Towards the Interoperability Enhancement of Semantic Web of Things

A Thesis Submitted to the Faculty of Computers and Information, Fayoum University in Partial Fulfillment of the Requirements for M.Sc. Degree in Information Systems

Submitted By:

Nedaa Hussein Ahmed Hussein
Information Systems Department,
Faculty of Computers and Information,
Fayoum University

Supervised By:

Prof. Dr\ Rania Abul Seoud
Electronics and Communication Department,
Faculty of Engineering,
Fayoum University

Prof. Dr\ Haytham Al-Feel
Information Systems Department,
Faculty of Computers and Information,
Fayoum University

Dr\ Ahmed Sadek
Computer Science Department,
Faculty of Computers and Information,
Fayoum University

Fayoum University

2022

Summary

Study Title: Towards the Interoperability Enhancement of Semantic Web of Things

Study Problem: Interoperability can occur in different layers of IoT systems. Here, in this thesis, we are interested in messaging protocol and syntactic levels.

The devices in IoT networks use different application layer protocols such as HTTP, CoAP, and MQTT protocols. Each protocol has its characteristics and messaging formats.

In syntactic interoperability, we need to convert among different data formats. Here, we convert between XML, JSON, and CSV formats.

Study Aims: This study aims to solve interoperability in two phases; where the first one is to obtain interoperability at the application protocol level. The translator can deal with three different IoT application protocols. These protocols are HTTP, MQTT, and CoAP.

The second phase depends on using semantic web technology to achieve syntactic interoperability. Currently, the supported data formats are XML, JSON, and CSV.

As the translator depends on the hub and spoke model, we can add additional protocols and data formats in the translator at any time.

Study Importance: IoT is a constantly growing network of devices embedded with actuators and sensors. They connected through wired and wireless technologies to communicate and share information. Interoperability is the ability of two or more systems, devices, platforms, or networks to collaborate to achieve a common goal. However, the current IoT systems are fragmented into silos according to the protocols, communication technologies, and data formats. This variety makes it difficult for systems and devices to communicate and share their data in the IoT network. So, the benefit of the IoT network is bounded by the lack of interoperability. In addition, the end to end interoperability should be considered to guarantee that all services reach all customers regardless of the technologies used.

Study Terms: Internet of Things, Interoperability, Multiprotocol translation, Message payload translation, SSN ontology

Study Hypotheses: A transparent translator to solve interoperability issues in two layers of an IoT system is proposed. The communication protocol layer is the first layer. In this layer, it is necessary to overcome the difference between the interaction patterns, such as request/response and publish/subscribe. The second layer includes the syntactic layer, which refers to data encoding. This type of interoperability is achieved through the semantic sensor network (SSN) ontology.

Study Method: The proposed architecture consists of three parts: the clients, translator, and servers. The clients are service consumers who send different requests to different servers. They can also receive data in any format they need, even if these data are stored in a different format on the server. The proposed translator is used to allow a client using a specific protocol to communicate with a server using a different protocol. It consists of a hub and multiple spokes. As this translator can translate among three different protocols, it has six spokes. At each operation, only two spokes are used according to the request. The hub is a conceptual representation and is represented using an intermediate format and SSN ontology. The intermediate format is used to convert one protocol to another. On the other hand, the SSN ontology is used only to achieve syntactic interoperability and is converted into different data formats.

Study Sample and Tools: The architecture was implemented using the JAVA language, and the spokes were implemented using the Java libraries.

The translator was run on a laptop with an Intel Core i5-2520M processor running Windows 8 at 2.50 GHz and 4.00 GB RAM. We measured the delay introduced by the translator in addition to the delay caused by using the SSN ontology. The tests were performed 1000 times per scenario.

Study Result: To validate the efficiency of the suggested translator, we compared the delay caused by the proposed translator with that caused by the Arrowhead translator. The Arrowhead translator was run on hardware that was different from that which we used. For this reason, we could not directly compare our translator with the Arrowhead translator. In the case of the Arrowhead translator, the authors measured and

evaluated the delay introduced in comparison with the Californium proxy. They ran the Californium proxy on the same hardware they used for running their proposed translator. We followed the same procedure to evaluate the proposed translator in comparison with the Arrowhead translator. The Arrowhead translator's delay is about 43.5% of that of the Californium proxy when implemented on the same platform, whereas the suggested translator's delay is only about 23.6% of that of the Californium proxy on the same platform. In addition, the proposed translator can map between different data encoding standards, a capability that is not available in the Arrowhead translator.