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# Proposed Concept for Ontology Communication between IOT Devices

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**Abstract:** ***Internet growth has become the challenge for the internet security. Our paper is divided into three sections. Section –I is introduction. Section – II is based on the concepts of IOT, Sensor, RFID and Ontology. In subsequent sections there is discussion about our proposed method in which, we have taken a concept of IOT devices and Smart controller communication. All IOT devices in network communicate to Smart controller device. Repository is a new concept with addition to this by which Smart controller take the responsibility for identifying new IOT devices based on communication done between Smart Controller and IOT devices. Communication is completed either if new device is confirmed or devices is already registered in repository and sending some semantical update. This will help to update on real time to all the connected devices.***

**Keywords:** Sensor, IOT, Onotology, OWL-DL, RFID.

## 1. Introduction

In past few years the growth of wireless industry and technology has also came with new challenges. Wireless technology is helping us both personally and professionally. Living in a technology, data-driven world fuels our need for a fast and reliable wireless connection whether we're at work, at home, or on-the-go.

As per the study done by CISCO [http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/VNI_Hyperconnectivity_WP.htmlAccessed 14June 2015] following are few challenging facts related to internet technologies.

1) Annual global IP traffic will pass the zettabyte (1000 exabytes) threshold by the end of 2016, and will reach 2 zettabytes per year by 2019.
2) Busy-hour Internet traffic is growing more rapidly than average Internet traffic. Busy-hour (or the busiest 60-minute period in a day) Internet traffic increased 37 percent in 2014, compared with 29 percent growth in average traffic. Busy-hour Internet traffic will reach 1.4 petabits per second (Pbps) in 2019, and average Internet traffic will reach 414 terabits per second (Tbps).
3) Metro traffic surpassed long-haul traffic in 2014, and will account for 66 percent of total IP traffic by 2019.
4) *Two-thirds of all IP traffic will originate with non-PC devices by 2019. In 2014, only 40 percent of total IP traffic originated with non-PC devices, but by 2019 the non-PC share of total IP traffic will grow to 67 percent. PC-originated traffic will grow at a CAGR of 9 percent, and TVs, tablets, smartphones, and machine-to-machine (M2M) modules will have traffic growth rates of 17 percent, 65 percent, 62 percent, and 71 percent respectively.*
5) *Traffic from wireless and mobile devices will exceed traffic from wired devices by 2016. By 2016, wired devices will account for 47 percent of IP traffic, and Wi-Fi and mobile devices will account for 53 percent of IP traffic. In 2014, wired devices accounted for the majority of IP traffic, at 54 percent.*

It is predicted that within the next decade billions of devices (Cisco predicts that the number of the Internet connected devices will be around 50 Billion by 2020 [1]) will generate large volumes of real world data for many applications and services in a variety of areas such as smart grids, smart homes, healthcare, automotive, transport, logistics and environmental monitoring [2]. The related technologies and solutions that enable integration of real world data and services into the current information networking technologies are often described under the umbrella term of the Internet of Things (IoT) [3].

## Section-II

## 2. Internet of Things (IoT)

As per the recorded version, the very first time the term Internet of Things (IoT) was used in to a presentation by MIT's Kevin Ashton in 1999.[4] In it, he famously stated that adding RFIDS to every-day objects would create an Internet of Things. Although now there are various other options is also there which are equally or better supporting wireless technology than RFID, like sensors, nanotechnology, mobile devices, and actuators. These all new technologies have given a new dimension to the things that they can communicate and process data to other compatible devices.

A report entitled "The Internet of Things Business Index: A quiet revolution gathers pace,"5 also found that 30% of business leaders feel that the IoT will unlock new revenue opportunities, while 29% believe it will inspire new working practices, and 23% believe it will eventually change the model of how they operate [*http://www.arm.com/files/pdf/EIU_Internet_Business_Index_WEB.PDF* Accessed 14June 2015].

Internet of Things enables to bridge the gap between virtual world and real world by providing and processing real world data for publishing and processing in web format, which can be further utilized for various other useful tasks. There are many examples how IOT can help us some of them are:

*According to us this can be broadly categorized into Personal base, industry based and government based. [5][6][7]*

**Personal based**: Based on sensor installed on different devices IOT can help as *Smart Utilization of Home appliances, auto temperature and humid management, electricity and water management, analyzing and identifying emergency and informing related management for assistance*. **Example** if sensor on human body can identify any kind of alarming situation which can lead the person into critical medical situation, then in this case sensor can send automatic data to emergency section of a hospital can medical help can be provided to person on time.

**Industry based**: IOT can help on each industry to improve day to day activity. **Example** smart sensor installed on each *automobile* can help the driver to understand upcoming potential risk, complete car health can be monitored on real time and communicated to driver for more updated information about the vehicle which will be safer. In *agriculture* smart sensors can help to get real time data about soil and remote pest can be identified which can help to take appropriate action well on time.

**Government based**: IOT can be useful for government perspective on various management. **Example** traffic management, disaster management, environmental conservation, security and other aspects as well.

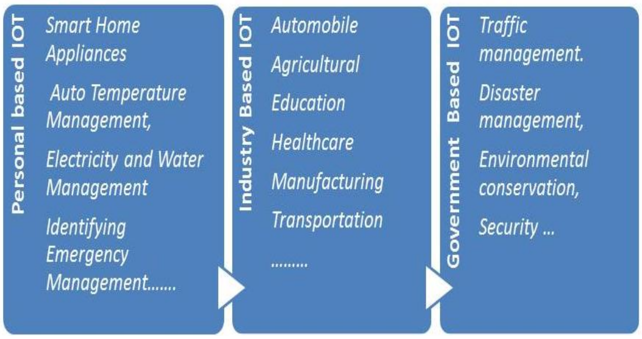


**Figure 1:** Three dimension of IOT Application

## 3. Challenges for IOT implementation

As predicted and estimated probable future IOT implementation and devices will be more around. Challenges for the adoption and implementation of IOT can be broadly categorized as follows [[1]http://www.forbes.com/sites/rakeshsharma/2013/11/12/five-challenges-for-the-the-internet-of-things-ecosystem/Accessed 14June 2015]

**Table 1:** Challenges for IOT

| | |
|---|---|
| **Lack of a Shared Infrastructure** | The Internet of Things is a complex interconnection of hardware, such as sensors and actuators, and software that works at the assembly level. Together, these constitute a platform for developers and companies. As of now only Apple (0.56%) and Google (0.68%) have Internet of things. There is a need for shared infrastructure which can help for smooth transmission of data. |
| **Lack of Common Standards** | There is a lack of open standards. The lack of open standards manifests itself at the Institutional level within the IoT space. Common standard and topology will help to communicate all devices. |
| **Battery Life** | Prolonged battery life that sources energy from unconventional power sources is a must for future development for the Internet of Things. |
| **Data Control** | From the user perspective, this is one of the more significant barriers to large-scale adoption of the technology. Data control is about who can access your data. And how to make this sure that only the authorized person can access this data. |
| **Data Sharing** | In the Internet of Things paradigm, data is utmost important. However, data provisioning builds off a social contract between large corporations and customers. Corporations provide a free or nominally-priced service in exchange for a consumer's personal data. This data is either sold to advertisers or used to develop further products or services useful to consumers. |

## 4. Semantical view for IOT

Internet world is full of heterogeneity; there is lot of diversity in hardware and software platform. To implement IOT there is a big need to identify how to achieve full interoperability at different levels. Many third party applications are developed without proper device information but due to generic in nature they can deploy IOT on devices, but this will not be possible to implement this automatically. But the gap between the device information and IOT application information can be bridged by semantic matchmaking. This means IOT applications/entities need to be continuously updated with their semantic properties. Issues related to interoperability, automation, and data analytics naturally lead to a semantic-oriented perspective towards IoT [8]. Applying semantic technologies to IoT promotes interoperability among IoT resources, information models, data providers and consumers and facilitates effective data access and integration, resource discovery, semantic reasoning, and knowledge extraction [9]. Some examples of semantic technology using IOT research are:

**Table 2:** Examples on Ontology for IOT Domain

| *Semantic Technology* | *Description* |
|---|---|
| SSN Ontology [10] | For annotating sensors and sensor networks |
| Linked data [11][12][13] | For sensor data publishing and discovery |
| Sem-SoS [14] | Semantic sensor observation services |
| IoT-A [15] | The project has identified entities, resources and IoT services as key concepts within the IoT domain. |

## 5. Ontology

Ontology refers to the interpretation of a group of ideas within a specific domain that defines the interrelationship between those ideas. Ontology can be used to study the existence of entities within a specific domain and sometimes can be used to identify the domain itself [16].The advantage of ontology is that it represents real world information in a manner that is machine process able. The reason ontologies are becoming popular is largely due to what they promise: a shared and common understanding of a domain that can be communicated between people and application systems [http://mecca.noc.uth.gr/ontologies_advantages.htm Accessed 14June 2015]. The W3C Incubator group on Semantic Sensor Networks has developed an ontology for describing sensors and sensor network resources that is SSN ontology [10], [17]. The ontology provides a high-level schema to describe sensor devices, their operation and management, observation and measurement data, and process related attributes of sensors. It has received consensus of the community and has been adopted in several projects [9].

In the work of Christophe et al in 2011 [18], authors present ongoing work towards an ontological framework for the representation and retrieval of connected smart objects in the Web of Things [19]. In the related work reported by Hachem et al, 2011 [20], authors state that have devised a global ontology for the IoT domain. The work emphasizes the representation of devices and also the composition and estimation of measurements.

## 6. OWL and OWL-DL Language

The OWL Web Ontology Language is an international standard for encoding and exchanging ontologies and is designed to support the Semantic Web. OWL is an ontology language for the Web. It became a World Wide Web Consortium (W3C) Recommendation in February 2004. As such, it was designed to be compatible with the eXtensible Markup Language (XML) as well as other W3C standards. [21]

OWL-DL is grounded on Description Logics, and focuses on common formal semantics and inference decidability. Description logics offer additional ontology constructs (such as conjunction, disjunction, and negation) besides class and relation.

The strong Set Theory background makes Description Logics suitable for capturing knowledge about a domain in which instances can be grouped into classes and relationships among classes are binary. OWL-DL uses all OWL ontology constructs with some restrictions.

**Section - III**

## 7. Proposed Model for IOT:

In our suggested model the concept of IOT communication can be divided into three verticals.

1. **Device identification:** This process will collect all the information about device, like device semantical property (vendor id, device type and manufacturing information) device mode of communication support (RFID, sensor, actuator etc.) and metadata about device.
2. **Communication identification:** Communication mode supported by device and various other semantical communication properties (network id, network type, communication mode, data supported, data capacity etc.) for smooth connection between devices and transferring ontological data.
3. **Smart device controller**: The device which will work as main operating center for the connecting devices or by which the person, organization, government will be directly in communication. This smart device controller either will be connected with the main repository for the collection of live real data or in some case this device itself can also work like repository (means repository connection is not required). This will have the semantical property (network id, data flow capacity, repository connection id, device authorization, connected all device listing etc.)

Apart from these three verticals REPOSITORY is also very important role to play in this, which will be connected to all the IOT devices along with the Smart device controller. Repository will be in connection with all devices and periodically updates semantic updates with ontological updates.

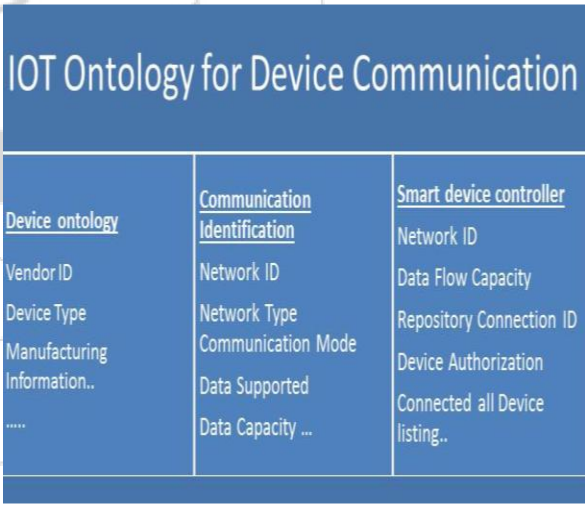


**Figure 2:** Suggested Model for IOT Communication

## 8. Ontology Creation

In order to show how the ontology will enables the property on different IOT devices for determining its real time state we have taken the help of OWL-DL ontology to describe its top-level hierarchy. The OWL ontology language is based on a family of description logics languages. In particular, OWL-DL is a syntactic variant of the SHOIN (D) description logic [22].

Based on shown properties in Figure 2, following ontology properties can be created:

**For Device Class**

```
<owl:Classrdf:ID="DEVICE">
</owl:Class>

<owl:ObjectPropertyrdf:ID="hasVednorID">
<rdfs:domainrdf:resource="# DEVICE "/>
<rdfs:rangerdf:resource="# VednorID "/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasDeviceType">
<rdfs:domainrdf:resource="# DEVICE "/>
<rdfs:rangerdf:resource="# DeviceType"/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasManufacturingInfo">
<rdfs:domainrdf:resource="# DEVICE "/>
<rdfs:rangerdf:resource="# ManufacturingInfo"/>
</owl:ObjectProperty>
```

In same pattern all attribute of Device class can be defined like.

**For Communication Identification (COMM) class**

```
<owl:Classrdf:ID="COMM">
</owl:Class>

<owl:ObjectPropertyrdf:ID="hasNetworkID">
<rdfs:domainrdf:resource="#COMM"/>
<rdfs:rangerdf:resource="#Network ID "/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasNetworkType">
<rdfs:domainrdf:resource="#COMM"/>
<rdfs:rangerdf:resource="#NetworkType"/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasCommunicationMode">
<rdfs:domainrdf:resource="#COMM"/>
<rdfs:rangerdf:resource="#CommunicationMode"/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasDataSupported">
<rdfs:domainrdf:resource="#COMM"/>
<rdfs:rangerdf:resource="#DataSupported"/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasDataCapacity">
<rdfs:domainrdf:resource="#COMM"/>
<rdfs:rangerdf:resource="#DataCapacity"/>
</owl:ObjectProperty>
```

**For Smart Device Controller (SmartControl) class**

```
<owl:Classrdf:ID=" SmartControl ">
</owl:Class>

<owl:ObjectPropertyrdf:ID="hasNetworkID">
<rdfs:domainrdf:resource="# SmartControl"/>
<rdfs:rangerdf:resource="#NetworkID"/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasDataFlow">
<rdfs:domainrdf:resource="# SmartControl"/>
<rdfs:rangerdf:resource="#DataFlow"/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasRepository">
<rdfs:domainrdf:resource="# SmartControl"/>
<rdfs:rangerdf:resource="# Repository "/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasConnectionID ">
<rdfs:domainrdf:resource="# SmartControl"/>
<rdfs:rangerdf:resource="#ConnectionID "/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasDeviceAuthorization">
<rdfs:domainrdf:resource="# SmartControl"/>
<rdfs:rangerdf:resource="# DeviceAuthorization"/>
</owl:ObjectProperty>

<owl:ObjectPropertyrdf:ID="hasDeviceListing">
<rdfs:domainrdf:resource="# SmartControl"/>
<rdfs:rangerdf:resource="# DeviceListing"/>
</owl:ObjectProperty>
```

Similarly other classes and their properties can be defined and the properties which are detected in later phases for the communication can be also be identified and sent in ontological format periodically to repository for update. From repository all other devices along with smart controller is also connected and updated on real time.

## 9. Conclusion and Future Scope

There are still a number of challenges are need to be addressed for the full implementation of IOT technology. In this paper we have proposed concept along with the repository along with the Device information, communication, and Smart Controller. Synchronization of IOT devices is needed and can be achieved with implementation of ontology.

Ontologies are light weighted which helps in communication. Future scope for the proposed concept is very high for further implementation and research.

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