IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 13, Issue 3, Ver. I (May. - June. 2018), PP 48-54
www.iosrjournals.org

Development of 6lowpan Mote for IOT

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***Abstract*:** *Internet of Things (IoT) has emerged these last years as one of the most attractive subjects in both the research community and the public. Wireless Embedded Internet aims for efficient connectivity for embedded devices to the internet. This requires the embedded devices to run IPv6 protocol. 6LoWPAN is IPv6 over Low-Power Wireless Personal Area Networks. Raspberry Pi B+ module is used as processor and TICC2520 is used as RF module. Customize the Linux kernel and boot loader for Raspberry Pi. And develop device driver for RF module. Evaluate the system and make a comparison between various other wireless protocols.*

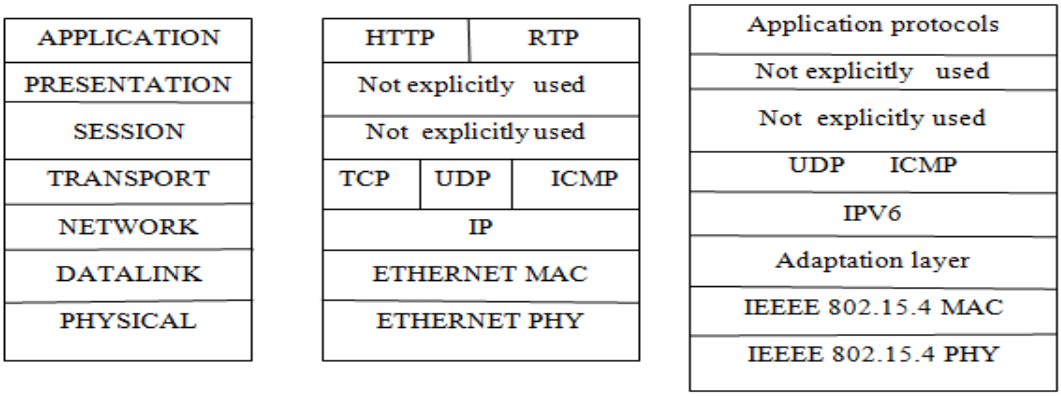
Date of Submission: 11-05-2018 Date of acceptance: 28-05-2018

I. Introduction

The Internet of Things is to be a next big challenge for the Internet research community and it has recently get significant research attention. Wireless sensor networks (WSNs) are considered as one of the most important elements in the IoT [1]. WSNs are most widely used in various areas to monitor physical and environmental conditions in the regions where human access is probably limited. In IoT applications such as Military purpose, Health care, Environmental monitoring, automotive applications etc, wireless sensor network are used. Wireless sensor network consist of sensor nodes. These sensor nodes are connected using wireless protocols such as Bluetooth, Wi-Fi, Zigbee etc. Bluetooth is short range of wireless technology. Wi-Fi based devices have large power consumption than other wireless protocols. Zigbee is for battery powered application which has low data rate, low cost and long battery life. It is based on IEEE 802.15.4 protocol. So it is most widely used in IoT applications for wireless transmission of data. Zigbee is a non IP based wireless technology where TCP/IP protocol is not used. Where wireless sensor network is a fast growing technology. Thousands of nodes and network are interconnected for large applications. Ipv6 over low power area network is 6LoWPAN is defined by Internet Engineering Task Force.6LoWPAN-based WSNs consist of Low Power objects equipped with sensors. They use IEEE 802.15.4 as the physical layer standard [2].That is through 6LoWPAN we get a IP enabled wireless sensor node. 6LoWPAN sensor nodes are characterized by short range, low bit rate, low power, low memory usage, low cost.

II . 6LoWPAN OVERVIEW

A LoWPAN is a low power personnel area network. It is a simple low cost communication network that allows wireless connectivity in IoT applications with limited power and relaxed throughput requirements. LoWPAN has IEEE802.15.4 protocol.IPV6 over Low power personal area network is 6LoWPAN which simply introducing IPV6 functionality in to wireless communication protocol. The 6LoWPAN was designed to enable the transmission of IPv6 packets over Low Power Wireless Personal Area Networks (LoWPANs). This enforces carrying IPv6 packets over IEEE 802.15.4 frame [3]. 6LowPAN uses an adaptation layer between the network layer and data link layer (IEEE802.15.4 MAC) to fragment and reassemble IPv6 packets. 6LoWPAN routing protocols must support 16-bit short and 64-bit extended MAC addresses. IP routing protocols are used to maintain routing tables on IP routers which indicates on which next-hop forwarding decision should be made for the destination of an IP packet.

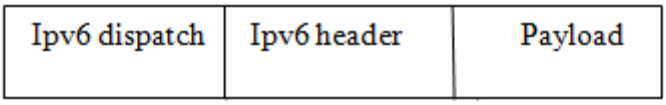


Protocol stack of ISO/OSI,TCP/IP and 6LoWPAN

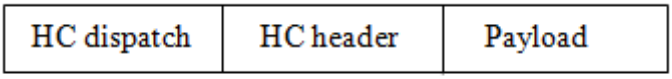
HEADER	SECURITY HEADER	FRAGMENT HEADER	IPV6 HEADER	UDP	PAYLOAD	FOOTER
23 BYTES	21BYTES	5BYTES	40BYTES	8BYTES	28 BYTES	2 BYTES

IEEE802.15.4 FRAME FORMAT

In 6LoWPAN protocol stack physical layer provides the basic communication in the network. It transmits the data bits over 802.15.4 by converting them into signals. The task of Data link layer is to detect and correct the errors which may occur during transmission of data. Medium access layer is present in data link layer. Adaptation layer is present between network layer and data link layer. It optimized the transport of packets in the IEEE 802.15.4 frame. It provides header compression mechanism for IPv6, UDP and ICMP headers. It provides sufficient fragmentation and reassembly of packets. Network layer which provides routing of the packets on the basis of Internet Protocol. This IP protocol provides addresses to the nodes. Communication between these nodes using transport layer.TCP, UDP and ICMP are the protocols used. UDP is preferred more than TCP. Because UDP has less complex and small header size. It offers end-to-end IP addressable nodes. Therefore in 6LoWPAN networks there is no need of gateways, routers to connect to IP. Fragmentation and Reassembly of packets, Maximum transmission unit (MTU) of IPv6 packets is of 1280 bytes. IEEE 802.15.4 have packet size is only 127 bytes. So in 6LoWPAN for successful transmission of this IPv6 packets over 802.15.4 frame is achieved by fragmentation. They need to be fragmented, transmitted and reassembled after reaching at destination. Reassembling process takes place at adaptation layer of receiver node.6LoWPAN the Maximum Transmission Unit of a packet is 127 bytes. Fig 4.1.2 shows the frame format IEEE of 802.15.4 . Out of this 127 bytes, link layer header has 23 bytes, 21 bytes for security header, 5 bytes takes fragment header and 2 bytes for footer. The upper layer headers are IPv6, TCP and UDP .They takes 76 bytes. Header compression is performed on adaptation layer . 6LoWPAN have two types of header compression, they are IPv6 header compression (HC1) and UDP header compression (HC2).



A LoWPAN encapsulated IPv6 datagram



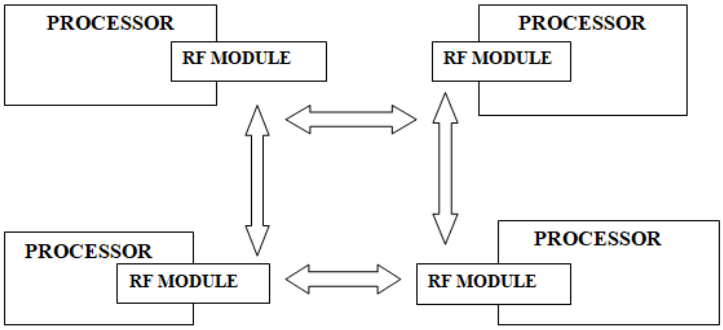
LoWPAN encapsulated LoWPAN Header compressed IPv6 datagram

The IPv6 packets will have huge size. So several header compression scheme is used to reduce the header size of data packet. Header compression is the process of minimizing the header size of a packet before the packet is being transmitted and decompressing the received header to its original form in the receiver side. Through this we can increases the data transmission rate of the network. 6LoWPAN routing protocols have small code size. 6LoWPAN technology reduces power consumption and improves robustness and easy to analyze because of low complexity. It has short range, low cost and low bit rate. This protocol enables all the capabilities of IPv6 on every sensor nodes in the network and thus opens new path to the IoT.

III. 6LoWPAN MOTE

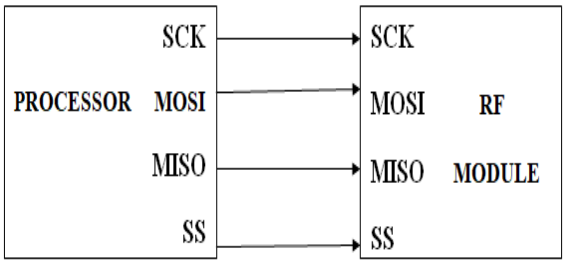
IoT application comprised of several sensor nodes for wireless data communication. Each sensing node consists of a processor and a RF module. A sensor node is also called mote. Each node is capable for collecting and processing sensing data and communicating with other interconnected nodes in the network. Here IPv6-enabled low power wireless personal area network (6LoWPAN) is used as wireless protocol for data transmission between each sensor node. 6LoWPAN carry packet of data in the form of IPv6 over IEEE 802.15.4 frame. It provides a IP enabled network with less power consumption. For experimental setup here, it consists of four sensor nodes or motes. Each node consists of a processor and a RF module. Processor is the heart of system which that takes inputs data and produces an output after processing this data. Processor have a Control Unit and Execution Unit .The control unit for fetching instructions from the memory. The Execution unit has circuits that implement the instructions for data transfer operation and data conversion from one form to another. Processor usually has small in size, and consumes less amount of power.

Sensor nodes usually consumes much less amount of power and have high performance. While designing sensor node, select a processor which operate in a power constrained environment with high performance. Here Raspberry Pi B+ module is used as processor. Because it is a fast processor with better power management and have low cost. RF Module (Transmitter & Receiver module) operates at Radio Frequency. This RF module comprises of an RF Transmitter and an RF Receiver. RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected to it. Here TICC2520 is used as RF module. The TICC2520 is second generation Zigbee or IEEE 802.15.4 RF transceiver for the 2.4 GHz frequency band. It provides extensive hardware support for frame handling, data buffering, burst transmissions, data encryption, data authentication, clear channel assessment, link quality indication and frame timing information. These features reduce the load on the processor.



Block diagram of 6lowpan mote

Interface between processor and RF module is using SPI protocol. The fig.3.2 shows serial interface between processor and RF module. Serial peripheral interface (SPI) protocol is used for communication between processor and RF module. It is a synchronous serial communication interface used for short distance communication with high speed. It is a simple four wire serial communication interface bus. In Serial peripheral interface bus data is shifted in or out one at a time and transmit data from master device to or from one or more slave devices over short distances with high speed. It have four interface pins they are MOSI (master out slave in), MISO (master in slave out) ,SCK (serial clock),SS(slave select). It have separate clock and data lines. Select line used to choose the slave device for communication.



Interfacing between processor and RF module

- MOSI (Master Out/Slave Input)– Line for the master to send data to the slave.
- MISO (Master Input/Slave Output) – Line for the slave to send data to the master.
- SCLK (Clock) – Line for the clock signal.
- SS/CS (slave select or chip select)- Line for the master to select which data send to which slave

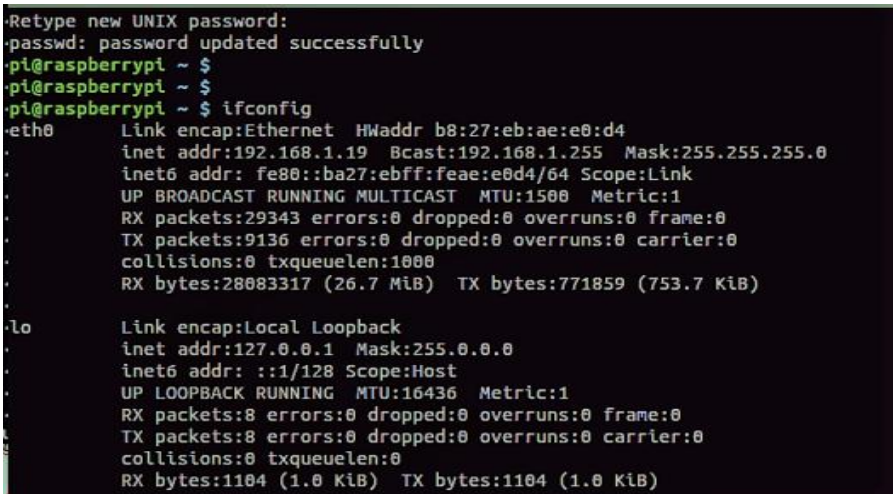
Raspberry Pi is a good platform for linux based systems. Raspberry Pi is a small single board computer was developed by Raspberry Pi foundation in United Kingdom. It has small size, low cost and also has low power consumption. Raspberry Pi model B+ is used for development of 6LoWPAN mote. It is used as processor.The raspberry pi board comprises a program memory (RAM), processor and graphics chip, CPU, GPU, Ethernet port, GPIO pins, UART, power source connector. And it has various interfaces for other external devices. SD flash memory card can be used mass storage.

Therefore Raspberry pi board can boot using SD card .Linux is commonly used free and open source operating system. It is flexible and powerful operating system built around the Linux kernel .Linux can be portable to any hardware platform. Source code for this software is freely available so anyone can work on it, change it, or enhance it. Developers are encouraged to pass their fixes and improvements back into the community so that Linux can continue to grow and improve. IEEE 802.15.4 modules are avilable and they can easily turn rasberrypi into a 6lowpan mote. Customize Linux kernel and boot loader for this Raspberry B module. Develop a device driver for TICC2520 module with 6LoWPAN utilities. And successfully evaluated power and data transmission rate of the network.6LoWPAN IoT network have less power consumption and high data transmission rate than other wireless protocols.

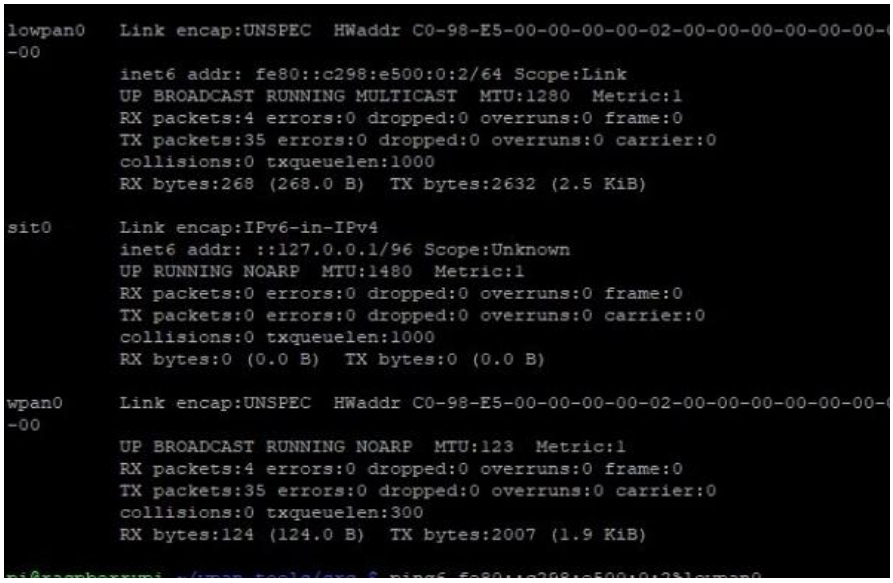
Experimental setup of 6LoWPAN MOTE

IV. Results And Discussion

In this system includes accomplishment of communication based on the TICC2520 and 6LoWPAN subsystem with low cost and low power embedded platform which supporting Linux.

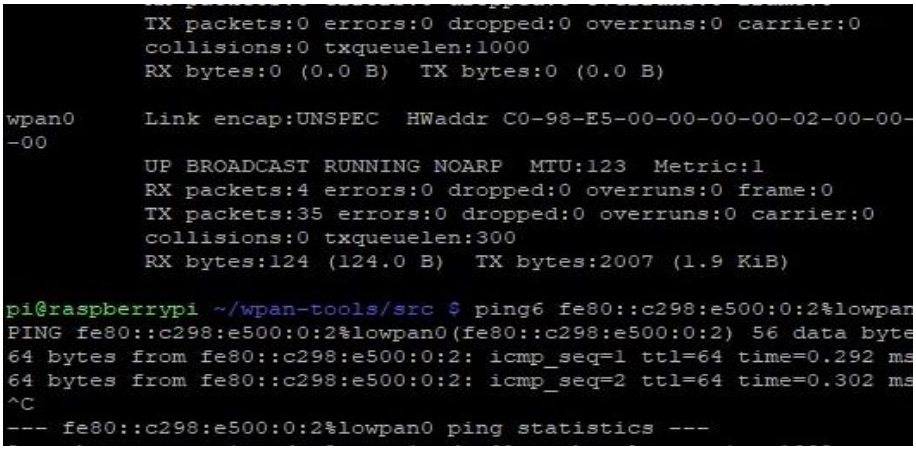


Interface configuration without 6LoWPAN support

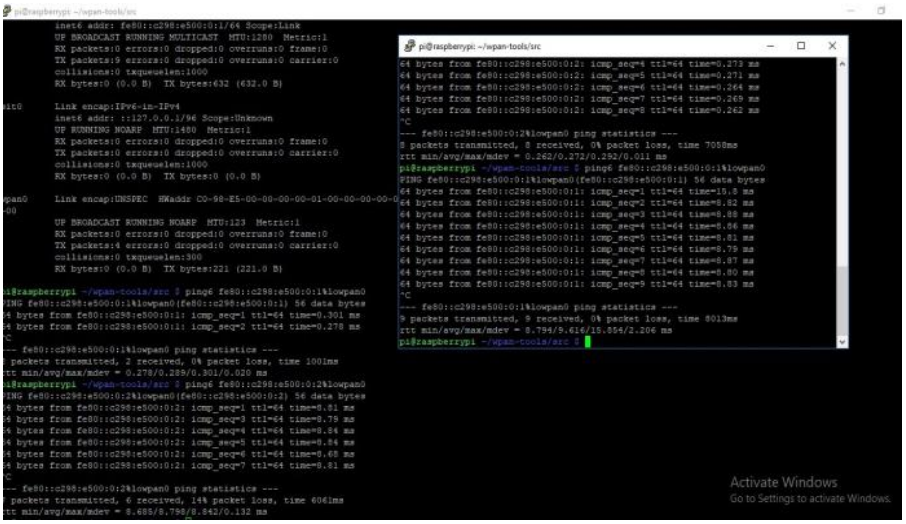


6LoWPAN support is enabled

We will configure two LoWPAN device with a Pan-id0X022.
Having hardware address co:98:e5:00:00:00:00:01 and co:98:e5:00:00:00:00:02.
For first node - ping6 Fe80:c298:e500:0:1
For second node - ping6 fe80:c298:e500:0:2



Communication for a sensor node



Communication between two sensor nodes using 6LoWPAN protocol

V. Conclusion

In IOT applications thousands of sensors are used for data communication. The 6LoWPan technology is simple wireless mesh technology that makes the individual nodes as IP-enabled**.** It provides the wireless sensor network (WSN) node with IP communication capabilities by putting an adaptation layer above the 802.15.4 link layer. IoT 6LoWPAN sensor node has less power consumption and higher data transmission rate than wireless protocols. In this paper we implemented a 6LoWPAN wireless sensor node with embedded Linux platform and a low power 802.15.4 radio. Through we can simplifies task of interconnecting wireless sensor node with internet, without any intermediate gateways. 6LoWPAN protocol offers encapsulation and header compression mechanisms for IPv6 packets to be sent to and received over IEEE 802.15.4 based networks. So packets can easily be forwarded over the link layer.

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IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) is UGC approved Journal with Sl. No. 5016, Journal no. 49082.

Krishnendu P, "DEVELOPMENT OF 6lowpan MOTE FOR IOT." IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) 13.3 (2018): 48-54.