A Simulation of Wireless Sensor Network Using ZigBee

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Abstract
Sensor networks have been a wide research area, during the last years. Wireless sensor networks are distributed network structures in which many sensors connect wirelessly to communicate with one another. In this paper the IEEE 802.15.4/ZigBee is used due to its low-power, rate and cost which allows the communication of two way wireless sensor network. In this paper IEEE 802.15.4 performance is analyzed based on OPNET simulator which allows the abilities of generating correct results and analysis to identify the actual behaviour of the real system. With this simulator program, the effect of performance parameters like throughput, data traffic received and data traffic sent for three system topology scenarios are presented.
Keywords: WSN, IEEE 802.15.4, performance.

1. Introduction

Wireless sensor networks generally contain a large number of sensor nodes deployed in an area of interest to gather physical or environmental conditions, such as temperature, humidity, pressure, etc. A WSN has a various selective attributes when contrasted with conventional wireless networks (Li, Peng et al. 2016). These incorporate limited bandwidth, limited computation capability of individual nodes, and limited energy supply. Self-organization, dynamic network topology, and multi-hop routing are additional key possible features of a WSN, which make them important for many applications (Hammoodi, Stewart et al. 2009, Li, Peng et al. 2016). It is profitable to perform exact re-enactments or to create models before sending WSNs in the field. Researchers have created numerous reproduction models on deferent recreation stages, for example, OPNET, NS-2, TOSSIM, EmStar, OMNeT++ and J-Sim(Li, Peng et al. 2016). Contrasted and different test systems, OPNET is more appropriate to perform practices of systems in this present reality. OPNET Modelle, as a net-work test system, gives an industry-driving system innovation advancement environment (Xue, Lee et al. 2007, Hammoodi, Stewart et al. 2009). The most appealing standard for remote sensor systems is the IEEE 802.15.4 standard (Piscataway 1996), which gives low-rate and The relating system design can be considered as a decent bargain between various levelled systems (e.g., those in light of the IEEE 802.11 standard and systems with lower control utilization (e.g., those in view of the IEEE 802.15.1 standard) (Piscataway 1996). Every one of these frameworks work in the 2.4GHz (Piscataway 1996).

In this paper the IEEE 802.15.4/ZigBee is utilized because of its low-power, rate and cost which permits two way wireless sensor network communication. In this paper IEEE 802.15.4 performance is analyzed based on OPNET simulator which allows the abilities of generating correct results and analysis to identify the actual behaviour of the real system. The results in this paper can be utilized to design IEEE 802.15.4/ZigBee strategies and set the related parameters, as a component of the sought application necessities.

2. The IEEE 802.15.4 Protocol

The IEEE 802.15.4 MAC programming stack gives essential data transport, API, indicate point, and star arrange (single-bounce transmission) usefulness for an assortment of Atmel 802.15.4 remote stages (Gribaudo, Manini et al. 2009) Figure 1 demonstrates the framework Architecture for the IEEE 802.15.4.

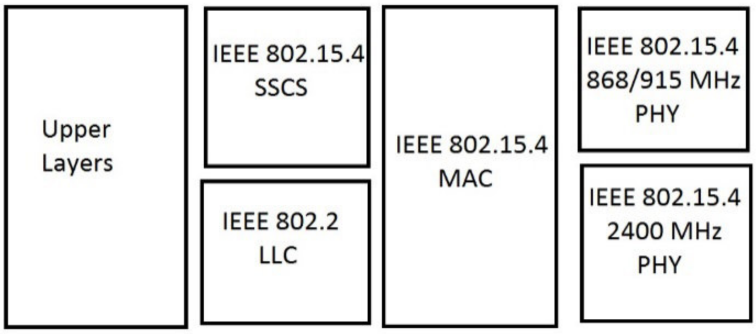

Figure 1: IEEE 802.15.4 System Architecture

In case that application requires bolstering for indicating point systems; wire substitution; nonspecific as well as restrictive remote controls; mechanical applications; or other indicate multipoint, basic star systems; then consider utilizing the Atmel IEEE 802.15.4 MAC programming stack for next application. The standard offers need to low-control, low-rate, and minimal effort, going for giving brought together standard to people or families. The attributes of LR-WPAN system are like the sensor system, and it is viewed as sensor correspondence standard by many research organizations (Xia, Fu et al. 2010). The gathering commits to the standard of the physical layer of WPAN system, i.e. PHY and media get to layer, i.e. Macintosh, going for giving correspondence gauges to interact with remote specialized gadget in the individual working space, i.e. POS and large alludes to the extent of 10 meters close to clients and clients can be stationary or moving inside this degree (Howitt and Gutierrez 2003) Table 1 demonstrates an empathy between various wireless technology.

Table 1: Various Wireless technology

Standard	Bandwidth	Protocol stack size	Application
Wi Fi	54Mbps	100+KB	Internet, Pc Network, file transfer
Bluetooth	1 bps	~100+KB	Wireless USB, handset, headset
Zigbee	250kbps	34KB/14 KB	Remote control ,Sensors

3. Opnet Modeler

The OPNET Modeler environment incorporates instruments for all periods of a study, including model outline, simulation, data accumulation, and data analysis (Pan and Jain 2008). OPNET Modeler gives a far reaching improvement environment supporting the demonstrating of correspondence systems and conveyed frameworks. Both behaviour and performance of a model can be examined by performing discrete occasion reproductions. A Graphical User Interface (GUI) bolsters the setup of the situations and the advancement of system models. There are three various levels for design which are separated: i) the system level making the topology of the system under scrutiny, ii) the hub level characterizing the conduct of the hub and controlling the stream of information between various practical components inside the hub, and iii) the procedure level, depicting the fundamental conventions, spoke to by limited state machines (FSMs) and are made with states and moves between states (Pan and Jain 2008). The source code depends on C/C++. The analysis simulated data is supported by a variety of built-in function (Wu and Tseng 2007). Table 2 show the processes used by OPNET. The simulation model implements physical and Media Access Control (MAC) layer defined in IEEE 802.15.4/ZigBee standards (Wu and Tseng 2007, Pan and Jain 2008).

Table 2: Processes used by OPNET

Processes	Description
ZigBee MAC model	Implements a model of the IEEE 802.15.4 MAC protocol.
ZigBee Application model	Represents a low fidelity version of the ZigBee Application Layer as specified in the ZigBee Specification.
ZigBee Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) mode	Implements the media access protocol of the MAC layer.
ZigBee Network model	implements the ZigBee Network Layer as specified in the ZigBee specification.

4. Network Topology

The physical topology of a system alludes to the arrangement of links, PCs, and different peripherals. Physical topology ought not to be mistaken for consistent topology which is the technique used to pass data between workstations. The IEEE 802.15.4 supports star topology, Cluster-tree topology, and Mesh Topology as appeared in Table 3.

Table 3: Network Topologies

Topologies	Description
Star Topology	A star network features a central connection point called a "hub" that may be a hub, switch or router. 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 (Fernández, Blasco et al. 2009).
Cluster-tree	Cluster topologies integrate multiple star topologies together onto a bus. Instead, there is a coordinator which acts as a root and either RFDs or routers connected to it, in order to increase the network dimension. The RFDs can only be the leaves of the tree, whereas the routers can also act as branches. In a Cluster-tree topology, a beacon structure can be employed in order to obtain an improved battery conservation (Al-Karaki, Ul-Mustafa et al. 2009).
Mesh Topology	Involve the concept of routes. Unlike each of the previous topologies, messages sent on a mesh network can take any of several possible paths from source to destination. Any source node can talk directly to any destination. The routers and the coordinator, in fact, are connected to each other, within their transmission ranges, in order to ease packet routing. The radio receivers at the coordinator and routers must be switched on all the time (Cuomo, Cipollone et al. 2009).

In our paper the three common topologies of WSNs are investigated namely: star, mesh and tree to evaluate the performance of OPNET in simulating all their topologies used in the OPNET Modeler Scenarios which has an equal number of end devices, routers, PAN coordinators as shown in Table 4.

Table 4: Scenarios

WSNs Topologies	Scenarios
Star Topology	In this scenarios, all end devices are connected to single PAN coordinator. In order to communicate each end device has to communicate to the PAN coordinator first and then the PAN coordinator communicates to the destination end devices i.e. no two end devices can directly communicate but only through the PAN coordinator.
Cluster-tree	Contains three PAN coordinators (Fully Functional Devices) which manage their local networks and communicate with each other, rest of the devices in the scenario are end devices that communicate with their respective PAN coordinator in peer to peer mode.
Mesh Topology	In contrast to the star topology, any device can communicate with any other device as long as they are in the range of one another.

5. Parameters

The physical, MAC and application layer for the three different layer of the three different scenarios namely; Star, Mesh and Cluster are presented in Table 5.

Table 5: application traffic and parameters for the physical, MAC and application layer

Physical layer parameter	
Data rate (kbps)	250
Receiver sensitivity (db)	-85
Transmission band (GHz)	2.4
Transmission power (W)	0.05
MAC parameters	
ACK wait duration	0.05
Number of Retransmission	5
Application layer parameter	
Packet interval time/ type (sec/constant)	1
Packet size/type (bits/constant)	1024

6. Simulation and Analysis

To study framework conduct and execution by a method for a genuine organization or setting up a proving ground may require much exertion, time and money expenses. The simulation results are not necessarily accurate. Consequently, the objective for any reproduction model is to precisely demonstrate and anticipate the conduct of a genuine framework. Exact IEEE 802.15.4/ZigBee reproduction display created in the OPNET Modeler test system. Opnet Modeler was picked because of its precision and to its advanced graphical. The effect of execution parameters like throughput, bundle dropped, and information movement got and information activity sent for three system topology situations. OPNET Modeler was picked because of its exactness and to its refined graphical. The thought behind this simulation model was activated by the need to assemble an extremely reliable model of the IEEE 802.15.4 and ZigBee conventions for Wireless Sensor Networks (WSNs). By applying this simulation, the effect of performance parameters like throughput, data traffic received and data traffic sent for three system topology scenarios are presented as following:

6.1 Throughput

Throughputs are used to evaluate and compare the data throughput for three different topologies. Throughput is the average number of bits or packets successfully received or transmitted by the receiver or transmitter channel per second. Figure 2 shows the throughput for the cluster, mesh and star topologies respectively.

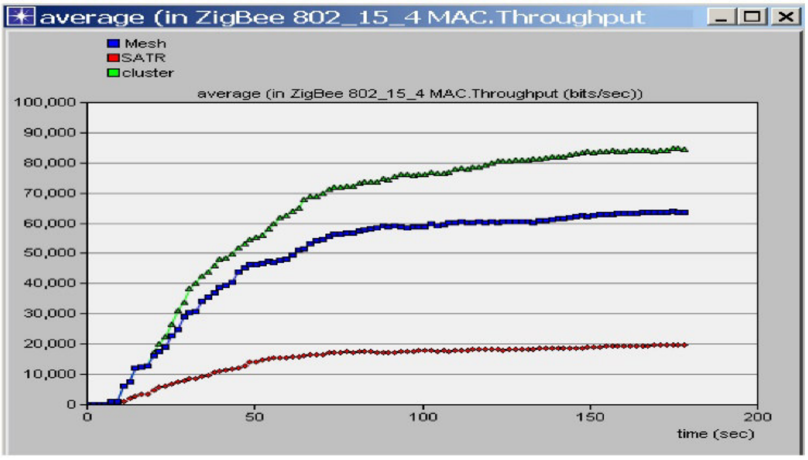

Figure 2: The throughput

The above figure demonstrates the insights for throughput for every situation and the most extreme throughput qualities are recorded has 81.765, 63.836 and 19.989 Kbits/sec for a cluster, mesh and star topologies separately. By examining the chart above and the conduct for the cluster tree topology has more throughput than star and mesh topology because each end device communicates with the Fully Functional Devices like PAN coordinator and routers, where the star topology interact with the single PAN coordinator which thus have more system load than cluster topology and every device in the mesh topology, can convey each other so the data transmission between the end device to end device are not effective than the data transmission between the end device and PAN routers. Thus the mesh topology has fewer throughputs than cluster topology in WSN.

6.2 Data Received

Figure 3 shows data traffic received for the cluster, mesh and star topologies. It is defined as a number of bits the data received per unit time.

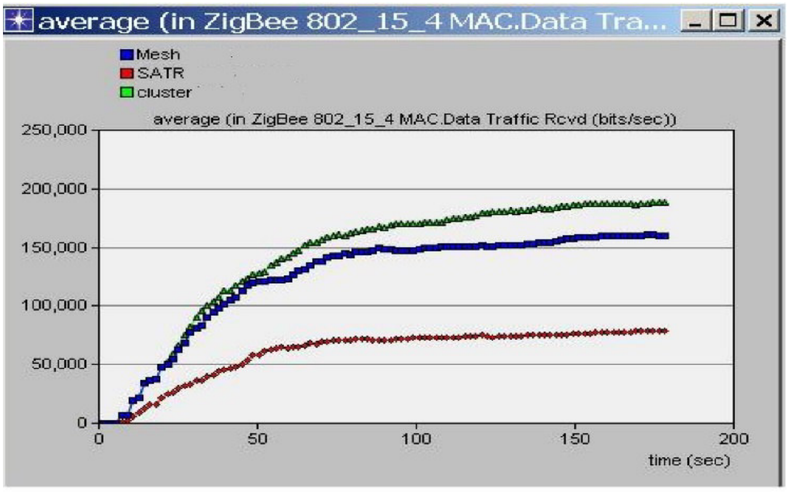

Figure 3: Dara received

The data received by the cluster, mesh and star topologiesis 192.764, 158.435and 80.769 Kbit/Sec respectively. It is obvious that the data received is maximum with the cluster topology due to all end devices that are communicating through PAN coordinate and all of these devices are responsible for traffic generation and routing. It is also clear that because of the lesser collision, low packet loss is leading to a maximum data traffic with the cluster topology.

6.3 Data Traffic Sent

The data traffic sent for the cluster, mesh and star topologies respectively are shown in figure 4 below.

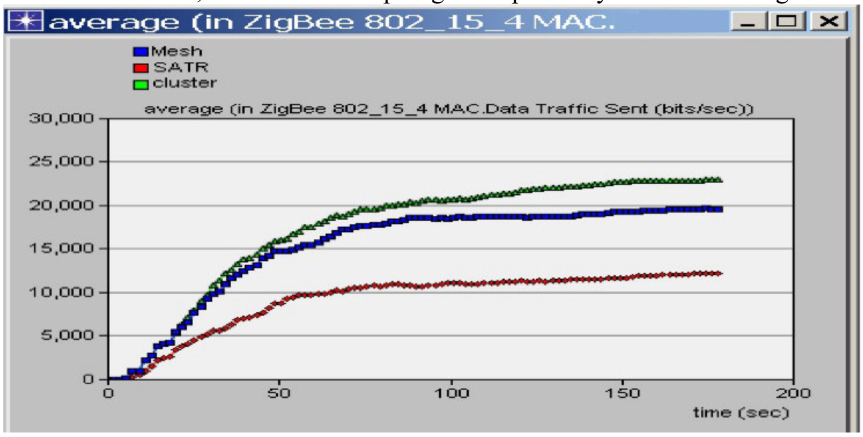

Figure 4: Data sent

The data traffic sent for cluster, mesh and star topologies is 23.653, 19.989 and 12.874 Kbit/Sec respectively. It clear that the maximum data traffic sent is greater in the case of cluster topology due to cluster topology which makes use of PAN coordinator for communication; these Fully Functional Devices are responsible for traffic generation and maintaining routing tables in PAN coordinators only.

7. Conclusion

The three common topologies of WSNs are investigated. The performance of OPNET in simulating all there topologies used in the OPNET Modeller Scenarios has an equal number of end devices, routers, PAN coordinators. The result indicates that throughput, data traffic received and data traffic sent is more efficient and best suited in case of Cluster topology compares to Mesh and Star topologies for IEEE 802.15.4/ Zigbee standard. Finally, it is concluded that the performance of cluster-based is best suited for the WSN application.

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