Effects of Different Topologies on Network Lifetime in WSN

Akanksha Agrawal, Manju, Vikas Raina, Ranjana Thalore, M. K. Jha

Abstract— Wireless Sensor Network (WSN) is an application of Wireless ad-hoc networks used in everyday lives. The energy efficiency of network is the major challenge facing WSN. This paper investigates the network lifetime of WSN and different network parameters like throughput, packets dropped, delay and jitter on different network topologies. Two WSN networks comprising of 20 nodes and 100 nodes with a PAN coordinator in 100 x 100 square meters terrain size has been implemented in QualNet 6.1 simulator. The result indicates that when the number of nodes is increased, Gradient time synchronized protocol topology gives the best network lifetime. Throughput is also highest for the GTSP topology. But the number of packets dropped is high and so as end to end delay.

Index Terms— End to end delay, Jitter, Network lifetime, Network topology, Throughput, WSNs, Wireless ad-hoc networks.

——————————— ◆ ———————————

1 INTRODUCTION

A Wireless Sensor Network (WSN) is promising novel tool for sensing and observing natural phenomena at large scale. WSN is composed of thousands of micro sensors which are small in size but capable of collecting and calculating data or information anytime under different situations. In future, WSN will be omnipresent; it could be applied in security, intelligent detecting, coordinating and controlling public and personal environment.

Basic topology structures for various WSN are focused to meet energy requirements in specific environments. Various parameters including network lifetime, throughput, end to end delay and jitter are affected by different topologies. In this paper, we present a comparison of different network topologies with two cases-for 20 nodes and 100 nodes-to give clear impact caused by number of nodes as well as topology.

The rest of paper is organized as following. Section 2 is literature survey. Section 3 includes network simulation presenting the scenario and simulation parameter values. And section 4 represents the results showing different parameters of WSN. Finally section 5 represents the conclusion.

2 LITERATURE SURVEY

Routing trees rooted at the sink is typical topology widely used in WSN in order to deliver data to the sink. The Shortest Path Tree (SPT) approach is one of the commonly used methods to construct routing trees in the many-to-one WSN [5]. The goal of SPT algorithms is to construct a tree rooted at the sink such that the path cost from any node to the sink is minimal. Walid Bechkit et. al explained that the energy consumption and the end-to end delay are correlated to the path length, the use of shortest paths in terms of hop count reduces

——————————————

• *Author Akanksha Agrawal is currently pursuing masters degree program in signal processing inMody Institute of Technology and Science(Deemed University), India, PH-09413275950. E-mail:akanksha.vka@gmail.com*

the energy dissipation and the end-to-end delay. They explained the network lifetime in WSN with tree topology [6].

Other topologies have also been investigated in this work to compare the results.

3 NETWORK SIMULATION

This section describes simulation scenario and various simulation parameters considered for performance analysis.

3.1 Simulation Scenario

To analyze the network lifetime we have simulated two WSN comprising of 20 and 100 nodes in terrain size of 100mX100m on QualNet 6.1 software. Simulation scenario for 100 nodes (only) is shown in Fig.1.

The Fig.1 indicates the following topologies:

3.1.1 Star Topology: Star networks are one of the most common computer network topologies. In its simplest form, a star network consists of one central switch, hub or computer, which acts as a conduit to transmit messages. This consists of a central node, to which all other nodes are connected; this central node provides a common connection point for all nodes through a hub as shown in Fig.1 (d).

3.1.1.1 Far Topology: Placements of nodes are done as far as possible from the PAN coordinator. Nodes are connected through the Traffic Gen. application with same star topology as shown in Fig.1 (a).

3.1.1.2 3 Near Topology: Placements of the nodes are done as near as possible to the PAN coordinator. Nodes are connected through the Traffic Gen. application with same star topology as shown in Fig.1 (c).

3.1.2 GTSP Topology: GTSP is Gradient Time Synchronization Protocol. GTSP is completely distributed, functioning on local information. It does not follow tree fashion [4]. It passes on the information to the nearest neighboring node as shown in Fig.1 (b).
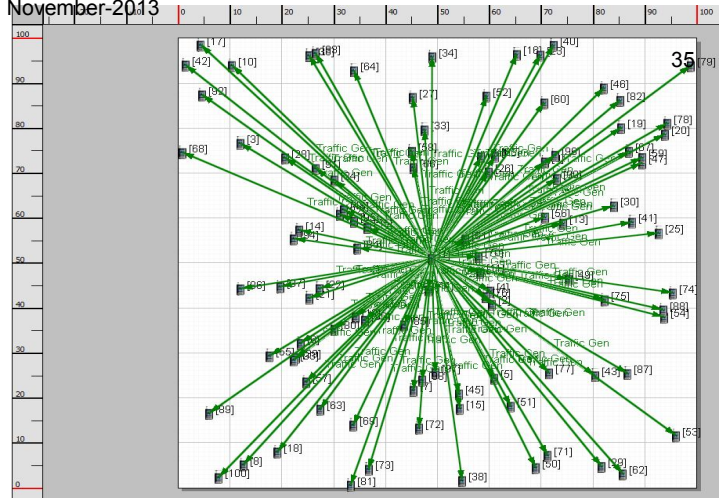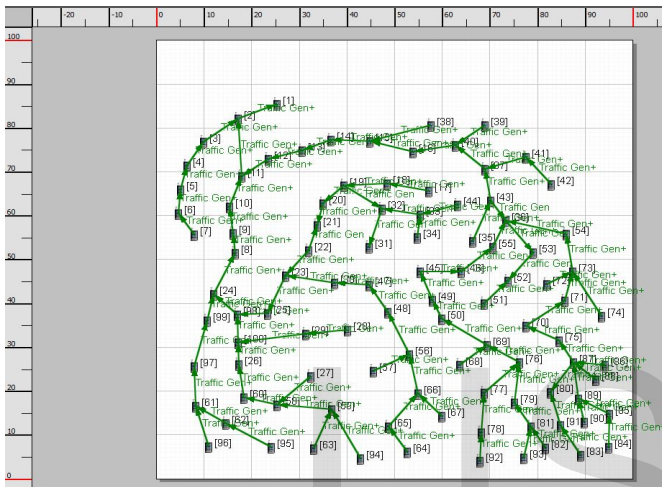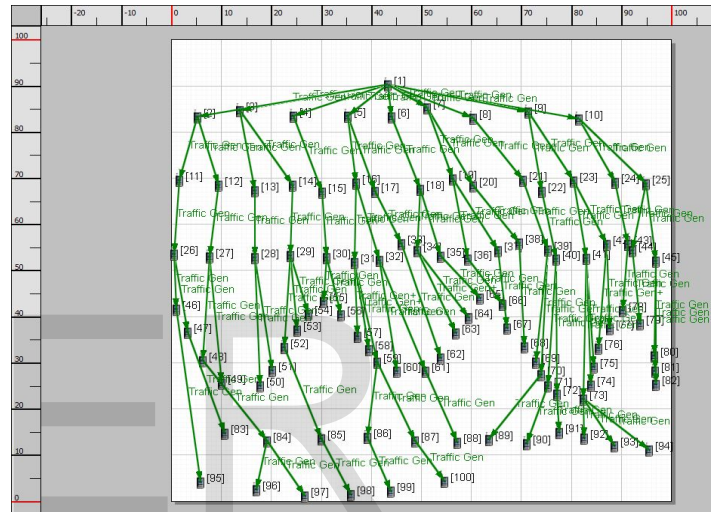
3.1.3 Tree Topology: A Tree based topology where a reference node is present known as root. Every other node synchronizes with its parent node as shown in Fig1 (e).
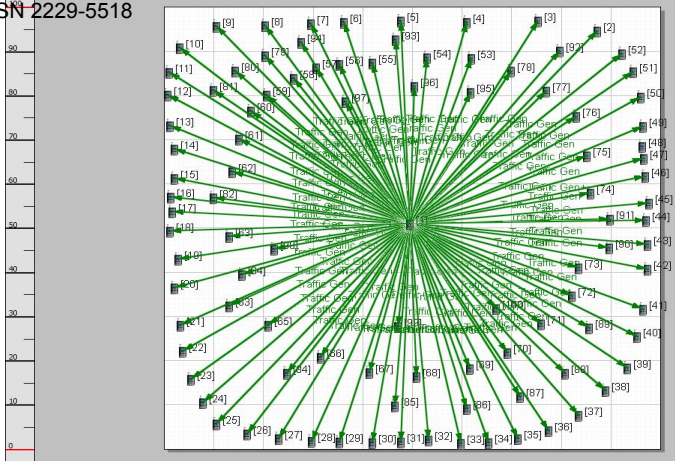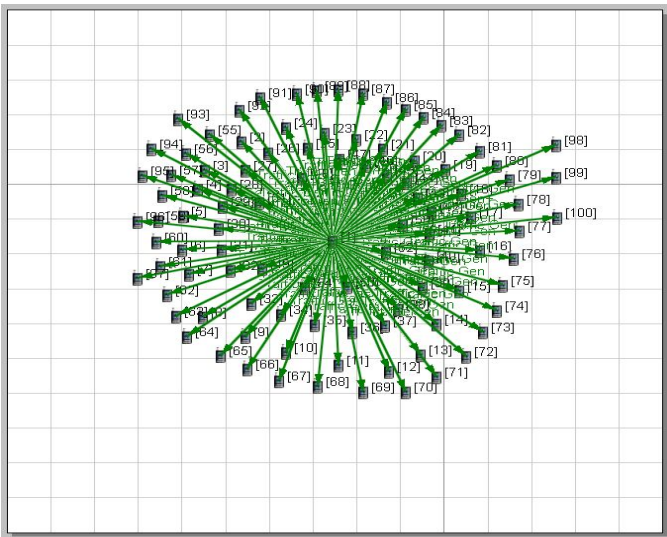
a.)Far_100nodes

d.)Star_100nodes

b.) GTSP_100nodes

e.) Tree_100nodes
Fig 1: Simulation scenario

c.) Near_100nodes

3.2 SIMULATION PARAMETERS

Table 1 gives the simulation parameters.

TABLE 1
SIMULATION PARAMETERS OF VALUES

S.No.	Parameters	Values (scenario 1)	Values (scenario 2)
1	Simulator	QualNet 6.1	QualNet 6.1
2	No. of nodes	20	100
3	PAN coord.	1(in no.)	1(in no.)
4	Traffic Type	Traffic Gen	Traffic Gen
5	Terrain Area	100 m X 100 m	100 m X 100 m
6	MAC Type	IEEE 802.15.4	IEEE 802.15.4
7	Protocol	AODV	AODV
8	BatteryModel	Linear	Linear
9	Energy Model	Mica motes	Mica motes
10	Simulation Time	100sec	100sec
11	Packet Size	38	38
12	Radio type	802.15.4Radio	802.15.4Radio
13	Channel type	Wireless channel	Wireless channel

A WSN with different topologies has been simulated. The results are then compared.

4 RESULT

With the use of QualNet 6.1 we have studied different parameters for two cases.

Network life time is defined in terms of number of surviving nodes after a particular interval of time [7]. This is calculated with the help of Residual battery capacity. Fig 2 shows the Network Lifetime.

Throughput is one of the dimensional parameters of the Wireless sensor network which gives the fraction of the channel capacity used for useful transmission whenever network selects a destination when simulation starts. Information of the data packets delivery to the destinations is observed. Fig 3 shows Unicast received Throughput.
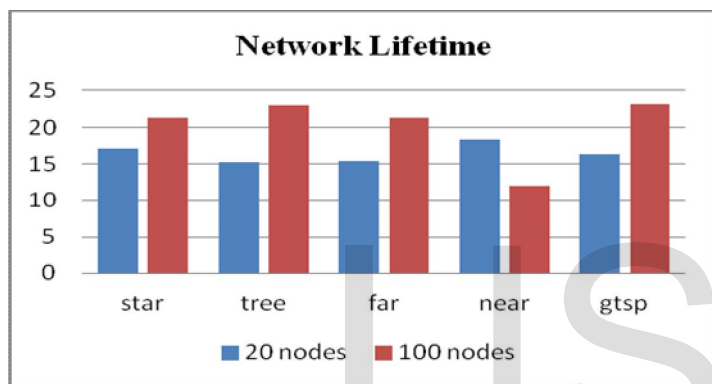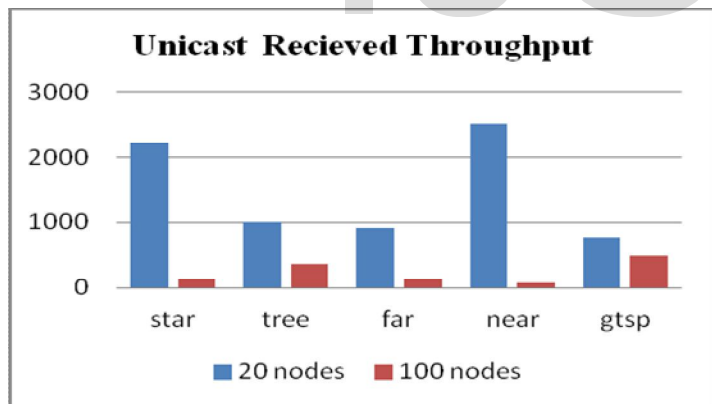
Fig 2: Network Lifetime

Fig 3: Unicast Received Throughput

The Average End-to-End Delay is the duration between the data packets generation time and the last bit arrival time at the destination. Fig 4 shows Average End to End delay.
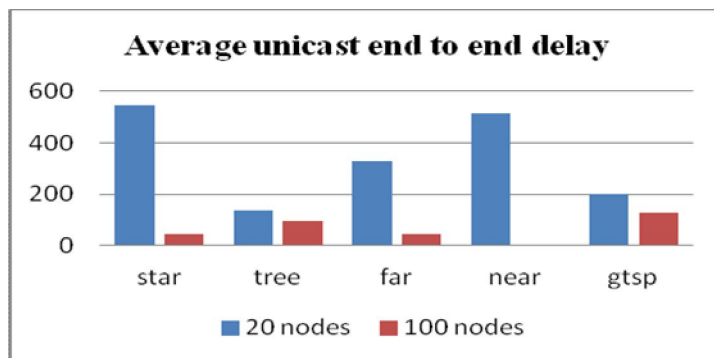
Fig 4: Average Unicast End to end Delay

Average Jitter is the variation of the packet-arrival times between the two successive packets received. Fig 5 shows Average Unicast Jitter.
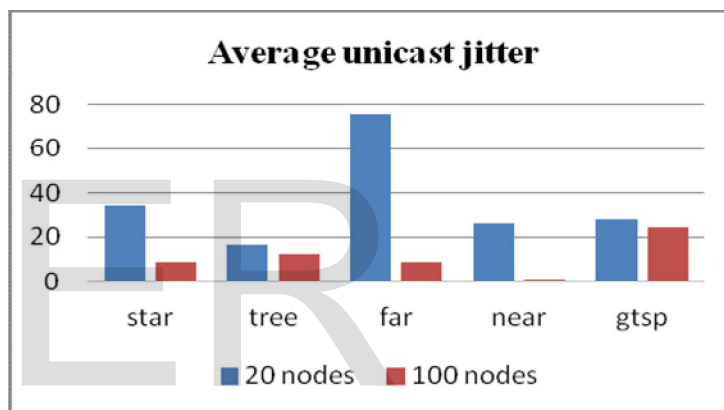
Fig 5: Average Unicast Jitter

Number of data Packets dropped due to channel access failure the number of packets dropped when the channel is proceeding to failure point. Fig 6 shows Number of Data Packets Dropped Due To Channel Access Failure.
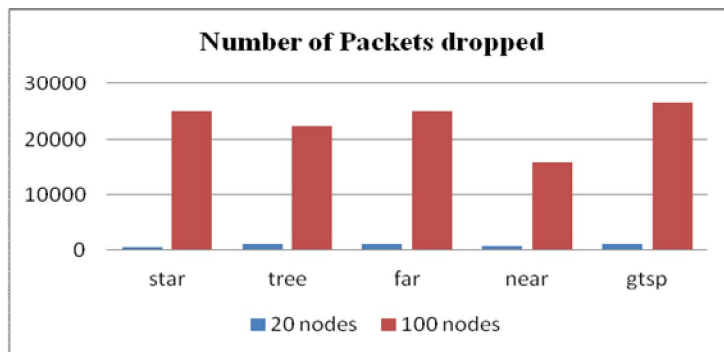
Fig 6: Numberof Packets Dropped

TABLE2
COMPARISON OF VARIOUS PARAMETERS

Topologies / Parameter	Star	Tree	Near	Far	GTSP
Network life-time(Days) (20 nodes)	17.041	15.26	18.27	15.43	16.33
Network life-time(Days) (100 nodes)	21.334	22.95	11.97	21.33	23.07
Unicast Received Throughput (bits/second) (20 nodes)	2235.9	997.4	2523.6	918.7	775.2
Unicast Received Throughput (bits/second) (100 nodes)	133.74	372.1	82.530	133.7	491.38
No. Of Data Packets Dropped Due To Channel Access Failure (20 nodes)	478	947	544	1106	1105
Number Of Data Packets Dropped Due To Channel Access Failure(100 nodes)	25027	22415	15693	25027	26480
Average Unicast End-to-End Delay (sec.) (20 nodes)	546.23	139.6	515.53	325.6	199.74
Average Unicast End-to-End Delay (seconds)(100 nodes)	43.303	99.56	2.8671	43.30	129.11
Average Unicast Jitter(seconds)(20 nodes)	34.5582	16.82	26.3431	75.65	27.9205
Average Unicast Jitter(seconds)(100 nodes)	8.8575	12.25	1.0175	8.857	24.578

5 CONCLUSIONS

The result indicates that with Gradient Time Synchronized Protocol [4], the network lifetime is increased as compared to any other topology when number of nodes is increased from 20 nodes to 100 nodes. If the nodes density is 20 nodes then Throughput of Near topology is highest compared to other topologies. But when nodes density is increased to 100, GTSP gives best Throughput.The problem with the GTSP is the packets dropped are higher than the other topologies. End to end delay is highest for near topology if nodes density is 20 nodes. If nodes density is increased to 100 nodes, End to end delay is highest for GTSP topology.

Hence if nodes density increases from 20 nodes to 100 nodes parameters like Network lifetime and Throughput improves for GTSP topology. But the values of parameters like End to end delay and Number of packets dropped increases leading to the disadvantage of GTSP topology.

REFERENCES

[1] Chaonan Wang; Liudong Xing ; Vokkarane V.M. ; Yan Sun "Reliability analysis of wireless sensor networks using different network topology characteristics", *Quality, Reliability, Risk, Maintenance, and Safe Engineering (ICQR2MSE)*, 2012 International Conference on Digital Object Identifier: 10.1109/ICQR2MSE.2012.6246179 Publication Year: 2012 , Page(s): 12- 16

[2] El-Aaasser; Ashour, M. "Energy aware classification for wireless sensor networks routing," *Advanced Communication Technology (ICACT)*, 2013 15th International Conference on Publication Year: 2013, Page(s): 66- 71.

[3] Yang Ning; Tian Hui; Huang Ping; Zhang Ping ,"Basic topology research on wireless sensor networks" *Electronics, Circuits and Systems*, 2005. ICECS 2005. 12th IEEE International Conference on Digital Object Identifier: 10.1109/ICECS.2005.4633515 Publication Year: 2005, Page(s): 1- 4.

[4] P. Sommer; R. Wattenhofer,"Gradient clock synchronization in wireless sensor networks." *Information Processing in Sensor Networks*, 2009. IPSN 2009. International Conference on Publication Year: 2009, Page(s): 37- 48.

[5] D. Luo, X. Zhu, X. Wu, and G. Chen. ", Maximizing lifetime for the shortest path aggregation tree in wireless sensor networks." *In Proc. IEEE INFOCOM*, pages 1566–1574, 2011

[6] W. Bechkit; M. Koudil; Y. Challal; A. Bouabdallah; B.Souici; K. Benatchba," A new weighted shortest path tree for convergecast traffic routing in WSN", *Computers and Communications (ISCC)*, 2012 IEEE Symposium on Digital Object Identifier: 10.1109/ISCC.2012.6249291 Publication Year: 2012 , Page(s): 000187- 000192.

[7] I. Dietrich and F. Dressler. *On the lifetime of wireless sensor networks.* ACM Trans. Sen. Netw., 5(1):1–39, 2009.