Simulative Investigation of Zigbee based Wireless Star Networks by using NS-2

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Abstract— ZigBee offers unique advantages for wireless applications. With a this new technology, realizing a standard specifies the PHY Layer and MAC Layer for low data rate wireless PANs. It is based on the IEEE 802.15.4 standard. The IEEE 802.15.4 standard specifies the PHY Layer and MAC Layer for low data rate wireless PANs. This paper includes ZigBee Alliance, IEEE 802.15.4 model, applications and advantages of ZigBee, future scope of ZigBee. The performance of the zigbee networks for various areas have been analysed and also the network application area had been reviewed. This paper includes ZigBee Alliance, IEEE 802.15.4 model, applications and advantages of ZigBee, future scope of ZigBee. The performance of the zigbee networks for various areas have been analysed and also the network application area had been reviewed.

Index Terms— Delivery ratio, IEEE 802.15.4, NS-2, Star topologies, WPAN, Zigbee Wireless networks.

1 INTRODUCTION

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standards for personal area networks. ZigBee devices are often used in mesh network form to transmit data over longer distances, passing data through intermediate devices to reach more distant ones. This allows ZigBee networks to be formed ad-hoc, with no centralized control or high-power transmitter/receiver able to reach all of the devices. Any ZigBee device can be tasked with running the network

ZigBee is targeted at applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 kbit/s, 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 ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth or Wi-Fi .with Bluetooth.

Star Topology

In the star topology, the communication is established between devices and a single central controller, called the PAN coordinator. The PAN coordinator may be mains powered while the devices will most likely be battery powered. Applications that benefit from this topology include home automation, personal computer (PC) peripherals, toys and games.

After an FFD is activated for the first time, it may establish its own network and become the PAN coordinator. Each start network chooses a PAN identifier, which is not currently used by any other network within the radio sphere of influence. This allows each star network to operate independently.

Peer-to-peer Topology

In peer-to-peer topology, there is also one PAN coordinator. In contrast to star topology, any device can communicate with any other device as long as they are in range of one another. A peer-to-peer network can be ad hoc, self-organizing and self-healing. Applications such as industrial control and monitoring, wireless sensor networks, asset and inventory tracking would benefit from such a topology. It also allows multiple hops to route messages from any device to any other device in the network. It can provide reliability by multipath routing.

Cluster-tree Topology

Cluster-tree network is a special case of a peer-to-peer network in which most devices are FFDs and an RFD may connect to a cluster-tree network as a leave node at the end of a branch. Any of the FFD can act as a coordinator and provide synchronization services to other devices and coordinators.

Only one of these coordinators however is the PAN coordinator.

The PAN coordinator forms the first cluster by establishing itself as the cluster head (CLH) with a cluster identifier (CID) of zero, choosing an unused PAN identifier, and broadcasting beacon frames to neighbouring devices. A

candidate device receiving a beacon frame may request to join the network at the CLH. If the PAN coordinator permits the device to join, it will add this new device as a child device in its neighbour list. The newly joined device will add the CLH as its parent in its neighbour list and begin transmitting periodic beacons such that other candidate devices may then join the network at that device. Once application or network requirements are met, the PAN coordinator may instruct a device to become the CLH of a new cluster adjacent to the first one. The advantage of this clustered structure is the increased coverage area at the cost of increased message latency.

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(This information is optional; change it according to your need.)

2 ZIGBEE ALLIANCE[2]

Zigbee Alliance is an association of companies working together to define an open global standard for making low-power wireless networks. The intended outcome of ZigBee Alliance is to create a specification defining that how to build different network topologies with data security features and interoperable application profiles. The association includes companies from a wide spectrum of categories, from chip manufactures to system integration companies. The number of members in the association is rapidly growing and is currently over 125. Among the members one can find Philips, Samsung, Motorola and LG. Digi is a member of the ZigBee Alliance and has developed a wide range of networking solutions based on the ZigBee protocol. XBee and XBee-PRO modules and other XBee-enabled devices provide an easy-to-implement solution that provides functionality to connect to a wide variety of devices [3]. ZigBee Alliance provided some ZigBee devices which are widely used viz.: XBee and XBee-PRO ZB, XBee and XBee-PRO ZB Adapters, ConnectPort X Gateways.

The Name ZigBee

The name ZigBee [3], is come from the domestic honeybee which uses a zig-zag type of dance to communicate important information to other hive members. This communication dance (the "ZigBee Principle") is what engineers are trying to emulate with this protocol a bunch of separate and simple organisms that join together to tackle complex tasks

3 WIRELESS STANDARDS COMPARISON [9]

Features	IEEE 802.11b	Bluetooh	Zigbee
Battery Life	Hours	Days	Years
Complexity	Very Complex	Complex	Simple
Nodes/Master	32	7	64000
Latency	Enumeration up to 3 seconds	Enumeration up to 10 seconds	Enumeration up to 30 msec
Range	100m-1000m	10m	70m-300m (ETSI),1600m(FCC)
Extendibility	Roaming possible	No	Yes
RF data rate	11 Mbps	1Mbps	250Kbps
Security	Authentication service Set ID (SSID)	64-bit,128-bit	128-bit AES AND Application Layer user defined

4 PERFORMANCE PARAMETERS

To evaluate the performance of the mesh interconnection networks, a simulation model has been developed in NS2 with only built-in options. Tcl is used for specifying the Mesh interconnection network simulation model and running the simulation. The existing routing algorithm to compute the path and for packet generation is used.

Flow control in interconnection networks has mainly been an issue to prevent buffer overflow and packet loss. Packet loss occurs when one or more packets of data traveling across a network fail to reach their destination. Packet loss can be caused by a number of factors including buffer overflow, congestion, corrupted packets rejected in-transit, faulty link, faulty nodes or deadlocks. In addition to this, packet loss probability is also affected by down of links and distances between the transmitter and receiver

5 PERFORMANCE MATRICES[10]

The following important matrices will be evaluated

Packet Delivery ratio (PDR)

Packet delivery ratio is calculated by dividing the number of packets received by the destination through the number of packets originated by the CBR source. The number of packets dropped does not take into account retransmissions. This would effectively make the number of transmitted packets equal to the sum of the number of received packets and number of dropped packets.

Delivery Ratio=

(No.of Received Packets/No.Transmitted_Packets) *100

Loss Packet Ratio (LPR)

Loss Packet Ratio is calculated by dividing the number of packets that never reached the destination through the number of packets originated by the CBR source. In this metric, the packets received are not taken into account as long as the packet is dropped. In other words, there is no difference between transmissions and retransmissions, and this metric is not an exact reflection of the successful delivery of the upper layer payload. The packet drop ratio can be used for the indication of congestion in the network.

Loss_Ratio=

(No. of_Packets_not_recieved/No of_Transmitted_Packets) *100

Routing Overhead

Routing overhead, which measures the ratio of total routing packets sent and the total number of packets sent. Routing overhead can be used for the indication of how many total routing packets sent in order to sent some data packets.

Routing_Overhead=

(Number_of_total_routing_packets_sent/Total_Number_of packets sent) *100

Performance Evaluation

The performance of the mesh interconnection networks, can be evaluated by a simulation model which has been developed in NS2 with only built-in options. Tcl is used for specifying the Mesh interconnection network simulation model and running the

simulation. The existing routing algorithm to compute the path and for packet generation is used.

6 ZIGBEE ADVANTAGES

The ZigBee protocol is designed to communicate data through hostile RF environments that are common in commercial and industrial applications.
ZigBee protocol features include:

1. Zigbee provides supports for point-to-point, point-to-multipoint and mesh networks.
2. It has low duty cycle which provides long battery life.
3. ZigBee has Low latency.
4. Direct Sequence Spread Spectrum (DSSS) is used in ZigBee technology.
5. ZigBee has ability to use upto 65,000 nodes per network.
6. 128-bit AES (Advanced Encryption Standard) encryption for secure data connections are used in it.
7. Collision avoidance, retries and acknowledgements are one of the most efficient features of ZigBee.

7 ZIGBEE APPLICATIONS [10]

There are many applications that are having redundant, self-configuring and self-healing capabilities of ZigBee wireless mesh networks. These applications include:

Building Automation

It provides security, HVAC (Heating, Ventilation, and Air conditioning) refers to technology of indoor or automotive environmental comfort. Now HVAC is widely used in the buses and cabs. It is also used in lighting control, access control and Adaptive Multi-Rate (AMR or AMR-NB) audio codec is a patented audio data compression scheme optimized for speech coding.

Energy Management and Efficiency

To provide greater information and control of energy usage, provide customers with better service and more choice, better manage resources, and help to reduce environmental impact**. Consumer Electronics**

To provide more flexible management of lighting, heating, cooling, security and home entertainment systems such as TV, DVD's, home theatre.

PC and Peripherals

To integrate the system to perform different types of tasks, we have input/output devices as well as high speed processors, storage media and many other devices such as joystick, OMR.

Home Control

To integrate the lighting, heating, cooling and security or we can say that it is responsible for controlling the home.

Telecommunication Services

It covers information services, Mobile Commerce, also known as M-Commerce or mCommerce, is the ability to conduct commerce using a mobile device, such as a mobile phone, Personal Digital Assistant (PDA), Smartphone, or other emerging mobile equipment such as dash top mobile devices.

Industrial Automation

To extend existing manufacturing and process control systems reliability [6]. The interoperable nature of ZigBee means that these applications can work together, providing even greater benefits.

Personal Health Care

ZigBee Alliance provided many devices which helps for the fitness of patients such as personal wellness monitoring, Electrocardiograph (ECG), chronic disease monitoring, glucose meter pulse oximeter.

8 RESULT & ANALYSIS

The performance parameters viz. Delivery ratio & loss ratio had been calculated by using tool Network Simulator-2, for different number of nodes and different areas for wireless star networks as shown in the table below. The simulation results are as follows. It shows that as the simulation area increases, the delivery ratio decreases and the loss ratio increases.

No. of nodes	Performance Analysis			Delivery Ratio (%)	Loss Ratio (%)
	Area	*Packet sent*	*Packet received*		
7	Small	38579	37633	97.54	2.45
	Medium	1820	0	0	100
	Large	1820	0	0	100
9	Small	38310	37548	98.01	1.98
	Medium	1820	654	35.93	64.06
	Large	1820	107	5.87	94.12
13	Small	1820	656	36.04	63.94
	Medium	1820	111	6.09	93.90
	Large	1820	0	0	100

TABLE 1: Performance Analysis of Wireless Star Network

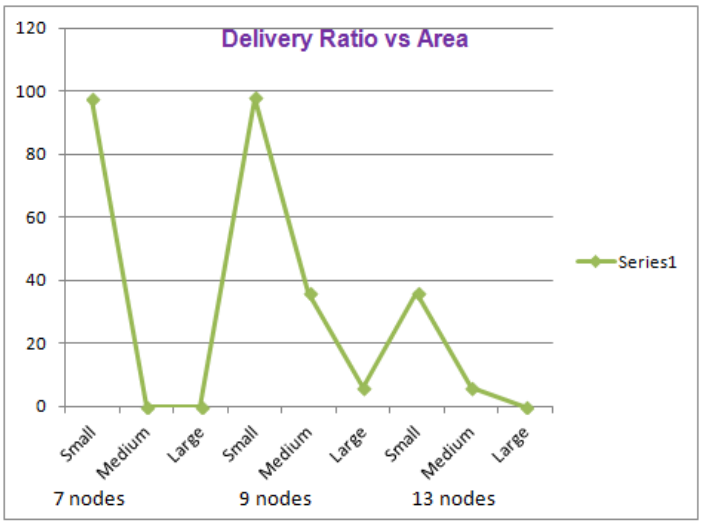

Fig.1. Delivery ratio for different no. of nodes with different

area.

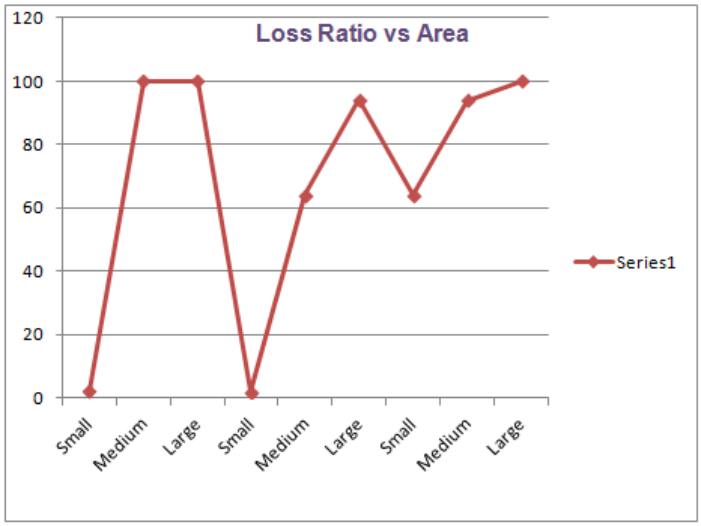

Fig.2. Loss ratio for different no. of nodes with different area

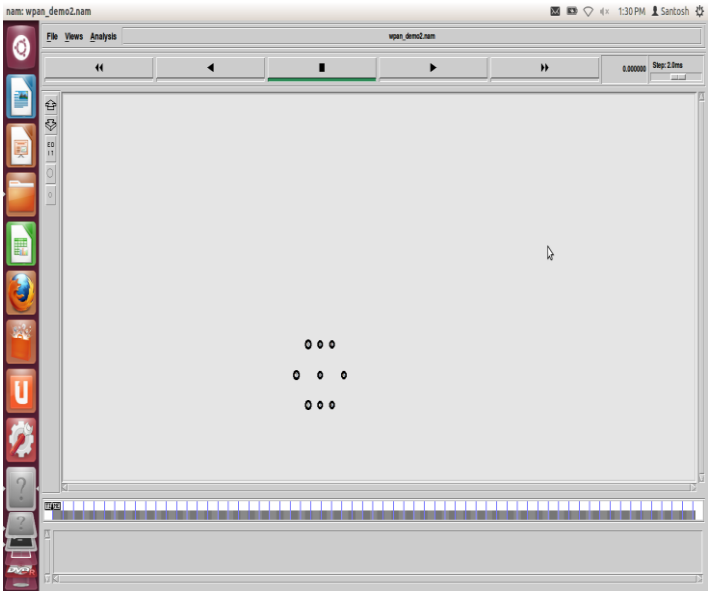

Fig.3.Zigbee WPAN star network having nine nodes

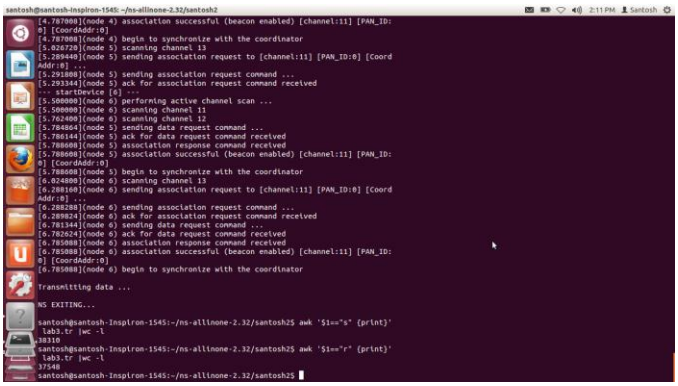

Fig.4. Simulation result for packet sent & Packet received nine no. of nodes for small area.

9. Conclusion

ZigBee is most promising technological standard for low data rate, low power consumption and has a long battery life. ZigBee networks are reliable and self-healing. These networks are easy to deploy which is cheaper as compared to other technologies. To-day main issue is its complexity of ZigBee networks. The main problem in this is security because intruders can easily hack ZigBee networks and too much technology makes people lazy.

The evolution of ZigBee technology is a big achievement, which will likely be targeted for use in applications such as road map tracking, medical application, consumer electronics, PC, Personal healthcare, commercial and residential control and many more by applying different actions.

The performance parameters for the Zigbee star wireless network are studied and analysed using network Simulator-2 (NS-2).From the observation table it is concluded that for the star wireless PAN network as the area increases delivery ratio decreases and loss ratio increases. For the same we have considered the personal area network for star and mesh topologies.

A simulation framework for mesh interconnection network will be designed, where the packet loss during the link down has been analyzed. Analysis and evaluation will be done on mesh interconnection networks on different traffic patterns using simulation on NS2.

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