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Survey on Tools & Technologies used in Semantic Web and Internet of Things (IoT)

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Abstract

Today, We are living in IT era and an ever growing interest in Internet of Things (IoT) with Web technologies are unleashing a true potential of designing a broad range of high-quality consumer applications. These all are used in smart home, smart cities, smart buildings, smart agriculture, smart business and smart health also which are currently benefiting and will continue to benefit from IoT and Web technologies in a foreseeable future. Similarly, semantic technologies have proven their activeness in various domains and a few among multiple general challenges which semantic Web technologies are addressing are to (i) Improve machine interpretation, (ii) Resolve heterogeneity for various devices, (ii) Provide self description of data and Integration, (iii) Help to extract new knowledge and (iv) interoperability for representation, management and storage of data.

In this paper, our focus will be on the combination of Semantic Web and IoT technologies for house hold devices and we will present to our audience that how a merger of these technologies is leading towards an evolution from IoT to Semantic Web of Things (SWoT). Also introduce the basics of Internet of Things, Semantic, Semantic Web, Existing tools and technology, Comparison of existing tools and semantic technology in IoT devices to demonstrate how semantic web technologies become robust for House hold IoT devices and what are the reasons that suggest we should implement semantic web for IoT devices.

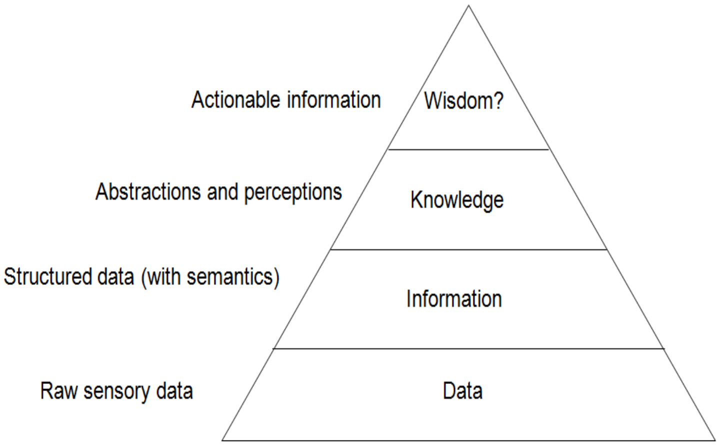
Keywords
Internet of Things (IoT); Semantic Web of Things (SWoT); Interoperability; Self Description of Data and Interpretation; XML; JSON; RDF; SSN; SPARQL.

Introduction

What if all the devices in your life could connect to the Internet? Here computers, cell phones, speakers, clocks, lights, cameras, door bells, water heaters and many home appliances. What if those devices could all communication, sends you information, and takes your commands? It's not science fiction; it's the Internet of Things (IoT), and it's a key components of home automation and smart homes [2], that's why we should know which types of data and how data are used in IoT[3].

- Data in IoT is collected by sensory devices or Actuator and also crowd sensing sources.
- It is time and location dependent.
- It can be noisy and the quality can vary in different difference situation.
- It may be random or continuous in streaming.
- Here we need manage device/network management issues.
- Here raw data is both an oxymoron and bad data for interpretation and self description.
- Multi modality, heterogeneity and volumes are key issues.
- We need interoperable and machine-interpretable solutions.

That's why we should convert data to actionable information like below Figure 1:



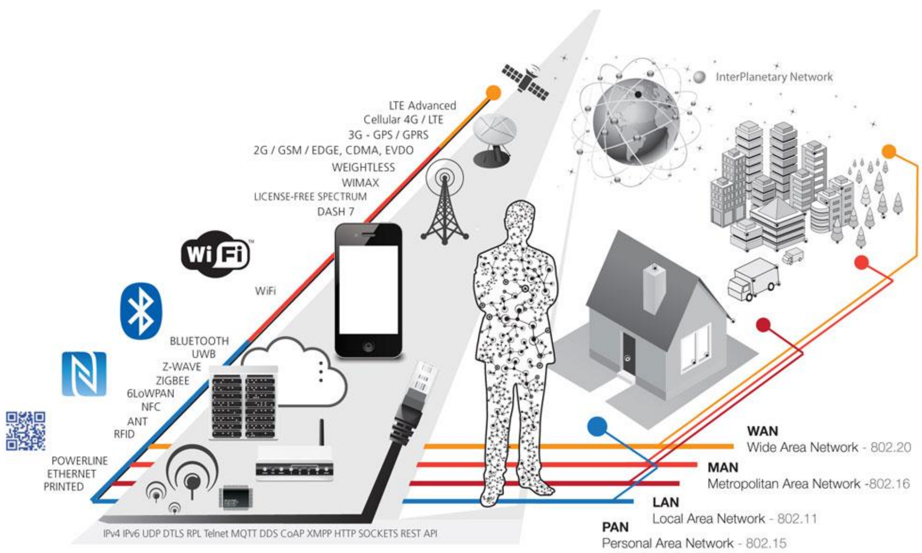
"Figure 1 - Knowledge Hierarchy in the context of IoT"

Semantic give more freedom to produced information for the IoT nodes. As pointed out by Berners-Lee et al. in their landmark article about the Semantic Web, "developments will usher in significant new functionality as machines become much better able to process and understand the data" [4], To do this we must select semantic technology that helps to provide below features of data in IoT devices:

- Make data with semantic annotations to improve machine learning.
- Improve quality of information.
- Handle unstructured data also.
- Provide standard Interpretable formats for multi model data.
- Links and interconnections in between resources.
- Identify background knowledge, domain information of resources.
- Apply hypotheses, expert knowledge for IoT devices.

Existing Tools and Technologies

In IoT lots of heterogeneous tools and technology are used to make thing as internet of things – Bluetooth Low Energy(BLE), Light Fidelity(Li-Fi), Near Field Communication(NFC), QR and Barcodes, Radio-frequency identification (RFID), IPv6, ZigBee etc., but in this paper we will focus on some technology which is related and comparable with semantic technology, that are Extensible Markup Language (XML), Javascript Object Notation (JSON), Resource Description Framework (RDF), Semantic Sensor Network(SSN) Ontology, SPARQL(Simple Protocol and RDF (Resource Description Framework) Query Language) that we can see below IoT technologies in Figure 2[5].



"Figure 2 - Internet of Things Technologies"

Here, we can see an overview of some technologies that are frequently used in IoT devices [5]:

Bluetooth Low Energy (BLE): Specification providing a low power variant to classic Bluetooth with a comparable communication range and disadvantages, including slow data speeds, poor data security and shortened battery life.

Light Fidelity (Li-Fi): Wireless communication technology similar to the Wi-Fi standard, but using visible light for communication and other issues are power consumption.

Near Field Communication (NFC): it is a short-range wireless connectivity standard for using magnetic field induction to enable communication in between devices within a 4 cm range only.

QR and Barcodes: Machine-readable optical tags that store information about the item to which they are attached.

Radio-frequency identification (RFID): Technology using electromagnetic fields to read data stored in tags embedded in other items.

IPv6: It means Internet Protocol version 6 (IPv6) is the most powerful and recent version of the Internet Protocol (IP), the communications protocol for an identification and location system for computers on networks.

ZigBee: Communication protocols for personal area networking based on the IEEE 802.15.4 standard, providing low power consumption, low data rate, low cost, and high throughput.

GSM (Global System for Mobile communications): It means an open and digital cellular technology used for transmitting mobile voice and data services over Internet.

XML (Extensible Markup Language): XML is a software- and hardware-independent tool for storing and exchanging data, XML are self-descriptive in terms of sender and receiver information, a heading and body of message.

JSON (JavaScript Object Notation): It is syntax for storing and exchanging data in the form of text and JavaScript object notation, When exchanging data between a browser and a server, the data can only be text, we can convert any JavaScript object into JSON, and send JSON to the server and We can also convert any JSON received from the server into JavaScript objects.

RDF (Resource Description Framework): it is a framework for describing resources on the web, it is written in XML, it uses Web identifiers (URIs) to identify resources and The RDF language is a part of the W3C's Semantic Web Activity. W3C's "Semantic Web Vision" is a future where: (i) Web information has exact meaning, (ii) Web information can be understood and processed by computers and machines, (iii) Computers and machine can integrate information from the web.

Semantic Sensor Network Ontology: means that most powerful ontology for describing sensors and its observations, studied features of interest, involved procedures, the observed properties and as actuators.

SPARQL: It is a Protocol and RDF Query Language that is used with semantic query language for databases that able to retrieve and manipulate data stored in Resource Description Framework (RDF) format.

Comparison with Different Tools and Technologies

One of the main challenges of IoT data formats is mapping between data formats and models used for constrained devices and data formats and models used in the Semantic Web, like Extensible Markup Language (XML), Javascript Object Notation (JSON), Resource Description Framework (RDF), Semantic Sensor Network(SSN) Ontology, SPARQL(

Simple Protocol and RDF (Resource Description Framework) Query Language) that below define in Figure 2[5].

In this paragraph, we outline the behaviour of different tools and technologies with and without semantic, we present the adopted technologies and we compare their basic characteristics. Throughout this comparison, we come to know three distinct levels are following: [6]

(a) The data level.
(b) The schema level.
(c) The query level.

Table 1 provides an overview of the current W3C standards adopted in each level in the XML and Semantic web world. In addition Table 1 outlines the history of the XML and SW technologies proposed by W3C.

Level	Without Semantic Web	With Semantic Web
Data	XML	RDF
Schema	XML Schema	RDF Schema – OWL (SSN)
Query	XQuery – Xpath	SPARQL

"Table 1 - Overview of the W3C Standards for With and Without Semantic Technology"

At the data level, the Extensible Markup Language (XML) [6] is used to the data representation language in the XML world, while the Resource Description Framework (RDF) [6] is used to represent the SW data.

At the schema level, the XML Schema [6] is used to describe the structure of the XML data. Currently, the XML Schema 1.0 is a W3C recommendation and the XML Schema 1.1 is under development, Regarding the SW, the RDF Schema (RDFS) [6] and the Web Ontology Language (OWL)[7] are used to describe the structure and the semantics of the RDF data. Recently, a new version of OWL, OWL 2.0 [8] has become a W3C recommendation and popular.

Finally, at the query level, the XML Path Language (XPath) [9] and the XML Query Language (XQuery) [10] are used for querying XML data. In the SW world, the SPARQL Protocol and RDF Query Language (SPARQL) [11] is the standard query language for RDF data. Currently, the W3C SPARQL working group [10] is working on the extension of the SPARQL query language in several aspects, resulting in SPARQL 1.1. and they added some components like the SPARQL 1.1 Query, Update, Protocol, Service Description, Property Paths, Entailment Regimes.

Challenges To Implement Semantic Web in IOT

An IoT is environments where lots of devices can communication with each other smoothly and smartly, so we need to care about contents with meaning and exchange of contents for those devices, but some challenges are presents for semantic web in IoT that are following defined [12]:

1. **Integration challenges** of IoT devices for different hardware vendors because many physical objects are heterogeneous in terms of their hardware resources for information such as storage, processing and interpretation.
2. **Annotation challenges** to linking of relevant data sources, integration and reusability of data and also enables interactions between sensor/actuators and IoT services.
3. **Management challenge** is used to creation and management of virtual sensors and actuators based on the composition also fusion of streams stemming from multiple data sources.
4. **Discovery challenge** for discovering and selecting sensor/actuators and data sources related to application requests within network environment.
5. **Analysis and Reasoning Challenge** to find out data analysis and reasoning tools for data interpretation.
6. **Visualisation challenge** for utilization of resources that are storage, computing cycle, sensor utilisation and many more across the multiple users.

Conclusion

At its best, research and development on IoT can produce a dynamic and universal network where billions of identifiable things can communicate with each other without any hesitation and we should keep in mind that things must become context-aware, configure themselves, exchange information, and show intelligent behaviour when exposed to a new environment and unforeseen circumstances. Here Adding semantics to IoT is one step in reaching this vision, In general, we can say that semantic technologies are used to improve machine-interpretation, sharing and integrating information, and inferring new knowledge also helps to creating machine-interpretability and self-descriptive of data.

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