A REVIEW: INTERNET-OF-THINGS GATEWAYS ARCHITECTURES AND CHALLENGES

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Abstract - This paper presents a survey of Internet-of- Things (IoT) gateways based on several reputation publications. A group of recent papers were studied to come out with good idea about the architectures and challenges regarding the IoT gateways that are used in the IoT applications in modern day living. Future outlines of each paper are presented and some problems are mentioned as motivation to complete the research in order to find out acceptable solutions. The aim of this study is to integrate the good properties that improve the used algorithms in data aggregations from the sensors (from the gateways side) and enhance the actuators response from the user in terms of time, accuracy and reliability. Open challenges and future trends in the design and programming of the IoT gateways are concluded.

Keywords - Internet-of- Things (IoT), Gateways, Radar Frequency Identifier (RFID), Wireless Sensor Network (WSN).

I. INTRODUCTION

By providing network connectivity to both sensors and actuators and making them connected with each other and with cloud the internet of things (IoT) is performed. IoT permits sensors and actuators (with embedded network connectivity) to be sensed and controlled remotely, creating opportunities for direct integration between the real world and computer-based systems, and causing improved accuracy, efficiency, and economic profit [1]. IoT has four architecture layers: Sensor Connectivity and Network, Gateway and Network, Management Service and Application. Gateway and Network layer of IoT must support massive volumes of IoT data produced by wireless sensors and smart devices and also requires a robust and reliable performance regarding private, public or hybrid network models. Network models are designed to support communication Quality of Service (QoS) requirements for latency, error probability, scalability and security while achieving high levels of energy efficiency [2]. It is important to integrate different types of networks into a single IoT platform. IoT sensors are aggregated with various types of protocols and heterogeneous networks using different technologies. IoT networks need to be scalable to efficiently serve a wide range of services and applications over large scale network [3].
In this paper, a review of used IoT gateways architectures is presented. Some of those architectures are not implemented yet. Firstly, the functional requirement of the gateway is explained, and then architecture for sensor access scheme design based on IoT gateways is depicted [4]. Secondly, An IoT gateway centric architecture to provide novel machine to machine (M2M) service is presented [5]. Thirdly, a design of IoT gateway based on radar frequency identifier (RFID) and wireless sensor network (WSN) technology is explained [6]. Forty, An IoT multi – interface gateway for building a smart space is presented [7]. Finally, the challenges and future trends that were induced by the study are mentioned.

II. FUNCTIONAL REQUIREMENT OF THE GATEWAY SIDE

Figure 1 shows the functional requirement of gateway side system. Communication module enables the gateway side to be accessed by the sensors and other terminal equipment in the perception layer. Flexibility and scalability are the properties of the universal resource description framework. This framework reflects the resources relationships and searches the resources easily. Scheduling rules are defined after finding the access devices by the Bootstrap server module, and resources registration module are notified based on those rules. The registrant, update, and delete messages are interpreted by the resources registration module to finish all operations on the database. An algorithm for search the resources is realized by formatted database which designed by the resources search and database. Address, description and allocation of the resources identifier are defined by a mechanism of the resources identifier allocation. Here are the functions of each interface inside the gateway:

R1: is an external interface which defines the registration format of the resource description information.
R2: returns messages format and defines request according to the Bootstrap rules.
R3: is an internal interface which allows resource storage module and authorization module to inquire information.
R4: permits write and read operation of resources registration to the database.
R5: returns the address of the resources according to the search request.

R6: solves the resources database addressing while Bootstrap or registration and uploads the data of the resources.

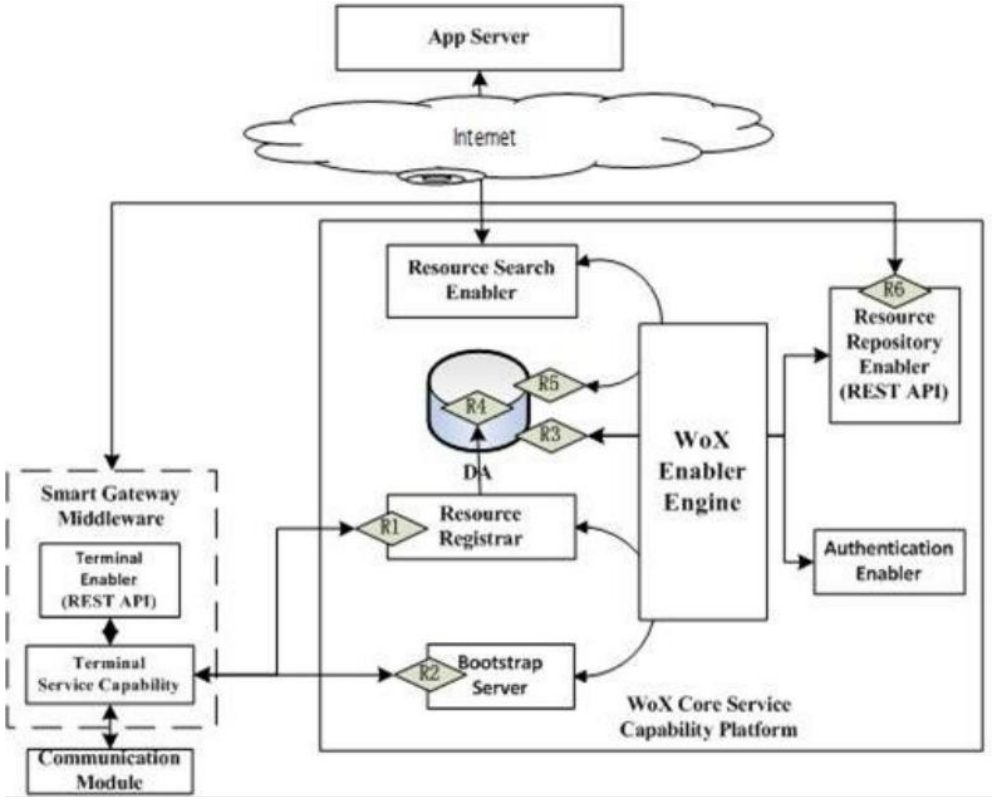

Fig. 1.Functional Requirement of Gateway Side System [4]

III. ARCHITECTURE FOR SENSOR ACCESS SCHEME DESIGN BASED ON IOT GATEWAYS

The standard architecture for the proposed gateway that includes sensor access scheme is shown in figure 2.

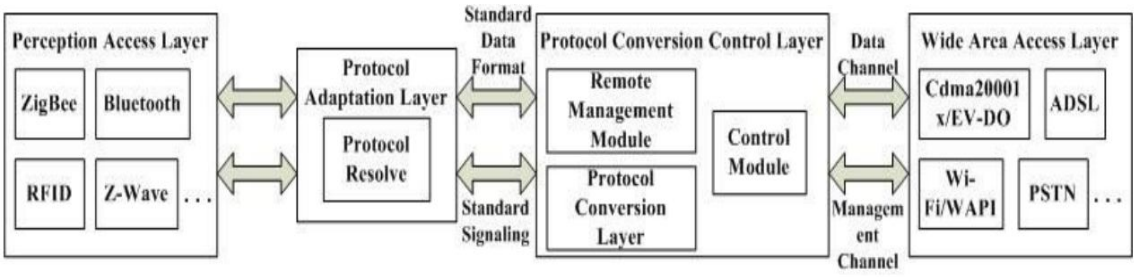

Fig. 2.Typical Architecture of IoTGateway[4]

From figure 2, we can recognize that the above architecture consists of four main layers:

1. Perception access layer.
2. Protocol adaptation layer.
3. Protocol conversion control layer.
4. Wide area access layer.

- **First layer:** in this layer, users can select a specific protocol or a combination of protocols, also interpolation module can realize several protocol extensions, so as to realize both fusion and access ability.
- **Second layer:** defines the typical access interface of the perception layer, to guarantee and insure the different protocols of the perception layer can be a unique data and signalling.
- **Third layer:** includes three modules, a- remote management module, b- control module, and c- protocol conversion module. Their purpose is to realize tow functions: 1- converts the protocol from perception network to the wide area network making unique packages of the data in typical format which uploaded from protocol adaptation layer, and tracking the send data by

the wide area network into typical format data. 2- built-in a protocol for management for docking both platform and protocol resolve managements, and convert it into control commands can be identified by first layer protocol.

- **Forth layer:** enables the interface access to the wide area network. There are two methods of access either single or a combination of several methods, first one applies to specific network and second one applies non-fixed network.

A. Futured outlines:

- No hardware specification given.
- Only software simulation was proposed.
- A good theory explanation for both the functional requirement and the architecture of the IoT gateways.

IV. AN IOT GATEWAY CENTRIC ARCHITECTURE TO PROVIDE NOVEL (M2M) SERVICE

Figure 3 shows the architecture of a wireless gateway (WG) provides novel (M2M) services

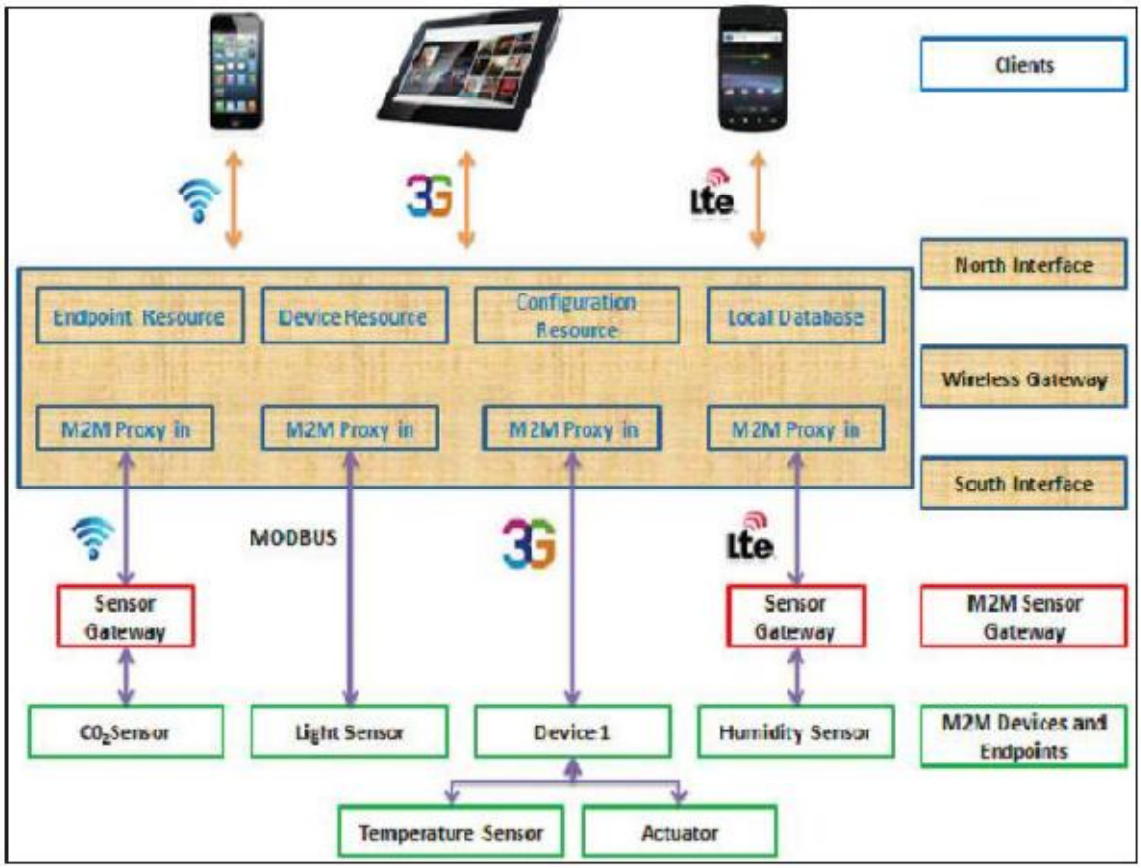

Fig.3.The proposed Internet of Things architecture[5].

The wireless gateway consists of two interfaces: upper and downer. The upper interface helps in discovery phase and connects with the mobile clients. The downer interface reacts with M2M devices and saves their configuration in the database.

B. Futured outlines

- A restful web service is used to realize the above gateway without developing any specified hardware platform for designing the gateway.
- A discussion of two scenarios in the real life was included and the above architecture can be used to implement them.
- Developing of mobile application and using it as a prototype for the gateway was presented.

V. A DESIGN OF IOT GATEWAY BASED ON (RFID) AND (WSN) TECHNOLOGY

A. The hardware construction of gateway:

The hardware structure of the gateway is shown in figure 4. This structure consists of three modules: 1- data acquisition module, 2- processing or the storage module, 3- access module. First module performs the data acquisition from real world, the data can be provided by sensor network, GPS, video acquisition equipment and so on. Second module is the centric module of the gateway; it realizes the processing and

saving of the data according to the protocol security, transition, management and so on. The gateway is connected to the internet or communication networks by the third module, two types of communication networks include wired networks like Ethernet, ADSL and so on, and wireless networks like WLAN, GPRS, 3G, satellite and so on. The different types of interface between first module and second one include: USB, UART, SPI, Ethernet, RS232/RS485, AD bus and so on, The different types of interface between third module and second one include USB, UART, AD bus and so on. The typical interface should be defined at the gateway development progress gradually.

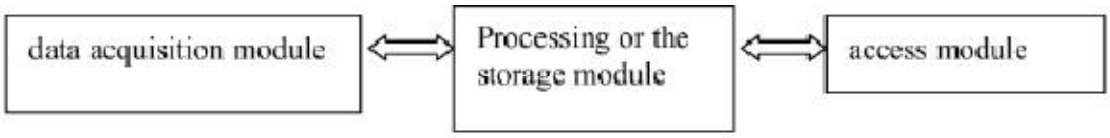

Fig. 4. The hardware composition of the internet of things gateway [6]

B. The hardware suggestion of the gateway

The hardware composition of the gateway is shown in figure 5. In order to implement this gateway you have two choices either to develop a special embedded hardware or to go with a universal embedded development platform which available in the market and conducting its peripheral circuit expansion. The authors of [6] used the second option for hardware implementation, they used a ready-available embedded platform which made by Friendly ARM Corporation. The circuit diagram is shown in figure 6.

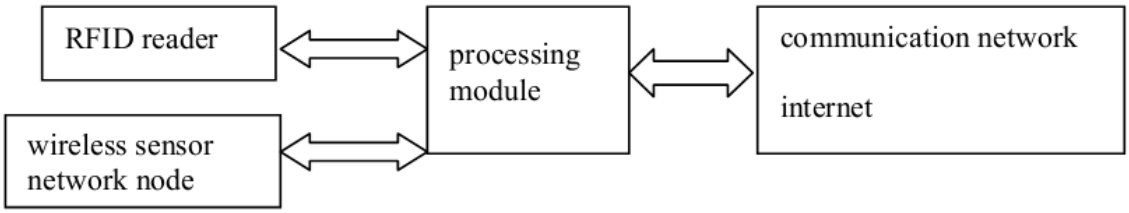

Fig. 5.The composition of gateway hardware [6]

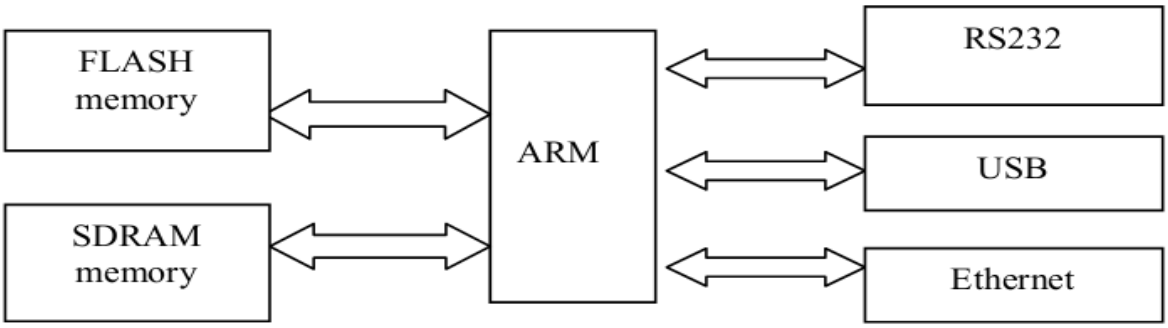

Fig. 6.The hardware composition of the internet of things gateway based on ARM [6]

C. Futured outlines:

- No specified algorithm to gather the information from the sensors.
- Also, no specified application is mentioned when the performance test was done.
- Giving good idea about using the platform as IoT gate way.

VI. AN IOT MULTI – INTERFACE GATEWAY FOR BUILDING A SMART SPACE

Heterogeneous gateway architecture is shown in figure 7 and from this figure we can recognize four different modules: 1- Octopus X wireless module, 2- ZX-Bluetooth module, 4- Infrared IR transmission use the universal asynchronous receiver/transmitter (UART) communication interface. The pulse width modulation pins on the Arduino board are connected with the third module which by using digital pins simulates IR analog signals. The pins of forth module are connected with the pins of Arduino board.

module and 4- wifly GSX module. Microcontroller board of Arduinotype is connected with the first and second modules which

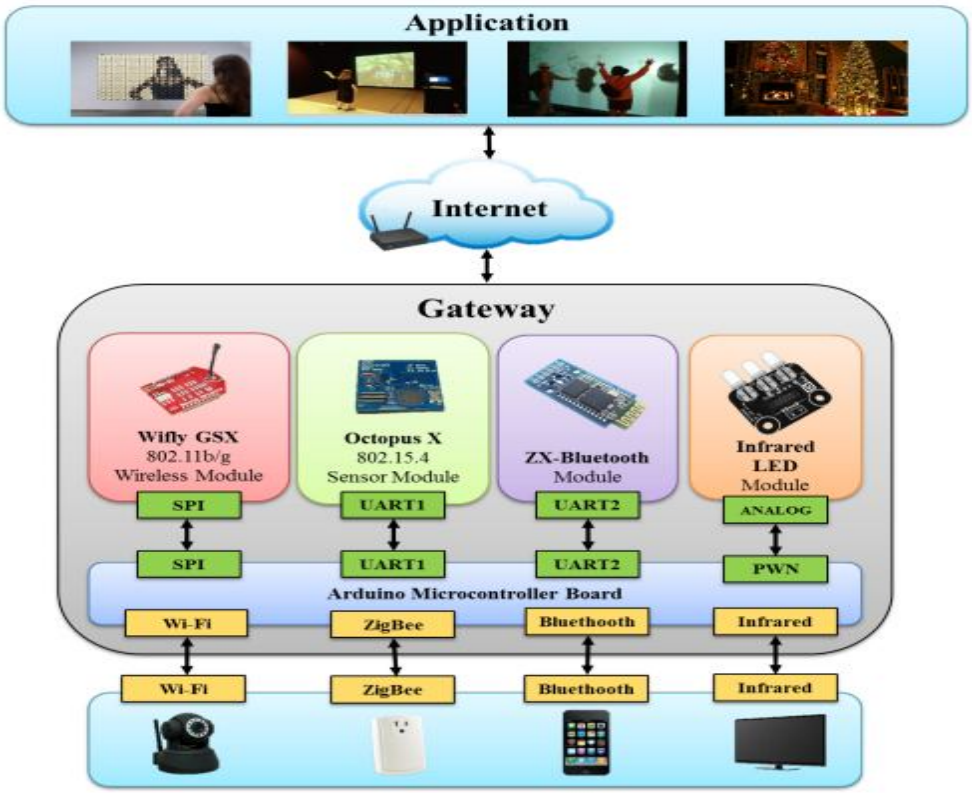

Fig. 7.The logic architecture of the developed heterogeneous network gateway [7]

A diagram of the heterogeneous network gateway is shown in figure 8. In this figure, it is clear how to make the individual connection with Arduino board with the individual modules which results in a heterogeneous gateway.

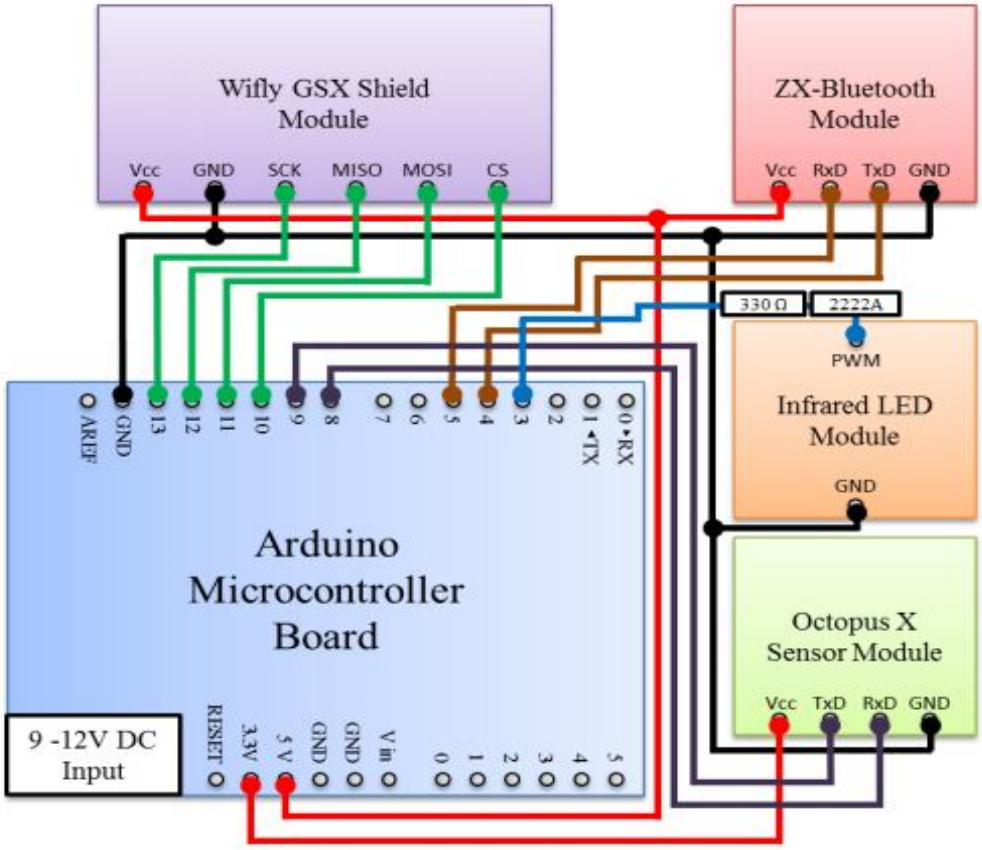

Fig. 8.Heterogeneous network gateway circuit diagram[7]

A. Futured outlined:

- Description of the multi – interface IoT gateway module and connections was provided.
- No performance test was carried on.
- No simple application was mentioned.

VII. CHALLENGES AND FUTURE TRENDS

After going through the above described architectures and from the future outlined of each studied paper, it is important to develop an integrated architecture that gathers the good properties of mentioned gateways. In addition, an improved algorithm to aggregate data from the sensors should be implemented in that gateway. Security methods and reliable connection must be integrated to ensure improved performance.
Once the mentioned gateway is implemented, it should be used in an application and performance test should be carried on and a comparison with present work is to be done so that the designed gateway proves its reliability.

CONCLUSION

The internet of things (IoT) will play the core role the future human life. IoT gateway is the translator between the sensor (and actuator) layer and the network (cloud) layer. A reliable design of such gateways is required to ensure good performance of the system.

In this paper, a sample of papers is studied. The future outlines from each paper are discussed. In the coming design of IoTgateway, merging of good properties is to be done and addressing of various challenges to be achieved.

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