A Network-Centric discussion of the Internet of Things

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Abstract

Internet of Things (IoT) is a concept that covers various aspects related to the extension of the Internet and the Web into the physical domain. Ubiquitous presence of target objects in the environment through different wireless networks connected each other. Every objects in this network are uniquely addressable in order to interact and cooperate with other objects thus create services and implement high-level applications. In this context, the infrastructure and criteria of network to which the objects connected is an important component to make the IoT work effectively. In this paper, three types of networks (Single-source Network, Hybrid Sensing Network and Semantic Sensor Network) have been addressed also with the emphasis on what is current work and what are the prospect as well as what are further researches.

Keywords: RFID; Wireless Sensor Network; Semantic Sensor Network; Internet of Things.

1   Introduction

The Internet of Things (IoT) is an Internet-like structure contains massive amount of addressable objects with their virtual information. Such target objects binding to the network have representation about them or useful data of surrounding environments associated with the object. Nowadays, the IoT has attracted significant attention in academia as well as industry. The main reasos is the network it creates is that all the objects around human are connected to the Internet and communicate with each other with minimum human intervention (Le-Phuoc 2009).

There are several definitions of the Internet of Things (IOT). A salient one of that is provided by the U.S. National Intelligence Council: "The "Internet of Things" is the general idea of things, especially everyday objects that are readable, recognizable, locatable, addressable, and controllable via the Internet - whether via RFID, wireless LAN, wide-area network, or other means."

In this context, it is not difficult to imagine transportation and logistics, healthcare and smart environment-based technology has become major research domain in relevant scenarios. What's more, other than current Internet of Things application researching topics, Smart Cities, Smart Car and mobility, Smart Home and Industries, public safety, energy and environmental protection, agriculture and Tourism (Peter Friess 2012)as part of a future IoT system, have become the most popular research directions in this field. Although various systems, applications and mechanism has been developed or applied in industry, it is still an early-age for the Internet of Things. Thus the combination and comprehensive application of emerging technologies is the catalyst to stimulate the development of the IoT.

Radio Frequency technology is a relatively mature key technology of the IoT as it simultaneously identifies and collects great numbers of target objects information. There are massive amount of RFID systems and applications adopted the concept of IoT and achieve phased success (Zhu, Mukhopadhyay and Kurata. 2012)in past decade. Meanwhile, the multiple sensor networks, as another one of the most essential component of the IoT, also attribute to construct an IoT system with different technologies and protocols.

With the concept of the IoT and its contained core technologies, it is particularly important to have an effective scheme of network infrastructure. This paper focuses on implementation of the IoT's network construction through essential technologies utilization. Moreover, it emphasizes the semantic sensor network, which is considered as a key method to improve heterogeneous problem with an independent section.

2 Infrastructure and criteria

The IoT's conceptualized goal is to create a whole network enable things to be connected anytime, anywhere, with anyone using any network. For any service in this world, objects around us know what we like, where we are, and what we need and accordingly without directly instructions (Dohr 2010). Thus an primary elaborate framework is the priority of a complete IoT network. However, there are still different prospective about a particular framework. Since there are still many uncertain views towards a definitive framework, there is a summarisation of the most important design aspects below about crucial framework-based researches with brief explanations.

Writing this list is intended to be parts of commentary criteria for the following networks infrastructure.

2.1 Protocol/Data heterogeneity management

Massive amount of heterogeneous devices will compose the whole Internet of Things. The IoT will be characterized with different ability of computing and communication between different data format. High dimensional data heterogeneity shall be supported by protocol level. In the IoT, devices in the network have different hardware and software capabilities. Frameworks should be developed applied to different versions, which can also run on different hardware and software configurations. (Miorandi, et al. 2012).

2.2 Architecture and composition

From data collection layer at the bottom to the application layer at the top, implementation of IoT should be based on an architecture consisting of functionality layers. The architecture should support automatic adaptation when the status of terminal changes (Ovidiu Vermesan 2013). Also, the layers or components in the system of IoT should be meaningful, and could be applied to various industries, enterprises and societies (Bandyopadhyay and Sen 2011).

2.3 Scalability

In IoT, a large scale network might connected to every possible identifier. Sensors or objects should abide by scalable principals, such as (i)"Things" management such as name and remove (ii)Communicating and interoperating. Assure the network working as new component added (iii) Data management (iv) Service provisioning and management. As massive number of services, it could be capable to handle heterogeneous data. (Miorandi, et al. 2012).

2.4 Self-organized capability

The IoT frameworks should be able to be interpreted by available data structure and data source (Perera, et al. 2014). Besides, the raw data should be automatically built an internal adaptable data models to provide the basic means for sharing and for performing coordinated tasks. Furthermore, raw

data should be retrieved and transformed into appropriate representation models correctly in order to minimize human intervention (Miorandi, et al. 2012).

2.5 Interoperability and semantic data management

Massive amounts of data generated from exchanging and sensing in the IoT. One of the most significant things for the IoT is heterogeneous data analysing and reasoning. It is important to build a standardized layer on the basis that semantic description of data format is adopted. A predefined language for semantic normalization will enable IoT system becoming more wide-scale with other sorts of sensors, tags or systems.

2.6 Energy efficient solutions

For majority of the IoT entities, energy spending optimization for the purpose of long distance information transition or ubiquitous computing is always a critical part. Additionally, a smart IoT house with multi-meters/sensors has a similar problem to minimize emission reduction (Markovica, et al. 2012). Therefore, a primary optimization of energy usage constraint should be taken into consideration. (Miorandi, et al. 2012)

2.7 Application programming interface

Application programming interface (API) should be accessed and used easily towards all the function. API can be used to improve scalability and extendibility with many management works towards applications. An API also simplifies the operation of relatively upcoming solutions. (Miorandi, et al. 2012)

2.8 Debugging mechanisms

It is crucial for a software development environment to have a debugging process. Debugging would be very difficult as the great number of possible environment composed by alternative node. Related work in this field is building debug mechanisms in the framework will help to achieve this challenge (Perera, et al. 2014).

2.9 Wireless communication support

The ubiquitous composition of smart objects required wireless technology as communication medium to exchange or collect data. These may raise issues in terms of spectrum availability, which is considered as a scarce natural resource.

2.10 Physical Location and Position

The relationship between the Internet and our nature is becoming more and more converged nowadays, beyond that, this association to the real world is very important to support searching or navigating support (ITU-T Technology Watch Report 2013). Moreover, the infrastructure should also support deriving information from geo-location based character (Ovidiu Vermesan 2013).

2.11 Monitoring and detect event:

One essential element of the IoT is events monitoring. Further response of the event will be launched after detecting an exception with data reasoning technology. This is how it helps users to make an actual physical decision easily and effectively. An IoT system with an autonomous monitoring/detect ability and mechanism is important and also a challenge in real time (Miorandi, et al. 2012).

2.12 Security and Privacy preserving mechanism

As industrial as well as personal information processes are concerned, a higher degree of security policy include such as: Resilience to attacks; Data authentication; Access control; Client privacy to protect the privacy of the owner of the tagged object (Weber 2010).

3 RFID Network

The initial vision of the Internet of Things was of a network where all "Things" are tagged and identified by RFID transponders (Gluhak 2011). While Radio-frequency identification is a wireless method use of radio frequency to transfer data, for the purpose of identification and tracking its tags attached to things. The tags usually contain electronic chip store information and response patterns. A battery powered tags may operate at hundreds of meters, which is superior to a bar code. Meanwhile, the other tags have no battery but collect energy from electromagnetic field, then act as a passive responder to emit microwave or ultra-high frequency radio waves. RFID systems can be classified by the type of tag and reader. Usually, a RFID system contains active readers and great amounts of passive RFID tags (Wikipedia).

RFID is an emerging technology that is becoming increasingly important to the IoT. Since RFID's character of tracking a massive amount of uniquely target objects, this technology is applied as a critical enabler of the IoT (Zhu, Mukhopadhyay and Kurata. 2012). In large-scale embedded sensor networks, the combination of ubiquitous computing and RFID technology is also related to the IoT.

3.1 An RFID-based IoT system

As the development of the Communication technology, RFID technology is become increasingly common in many areas. Thus discussion of all IoT applications seems unrealistic, let alone all potential applications. The following example is a typical system building with a single-source technology of the IoT.

3.1.1 RFID ecosystem

In (Welbourne 2009) , a real IoT system using RFID is built in a computer department building at the University of Washington. Researchers created a suite of user-level, web-based system which with RFID technologies and conducted a four-week user data to study the meaning of users' massive data and future utilization of their tools.

They built a RFID ecosystem which spans seven floors of 8000-square-meter department building. The ecosystems consists of 44 RFID readers, 161 antennas and thousands of RFID tags positioned everywhere in the building. 67 participants were recruited who work in the department building on a daily basis. Participants stick RFID tags as badges on their personal belongings to collect meaningful data. There is a special tag-object association kiosk in this system where users can create a relationship between RFID tags after they attached the tags on their personal objects.

The system has an event data generate scheme which record RFID raw data in a standard format (tag ID, antenna ID, time). Data is transmitted through a RFID reader, which runs a network protocol to synchronize their time. After that, all detected data will stream into a central server then stored in to a

server database. Software written by the authors assure that data transmit between reader and database has been applied various secure policies.

Figure 1 Tag Manager

3.1.2 Middleware software

Tag Manager is a tool attached to RFID kiosk to associate physical tags with an specific personal object. A new user can use this to register several belongings with tags. Another tool, Place Manager displays every RFID antenna's location with icons for the RFID ecosystem. Meanwhile, as one part of secure and privacy policies, user could create or edit a collecting antenna's location by clicking on corresponding icons. As another part of privacy policy, user may use Scenic tool to mange a specific activity with an object they would like to have. With RFID metadata binds things and antennas to locations, application or system middleware could generate new high-level data meaning information with LBS meaning and more directly information.

In addition, the RFID ecosystem also contains Data Browser, which lets users review or edit their behaviours with a table structure interface and an Access Control Interface which allows user to control the data authentication, e.g. to reserve or disclose their behaviour information to an specified person or group.
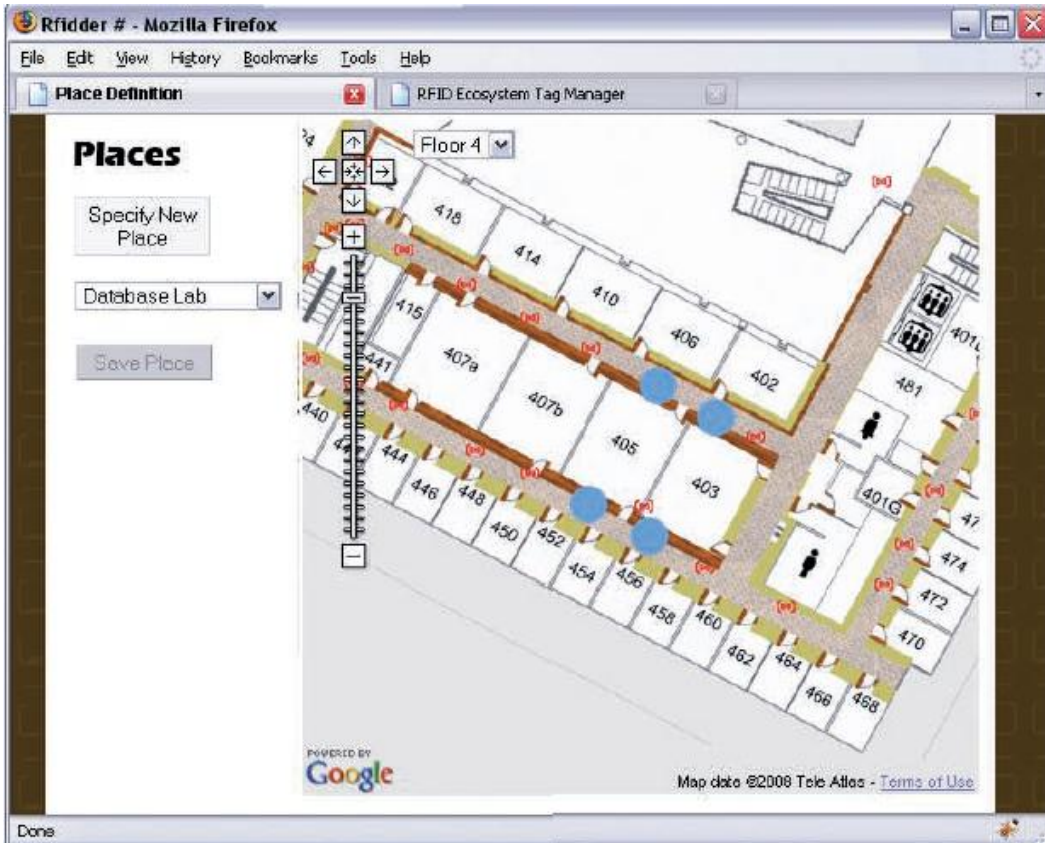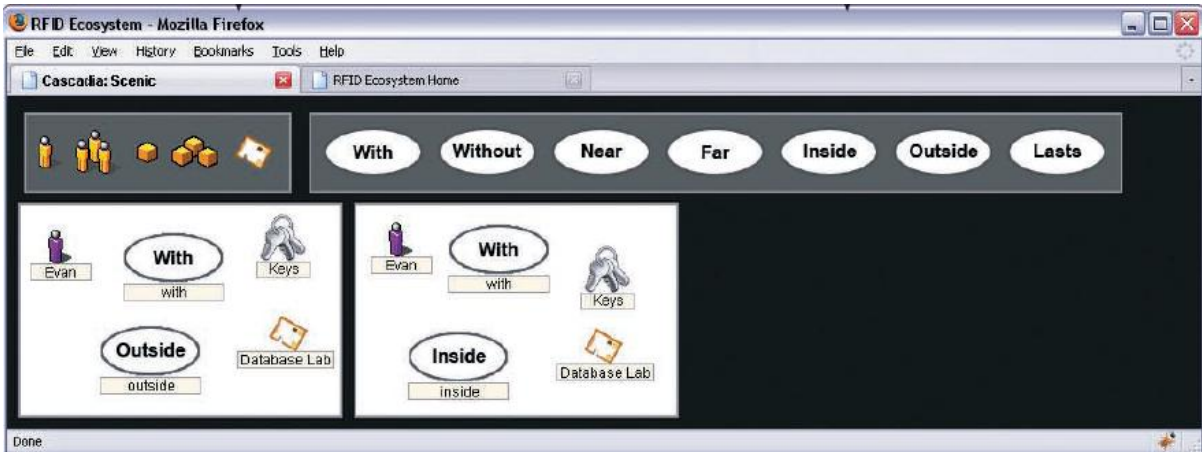
Figure 2 Rfidder

Figure 3 Scenic

3.1.3 Advantages and Disadvantages

Followed by our predefined basic criteria, we can have a primary evaluation of this typical IoT ecosystem with its features and characters. Structure is one of the most important parts in the Internet of Things. Since different solutions were developed with a narrow objective in the real world, an explicit architecture known from different solutions enable a fast and standard network. Although there is not an explicit statement of the whole structure for this ecosystem, we can find an idea of the infrastructure. In addition, characters of scalability and self-organized capability can be found in this paradigm. Moreover, this ecosystem applied a well-understood privacy user interface for participants to manage their personal data.

Since this is a prototype of the IoT system, no energy efficient solution or programming API has been put forward to discuss. However, the interoperability and data management along with the ability of monitoring and detect event is not in this deployment. As the paper said, all participants' behaviour meaning is programmed separately and manually on the basis of every individual's character. Massive interaction behaviours between arbitrary combination of human and objects form a complicated network which generates great amounts of data. A system without a pervasive data self-awareness or data mining mechanism will cost a large effort to manually classify each of the information. Moreover, lack of interoperability will have a huge impact on system's scalability and self organisation performance.

3.2 Future research about RFID system

In this case, three future research directions of RFID ecosystem are as follow:

Social Network orientation: A thorough design and integration of privacy policy, access control and real-time updates form three important elements of a social network application. Exist social network offers information stream and updates with activities, which is supported by a RFID-based IoT also. Using aforementioned Rifdder middleware to post a status like "Bob has working in the laboratory for 3 hours" or "Doctor Hofstadter is having a conversation with Reese now" is exactly the same as a social network's status sharing function.

Human behaviour study: Through a certain periodical record of historical event data, researchers may acquire the trends or characters of a special group of people or individuals. There is ample scope to deploy it in areas like security and health care. With more precise and specialized data, cognitive behaviour therapy will gain more theoretical support during the process supervision.

Additionally, a log of events record "whom the user has communicated with", "where the situation happens", "how long it last" will display a succinct review of user's daily schedule. This may help user on recalling important event during the day or help user to arrange efficient timetable as well as to build up improved habits.

Searching engine: This is the most straightforward application associate with the IoT ecosystem. Implementation of Web-based features enable user to dig up location information of a specific object. In general, this is uncommon for individual requirement but is a definitely necessary feature for logistics management dealing with bulk commodity transportation.

In summary, with the rapid development of Communication technology, RFID has been assigned to the forefront of the IoT. Substantial amount of its application have been studying in many experimental and industrial fields (Zhu, Mukhopadhyay and Kurata. 2012). The value of Information tracked by RFID tags can be utilized both in industrial production networks or social networks.

The future research directions toward RFID will be how to reduce large-scale system's cost; how to design application-oriented RFID systems rather than theoretical but unimplemented systems; and how to alleviate increasingly important privacy and security issues. Although there are many hardware, privacy policy constrains in this field, researchers believe RFID technology has a bright future (Zhu, Mukhopadhyay and Kurata. 2012).

4 Hybrid Sensing Network

Traditional ubiquitous system is constructed under a predefined experimental objective with a set of specific physical parameters (Xiong, et al. 2012). However, The Internet of Things not only refers to single information system, (sensor networks, RFID reader and tag devices) also encompassed by Hybrid positioning systems and other short-range wireless ad hoc networks based on M2M communication models (Cooper 2009). In practice, wireless systems for Human Machine communications such as pervasive indoor or outdoor positioning systems are provided by special network architecture, which is known as heterogeneous network (Niyato 2011)or Hybrid Sensing System (Xiang 2013).

4.1 Digital Zoo Hybrid Sensing Network

A straightforward Hybrid Sensing Network is proposed by (Karlsson 2010), which is a wireless sensor network system, emerged with Augmented Reality technology that enhances a user's empathy to a zoo. Their system is consisted of two main parts; an animal tracking system applied a Wireless Sensor Network (WSN) with cameras and RFID technology and a mobile Augmented Reality application that provides visualization about individual animals. The information provided by a mobile visualized application indicates the location of target animals with an overlook view from a camera. Through the Wireless Sensor Network the system tourist may find the location of each animal in the zoo. After that, user may use their mobile device like a searching map that points out different animals. Furthermore, extra information of a selected animal will be display on the application too when the system spot an animal.

The system consists of different types of sensor and RFID mechanism provides a relatively complete view of hybrid sensing network. Event monitoring and Location Based Service to some extent were reflected in this self organized system. Nevertheless, it is a conceptualized model without any elaborate statement of API implementation or semantic data management, which make this system barely satisfactory.

4.2 Indoor Navigation Hybrid Sensing Network

4.2.1 GPS Positioning

The most popular outdoor positioning system is Global Positioning System (GPS), a worldwide network receives signals from multiple satellites measure the distances with a great accuracy. Outdoor object longitude and latitude can be computed to an accurate rate with an error around five meters. Recently emerging High Sensitivity GPS technology can provide positioning in some indoor locations (tracking can be continued down to levels approaching −190 dBW (Wikipedia n.d.)) but not all indoor locations. The positioning accuracy will be attenuated when obstacle surpasses the thickness of 3 layers of brick wall or likely.

The typical accuracy of GPS is performing well but has about a five meters tolerance. Since five meters vertically in a building could mean a difference of 3 floors, the Indoor positioning technology research emerges at the right moment. Unlike GPS positioning, the Indoor positioning system is relies on nearby Access Point, which either actively locate tags or passively provide environmental context (time, angle, Received signal strength and so on) for devices to sense (Wikipedia, Indoor Positioning n.d.).

4.2.2   Indoor Positioning

Dating back to April 2013, Apple had acquired an indoor location start-up company WiFiSLAM, whose core technology is using a combination of Hybrid Sensor Network methods to get better indoor locations (Wikipedia, Indoor system n.d.) based on algorithm of Gaussian Process (Ferris 2007). In around 90 seconds, user should take a picture of a floor plan map, walk to a specific location to be logged then upload it to the server. This process uses any hotspot including hidden and password-protected hotspots that respond to requests. Data sets include RSSI (Radio Signal Strength identification) and data collected from accelerometers, gyroscopes and magnetometers. After simultaneous localization and mapping, it also applies pattern recognition together with studies of human psychological decision-making to predict the routes user would take through a building. Carrying an iPhone, everyone walk in an unfamiliar place would be charting at least a passive map of this location. This is a breakthrough for Apple to shorten the gap of Indoor Positioning technology comparing with other companies like Google. In spite of this, there are still two deficiencies of this application are: it is a 2D-based navi-system, which appeals to a basic floor plan data collection of each floor in every building. Meanwhile, update and maintenance of the database is also an obstacle for public-oriented implementation.

Google's Tango Project, which has newly unveiled a prototype smartphone fitted with 3D sensor, is a customized phone with hardware and software designed to simultaneously create a map of the environment it scans. This project aims to give mobile devices a human-scale understanding of space and motion (Google n.d.). Capturing the dimensions of an unfamiliar indoor environment, visually impaired could navigate with smart Google equipment unassisted. Moreover, data entry for this massive database would be contributed spontaneously from every user equipped with this customized 3D-sensor mobile phone. However, hypotheses for this product aren't been tested. Power consumption and accuracy of customized 3D sensor is still under an experimental phase.

The most straightforward application from 3D sensor technology should be an indoor navigation of a shopping mall. However, the service Indoor Positioning System provides shouldn't be simply a voice or text data query like vehicle navigation notification "Burberry is on the 5th floor, turn left and walk straight, 50 metres". Those systems would not fit users' requirement and objectives, or would fit special need only under indoor rescue circumstance.

Other than indoor navigation based technology, a promising Indoor Positioning Interactive System should include not only the data of floor plan, real-time video, data of a specific dealer, brand or product, but reasonable dealing record, social network, online purchase service embedded into the Indoor Positioning System.

4.3   Future of Hybrid Sensing Network

For the Indoor Positioning System, the future should be a revolution from the perspective of real scenario based on development of positioning technology. What service an application should support that will grant customers the best interaction experience? Undoubtedly, it will be an interactive system boosts massive incremental value derived from such systems, which provides mutual benefits to customers, sellers and the Indoor Positioning System platform provider.

To summarize, when compared with RFID technology, the Hybrid Sensing Network refers to a more inflexible and dynamic network. Relatively broad coverage of Hybrid Sensing Network enables it to be a network with more features towards various combinations of sensing and other technologies. The future of Hybrid Sensing Network should be human-centred smart-oriented network encompasses

everything in our life. The ultimate model of Hybrid Sensing Network will tend to be universal technologies applied in a real Smart City (ITU-i 2012).

5 Semantic Sensor Network

Actual estimates for how many devices will be connected by 2020 vary from around 30 billion (ABI Research report) to 50 billion (Cisco Systems CSCO (cisco 2011)). As the amount of device has proliferated in the network, heterogeneity from various approaches or hybrid wireless sensor network would radically challenge interoperability. The implementation of communication protocols and standard such as Bluetooth, DLNA, Zigbee to some extent diminish the operational challenges and improve the readability of raw data. However, as the approaches developer applied to different networks is becoming more complicated, the devices adopted in the identification layer do not carry an integrated set of network interface for interacting with as much nodes as possible. Therefore, Semantic technology is becoming a feasible and key method to solve high-level interoperability challenges within heterogeneous world of objects and systems (A. Katasonov 2008).

5.1 Background knowledge

The Open Geospatial Consortium (OGC), an international industry consortium consists of 474 companies, government agencies and universities to develop publicly available interface standards has developed a Sensor Web Enablement initiative as a criteria which enable an interoperable usage of wireless sensors. The objective of this programme is to enable developers use the specifications in creating, monitoring and accessing applications in a real-time awareness. Such standardized items are very useful as it enable programme developer use the high-level data abstractions from heterogeneous sensors rather than metadata. The candidate specifications include seven services which are all useful for various sensors source data processing. For instance, Sensor Observations Service, a Standard web service interface for requesting, filtering, and retrieving observations and sensor system information and Sensor Alert Service (SAS), a standard web service interface for publishing and subscribing to alerts from sensors (Sensor Web Enablement DWG n.d.).

Ontology is the centre of semantic technology, defined as a specification of a conceptualization, also is a mechanism for knowledge sharing and reuse (Aggarwal 2013). RDF and OWL, in this domain, are two important semantic network ontology representation formalisms.

In literally, RDF (Resource Description Framework) is a language to depict different objects or any concept in the world. It could be a subject, a predicate or anything else for instance. Moreover, for each resource it uniquely describes, there attached a correspondingly Unique Resource Identifier. Whereas OWL (Ontology Web Language) is another ontology formalism which has more functional representation than RDF has (Aggarwal 2013).

The World Wide Web Consortium launched the Semantic Sensor Networks Incubator Group (SSN-XL) to develop Semantic Sensor Network Ontologies for sensor description and observations. The SSN ontology, with a sensor-management perspective, has been divided into four directions: (i) Data discovery and linking, (ii) Device discovery and selection, (iii) Provenance and diagnosis, and (iv) Device operation, tasking and programming (Aggarwal 2013). In this context, SSN construction use ontology is on the basis of describing sensor networks developed in an OWL derivative language, namely OWL-DL. The SSN ontology is able to specify the capabilities of sensors, the measurement processes and the resultant observations (Vicente Hernández Díaz 2013). It can be aligned with other

ontology rules which are specialized in particular contexts or domains (e.g. DOLCE Ultra Lite upper ontology (W3C 2005)).
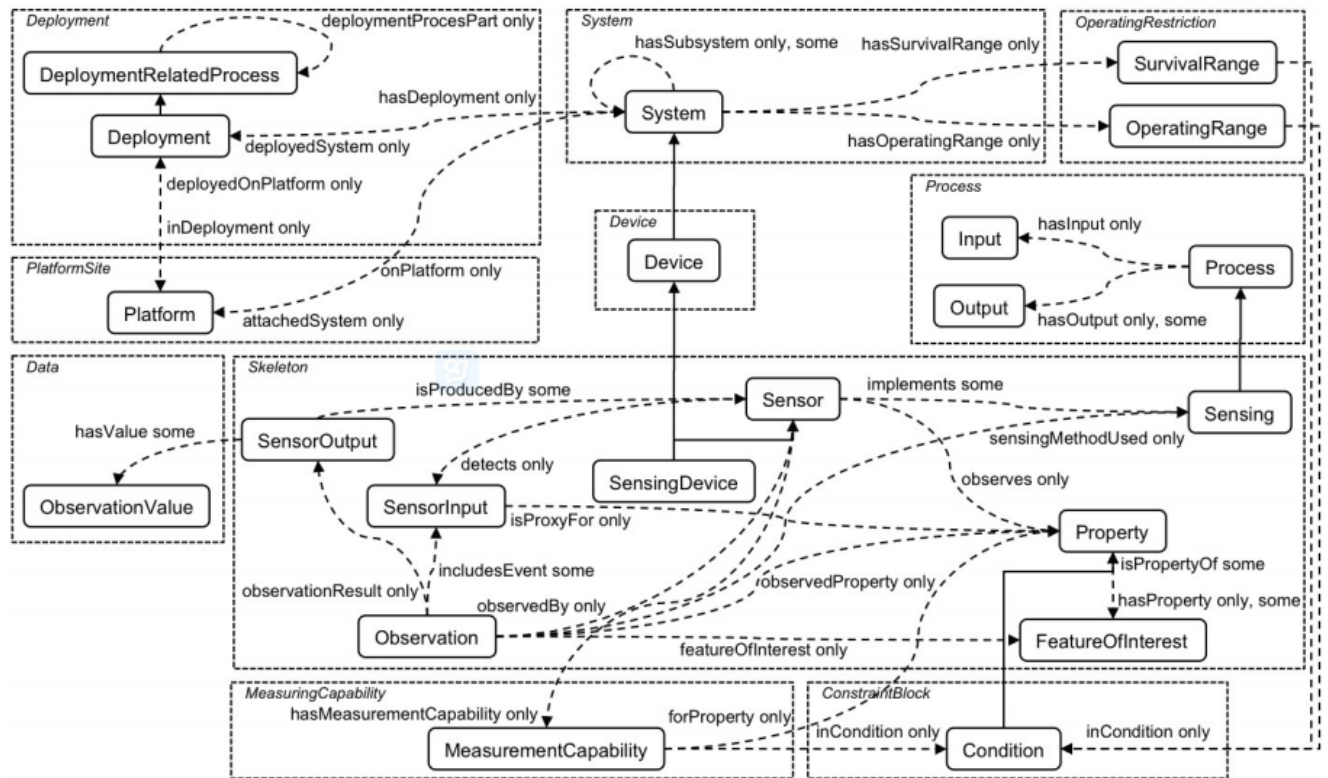

Figure 4 SSN ontology is built around a central Ontology Design Pattern
(The full ontology consists of 41 concepts and 39 object properties, directly inherited from 11 DUL concepts and 14 DUL object properties)

The semantic sensor network vision proposed the solutions from perspective of sensor management which arise mostly conceptual research topics with SSN framework. (Rajani Reddy Gorrepati 2013) and (Gaire 2013) proposed Service Oriented Architecture SSN enabling systems separately in terms of smart farm and bird ecological protection research. However, the common issue for agricultural and ecological systems is the limitation of scalability. Adoption of same system in another environment would cause a totally new construction and initialization work. In practical, these two SSN prototypes utilized a fraction of SSN ontology idea. To some extends, both system resolved data heterogeneous problem from the application layer but did not reserve any APIs. In spite of this, the advantages of these two SOA Semantic Sensor Networks are that they do have semantic analysis enable interoperability of the heterogeneous resources and have visualized middleware.

5.2 Current Works

As the IoT initiative (IoT-i), an EU Framework Programme 7 project indicted in its 2013 public work report: "Currently, there are several projects that, in a way or another, make use of semantic middleware architectures, or at least that are partially inspired by them (Vermesan 2013)."

Web of Objects is an ITEA2 project aims to establish a network and services infrastructure consist of smart objects simplifying the deployment of the applications independent of proprietary protocols.. WoO's expected results are semantic annotation tools, semantic service framework in modelling devices with a context-awareness approach and device-specific services.

Experiential Living Labs for the Internet of Things (ELLIOT), aims to develop a public platforms service of IoT and Ambient Intelligence by and for user to get involved in creating and exploring with ELLIOT Experiential Platform in an experience-gathering environment (Experiential Living Lab for the Internet Of Things 2012).

Enabling the Business-Based Internet of Things and Services (EBBITS) is a project researching for enterprise systems with a SOA-based protocols and middleware. The basic idea is to enable business architecture to semantically integrate the Internet of Things into mainstream end-to-end business applications (EBBITS-project 2013). The expected outcome is to effectively transform every subsystem or device into a web service with semantic resolution.

5.3 Future of SNN

W3C's Semantic Sensor Network ontology has shown success in describing common attributes from various resource networks by accommodating requirements from different stakeholders (Barnaghi 2012). However, the complexity of network strategies using detailed ontology hinders adoption of semantic models. Using semantics in the IoT is still in its beginning days. Interdisciplinary collaborations are the assurance to have classification, definition works and to integrate various frameworks with different resources, data and services. To increase interoperability among different mechanisms, ontology strategies could be merged to assure data applied in different domains that abide its source ontology could understand ontology (Vicente Hernández Díaz 2013). Thus, scalability and reusability of data structure in the Internet of Things systems will have a substantial improvement. The future prospect of using semantics in the IoT, ontology like DOLCE Ultra Lite upper ontology will stand out from the rest because its lightweight feature. Future work with SNN should be a complete, dynamic, scalable schema (Barnaghi 2012) provides unified solutions applied to various resource and distributed environment.

6   Conclusion

The IoT, consists of a great amount of uniquely addressable objects which may be RFID-based tags, web-based sensors, actuators, or other embedded devices. It collects and transmits data in a smart and self-organized way. Scalability of the Internet of Things makes its capacity expending gradually, along with various corresponding challenges of scale in terms of heterogeneity, privacy, security, context awareness, data management and analytics. The Internet of Things has a complicated data-centric process in terms of collection, processing, reasoning, storage, query and maintenance. The decisions made at the early processing framework may have a significantly impact on the later steps. Hence a well-organized infrastructure of the IoT is a crucial construction work.

There are massive research directions lied in different layers of the infrastructure. As the criteria stated in this paper, each items of the criteria is one of the existed research challenges. This paper discusses about three important networks of the IoT with emphasis on what is current work and what are the prospect as well as what are further research. Current research makes the IoT concept over-complicated, but through the continuous research such issues will be a powerful solved components for network research in both industrial and academic fields.

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