Performance Evaluation of MAC Protocol for IEEE 802.11, 802.11Ext. WLAN and IEEE 802.15.4 WPAN using NS-2

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ABSTRACT
The wireless communication has shown its improvement in sensor skills which motivates the wireless sensor networking. IEEE 802.15.4 was created with having few tremendous advantages like low-power ,very low cost and low energy consumption in wireless consumption From the last few years it has been used in man applications including hospitals, hotels, home, industrial controlling networks and the environmental monitoring. It is the basic standard which specifies the MAC layer and Physical layer for low rate wireless PAN at 2.4GHz ISM band. IEEE802.15.4 is susceptible to interference from the other wireless technologies such as IEEE802.15.1 and IEEE80.11. Here we have given a overview of the IEEE 802.15.4 and IEEE 802.11 and analyse the performance of IEEE 802.15.4 and IEEE 802.11. The parameters on which the simulation is done are packet loss, packet received, End-to-End delay, Energy consumption, bandwidth used and packet delivery ratio by using NS2 simulator software. The final simulation results evaluated by taking 30 and 50 nodes for both 802.11 and 802.15.4 based networks.

Keywords
Wireless personal area network , Mac, IEEE 802.11, IEEE 802.11 Ext. IEEE 802.15.4, NS2

1. INTRODUCTION
With the advancement in the wired and wireless networks, the technology is improving at very fast rate in which the wireless groups are more concentrating on the automation which may be in home or in the office. The Low Rate wireless PAN such as wireless light switch in lamps, advance wireless electrical equipment and wireless home displays etc. which needs low rate data transfer and low rate data transfer and low energy consumption. Zig-bee is the latest technology which is based on IEEE802.17.4 standard for WPAN. It is widely used in radio frequency applications as it is also require low data rate, secure networking and giving a long battery life. It is less costly than the other WPAN's like Bluetooth and Wi-fi technology. IEEE802.15.4 standard is trying to resolve the issues coming n Bluetooth technology. There are many IEEE papers through the literature review are reviewed based on both technologies to understand the different working processes. There are many ideas and techniques used in different papers are observed to implement on my paper. The wireless sensor networks and the zig-bee technology which is based on wireless personal area network have very clearly explained in the paper .IEEE 802.15.4 is different from other wireless standards such as IEEE 802.15.4 and IEEE 802.11 by having some unique features that is clearly defined in the paper. The power consumption in Wi-Fi is very high which affects the battery life miserably in mobile devices so the use of Wi-Fi over wider ranges is very limited. Wifi and Zig-bee technologies both operate in the 2.4GHz ISM band so its very important to evaluate the coexistence issues come in both of these technologies and how they affect each other. In this paper we have analysed the performance of IEEE802.15.4 and IEEE 802.11 standards. There are few important parameters on which the simulation is done are packet loss, packet received, energy consumption, packet delivery ratio, bandwidth used and End-to-End delay using Network Simulator 2 (NS2) and then after we have analysed the performance by taking 30 and 50 nodes in the wireless network

2. INTRODUCTION TO IEEE 802.11
It is a combination of MAC layer and PHY layer specifications for executing WLAN in 2.4, 3.6, 5 and 60 GHz frequency bands. They have formed and continued by the LAN and MAN Standards Committee of IEEE 802 family. The 802.11 family contains a chain of modulation techniques.

The most prevalent are those which the amendments to the original. standard network. IEEE 802.11 was the first wireless standard developed, but 802.11b was the first one which Used widely, trailed by IEEE802.11g, IEEE802.11a and IEEE802.11n..802.11b and 802.11g use the 2.4 GHz ISM band, operating in the United States under the U.S. Federal Communications Commission. Because of this choice of frequency band,802.11 band equipment's may occasionally suffer interference from microwave ovens, cordless telephones and Bluetooth devices .IEEE802.11 band IEEE802.11g control their interference and susceptibility by using DSSS and OFDM signal techniques.

2.1 Medium Access Control Layer
The MAC sub layer IEEE 802.11 deals with wired and wireless communication for multiple nodes within a LAN or Metropolitan Area Network . The MAC sub layer is responsible for the channel allocation procedure, error checking, Protocol Data Unit addressing, frame formatting, and fragmentation and reassembly. The Distributed Coordination Function (DCF) is the fundamental access method of IEEE 802.11 MAC which is used by stations to transmit data, contend to access the channel. PCF wastes the channel bandwidth when stations responds to a poll command by transmitting a null packet. That is why PCF is not broadly used for commercial Access Points (APs). Request to Send/Clear to Send (RTS/CTS) is another optional method that can be implemented on top of the DCF to improve the performance of channel accessing by reserving the medium for a given frame. Three different frames such: management frame, control frame, and data frame are supported by IEEE 802.11

2.1.1 DCF
The DCF is a MAC technique based on the CSMA/ CA protocol to change the medium. Receiver node transmits an

ACK frame to the transmitter after every frame reception to inform that transmission was successful. Priority of different type of frames can be controlled by utilizing Inter frame Space (IFS). The standard defines three different IFS intervals: Short IFS (SIFS), PCF Inter frame Space (PIFS) and DCF Inter frame Space (DIFS).Before stations try to access the channel, they should sense the channel to be ideally constant. If a station senses that the channel is idle, it waits for a IFS period according to the packet type and then after that, it checks the channel again and If the channel is still idle, station can access to the channel. ACK frame that has the smallest IFS, i.e. SIFS, is able to access the channel faster compared to the data frame.

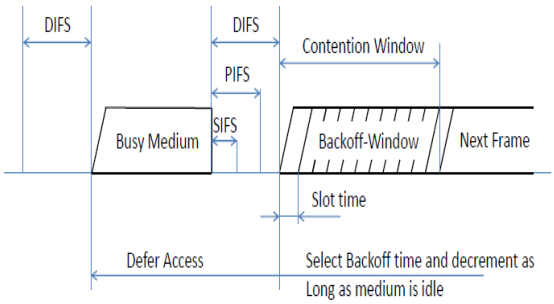

Fig. 1 working of DCF

2.1.2 RTS/CTS

When a source station is not able of listen to the channel during its transmission, the whole MAC Protocol Data Unit (MPDU) is transmitted even though collision occurs. Collision mostly occurs in the CSMA/CA mechanism due to the hidden stations which are not in position of sensing the transmission of originating station. Request to send (RTS), Clear to Send (CTS) control frames can be utilized to reserve the channel prior to the MPDU transmission and minimize the collision time. Source station transmits a RTS control frame before the MPDU and informs the destination about the duration of MPDU to be transmitted. Other stations set their Network Allocation Vector (NAV) on hearing this message and reading the time duration. Waiting time is indicated by NAV that station must wait until on-going transmission session is completed. Destination station responds the RTS with CTS immediately just after a SIFS period. Stations including hidden stations after hearing the CTS message, from source station read the duration held and update their NAV. Source station starts to transmit MPDU after successful reception of CTS on a reserved medium. Other stations can also access the channel after destination station transmits a ACK message.

3. WIRELESS PAN STANDARDS

In recent years we have witnessed a great development in WPAN technology. The advantage of WPAN is its low cost and low power consumption during transmission but it decreases the transmission range and rate. The other name of this is short distance wireless networks. This technology is just opposite the WLAN technology. WLAN technology have higher rate and longer range which increase the cost and power. For theoretical part, we used IEEE 802.15 serial standard. IEEE 802.15 serial standards are established by IEEE 802.15 Working Group for Personal Area Network.

3.1 IEEE 802.15.1 (BLUETOOTH)

The lower layer transport layer of the wireless Bluetooth technology was defined by 2002 Standard. The standard adaptation of the Bluetooth Specification Foundation MAC and PHY (Radio) was provided by them. It also has done reviewed and specifies the other related aspects. This all thing is done mainly to establish the implementation Bluetooth device. By definition, Bluetooth is defining as a wireless technology used for exchanging data over short distances. It is an alternative to RS-232 data cable and used for solving the problem of synchronization. Bluetooth use the radio waves in the ISM band from 2.4 to 2.485 GHz. It works between fixed and mobile devices, and used in building personal area networks (PANs). The Bluetooth was originally standardized as IEEE 802.15.1, but the standard is not maintained longer. Bluetooth Special Interest Group (SIG) manages the qualification programs, specification development, and trademark protection for Bluetooth. Any device which qualify the standards define by SIG can be marketed as Bluetooth device. SIG is working in the areas of telecommunication, computing and networking with more than 20,000 members. The specifications are given in the table below. Bluetooth is mainly designed for low power consumption. It has short range because each device has low-cost transceiver microchips. Because the devices use a radio communications system, it also known as standard wire-replacement communications protocol. Bluetooth have radio communications system but they do not have to be in visual line of sight of each other. There are several factors on which the effective range of Bluetooth depends such as battery conditions, propagation conditions and antenna configurations. In indoor application like in home, the attenuation of walls and signal fading will make the range lower than the specified line-of-sight ranges for Bluetooth products**.**

3.1.1 IEEE 802.15.1 vs. IEEE 802.11

Bluetooth and Wi-Fi are almost same in applications like network setup, transferring files and printing. Wi-Fi sometimes called wireless local area networks (WLAN). It was intended to replace high speed cabling for local area network access. Bluetooth sometimes called wireless personal area network (WPAN) and it was intended for portable equipment and their applications by replacing cable in a variety of personally carried applications or fixed location applications. Wi-fi and Bluetooth are also complementary to each other at some extant in terms of their applications and usage. Wi-Fi has usually a fixed access point say centre, and asymmetrical client-server connection, while in Bluetooth has usually symmetrical client-server connection say between two Bluetooth devices. Bluetooth have lower speed but simple connection configuration as compared to Wi-Fi. Ad-hoc network connections are possible with Wi-Fi though not as simply as with Bluetooth

3.1.2 IEEE 802.15.4

Wireless medium access control sub layer and physical layer (PHY) specifications for low-rate wireless personal area networks (WPAN) were specifies by IEEE 802.15.4. It was developed by the Institute of Electrical and Electronics Engineers (IEEE).Its main purpose is to make the communication between two devices. Coexistence analysis of WLAN and WPAN in Zig-bee is also explored by it. The layer called as the physical (PHY) layer and the MAC sub layer of Zig-bee were specified in IEEE 802.15.4.

4. ZIG-BEE TECHNOLOGY

Zig-bee technology is a standard that defines a communication layer at level 3 and in the OSI model it is upper layer with a main motive of creating a network topology with some extra features of communication like authentication, encryption, association where number of devices communicate with each. Zig-bee Alliance a set of few companies was created the Zig-bee technology. Zig-bee is a specification for a suite of high level communication protocols used to create personal area networks built from small, low-power digital radios. Zig-bee is based on an IEEE 802.15 standard. Though low-powered, Zig-bee devices can transmit data over long distances by passing data through intermediate devices to reach more distant ones, creating a mesh network; i.e., a network with no centralized control or high-power transmitter/receiver able to reach all of the networked devices. The decentralized nature of such wireless ad hoc networks make them suitable for applications where a central node can't be relied upon.

Zig-bee is used in applications that require only a low data rate, long battery life, and secure networking. Zig-bee has a defined rate of 250 kbps, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates. The technology defined by the Zig-bee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth or IEEE 802.11aIEEE 802.11a has been described in the specification of 1999 whereas the OFDM waveform specified in 2012 at 5.8 GHz which gives protocols that allow transmission and reception of data at 1.5 to 54 mbps. It has seen a worldwide execution in the corporate world of wireless LAN. As the original amendment is not valid now, IEEE802.11a used by wireless access point producers

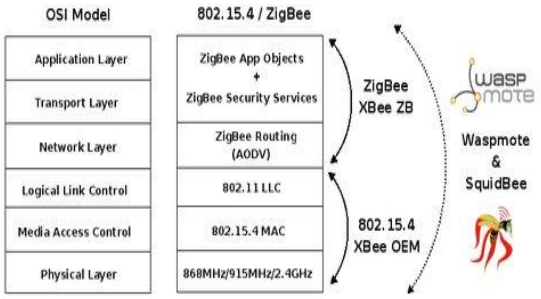

Fig. 2 Zig-bee Upper layer

5. IMPLEMENTATION

Implementation is carried out using window based Network Simulator 2(NS2). Several script have been written by taking 30 and 50 nodes for 802.11,802.11 Ext. and 80215.4 networks.NS2 is an open source event driven simulator designed especially for research in computer communication networks.NS2 provides the simulation an d research supports for the wired networks, wireless networks by using TCP and UDP,IP and CBR pattern of communication .

Needs & benefits:

- Real environment is not easily accessible in terms of cost.
- Simulation is Cheap: It does not require costly equipment.
- Complex scenarios can be easily tested.
- More ideas can be tested in a smaller time-frame.
- Controlled experimental conditions.
- Repeatability is time and cost efficient which proves beneficial in debugging.

Different Parameters Used:

- .Packet delivery ratio
- .Packet loss
- Packet received
- Energy consumption
- End to end delay
- Bandwidth used

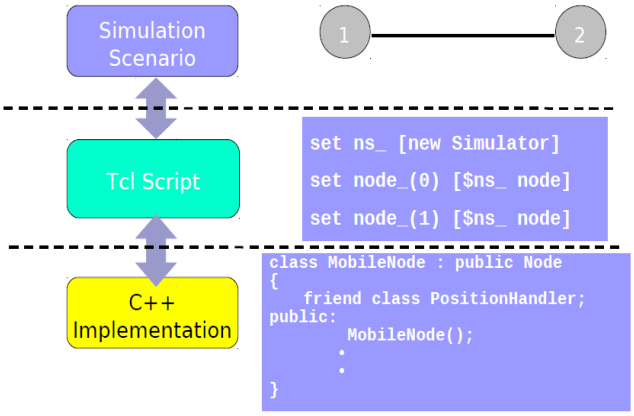

Fig. 3 NS2 simulation scenario

6. BAR GRAPH RESULTS

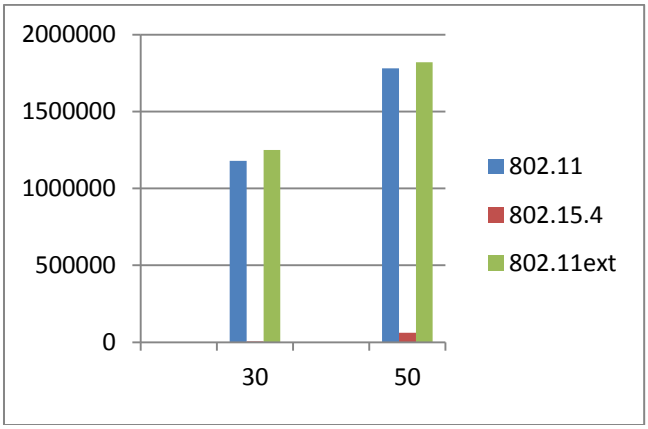

Fig. 4 Bar Graph comparison for bandwidth used

In fig 4, if we compare the bandwidth usage over 30 and 50 nodes then for 30 nodes IEEE 802.11ext. protocol has used up the largest bandwidth while IEEE802.15.4 protocol has used up lowest bandwidth. For 50 nodes IEEE 802.15.4 protocol used up the lowest bandwidth while IEEE 802.11ext. protocol used the largest bandwidth..

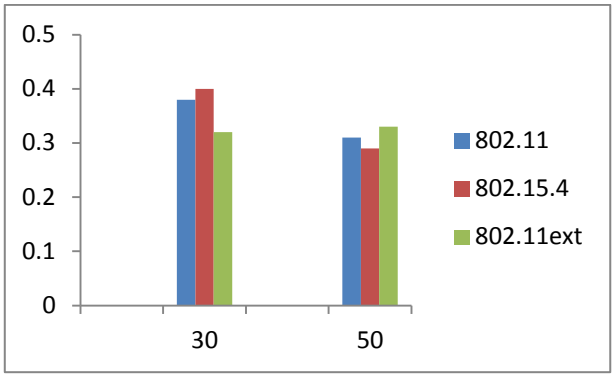

Fig. 5 comparison for packet delay

In fig 5, we can compare the parameter packet delay over 30 and 50 nodes. For 30 nodes, IEEE 802.15.4 protocol has given the lowest packet delay while IEEE802.11ext. has given up the largest delay of packets. For 50 nodes, IEEE 802.11ext. has given up the largest delay in the packets while IEEE 802.15.4 has given the smallest packet delay.

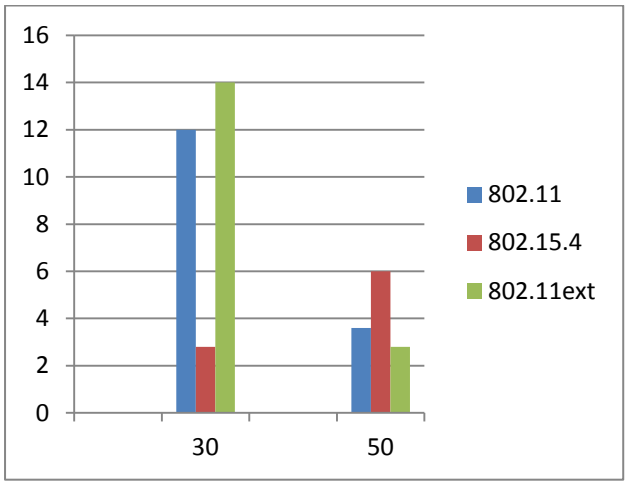

Fig.6 comparison of packet loss

In fig, we can compare the packet loss over 30 and 50 nodes. For 30 nodes, IEEE 802.15.4 has the lowest packet loss while IEEE 802.11ext. has the highest packet loss and for the 50 nodes, IEEE 802.11ext. has the lowest packet loss and IEEE 802.15.4 has the highest packet loss.

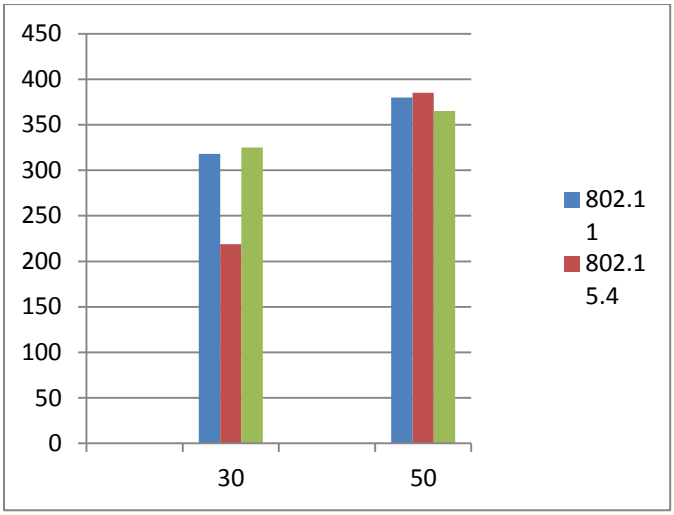

Fig.7 comparison of packet received

In figure 7, we can compare the packet received over 30 and 50 nodes. For 30 node, IEEE802.15.4 has received the lowest number of packets while IEEE802.11ext. has received the highest number of packets and for 50 nodes, IEEE 802.15.4 has received the largest number of packets while IEEE 802.11ext. has received the lowest number of packets.

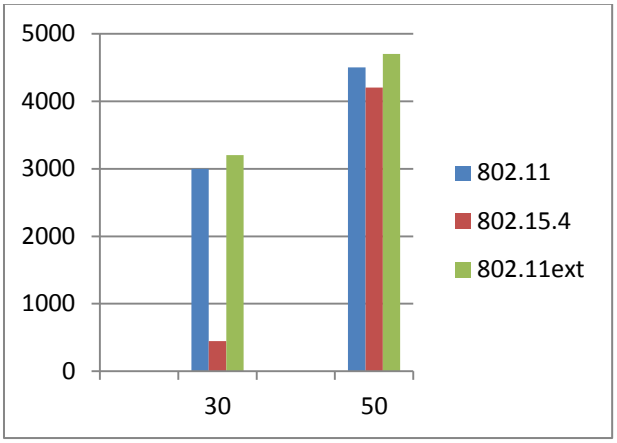

Fig. 8 comparison for energy consumption

We can compare the parameter for energy consumption over 30 and 50 nodes. For 30 nodes, IEEE 802.11ext. protocol has consumed the highest energy while IEEE 802.15.4 has consumed the lowest energy. For 50 nodes, IEEE 802.11ext. protocol has consumed the largest energy while IEEE802.15.4 protocol has consumed the lowest energy.

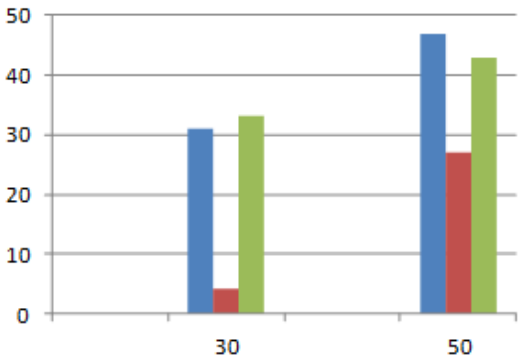

Fig. 9 comparison of packet delivery ratio

We can compare the parameter packet delivery ratio over 30 and 50 nodes. For 30 nodes, IEEE 802.15.4 protocol has given the lowest packet delivery ratio while IEEE 802.11ext. has given up the highest packet delivery ratio. For 50 nodes, IEEE 802.11 has given up the highest packet delivery ratio while IEEE 802.15.4 has given up the lowest packet delivery ratio.

Table 1.Performance comparison of 30 nodes

PARAMETERS	IEEE802.11	IEEE802.15.4	IEEE802.11 EXT
Bandwidth	1180000	6700	1250000
Routing delay	0.38	0.40	0.32
Energy consumption	3000	450	3200
Packet loss	318	209	325
Packet received	12	2.8	14
Packet delivery ratio	31	4	33

Table 2.Performance comparison of 50 nodes

PARAMETERS	IEEE802.11	IEEE802.15.4	IEEE802.11 EXT
Bandwidth	1780000	61000	1820000
Routing delay	0.31	0.33	0.29
Energy consumption	4500	4200	4700
Packet loss	380	364	385
Packet received	3.6	6	2.8
Packet delivery ratio	47	43	27

7. CONCLUSION

There are many wired and wireless sensors network applications which has covered a wide range for industrial and home markets in which WLAN and Zig-bee are the most famous technologies. For 802.15.4 standard applications requires low power consumption and less complexity and longer battery life which are better than the other wireless standards using in the market like Bluetooth and Wi-Fi. There was a need of wireless technology that can overcome the above needs. So, IEEE802.15.4 has developed which is being used up in the global sensors and monitoring network standard in the indoor and outdoor environment. Here the performance of IEEE 802.15.4, 802.11, 802.11ext. standards are evaluated over the 30 nodes and 50 nodes through various parameters like Packet delivery ratio, End-to-End Delay and Packet Loss, Packet Received, Energy Consumption and Bandwidth Used parameters. From the simulations we have found that performance of IEEE 802.15.4 with respect to the bandwidth used, packet loss and energy received parameter for 30 nodes is better as compared to IEEE802.11 and 802.11ext. whereas the performance of IEEE 802.11ext. with respect to packet delay, packet received packet delivery ratio for 30 nodes is better as compared to IEEE 802.11 and 802.15.4 wireless standard. For 50 nodes again IEEE 802.15.4 WPAN gives the better performance with respect to the bandwidth used, packet delay, packet received and energy consumption parameters then the IEEE 802.11 and 802.11ext.WLAN. EEE802.11ext. gives the better performance with respect to the packet loss parameter for 50 nodes then the IEEE 801.15.4 and 802.11. while IEEE 802.11 gives the better performance over the packet delivery ratio parameter for 50 nodes then the IEEE 802.11ext. and 802.15.4 wireless standard.

8. FUTURE WORK

We analyse the performance of IEEE 802.11 and 802.11ext. WLAN standard as compare with IEEE 802.15.4 WPAN standard. In the simulation results, we have seen and evaluate different parameter like packet delivery ratio, packet loss, packet received, energy consumption, end to end delay and bandwidth used. Our future work includes the study of various other parameters of 802.11a, 802.11b, 802.11g, 802.11n WLAN standard and 802.15.4 WPAN standard on transport layer using DYMO protocol. The 802.15.4 WPAN standard on transport layer called the Zig-bee Alliance. The work can be further extended for the study on various other parameters.

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