Chapter 7

Internet of Things standardisation - Status, Requirements, Initiatives and Organisations

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1.1 INTRODUCTION

This section was originally created with IERC (www.internet-of-things-research.eu) stakeholders to link their IoT research, development and innovation activities to international standard organisations, including ETSI, ITU-T, CEN/ISO, CENELEC/IEC, IETF, IEEE, W3C, OASIS, oneM2M and OGC. In 2013 the IERC IoT standard coordinators have asked contributors to focus on latest IoT standardisation issues and to recommend candidate organisations where technical specifications and standards should be developed?

1.1.1 What is standardisation ?

Which definition of standardisation are we using in this chapter?

Standardisation is a voluntary cooperation among industry, consumers, public authorities and other interested parties for the development of technical specifications based on consensus. Standardisation complements market-based competition, typically in order to achieve objectives such as the interoperability of complementary products/services, to agree on test methods and on requirements for safety, health and environmental performance. Standardisation also has a dimension of public interest. Standard makers should be close to standard users/implementers.

1.1.2 What are the gaps between IoT standardisation, IoT research, IoT development and IoT innovation?

There are gaps between IoT standardisation and IoT Research, Development and Innovation life cycle. How do IERC stakeholders bridge them?

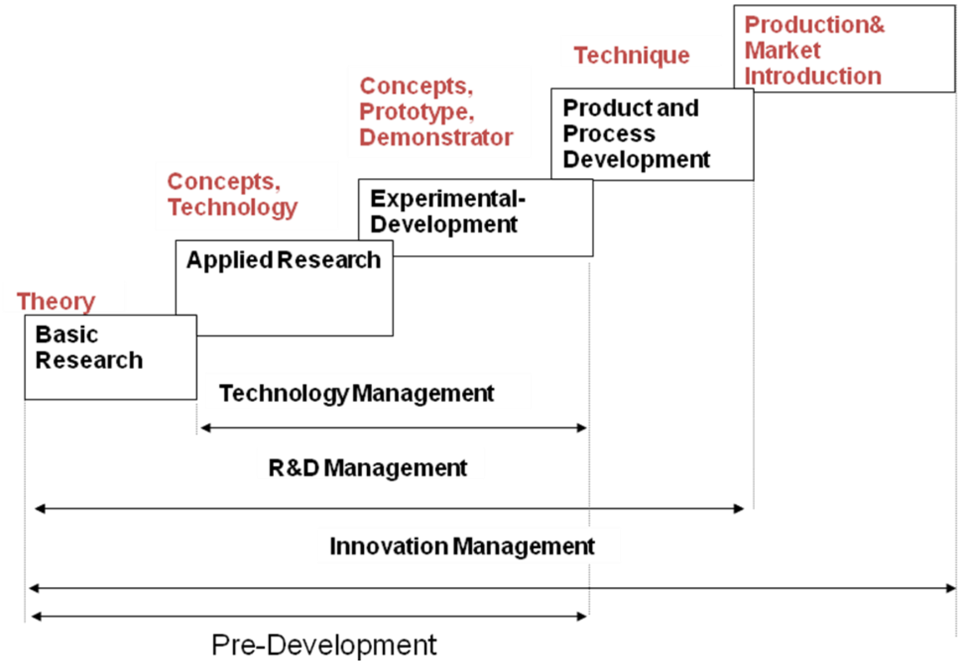

Figure 1.1 **Research, Development and Innovation life cycle.**

In order to fill gaps between IoT Research, Development and Innovation and standardisation life cycles (Figure 1.1), IERC encourages the creation of pre-standardisation groups. They allowed to build communities around consensus to develop standards, for example on Semantic Interoperability. Because of many options, IERC has helped to select and coordinate a lot of standards initiatives. IERC is also required to keep IoT Research and Development close to industry innovation and market. How has that been possible?

Industrial workshops have been co-organised with project and the European Commission in order to feed back IoT standardisation activities conducted by industrial stakeholders into EC funded projects. For example ETSI has co-organised workshops on Future Networks, M2M, Cloud, Smart Cities, ITS and RRS. IoT communities also welcomed the organisation of events (like Plugtests/Plugfests, Connectathon, Bake-off) focussing on interoperability testing, coexistence trials and compatibility involving applications or pilots/trial. Next workshops and interoperability “Plugtests/Connectathon” events should focus on IoT performance, optimization, quality (QoS, QoE), trust, safety, privacy, governance and security.

While pre-standardisation like conducted in IRTF/ISOC, ITU-T Focus Group, IEEE-SA Industry Connection Program and ETSI Industry Specification Groups facilitates to bridge the gaps between research and standardisation, the on-time creation of Technical Committees (like ETSI TC M2M, TC NTECH) and international Partnership Projects (like ETSI 3GPP and oneM2M) helps to link the international industry with IERC research.

1.1.3 What are current IoT requirements?

Without IoT standards, FI-WARE (www.fi-ware.eu)for example would not have been able to successfully provide open “Generic Enablers” for Future Internet/IoT developments in Phase 2 and 3 of FI-PPP (www.fi-ppp.eu). In IERC standardisation coordination meetings the most important IoT requirements for cross-domain standardisation were about cybersecurity, privacy, identification, traceability, anonimization, semantic interoperability, interoperability or coexistence testing, performance characterization and scalability, auto-configuration, discovery, self-configuration, service robustness and resilience. Future standards adopters must be the standards makers. They know best what they need to drive their business. There is a risk that standards are not used if these two kinds of actors are different. An incentive to facilitate common early standard development is to include pre-standardisation “work packages” within research projects proposals. However, there could be a lack of industrial involvement. This is why IERC tries to be a central reference for pre-standardisation activities of EC IoT research projects to increase overall efficiency and raise mutual awareness, defragment and synergize in one unique place important information for stakeholders: Industry, Standard Development Organisations (SDOs), European Commission (EC). Before enforcing EC priorities using EU Regulation (Communications, Recommendations, Mandates or Directives) the EU funded programs are giving indication to proposers on EC priorities and domains, SDO / pre-standardisation activities to use, other ongoing projects, actions and deliverables to coordinate with. The IERC exists exactly for that, it allows exchanges between IERC, other EC clusters and projects like Future Networks, Cloud, FI-PPP, and FIA. This helps to detect standards gaps and overlaps and to link with regulation.

1.2 M2M SERVICE LAYER STANDARDISATION

1.2.1 M2M service layer in IoT

In order to be able to move from a vertical only approach to an integrated horizontal approach a standardisation of generally used service for the communication between devices and devices and applications is essential.

Only by a world-wide standardisation on a protocol layer between transport and application a smooth integration of the diverge underlying communication technologies on the lower layers can be guaranteed. Already in a single vertical application domain a large variety of different communication standards exist and will exist in the future. It is not realistic to assume that a single standard on the lower protocol layers can be defined. Thus the integrating mechanism of the future horizontally integrated Internet-of-Things need to be a common cross vertical service layer. This service layer has to provide a set of general services to the applications at all component of the overall architecture from the devices level over the gateways to the network domain. A future worldwide standardised M2M service layer including definitions of interworking with existing underlying standards like 3GPP [5] or iPv6 on the WAN side, ZigBee or KNX on the M2M area side [4] and a clear definition of application interfaces will open up a complete new business opportunities for existing players and more important for new players. The heterogeneous standards environment is depicted in Figure 1.2. As such this horizontally integrated service layer can be seen as the operational system of the future IoT providing a set of commonly required services to a broad range of applications and underlying communication technologies.

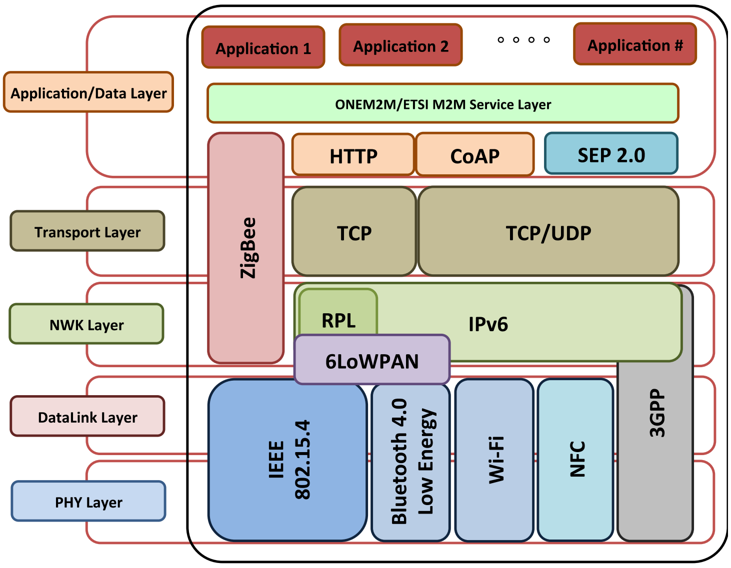

Figure 1.2 **Heterogeneous standards environment in IoT.**

1.2.2 Cross vertical M2M service layer standardisation

The main tasks in the standardisation activities will be the integration of different vertical including their communication standards and the definition of clear interoperability methods.

Here a worldwide standardised service layer for M2M type of communication will provide a framework for the integration of the different communication technologies deployed in the field of IoT. This M2M service layer will provide the needed services like data transport, security, devices management and device discovery [1] in a harmonized manner across a multitude of vertical domains to the application layer. These services will be independent from the underlying communication infrastructure and the deployed standards. In addition to these basic services across vertical semantic support should be included into the service layer capabilities allowing the different vertical domains to represent their semantic information in a horizontal framework.
In recent years several standardisation activities towards a horizontal service layer approach have been started by different standardisation organizations (SDO) world-wide. Here the activities at TIA in the TIA-50 group (M2M Smart Device Communication) in the USA, CCSA TC10 in China and the activities in the ETSI TC M2M group in Europe should be explicitly mentioned. The European activities in ETSI in the scope of ETSI TC M2M can be seen as the most advanced set of horizontal M2M service layer specification with a first release of the standard at

the end of 2011 [1] [2] [3] and a finalization of Release 2 during 2013. Figure 1.3 gives an overview over the different communication domains and objects in the ETSI M2M solution.

Since the creation of oneM2M PP the ETSI technical work on the core M2M service layer will be moved to oneM2M. The scope of the ETSI M2M activity will evolve towards a broader handling and coordination of IoT related standardisation topics and the interfacing between oneM2M and the European organisations (EU Mandates, EU regulation) and EU research projects including the IERC cluster.

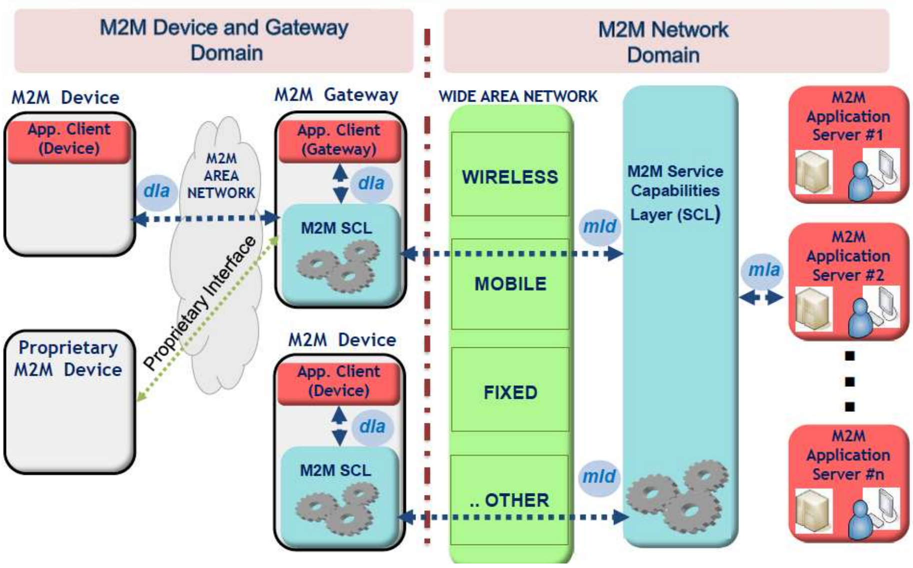

Figure 1.3 **Example: Different M2M domains and the corresponding ETSI M2M objects [source: ETSI TC M2M].**

The CCSA (http://www.ccsa.org.cn/) in China standard defines a simple service layer with main drawback in the security and privacy domain. Based on these developments an operational M2M service layer called WMMP exists and is being used by China Mobile. This service layer has a limited capability and can be seen as light version of a service layer.

The TIA-50 (http://www.tiaonline.org/) activities in USA have lead to an initial set of standards with the main focus on the devices and gateway side with a clear lack of network support. Just recently corresponding activities have been launched in this group.

In 2010 the major players in the field have identified the need of a world-wide harmonized standard for the service layer for an M2M like communication. Based on this clear requirement the leading SDO in Europe (ETSI), USA (TIA, ATIS), China (CCSA), Korea (TTA) and Japan (TTC, ARIB) have created a world-wide partnership project called ONEM2M (http://www.onem2m.org/) which is

operational and in place since September 2012. Participation in the partnership project is open for the individual SDO member companies and institutions. The participating SDOs intend to transfer all standardisation activities in the scope of M2M service layer to the ONEM2M PP and with that stop their individual activities in the domain. Regional tasks and adaptation of the standards toward the regional regulation will stay in the responsibility of the regional SDOs. In the near future the participation to the ONEM2M will be opened to other standards group and fora like the Broad Band Forum (BBF) and the Continua Health Alliance as representatives of specific vertical application domains.
OneM2M is planning a first release of a set of standards for a service layer for the beginning of 2014. The requirements are based on the use cases developed in the different SDO's and will lead to a world-wide M2M service layer solution.

1.2.3 Business opportunities and future markets

Existing service layer are mainly focused on a single vertical solution like the smart home or smart office environments.

These proprietary solutions are provided by companies like iControl (http://www.icontrol.com/) and nPhase (htt://www.nphase.com/) with a limited possibility to extend the solution and to adapt it to new application areas and domains.
An open world-wide standard M2M service layer based on the future ONEM2M standard will open up the possibility for a broad range of companies and players to enter the business field with different sets of possible business models. A broad range of business models and solutions can be envisaged.
In an initial deployment phase companies can provide the software and the required services for the implementation of a full M2M network for the service providing companies and the device manufacturers. The available open application interfaces in the different component of the M2M architecture (device, gateway, network) will allow for an open market place for the development of M2M applications. These applications can be integrated into the M2M network components and thus can extend the capabilities in a very flexible manner. These applications can be independent of the deployed communication technology and thus can address a much broader market place than specific applications.
Service provider can initially focus on specific domains using a standardised service layer and still having the possibility to extend the business towards new field if needed.

1.3 OGC SENSOR WEB FOR IOT

1.3.1 Location and sensors in IoT

All IoT things are at a location. Location is a fundamental piece of information for most of the new and innovative applications enabled by IoT. Location information is ubiquitous but not always correct. Location data quality can be easy to maintain, but subtle mistakes can creep in and cause failures, damage and death. Accurate handling of location information in IoT is being built on the standards for location well established by several standards developing organizations, in particular as established by the Open Geospatial Consortium (OGC)[i].

Sensors and actuators associated with IoT devices are bringing a new awareness and control of the environments in which we live and work. To achieve this capability most broadly, observations made by sensors must become as interoperable as the information accessible on the Web. Most sensor observations will not be used directly by humans but rather will be processed by software as the information goes from the sensor to the human. Here again IoT benefits from established standards.

The Open Geospatial Consortium (OGC) is an international industry consortium of 481 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards. OGC® Standards support interoperable solutions that "geo-enable" the Web, location-based services and IoT.

1.3.2 OGC Sensor Web Enablement

“In much the same way that HTML and HTTP enabled WWW, OGC Sensor Web Enablement (SWE) will allow sensor webs to become a reality.” This vision in 2001 by Dr. Mike Botts was a basis for initiating development of SWE. Due to the large number of sensor manufacturers and differing accompanying protocols, integrating diverse sensors into observation systems is not straightforward. A coherent infrastructure is needed to treat sensors in an interoperable, platform-independent and uniform way. SWE[ii] standardizes web service interfaces and data encodings as building blocks for a Sensor Web (Figure 1). SWE standards are now mature specifications with approved OGC compliance test suites and tens of independent implementations. The SWE standards are deployed in operational systems, including safety critical systems.

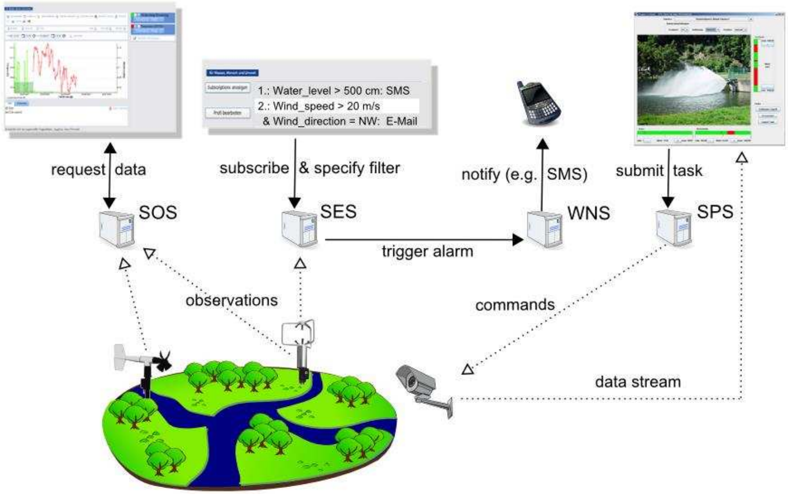

Figure 1. Deployment scenario for OGC Sensor Web Enablement (Source: Bröring[iii])

The OGC SWE framework includes:

- **Sensor Observation Service (SOS)** – standard web interface for accessing observations and subscribing to alerts
- **Sensor Planning Service (SPS)** – standard web interface for tasking sensor system, models, and actuators
- **Web Notification Service (WNS)** – service for asynchronous dialogues (message interchanges) with one or more other services.
- **Sensor Alert Service (SAS)** – web service for publishing and subscribing alerts from sensor or simulation systems.
- **SensorML** – models and schema for describing sensor and actuator systems and processes surrounding measurement and the tasking of assets
- **Observations and Measurements (O&M)** – models and schema for packaging observations

1.3.3 OGC Sensor Web for IoT

Interoperability of IoT devices based on open standards will be required to meet the vision of IoT. Based on a series of community workshops, OGC members chartered development of a *Sensor Web for IoT* standard. OGC's existing standards for location information and sensor observations are the basis for this work. The new OGC Sensor Web for IoT Standards Working Group (SWG)[iv] is to develop one or more standards based on existing protocols while leveraging the existing and proven OGC SWE family of standards.

IoT has the potential to change the world, just as the Internet and WWW did. A huge variety of day-to-day objects will become IoT enabled. A plethora of applications, from personal interest to environmental monitoring, will emerge by mix-and-match of different sensors, mobile devices, and cloud-based resources. Heterogeneity of devices and applications (Figure 2) demands *interoperability*. The Sensor Web for IoT SWG aims for interoperability based on open standards as key factor for the success of IoT, resulting in a greater accessibility and utilization of IoT information (Figure 3).

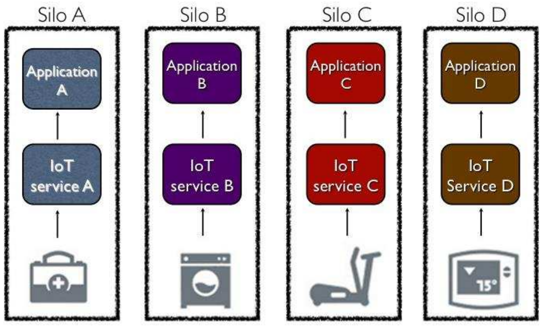

Figure 2. Non-interoperable IoT sensing applications

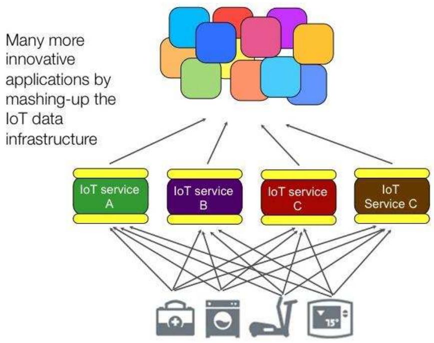

Figure 3. OGC Sensor Web for IoT interoperability

Building on SWE and other IoT protocols, the *OGC Sensor Web for IoT SWG* is developing a standard that makes observations captured by IoT devices easily accessible. This functionality is defined as lightweight RESTful web interface using CRUD (i.e., create, read, update, and delete) functions on IoT resources. While nearly complete, Sensor Web for IoT is ongoing and OGC invites others to join the process to define an easy-to-use interface for sensors to realize the Open IoT vision.

ETSI and OGC are collaborating on LBS (Location-Based Services), Intelligent Transport Systems (ITS) and GNSS (Global Navigation Satellite Systems) in SUNRISE research project (www.sunrise-project.eu) funded by the European GNSS Agency (www.gsa.europe.eu) in the framework of 2 **Open GNSS Service Interface Forum** (sunrise.opengnssforum.eu). ETSI see here an opportunity for GNSS, Augmented Reality and IoT to collaborate on LBS.

1.4 IEEE AND IETF

The main focus of the IEEE standardisation activities are on the lower protocol layers namely the Physical layer and the MAC layer. The IETF activities are positioned above that layer in the Networking and transport layer with some elements in the layers above, see **Error! Reference source not found.**.

The IEEE laid an early foundation for the IoT with the IEEE802.15.4 standard for short range low power radios, typically operating in the industrial, scientific and medical (ISM) band. Having shown some limitations with the initial solutions such as Zigbee, the basic 15.4 MAC and PHY operations were enhanced in 2012 to accommodate the requirements of industrial automation and smartgrid metering. The new version of the standard introduced the 802.15.4g PHY, which allows for larger packets up to two KiloOctets and in particular comfortably fits the IPv6 minimum value for the maximum transmission unit (MTU) of 1280 octets, and the 802.15.4e MAC, which brings deterministic properties with the Time Slotted Channel Hopping (TSCH) mode of operation.

The value of the TSCH operation was initially demonstrated with the semi-proprietary wireless HART standard, which was further enhanced at the ISA as the ISA100.11a standard, sadly in an incompatible fashion. The most recognizable enhancement by ISA100.11a is probably the support of IPv6, which came with the 6LoWPAN Header Compression, as defined by the IETF. Another competing protocol, WIAPA, was developed in parallel in China, adding to fragmentation of the industrial wireless automation market, and ultimately impeding its promised rapid growth.

A strong request is now coming from the early adopters, in the industrial Process Control space, for a single protocol that will unify those existing protocols in a backward compatible fashion, and extend them for distributed routing operations. Distributed operations are expected to lower the deployment costs and scale to thousands of nodes per wireless mesh network, enabling new applications in large scale monitoring. the 6TSCH Working Group is being formed at the IETF to address the networking piece of that unifying standard.

Based on open standards, 6TSCH will provide a complete suite of layer 3 and 4 protocols for distributed and centralized routing operation as well as deterministic packet switching over the IEEE802.15.4e TSCH MAC. Most of the required 6TSCH components already exist at the IETF in one form or another and mostly require adaptation to the particular case, and 6TSCH will mostly produce an architecture that binds those components together, and provide the missing glue and blocks either as in-house RFCs, or by pushing the work to the relevant Working Groups at the IETF.

Yet, there is at least one entirely new component required. That component, 6TUS, sits below the 6LoWPAN HC layer in order to place the frames on the appropriate time slots that the MAC supports, and switch frames that are propagated along tracks that represent a predetermined sequence of time slots along a path.

Centralized routing is probably a case where work will be pushed outside of the 6TSCH WG. That component will probably leverage work that was done at the Path Computation Element (PCE) Working Group, and require additions and changes such as operation over the CoAP protocol, and new methods for advertising links and metrics to the PCE. All this work probably belongs to the PCE WG. Another example is the adaptation of the IPv6 Neighbor Discovery (ND) protocol for wireless devices (WiND) that will extend the 6LoWPAN ND operation and will probably be conducted at the 6MAN working group in charge of IPv6 maintenance.

Distributed route computation and associated track reservation, on the other hand, can probably be addressed within the 6TSCH Working Group, as it is expected to trivially extend the existing RSVP and RPL protocols. Same goes for PANA that may be extended to scale the authentication to the thousands of devices.

The next step for this work is a so called BoF in July 2013 in Berlin. The BoF will decide whether a WG should be formed and determine the charter for that WG.

IEEE ComSoc has appointed the key partners of the IOT6 project to lead the newly created IOT track within the Emerging Technologies Committee. IOT6 created a web site and attracted 400 members in the first 3 months: http://www.ipv6forum.com/iot// . IOT6 will use this platform to disseminate IOT6 solutions on a large scale basis. The Globecom IOT track is under preparation. http://www.ieee-globecom.org/CFP-GC13-SAC-IOT_final.pdf

1.5 ITU-T

The Telecommunication Standardization Sector of the International Telecommunication Union (ITU-T) is progressing standardization activities on Internet of Things (IoT) since 2005.

After a report on "The Internet of Things", published by the ITU in 2005, the ITU-T established a Joint Coordination Activity (JCA-NID), which aimed at sharing information and performing coordination in the field of network aspects of Identification systems, including RFID. The JCA-NID supported the work of the ITU-T Study Groups which led to the approval of initial Recommendations in the areas of tag-based identification services, Ubiquitous Sensor Networks (USN) and Ubiquitous Networking, and their application in Next Generation Networks (NGN) environment.

With the official recognition in 2011 of the centrality of IoT in the evolution of future network and service infrastructures, the JCA-NID was renamed as JCA-IoT (Joint Coordination Activity on Internet of Things) - itu.int/en/ITU-T/jca/iot - and the working structure of the IoT-GSI (IoT Global Standards Initiative) - http://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx - was formally established. Since then, the ITU-T activities related to IoT have greatly expanded and produced additional Recommendations spanning various areas of application (e.g. networked vehicles, home networks, mobile payments, machine oriented communications, sensor control networks, gateway applications), as well as IoT framework aspects (basic concepts and terminology, common requirements and capabilities, ecosystem and business models etc.) and, more recently, testing aspects.

Beyond the above mentioned IoT focused activities and the potential future IoT studies, which are included in the "IoT workplan" (a living list maintained by the IoT-GSI), it has to be noted that there are other ITU-T ongoing studies closely related to the IoT - it is worthwhile to mention here those related to Future Networks, Service Delivery Platforms and Cloud Computing.

In parallel with the JCA-IoT's coordination efforts with external entities and its maintenance of a cross-SDO list of IoT standard specifications and associated roadmap (the "IoT Standards Roadmap", freely available from the JCA-IoT web page), a remarkable milestone has been achieved by the IoT-GSI via the finalization in June 2012 of the ITU-T Recommendation Y.2060 "Overview of Internet of Things" [6]: the "IoT" is there defined – in fundamental alignment with the European IERC vision of IoT – as *"a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies"*. To note that, in this perspective, the Machine to Machine (M2M) communication capabilities are seen as an essential enabler of the IoT, but represent only a subset of the whole set of capabilities of IoT.

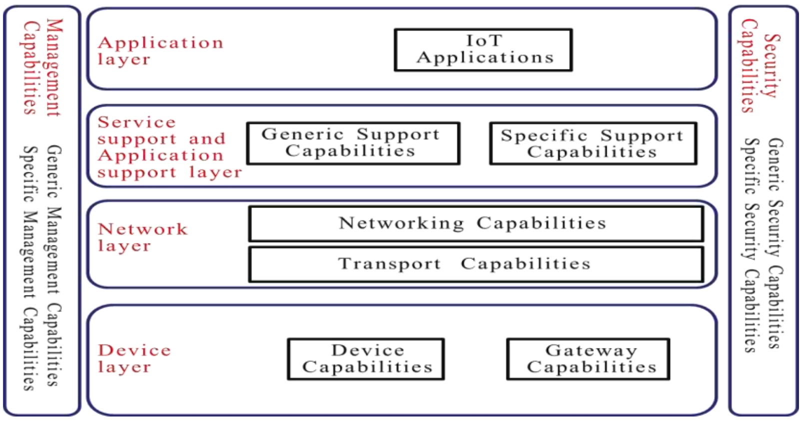

Figure 1.4 IoT Reference Model [source: ITU-T Y.2060]

Among the various ITU-T IoT-related efforts, the Focus Group on M2M Service Layer (FG M2M) - http://www.itu.int/en/ITUT/focusgroups/m2m/Pages/default.aspx - deserves a special mention: established in 2012 with the key goal to study requirements and specifications for a common M2M Service Layer, it focuses its developments on the "e-health" application domain (priority scenarios being those of remote patient monitoring and assisted living). The FG M2M is also targeting the inclusion of vertical market stakeholders not part of the traditional ITU-T membership, such as the World Health Organization (WHO), and the collaboration with M2M and e-health communities and SDOs.

The FG M2M work is currently developing deliverables dealing with e-health use cases and ecosystem, M2M service layer requirements and architectural framework, APIs/protocols and e-health standardization gap analysis. In this context, the M2M service layer capabilities aim to include those common to the support of different application domains as well as those required for the support of specific application domains.

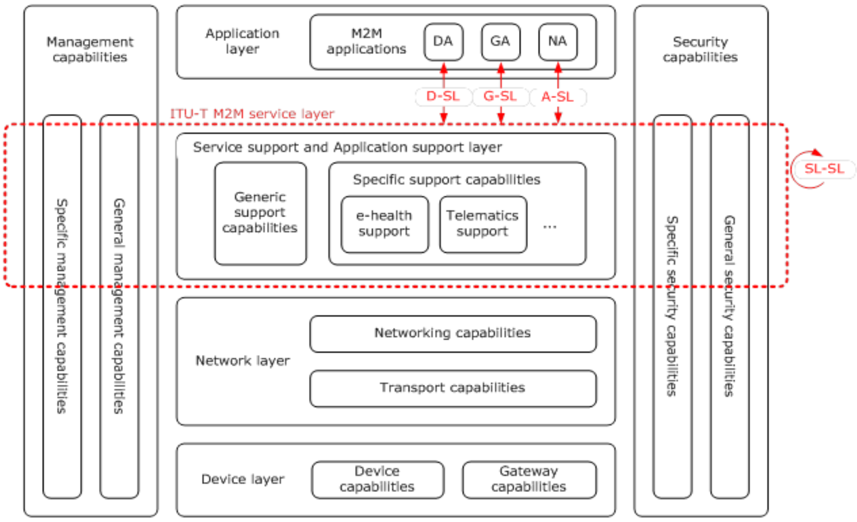

Figure 1.5 The ITU-T M2M Service layer [work in progress in the FG M2M]

As highlighted by Marco Carugi (ITU-T Question 2/13 Rapporteur and vice-Chair of the FG M2M), representing ITU-T at the latest IERC/IoT standardisation coordination meeting in Delft (February 7-8 2013), IERC and ITU-T have entertained good relationships all along the IoT standardization activities of ITU-T, particularly in the context of JCA-IoT and IoT-GSI.

IERC has liaised with ITU-T and taken an active role in the discussions which led to the finalization of the ITU-T definition of "Internet of Things" and the approval of ITU-T Y.2060 (aspects related to IoT Reference Model, IoT Ecosystem, high-level requirements of IoT and other IoT definitions).

More recently, exchanges have taken place with respect to the IoT-A project in the context of requirements, capabilities and functional architecture of IoT (Question 2/13, FG M2M).

The ITU and IERC collaboration and coordination are expected to continue in the future and might involve also IoT "vertical" matters, for example e-health (FG M2M, ITU-T SG13 and SG16), Smart Cities (FG on Smart Cities), Smart Grids (JCA-SG&HN), Intelligent Transport Systems (FG CarCOM, collaboration initiative on ITS communication standards etc.).

1.6 CONCLUSIONS

There is a good momentum on M2M service layer standardisation, semantic interoperability and Future Networks standardisation as a main driver of the future success of integrated IoT. In addition several PHY and MAC layer standards activities in IEEE, ETSI (low power DECT) and other groups will provide required lower layer enabling technologies for the integration into the overall IoT.

IERC and its participating projects are seen as a catalyst and an European IoT coordination platform facilitating international world-wide dialog. IoT Workshops co-organised between the European Commission, IoT Research and innovation projects, IoT Industry Stakeholders and IoT Standard Organisation groups should continue. These workshops should facilitate Interoperability Testing events to stimulate IoT community building to reach consensus on IoT standards common developments on all protocol layers. The results of these events can be seen as an essential input for the further development and evolution of the IoT standardisation. New domains have to be integrated into the overall view like the standardisation development in ITS (Intelligent Transport Systems) in ETSI and ISO.

A significant effort will be required to come to an overall cross vertical IoT vision and interoperable standards environments.

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