Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 191 (2021) 511–517

Procedia Computer Science

www.elsevier.com/locate/procedia

International Workshop on Edge IA-IoT for Smart Agriculture (SA2IOT)
August 9-12, 2021, Leuven, Belgium

Internet of Things: a new Interoperable IoT Platform. Application to a Smart Building

Rachida Ait Abdelouahid[a,*], Olivier Debauche[b], Abdelaziz Marzak[a]

[a] *Hassan II University of Casablanca-Faculty of Sciences Ben M'sik , LTIM, Laboratory , Cdt Driss El Harti, BP 7955 Sidi Othman Casablanca, Morocco*

[b] *Faculty of Engineering - ILIA / Infortech University of Mons Mons, Belgium, Place du Parc 20, Mons 7000, Belgium*

Abstract

According to statistics provided by Cisco, the Internet of Things market will grow rapidly and will reach 50 billion devices connected to the Internet by 2020. All these connected devices, in smart Home/Building should make life easier, sweeter and more enjoyable. Ideally, each device must work immediately and not require people to try to make them work. However, connected things come from different manufacturers using different protocols of communication. The diversity of protocols and sometimes their incompatibilities stay a major issue. Although, efforts have been made in recent years to improve the compatibility of the protocols, but these interactions remain limited. One solution to address this issue is to use an Internet of Things (IoT) platform to facilitate their interaction, control them intelligently using a web interface or a voice assistant. In this paper, we define connectivity requirements to improve interoperability between devices that make up the Internet of Things (IoT). An implementation of a Web application and virtual assistance that ensures interoperability regardless of form factor, operating system, service provider or transport technology, creating a" network of everything".

Keywords: Internet of Things (IoT); interoperability; protocol compatibility; IoT platforms; IoT Architecture; Model Driven Architecture

1. Introduction

Following strong market growth of the IoT market and according to statistics provided by Cisco, 50 billion devices will be connected to the Internet by 2020 [11]. With the rapid grow of connected thing number, new problems have arisen such as network congestion, data storage, processing capacities, etc. Moreover, connected things come from different manufacturers which implement protocols of communications, sometimes proprietary and generally incompatible with each other. Ideally, connected objects should make life at home easier, sweeter, and more enjoyable

* Corresponding author. Tel.: +212-6-3824-2829 ; fax: +32-71-140-095
E-mail address: rachida.aitbks@gmail.com

1877-0509
10.1016/j.procs.2021.07.066

by task automation and automatic decision making. The devices must work immediately and not require people to configure and try to make them work. Our goal will be to define connectivity requirements to improve interoperability between devices that make up the Internet of Things (IoT). Multiple related research in the literature have tried to solve the problem of interoperability between connected things. Different approaches have been proposed to fix interoperability issue such as middleware, IoT platform and more recently efforts of manufacturer to implement several protocols supports on nodes, and adaptation of protocols to improve compatibility of protocols [9]. For example, [12] have proposed an approach based on hash tables distributed systems and the VCP protocol (Virtual Cord Protocol), [5], proposed and deployed a complete mobile gateway software architecture to support IoT interoperability via an application centered on the smartphone [6], proposed a new design architecture which is mainly based on protocols distributed by hash table to provide the required flexibility, [10] have proposed a semantic web-based IoT architecture to ensure interoperability between systems, using communication and data standards established using SGS (semantic gateway as a service), Among these solutions, platforms of connectivity makes possible to support of multiple protocols of communications and ensure the connectivity between the objects from different manufacturers. In our case study we will be use of the open-source platform OpenHAB.

An IoT interoperability platform implement a Web application and a virtual assistance that ensures interoperability regardless of form factor, operating system, service provider or transport technology, creating a" network of everything". By bringing together companies from various markets, including automotive, consumer electronics, commerce, health, home automation, industry. Device-to device or device-to-service interactions, where incoming devices generate information, share it, and act based on that information. For example, a motion detector in the intelligent security system, when it detects movement, can cause smart lighting to turn on the light in the room or the thermostat to adjust the climate controls. This article aims to validate our previous contributions as well as the development of a universal intelligent object prototype capable of guaranteeing a high level of interoperability between different connected objects which come from different manufacturers. This paper is organized as follows: second section presents our previous research works. The third section present: (1) the implementation of the architecture of our project; (2) the business modeling from our prototype universal intelligent object; (3) the physical architecture deduced from our contribution of a general architecture of interoperability, and the circuit diagram, the chosen connectivity platform: openHAB and the implementation of the use case. The last section is dedicated to the presentation of the conclusion and our future works.

2. Related Works

There are many building automation solutions and Internet of Things (IoT) gadgets on the market, all of which are useful in themselves. They come in their own way on how to install and configure devices. In this section, we compare different Iot Platforms adapted for automation in Smart Home and Smart Building applications. **openHAB**[1] which is an open-source solution that integrates smart devices, home automation systems and other technologies to provide a uniform user interface. It also provides a common approach to automation rules across the entire system, no matter how many manufacturers and subsystems involved [16, 14]. **IoT HUB**[2] is an open source IoT platform developed by DIGORA [4], it presents a complete solution that combines agility, ergonomics, security, and availability [8]. **Home Assistant**[3] is an open source home automation solution perfect for lighting a Raspberry Pi or a local server allows Observation by a Home Assistant who will monitor the status of all devices in your home, so you do not have Do it, Control all your devices from a single, mobile-friendly interface and provide a way to secure your data by using the home wizard that does not publish data to the cloud [5]. **The IBM Watson IoT**[4] platform ingests device data and transforms it into relevant information, which can optimize processes and guide the design of new products [13]. **OpenNetHome**[5] is an IoT platform that allows to guarantee the connectivity between multiple devices from different providers, It is portable, their GUI is web-based [15].

[1] https://www.openhab.org/
[2] https://www.digora.com
[3] https://www.home-assistant.io/
[4] https://www.ibm.com/cloud/watson-iot-platform
[5] https://opennethome.org/

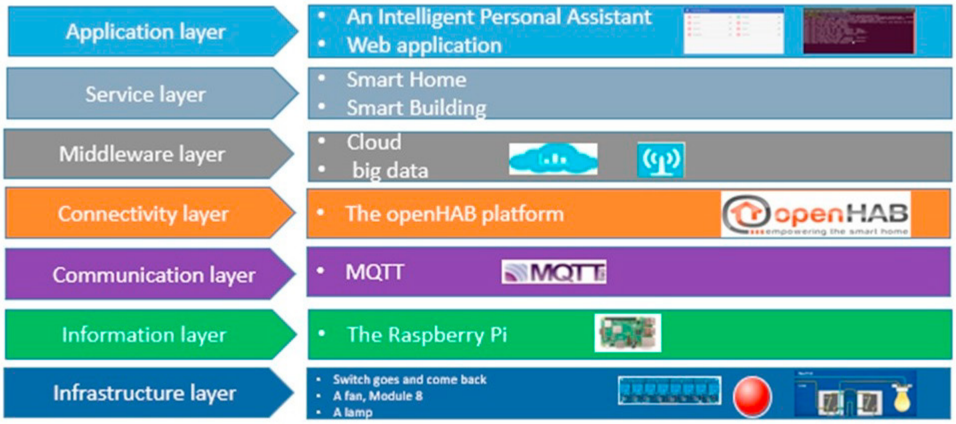

Fig. 1. Physical Architecture of our proposal IoT Platform.

3. Background

This article is part of the technical evaluation of a set of research works proposed in the following articles: (1) a comparative study of IoT interoperability architectures [1], (2) Prototype Models of IoTs Interoperability [7], (3) Towards an IoT interoperability architecture [3], (4) Towards a meta-model of interoperability [2], (5) Towards to a New Interoperability Quality Model for IoTs [17].

4. Results

Ensuring interoperability between building equipment is a crucial step to talk about intelligent building. our solution will play a very important role in the arbitration of all energy solutions of the building according to various criteria such as" economic and uses" and which ensures the interconnection of the different objects connected to each other with an interaction of the different objects between them via our smart object. In this article, we limit ourselves to the proposition of a smart object with a universal interface to offer better interoperability between connected objects which come from different manufacturers. Moreover, our Smart Object implement our generic architecture proposed in section two. This architecture makes it possible to: control remotely connected objects via a voice assistant or a Web application; View the status of each connected object via a web application; Configure new objects and configure voice assistance.

4.1. Physical Architecture and The Scheme Circuit

In this part, we identify the hardware tools we used for our project and the hardware architecture of our application. The hardware used for the achievement of our project is: Raspberry card, an 8-relay card, a lamp, a fan, a switch, and DC 5V and AC 220V power sources. In this case study, we have also chosen a raspberry card as the basis of our smart object solution in which we installed our chosen platform" openHAB" to ensure connectivity between connected objects, as well as a local Linux server which relates to a relay normally open to guarantee a remote control of objects related to our smart object by means of the interface. See Fig. 1 and Fig. 2.

4.2. Material environment

1. **Raspberry Card**: The most important part for our use case is the GPIO port. This 40-point connector is the means provided by the creators of the Raspberry Pi to allow us to access the input / output ports of the BCM2837 processor. There are 26 GPIOs that can be used as digital input / output. They only work in all or nothing, 0 or 1,

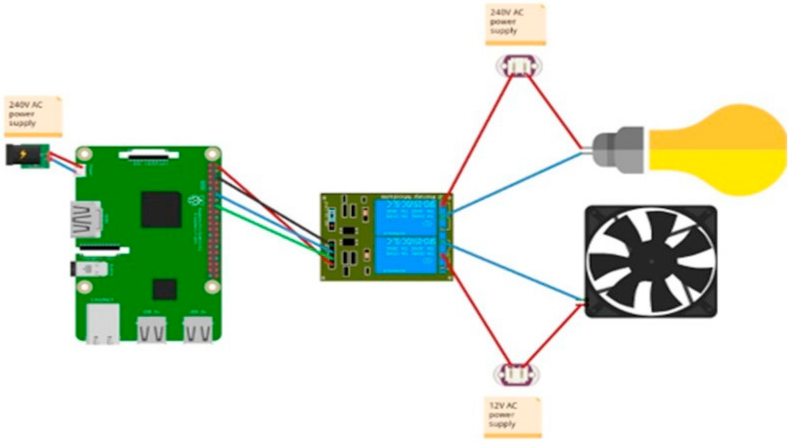

Fig. 2. The Scheme Circuit of our Solution

0V or 3.3V. There is no analog port (continuously variable voltage). Capabilities of the card can be extended by means of supplementary cards that can be connect with the Raspberry Pi.

2. **8 relays module**: A 5v relay modules allow the opening and closing the electrical circuit. Each relay can operate independently with different DC/AC voltages.
3. **Switch Goes and comeback**: The switch" back and forth" is a type of switch that can turn on one or more spotlights, in several different places. Specifically, it helps you turn on and off one or more lamps from different places in your home.

For the realization of our project. In this part we will introduce the software tools used to know, development and design tools and a home automation platform. Development and design tools: We have used Power AMC as design tool, Sublime Test as development tools, Xampp a Database Management Tool has been used to manage the database. While Mobile application development have been achieved with Android Studio.

4.3. Home automation platform

The open home automation bus (openHAB) is an independent home automation platform that is the center of your smart home. Its ability to integrate a multitude of other devices and systems. openHAB brings together other home automation systems, (smart) devices and other technologies in a single solution. Provide a uniform user interface and a common approach to automation rules across the entire system, regardless of the number of manufacturers and subsystems involved. By offering you the most flexible tool available to realize almost all the wishes of home automation, Hardware configuration: Raspberry Pi 2 or newer, SD card (16 GB or more), Power Supply, Ethernet, or Wi-Fi connection. First steps: connected via SSH, run the Raspbian configuration menu by running *sudo raspi-config*. It is recommended to perform a full upgrade and install the packages you like or need (a set of useful packages is given as an example). Note on Java: Raspbian in the latest full version already includes Oracle Java 8. Raspbian Lite is delivered without Java.

4.4. Business modeling of the use of our case study based on our generic architecture

The business process is specifically developed to coordinate the sequences of actions and messages that exist between the different business players in the company.

1) Voice control operating process: This business process makes it possible to control an object or request a google cloud service by invoking google voice assistance which presents a linguistic interface, the user of which will choose the object and the order of action to be performed or else the service. to invoked. See Fig. 3.

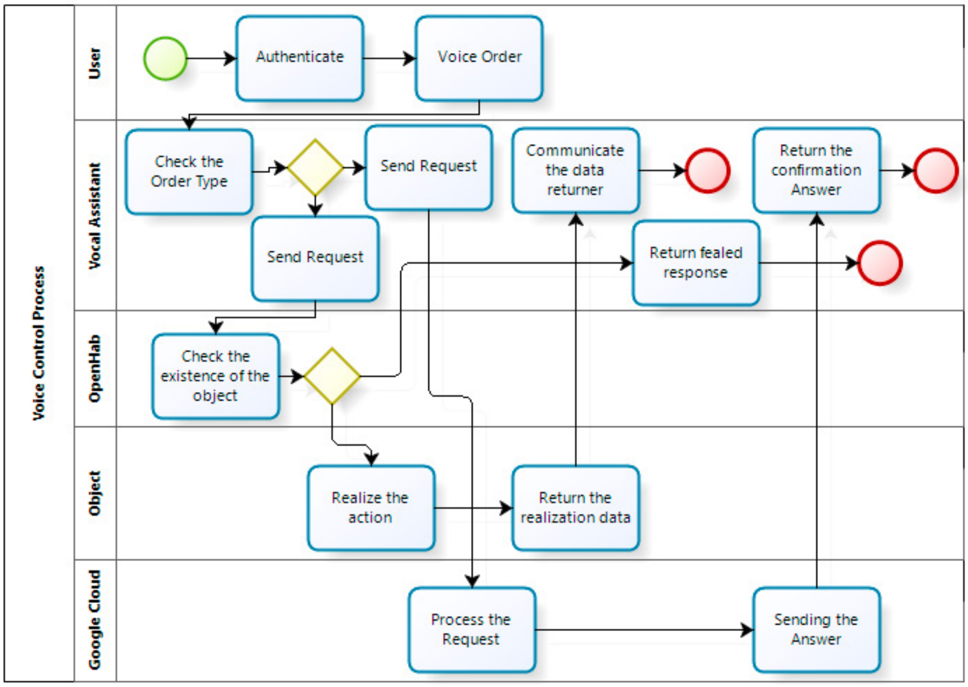

Fig. 3. Voice control operating process.

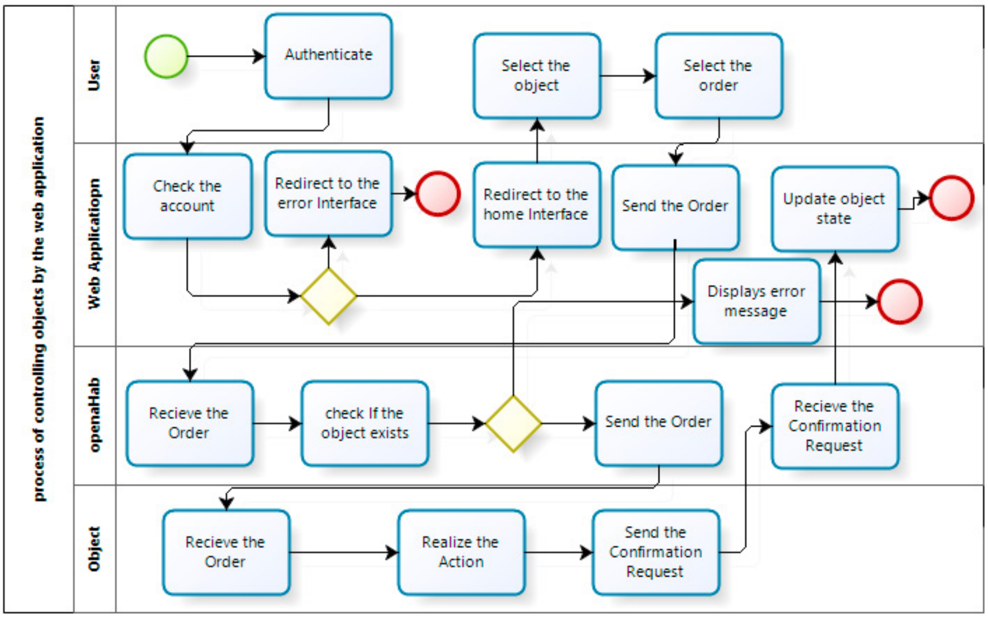

Fig. 4. Control process by the web application.

2) Control process by the web application: This business process makes it possible to control an object connected to our smart object from the web application, the user of which must authenticate himself by their account with the web application then choose the object and place the order web will communicate the information entered by the user to the openHAB platform to check the existence of the object and then pass the action to it. See Fig. 4.

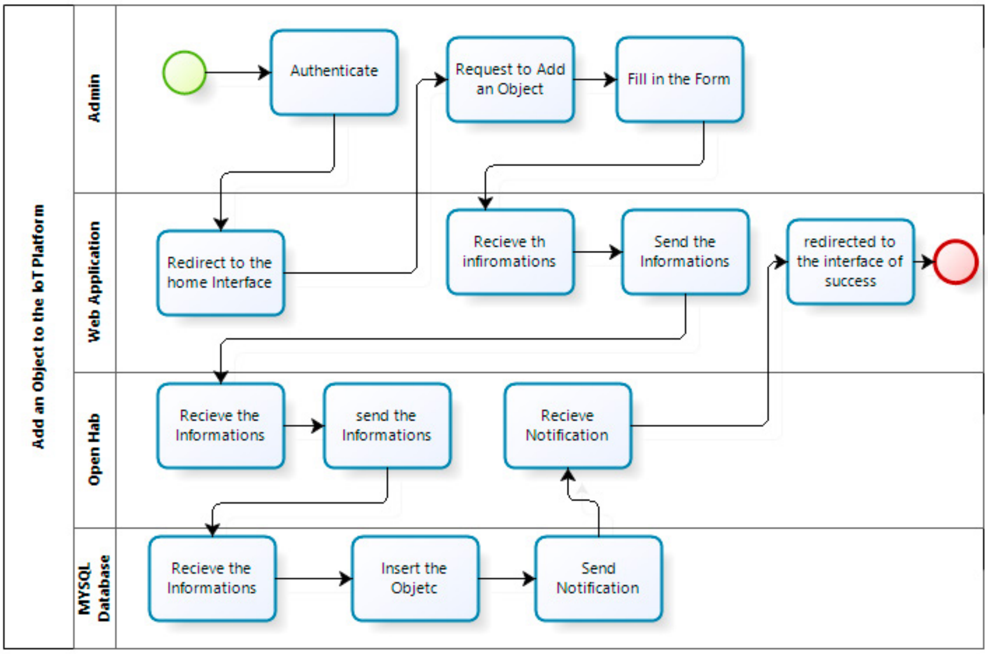

Fig. 5. Business process for adding a new object to the platform.

3) Operating process for adding an object via the web application: This business process allows you to see a global view on adding objects so that the platform can communicate with them, after authentication the user can simply control an object configured by the admin or by the voice assistant or through the web application. See Fig. 5.

4.5. Prototype of universal intelligent object of interoperability IoT

We aim to define connectivity requirements to improve interoperability between the devices that make up the Internet of Things (IoT). An implementation of a web application and virtual assistance ensuring interoperability whatever the form factor, the operating system, the service provider, or the transport technology, creating a" network of everything". By bringing together companies from the automotive, consumer electronics, commerce, healthcare, home automation, and industry industries. This IoT platform guarantees scholarly services, remote control of connected objects via voice assistant or web application. Automatically or manually configure a new object, manually configure voice assistance and consultation of the status of each connected object via a Web application. See Fig. 6.

5. Conclusion

In this article, we are helping to overcome the problems of interoperability between connected objects, through a characterization, modeling, implementation, and validation approach. Indeed, the literature review has shown that the architectures adapted in IoTs projects lack a vision of interoperability and often do not use solutions that offer a higher level of interoperability. And to overcome this problem we have proposed an interoperability architecture for the Internet of Things domain, with the aim behind its creation being a multitude of uses, namely; generation of specific architectures, guarantee interoperability between IoT platforms, guarantee technical transparency and maximize productivity, then we proposed as a validation step for our proposals a prototype of intelligent object with a universal interface to offer better interoperability between the connected objects which come from different manufacturers and which makes it possible to; remotely control connected objects via a voice assistant or web application, configure a new object automatically or manually, configure voice assistance and view the status of each connected object via a

Fig. 6. Exemplary embodiment.

web application. in the next work, we aim to develop this prototype and test the implementation of different case of study of IoT projects on our proposed generic IoT interoperability architecture [13].

References

[1] Abdelouahid, R.A., Chhiba, L., Marzak, A., Mamouni, A., Sael, N., 2017. Iot interoperability architectures: Comparative study, in: First International Conference on Real Time Intelligent Systems, Springer. pp. 209–215.

[2] Abdelouahid, R.A., Marzak, A., Sae, N., 2018a. Towards a new meta-model of io lnteroperability, in: 2018 IEEE 5th International Congress on Information Science and Technology (CiSt), IEEE. pp. 54–63.

[3] Abdelouahid, R.A., Oqaidi, M., Marzak, A., 2018b. Towards to a new iot interoperability architecture, in: 2018 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD), IEEE. pp. 148–154.

[4] Agarwal, P., Alam, M., 2020. Investigating iot middleware platforms for smart application development, in: Smart Cities—Opportunities and Challenges. Springer, pp. 231–244.

[5] Aloi, G., Caliciuri, G., Fortino, G., Gravina, R., Pace, P., Russo, W., Savaglio, C., 2016. A mobile multi-technology gateway to enable iot interoperability, in: 2016 IEEE First International Conference on Internet-of-Things Design and Implementation (IoTDI), IEEE. pp. 259–264.

[6] Blackstock, M., Lea, R., 2014. Iot interoperability: A hub-based approach, in: 2014 international conference on the internet of things (IOT), IEEE. pp. 79–84.

[7] Casablanca, O., 2018. Prototype models of iots interoperability. International Journal of Computer Science and Information Security (IJCSIS) 16.

[8] Cirani, S., Ferrari, G., Iotti, N., Picone, M., 2015. The iot hub: A fog node for seamless management of heterogeneous connected smart objects, in: 2015 12th Annual IEEE International Conference on Sensing, Communication, and Networking-Workshops (SECON Workshops), IEEE. pp. 1–6.

[9] Debauche, O., Trani, J.P., Mahmoudi, S., Manneback, P., Bindelle, J., Mahmoudi, S., Lebeau, F., 2021. Data management and internet of things: A methodological review in smart farming. Internet of Things , 100378.

[10] Desai, P., Sheth, A., Anantharam, P., 2015. Semantic gateway as a service architecture for iot interoperability, in: 2015 IEEE International Conference on Mobile Services, IEEE. pp. 313–319.

[11] Evans, D., 2011. The internet of things: How the next evolution of the internet is changing everything. CISCO white paper 1, 1–11.

[12] Fersi, G., 2015. A distributed and flexible architecture for internet of things. Procedia Computer Science 73, 130–137.

[13] Guth, J., Breitenbücher, U., Falkenthal, M., Fremantle, P., Kopp, O., Leymann, F., Reinfurt, L., 2018. A detailed analysis of iot platform architectures: concepts, similarities, and differences, in: Internet of everything. Springer, pp. 81–101.

[14] Gyory, N., Chuah, M., 2017. Iotone: Integrated platform for heterogeneous iot devices, in: 2017 International Conference on Computing, Networking and Communications (ICNC), IEEE. pp. 783–787.

[15] Haapasaari, M., 2015. Raspberryn soveltaminen kotiautomaatioon .

[16] Heimgaertner, F., Hettich, S., Kohlbacher, O., Menth, M., 2017. Scaling home automation to public buildings: A distributed multiuser setup for openhab 2, in: 2017 Global Internet of Things Summit (GIoTS), IEEE. pp. 1–6.

[17] Marzak, A., et al., 2018. Towards a new interoperability quality model for iots, in: 2018 fifth international symposium on innovation in information and communication technology (ISIICT), IEEE. pp. 1–6.