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.

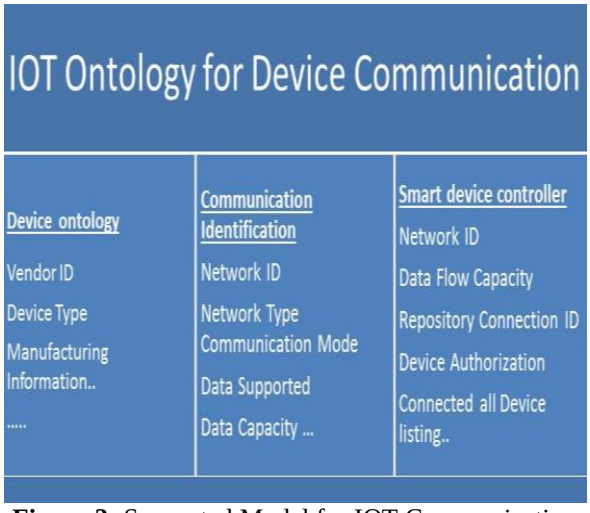

Figure 2: Suggested Model for IOT Communication

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:

Licensed Under Creative Commons Attribution CC BY

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.

References

[1] D. Evans, “The internet of things: How the next evolution of the internet is changing everything,” 2011.
[2] R. v. Kranenburg, E. Anzelmo, A. Bassi, D. Caprio, S. Dodson, and M. Ratto, “The internet of things,” Draft paper Prepared for the 1st Berlin Symposium on Internet and Society, Berlin, Germany (October2011), 2008.
[3] L. Atzori, A. Iera, and G. Morabito, “The Internet of Things: A survey,” Computer Networks, vol. 54, pp. 2787–2805, Oct. 2010.
[4] Kevin Ashton, RFID Journal, 22 June 2009: I could be wrong, but I'm fairly sure the phrase `Internet of Things' started life as the title of a presentation I made at Procter & Gamble (P&G) in 1999"

Licensed Under Creative Commons Attribution CC BY

[5] European Commission, Directorate-General for the Information Society and Media, "Vision and challenges for realizing the Internet of things," 2010.
[6] IEEE Communications Magazine, special issue on "Recent progress in machine-to-machine communications," April 2011
[7] IEEE Wireless Communications, special issue on "The Internet of things," December 2010.
[8] L. Atzori, A. Iera, and G. Morabito, "The Internet of Things: A survey," Computer Networks, vol. 54, pp. 2787–2805, 2010.
[9] P. Barnaghi, W. Wang, C. Henson, and K. Taylor, "Semantics for the Internet of Things: early progress and back to the future," International Journal on Semantic Web and Information Systems, special issue on sensor networks, Internet of Things and smart devices, vol. 8, pp. 1–21, 2012.
[10] M. Compton, P. Barnaghi, L. Bermudez, R. G. Castro,O. Corcho, S. Cox, J. Graybeal, M. Hauswirth, C. Henson,A. Herzog, V. Huang, and K. Janowicz, "The SSN Ontology of the Semantic Sensor Networks Incubator Group," Journal of Web Semantics, 2011.
[11] C. Bizer, T. Heath, and T. Berners-Lee, "Linked Data – The Story So Far," International Journal on Semantic Web and Information Systems, vol. 5, no. 3, pp. 1–22, 2009.
[12] P. Barnaghi, M. Presser, and K. Moessner, "Publishing Linked Sensor Data," in Proceedings of the 3rd International Workshop on Semantic Sensor Networks (SSN), Organised in conjunction with the International Semantic Web Conference (ISWC) 2010, 2010.
[13] J. Pschorr, C. Henson, H. Patni, and A. Sheth, "Sensor discovery on linked data," in Proceedings of the 7th Extended Semantic Web Conference, ESWC2010, 2010.
[14] C. A. Henson, J. K. Pschorr, A. P. Sheth, and K. Thirunarayan, "SemSOS: Semantic Sensor Observation Service," in Proceedings of the 2009 International Symposium on Collaborative Technologies and Systems (CTS 2009), Baltimore, MD, May 2009.
[15] C. M. et al, "IoT-A project Deliverable D1.4 – Converged architectural reference model for the IoT v2.0," 2012.
[16] Computer Ontology, http://www.techopedia.com /definition /591/computer-ontology
[17] L. Lefort, et al., "Semantic Sensor Network XG Final Report," W3C Incubator Group Report", 2011.
[18] P. Barnaghi, W. Wang, C. Henson, and K. Taylor, "Semantics for the Internet of Things: early progress and back to the future," International Journal on Semantic Web and Information Systems, special issue on sensor networks, Internet of Things and smart devices, vol. 8, pp. 1–21, 2012.
[19] M. Compton, P. Barnaghi, L. Bermudez, R. G. Castro, O. Corcho, S. Cox, J. Graybeal, M. Hauswirth, C. Henson, A. Herzog, V. Huang, and K. Janowicz, "The SSN Ontology of the Semantic Sensor Networks Incubator Group," Journal of Web Semantics, 2011.
[20] O. Specification, "OpenGIS Sensor Model Language (SensorML) Implementation Specification," 2007.
[21] Chapter 2, "AN INTRODUCTION TO THE OWL WEB ONTOLOGY LANGUAGE", Jeff Heflin.
[22] Victor Raskin, Christian F. Hempelmann, Katrina E. Triezenberg, and Sergei Nirenburg. Ontology in information security: A useful theoretical foundation and methodological tool. In Proceedings of NSPW-2001, pages 53 – 59. ACM, ACM, September 2001.

Author Profile

Dr. Deo Brat Ojha, Ph.D from Institute of Technology, Banaras Hindu University, Varanasi (U.P.), INDIA. His research field is Optimization Techniques, Functional Analysis & Cryptography. He is Professor at Mewar University Chittorgarh Rajasthan INDIA. He is the author/co-author of more than 250 publications in International/National journals and conferences.

Mr. Vinod Kumar Shukla received the degree of MCA from U.P. Technical University in 2004, has total experience of nine years in teaching and training. He is currently pursuing PhD from Mewar University, Rajasthan, India in the area of Semantic web and Ontology

Licensed Under Creative Commons Attribution CC BY