Marco Carugi
ITU Expert, Mentor of ITU-T SG20 and ITU-T SG13

Marco Carugi works as consultant on advanced ICTs and associated standardization, engaged with customers, including in promotion of customers' interests in international standardization. Technical areas of current involvement include Internet of Things/M2M, Future Networks incl. IMT-2020/5G, Big Data and AI. He has professional experience in R&D and technology strategy, and he has worked in different market roles (Telecommunication Engineer in the Solvay group, Research Engineer in Orange Labs, Senior Advisor in Nortel Networks CTO division and Senior Expert in ZTE R&D Technology Strategy department).

Marco is active in standardization since long time, leading standards specifications in different domains (NGN, IoT/M2M, Big Data, IMT2020) and holding numerous leadership positions (incl. ITU-T SG13 Vice-Chair, ITU-T Rapporteur in four study periods, ITU-T FG M2M Service Layer Vice-Chair, ITU-T FG Cloud Computing WG Chair, OIF Board member, IETF Provider Provisioned VPN WG co-Chair). In the current 2017-2020 ITU-T study period, he serves as ITU-T SG20 Mentor and Rapporteur for Question 2 ["Requirements, capabilities and use cases across verticals"], as well as ITU-T SG13 Mentor and Associate Rapporteur for Question 20 ["IMT-2020: Network requirements and functional architecture"]. He also plays ITU-T Liaison Officer roles, incl. SG20 Liaison Officer to ISO/IEC JTC1/SC41, to JCA-IMT-2020, to CITS (Collaboration on ITS Communication Standards) and to/from the Alliance for IoT Innovation (AIOTI) (WG03 on IoT standardization). Since Q3 2017, he is leading the Use Cases and General Requirements analysis activity within the ITU-T Focus Group on “Data Processing and Management to support IoT and Smart Cities & Communities” as well as acting as a co-leader of the High Level Architecture group within AIOTI WG03. He is also active participant in the ITU-T Focus Group on “Machine Learning for Future Networks including 5G”.

In May 2018 he has been named Rapporteur for the European Commission in the joint MSP/DEI Working Group on Standardisation in support of Digitising European Industry. Marco is author of standards specifications, papers and articles (IEEE magazines and others), co-author of the IoT European Research Cluster (IERC) yearly books, and regular speaker in international and regional conferences and workshops.

He holds an Electronic Engineering degree in Telecommunications from University of Pisa (Pisa, Italy), a M.S. in Engineering and Management of Telecommunication Networks from National Institute of Telecommunications (Evry, France) and a Master in International Business Development from ESSEC Business School (Paris, France). He has also completed an Executive Program on Big Data Science at Ecole Centrale (Paris, France).

AREGNET Workshop on IoT & M2M
Manama – Bahrain, 1 October 2018

Internet of Things: advances, perspectives and challenges in some technical areas including standardization

Presented by:
Marco Carugi, ITU expert
ITU-T Q2/20 Rapporteur and SG20 Mentor
marco.carugi@gmail.com

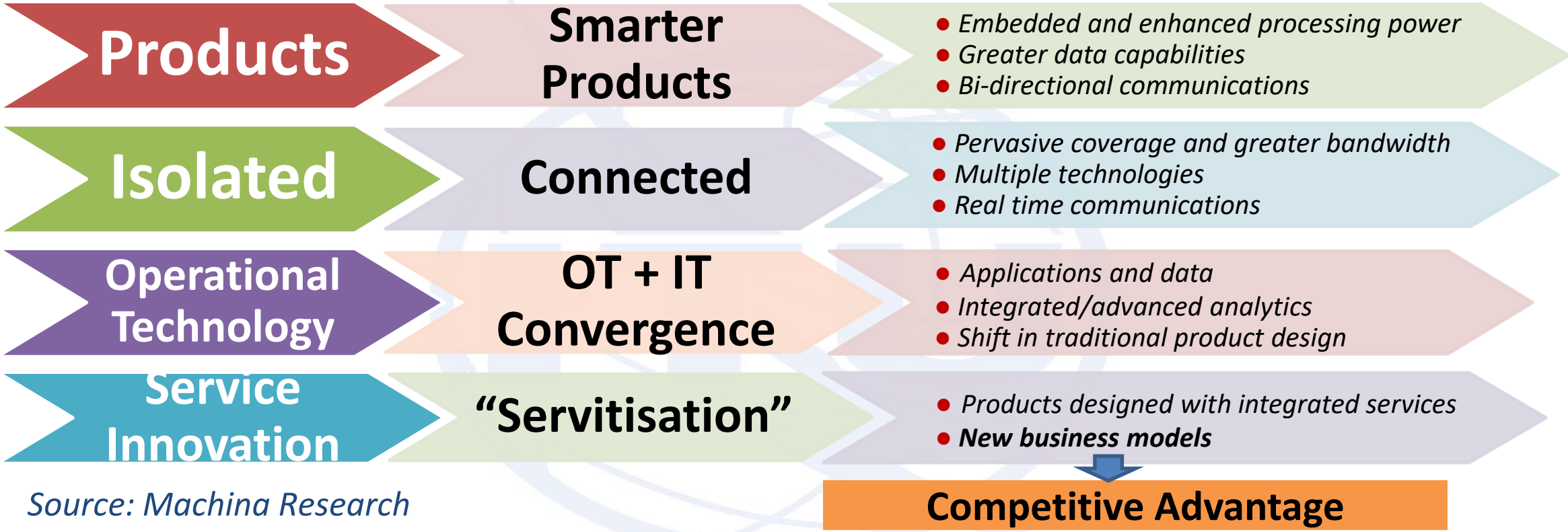
Outline

- Internet of Things - introduction
- Advances, perspectives and challenges in standardization of the IoT
  - ITU-T and some other relevant international organizations, one example of initiatives promoting standardization
- Advances, perspectives and challenges in some technical areas of the IoT
  - Architectures
  - Platforms
  - Smart Cities
  - Data in the IoT and Intelligence from Data

NOTE - Backup slides include some details on different standardization related activities and examples of application domains of the IoT

Internet of Things - introduction

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

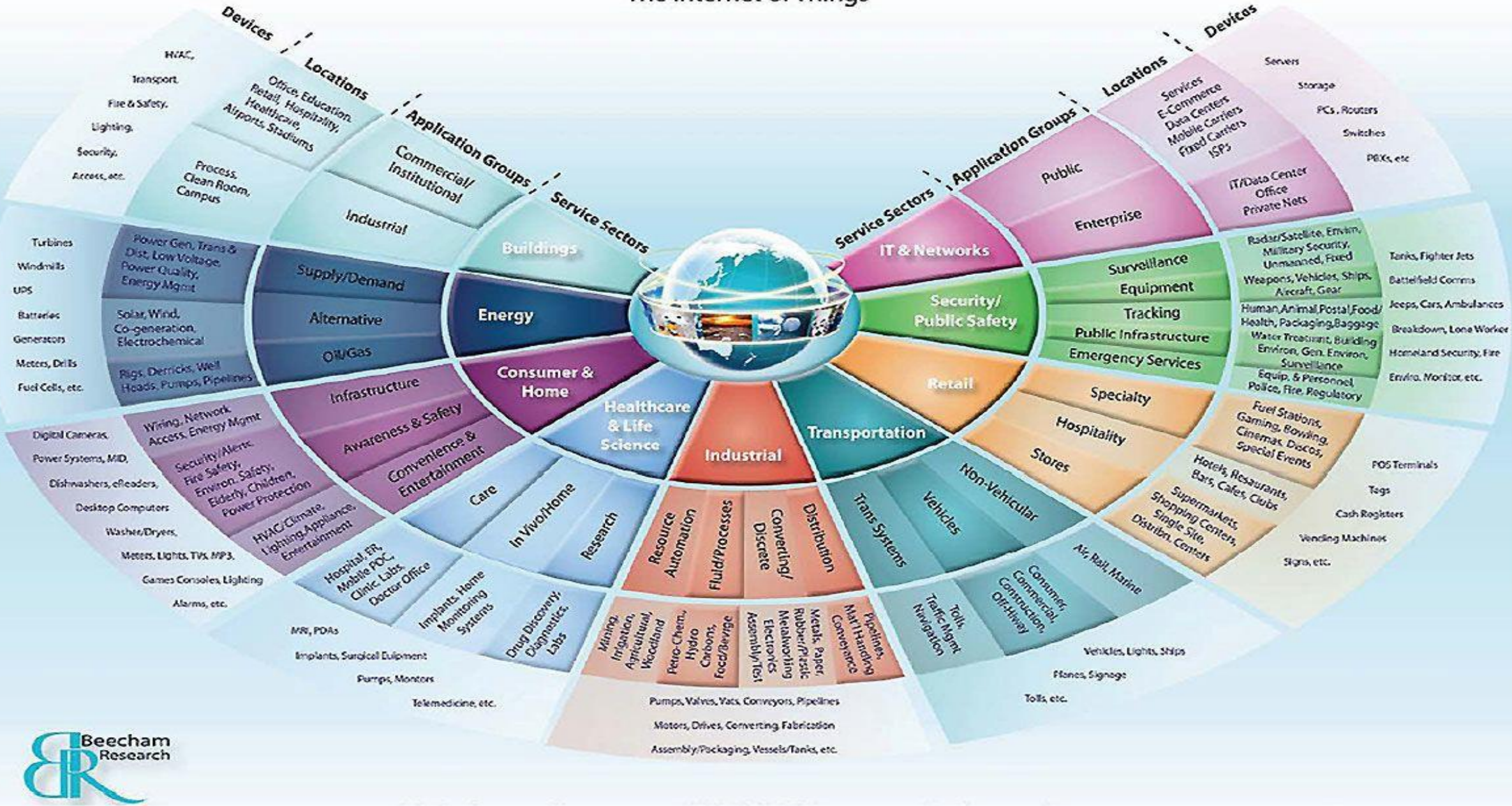


Source: Machina Research

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]

The Internet of Things



Beecham Research

IoT and leading technologies

The IoT will benefit from the integration of a number of leading technologies, 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
- Big Data management
- Distributed Ledgers (Blockchain)
- Semantics support
- Machine Learning/AI
- Service Delivery Platforms
- Security, Privacy and Trust

Advances, perspectives and challenges in (technical) standardization of the IoT

ITU-T Study Group 20: Internet of things (IoT) and smart cities & communities (SC&C)

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

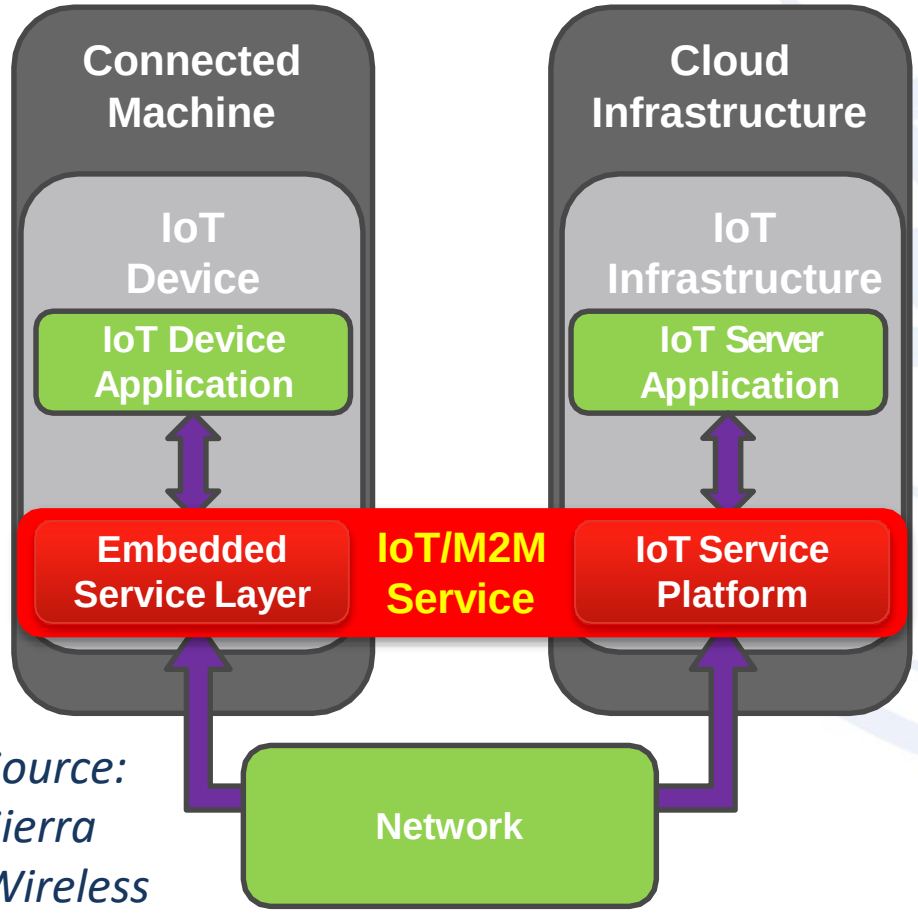
Established in June 2015 to consolidate the various ITU-T activities on IoT

Last SG20 meeting on 6-16 May 2018, Cairo (Egypt)

Next SG20 meeting on 3-13 Dec 2018, Wuxi (China)

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

oneM2M partnership - its working space



Source: Sierra Wireless

The layers of the oneM2M Architecture

Application Layer

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

Service Layer

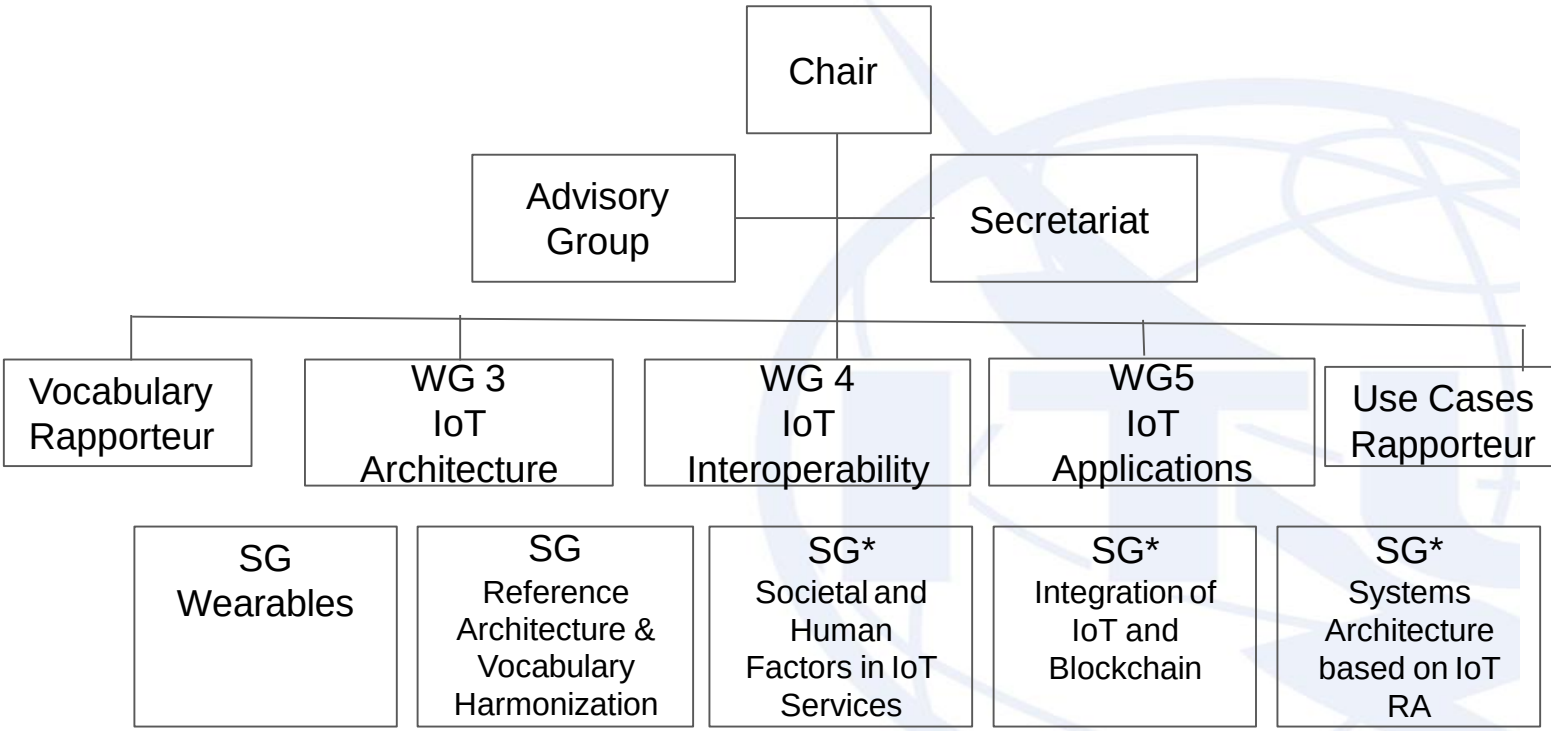
Provides horizontal services that IoT applications across different industry segments commonly need (e.g. data management, security, etc.)

Network Layer

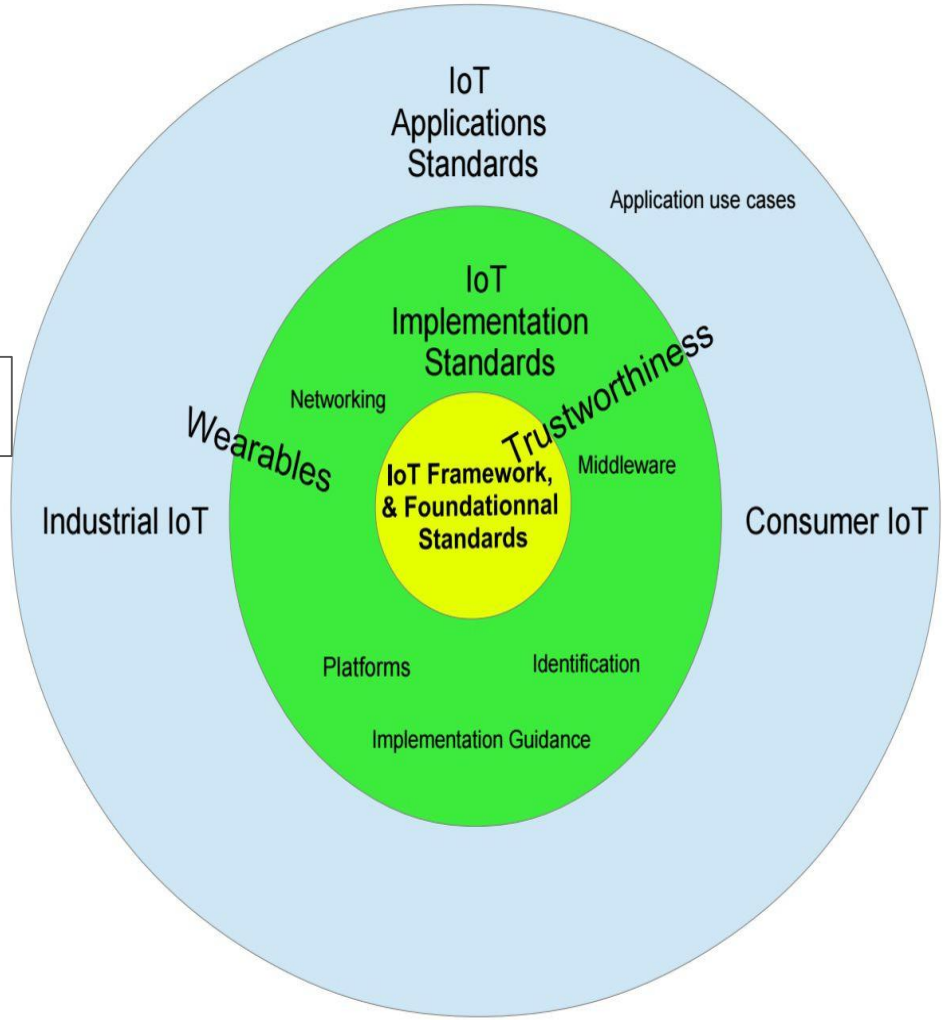
Can be deployed on devices, gateways and servers in highly distributed deployments

oneM2M was created in 2012 to specify and promote **a standard for an IoT/M2M Common Service Layer**

ISO/IEC JTC1 SC41 - structure and working space



*Under Letter Ballot (in June 2018)



A view from SC41 Chair

SC41 has been created in Nov 2016 incorporating two previous ISO/IEC JTC1 efforts: WG10 (IoT) and WG7 (Sensor Networks)

Key IoT achievement: **ISO/IEC 30141 IoT Reference Architecture** (project inherited from WG10)

The Alliance for IoT Innovation (AIOTI) – an example of organization promoting standards convergence/harmonization

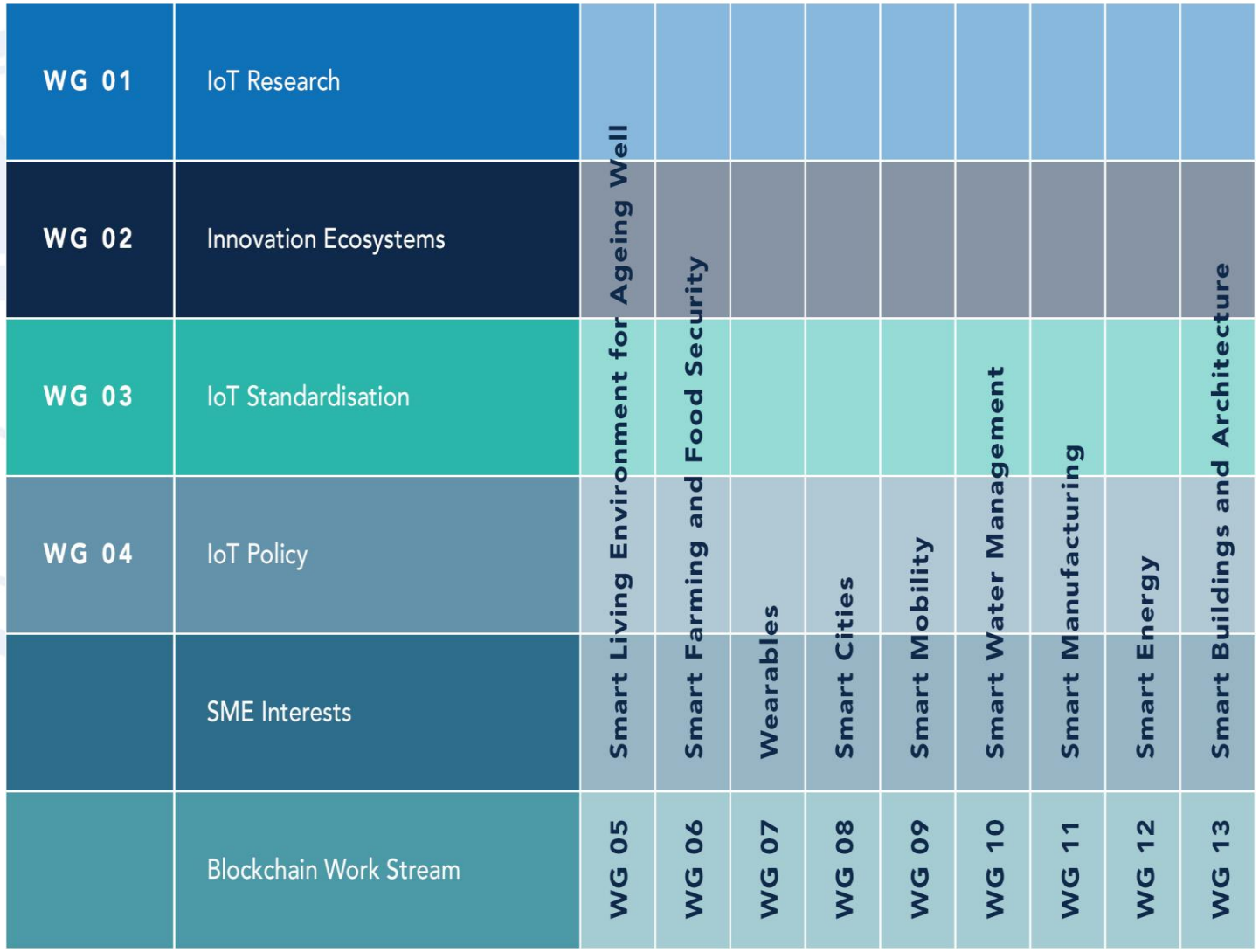
AIOTI

- Initiated by the European Commission in 2015 (now a legal entity on its own)
- Aim to strengthen the dialogue and interaction among IoT players in Europe, and to **contribute to the creation of a dynamic European IoT ecosystem** to speed up the take up of IoT.

AIOTI key strategic challenges

- Addressing rapid technological developments
- User acceptance of IoT innovation, building trust
- Drive towards deployment
- **Managing the risk of fragmentation, converge in a field of international competition**
- Education and information to stakeholders in their context

AIOTI Working Groups



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 =>> the key role of international SDOs in standards convergence/harmonization (ITU-T as key actor)

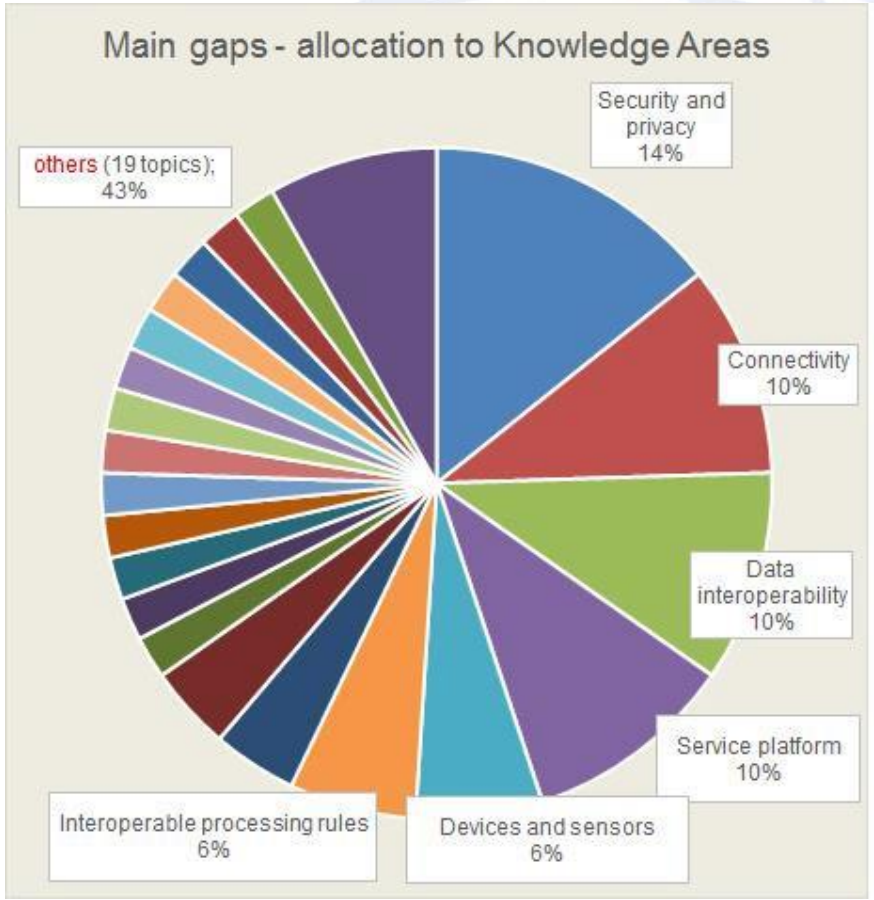
Open innovation systems move fast =>> Standardization needs to cope - process, collaboration

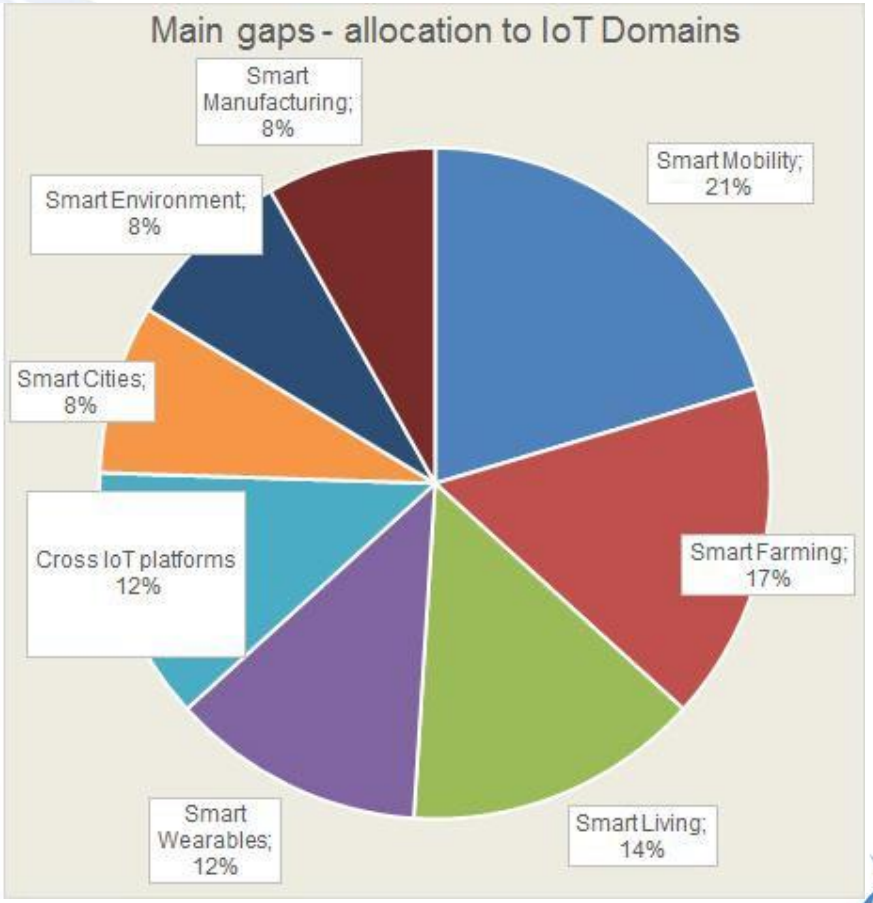
Source: AIOTI WG3 (IoT Standardisation) – Release 2.8

IoT standards gaps (technical, but also business and societal) - view from AIOTI supporting study (first phase ended 1H 2017, second phase started 2H 2018)

Consolidated view of 49 main gaps

Standards gaps as both missing and competing standards





Extract from AIOTI WG03-EC workshop, Feb 2017 (results published as ETSI TR)

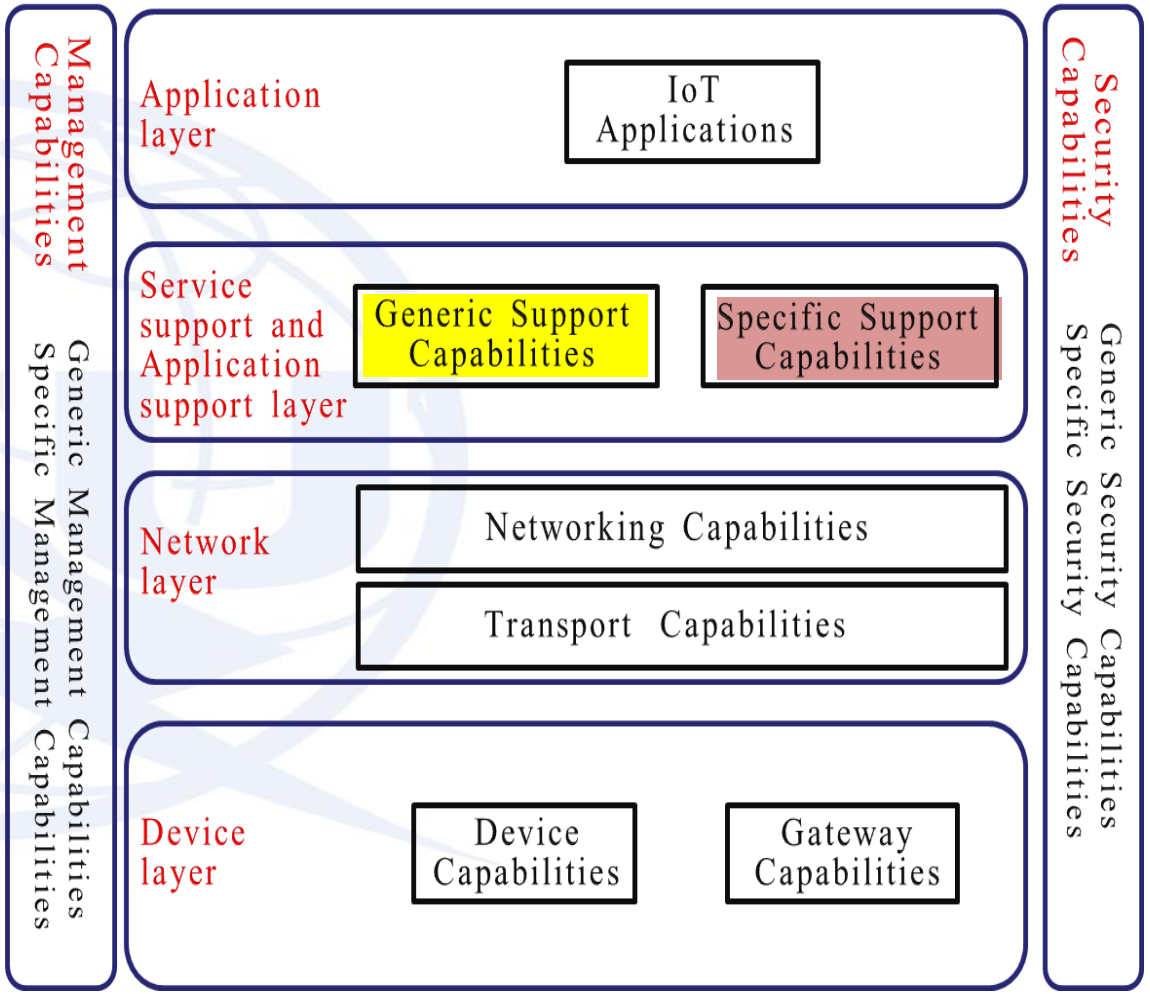
Advances, perspectives, challenges in some technical areas of IoT and Smart Cities

Architectures

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

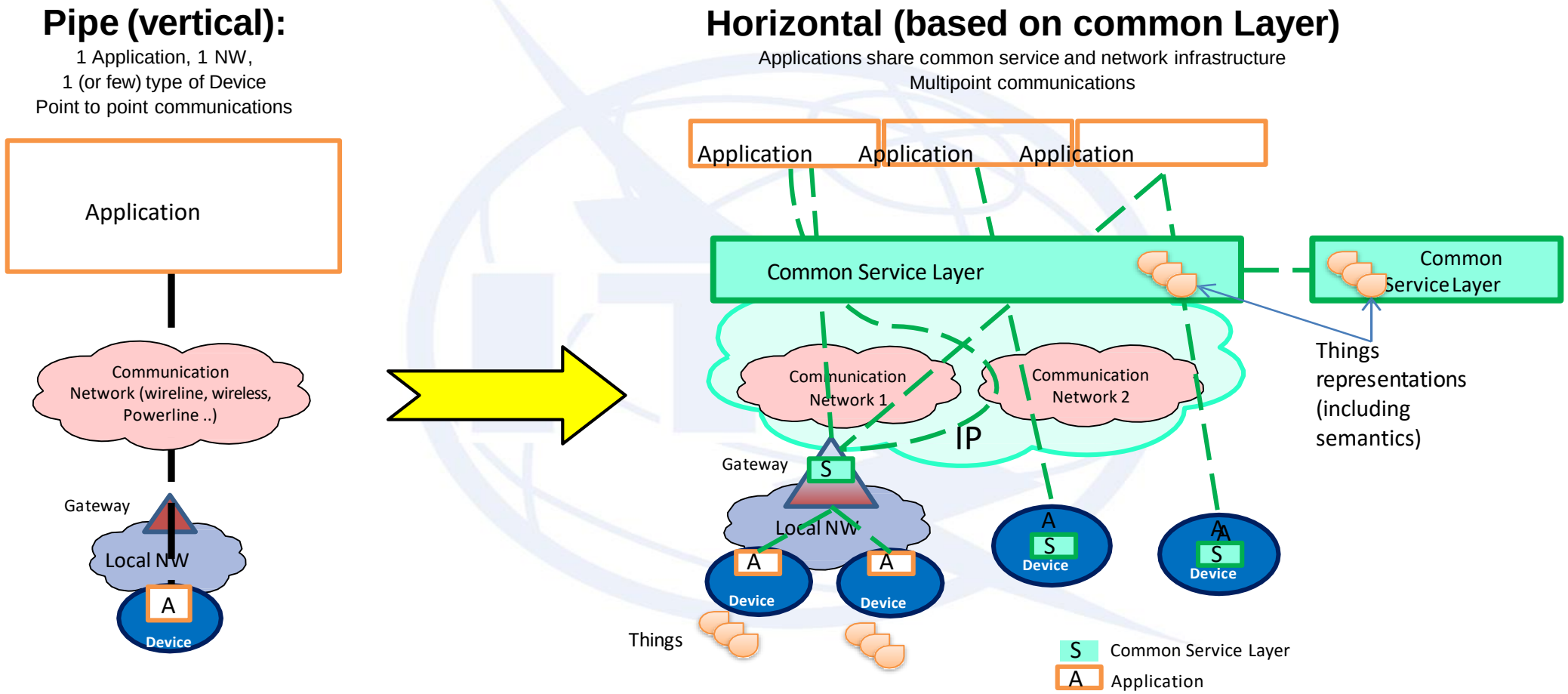
Capability view of the IoT infrastructure

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



Source: ITU-T Y.2060 /Y.4000 "Overview of the Internet of things"

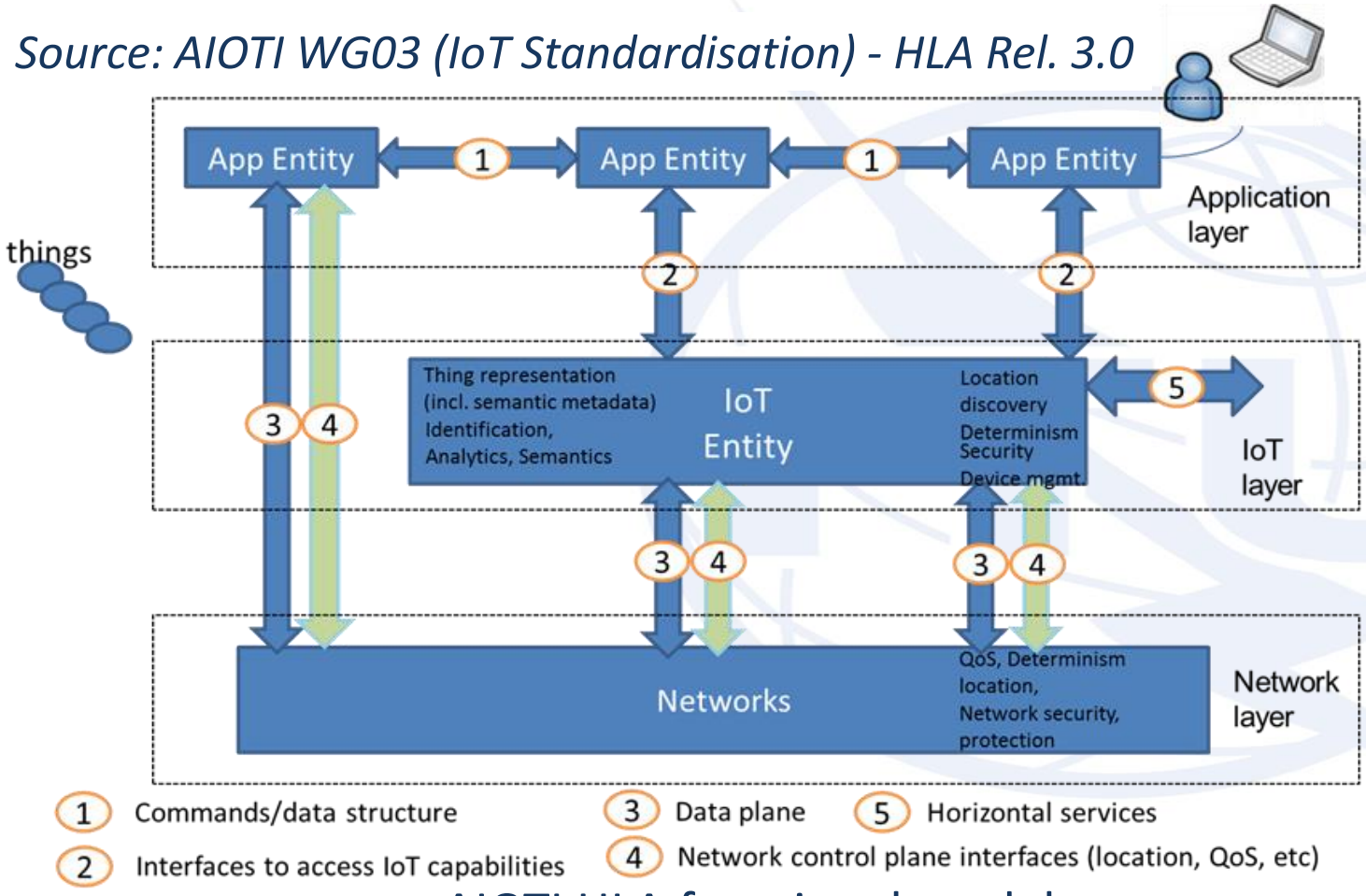
The oneM2M architecture approach



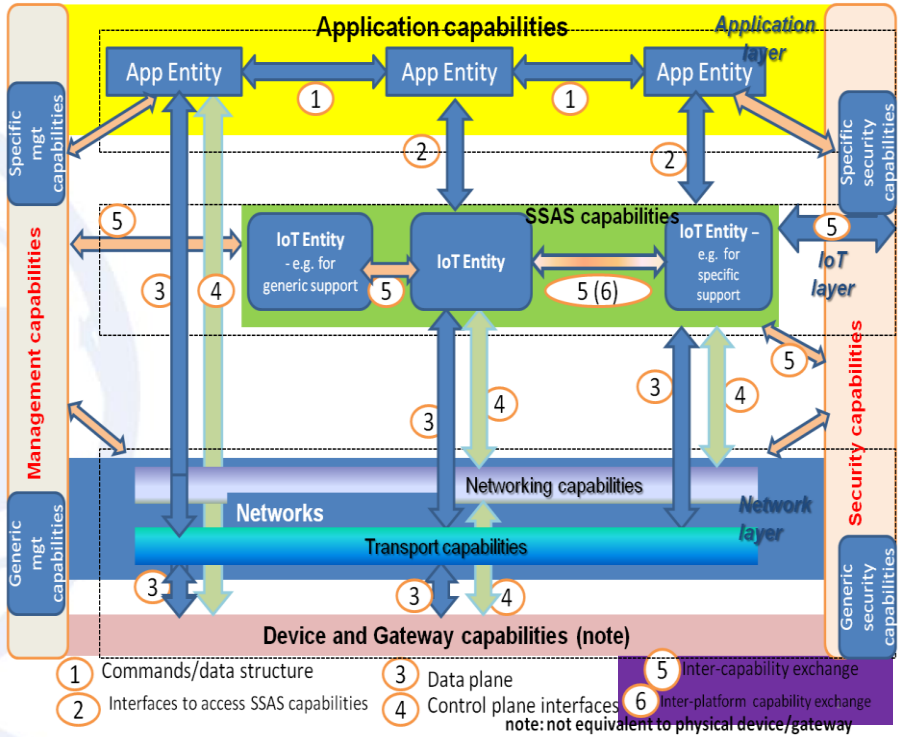
As result of a concrete collaboration initiative between ITU-T SG20 and oneM2M, a number of oneM2M specifications have been adopted since Sept 2017 as ITU-T Recs or Supplements (incl. oneM2M Architecture)
Further collaborations are expected (as well as between ITU-T SG20 and ISO/IEC JTC1 SC41)

The AIOTI High Level Architecture (HLA) aiming to promote convergence and harmonization across the different IoT architecture standardization efforts

Source: AIOTI WG03 (IoT Standardisation) - HLA Rel. 3.0



AIOTI HLA functional model



ITU-T IoT Reference Model mapping to the AIOTI HLA

A number of IoT Reference Architectures across SDOs, projects and market deployments

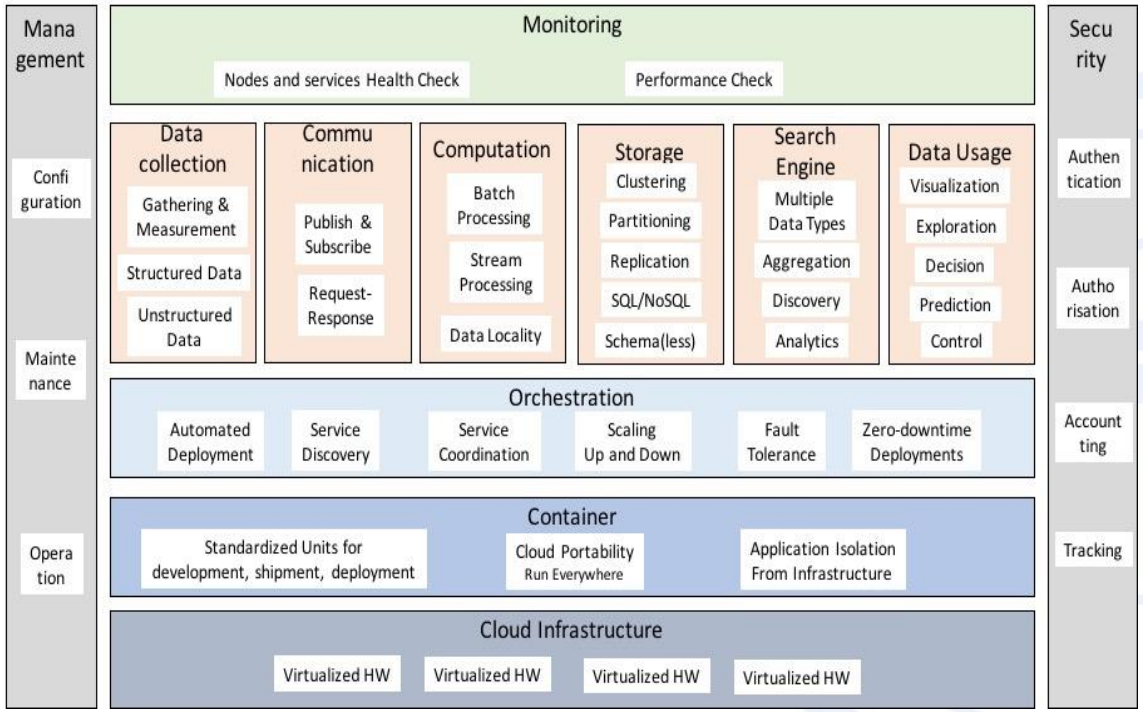
The studies on IoT Architectures need to continue …

Gaps with reference to the three AIOTI HLA layers [from AIOTI supporting study]

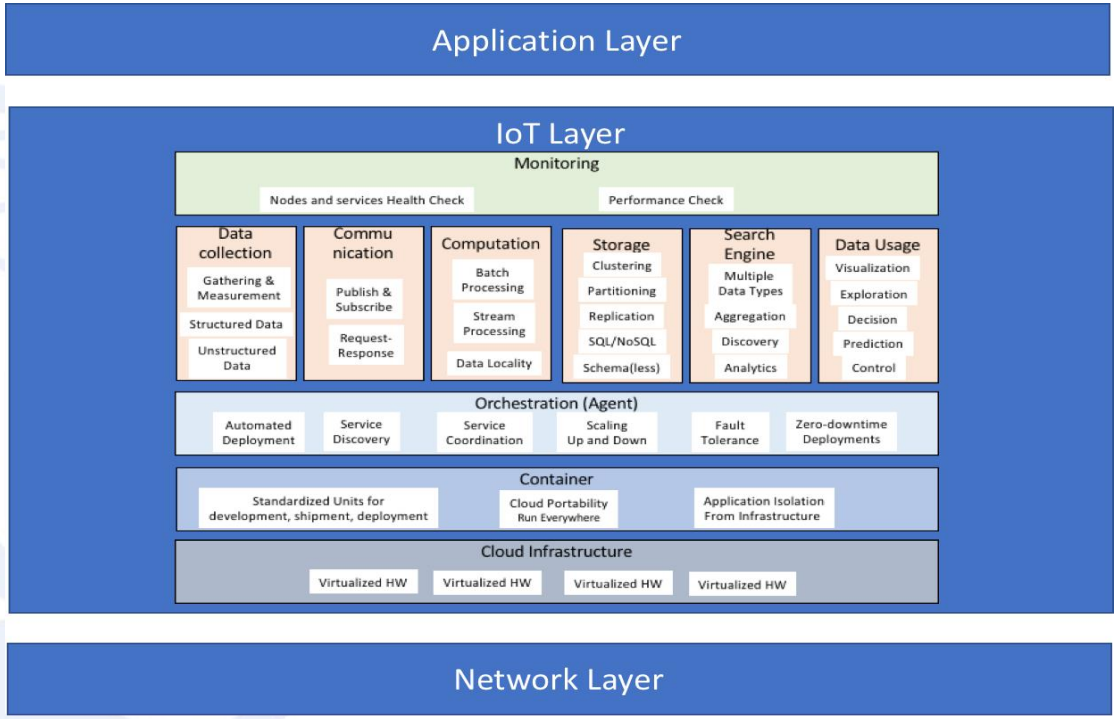
Identified gap	Impact on AIOTI HLA
Competing communications and networking technologies	Network layer
Easy standard translation mechanisms for data interoperability	IoT and application layers
Standards to interpret the sensor data in an identical manner across heterogeneous platforms	IoT layer
APIs to support application portability among devices/terminals	IoT layer
Fragmentation due to competitive platforms	Not specific to HLA
Tools to enable ease of installation, configuration, maintenance, operation of devices, technologies, and platforms	Mostly IoT layer, also Appl. and Network
Easy accessibility and usage to a large non-technical public	Not specific to HLA
Standardized methods to distribute software components to devices across a network	IoT and network layers
Unified model/tools for deployment and management of large scale distributed networks of devices	All layers; critical in IoT layer
Global reference for unique and secured naming mechanisms	All layers
Multiplicity of IoT HLAs, platforms and discovery mechanisms	Addressed by HLA
Certification mechanisms defining “classes of devices”	Network layer
Data rights management (ownership, storage, sharing, selling, etc.)	All layers
Risk Management Framework and Methodology	All layers; interface definition

Source: AIOTI WG03-EC workshop, Feb 2017

Studies on Virtualization of the IoT infrastructure: the example of an architectural approach based on microservices



An example of microservices-based functional architecture for IoT Virtualisation



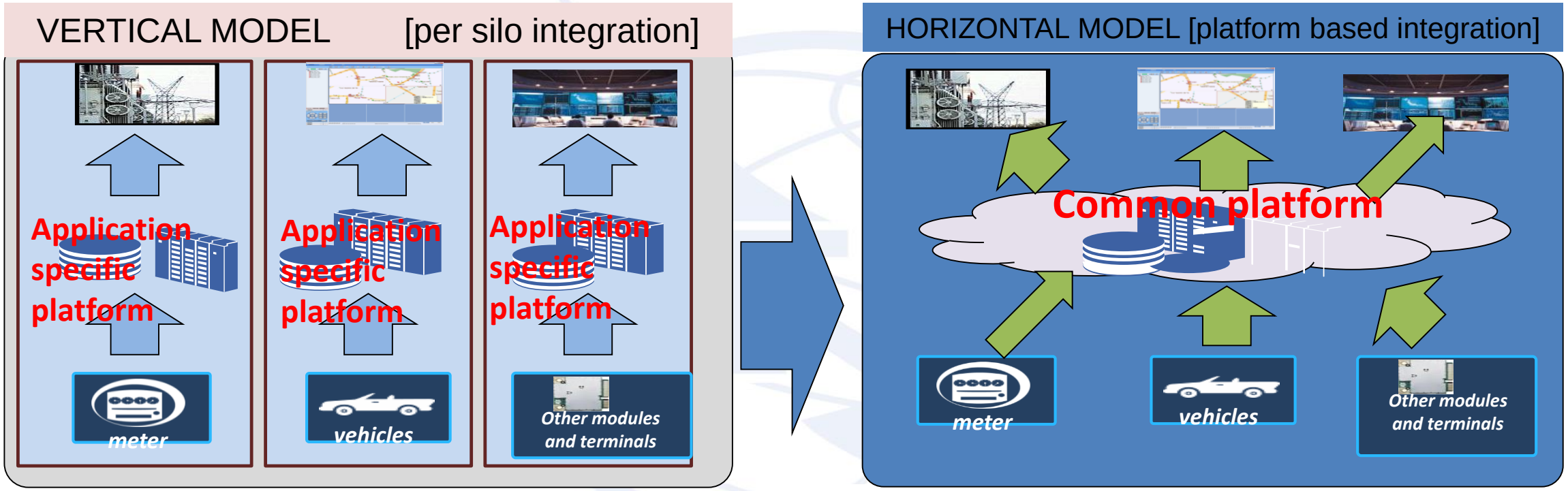
Mapping of microservices-based functional architecture on AIOTI HLA

Source: AIOTI High Level Architecture R4.0

Platforms
[a hot topic but also an abused term]

From vertical to horizontal platforms

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



Platform configured per vertical application (application domain)

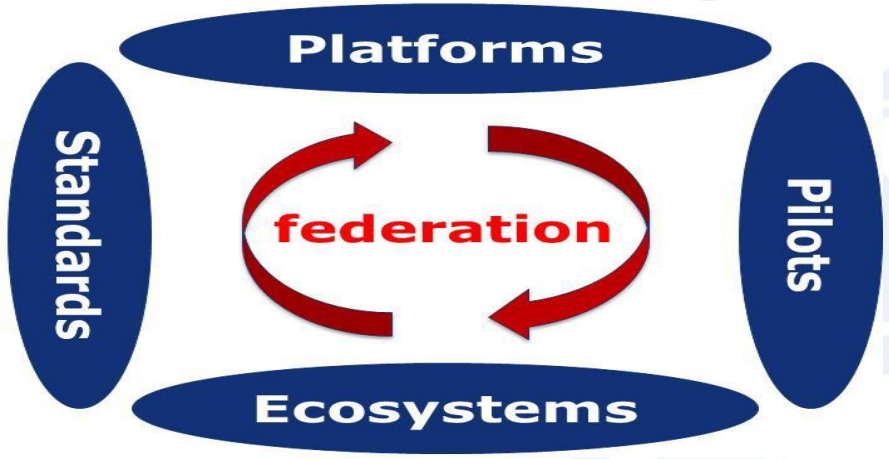
Horizontal platform supporting multiple vertical apps
(with common components and application-specific components)

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

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

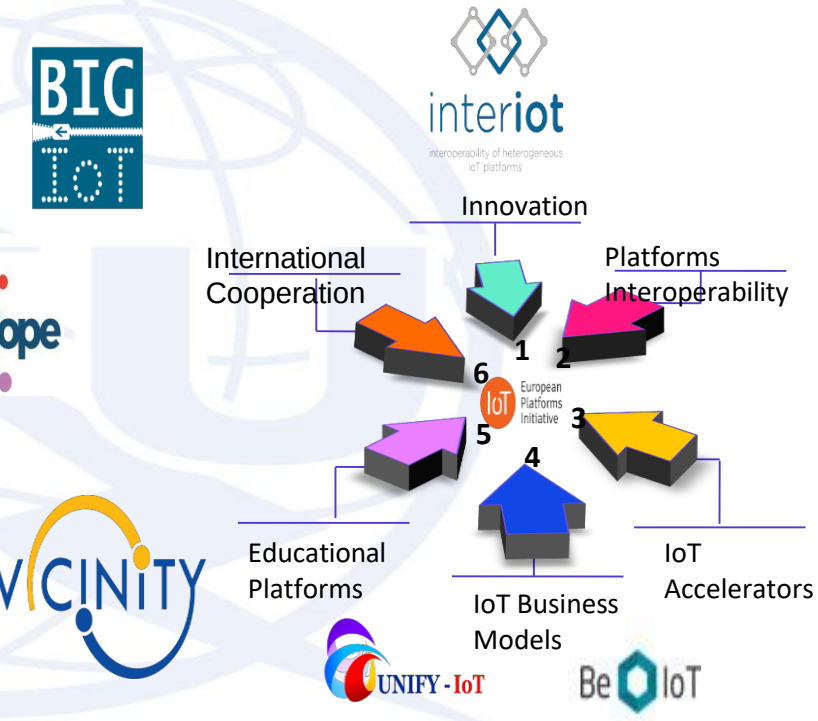
Platform based integration *with the key role of open standards and open source*

Digital Industrial Platforms: pan-European platform building and piloting



- Integration of key digital technologies
- Platforms, reference architectures, …
- Reference implementations, large-scale pilots, experimentation environments
- Ecosystem building and standardisation

IoT European Platforms Initiative (EPI)



*NOTE - **Technically, "Platform" is an ambiguous term, overused in the market for various distinct purposes (e.g. connectivity management, data exchange).***

The EPI work is - among others - addressing platform taxonomies for easier technical analysis and more.

Smart Cities

Smart Cities as super application domain of the IoT

Integration of multiple verticals

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

Still a number of technical challenges incl. interoperability, security and privacy

The brain of the city

Data collection, analysis, knowledge, planning, action

The senses of the city

City data sources

Source: Dr. Levent Gürgen

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

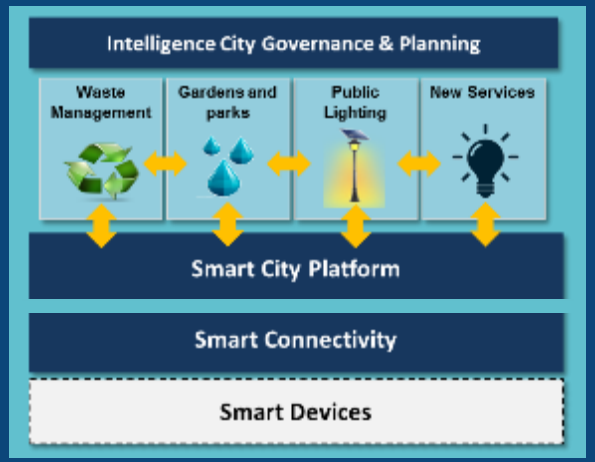
1 2 3 4

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

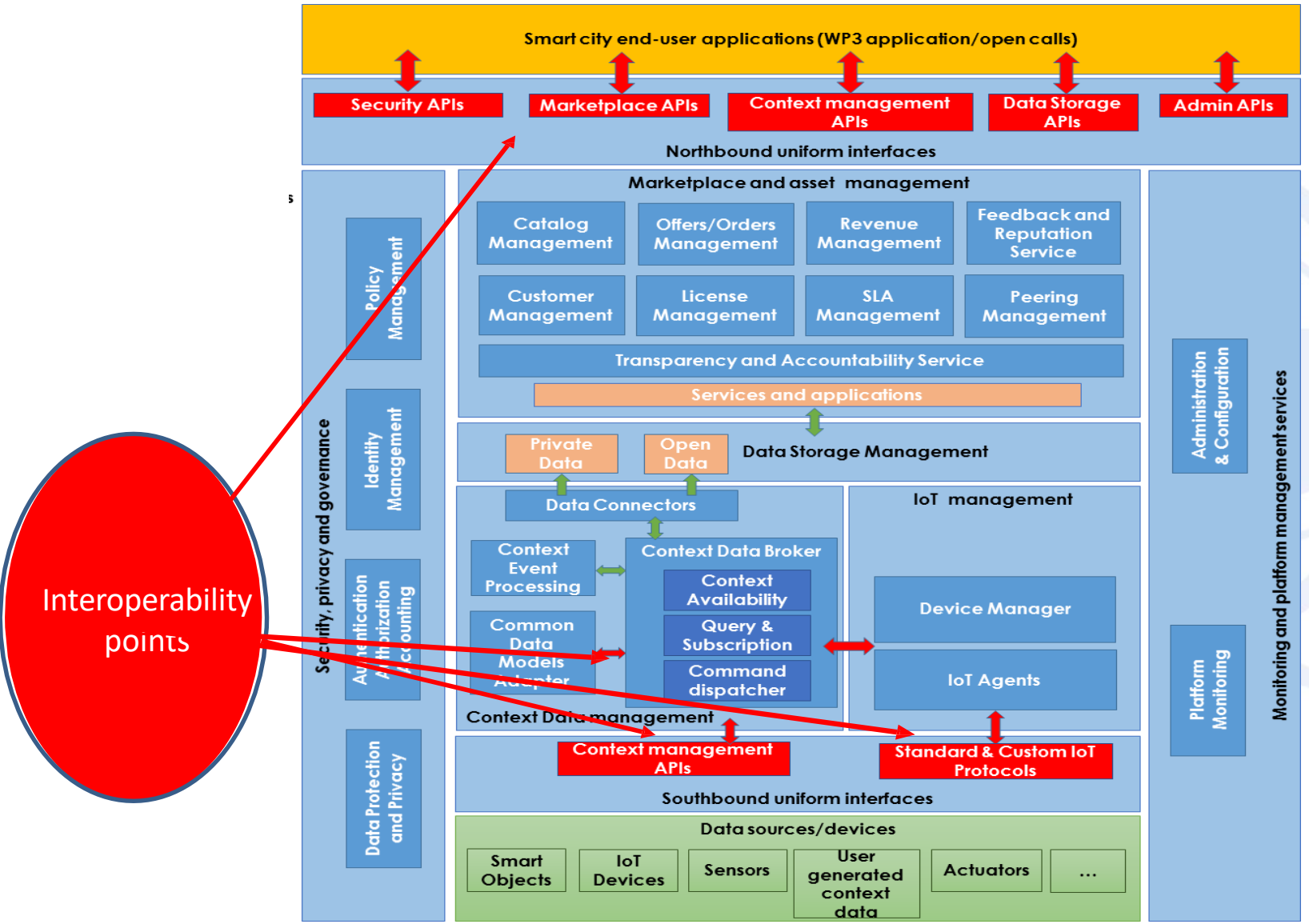
- Right-time context info published to third parties
- Exchange of context info with systems from other domains

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)

Data in the IoT and Intelligence from Data

Internet of Things and Data

Some analysts indicate that by 2020 40% of data will come from sensors

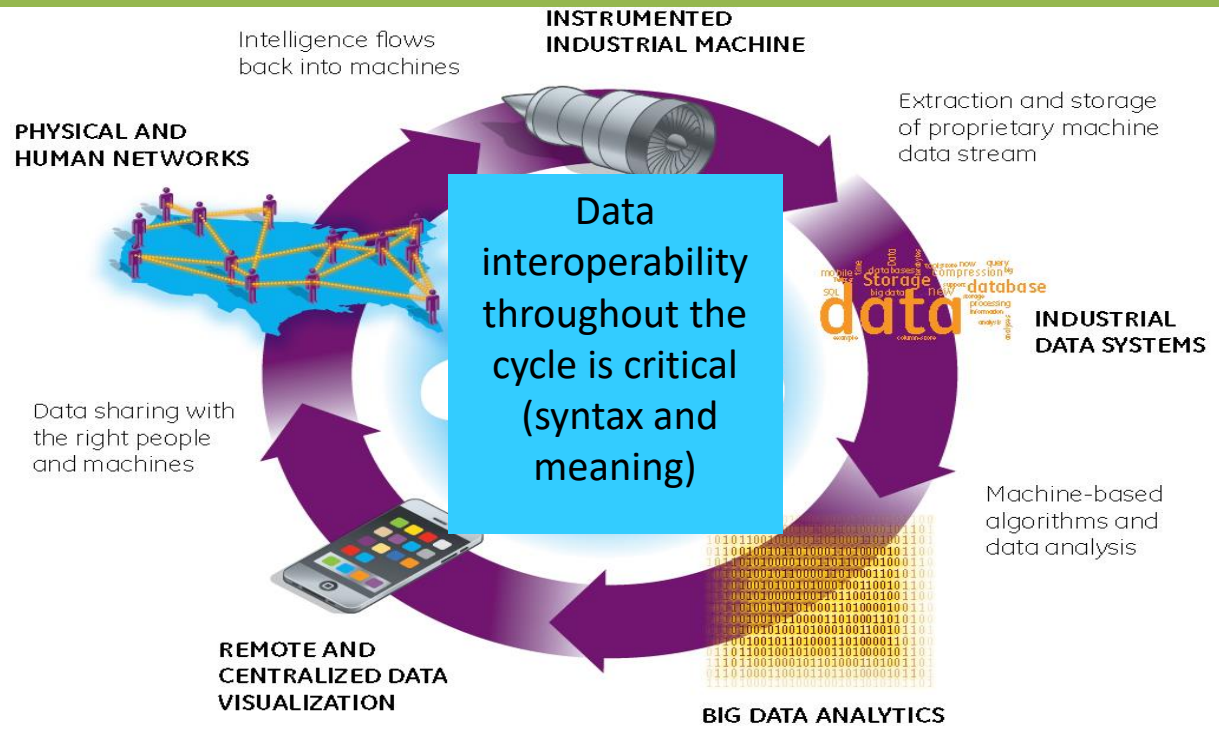
Multiple data sources (things, context, historical data, social data)

Data with different velocity, formats, precision and confidence levels, quality

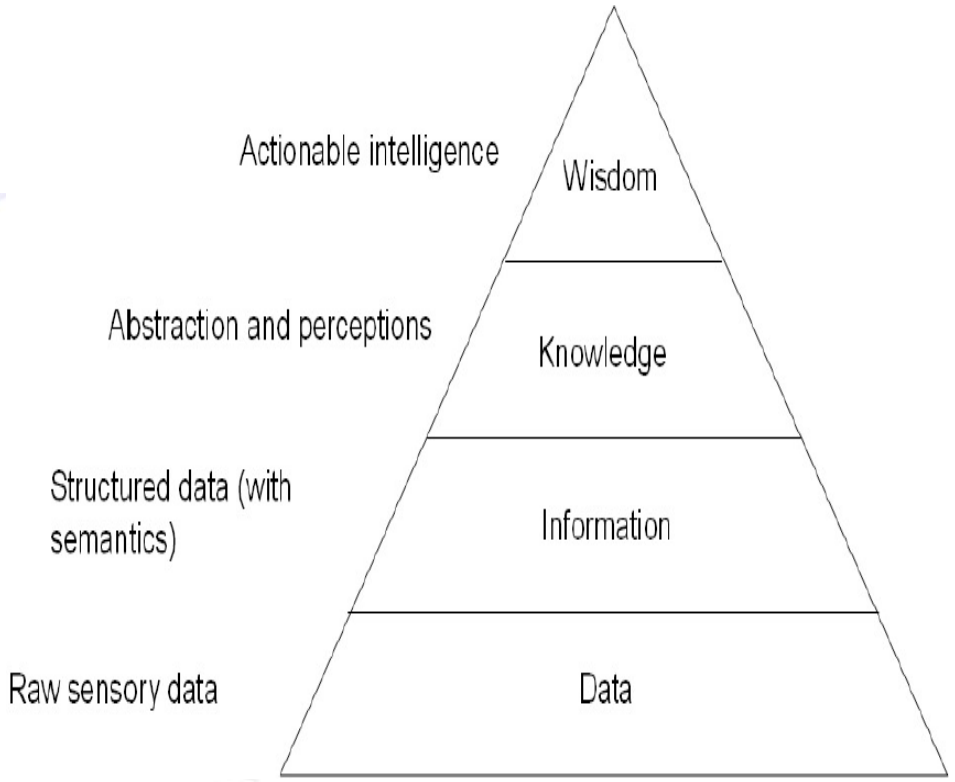
Different operations on data for extraction of actionable intelligence

Target: the right data, at the right time, at the right location

The Industrial Internet Data loop *[source: GE whitepaper]*



Knowledge hierarchy applied in data processing



Source: Barnaghi and al., IJSWIS, 2012

Opportunities and challenges of (Big) Data in IoT (but not limited to)

Process optimization and data monetization via analytics - driving revenue by sharing, analysing and interpreting data, for multiple purposes

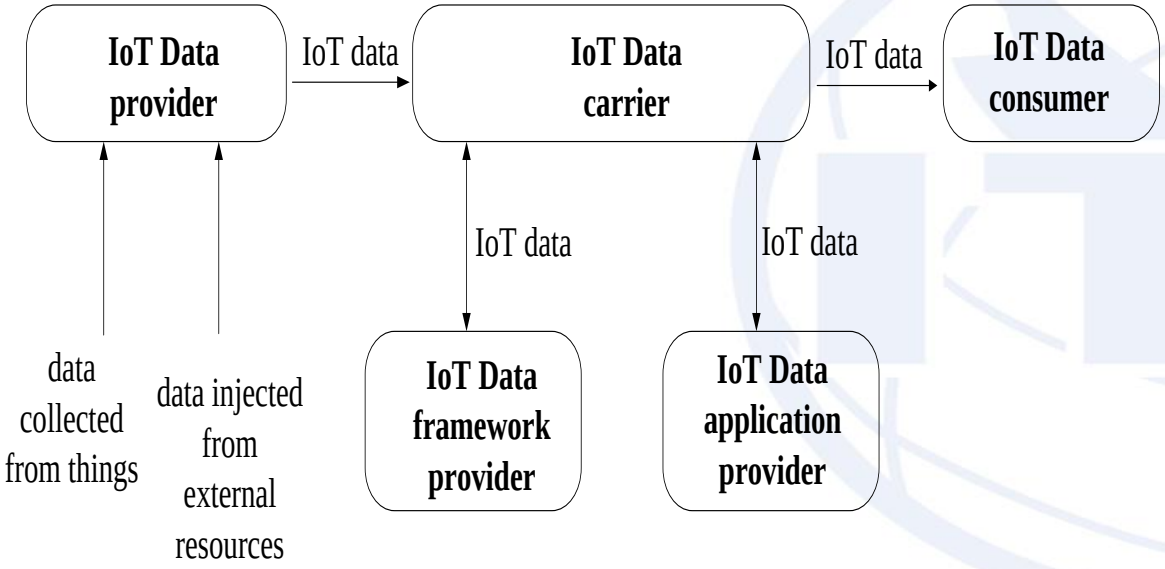
- Extraction of tangible business and technology value
- Response and action in real time, improving productivity/business processes, lowering costs
- Long-range forecasts enabling strategic actions - business differentiation
- New/improved business models and service offer, faster, more efficiently and agile

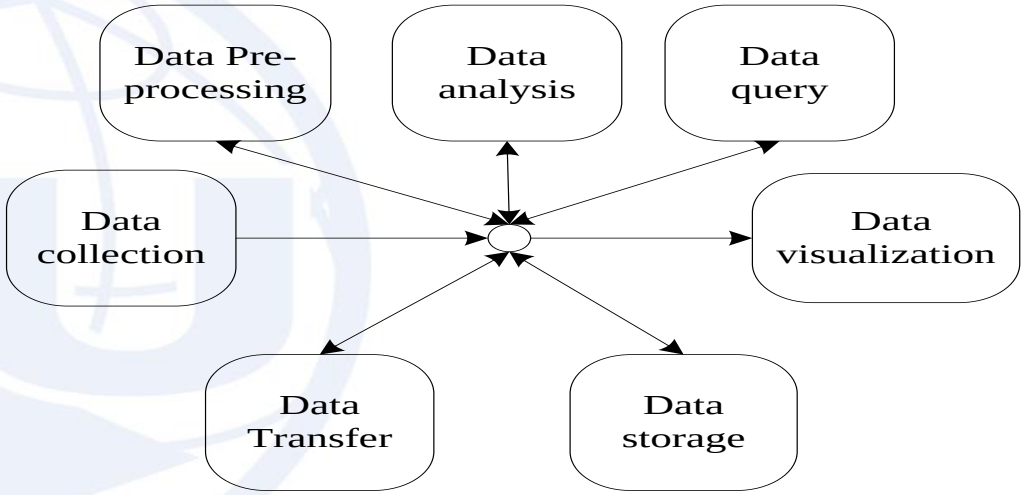
Some significant challenges

- Dealing with the “V”s of data : Volume, Variety, Velocity, Veracity
- Discovery (devices and data sources), integration (heterogeneous devices, networks and data)
- Scalability (number of devices, diverse and huge data, computational complexity of data interpretation)
- Availability and (open) access to data, data query
- Interpretation (extraction of actionable intelligence from data)
- Massive data mining, efficient processing
- **Trust, security and privacy of data (technical and non-technical)**
- **Other non-technical challenges are also essential, including data governance and ownership**

A foundational ITU-T Recommendation on Big Data in IoT: ITU-T Y.4114 "Specific requirements and capabilities of the IoT for Big Data"

Specific 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)

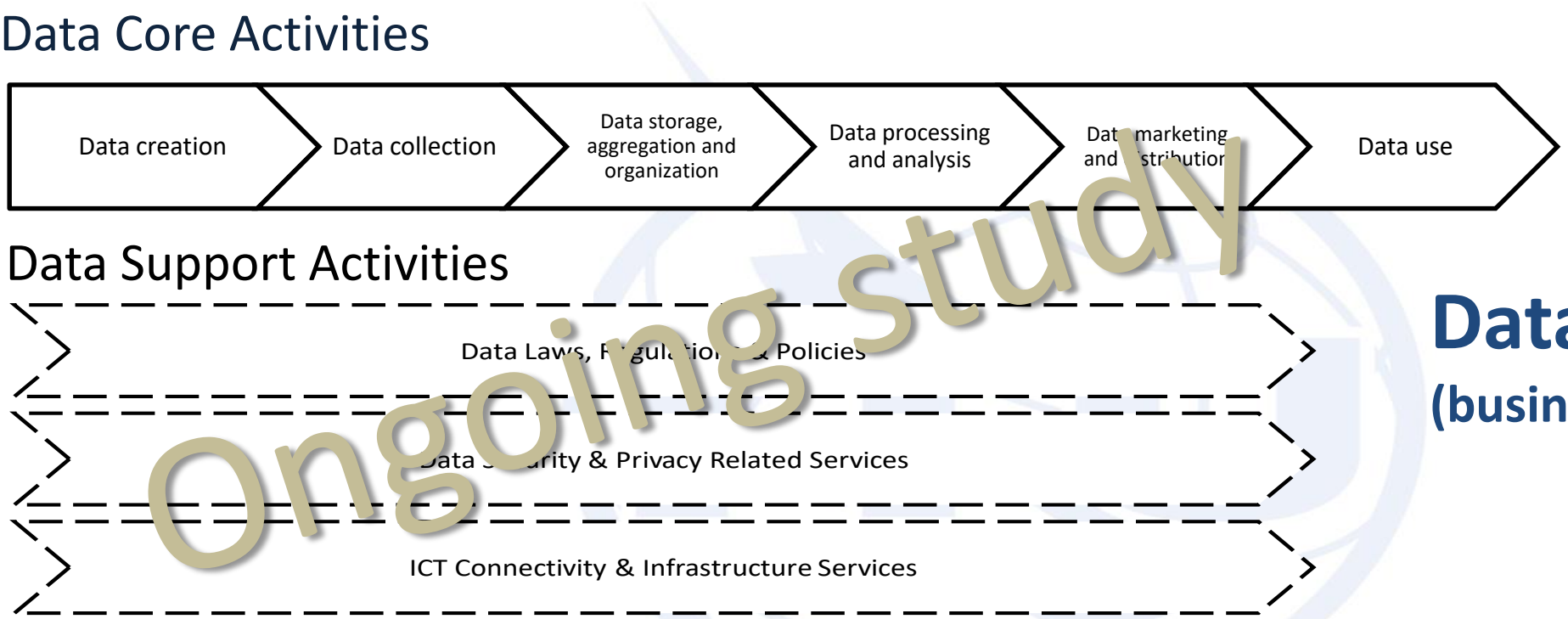
An ITU-T initiative specific on data and IoT: the Focus Group on “Data Processing and Management to support IoT and SC&C” (ITU-T FG-DPM)

FG-DPM Working Groups
WG1 **Use Cases, Requirements and Applications/Services**
WG2 **DPM Framework, Architectures and Core Components**
WG3 **Data sharing, Interoperability and Blockchain**
WG4 **Security, Privacy and Trust including Governance**
WG5 **Data Economy, commercialization and monetization**

Partial list of deliverables

- **D1.1 Use Cases Analysis and General Requirements for DPM**
- **D2.1 DPM Framework for Data-driven IoT and SC&C**
- D2.2 DPM Functional Architectures
- D2.3 Data Modeling and Formats Specification for DPM
- **D3.1 Framework of Open/Private Data**
- **D3.2 Technical Enablers for Open Data Platform**
- **D3.3 Framework to support data interoperability in IoT environment**
- **D3.6 Blockchain-based Data Exchange and Sharing Technology**
- **D4.1 Framework of Security and Privacy in DPM**
- **D4.5 Data Governance Framework for IoT and SC&C**
- **D5.1 Modeling of Data Economy for value creation and Stakeholders identification**
- **D5.2 Business models, commercialization, monetization to support data economy**
- **D5.3 Data economy impact assessment, policy and sustainability implications**
- Cross-WG studies: DPM taxonomies and vocabularies, gap analysis, DPM standardization roadmap

Data Economy, commercialization and monetization (FG-DPM WG5)



Data Value Chain

(business perspective)

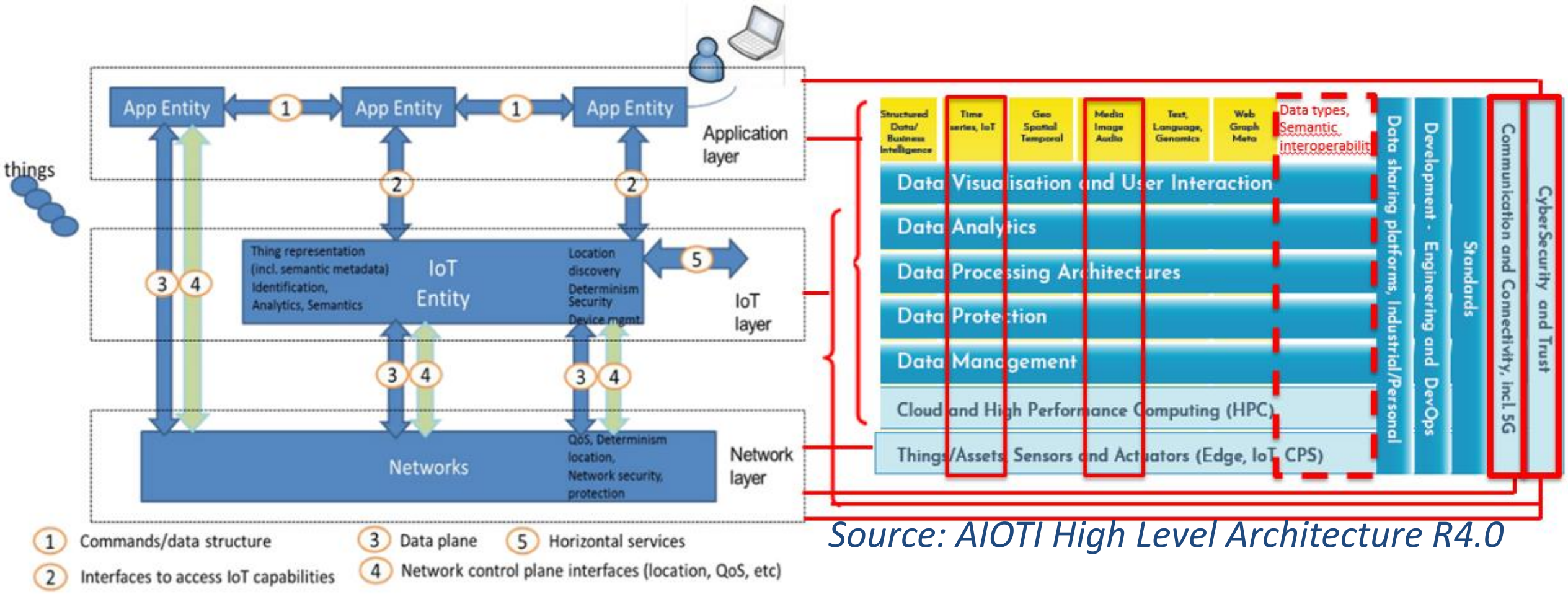
Data laws, regulations and policies: formulation and enforcement of data related laws, regulations and policies

Data security and privacy services: provisioning of data related security and privacy services for implementing and enforcing data laws, regulations and policies.

ICT connectivity and infrastructure services: provisioning of ICT connectivity and infrastructure services for implementing data value chain activities

Interaction between FG-DPM WG5 (business perspective on DPM ecosystem) and FG-DPM WG1/WG2 (technical perspective on DPM ecosystem)

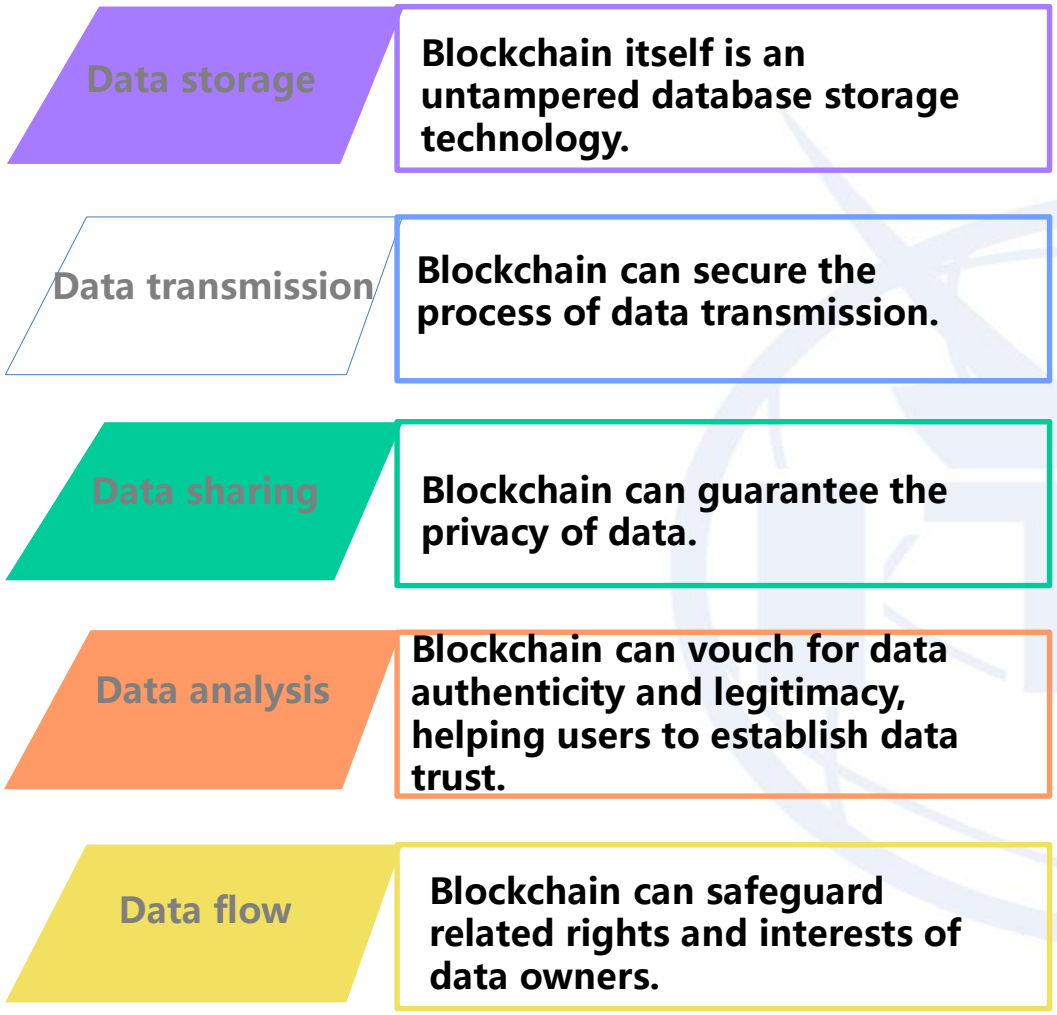
Big Data Value Association's BDV Reference Model and its mapping to the AIOTI High Level Architecture



Source: AIOTI High Level Architecture R4.0

Key step in front of the IoT standardization work plan: Big Data-IoT architectural integration

Blockchain for Data Management



Source: Tai Cloud Corporation

- Blockchain and other Distributed Ledger Technologies are booming these days; new technology approaches, uses cases, business models coming up regularly
- Still not completely prepared to support many real processes in today's economy
- Some specific issues in IoT (incl. performance and capacity requirements not fitting constrained environments, data security and privacy is relative)
- Standardization is expected to play a relevant role in their application (but should not slow down innovation)
- ITU-T is involved in the ongoing standardization efforts (incl. SG13, SG17, SG20, FG-DPM, FG DLT)

*Blockchain technology fosters a new generation of transactional applications that **establish trust, accountability, transparency and efficiency.** It shows great promises across a wide range of business applications in many fields. **However, its applicability needs to evaluated according to the specific scenarios.***

Machine Learning (ML) technologies for enhanced intelligence from data

Potential of ML for network design, operation and optimization

- coping with massively increased complexity
- enhancing network operations' efficiency and robustness
- increasing network self-organization feasibility
- providing reliable predictions

As well as potential of ML to enable new advanced applications

But a number of challenges need to be addressed [beyond trust]

- how to deal with stringent requirements of many applications (latency)
- how to ensure robust ML given small data sets and under latency constraints
- how to deal with distribution of data at different locations and diverse data formats
- usage of distributed learning to have efficient usage of scarce resources
- how to deal with (wireless) channel noise, dynamicity and unreliability
- how to ensure good tracking capabilities
- how to exploit context info and expert knowledge (hybrid ML approaches)

Source: initial meetings of ITU-T FG-ML5G

ITU-T FG on "Machine Learning for Future Networks including 5G" (FG-ML5G)

- created in Nov 2017 , SG13 as Parent ITU-T Study Group

*- **a number of challenges and opportunities common to the IoT***

Accountable and Ethical Data Management and Analytics
(with specific relationship to ML/Artificial Intelligence technologies)

- Opening the black box of Deep Learning
- Data provenance and usage monitoring
- Progressive user-centric analytics
- New paradigms for information flow monitoring
- Fact-checking requiring explicit, verifiable argumentation integrating heterogeneous data sources and explainable reasoning

Source: N. Boujemaa, INRIA, BDVA Board member

Marco's opinion: International coordination on Big Data and AI/ML standardization (for networks and services) is definitely necessary between ITU-T and relevant SDOs, Alliances, Consortia

“Personal Data” processing and management

This is a very relevant topic at both technical and policy & regulation levels
Data technologies (and others) need to fully address this matter - research, solutions, …

Personal data in GDPR

‘personal data’ means any information relating to an identified or identifiable natural person (‘data subject’)

An identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person. *Source: GDPR*

Article 4, Definitions

GDPR is the European Union’s “General Data Protection Regulation ” on usage and protection of personal data in EU - enforceable since 25 May 2018

GDPR principles for personal data

- Processed lawfully, fairly and in a transparent manner (“**Lawfullness, fairness and transparency**”)
- Collected for specified, explicit and legitimate purposes (“**Purpose limitation**”)
- Adequate, relevant and limited to what is necessary (“**Data minimization**”)
- Accurate and, where necessary, kept up to date (“**Accuracy**”)
- Identification no longer as necessary for the purposes (“**Storage limitation**”)
- Processed in an appropriate manner to maintain security (“**Integrity and confidentiality** ”)
- **Accountability** (documentation)

Source: Austrian Data Protection Authority

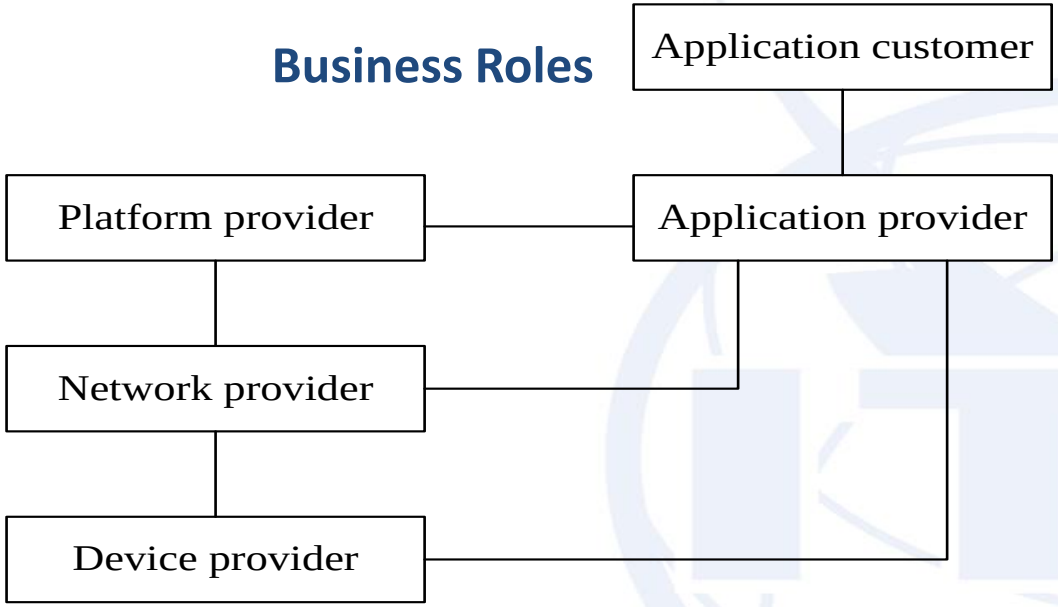
Thank you very much for your attention

Backup information

Some details on different standardization related activities

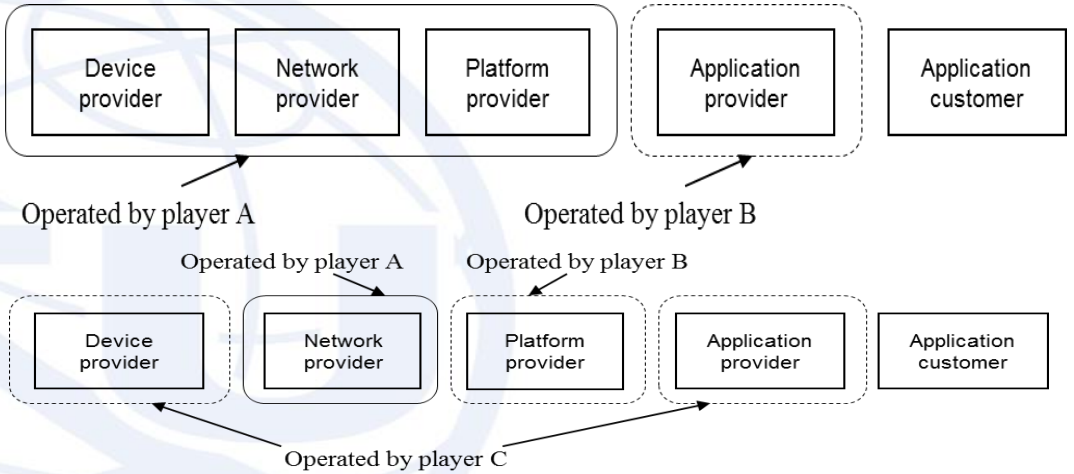
IoT ecosystem(s): business roles and models
(source: Appendixes of ITU-T Y.2060)

Business Roles



"Simplified view" of business roles and relationships (no ambition to represent all roles and relationships across the huge number of real IoT business deployments)

Business models (5 typical examples in Y.2060)



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

The exercise has been replicated by ITU-T in specific domains (e.g. e-health, Big Data)

IoT SDOs and Alliances Landscape (Technology and Marketing Dimensions)

Source: AIOTI WG3 (IoT Standardisation) – Release 2.8

ITU activities on IoT and Smart Cities

ITU-T Study Group 20:
Development and implementation of international standards

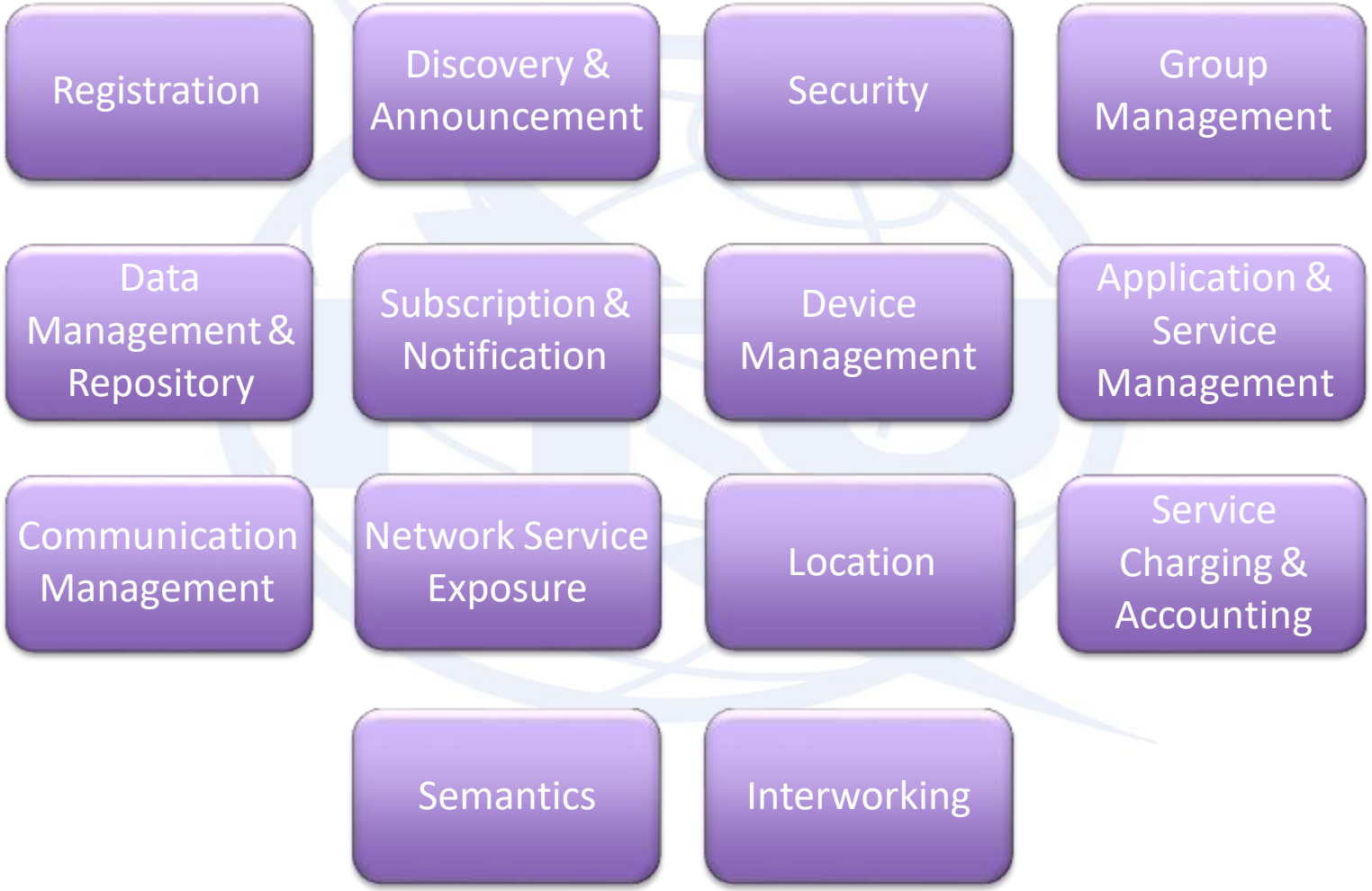
U4SSC:
UN global platform for knowledge sharing

ITU-T FG-DPM:
Research & pre-standardization work on data processing & management

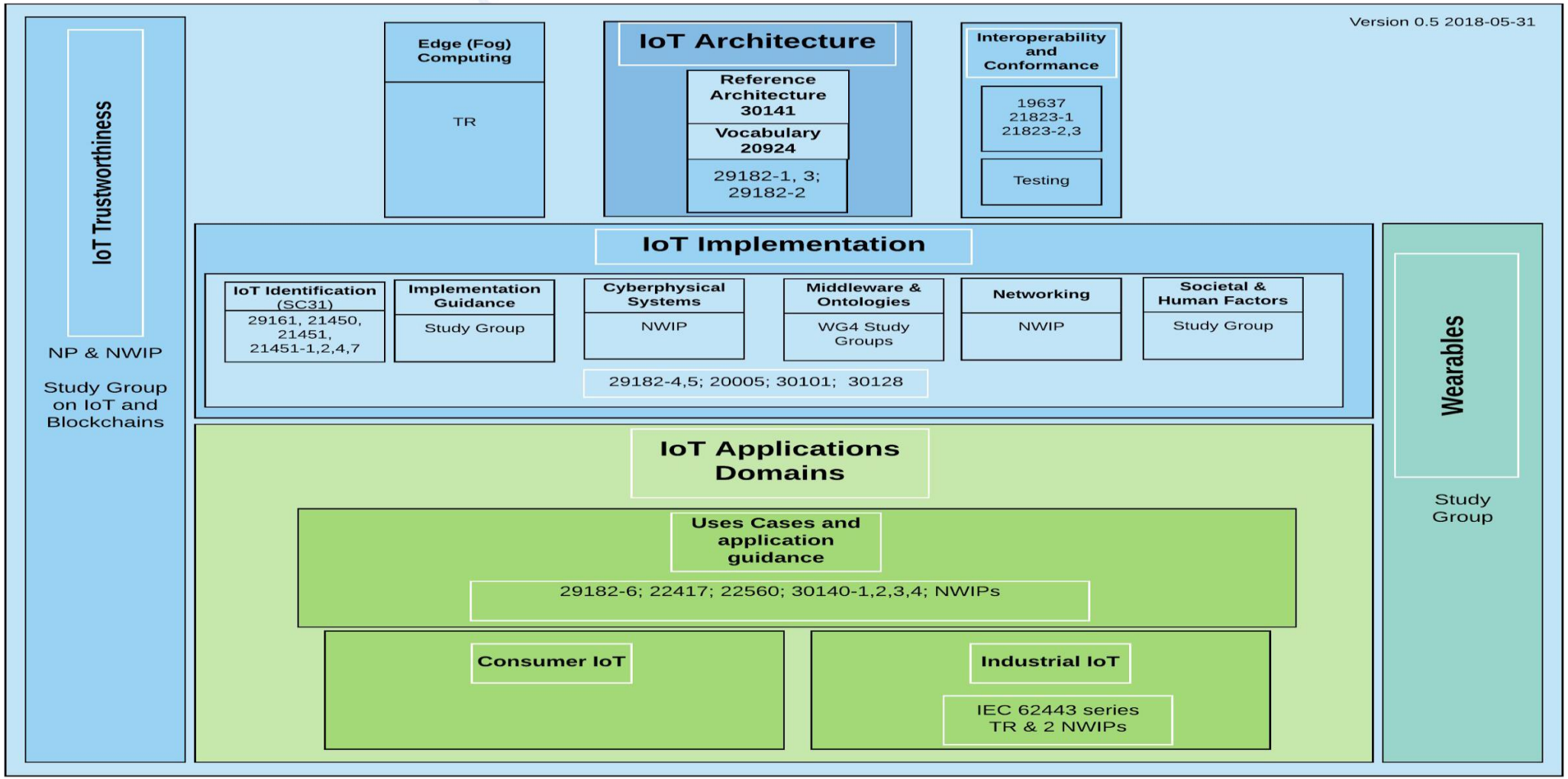
Resolution 98
Enhancing the standardization of IoT and Smart Cities and Communities for global development

IoT4SDGs: *Considers the importance of IoT to contribute to achieving the 2030 Agenda for Sustainable Development*

oneM2M Common Service Functions (CSE)



ISO/IEC JTC1 SC41 space



ITU-T Focus Group on Data Processing and Management to support IoT and Smart Cities & Communities (ITU-T FG-DPM)

Essential tasks

- Identify challenges in IoT and smart cities for DPM
- Identify key requirements ad capabilities for DPM
- Promote the establishment of trust-based data management frameworks for IoT and SC&C
- Investigate the role of emerging technologies to support data management incl. blockchain
- Identify and address standards gaps and challenges

1st meeting in July 2017 (SG20 is parent SG)
5th meeting in Sept 2018

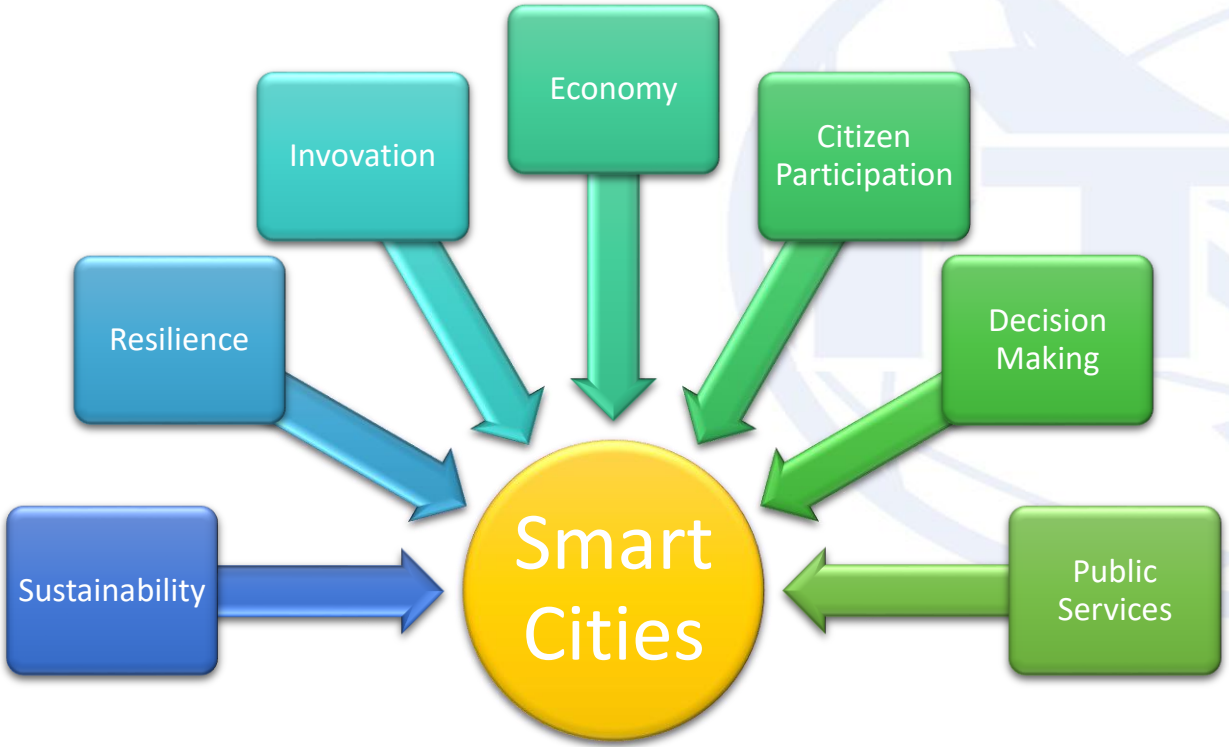
It has also held two ITU Workshops on Data Processing and Management for IoT and SC&C (Feb 2018, Sept 2018)

WG1 - Use Cases, Requirements and Applications/ Services	WG2 - DPM Framework, Architectures and Core Components	WG3 - Data sharing, Interoperability and Blockchain	WG4 - Security, Privacy and Trust including Governance	WG5 - Data Economy, commercialization and monetization

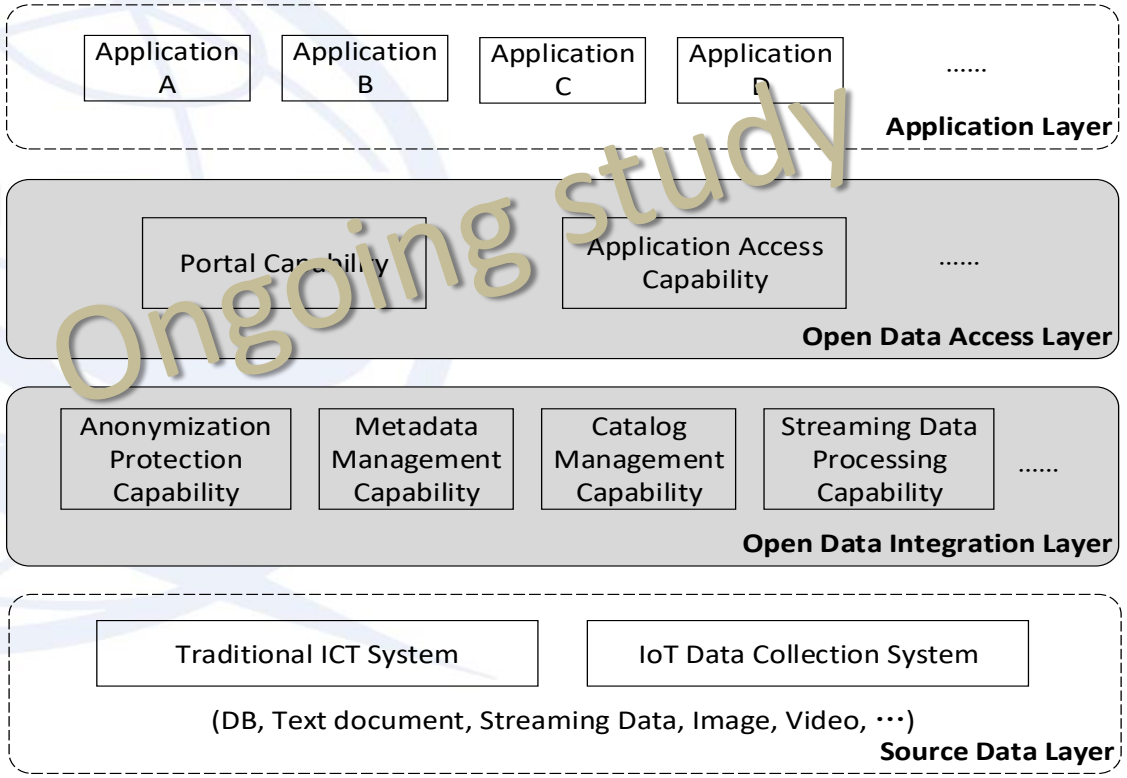
Liaisons/interactions established with numerous SDOs, Fora, Alliances and projects
E.g. ISO, ETSI ISG CIM, BDVA, various H2020 projects

Open Data in Smart Cities

Open Data facilitates the advancement of Smart Cities



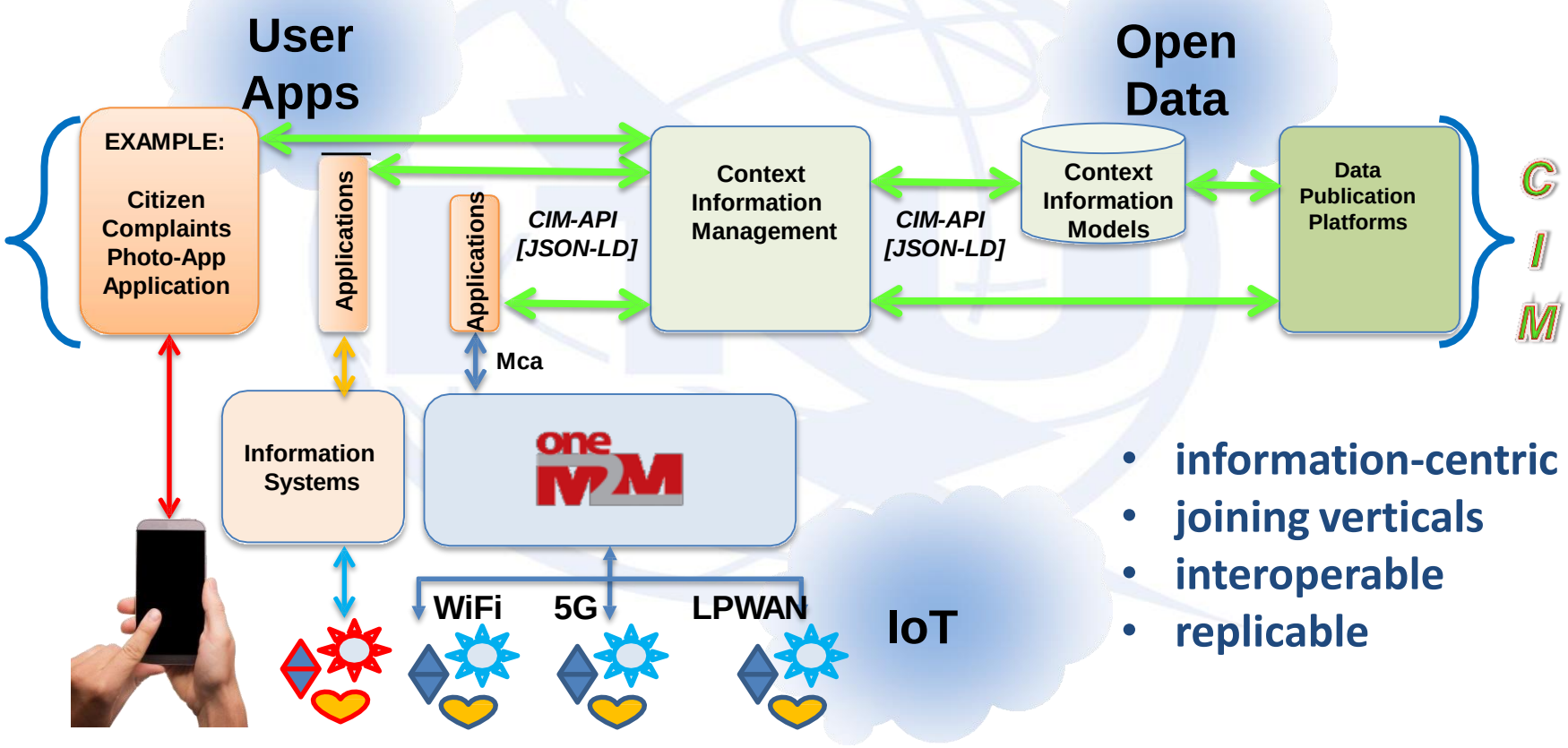
Functional architecture of Open Data in Smart Cities



Ongoing ITU-T draft Rec. Y.SC-OpenData “Framework of Open Data in Smart Cities”

ETSI Industry Specification Group on Context Information Management (ETSI ISG CIM)

ETSI ISG CIM has mandate to establish an info-exchange layer
on top of IoT platforms especially targeting Smart City applications



Context Information Management Layer - exchanging information between domains

Collaboration with SDOs (ITU-T FG-DPM, oneM2M, W3C ...) & open-source implementations

AIOTI WG03 (IoT standardization): engagement model

WG03 support to AIOTI in:

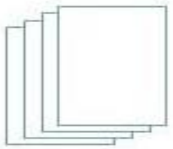
- **Digital Single Market**
- **Digitising European Industry**
- **H2020 Large Scale Pilots**

Analyze landscape

Identify gaps, divergences, common concerns

Task sub-teams to address themes

Publish guidance and recommendations



Engage, disseminate and influence

AIOTI WG03

- *High Level Architecture*
- *Semantic Interoperability*
- *Identifiers, IoT and 5G*
- *Security and (Personal) Data Protection (with WG4)*

Source: AIOTI WG03

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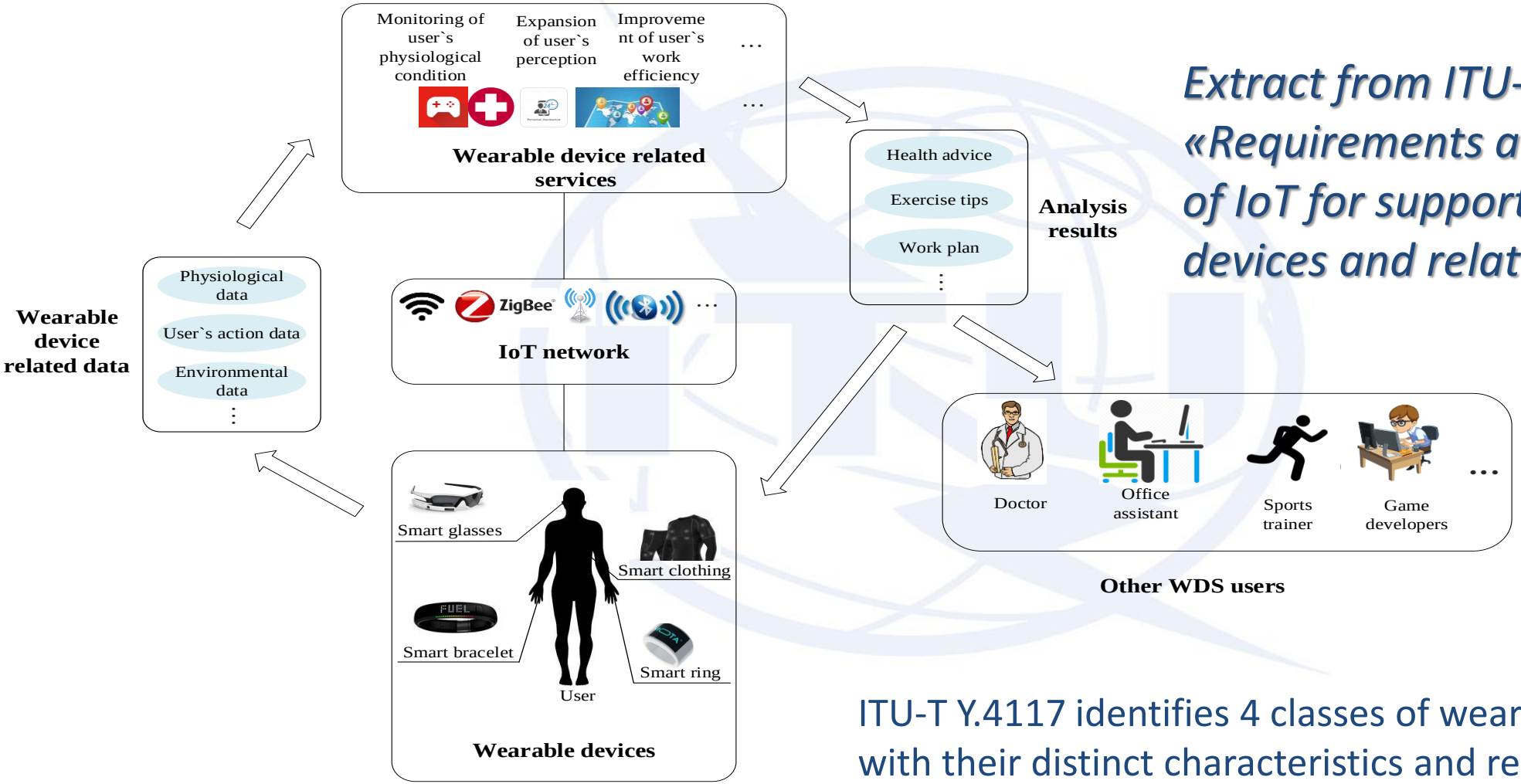
Examples of application domains of the IoT

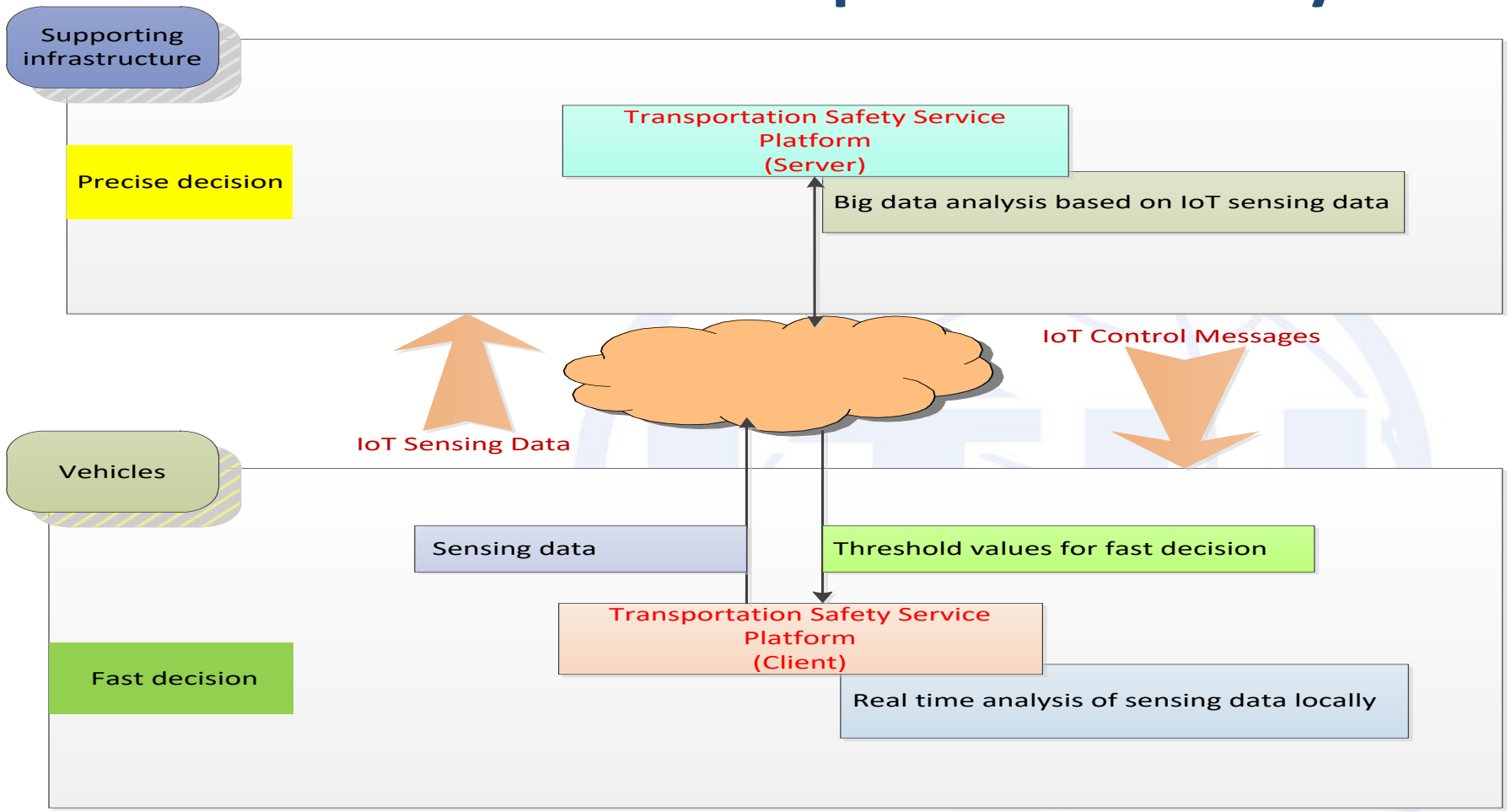
IoT for wearable devices and related services



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

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

IoT for transportation safety services



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

The picture shows an example of distributed processing-based decision making

Vehicles locally process and compare **sensing data** to threshold values for fast decision.

Sensing data from vehicles and transportation infrastructure are delivered to the transportation safety service platform (server side).

The platform generates threshold values (e.g. safety indexes) for more accurate decision based on big data analysis.

The generated threshold values are delivered to vehicles for appropriate adjustment of the local decision making process.

IoT for Industry: monitoring/predicting industrial plant failures

Customer's challenge

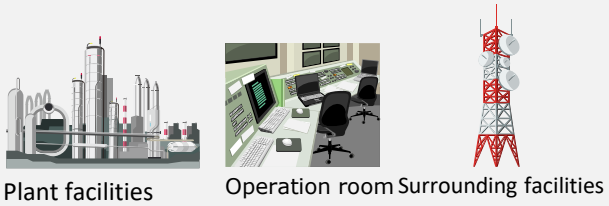
- Avoid damages by predicting failures, shorten the lead time to identify the cause of failure

Effect of solution

- Monitor/detect prediction of failures of plant facilities
- Detect abnormalities from large volume of sensor data at an early stage, avoid large-scale damage before it happens

Point of introduction

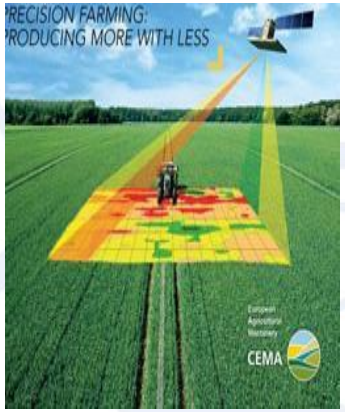
- **Visualize operational status from existing data by Analytics technologies**
- **Utilize massive data in real time and realize high accuracy monitoring/detection of failure prediction**

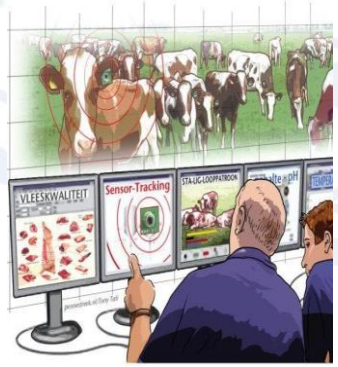


Analysis of large amounts of metric data collected from multiple sensors to automatically identify relationships and detect anomalies

Analytics Technologies example from NEC

Internet of Things in Food & Farming





Source: IoF 2020 INTERNET OF FOOD & FARM

Source: ISO