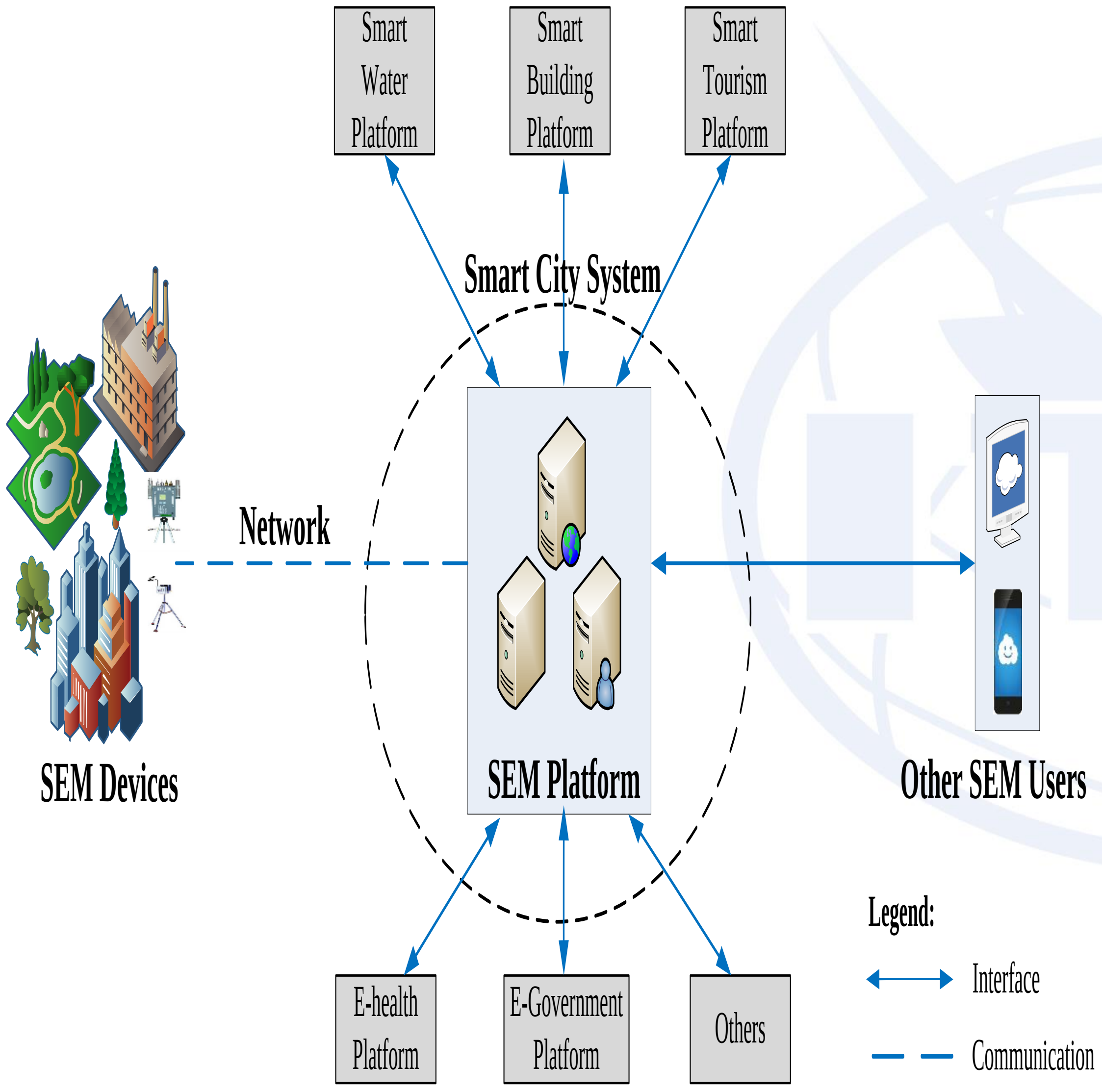
"Requirements for a Smart Port as a city element and its interoperation with the Smart City"



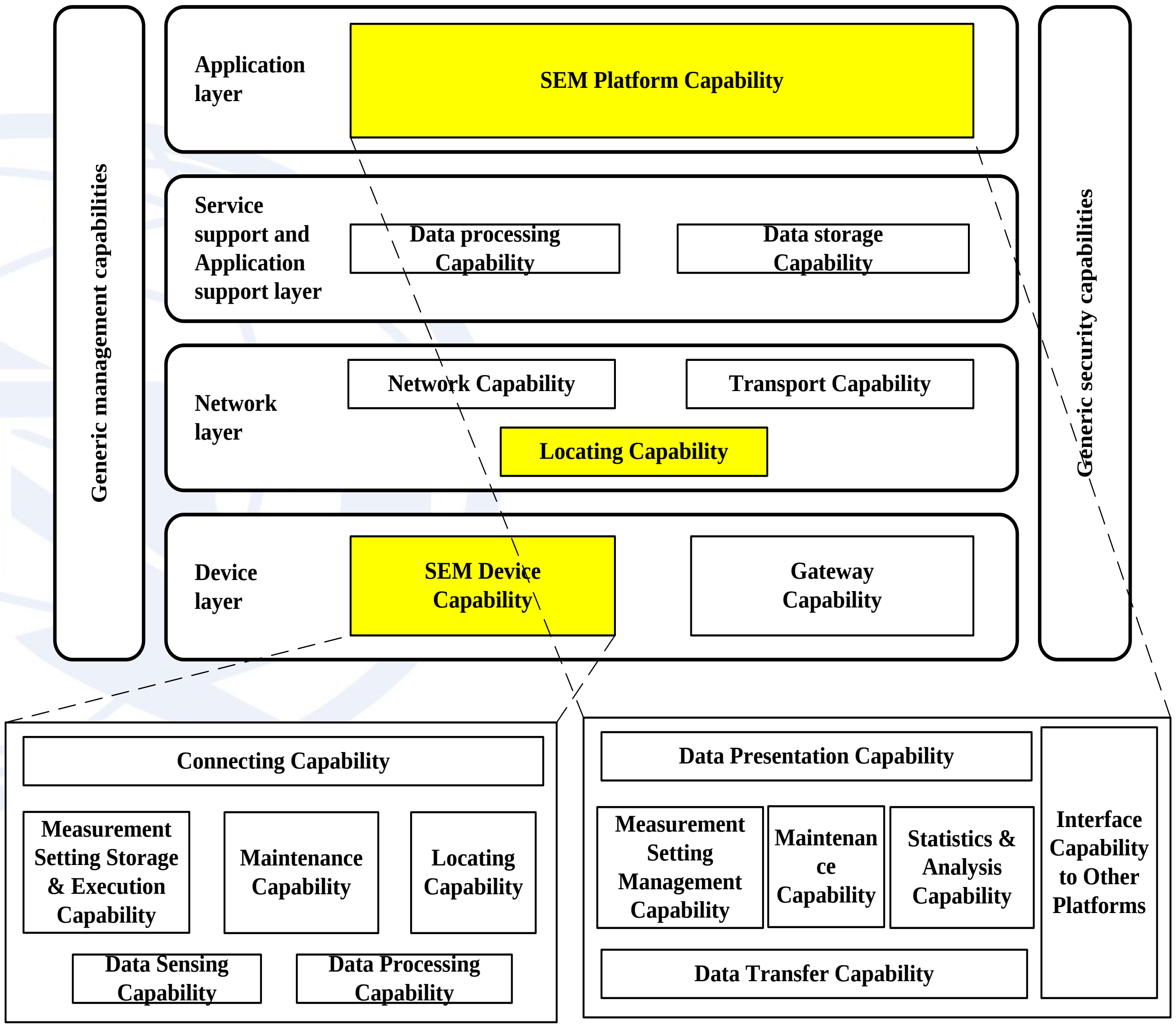
- Deployment of IoT technologies in ports can improve ports' operation and service offer
- Integration between port and city enables reciprocal access to the respective services. And cities can improve their services too.

Similar ITU-T studies are in progress concerning Smart Railway Station and Smart Airport.

IoT-based smart environmental monitoring (SEM) [Y.4207 under AAP]



Conceptual diagram of SEM



Capability framework of SEM

Smart Cities and other IoT application domains

IoT application domains – the example of the studies within ITU-T (SG20)

- Smart Cities (parking, lightning, water and waste management, fire smoke detection, buildings, citizens' safety services, physical city assets monitoring etc.)
- Smart Rural Communities and Smart Residential Communities
- Smart Tourist destinations
- Smart Port, Smart Airport, Smart Railway Stations
- Smart Transportation (Cooperative Intelligent Transport Systems, Automotive Emergency Response Systems, Transportation Safety Services, Unmanned Aircraft Systems, Autonomous Driving, other)
- Smart Retail
- Smart Farming (Agriculture, Livestock)
- Smart Manufacturing (Framework in the context of Industrial IoT)
- Wearables
- E-health Monitoring
- Smart Environmental Monitoring
- Monitoring and study of Global Processes of the Earth for disaster preparedness
- Micro-Grids and Advanced Metering Infrastructure
- Connected Home Networks
- Smart Education
- Others

Smart Cities as super application domain of the IoT

Smart City in simple layers

Integration of multiple verticals

Citizen-centric services incl. open data apps, 3rd party apps, city apps and dashboards

The brain of the city

Data collection, analysis, knowledge, planning, action

The senses of the city

City data sources

A number of technical challenges still to be addressed including Interoperability (large variety of systems, devices, data types), Security, Privacy.

But, also, it is needed harmonization between technical and policy issues (e.g. data ownership and security)

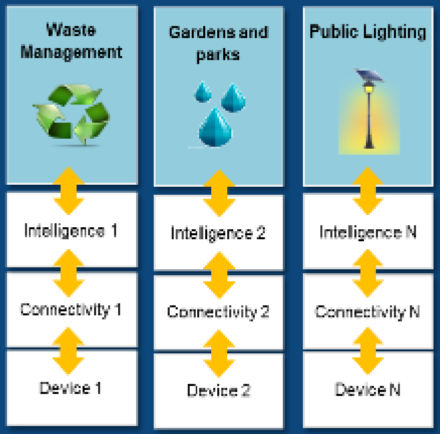
Source: Dr. Levent Gürgen

Smart Cities: an incremental and participatory journey towards full support to Data Economy

1 → 2 → 3 → 4

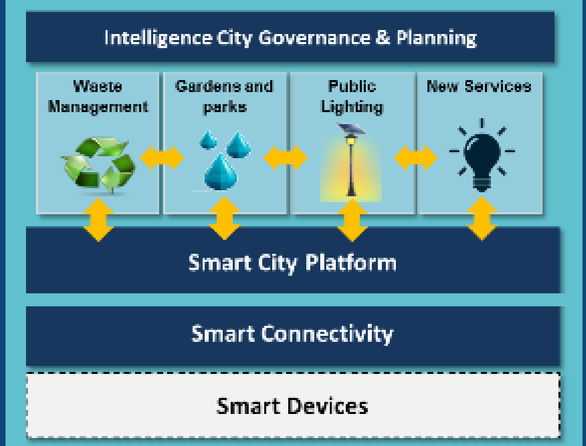
Efficient and Open

- Vertical solutions bringing efficiency in silos
- Historic data as open data
- Information still in vertical silos, no global picture



Truly Smart

- Horizontal platform integrating “right-time” context info from different vertical services
- Predictive and prescriptive models



Unleashing Right-time Open Data

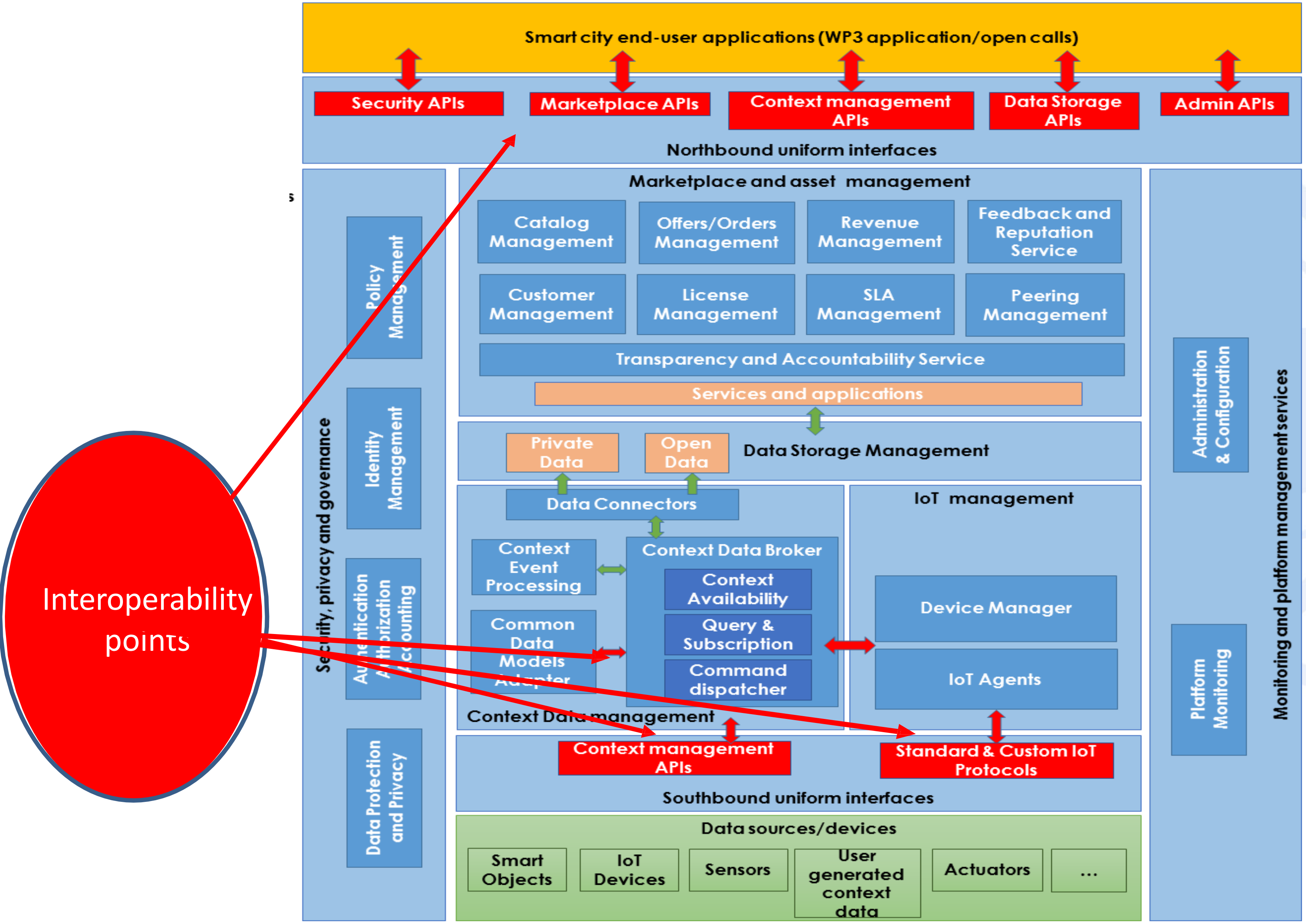
- Right-time context info published to third parties
- Exchange of context info with systems from other domains

Support to Data Economy

- City as a platform including also 3rd party data enabling innovative business models
- Open and commercial data enabling multi-side markets

Source: FIWARE

A lot of Smart Cities architectures: the example of the SynchroniCity Reference Architecture



Source: SynchroniCity

SynchroniCity is part of the European H2020 Large Scale Pilots programme

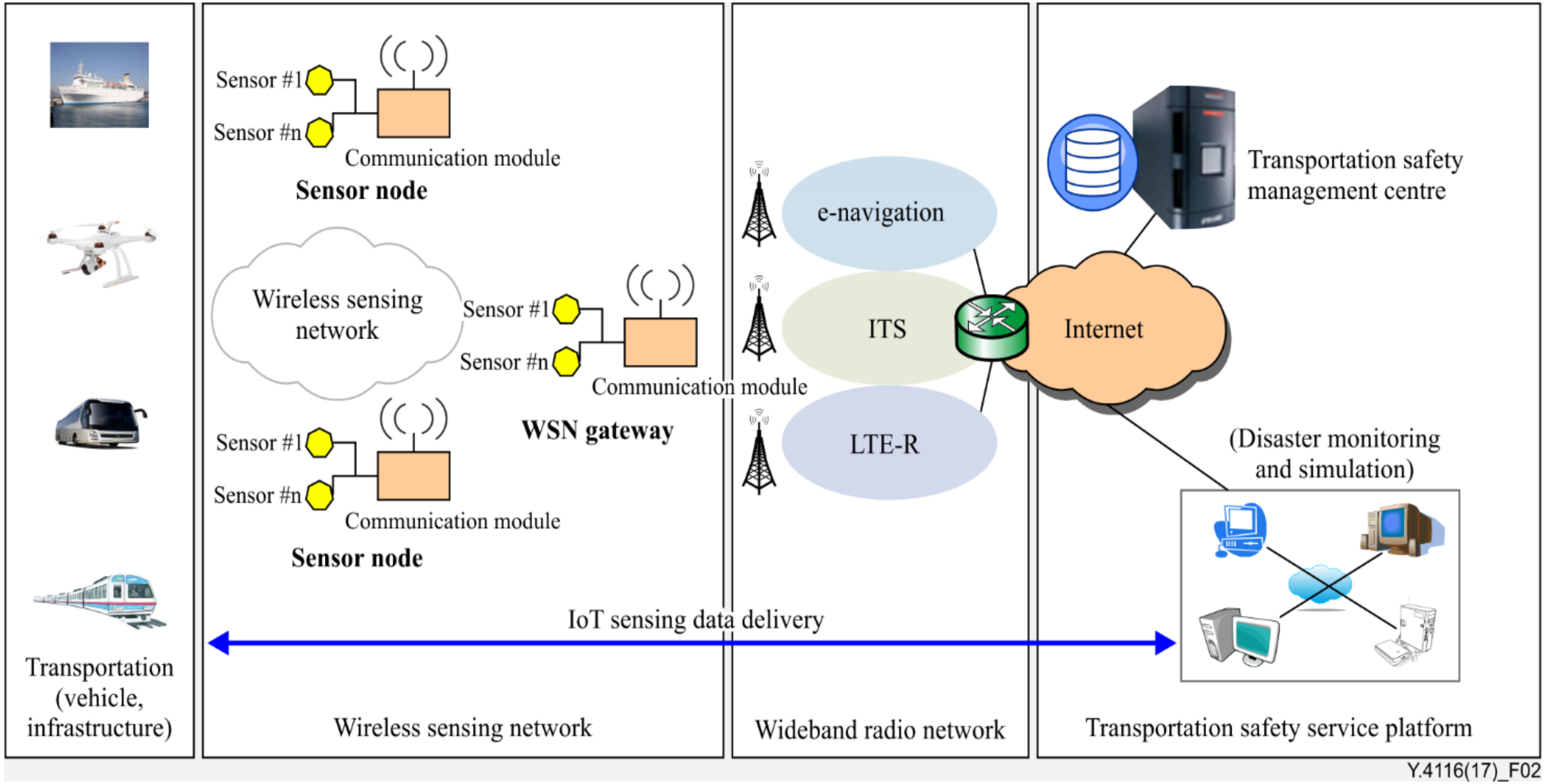
SynchroniCity goal: start building a Single Digital Market for IoT-enabled Smart City solutions for Europe

(11 reference zones with 8 European cities, 3 outside (Mexico, Korea, US))

Key concept of SynchroniCity Reference Architecture: definition of interoperable points

Synchronicity also works on a set of common data models for different verticals (for semantic interoperability)

IoT for transportation safety services [Y.4116]

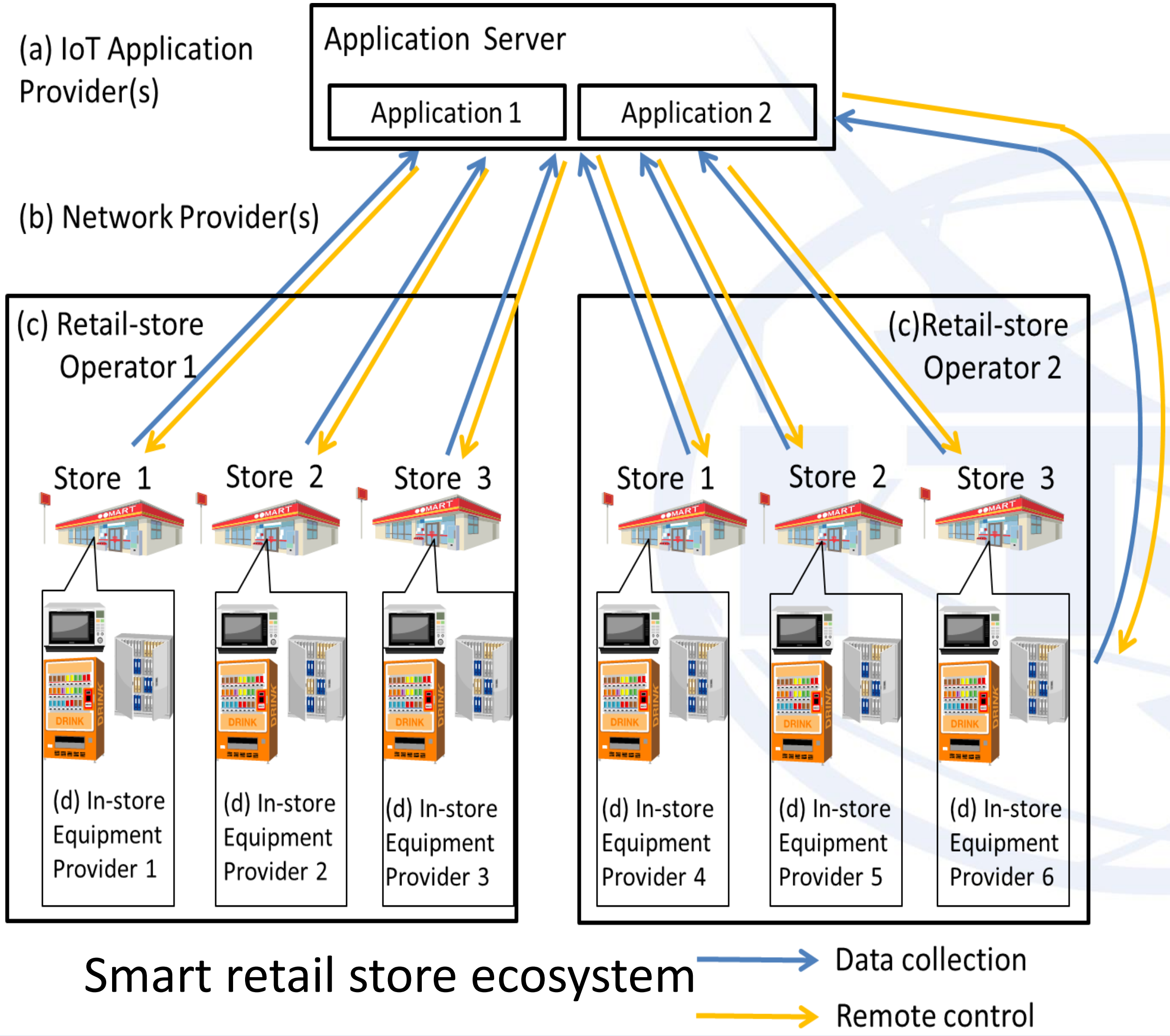


Extract from Y.4116 "Requirements of transportation safety services including use cases and service scenarios"

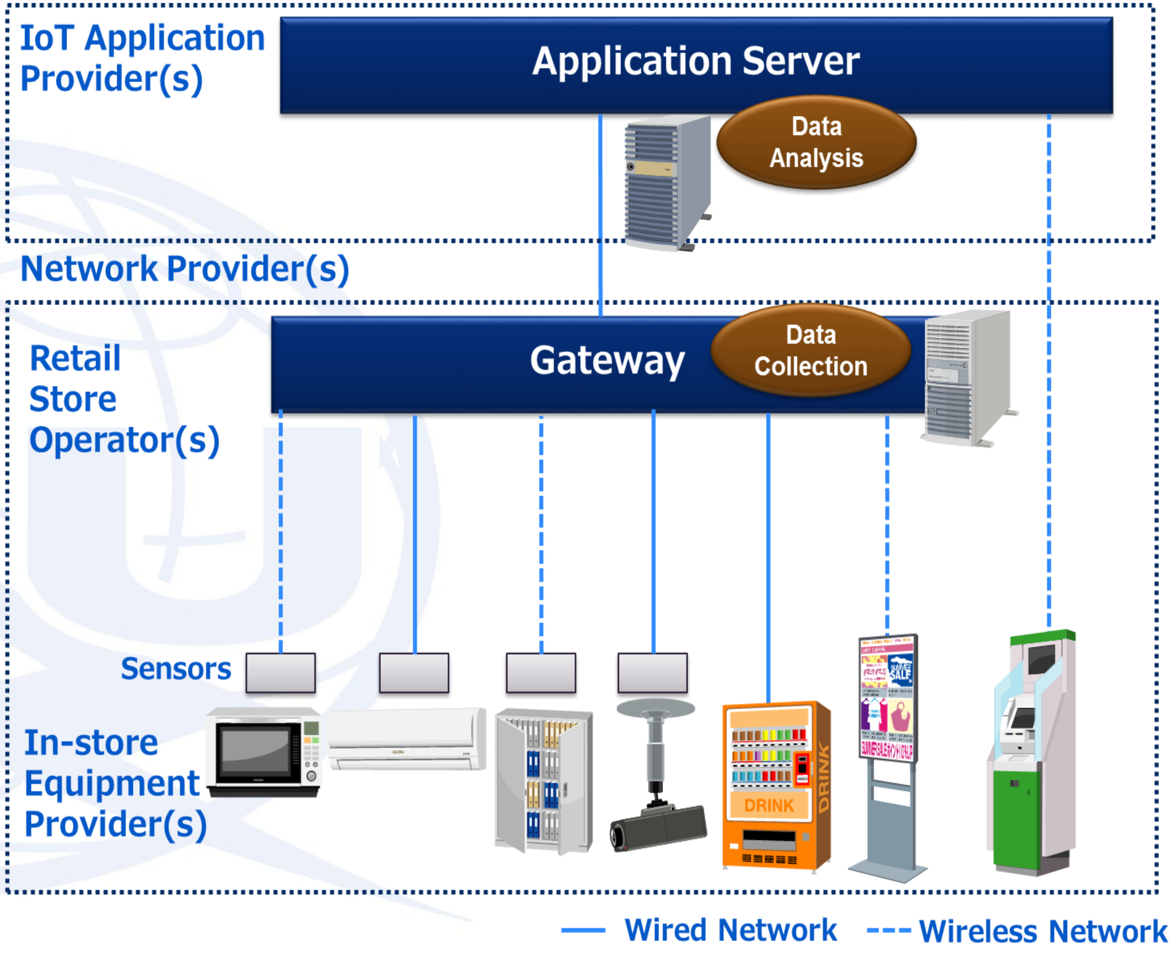
IoT technologies usage can reduce/prevent occurrence of accidents and disasters

The transportation safety management centre monitors the safety status of vehicles and transportation infrastructure, and influences the operations of vehicles and infrastructure, by collaborating with the transportation safety service platform, including generation of alarms.
The transportation service platform monitors transportation safety relevant conditions and parameters, performs disaster simulations and decides the threshold values for disaster prediction and detection.

IoT enabled applications for retail stores [Y.4120]



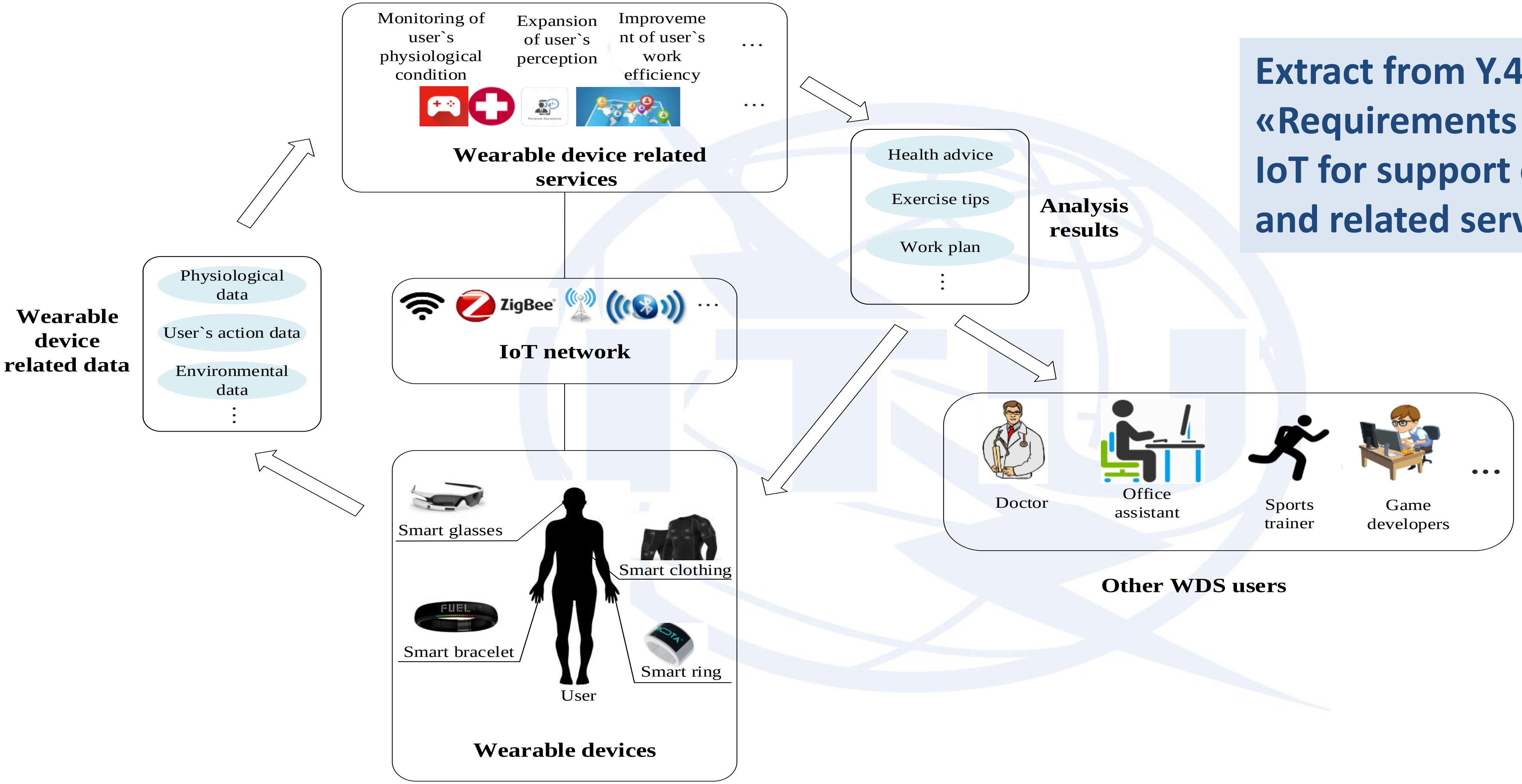
Smart retail store ecosystem



Data collection and analysis for smart retail stores

IoT technologies can enable ***safe and efficient retail store management system for non-stop operation (24 hours / 365 days)****: collection and monitoring in real time of equipment information may allow early detection of equipment failure and accurate prediction of equipment problems.*

IoT for wearable devices and related services [Y.4117]

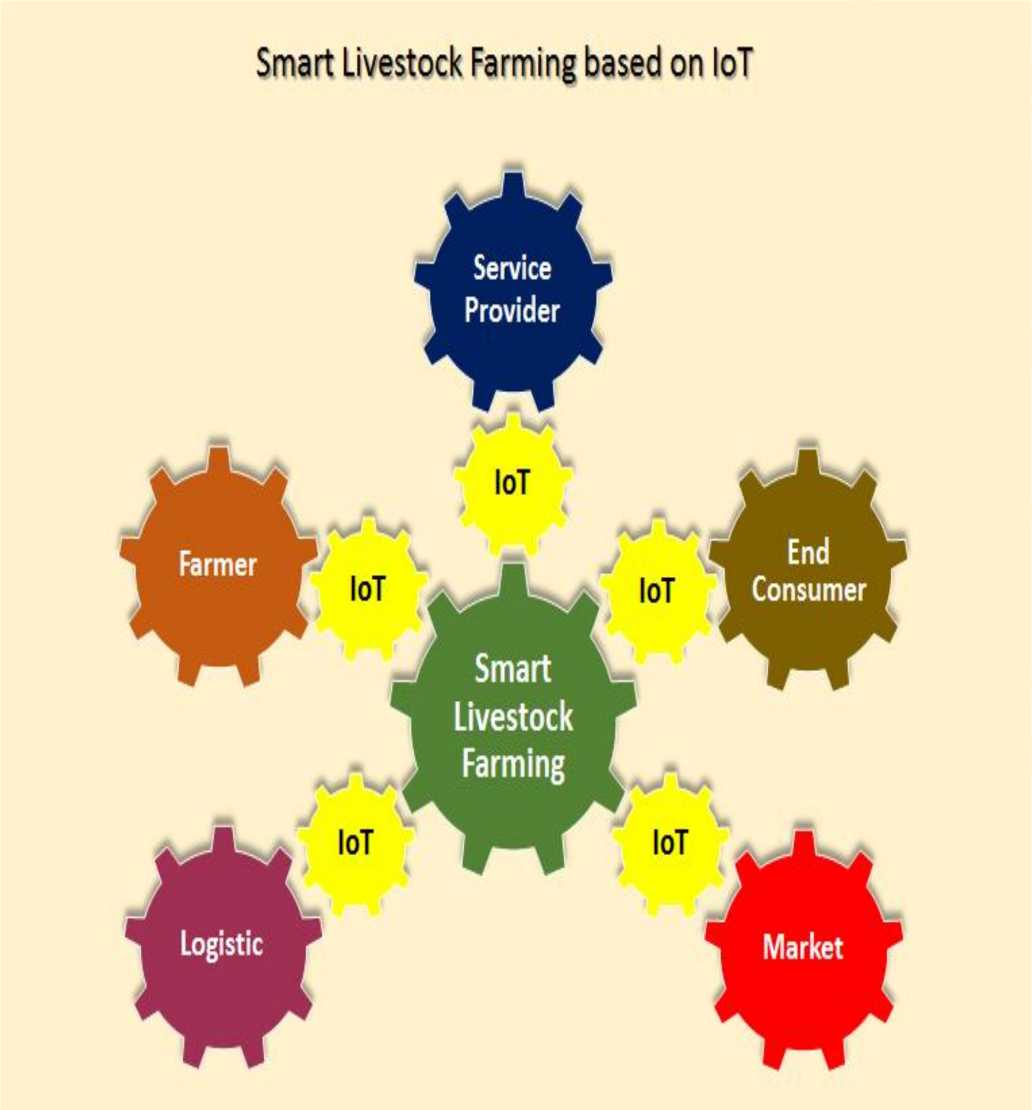


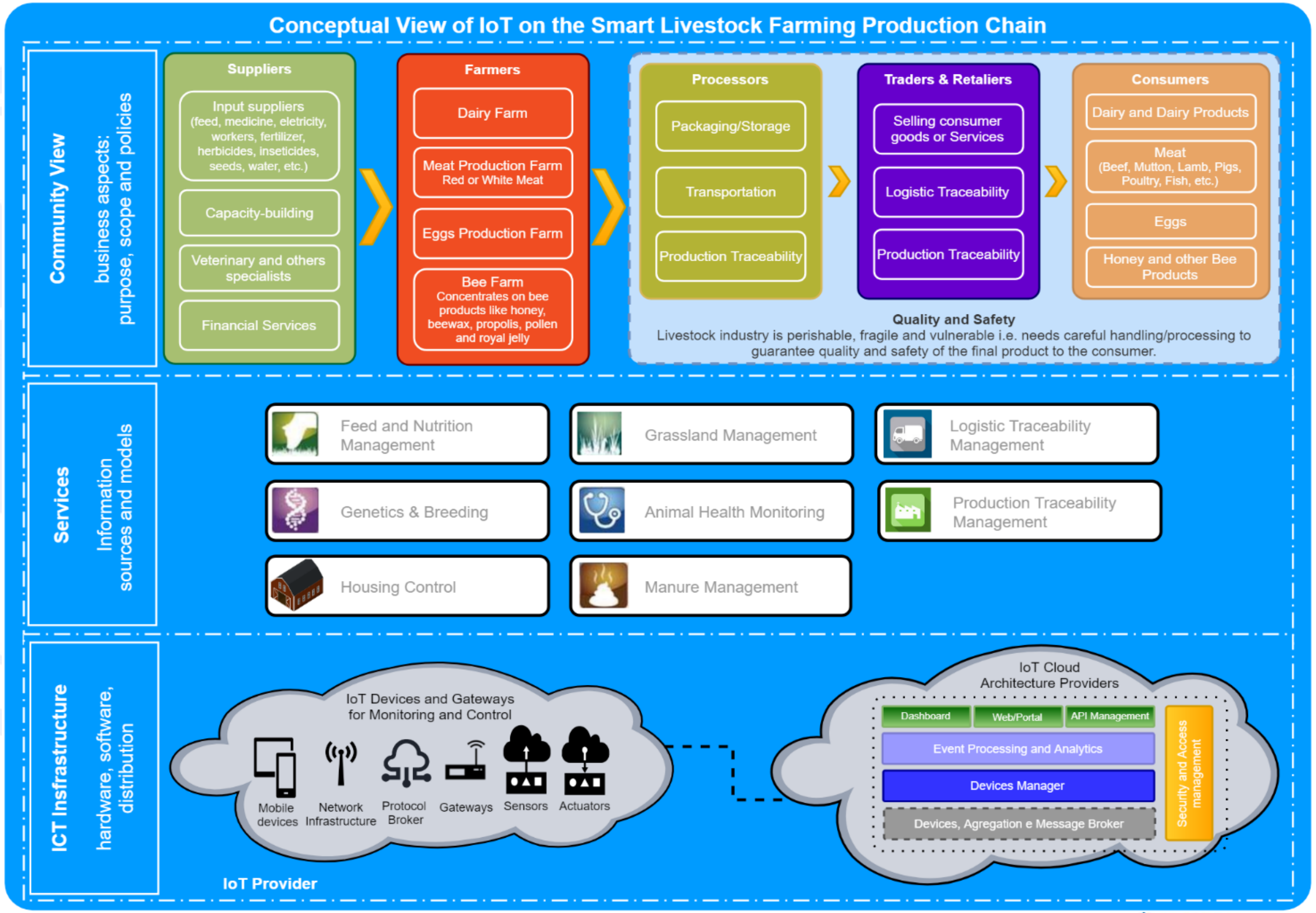
Extract from Y.4117 «Requirements and capabilities of IoT for support of wearable devices and related services»

Y.4117 identifies 4 classes of wearable services, with their distinct characteristics and requirements for the supporting IoT network

Smart Livestock Farming [ongoing Y.IoT-SLF]

«Framework and Capabilities for Smart Livestock Farming Based on IoT»





Three tier conceptual model for Smart Livestock Farming production chain

Thank you very much for your attention

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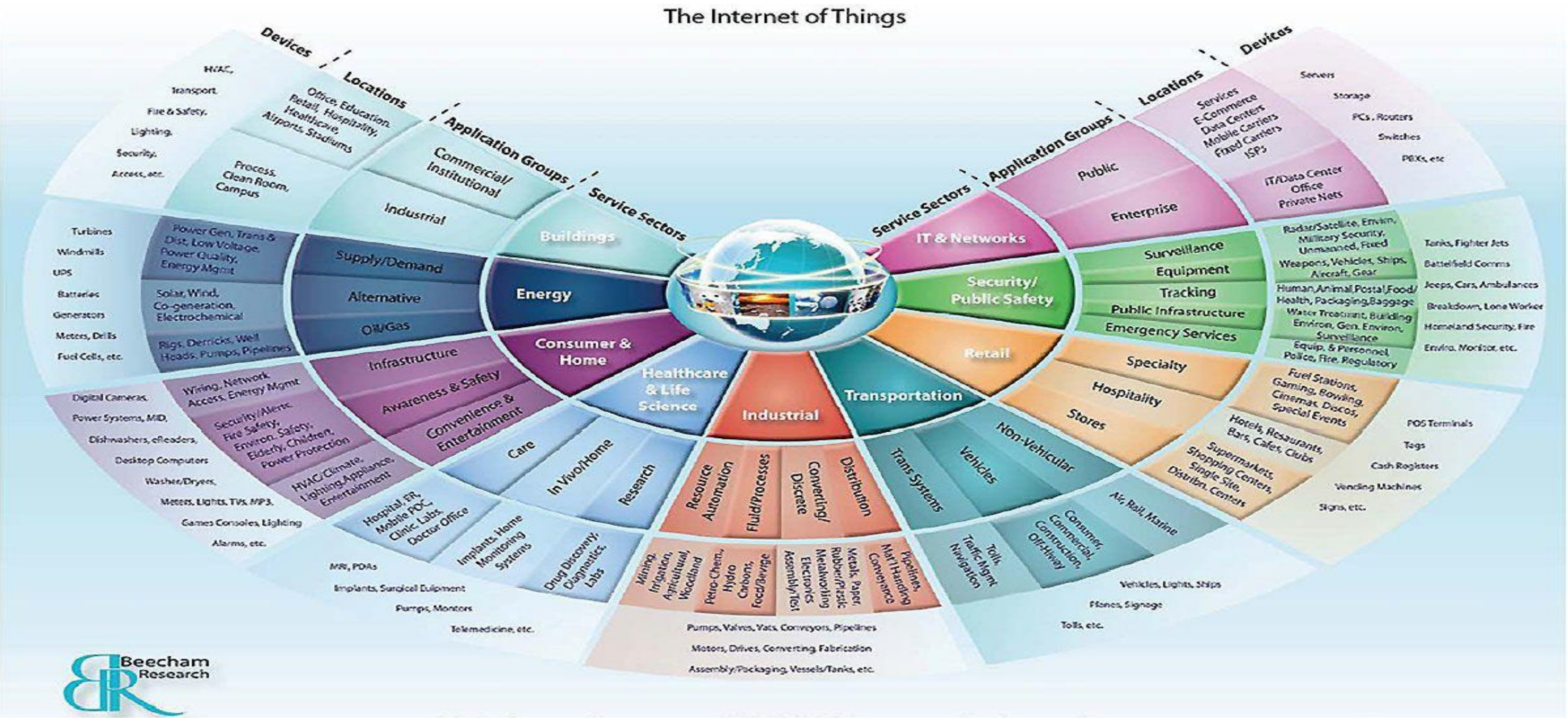
Backup information



IoT is driving a profound transformation of the industries, with impact on products, processes, business models and ecosystems, social life

IoT SDOs and Alliances Landscape (Technology and Marketing Dimensions)

Landscape in continuous evolution

Source: AIOTI WG3 (IoT Standardisation) – Release 2.8

ITU-T Study Group 20: “IoT and Smart Cities & Communities”

Lead Study Group on

- Internet of things and its applications
- Smart Cities and Communities, incl. its e-services and smart services
- IoT identification

SG20 structure	
WP1/20	
Q1/20	End to end connectivity, networks, interoperability, infrastructures and Big Data aspects related to IoT and SC&C
Q2/20	**Requirements, capabilities and use cases across verticals**
Q3/20	Architectures, management, protocols and Quality of Service
Q4/20	e/Smart services, applications and supporting platforms
WP2/20	
Q5/20	Research and emerging technologies, terminology and definitions
Q6/20	Security, privacy, trust and identification
Q7/20	Evaluation and assessment of Smart Sustainable Cities and Communities

Established in June 2015 to consolidate the various ITU-T activities on IoT

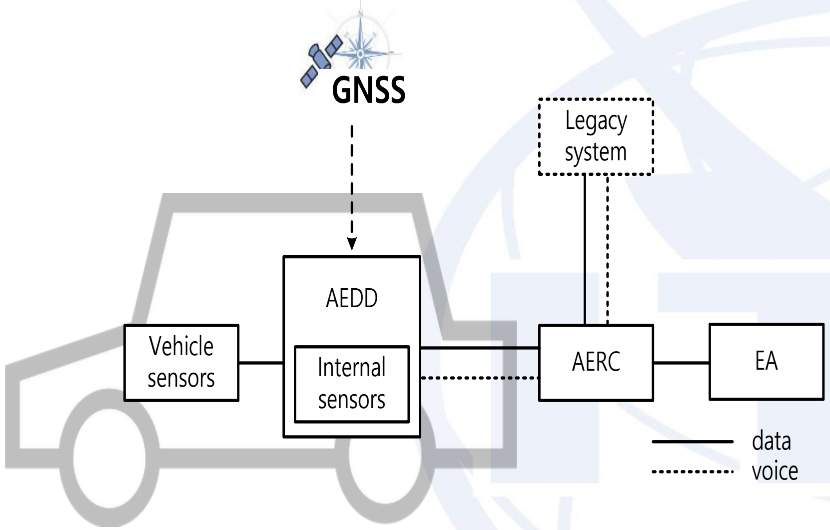
Last SG20 meeting on 9-18 April 2019, Geneva (Switzerland)

Next SG20 Rapporteurs’ group meeting on 22-26 July 2019, Geneva

SG20 Home page: http://www.itu.int/en/ITU-T/studygroups/2017-2020/20/Pages/default.aspx

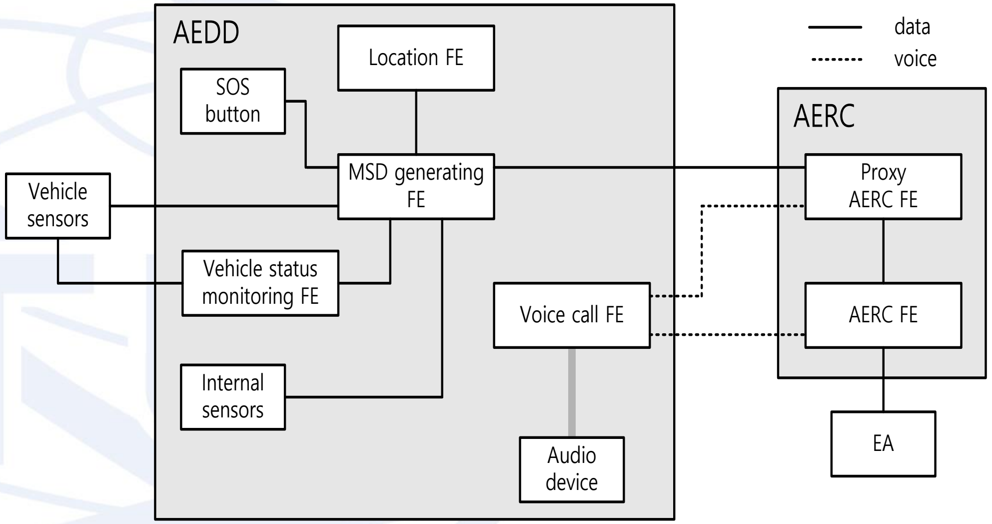
IoT-based Automotive Emergency Response System [Y.4119]

Overview of the AERS



AEDD automotive emergency detection device
AERC automotive emergency response center
EA emergency authority
GNSS global navigation satellite system

Capability framework of the AERS

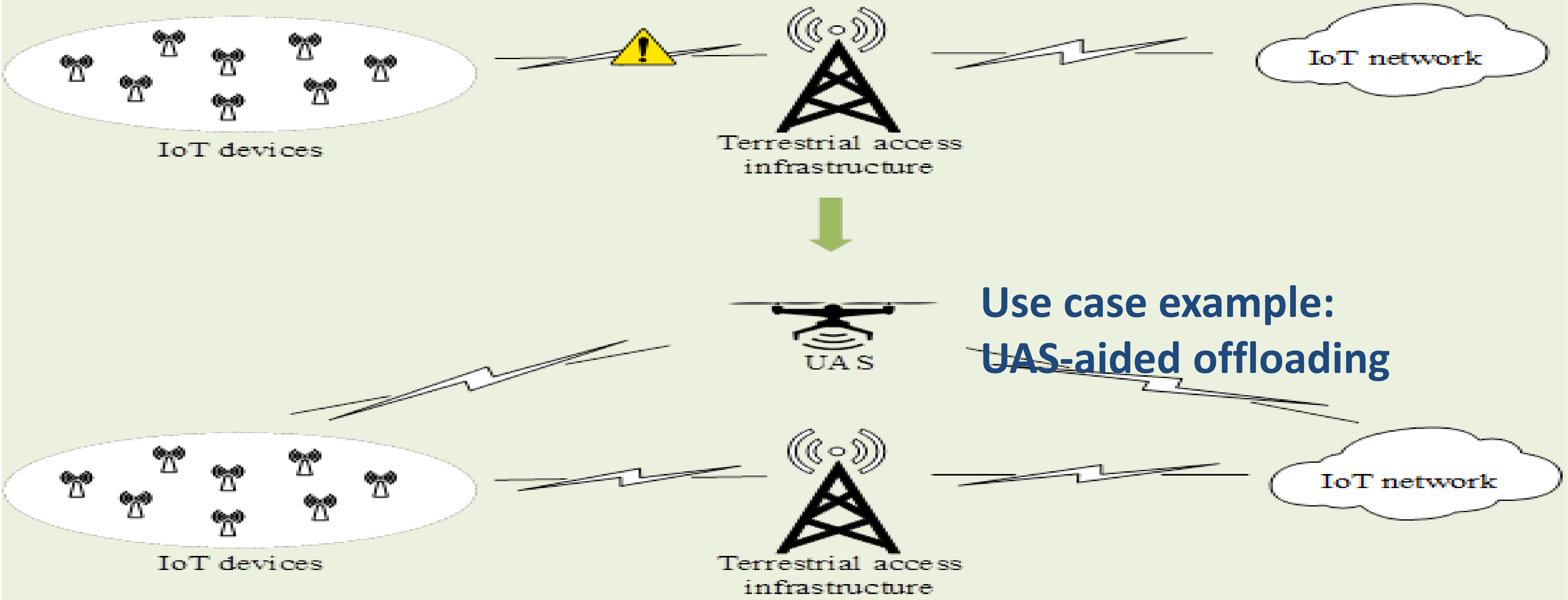


An IoT-based automotive emergency response system is expected ***to reduce the automobile accident detection and reporting times*** *using automatic accident detection-report procedures.*
Furthermore, since a sensor assisted geographical positioning allows to pinpoint the exact location of the accident, ***the time for rescue to reach the accident scene is expected to be shortened significantly.***

Unnamed aircraft systems (UAS) [ongoing Y.IoT-UAS-Reqts]

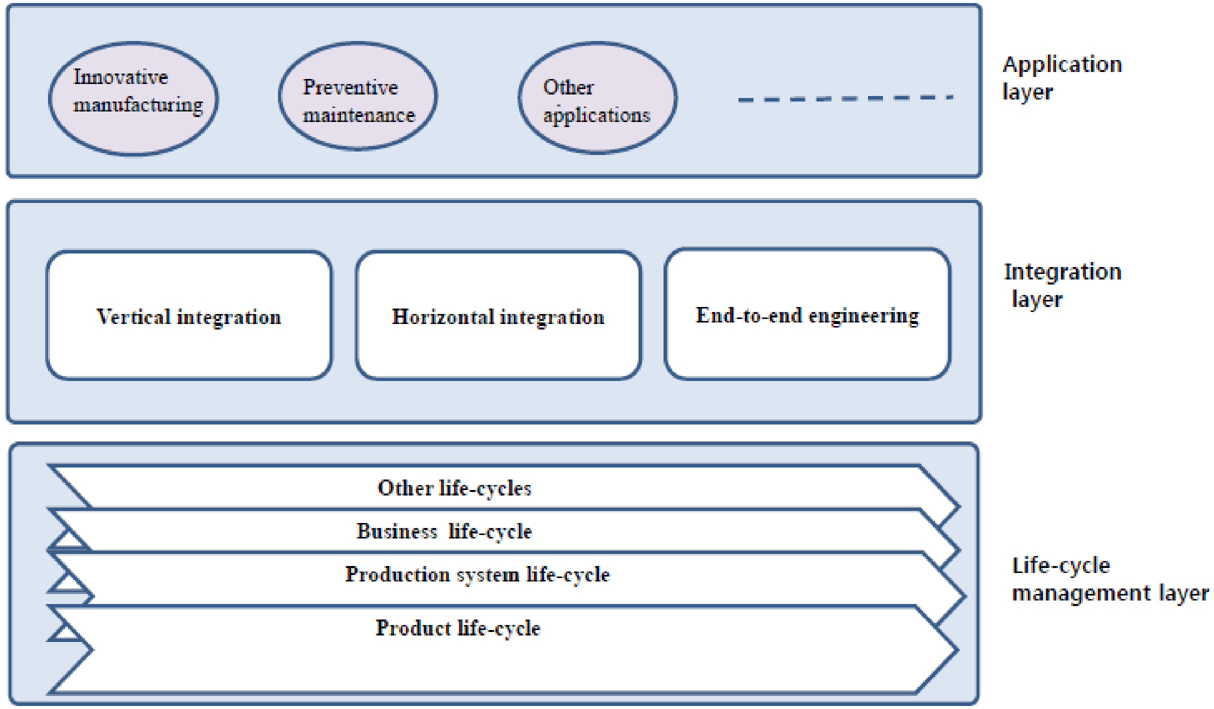
"Use cases, requirements and capabilities of UASs for Internet of Things"

UASs can act as as wireless communication platforms in the IoT

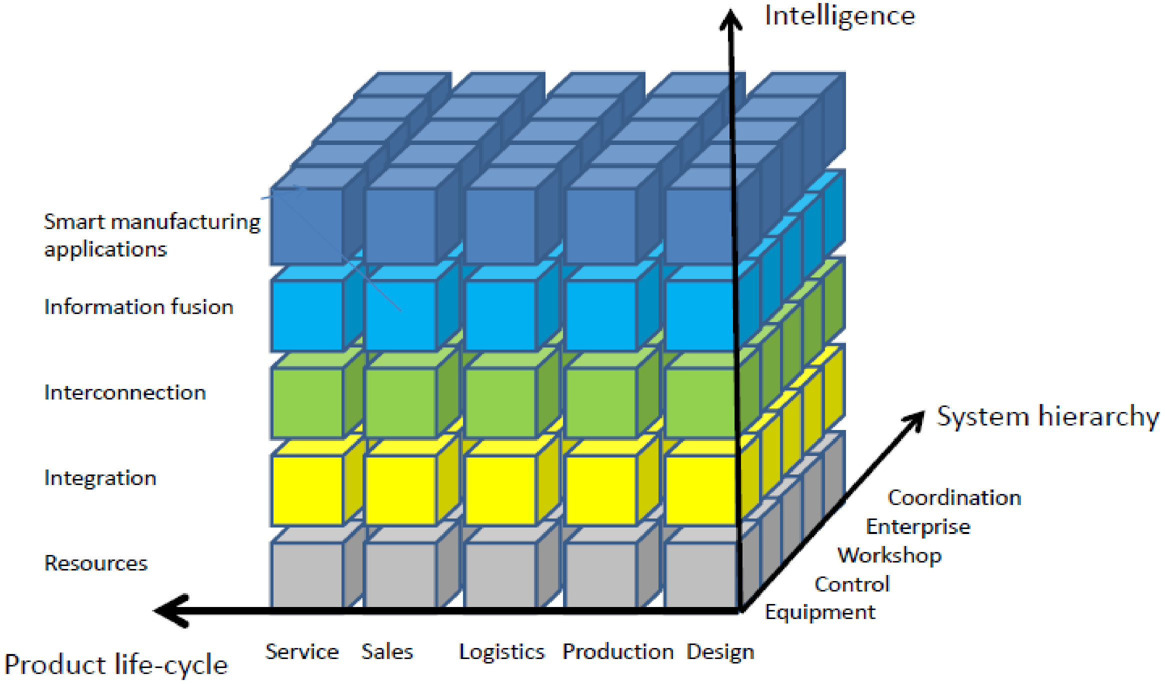


Use case example:
UAS-aided offloading

Smart Manufacturing in the context of the Industrial IoT [Y.4003]



Overview of smart manufacturing from the functional layering perspective



Reference model of smart manufacturing in the context of the Industrial IoT from the product life-cycle view

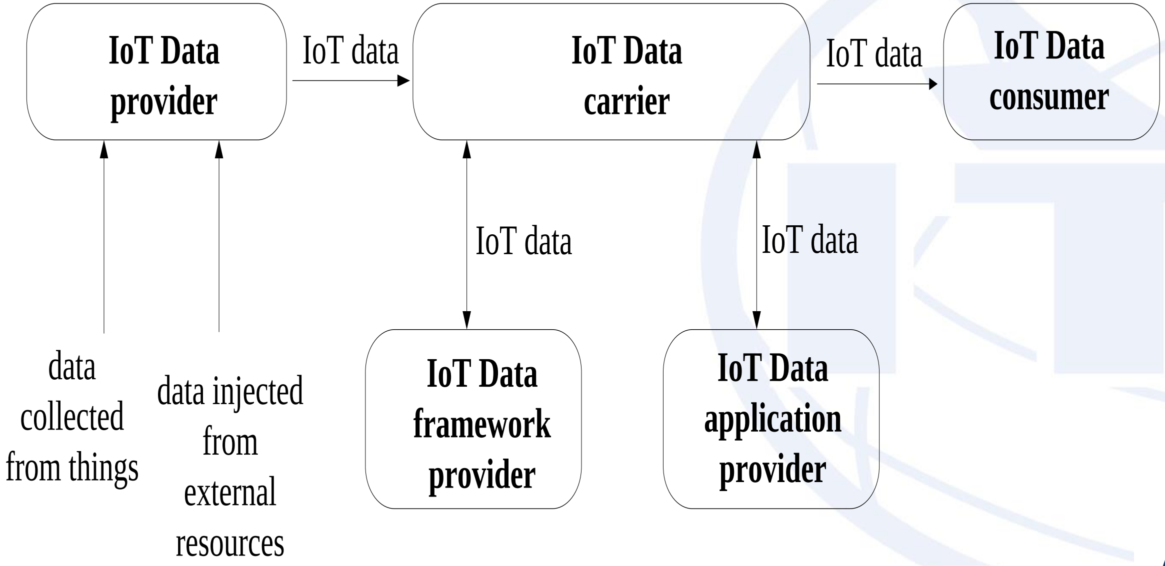
Y.4003: Overview of smart manufacturing in the context of the industrial Internet of things

Smart Manufacturing, and Industrial IoT in general, is a strategic business objective in the international competition, as well as a hot standardization topic with numerous international, regional and national standards initiatives

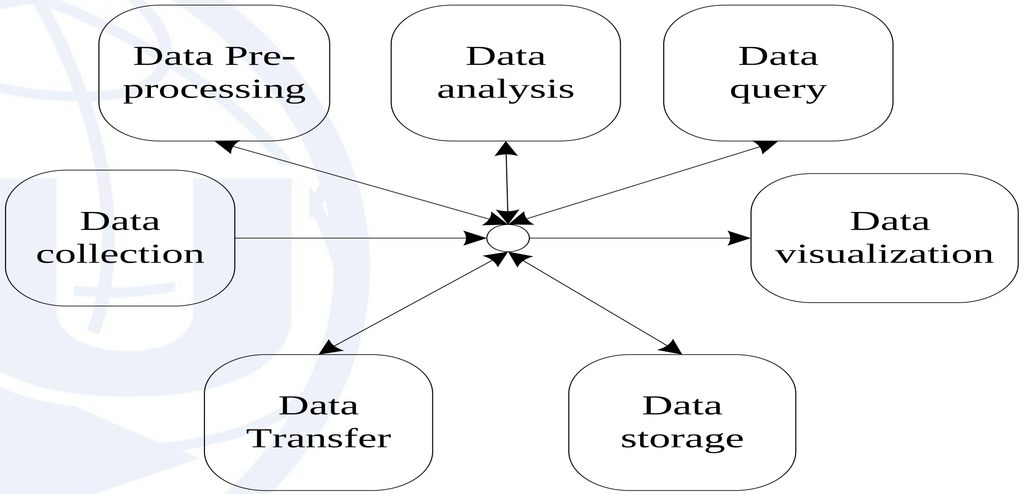
Horizontal capabilities and technologies

[Standards-based integration of] Data Management capabilities in the IoT

The first study in ITU-T: Y.4114 "Specific requirements and capabilities of the IoT for Big Data"
[Requirements and capabilities the IoT is expected to support to address the challenges related to Big Data]



The IoT data roles identified in Y.4114
[the key roles relevant in an IoT deployment from a data operation perspective]



Abstract representation of IoT data operations and related data flows (diverse concrete IoT deployments do not imply unique logical sequencing of IoT data operations)

Relevant ongoing initiative for further progress of Data Management standardization: ITU-T Focus Group on Data Processing and Management to support IoT and Smart Cities & Communities (FG-DPM)

Semantics based technologies are a promising tool for intelligence enablement from data

Shared vocabularies and their relationships [ontologies]

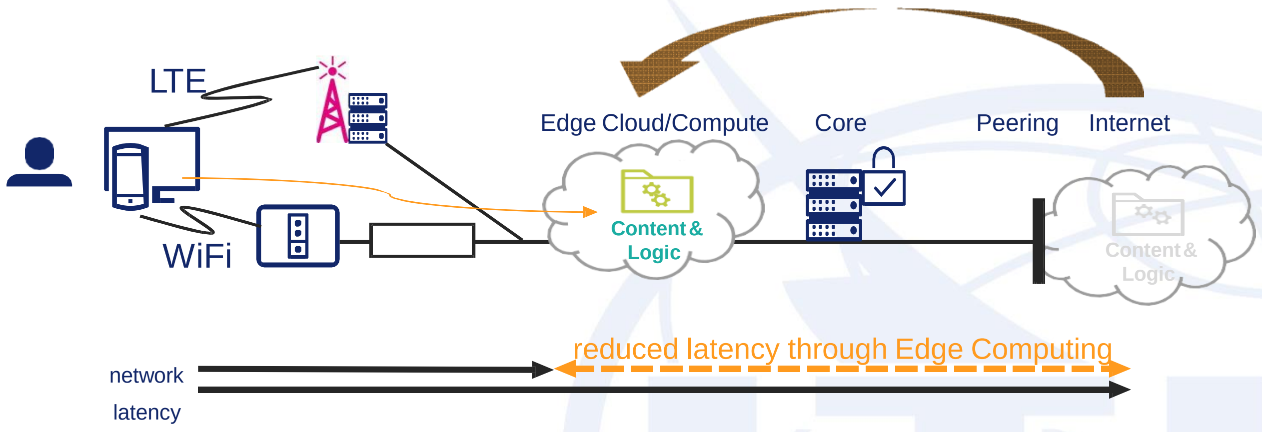
The IoT has requirements for interoperability, scalability, consistency, discovery, reusability, composability, automatic operations, analysis and processing of data

- ***Semantics based approaches have outstanding features towards these requirements***
- Promising experimentations of semantic technologies, but further development, validation, standardization are needed

Standardization of semantics based capabilities is ongoing in various expert groups, incl. W3C, ETSI SmartM2M/oneM2M (see SAREF), OGC

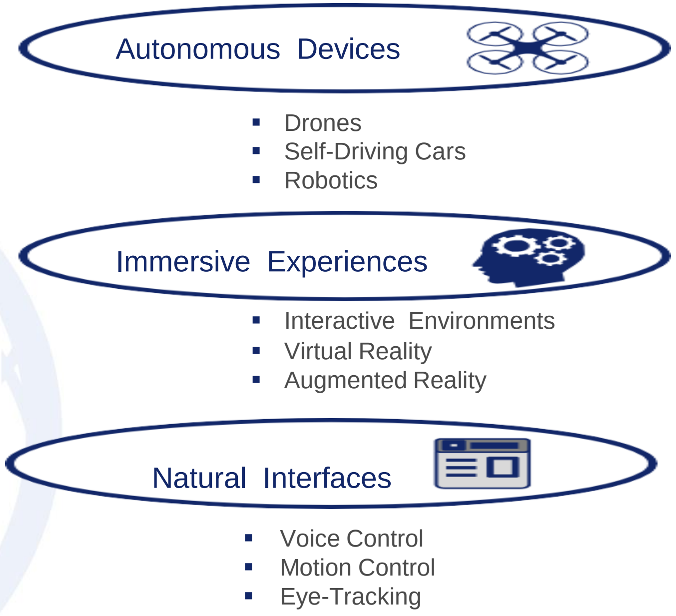
Y.4111: “Semantics based requirements and framework of the IoT”

Edge Computing technology [ongoing Y.IoT-EC-Reqts and Y.IoT-EC-GW]



Pure centralized cloud solutions will not scale for continuous and timely processing of growing amounts of real-time streams => solutions mixing edge and central cloud processing with high performance computing capabilities are required

Low latency applications

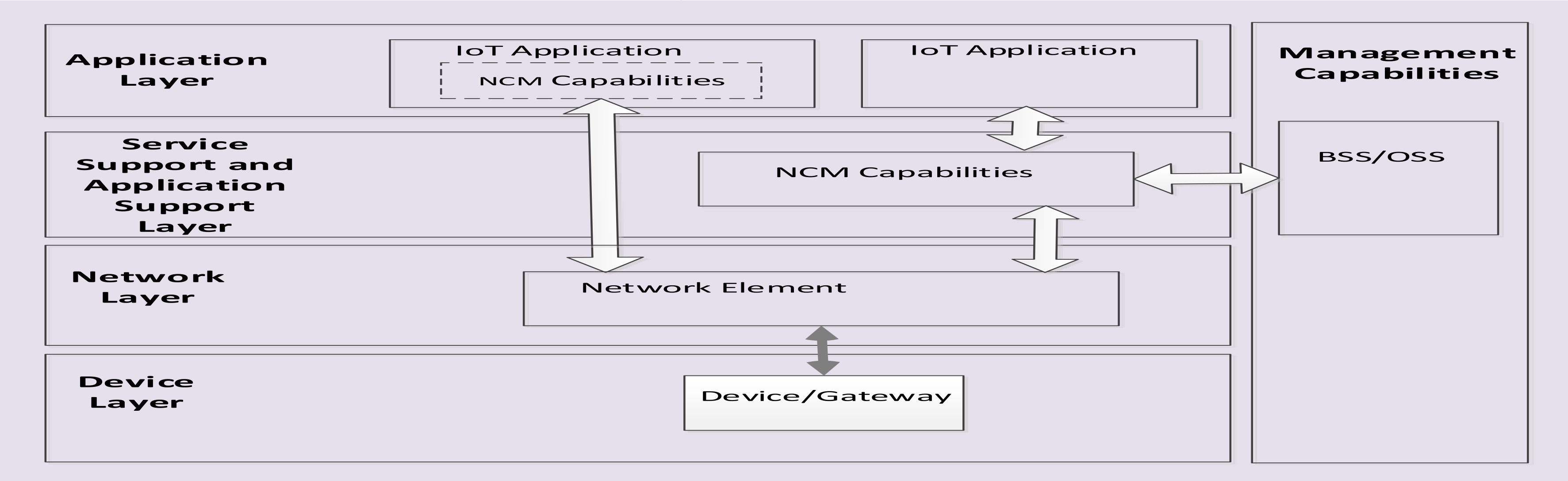


Some key benefits of Edge Computing for IoT [Y.IoT-EC-Reqts]

- Reduction of data overload
- Trustworthy data management
- More flexible service provisioning

Edge Computing … and more: Fog/Device Computing

Capabilities for management of network connectivity in large scale device deployments (connectivity platforms)



Extract from ongoing Y.IoT-NCM-Reqts «Requirements and capabilities of network connectivity management in the Internet of Things»

Enterprise customers and IoT service providers offer products and services to end users, with Wide Area Network connectivity embedded in. Quality and reliability of embedded network connectivity of each IoT device needs to be ensured.

With a large number of deployed devices, it is difficult to monitor and manage network connections manually through traditional customer care services provided by network operators.

To solve this problem, standardized Network Connectivity Management (NCM) should be provided to enterprise customers and IoT service providers by network operators.

Support for self-service provisioning, network connectivity status monitoring and diagnosis, network connectivity control, event notification and analysis.