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Networking for IoT and applications using existing communication technology

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ABSTRACT

Converging of MANET with WSN used in ubiquitous smart environments opens new prospect in monitoring the large scale urban area and makes a new communication platform for different applications in Internet of Things (IoT) domain. Sensors used for IoT applications, sense the environment and send the data to the gateway node, which in turn send the collected data to the MANET node, especially used for data harvesting. Here we considered two IoT applications which are monitored by wireless sensor nodes. The challenging part of this work is to make a platform by converging sensor network with the MANET network because nodes have different power levels, heterogeneous protocols and have chances of co-channel interferences. We proposed a total solution which includes network protocols, spectrum distribution, node deployment, MANET routing and mobility pattern and finally implementation of the IoT applications which are simulated using Omnet++ simulator and shown their performances and feasibility.

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1. Introduction

A recent paradigm of communication which popularly known as Internet of Things (IoT), where all the objects of different kinds of our daily life spanning from smart phones, sensors or devices are associated with network enabled objects (like RFID) can communicate with each other and makes a part of Internet. The main aim of IoT is to make Internet more and more inspiring and pervasive. By connecting wide variety of heterogeneous devices and making easy access of the devices, several applications are being used in IoT, which deals with the large number of data generated by the attached devices and make some decisions which is very important for the industry or control the attached devices based on the generated data. There is a huge use of IoT in several domains like medical aids, home automation, industrial automation, mobile

health care, electricity transmission and distribution etc. Now a day smart cities are one of the emerging domain of IoT, where researchers are proposing several communication models and standards and provide some applications which facilitate the residing citizens by enhancing their everyday standard of life.

With the advancement of communication technology and microcontroller technology, Wireless Sensor Network (WSN) plays an important role in IoT. Sensor nodes, which are very tiny low cost devices, can sense different parameters in the environment, it can store data in its memory temporarily and can communicate with other electronics devices by using communication technology like IEEE802.15.4 or Bluetooth Low Energy (BLE). On the other hand RFID tag is also a useful device in IoT, which is used to identify an object attached with a RFID tag.

In our work, MANET plays a vital function, which is used as the backbone of the IoT network. Due to its inherent properties, the MANET nodes can build spontaneous connections with other nodes without the need of any infrastructure. MANET nodes can move around the IoT network and collect data from the sensors, RFID attached nodes, or any fixed Wireless nodes. Thereafter it can process the data and send it to the Internet gateway through some intermediate MANET nodes. The MANET nodes use the efficient path to reach one of the available Internet gateways. Like sensor nodes, MANET nodes can be used as key technologies in several applications in IoT. Due to the nature of self-configuring, MANET

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nodes as well as the sensor nodes (including the RFID enabled devices) can be deployed in large scale. In this work we have used the nodes in four different hierarchical levels. Instead of connecting the low power sensor nodes to the Internet directly, we have used MANET nodes in between the sensor and Internet Gateway. Sensor nodes or RFID enabled objects either send data to the MANET node or to ‘Access point’ of WLAN and in both cases data is forwarded via sensor gateway nodes. There are several applications in smart cities, where these devices play an important role and provide different services to the citizens which include monitoring of environment, management of traffic etc.

In this paper we have considered a smart city (urban area), facilitates with several IoT applications powered by different types of wireless communicating devices. We have proposed an IoT architecture and used it in two very useful IoT applications. The first one is the Hospital Information system, where things like the patients, doctors, beds, all examining equipments etc are connected to internet through sensors, RFIDs, WLAN and MANET nodes. People can get all necessary information from the Internet, and these information can also be used to monitor the hospital by the authority. The next IoT application is based on worldwide popular soccer game. Players are considered as objects and send their sensed biological parameters to the gateway nodes. Mobile devices, that are carried by the referee and linesman are considered as gateway nodes. Along with the architecture we have also proposed the required protocol stacks of different nodes and network parameters suitable for implementing both applications.

Organisation of the paper is as follows. In Section 2, we have discussed the works related to IoT. Architecture and protocols are discussed in Section 3. We have considered two applications of IoT, illustrated in Section 4. Simulation and results are given in Section 5 and finally conclusion is drawn in Section 6.

2. Related work

For a decade researches are going on the IoT field by using several matured technologies like Mobile Adhoc Network (MANET), Wireless Sensor Network (WSN), Radio Frequency Identifiers (RFID) and so forth. Researchers have raised several technological issues and also proposed solution for using these technologies in IoT [3,15]. The main challenging factors of these work is to combine all the heterogeneous technologies and make a single architecture for the IoT, which will be widely acceptable. In [5] Authors have proposed some methods of combining MANET and WSN in IoT, where emergency data generated by the sensors can be forwarded to the control centre by the MANET nodes, which are used for data harvesting. Throughout the world, smart city projects will make a good business in the market. Industries are spending large amount of money for this and it is expected by 2020 the market will reach hundreds of billion dollars. Smart city is one of the most demanding and growing applications of IoT. Several works have been done on this field [37,12,25,38,31,9] and as a result several protocol models have come into proposal. But not a single model is widely accepted due to lack of available architecture which can be used for all types of services.

In a smart city, the available services are mainly structural health of the building or bridge, noise pollution monitoring, air pollution monitoring, waste management monitoring, traffic management in the road, smart parking, energy consumption monitoring etc. In [21] authors have proposed an architecture of sensor based IoT network, which will continuously sense the building condition and send the data to the internet for further processing to know the health of the infrastructure. Waste management is another important service in the city. Authors [27] have proposed IoT based waste management service, which optimizes the use of the

resources like trucks, roads, time etc. IoT networks connects all the vehicles and collect data from those objects for processing, which finally manage the resources in an optimize manner. In paper [1], researchers have proposed an IoT network architecture which consist of GPRS based sensors. These sensors are deployed throughout the city, sense the greenhouse gases and as a result IoT can monitor the emission of such harmful gases. Noise monitoring [23] is another IoT application in a smart city. In noise monitoring, sensor can sense the sound levels of the objects in the environment and monitoring the levels by imposing restriction in the affected zone. Traffic management and car parking [19,18] are being automated by using special sensors in IoT based application. Congestion can be controlled by using the traffic management application, where as smart car parking makes the people aware of the status of parking slots in advance and remotely through IoT application.

In the IoT literature, it has been tried to combine WSN with mobile nodes. To improve the efficiency of the WSN networks authors [41,2,39] have proposed two different interfaces in some of the WSN nodes. But this deployment ideas are not cost effective. Combining MANET nodes with WSN nodes where mobile nodes act as data harvester, is a very hot research field in IoT. The exploitation of mobile nodes as data harvesters and as WSN gateways towards the Internet is a hot IoT research area. Authors in [6] have proposed some predictable path of the mobile nodes for reducing energy consumption and latency. Wang et al. proposed the concept of relay mobile node, which can improve the WSN lifetime [40]. In [22,26], authors have used hierarchical architecture of WSN nodes, where the sensor nodes form the cluster around the mobile node, which act as the gateway of the Internet.

The web applications which are mainly XML based are not suitable for constrained devices like sensor or RFID devices. So in IoT [29,10,33,32], people have started developing web based applications which are based on CoAP(constrained application protocol) in the application layer. It has been provided for accessing the constrained devices like sensors through Uniform Resource Identifiers (URI). In paper [35], authors have proposed CoAP, which is demonstrated in Constrained RESTful Environment (CoRE) [34] and combined XML format with the format of Efficient XML Interchange (EXI) [28,35].

Almost all these papers are based on conventional IoT architecture, where different heterogeneous networks directly communicate with Internet through their own gateways. In all referenced paper, authors have proposed different protocols for the constrained devices of their own models but still there are some issues, which are unexplored. Here we have proposed an IoT architecture, which is different from the conventional one. It consists of four hierarchical levels, which combines MANET nodes, infrastructure based WLAN, WSN nodes and Internet all together with an aim of using all these for different IoT applications in an efficient and effective manner.

General practice of IoT is to connect WSN (Data Source) to Internet (where all users are interconnected). This sort of IoT has inherent limitation in terms of area coverage, delay in the network, energy and IoT applications. In order to mitigate all the limitation and to bridge the big technical difference between WSN and Internet, we have introduced MANET in between and accordingly shown the design aspect from existing technologies as well as some application.

3. Proposed IoT architecture

In an urban area, there are factories, long bridges, tall buildings, schools, market, hospitals, offices etc and above all there are wide roads, which connect all these. Fig. 1 shows a model of IoT enabled

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