PERFORMANCEOF IEEE 802.15.4 IN VARIOUS TRAFFIC PATTERNS

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Abstract: *"***For** low rate wireless personal area networks (LRWPANs), a new standard IEEE 802.15.4 is uniquely designed. ZigBee, a low-cost, low-power, wireless mesh networking standard is designed for wireless Automation and other lower data tasks such as smart house automation and remote area monitoring". The low cost allows the technology to be widely deployed in wireless control and monitoring applications. The low power usage allows for a long life with smaller batteries, and the mesh networking provides high quality of being trustworthy in larger range. Due to its low-cost and low-power usage this wireless technology is widely used in House Automation, Smart Energy, Telecommunication Applications, Personal House, and Hospital Care. ZigBee enables new opportunities for wireless sensors and control networks. ZigBee is standard based, low cost, reliable and self-healing, supports large number of nodes. It can be used globally. This is easy to deploy because of its long battery life and it is secure. In non-becon enabled mode and under moderate data rate, the new IEEE 802.15.4 standard, compared with IEEE 802.11. It is more efficient in terms of overhead and resource consumption. It also enjoys a low hop delay (normalized by channel capacity) on average. In beacon enabled mode, an LR-WPAN can be flexibly configured to meet different needs, such as link failure, self-recovery and low duty cycle. In both beacon enabled mode and non-beacon enabled mode, association and tree formation proceed smoothly and the network can shape up efficiently by itself.

This study has been undertaken to investigate, analyze the performance of IEEE 802.15.4 standard protocolusing three different traffics(CBR, Poisson, FTP). We are using NS2 simulator to analyze the performance. Our results show that CBR traffic achieves higher packet delivery ratio(PDR), higher throughput and lower packet loss.

***Index Terms* – ZigBee, Becon enabled, WPAN, NS2.**

I. INTRODUCTION

A wireless network connection such as Wi-Fi allows houses, telecommunications networks and businesses to avoid the process of using cables in a building or between equipment locations though it is very expensive. Using radio communication, Wireless telecommunications networks are administeredand implemented. This implementation takes place at the physical level (layer) of the OSI model network structure. We use PAN(Personal area network) for communication amongcomputerized devices, including personal digital assistants, telephones . This can be used for intrapersonal communicationamongthe personal devices, or for connecting to a higher level network in the Internet . A wireless personal area network (WPAN) is a computer network for inter connecting devices centered on an individual person's workspace. WPAN is a PAN carried over wireless network technologies such as: IrDA, Wireless, Bluetooth, Z-Wave, ZigBee.

1.1 Body Area Network

The reach of a WPAN varies from a few centimeters to a few meters. A PAN may also be carried over wired computer buses such as USB andFireWire.

a. WIRELESS PERSONAL AREA NETWORK

A wireless personal area network (WPAN) — a network for interconnecting devices centered around an individual person's workspace. These connectionsare totally wireless. Wireless PAN is based on the standard IEEE 802.15. Bluetooth and Infrared Data Association are the two kinds of wireless technologies used for WPAN .A WPAN could serve. Many people carry with them WAPAN which serve to interconnect all the ordinary computing and communicating devices It also allows the surgeons to communicate during an operation.A key concept in WPAN technology is known as "plugging in". When any two WPAN-equipped devices becomevery close i.e. within a fewkilometers of a central server, they can communicate as if connected by a cable. Another feature of this technology is to enable each device to lock out other selective devices which prevent unauthorized access to information.

This WPAN technology is in infant stage and is undergoing rapid development. Proposed operating frequencies are around 2.4 GHz in digital modes. The objective is to facilitate seamless operation among houses or business devices and systems. Each device in a WPAN will be able to plug into any other device in the same WPAN, those are within physical range of one another. WPANs will be worldwide interconnected. Like an archaeologist on site in Greece uses a PDA to directly access databases at the Minnesotan Minneapolis, and to transmit findings to that database.

Bluetooth uses short-range radio waves over distances up to approximately 10 meters.It is a wireless technology standard used within short distances by using short-wavelength UHF radio waves in the industrial, scientific and medical radio bands,for exchanging data between fixed and mobile devices from 2.400 to 2.485 GHz.It is also used for building personal area networks (PANs), For example, Bluetooth devices such as keyboards, pointing devices, audio headsets, printers may connect to personal digital assistants (PDAs), cell phones, or computers wirelessly.A Bluetooth PAN is also called a piconet which is composed of up to 8 active devices in a master-slave relationship, a very large number of devices can be connected in "parked" mode. A piconet typically has a range of 10 meters (33 ft), although ranges of up to 100 meters (330 ft). Usually in a local area network (LAN) environment, Wi-Fi uses radio waves for connection over distances up to around 91 meters. It can be used to connect LAN, to connect cell phones to the Internet to download music and other multimedia. It also allows PC multimedia content to be stream to the TV, Wireless as well as to connect video game consoles to their networks. The body area networks, are based on the IEEE 802.15.6 standard for transmission via the capacitive near field of human skin.That allows near field communication of devices worn by and near the wearer. Its Simple implementation can communicate and

detect up to 1 meterfrom a human body. In addition to that it is also used for access control to door locks and jamming protection in convertible car roofs.

II. The Overview of IEEE 802.15.4

For low-rate wireless personal area networks (LR-WPANs)IEEE 802.15.4 is a standard. It specifies the physical layer and media access control . It is maintained by the IEEE 802.15 working group, which is the basis for the ZigBee, MiWi specifications, Wireless HART,ISA100.11a. Each one ofthese standard further extended by developing the upper layers, those are not defined in IEEE 802.15.4. It can be used withstandard Internet protocols and 6LoWPAN to build a wireless embedded Internet.

2.1. Overview

IEEE standard 802.15.4 is intended to offer the fundamental lower network layers of a type ofWPAN. It focuses on low-cost, low-speed ubiquitous communication between devices, which are in contrast with each other and more end-user oriented approaches like Wi-Fi. This system emphasizes on very low-cost communication of nearby devices even with very little underlying infrastructure intended to exploit this to lower power consumption. The basic framework conceives a 10-meter communications range with a transfer rate of 250 Kbit/s. Tradeoffs are made possible to favor radically embedded devices with lower power requirements through the definition of several physical layers. Lower transfer rates of 20 and 40 Kbit/s are initially defined with the 100 Kbit/s rate is added in the current revision. Lower rates can be considered with the resulting effect on power consumption. The main identifying feature of IEEE 802.15.4 among WPANs is important in achieving extremely low manufacturing and operation costs and technological simplicity, without flexibility.

Real-time suitabilityis one of theImportant features. It isoccurred by reservation of guaranteed time slots,Integrated support for secure communications and collision avoidance through CSMA/CA. Power management functions link quality and energy detection are also includedin the devices. The IEEE 802.15.4-conformant devices may use one of three possible frequency bands for operation.

2.2 Protocol Architecture

In a simple wireless network devices are conceived to interact with each other."The definition of the network layers is based on the OSI model". The lower layers are defined in the standard and the upper layers interaction is intended. It is possible usingan IEEE 802.2logical link control, accessing the MAC sub layer through a convergence sub layer. Implementations may rely on external devices or be purely embedded, self-functioning devices.

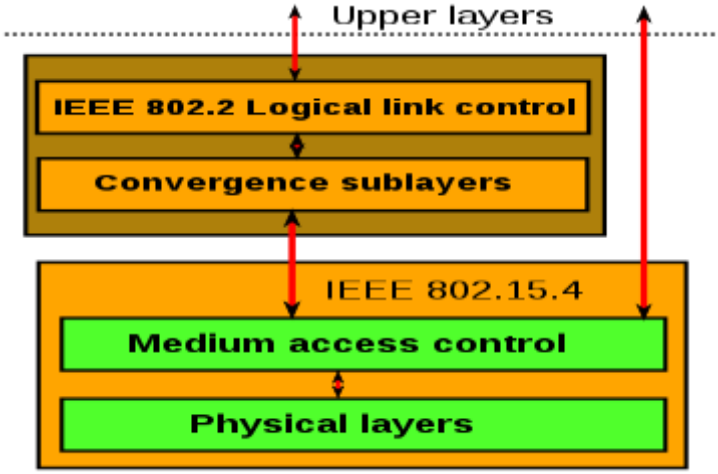

Fig 1: The Protocol ArchitectureThe physical layer

The data transmission service and theinterface to the entity is provided by the Physical layer.It maintains a database of information on related personal area networks and it offers access to every layer management function. So the physical RF transceiver is manage by PHY and performs channel selection, energy and signal management functions. Any one of following three possible unlicensed frequency bandsis operated by it:

- 868.0-868.6 MHz: Europe, allows one communication channel (2003), extended to three (2006)
- 902-928 MHz: North America, up to ten channels (2003), extended to thirty (2006)
- 2400-2483.5 MHz: worldwide use, up to sixteen channels (2003, 2006)

The original 2003 version of the standard specifies two physical layers based on direct sequence spread spectrum (DSSS) techniques: one working in the 868/915 MHz bands with transfer rates of 20 and 40 kbit/s, and one in the 2450 MHz band with a rate of 250 Kbit/s.The 2006 revision improves the maximum data rates of the 868/915 MHz bands, bringing them up to support 100 and 250 Kbit/s as well. Moreover, it goes on to define four physical layers depending on the modulation method used. Three of them preserve the DSSS approach: in the 868/915 MHz bands, using either binary or offset quadrature phase shift keying (the second of which is optional); in the 2450 MHz band, using the latter. An alternative, optional 868/915 MHz layer is defined using a combination of binary keying and amplitude shift keying (thus based on parallel, not sequential spread spectrum, PSSS). Dynamic switching between supported 868/915 MHz PHYs is possible.Beyond these three bands, the IEEE 802.15.4c study group considered the newly opened 314-316 MHz, 430-434 MHz, and 779-787 MHz bands in China, while the IEEE 802.15 Task Group 4d defined an amendment to 802.15.4-2006 to support the new 950 MHz-956 MHz band in Japan.In April 2009 the first standard amendments by these groups were released.In August 2007, IEEE 802.15.4a was released expanding the four PHYs available in the earlier 2006 version to six, including one PHY using Direct Sequence ultra-wideband (UWB) and another using chirp spread spectrum (CSS). The UWB PHY is allocated frequencies in three ranges: below 1 GHz, between 3 and 5 GHz, and between 6 and 10 GHz. The CSS PHY is allocated spectrum in the 2450 MHz ISM band.[3]In April, 2009 IEEE 802.15.4c and IEEE 802.15.4d were released expanding the available PHYs with several additional PHYs: one for 780 MHz band using O-QPSK or MPSK,[4] another for 950 MHz using GFSK or BPSK.[5]IEEE802.15.4e was chartered to define a MAC amendment to the existing standard 802.15.4-2006. It adopts channel hopping strategy to improve support for the

industrial markets increases, robustness against external interference and persistent multi-path fading. On February 6, 2012 the IEEE Standards Association Board approved the IEEE 802.15.4e which concluded all Task Group 4e efforts.

III. The Overview of ZIGBEE

"**ZigBee** is a specification for a suite of high level communication protocols". It is used to create personal area networks built from small, low-power digital radios. It is based on an IEEE 802.15 standard. It is low-powered but it's devices often transmit data over longer distances by passing data through intermediate devices to reach more distant ones, It creates a mesh network with no centralized control or high-power transmitter or 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.

This is required to apply in a low data rate, long battery life, and secure networking. It has a defined rate of 250 kbit/s, which is best suited for periodic data or a single signal transmission from a sensor or input device. It's applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment. It requires short-range wireless transfer of datain relatively low rates. The technology defined by it's specification is intended to be simpler and less expensive rather than WPANs, such as Bluetooth or Wi-Fi.It's networks are secured by 128 bit symmetric encryption keys. Transmission distances range from 10 to 100 meters line-of-sightis applicable in house automation depends on power output and environmental characteristics. ZigBee was conceived in 1998and standardized in 2003. It is revised in 2006. The name refers to the waggle dance of honey bees after their return to the beehive.It is a low-cost and low-power, wireless mesh network standard. It's low cost allows the technology to be widely deployed in wireless control and monitoring applications. And the low power-usage allows longer life with smaller batteries. The Mesh networking provides high reliability and more extensive range. The ZigBee chip vendors typically sell integrated radios and microcontrollers with between 60 KB and 256 KB flash memory.ZigBee operates in the industrial, scientific and medical (ISM) radio bands; 868 MHz in Europe, 915 MHz in the USA and Australia and 2.4 GHz in most jurisdictions worldwide. Data transmission rates vary from 20 kilobits/second in the 868 MHz frequency band to 250 kilobits/second in the 2.4 GHz frequency band. The ZigBee network layer natively supports both star and tree typical networks, and generic mesh networks. Each network must have one coordinator device, tasked with its creation, the control of its parameters and basic maintenance. The coordinator must be the central node within star networks. In order to extend communication at the network level both trees and meshes allow the use of ZigBee routers

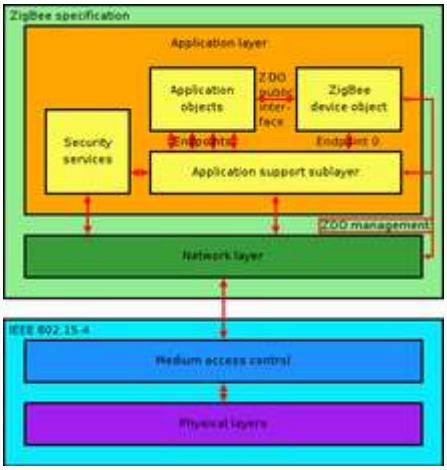

Fig 2:ZigBee protocol stack

"For low-rate WPANs ZigBee builds on the physical layer and media access control defined in IEEE standard 802.15.4 (2003 version) . The specification goes on to complete the standard by adding following components: network layer, application layer, ZigBee device objects (ZDOs) and manufacturer-defined application objects. These component allow for customization and favor total integration".

The most important improvement of ZigBee apart from two high-level network layers to the underlying structure is the introduction of ZDOs. A no of tasks are responsible for these that include keeping of device roles and management of requests to join a network,security and device discovery.It is not only intended to support power line networking but also to interface withZigBeeat least for smart appliance and smart metering purposes.Because the nodes of ZigBee can go from sleep to active mode in 30 ms or less.In this casethe devices can be responsive andthe latency can be low. This is particularly compared to Bluetooth wake-up delays. These are typically around three seconds, becausethe nodes of ZigBee can sleep most of the time.It's average power consumption can be low which results in long battery life.

IV. NETWORK SIMULATOR AND IMPLEMENTAION

Here we represent the simulation scenarios and implementation by using NS2 simulator. So this model used in the experiment is a wireless random model. We have created 20 wireless nodes in the area of 150x150 sq.mt. The transmission range of each node is 15mt/sec. The simulation time is 900seconds. We have used AOD routing protocol. The parameters used for the simulation is shown in Table-1.

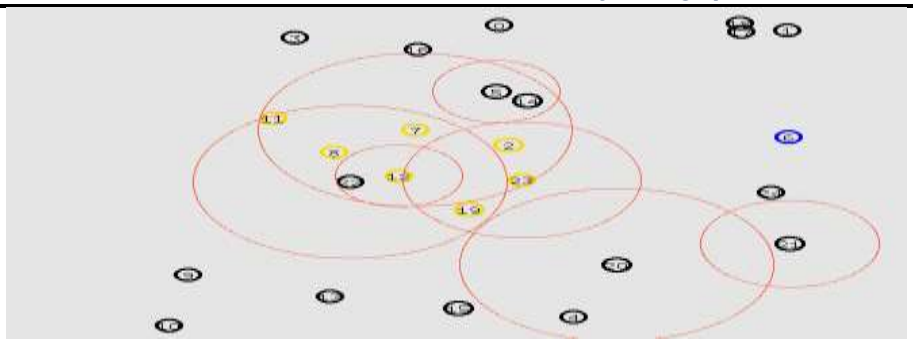

Fig 3: The simulation scenarios used

Parameters used for Evaluation:

PDR (Packet Delivery Ratio): "The ratio of packets successfully received to packets sent in MAC sub layer. This metric does not differentiate transmissions and retransmissions, and therefore does not reflect what percentage of upper layer payload is successfully delivered, although they are related".

Throughput: It is the average rate of successful message delivery over a communication channel.

Packet Loss: No. of packets send- No. of packets received.

Table 1: Parameter used in the simulation.

Number of nodes	25
Area	150 X 150 sq. metre
Traffic type	ftp/cbr/poisson
Transmission Range	15 metre
Duration	900 seconds
Routing Protocol	AODV

The results computed using NS2 simulator is shown below. Initially Packet Delivery Ratio(PDR) is computed for different number of nodes. As shown in Fig4 it is observed that PDR of CBR traffic is higher than Poisson and FT traffic and PDR is decreasing with increase of number of node.

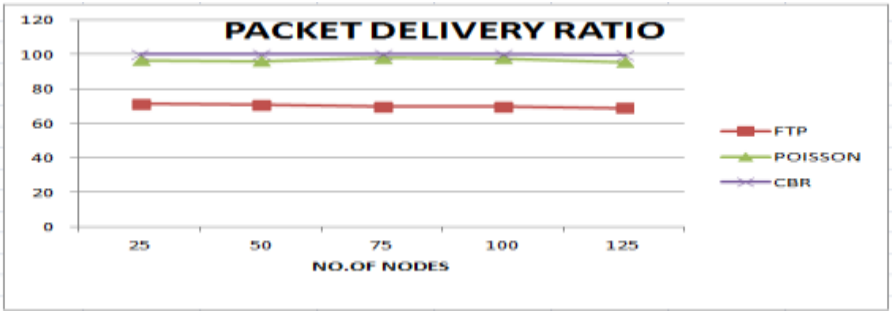

Fig 4:Packet Delivery Ratio(PDR) Vs Number of nodes

Then throughput is computed for different number of nodes. As shown in Fig5 it found that throughput of CBR traffic is higher than Poisson and FT traffic and throughput increases with increase of number of node.

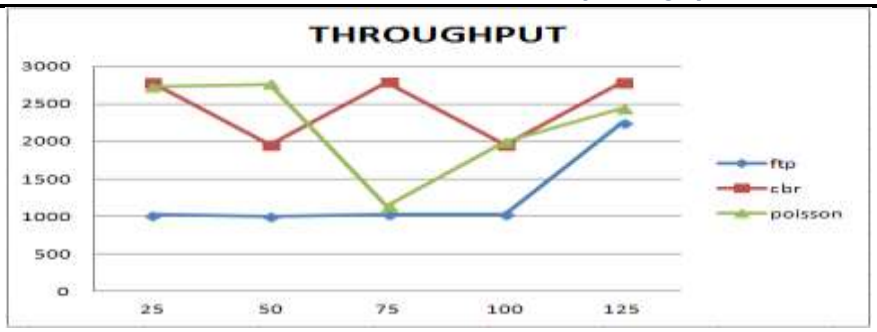

Fig 5: Throughput Vs Number of nodes

Then Packet loss is computed for different number of nodes. As shown in Fig 6 it is observed that packet loss of CBR traffic is lower than Poisson and FT traffic and however it increases with number of nodes.

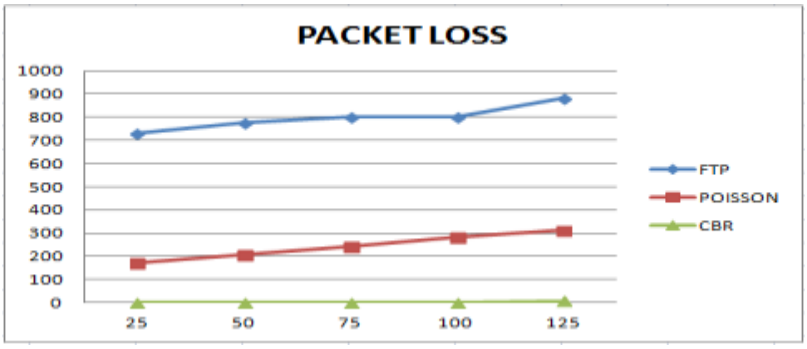

Fig 6: Packet loss Vs Number of nodes

V. CONCLUSION

At this earth ZigBeeis the new standard IEEE 802.15.4 standardwhich is designed for low rate wireless personal area networks (LR-WPANs), is an enabling standard. It brings to light a host of new applications as well as changes many other existing applications. It is the first standard to allow simple sensors and actuators to share a single standardized wireless platform.

In our paper we have implemented IEEE 802.15.4 standard using three different traffics namely CBR, Poisson and FTP. Our simulation results using NS2 shows that CBR traffic achieves higher packet delivery ratio(PDR) and higher throughput and lower packet loss.

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