

## STANDARDIZATION WITH IOT (INTERNET-OF-THINGS)

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### **Abstract:**

Standards mean in general common methods, norms and regulations, based on which some work must be done, some product or service must be produced or some actions be conducted. Standards can be official and binding (*de jure*). These defined by official standardization organizations and can be connected to some legislation and they should be followed. Standards can be also unofficial (*de facto*), which have become common practices in certain industries without formal decisions and connections to laws and other official regulations. *De facto* standards can be formed by companies or groups of companies (interest groups, consortia, alliances, associations, etc.) which have come first into the market or application area and therefore the used methods/protocols etc. have become *de facto* standards. Standards play an important role in applying new technologies. With standards different actors in industry and in ecosystems can utilize similar and connective systems. This is even more important in complex global systems. Actually increasing complexity of system requires common platforms defined by standards. On the other hand standards can also be harmful in some business situations. Standardization processes are typically very time consuming. In digitalization development waiting for the official standards may cause loss of significant business opportunities. Generally standardization has been seen as a positive thing from the digitalization development points of view. Internet of Things is rather new digitalization based development where standardization is a contemporary question – both pros and cons of standardization are of great interest. This research looks at the standardization development globally. The research is done with a literature and internet search. The findings indicate that standardization in the field of Internet of Things is still expanding. There is an extensive amount of organizations that are dealing with standards, both official and non-official, and the application space is wide. Many emerging applications are exploiting their own standards and many standards are still under development. The solutions rely on various co-existing protocols, interfaces and platforms, either proprietary or standard. Some of the Internet of Things standards will be official standards, whereas some will be *de facto* standards that are agreed by forums or alliances or dictated by companies in decisive roles. Collaboration among various organizations is important and needed.

*Keywords:* digitalization, standardisation, *de jure*, *de facto*, industrial internet, industry 4.0

## **1. INTRODUCTION**

### **1.1. Background**

Internet with extensive digitalization will influence on us in all areas of life: work, leisure, hobbies, social activities, etc. It will have a changing influence on industries, businesses and societies. This development has been named as Internet of Things. The concept has been first introduced by Ashton with a presentation he made at Procter & Gamble in 1999 (Ashton, 2009).

Concepts like Real-World Internet (RWI), Internet Connected Objects, Internet of Everything, Industrial Internet and Industry 4.0 have been used to describe the similar phenomenon. Morgan (2014) states that "There are a lot of complexities around the "Internet of things"". He defines the IoT as "a concept of basically connecting any device with an on and off switch to the Internet (and/or to each other). This includes everything from cell phones, coffee makers, washing machines, headphones, lamps, wearable devices and almost anything else you can think of. This also applies to components of machines, for example a jet engine of an airplane or the drill of an oil rig. ... The IoT is a giant network of connected "things" (which also includes people). The relationship will be between people-people, people-things, and things-things."

In addition to technological developments in the IoT world other aspects have been addressed like to business ecosystems (livari, et al 2015, Toivanen et al, 2015). However the standardization has so far attracted less interest in the research communities. The technical side of the IoT has some development in this area like several network management frameworks have been specified during the last decades by various standardization bodies and forums. Organizations like IETF, 3GPP, DMTF and ITU are trying to specify interfaces, protocols and information models by taking into consideration the respective network infrastructure i.e., telecom world, the Internet and cellular communications. (Kousaridas, et al 2011)

Standardization has been an important precondition in digitalization. Larsen (2016) describing the situation in life science is in line with this by stating that "data integration and standardization is a crucial foundation and precondition for the digitalization in life sciences". Further he understands the challenges of standardizations. "A common denominator for all mentioned standards is that they all require extensive change management efforts, comprehensive data management expertise and technology, as well as resources to be adopted, maintained and used appropriately in the organizations." Larsen (2016)

Standardization plays a significant role in how fast the general approach and the industrial internet technologies will be taken into use; what kinds of ecosystems and platforms there will be; which businesses and domains will be the first to adapt to the change of the new paradigm; and who will be the winners in this change. The issues of standardization in the area of The Internet of Things (IoT) are very challenging both from scientific and managerial point of view because, like Elloumi et al (2015) state "As the pace of IoT deployments accelerate, IoT standards are undergoing major evolutions, sometimes revolutions".

The concept of IoT is very broad in its scope covering nearly all aspects of life. This is a rational reason that the potential number of standards is very large and the standards themselves form a very complex landscape. Any IoT related standardization must pay attention to how regulatory measures in a particular applied sector will eventually drive the need for standardized efforts in the IoT domain. In addition to all this, technology is continuously evolving bringing new challenges.

In this article the objective is to give an overview on IoT related standards. The application area where standards are evaluated is that of industrial maintenance. There would be many other interesting application areas like the life science with all medical devices. But to have a focused approach one area has been selected for this study.

### **1.2. The Research question**

The research question of this study has been expressed as follows:

What is the existing state-of-the-art and what are future developments of the standardisation related to Internet of Things (IOT)?

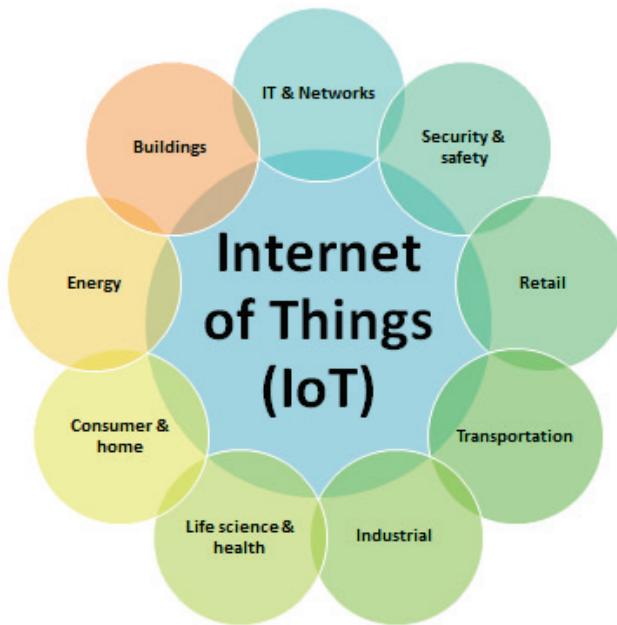
The research question will be answered using extensive literature and Internet search and content analysis using the Internet of Things concept as the background theory.

## 2. INTERNET OF THINGS

Muhonen (2015) as well as Muhonen et al (2015a, 2015b) have used the Industrial Internet Consortium definition as: "the Industrial internet connects smart machines and devices and people at work, leading to better decision making through advanced analytics that result in transformational business outcomes". Industrial internet comprehends the non-consumer side of IoT and applies "internet thinking" in industrial settings. IEEE (2015) has used in their research IoT definitions as follows: "IoT refers to any systems of interconnected people, physical objects, and IT platforms, as well as any technology to better build, operate, and manage the physical world via pervasive data collection, smart networking, predictive analytics, and deep optimization."

A schematic picture of the elements of the IoT is exhibited in the picture 1 (Muhonen, 2015, Muhonen et al 2015a, 2015b).

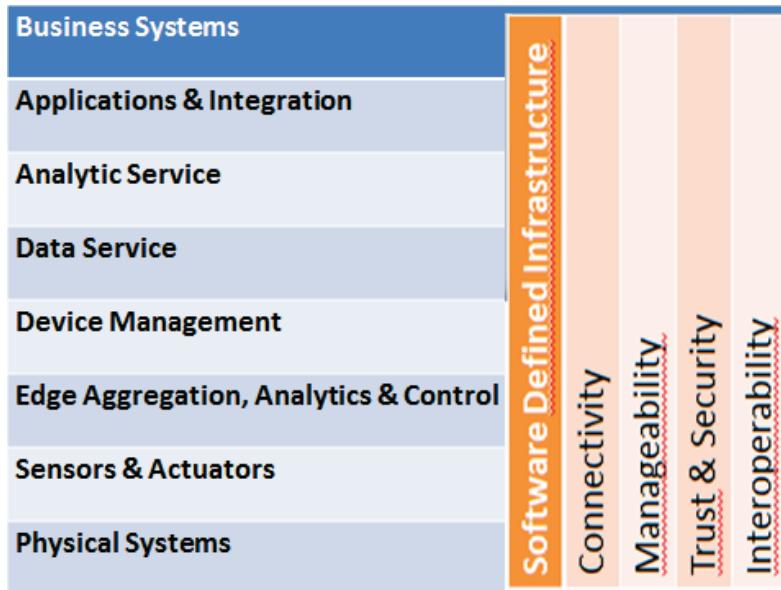
**Picture 1:** IoT framework



The picture shows, that IoT can be applied in nearly all areas of human and business life.

The Industrial Internet Consortium has created a 2 dimensional framework (Picture 2)

**Picture 2:** IoT in two dimensions



The framework describes system as hierarchies with the physical (real world) system as the basis and the business system utilizing digitalization as the highest level on the hierarchical system. The digitalization enables in this framework connectivity, manageability, trust and security as well as interoperability.

### 3. STANDARDIZATION OF THE INTERNET OF THINGS

#### 3.1. Standardization in general

International Standard Organisation (ISO) has a strong opinion about the benefits of international standards: “A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose. International Standards bring technological, economic and societal benefits. They help to harmonize technical specifications of products and services making industry more efficient and breaking down barriers to international trade. Conformity to International Standards helps reassure consumers that products are safe, efficient and good for the environment”.(ISO, 2016)

#### 3.2. Standardization of IoT

Clearly the development and wide application of IoT requires standardisation. As ‘things’ are connected with each other the interfaces between the ‘things’ must be defined at technical and at application levels in order to achieve the full benefits from the IoT.

The IoT standardization work is progressing in many fronts. An extensive literature and Internet search has produced the following organizations that are working with standardization tasks in the area of IoT. The results from this research are collected into the Table 1.

**Table 1:** IoT Organisations and their standardisation activities

Organization with Interest of Things Activities	Standardization activities
AllSeen Alliance <a href="https://allseenalliance.org/">https://allseenalliance.org/</a>	AllJoyn is an open source software framework that makes it easy for devices and apps to discover and communicate with each other.
AIM (Association for Automatic Identification and Mobility) <a href="http://www.aimglobal.org/">http://www.aimglobal.org/</a>	Internet of Things (IoT) committee provides a forum for members to understand and help shape the rapidly changing landscape of the interconnected world of products, services, and, information. The committee enables participants to lay the foundation for a smarter, more efficient world using automatic identification and mobility technology solutions. The committee is comprised of AIM member companies with an interest in influencing the direction and definition of the Internet of Things, especially as it relates to bar code, RFID and mobile computing solutions.

Bluetooth Special Interest Group (SIG) <a href="https://www.bluetooth.com/">https://www.bluetooth.com/</a>	The Bluetooth Special Interest Group (SIG) just announced version 4.1. With 4.1, the Bluetooth SIG is aiming to become a major player in the much-hyped Internet of Things (IOT) market.
CCSA (China Communications Standards Association) <a href="http://www.ccsa.org.cn/english/">http://www.ccsa.org.cn/english/</a>	General framework and technical requirements of IoT (Internet of Things) Document # YD/T 2437-2012
Eclipse Foundation <a href="http://iot.eclipse.org/">http://iot.eclipse.org/</a>	The IoT Working Group is supporting open standards for the Internet of Things. Provides open source implementations for IoT protocols such as CoAP, ETSI SmartM2M, MQTT or LwM2M.
ETSI (European Telecommunications Standards Institute) <a href="http://www.etsi.org/">http://www.etsi.org/</a>	M2 TS 103 267SmartM2M; Smart Appliances; Communication Framework TS 103 264 SmartM2M; Smart Appliances; Reference Ontology and oneM2M Mapping TR 118 501 oneM2M Use Case collection TR 103 290 Machine-to-Machine communications (M2M); Impact of Smart City Activity on IoT Environment TR 118 502 Architecture Part 1: Analysis of the architectures proposed for consideration by oneM2M TR 118 503 oneM2M Architecture Part 2: Study for the merging of architectures proposed for consideration by oneM2M TR 118 506 Study of Management Capability Enablement Technologies for Consideration by oneM2M TS 118 101 Functional Architecture TS 118 102 oneM2M Requirements TS 118 103 oneM2M Security solutions TS 118 104 oneM2M Service Layer Core Protocol Specification TS 118 105 oneM2M Management Enablement (OMA) TS 118 106 oneM2M Management Enablement (BBF) TS 118 108 oneM2M CoAP Protocol Binding TS 118 109 oneM2M HTTP Protocol Binding TS 118 110 oneM2M MQTT Protocol Binding TS 118 111 oneM2M Common Terminology TR 103 245 Electromagnetic compatibility and Radio spectrum Matters (ERM); GS LTN 002 Low Throughput Networks (LTN); Functional Architecture GS LTN 003 Low Throughput Networks (LTN); Protocols and Interfaces
GISFI (Global ICT Standardization Forum for India) <a href="http://www.gisfi.org/">http://www.gisfi.org/</a>	Internet of Things (IoT) Working Group <a href="http://www.gisfi.org/workinggroups.php?wg=IoT">http://www.gisfi.org/workinggroups.php?wg=IoT</a>
GS1 / EPCGlobal <a href="http://gs1oliot.github.io/oliot/">http://gs1oliot.github.io/oliot/</a>	Oliot (Open Language for Internet of Things) is aiming an international standard based Internet of Things (IoT) Infrastructure Platform, by extending the code system of GS1 and their standard architecture to support various IoT connectivity and protocols such as bar code, RFID, ZigBee, 6LoWPAN, etc. Oliot also aims a complete implementation of GS1/EPCglobal standard.
HART Communication Foundation <a href="http://en.hartcomm.org/">http://en.hartcomm.org/</a>	WirelessHART
International Electrotechnical Commission(IEC) <a href="http://www.iec.ch">http://www.iec.ch</a>	
IEEE (Institute of Electrical and Electronics Engineers) <a href="http://standards.ieee.org/innovate/iot/">http://standards.ieee.org/innovate/iot/</a>	The IEEE Standards Association (IEEE-SA) has a number of standards, projects and events that are directly related to creating the environment needed for a vibrant IoT.
IETF (Internet Engineering Task Force) <a href="https://www.ietf.org/">https://www.ietf.org/</a>	Internet-of-Things Directorate
IIC (Industrial Internet Consortium) <a href="http://www.iiconsortium.org/">http://www.iiconsortium.org/</a>	Industrial Internet Reference Architecture defines Industrial Internet Systems, and specifies a framework to aid in the development, documentation and communication of the Industrial Internet.
INCITS (International Committee for Information Technology Standards) <a href="http://www.incits.org/">http://www.incits.org/</a>	Technical committee on Internet of Things (IoT), INCITS/IoT10 will address standardization in the areas assigned to JTC 1/WG 10 on Internet of Things (IoT).
IPSO Alliance (The Internet Protocol for Smart Objects Alliance) <a href="http://www.ipso-alliance.org/">http://www.ipso-alliance.org/</a>	IP (Internet Protocol) for the networking of smart objects. the IPSO community provides information to people interested in specifying, building, testing, or just trying out Smart Object systems.
ISA (International Society of Automation) <a href="https://www.isa.org/">https://www.isa.org/</a>	ISA100 Committee
ISO (International Organization for	The ISO/IEC JTC 1/SWG 5: 1. Identify market requirements and standardization gaps for Internet of Things (IoT);

Standardization) ISO/IEC JTC 1 Information technology <a href="http://www.iso.org/iso/iso_technical_committee?commid=45020">http://www.iso.org/iso/iso_technical_committee?commid=45020</a>	2. Encourage JTC 1 SCs and WGs to address the need for ISO/IEC standards for IoT; 3. Facilitate cooperation across JTC 1 entities; 4. Promote JTC 1 developed standards for IoT and encourage them to be recognized and utilized by industry and other standards setting organizations; 5. Facilitate the coordination of JTC 1 IoT activities with IEC, ISO, ITU and other organizations that are developing standards for IoT; 6. Periodically report results and recommendations to JTC 1/SWG on Planning; 7. Provide a written report of activities and recommendations to JTC 1 in advance of each JTC 1 plenary meeting; and 8. Study IoT reference architectures/frameworks and provide a study report.
Internet Engineering Task Force (IETF) <a href="http://www.ietf.org">http://www.ietf.org</a>	The IoT directorate will (1) improve coordination between working groups focused on IoT-related technologies, (2) will provide review for IoT-related specifications for any area director or work group chair requesting such a review and will (3) provide insight on IoT work advancing outside of the IETF to the IoT-related working groups and to the IESG.
ITU (International Telecommunication Union) <a href="http://www.itu.int">http://www.itu.int</a>	The Global Standards Initiative on Internet of Things (IoT-GSI) Recommendation ITU-T Y.2060 provides an overview of the Internet of things (IoT). It clarifies the concept and scope of the IoT, identifies the fundamental characteristics and high-level requirements of the IoT and describes the IoT reference model. The ecosystem and business models are also provided .
NIST (National Institute of Standards and Technology) <a href="http://www.nist.gov">http://www.nist.gov</a>	NIST Draft Framework on the Internet of Things: Framework for Cyber-Physical Systems is intended to serve as a common blueprint for the development of safe, secure, and interoperable systems as varied as smart energy grids, wearable devices, and connected cars.
OASIS (Organization for the Advancement of Structured Information Standards) <a href="https://www.oasis-open.org/">https://www.oasis-open.org/</a>	<a href="http://interoperate-iot.oasis-open.org/">http://interoperate-iot.oasis-open.org/</a>
OGC (Open Geospatial Consortium) <a href="http://www.opengeospatial.org/">http://www.opengeospatial.org/</a>	The OGC Sensor Web for IoT Standards Working Group <a href="http://www.ocnetwork.net/IoT">http://www.ocnetwork.net/IoT</a>
OIC (Open Interconnect Consortium) <a href="http://openconnectivity.org/">http://openconnectivity.org/</a>	The IoTivity architecture will provide a roadmap for manufacturers and service providers, including: <ul style="list-style-type: none"><li>• Common solution</li><li>• Established protocols</li><li>• Common approaches</li><li>• Defined commonalities</li><li>• Interoperability</li><li>• Innovation opportunities</li><li>• Necessary connectivity</li></ul>
OMA (Open Mobile Alliance) <a href="http://openmobilealliance.org/">http://openmobilealliance.org/</a>	Oma Requirements Working Group specifications for: <ul style="list-style-type: none"><li>• The Always Online Infrastructure (AOI)</li><li>• The Converged Address Book (CAB)</li><li>• The Converged IP Messaging (CPM)</li><li>• The Converged Personal Network Service (CPNS)</li><li>• The Mobile Advertising (MobAd)</li><li>• The Mobile Augmented Reality (MobAR)</li><li>• The Open Connection Manager API (OpenCM API)</li><li>• The Mobile Spam Reporting (SpamRep)</li><li>• The Unified Virtual Experience (UVE)</li><li>• The Social Network Web (SNeW).</li></ul>
OMG (Object Management Group) <a href="http://www.omg.org">http://www.omg.org</a>	OMG IIoT standards and activities include: <ul style="list-style-type: none"><li>• Data Distribution Service (DDS)</li><li>• Dependability Assurance Framework</li><li>• Threat Modeling</li><li>• Structured Assurance Case Metamodel</li><li>• Unified Component Model</li><li>• Automated Quality Characteristic Measures</li><li>• Interaction Flow Modeling Language™ (IFML™)</li></ul> <a href="http://www.omg.org/hot-topics/iot-standards.htm">http://www.omg.org/hot-topics/iot-standards.htm</a>
OneM2M <a href="http://www.onem2m.org">http://www.onem2m.org</a>	OneM2M is the global standards initiative for Machine to Machine Communications and the Internet of Things
OPC Foundation <a href="https://opcfoundation.org/">https://opcfoundation.org/</a>	OPC UA, the Infrastructure for Internet of Things, Industrial Internet of Things, Industrie 4.0
Open Group <a href="http://www.opengroup.org">http://www.opengroup.org</a>	The Open Group Internet of Things (IoT) Work Group developing open standards for the Internet of things. It has produced two Open Group IoT standards: the Open Data Format (O-DF) and the Open Messaging Interface (O-MI)
Thread Group <a href="http://www.threadgroup.org">http://www.threadgroup.org</a>	Thread is to create the very best way to connect and control products in the home. The concept is built on open standards and IPv6/6LoWPAN protocols
TTA (Telecommunications Technology Association) <a href="http://www.tta.or.kr/English/">http://www.tta.or.kr/English/</a>	IoT Special Technical Committee (STC1): IoT/M2M Convergence (SPG11) and IoT/M2M Networking (SPG12)
W3C <a href="https://www.w3.org">https://www.w3.org</a>	The Web of Things Community Group provides an informal, pre-standards discussion forum to research, prototype, and create working systems for the Web of Things.

XMPP Standards Foundation <a href="http://xmpp.org">http://xmpp.org</a>	<a href="http://xmpp.org/uses/internet-of-things.html">http://xmpp.org/uses/internet-of-things.html</a>
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Note: all sites : [Accessed 27.2.2016]

The results show that there is a great number of organizations working in the area of standardisation of various aspects of the Internet of Things. Standardization is indeed needed to maximize the full potential of IoT for scalability and flexibility purposes. Standardization enables also the optimization between functionality, costs and quality of various IoT applications and solutions. Standardisation helps also companies to deliver devices and applications with a faster time-to-market results. (oneM2M, 2015)

#### 4. DISCUSSION

Internet of Things is one new digitalization based development where standardization is a contemporary question – both pros and cons of standardization are of great interest

This research looks at the standardization development globally. The research is done with a literature and internet search. The findings indicate that standardization in the field of Internet of Things is still expanding. There is an extensive amount of organizations that are creating standards, both official and non-official, and the application space is wide. Many emerging applications are exploiting their own standards and many standards are still under development. The solutions rely on various co-existing protocols, interfaces and platforms, either proprietary or standard. Some of the Internet of Things standards will be official standards, whereas some will be de facto standards that are agreed by forums or alliances or dictated by companies in decisive roles.

Tech2editorial (2016) has listed IoT technologies and development for the coming years as follows: "IoT Security, IoT Analytics, IoT Device (Thing) Management, Low-Power, Short-Range IoT Networks, Low-Power, Wide-Area Networks, IoT Processors, IoT Operating Systems, Event Stream Processing, IoT Platforms and IoT Standards and Ecosystems. Standards and their associated application interfaces will be essential because IoT devices will need to interoperate and communicate, and many IoT business models will rely on sharing data between multiple devices and organizations. Many IoT ecosystems will emerge, and commercial and technical battles between these ecosystems will dominate areas such as the smart home, the smart city and healthcare. Organizations creating products may have to develop variants to support multiple standards or ecosystems and be prepared to update products during their life span as the standards evolve and new standards emerge." These are very much in line with the research implications of this research. Collaboration among various organizations is important and needed.

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