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IOT Enabling Modular Wireless Controller Using 6LowPAN Technology

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Abstract-Internet of things is the latest advancement in the internet world which can connect millions of devices to the network. This paper brings out 6LowPAN wireless technology which enables energy efficient and ip based data transmission using contiki OS. The MQTT Protocol is used to connect devices to the network which can be controlled using mobile applications . Even the smallest devices in the day to day life can be connected to internet with this technology.

Index Terms- Internet of things, 6LowPAN, Contiki OS, MQTT

1. INTRODUCTION

1.1. *Overview*

The internet of things can be defined as linking everyday equipments like mobiles, washing machines, televisions, sensors etc. to the internet world where it can be intelligently controlled and monitored. It enables various ways to establish communication between devices and humans [1]. In the fast growing world of Internet and communication innovation, our lives are progressively driven to another dimension of enhanced reality.
The importance of enabling IOT to the device has become significant since last couple of years. According to scientific research, 2 billion devices are expected to be connected to the internet by the year 2021 at the rate of 36% increase per year. New wireless technologies are being introduced to the market day by day and one among the new intervention is the 6LowPAN wireless technology, which introduces energy efficient and long range communication, most suited for industrial application [5].The 6lowPAN is the acronym for ipv6 low power wireless personal area network and the concept was introduced with the idea of providing internet protocol even to the smallest of devices.

1.2. *Advantage of the iot enabling system*

The sensor and actuator system are devices which we come across daily and if the system can be controlled remotely then it will be an added advantage for the users. This proposed system enables IOT to the needed products. The sensor data will be acquired from the system and is packed as data frame ,which is then send to the remote mote connected to the internet through ipv6 enabled 6lowpan wireless technology. The data can be monitored and controlled using smart phone mobile application if the phone have internet service [2].

2. PROPOSED SYSTEM AND ARCHITECTURE

The Block diagram representation of the proposed system is
shown below in figure 1.

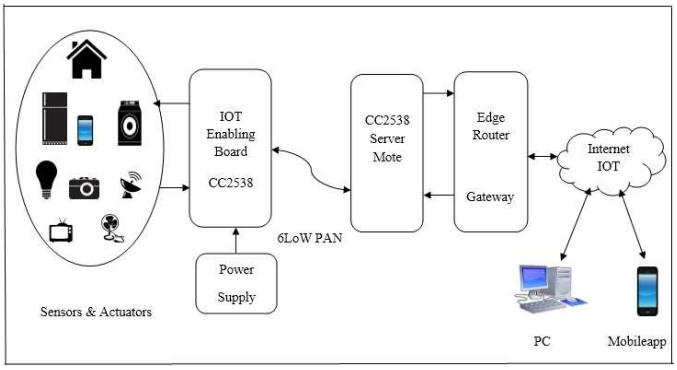

Fig 1 Block Diagram

The system which we need to control and monitor comprises of sensors and actuators. The devices like washing machine, air conditioners, lighting systems can be considered as the system mentioned here. The sensors like light sensor, temperature sensor, accelerometer can be connected to the internet to monitor the conditions.
The data acquired from the system is given to the input section of the client device. The data get processed in the controller and packed for transmission to remote mote. The mote will act as a transmitter while sensor data is monitored and as receiver in the controlling part of the system. The RPL (Routing protocol for low power and lossy networks) routing protocol is established by the device, with which this routers will act as ipv6 routers.
The receiver at the other end of the system which is located inside the transmission range of 6lowpan will

receive the packed data .The receiver node will be connected to the internet through an edge router. The receiver mote will forward the received data packet to the edge router.

The edge router is a device which acts as the entry point for a system to inter network. The receiver node will be connected to the edge router devices like beaglebone black, Rasberry pi, ENCH 28J60 etc. and cc2538 itself can work as edge router. These devices will connect the hardware to internet. The edge router with SPI connectivity will provide network connectivity to the micro controllers.

The cloud service and computing will provide on demand network access to devices and computers. The devices connected to the cloud can be monitored and controlled from anywhere if we have internet services. The cloud providers which can be explored for IOT are ibm cloud for internet of things, thingsqaure cloud etc.

2.1. *6LowPAN Protocol*

The 6Lowpan protocol stack comprise of IEEE 801.15.4 physical layer & MAC layer, adaptation layer, network layer, transport layer and application layer. The main distinction between OSI and 6LLowpan layer is the inclusion of adaptation layer.

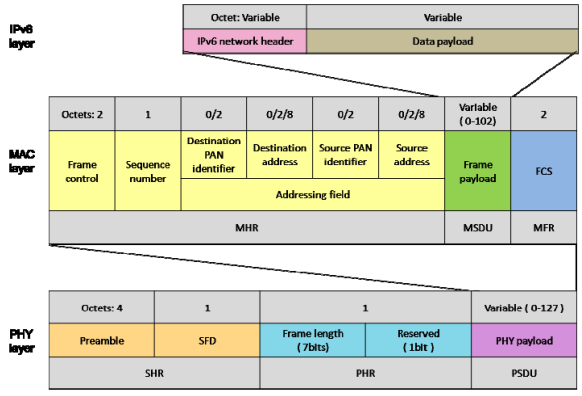

Fig 2 6LowPAN Stack

The physical layer provides two services PHY data service and PHY management service which includes radio transmission of data. PHY consist of synchronisation header, physical layer header and phy payload. SHR encompasses preamble & SFID and PHR encompasses frame length. The PHY payload should be a maximum of 128 bytes

The MAC layer enables data transmission and reception. MAC layer includes data frame for data transfer, beacon frame for synchronization, command frame for management entity and acknowledgement frame for acknowledgement. These headers are shown in the figure 2.

The Adaptation layer has three primary elements fragmentation and reassembly, header compression and routing. The maximum transmission unit of IEEE 802.15.4 is 127 bytes but ipv6 packets over IEEE 802.15.4 is 1280 bytes, since the packet size is larger than the frame size the data should be fragmented for transmission and the data is re assembled in the receiver end. The ipv6 header size is 40bytes, UDP and icmpv6 are 4 bytes each, and fragmentation header adds another 5 bytes IEEE 802.15.4 frame which has maximum packet size of 128 bytes so header compression is needed for efficient transfer.

The 6LoWPAN network layer provides the internetworking capability to sensor nodes. Auto configuration and neighbor discovery is established by network layer. The transport layer includes either UDP or TCP protocol. At the destination side the UDP or TCP packets are send by the network layer , the data are processed based on the protocol used for transmission and is transferred to the application layer. For specific application the 6lowpan application layer uses socket interface. Each application opens a socket which is used to receive or send packets

2.2. *RPL Routing*

RPL abbreviated as routing protocol for low power and lossy network, is used as routing protocol in 6Lowpan for energy efficient data transfer which is most suited for industrial application where energy consumption is the prime constrain. RPL provides an operation where multi point to point traffic from devices in the network to a central point and vice versa are supported. The LLN network consist of UDP client and UDP server which is the gateway.

RPL protocol starts when the root node triggers DODAG formation by sending DODAG information object message to neighbors. The root node rank will be 0 and the node rank gets updated while DIO message traverse. The node chooses its parent node which will act as the route to root node. The rank and the path will be formed as shown in the figure 3.

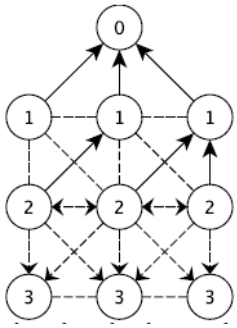

Fig 3 RPL Routing

UDP client is the node where the sensors and actuators are connected. UDP client mainly does two tasks, sets up UDP connection and transfer packet to the server/gateway periodically.

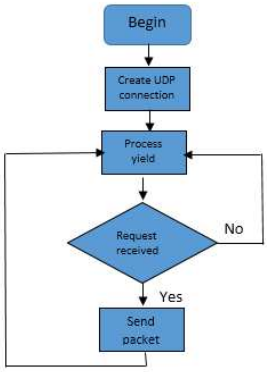

Fig 4 RPL Client

UDP server will act as the gateway for transferring the data from client to the network.The primary tasks of the UDP servers are initializing the RPL DAG (Directed acyclic graph), sets up UDP connection, delays for the reception of packet from the server and transfers to the gateway.

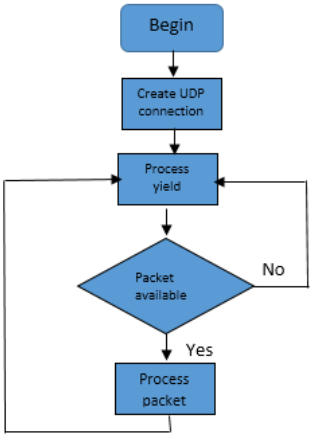

Fig 5 RPL Server

3. IMPLEMENTATION

In order to test the proposed model we have chosed the three colored leds in the board as the sensing and actuating systems. The leds have been IOT enabled using mobile app for monitoring and controlling.One CC2538 EM will act as the client with the LEDs and the other board acts as the gateway which is connected to ethernet board ENCH28j60 and then to Wifi router which is connected to internet . The prototpe of the proposed system is shown in the figure.

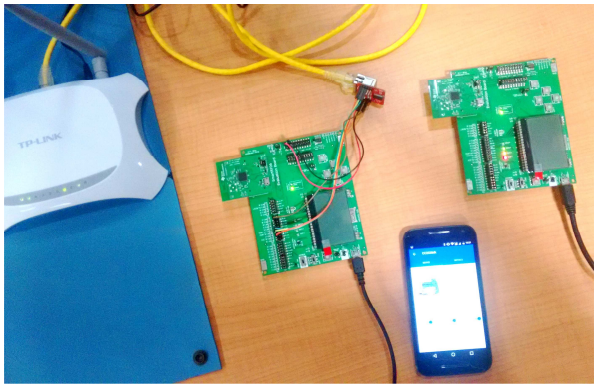

Fig 6 Prototype

The system is implemented in mqtt protocol which is for iot application, client in the system will act as the mqtt client and the server at the other end it acts as mqtt broker. It works as an ISO standard subscribe publish based protocol. The broker/server will be responsible for sending the data to particular client based on the topic.

3.1. *Hardware required*

3.1.1 TI CC2538 Development kit- It includes two RF evaluation modules, two development boards and sniffer for packet sniffing.CC2538 is an SOC ARM cortex M3 based processor which can be used for internet of things application and 6lowpan wireless communication

3.1.2 ENCH28J60 H- it is an Ethernet controller in a compact form and a lan connector with build in transformer. Provides the gateway to the internet through wifi router.

3.2. *Software required*

3.2.1. Contiki- It is an open source OS for the internet of things.Contiki provides a mechanism for energy efficient working of the hardware. Contiki provides cooja simulator which can be used for simulating ipv6 RPL 6lowpan multiple node simulation.

3.2.2. TI Smart RF Flash Programmer – It is used for programming the flash memory in ARM based TI products.

3.2.3. Wireshark- It is a free and open source packet analyser used to analyse the packets reveived using hardware TI packet sniffer.

4. RESULT

The client with inbuilt LEDs can be controlled and status can be monitored using mobile app which is connected to internet, which infers that any devices can be controlled and monitored using the proposed system.

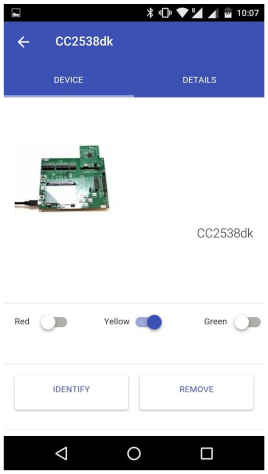

Fig 7 Mobile app screenshot

The simulation result of the ipv6 RPL 6Lowpan routing simulation is given below.

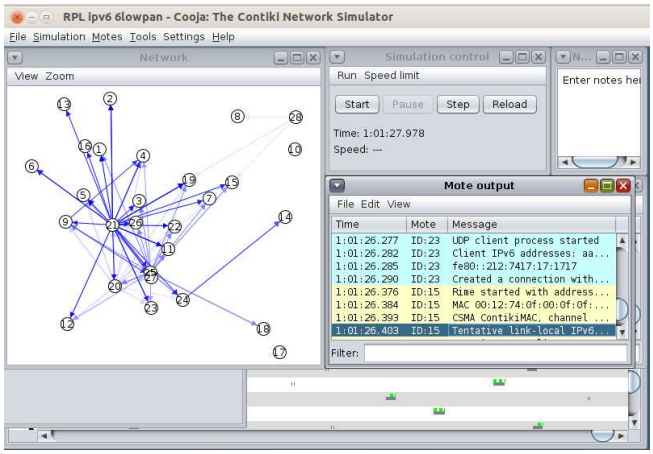

Fig 8 Simulation Screenshot

5. CONCLUSION

We have developed a system to enable internet access over 6lowpan wireless technology. There are several criteria's to be considered before automating devices, which is energy efficiency so we came up with TIs cc2538 with 6lowpan and contiki OS which brings out energy efficient IOT system. The system can be controlled from anywhere in the world by connecting to internet .

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