# Considerations on Standardization of WoT

A Position Paper for W3C's Web of Things Workshop

Jonghong Jeon, Minkyo In, Seungyun Lee
Protocol Engineering Center, ETRI,
161, Kajong-Dong, YuSong-Gu, Daejeon, Republic of Korea
{ hollobit, mkin, syl@etri.re.kr }

## Background & Motivation

Ubiquitous computing which has been extensively studied for many years, is experiencing radical changes recently as the physical world devices, e.g., home appliances and industrial machines, are becoming smart thanks to the progress in computing technology development. In parallel, the communication techniques also make much progress recently. Internet access will very likely become commonly accessible by those "smart things", motivating the concept of Internet of Things (IoT) [1].

The Internet of things (IoT) tries to find a way interconnecting things based on interoperable information and communication technologies. Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst maintaining the required privacy.

Although the Web of Things(WoT) has a similar viewpoint to the IoT, the WoT is intended so that digital things can be accessed as resources of the web and services/applications can be provided based upon a web-based service environment as well as legacy telecommunications.

The World Wide Web (WWW) is used as a platform to deliver services to an end-user, the web enables business entities and applications to intercommunicate openly with each other over a network. The web has program language independent properties, uses message driven communications and easily bounds to different transport protocols. As a result, web technology allows the exposure of physical devices as resources on the web using a WoT approach. Therefore, users can interact with the devices using web interfaces. The WoT can provide capabilities of device reusability, portability across several heterogeneous networks and accessibility based on web with web standards [2, 3].

## One paradigm, many visions

In Fig. 1, the main concepts, technologies and standards are highlighted and classified with reference to the IoT vision/s they contribute to characterize best. From such an illustration, it clearly appears that the IoT paradigm shall be the result of the convergence of the three main visions addressed below. The diagram clearly depicts that IoT paradigm will lead to the convergence of the three visions of IoT [4].

Differences, sometimes substantial, in the IoT visions raise from the fact that stakeholders, business alliances, research and standardization bodies start approaching the issue from either an ''Internet oriented" or a

''Things oriented" perspective or a "Semantic oriented" perspective, depending on their specific interests, finalities and backgrounds.

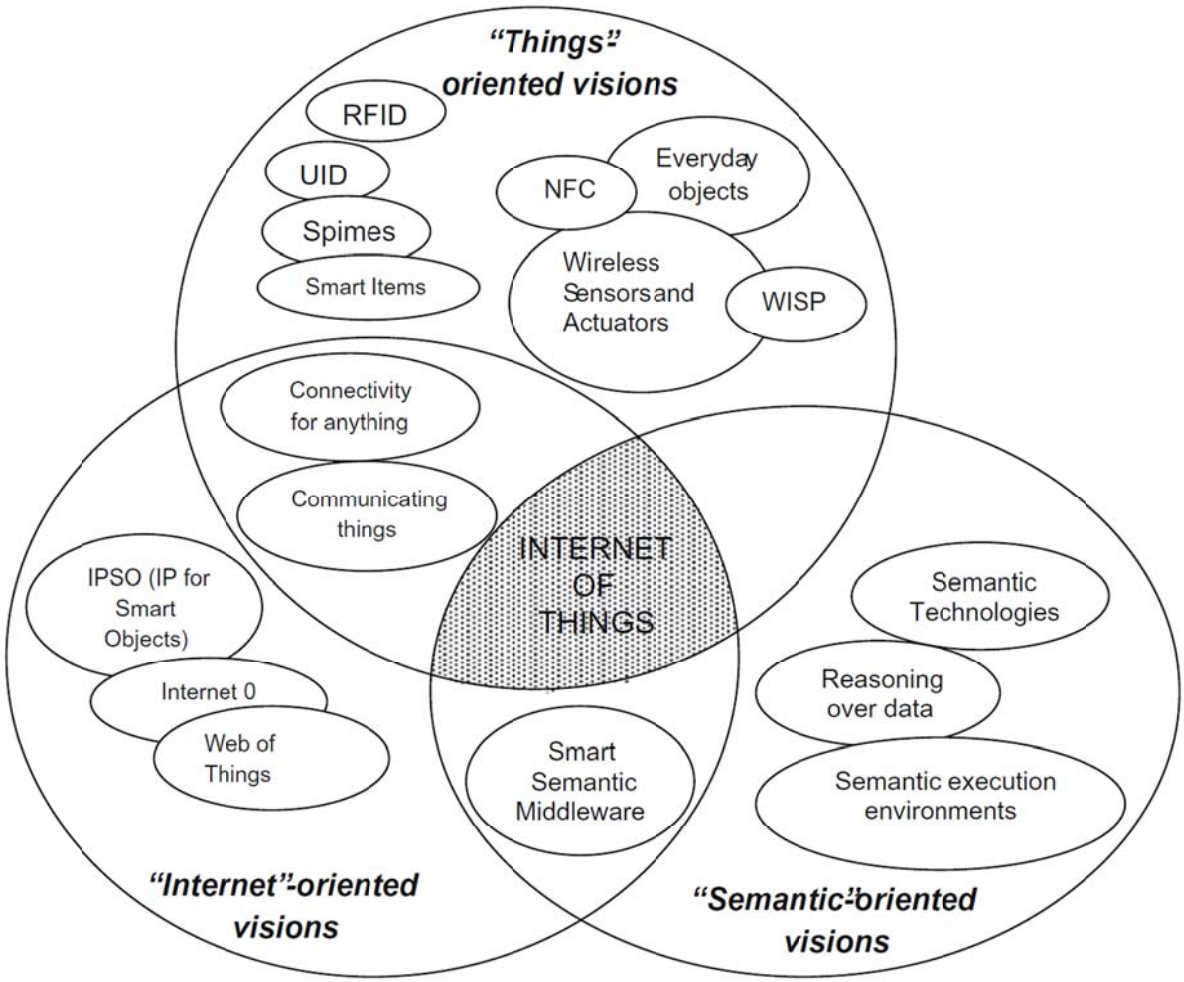


**Figure 1: ''Internet of Things" paradigm as a result of the convergence of different visions [4]**

## Interoperability and Complexity on IoT

Interoperability issues are needed at all levels. In the IoT scenario, the objects are all digital things connected to the Internet. They are monitored and controlled through service frameworks and various applications. Consider a smart home scenario where all the lighting are connected and controlled through a web interface. An introduction of a new light bulb, from a different vender, should not alter the setup and create the need for a gateway for interoperability. Thus there is a strong need for standardization, that enables the semantics being conveyed and understood, and also for interoperability of devices from multiple vendors [5].

On the other side, in these early days of building the Internet of Things, many voices are calling for the development of standards. However, the trouble is less a lack of standards than it is a lack of agreement about which standards to use under what circumstances. Here are some of the many standards activities that apply to the IoT [6].

- ITU-T leads the work of the ITU on standards for next generation networks (NGN) and future networks. The IoT is described as including Ubiquitous Sensor Networks (USN), Smart Ubiquitous Networks (SUN), the Web of Things (WoT), Machine-oriented Communication (MOC, i.e. M2M), and Network Identification (NID, i.e. network aspects of identification systems and tag-based identification).

- In Europe, European Standardisation Organisations (ESOs) work hard to support Machine to Machine (M2M), in particular by implementing three European Commission mandates: M441 on smart metering, M/468 for electric vehicles, and M/490 on smart grid. Since 2013, the oneM2M Partnership Project to which ESOs participate develops globally agreed-upon, access independent, end-to-end specifications for an M2M communications and management system that can be readily embedded within various hardware and software, connecting the wide range of devices in the field with M2M application servers worldwide.

- AllSeen Alliance: This alliance is developing a framework initially based on the AllJoyn open-source project, which seeks to create a language and protocol that will allow devices to communicate over various transport layers. The alliance will also promote the adoption of products, systems, and services based on the framework.

- DDS SIG: Coming out of the Object Management Group, the DDS (data distribution service) is a middleware standard for publish-subscribe communications in embedded systems.

- HyperCat: This is an open, lightweight JSON-based hypermedia catalogue format for exposing collections of uniform resource identifiers. It aims at making it easy for IoT systems to locate and identify the data resources that other systems are collecting and making public. The goal is to facilitate the free exchange of that data.

- IEEE Standards Association: This branch of the IEEE works to build consensus on standards issues. It has recently turned its attention to the IoT. Its activities can be explored by searching for "smart devices" on the group's website.

- Internet Engineering Task Force: The IETF handles many standards being used in IoT applications. Some of the key activities include the Constrained RESTful environments Working Group, which is developing the CoAP protocols for request/response transfers without the overhead of HTTP, along with the 6lo Working Group for further development of the 6LoWPAN wireless standard.

- IPSO Alliance: This organization aims to promote the use of the Internet Protocol by smart objects (IoT devices). Though it does not define standards, it will establish interoperability testing for its members' devices.

- ITU JCA-IoT: This group, part of the International Telecommunications Union, seeks to coordinate all activity within the organization that relates to the IoT, including addressing naming conventions and charging/settlement/billing mechanisms for device use of telecom resources.

- OneM2M: Its goal is to develop technical specifications for a common M2M service layer that can be embedded in IoT devices, addressing issues such as communications protocols, security and

privacy, remote management, and interoperability.

- OSGi Alliance: This organization aims to modularize Java to reduce software complexity. Oracle's new Java ME 8 specifically targets IoT development, seeking to allow both devices and apps to be programmed in Java.

- Weightless SIG: Weightless is an alternative technology to cellular communications for IoT devices, seeking to provide a 5 km range using wireless spectrum reclaimed from unused broadcast television channels.

- Wi-SUN Alliance: The alliance seeks to promote seamless connectivity for smart utility networks worldwide using wireless communications. Many IoT devices targeting home and building automation will eventually need to interact with the smart grid for power management.

- XMPP Standards Foundation: The Extensible Messaging and Presence Protocol (XMPP) is an open technology for real-time communication. Many are eyeing it as a standard for IoT device communications that have a real-time requirement, such as industrial control.

Too many standards are raising the issues about the complexity and interoperability.

## The Web as a universal standard

The World Wide Web (WWW, or simply Web) is a universal standard. The Web is an information space in which the items of interest, referred to as resources, are identified by global identifiers called Uniform Resource Identifiers (URI) [7].

The web has already become the major medium of communication in today's Internet. On the other hand, tiny web server technology has been researched for decades and now various embedded tiny web servers are available. More specifically, web services have been proven to be indispensable in creating interoperable applications on today's Internet. Smart things with embedded web servers can be abstracted as web services and seamlessly integrated into the existing web. It is natural to reuse existing web technologies and standards to unify the cyber-world and the physical-world. This yields higher flexibility, customization and productivity. In brief, different from traditional view of IoT which gives everyday device an IP address and makes them interconnected on the Internet, WoT enables them to speak the same language, so as to communicate and interoperate freely on the Web [1, 8, 10, 11].

## The Web Technology for Things

Before progressing W3C standardization activity, we need to consider in several perspectives, e.g. web technologies for small devices, lightweight protocol, architecture model, lightweight application model, device APIs, and privacy/security model.

The Web of Things could be defined a set of technologies how to access/control/management the Things by the web.  Though now cannot define the general requirements in detail, W3C seems necessary to consider further for the under standardization issues.

- ✓ Philosophical/Conceptual issues
  - What is a Thing in the web of things (Physical ? Virtual ? Everything ?)
- ✓ Architectural issues
  - Simple architecture model & Gateway based architecture model
  - RESTful pattern
  - Use cases and requirements
  - Common framework to integration various web resources
  - Identification & Discovery (Services, Resources, Things, Capability..)
  - Lightweight protocols for Things – push, HTTP extension
- ✓ Management
  - Web based Device Management protocol and APIs
  - System setting APIs
  - Caching
- ✓ Remote Access of Thing's Resources
  - How can we access through the firewalls, NATs..
  - Web technologies for small devices (accessory, sensors…)
- ✓ Device capability access
  - Access to the device capabilities
  - RESTful remote access of device capabilities
  - Harmonization with DAP WG, sysapps WG, webapps WG in W3C
- ✓ Presentation issues
  - presentation on the non-visual small devices (no screen device)
  - Harmonization with traditional web standards
- ✓ Privacy and security
  - Privacy Protections mechanism
  - Security model for small devices
  - Security Model for Web of Things

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