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Study and Evaluation of Different Topologies in Wireless Sensor Network

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***Abstract*—The network technologies development made wireless sensor network (WSN) to have many ways in reducing the complexity, cost and in improving reliability. The objective of this paper is to provide an effective topology modeling to conserve the energy of individual nodes in wireless sensor network and preserving its coverage maintenance and graph connectivity. This paper presents the types of topologies: Bus, ring, star and its evaluation in terms of Receiving energy, Residual energy, Idle-state energy, number of packets sent or received in the network.**

***Index Terms*—Topology, Wireless sensor network, Receiving energy, Residual energy, Idle-state energy, number of packets sent or received.**

I. Introduction

A wireless sensor network is a network connecting a huge number of sensor nodes in wireless scenario. The sensor nodes are tiny elements which are operated automatically; consist of computing engine, storage and communication subsystems, energy supply, sensors and actuators. These sensor nodes play a vital role in receiving and transmitting the collected information from environment and forward it on in the network up to a destination, which is able to store the parameters and make it available for the end users present in the network [1].

In most of the applications of wireless sensor network, the deployment of sensor nodes takes place randomly and are activated to work efficiently and effectively. Due to this random deployment of sensor nodes, there occurs a variation in node density in Wireless Sensor Network. The energy conservation is an important criterion to be considered in wireless sensor network. Preserving energy pays a way for increasing the lifetime of the network [2]. The energy consumption occurs in certain aspects like computation, sensing and communication.

Due to this energy constraint of the sensor nodes, they are liable to die slowly and make the sensor network less populated. This makes the difference in the sensor node density in some regions of the Wireless Sensor Network.

The wireless network need to be maintained with fault tolerant as in most cases of sensor network environment, the deployment of sensor nodes are found to be not working or faulty [3]. For this reason, the sensor network needs to be fault-tolerant so that the network needs to be maintained. Typically the wireless sensor network topology is continuously subjected for alteration dynamically, but it is actually not a desired solution to boost it by infusing new sensors instead the depleted ones. It is important to develop a solution to this problem by selecting a perfect and efficient topology. The topology control deals with some aspects like identifying the nodes connected in a network at maximum transmission, calculating minimum transmission power for an individual node for energy conservation and connecting the nodes with shortest algorithm or minimum-energy level [4].

The topology control algorithm is proposed to extend the network lifetime balancing the energy consumption in a node [5]. The consumed energy could be reduced in a large scale sensor network by considering a mobile sink node [6] in the observing area [7]. In the case when the event node is on movement reducing the mean distance among nodes, it leads to increase the latency of packet transmission and its interference level [8].

The network lifetime of a wireless sensor network can be increased by adjusting the node power, deciding the cost of communication link dynamically [9].

The rest of the paper is organized as follows. Section II presents the Bus topology. Section III presents the Ring topology and its simulation results, Star topology and its simulation results are presented in Section IV. Section V presents the conclusion.

II. Bus Topology

In bus networks a common backbone is used to connect all devices. Here all the nodes are deployed in bus orientation in wireless media. Energy consumption is usually compared against the metrics like packet size, range (hops in case of multi-hop network), number of nodes in the network.

In this paper the network simulator (ns2) is used as simulation platform to emulate AODV, DSDV, DSR protocols on bus topology. This comparison is given in terms of remaining energy, receiving energy, idle state energy.

A. Simulation Parameters

- The sensor nodes are deployed in a bus topology network in a particular distance range.
- The destination is fixed in the network.
- After the deployment sensor nodes are made stationary.
- The nodes communicate with the destination via multiple hops.
- Initial energy is maintained same for each node (see Table I).

TABLE I
SIMULATION PARAMETERS.

Network area	1500 $*$ 1500 m
Initial energy	10 J
Packet size	Varied
Data rate	0.1 Mbps
Number of nodes	23
Packet interval	2 s
Distance range	10, 20, 30 m

TABLE II

Simulation time	Packet size (bytes)	No. of packets sent	No. of packets received	No. of bytes
50	50	20	20	1000 (sent) 1400 (received)
50	100	20	20	2000 (sent) 2400 (received)
50	150	20	0	3000 (sent) 0 (received)
100	50	45	31	2250 (sent) 2170 (received)
100	100	45	20	4500 (sent) 2400 (received)

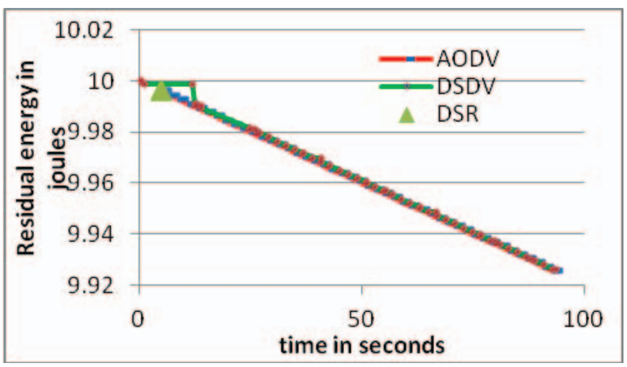

Fig. 1. Remaining energy of a sink node.

It is shown that there occurs a reduction in number of packets when size of a packet is increased in a network depicting the network lifetime in Table II

The variation of remaining energy, receiving energy, idle state energy with time for AODV, DSDV, DSR protocols are shown in the Figs. 1 through 3.

The energy consumption is measured by varying the range of distance between the nodes and its packet size as shown in Figs. 4 and 5.

III. RING TOPOLOGY

A ring network is a network topology in which nodes are arranged in such a way that each node is connected exactly to two nodes forming a continuous pathway for signals through each node, forming a ring. Data travels from node to node, with each node along the way handling every packet. The nodes in wireless sensor network (WSN) are developed

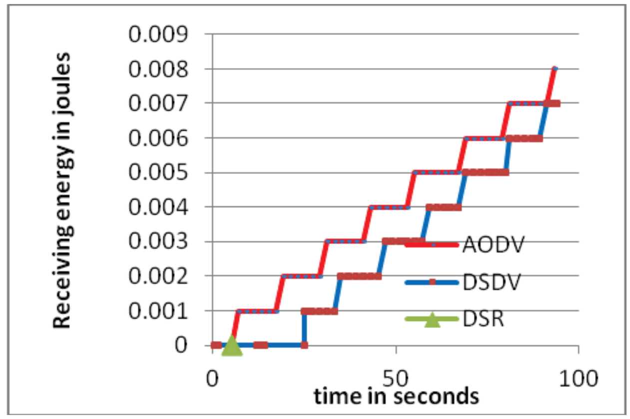

Fig. 2. Receiving energy of a sink node.

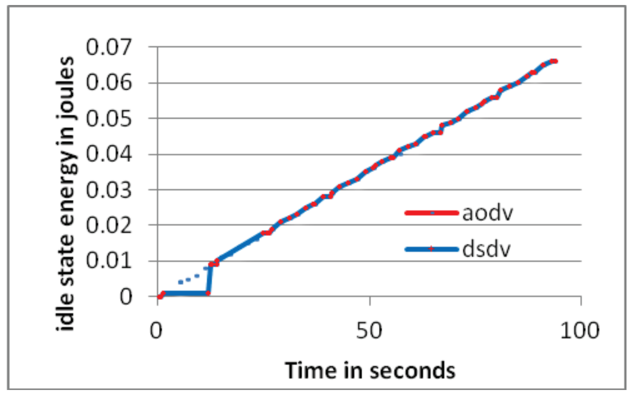

Fig. 3. Idle-state energy of a sink node.

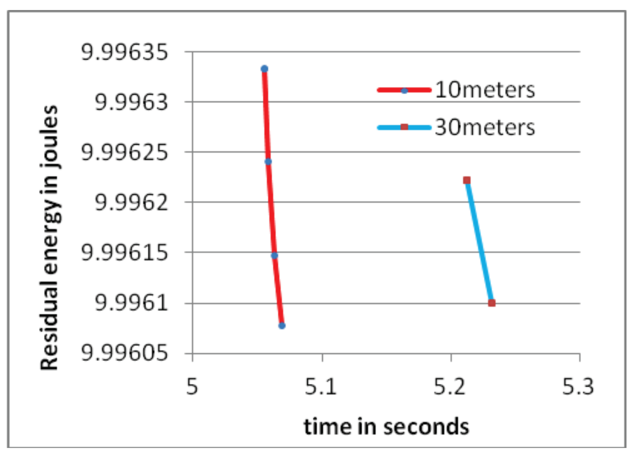

Fig. 4. Residual energy with different range of distance.

based on IEEE 802.15.4 consists of low-rate capacities i.e. limited power source and communication capabilities [10], somehow expected to operate at relatively long time in harsh environment.

The various packets transmitted and received for different packet size and time is shown in Table III.

The variation of remaining energy, receiving energy, idle state energy with time for AODV, DSDV, DSR protocols are shown in the Figs. 6 through 8.

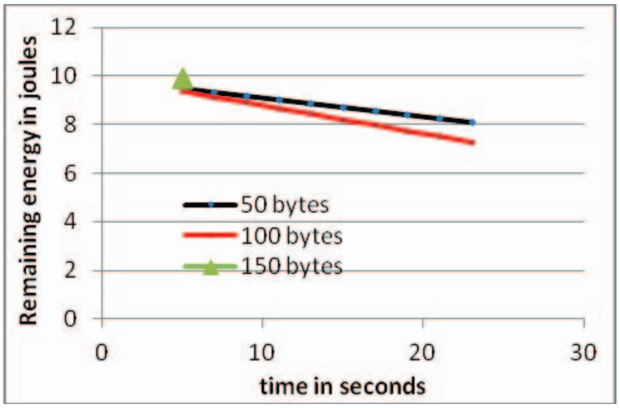

Fig. 5. Remaining energy with different packet size.

TABLE III

Simulation time	Packet size (bytes)	No. of packets sent	No. of packets received	No. of bytes
50	50	20	20	1000 (sent) 1400 (received)
50	100	20	20	2000 (sent) 2400 (received)
50	150	20	0	3000 (sent) 0 (received)
100	50	45	45	2250 (sent) 3150 (received)
100	100	39	37	3900 (sent) 4440 (received)

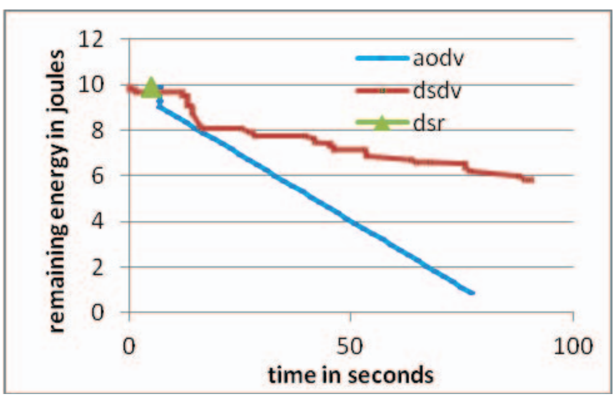

Fig. 6. Remaining energy of a sink node.

Energy consumption is usually compared against the metrics like packet size, range (hops in case of multi-hop network) and it is shown in the Figs. 9 and 10.

IV. Star Topology

In star topology, all nodes are connected to a single sink node or hub in the center. Here transmission is done directly between source and destination nodes, so hopping among other nodes is not needed.

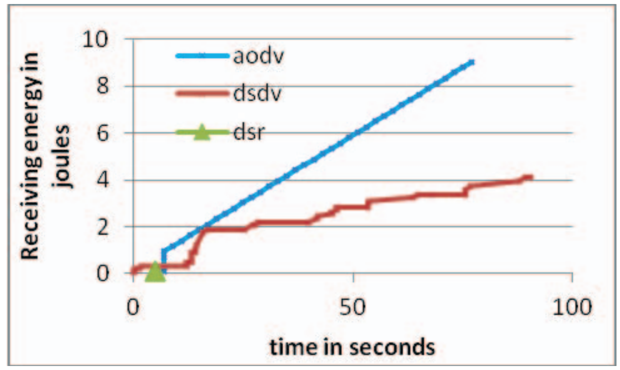

Fig. 7. Receiving energy of a sink node.

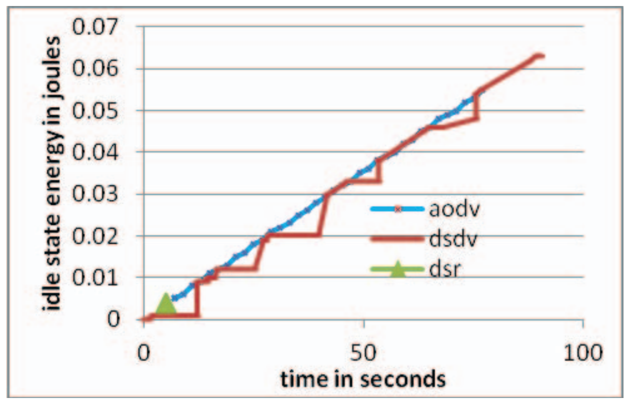

Fig. 8. Idle-state energy of a sink node.

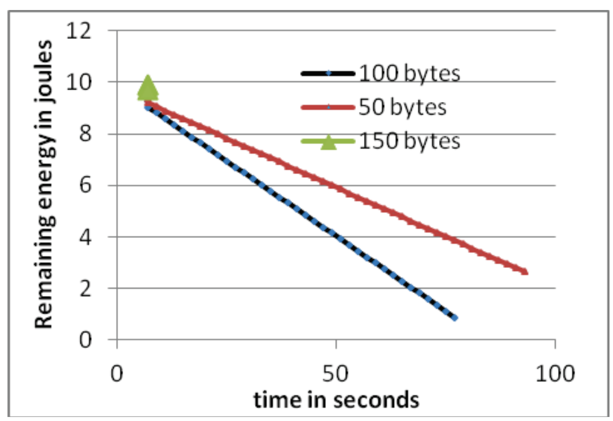

Fig. 9. Remaining energy with different packet size.

When number of nodes increases, the energy of sink node gets depleted soon in star topology when compared to others topologies.

The various packets transmitted and received for different packet size and time is shown in Table IV.

The variation of remaining energy, receiving energy, idle state energy with time for AODV, DSDV, DSR protocols are shown in the Figs. 11 through 13. The change in remaining energy with various packet sizes is depicted in Fig. 14.

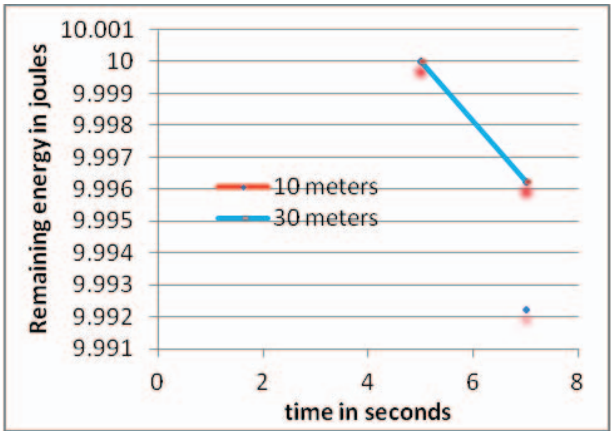

Fig. 10. Remaining energy with various ranges.

TABLE IV

Simulation time	Packet size (bytes)	No. of packets sent from three nodes	No. of packets received	No. of bytes
50	50	43, 22, 21	69	2150, 1100, 1050 (sent) 4830 (received)
50	100	43,22,21	43	4300, 2200, 2100 (sent) 5160 (received)
50	150	43, 22, 21	0	6450, 3300, 3150 (sent) 0 (received)
100	50	93, 47, 46	69	4650, 2350, 2300 (sent) 4830 (received)
100	100	93, 47, 46	43	9300, 4700, 4600 (sent) 5160 (received)

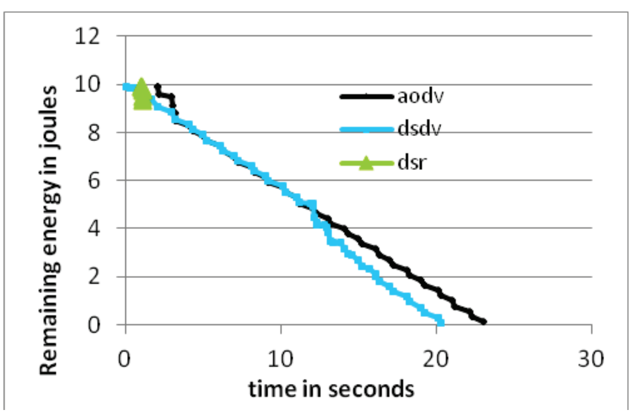

Fig. 11. Remaining energy of a sink node.

V. Conclusion

This paper analyzes the receiving energy, residual energy, idle-state energy, comparison of energy consumption against change in packet size and range of distance between nodes.

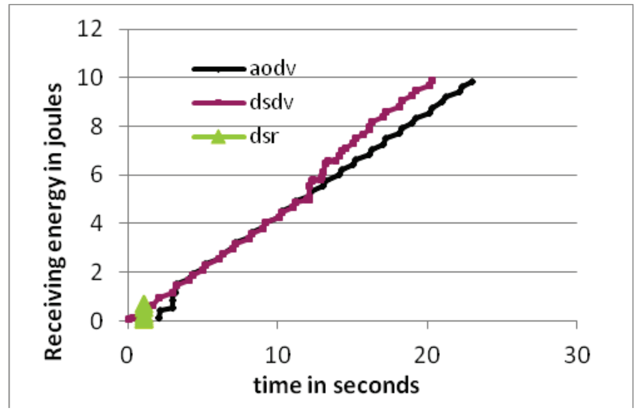

Fig. 12. Receiving energy of a sink node.

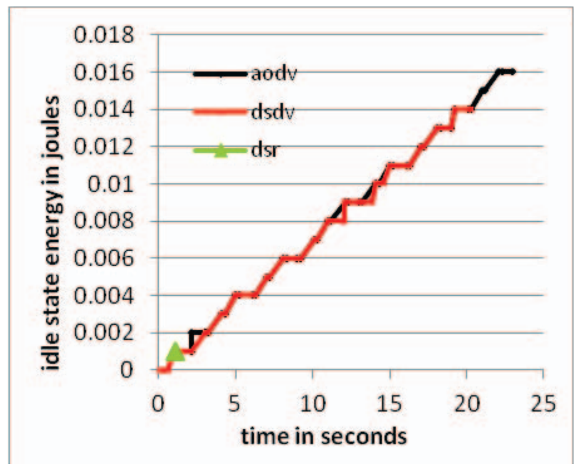

Fig. 13. Idle-state energy of a sink node.

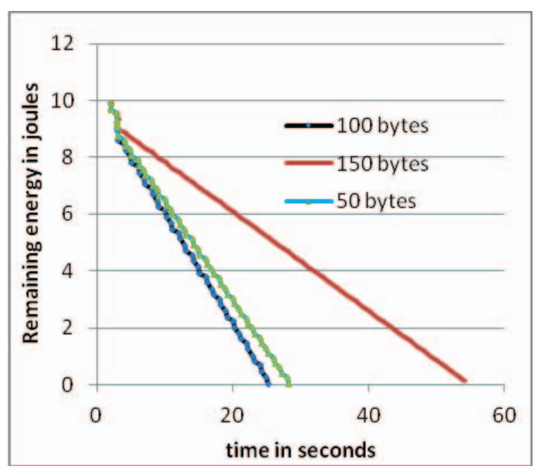

Fig. 14. Remaining energy with different packet size.

References

[1] L. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “A survey on sensor networks,” *IEEE Communications Magazine*, vol. 40, no. 8, pp. 102–114. vol. 25, no. 4, pp. 114–124, 2002.

[2] Trong-The Nguyen, Chin-Shiuh Shieh, Thi-Kien Dao, Jaw-Shyang Wu, and Wu-Chih Hu Robot, “Prolonging of the network lifetime of WSN

using fuzzy clustering topology," in *Vision and Signal Processing (RVSP), 2013 Second International Conference*.

[3] Rai B. Shamantha, Niharika Ananad, and Shirshu Varma, "Scrutinizing localized topology control in wsn using rigid graphs" in *Computing for Sustainable Global Development (INDIACom), 2015 2nd International Conference*.

[4] Mohd Zaki Shahabuddin, Halabi Hasbullah, and Izzatdin A. Aziz, "Preliminary framework of topology control algorithm in WSN to achieve node's energy efficiency," in *2016 3rd International Conference on Computer and Information Sciences (ICCOINS)*.

[5] Xiang Yi, Wu Ying, and Peng Jun, "A kind of topology control algorithm aimed at extending the life cycle of the WSN," in *2014 IEEE 13th International Conference on Cognitive Informatics and Cognitive Computing*.

[6] Tao Yang, Makoto Ikeda, Leonard Barolli, Arjan Durresi, and Fatos Xhafa "Performance evaluation of wireless sensor networks for different radio models considering mobile event," in *2010 International Conference on Complex, Intelligent and Software Intensive Systems*.

[7] Jiu-qiang Xu, Hong-chuan Wang, Feng-gao Lang, Ping Wang, and Zhen-peng Hou "Study on WSN topology division and lifetime," in *2011 IEEE International Conference on Computer Science and Automation Engineering*.

[8] Tao Yang, Makoto Ikeda, Gjergji Mino, Leonard Barolli, Arjan Durresi, and Fatos Xhafa "Performance evaluation of wireless sensor networks for mobile sink considering consumed energy metric," in *2010 IEEE 24th International Conference on Advanced Information Networking and Applications Workshops*.

[9] Xiang Yi, Wu Ying, and Peng Jun, "A kind of topology control algorithm aimed at extending th elife cycle of the WSN," in *Cognitive Informatics & Cognitive Computing (ICCI*CC), 2014 IEEE 13th International Conference*.

[10] Ashraf A. M. Khalaf and Mostafa S. A. Mokadem, "Effects of ZigBee component failure on the WSN performance with different topologies," in *Microelectronics (ICM), 2016 28th International Conference*.