Implementation of a Modular IoT Framework with Scalability and Efficient Routing

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***Abstract*—Internet of Things (IoT) is being researched all over the world. The ability to communicate with the physical world through digital sensorial and actuator devices has enabled human being to understand, control and maintain nature with more efficiency. Several research are presented in the literature where majority focused on specific applications, or some specific challenge. These works often require major tweaking for adoption into different applications which pose various technical challenges. In this paper a modular architecture is presented, which is easy to customize and deploy in diverse applications. Wide range of hardware devices are utilized and tested for realizing its performance in different applications. Apart from hardware implementation, routing of data in an IoT network has great impact on system efficiency. Routing between sensorial devices is currently being studied and will be included in the final manuscript.**

Keywords—Internet of Things, modular architecture, implementation, sensor network

I. INTRODUCTION

IoT transforms any object, or thing, into smart by adding sensors, embedded devices, wireless transceivers and internet connectivity. For example, daily appliances in houses and offices, sophisticated machineries in hospitals or industries, all of these can become smart with IoT. A growing number of things are being connected to the internet realizing the idea of IoT and enabling diverse range of applications including, but not limited to smart-homes [1], precision agriculture [2], structural health monitoring [3], remote healthcare [4], indoor location based applications [5], smart-cars [6] etc.

Besides all the applications that IoT can offer, numerous challenges are present to bring IoT into reality. Among the many challenges, this paper presents the gist of a master's thesis work which is focused on challenges in scalability, data routing, and security in IoT architecture implementation. Scalability in the context of an IoT framework implies applicability to a broad range of applications. So far, majority of research focused on IoT framework for a specific application [1-6], with less emphasis on scalability. This work presents an implementation of a modular IoT framework that can be easily adapted for various applications including, but not limited to health care, structural health monitoring (SHM), agriculture, location aware indoor tour guide system etc. As each of these application have diverse requirement in terms of physical size, power consumption, computational ability etc., the framework has the capability to replace and substitute different components at different architectural levels so as to work seamlessly in each application.

Data routing refers to the phenomena of sending data from a sensor node to gateway device which will then push information to the internet. The network for IoT data communication requires to be low-powered, and such networks are typically lossy by nature. Moreover, in IoT networks, the nodes can be deployed in an unplanned manner. To ensure routing efficiency, many routing protocols have been proposed in the literature. Among those, RPL is a routing protocol specifically designed for IoT networks developed by Internet Engineering Task Force (IETF) [7] and is being studied in many research works [8, 9]. The applicability of RPL in the proposed framework and the security features of RPL are currently being studied and will be implemented in the framework.

The rest of this paper is divided in five sections. Sections II presents the architecture. Then in section III the implementation of different applications is illustrated. Section IV describes the works in process and section V concludes the papers

II. PROPOSED ARCHITECTURE

This section presents the proposed modular IoT architecture. The proposed architecture is composed of five modules depicted in Fig. 1. In each sub-section a brief description of each architectural level will be discussed.

A. *Physical Sensors and Actuators*

This is the lowest layer in this architecture which consists of the different sensors and actuators, as used to measure the attributes of different target applications and activate some sort of feedback based upon the situation.

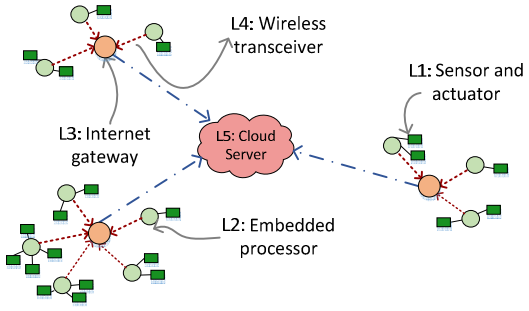

Fig. 1. Proposed Architecture

B. *Embedded processor*

This is the second layer in the proposed architecture. The primary role of this processing unit is to capture information from sensors, perform fundamental data interpretation, provide feedback to the user as necessary, and relay information the internet gateway.

C. *Wireless Transceiver Technologies*

This is the third layer in the proposed architecture. This layer provides wireless connectivity to different components of the architecture. However, highest current consumption occurs during the time of transmission and reception by wireless transceivers and thus needs to be chosen and utilized properly.

D. *Internet Gateway*

The sensor nodes collect sensor data and relay it to an internet gateway. This gateway further relays the information to the cloud server and also can send feedback from server to the sensor nodes. After testing and comparing a bunch of platforms, Raspberry Pi 3 has been adopted for this work due to its functionality, low cost, moderate power consumption and numerous online support.

E. *Application Management Cloud Server*

This is the highest layer in the proposed architecture and is responsible for facilitating the end-users' ability to access the sensed data universally. A custom made server is setup as a prototype, to push and store data online. Thingworx is also used is some applications, for instance, SHM.

III. Implementation and Evaluation

As explained before, the purpose of the work was to implement a framework with scalability among various applications. The framework was tested in the following applications, a) healthcare, b) structural health monitoring, c) agriculture, d) indoor tour guide system. The modules in different application are shown in Fig. 2.

IV. Work in Progress

While deploying the IoT network our realization was that successful network formation and routing is of paramount importance while gathering data from huge number of things. Typically networks are of three topologies, 1) star, 2) mesh and 3) tree. RPL is a tree based routing protocol specifically designed for IoT applications. Till now the proposed architecture follows the star topology, which has limitation in network expandability and is prone to failure if central node fails. Hence, the tree based RPL will be implemented on the architecture for more efficient routing of information in large networks. Security of data routing in RPL topology is also under consideration.

V. Conclusion

The end goal of this work is developing an IoT architecture with scalability among applications, efficient routing and security in data transmission between nodes and node to gateway. A modular architecture is presented in this paper which has higher scalability than the works in the literature. Different modules in this architecture can easily be removed, added or replaced according to application needs which has been proven by experimenting in multiple diverse applications with unique system requirements.

VI. References

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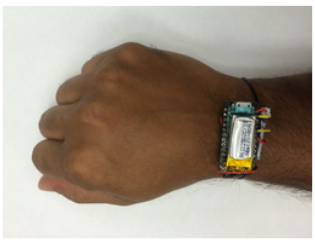

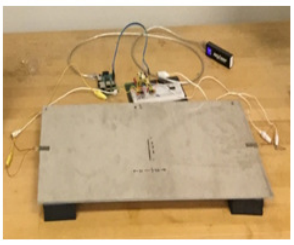

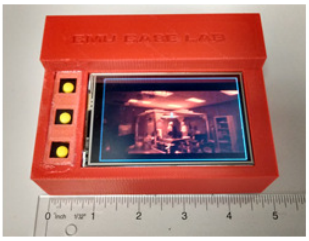

Healthcare	SHM	Agriculture	Tour guide
Motion detection, Activity monitor, Sudden fall detection	Damage location and size detection in structure	Monitor soil and environmental parameters to decide	Location aware system to present personalized information

Fig. 2. Implementation of the architecture in different applications