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QoS based Evaluation of Routing Protocols in WSN

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Abstract: *Wireless sensor networks (WSNs) generally focus on information gathering capacity of various applications and depends on the application types that may require certain quality of service (QoS) guaranteeing reliable transmission of data. However, providing QoS support is a challenging issue due to unreliable wireless links, highly resource constrained nature of sensor nodes and harsh operation environments. In this paper we investigate the utility of reactive routing protocol (AODV) in wireless sensor network to achieve improvements in throughput, packet delivery ratio and energy consumption per successful data delivery (ECSSD). Performance gains in the order of 30-50% could be achieved by altering path update rules for table driven routing schemes (DSDV).*

Keywords: Zigbee ; IEEE 802.15.4 ; Wireless Sensor Networks ; Energy consumption ; NS-2

I. Introduction

Over a decade of time, the demand in area of wireless technology has increased. IEEE 802.11, a wireless communication standard was concerned with features like message forwarding, ethernet matching speed, data throughput of 2-11Mbps etc. So far, attention was mainly focused on high data rate and relatively long range applications. The growth of mobile devices such as mobile phones palmtops, personal digital assistants (PDAs), bluetooth [4][5], pocket computers and sensors have created a demand for short range low rate wireless standards. Therefore, IEEE 802.15.4 working group was formed to focus on short range applications in the field of medical, industry automation, home automation, chemical attack detection and many more [1]. Therefore, ZigBee alliance [3] and IEEE are working together to achieve the goal i.e. highly reliable technology along with low cost and high battery life. IEEE 802.15 devices generally differentiated by data rate, battery drain and quality of service (QoS) parameters, operate in limited personal operating space (pos), and can be classified as:

- 1) **The high data rate** WPAN (IEEE 802.15.3) also known as ultra wide band (UWB), suitable for multimedia applications that require very high QoS.
- 2) **Medium data rate** WPANs (IEEE 802.15.1/Bluetooth) handle a variety of tasks ranging from cell phones to PDA communications and have QoS suitable for voice communication.
- 3) **The low rate** WPANs (IEEE 802.15.4/LR-WPAN), known as Wireless Sensor Network (WSN) are specifically designed for low cost, low power consumption, and low data rate in an ad-hoc, self-organizing network[6][7].

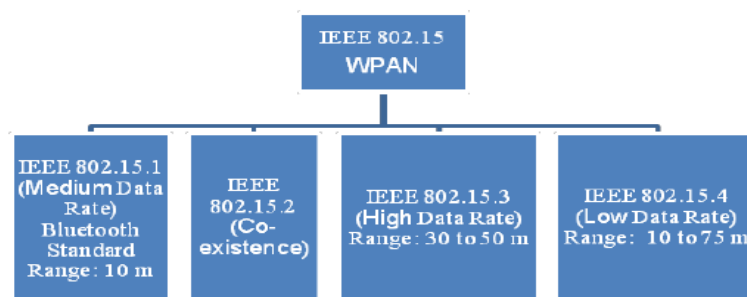


Figure 1 WPAN Standards

In this paper, we consider an IEEE 802.15.4-based Wireless Sensor Network (WSN) as one of the emerging technologies that combine industrial automated sensing[8], embedded computing and wireless networking into tiny embedded devices ,multimedia or visual wireless sensor networks [9][10]. These emerging application domains have performance and quality of service (QoS) assurances in common.

Therefore, QoS brings the ability of giving different priorities to various users, applications, and data flows, frames or packets based on their requirements by controlling the resource sharing. Hence higher level of performance being our objective can be provided through a set of measurable service parameters like throughput, packet delivery ratio and energy consumption per successful data delivery [14] as the performance metrics.

We have implemented the two routing schemes namely AODV and DSDV that have been proposed in the framework of the ZigBee Alliance (in section 2) for IEEE 802.15.4 sensor networks using Ns-2 and their performances in section 4.

II. Zigbee/IEEE 802.15.4 Architecture

In this section, a brief overview to the IEEE 802.15.4 protocol is provided. An IEEE 802.15.4 WPAN is composed of one PAN coordinator and a set of devices. The PAN *coordinator* being the primary controller of the network is responsible for initiating the network operations, maintaining, terminating, or route communication around the network. IEEE 802.15.4 devices can be full-function devices (FFD) or reduced-function devices (RFD) according to their capabilities and available resources. An FFD can talk to RFDs or other FFDs, while a RFD can talk only to FFD. In [13], a set of procedures is defined to allow the PAN coordinator to start a new WPAN, and to allow devices to join this WPAN. There are two types of procedures to establish and maintain device membership in a WPAN as explained below:

A. Association Procedure

The operation of associating a device to join a WPAN can be performed as:

- a) Scanning for available WPANs
- b) Selecting the WPAN to join in the network
- c) Initializing the association procedure

Due to the origination of beacon frames by scanning of the devices or PAN coordinator the discovery of all available devices or WPAN is done. Broadcasting of beacons can be done in non beacon-enabled and beacon enabled modes. Two different types of scan for the association phase are:

- 1) **Passive scan:** In beacon-enabled networks the associated FFDs periodically transmit beacon frames where the information on the available WPANs can be directly derived by eavesdropping the wireless channels i.e. by capturing the beacon frames.
- 2) **Active scan:** In non-beacon-enabled networks the beacon frames are not periodically transmitted by coordinators; a device scanning the channels shall explicitly request beacon frames (by a *beacon request command*) and shall wait for replies from the available coordinators. This procedure results in a set of MAC association generally forming a tree rooted relationship between devices and the PAN coordinator.

B. Realignment Procedure

Due to high variability of wireless channels or limited power a sensor node can lose its synchronization and get disconnected with the coordinator. In this case, realignment procedure describes the re-association of devices with the coordinator. Then an orphan *scan* phase, is initiated which aims at re-establishing synchronization with the previous coordinator if it is still reachable with help of *orphaned* device. Otherwise, a new association procedure is triggered. Therefore, the data sent between a device and its coordinator after the connection establishment can be performed in one of the ways shown in Figure 2. Acknowledgments are optional in all transfers from a device to its coordinator, but they are required in transfers from the coordinator. When transferring from a coordinator to a device, the device must first request the data from the coordinator. In a non beacon enabled network, devices must poll the coordinator for data at an application-specified rate, as there are no beacons to indicate to the device that there is data pending for it.

III. Routing Protocols for IEEE 802.15.4 / Zigbee Standard

There are several kinds of routing protocols for wireless sensor networks. These routing protocols are categorized as reactive or proactive routing protocols [16]. In this paper, we have used AODV and DSDV routing protocols for the analysis of WSN, both are discussed in the following section.

A. Destination-Sequenced Distance Vector(DSDV)

Destination-Sequenced Distance Vector routing protocol (DSDV) is a proactive routing protocol based on the Distributed Bellman-Ford algorithm [1] and belongs to the table-driven family. Routes between the nodes in the network are tagged with the sequence number indicating how old the route is along with the distance to every node in WSNs [11]. Each node has its own sequence number achieved by incrementing it two greater than the old one except when the node discovers an expired path where the increment is by one. Thereby, preventing —routing loop and —count to infinity problem. Routing updates takes place as the topology changes, and it can be performed as —full dump or —incremental update. In the former, the complete routing table is transmitted by the node whereas in the latter it updates only the last entry which was changed.

In fast changing network, incremental messages could increase and affect the performance of the network, so full dumps are preferred in a fast changing network [12].

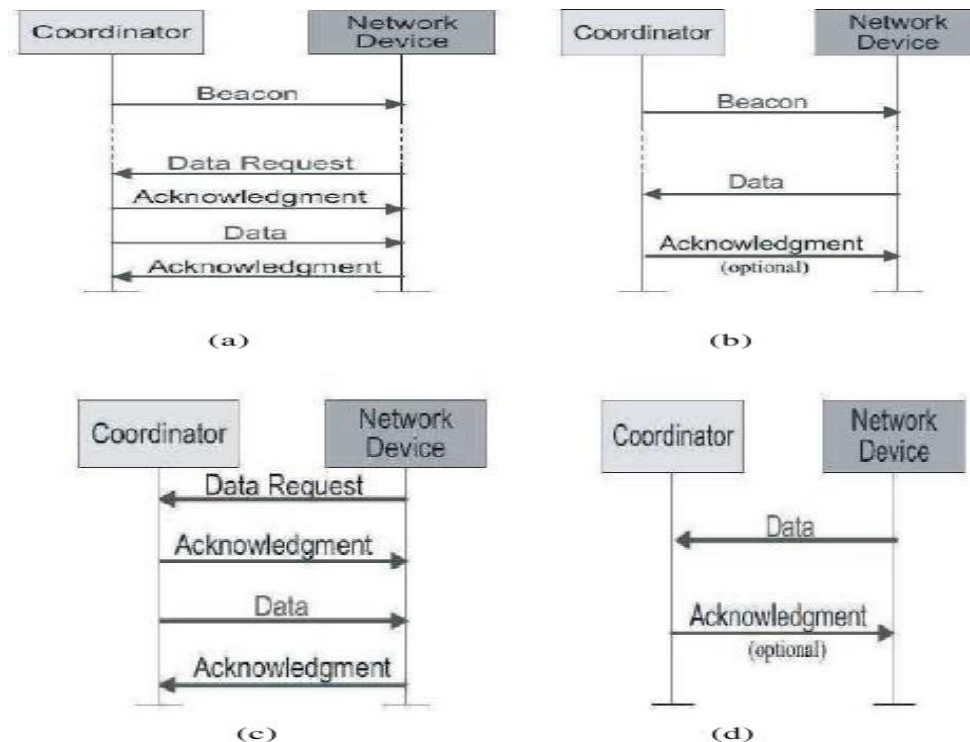


Figure 2 Data transfer between a coordinator and its devices a)Coordinator to Device with Beacons enabled b) Device to Coordinator with Beacons enabled c) Coordinator to Device with Beacons disabled d)Device to Coordinator with Beacons disabled ([6])

B. Ad-hoc On-Demand Distance Vector(AODV)

AODV generally used for ad-hoc networks, is widely used in WSNs [11] is an improvement on DSDV algorithm. It is a reactive routing protocol that establishes routing paths between the nodes only if demanded by the source node. In AODV, each node periodically broadcasts HELLO messages to its neighboring nodes and then uses these neighbors to establish routes and send messages. A Route Request Message (RREQ) is used to send messages to the nodes which are not the neighbors of the source node as shown in Figure 3. AODV also has the ability of Route Error message (REER) which allows it to adjust the route when node moves around. It is suitable for large mobile nodes and can handle different mobility rates with a variety of data traffic levels and quickly adapt to dynamic link conditions. Low processing times, small memory overhead, low-network utilization, are some more advantages of AODV protocol [11].

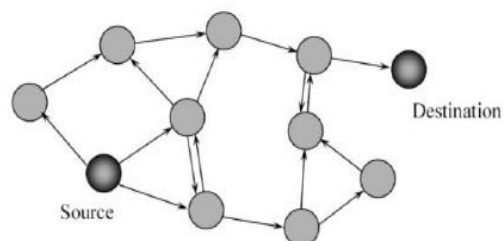


Figure 3 Route Request (RREQ) broadcast

IV. Simulation Results

The main objective of this simulation study was to evaluate the performance of 802.15.4 for different reactive routing protocols like AODV [10] and DSDV [11] with varying traffic loads. The simulations have been performed using Ns-2 simulator [15] MAC and Physical layer protocol used for experimentation are IEEE

802.15.4. PAN coordinator is placed at the centre of the simulation area. QoS parameters are analyzed for varying traffic load, data rate and number of nodes. The results are shown from Figure 4 to 7. The simulations parameters are shown in Table 1.

TABLE I. SIMULATION PARAMETERS

Simulation Parameters	Parameter value
Number of Nodes	10 to 30
Simulation time	100 Seconds
Channel frequency	2.4GHz
Simulation Area	50 x 50 m ²
Traffic Type	CBR/FTP/Poisson
Routing Protocol	AODV and DSDV
Path Loss Model	Two Ray Model
MAC Model	IEEE 802.15.4
Energy Model	Energy Model
Data Rate	10,20,30,40,100
Initial Energy	100 Joules
BO,SO	3

Following performance metrics are used for the analysis study of routing protocols:

1) Throughput

It is defined as the total number of packets received at the sink node divided by the simulation time. It is generally measured in bits/Sec (bps) or kilobits/Sec (kbps). Figure 4 shows the graphical representation of throughput which increases with the network size with respect to number of nodes.

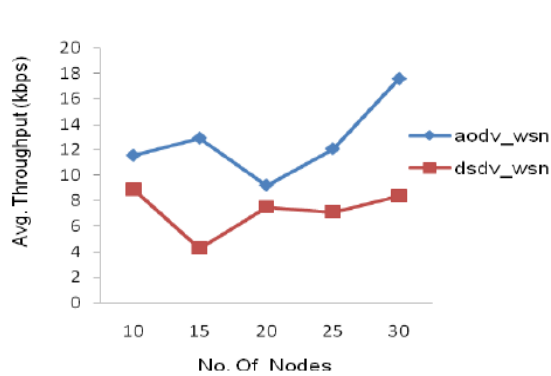


Figure 4 Avg. Throughput versus Number of Nodes

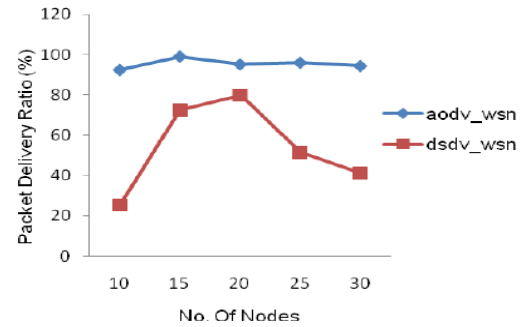


Figure 5 Packet Delivery Ratio versus Number of Nodes

2) Packet Delivery Ratio (PDR)

PDR is defined as the number of packets received at sink node divided by the number of packets sent by the source node. As shown in Figure 5, the packet delivery ratio in AODV is much better when compared with DSDV. The reason for the better packet delivery ratio in AODV over DSDV is that DSDV is a table-driven protocol and updates its table periodically which leads to an increase in the routing load in the network and less packet delivery ratio. On the other hand, AODV is an on demand routing protocol and adapts faster than DSDV to the change of the routing caused by mobile nodes in WSNs.

3) Energy Consumption per Successful Data Delivery (ECSSD)

It is the ratio of total network energy consumption to the number of data packets successfully delivered to the sink. The network energy consumption includes all the energy consumptions (including MAC layer controls). A less value of ECSSD indicates that most of that packets being delivered with less energy and is an achievement sign of protocol on energy efficiency as shown in Figure 6 and Figure 7, where AODV consumes far less energy as compared to DSDV when varied with respect to number of nodes, traffic type and data rate.

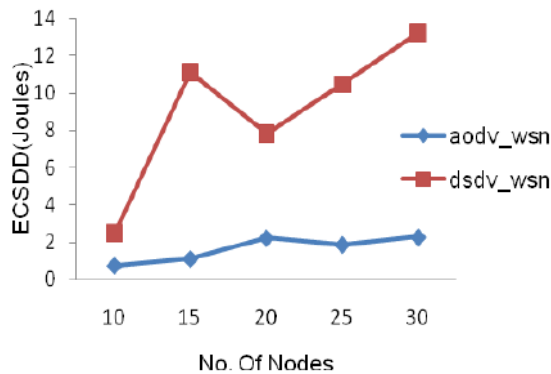


Figure 6 ECSDD versus Number of nodes

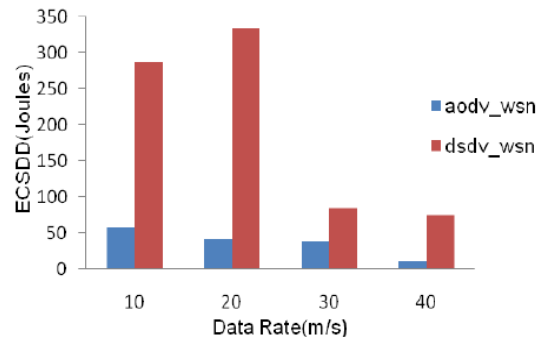


Figure 7 ECSDD versus Data Rate

This is due to the fact that probability of the link breakage goes up when increases speed of node mobility in case of DSDV. Because of staled routing table entries, packets are sent or forwarded over the broken links. This increases the retransmission attempts for successful transmission. It leads DSDV to consume large amount energy for unsuccessful communication. In addition, DSDV consumes significant amount of energy to construct unusable routes periodically.

V. Conclusion and Future Scope

In this paper, a simulation based performance analysis of QoS parameters for WSN based on IEEE 802.15.4 in beacon enabled mode is done using Ns-2. From the analysis and simulation results, it can be concluded that the performance of AODV is far better when energy consumption per successful data delivery is considered with number of nodes and data rate. In case of Packet Delivery Ratio AODV has better performance than DSDV. As far as throughput is concerned AODV performs far better as compared to DSDV. Average throughput in both protocols increases steadily with an increase in the number of nodes. In general AODV performs better than DSDV specially while considering energy consumption per packet successful data delivery. However, both protocols have their own advantages as well as its disadvantages making it suitable for some applications and not for others. Hence, an efficient routing protocol should be selected that suits the desired sensing task. In future, modified version of the selected routing with high rate of route establishment leading to efficiency and reliability may be improvised. Secondly, security as a QoS parameter has not been evaluated here. So, new security based routing protocols for IEEE 802.15.4 networks can be a field of study.

VI. References

- [1] I. Akyildiz, Weilian Su, Yogesh Sankarasubramaniam and Erdal Cayirci, —Wireless Sensor Network: A Survey on Sensor Networks ,IEEECommunications Magazine, 40(8); pp. 102-114, August 2002.
- [2] IEEE standard 802.11 Wireless Medium Access Control and Physical Layer Specifications 1999.
- [3] ZigBee Resource: <http://www.zigbee.org>
- [4] Bluetooth SIG, —Specifications of the Bluetooth System – Version 1.2, Nov. 2003.
- [5] Bluetooth Special Interest Group, —Specifications of the Bluetooth System, vol. 1, v.1.0B Core and vol.2.oB Profiles, Dec. 1999.
- [6] Sinem Coleri Ergen, —ZigBee/IEEE 802.15.4 Summary, September 10, 2004.
- [7] Jianliang Zheng and Myung J. Lee, —Will IEEE 802.15.4 Make Ubiquitous Networking a Reality?A Discussion on a Potential Low Power, Low Bit Rate Standard, IEEE Communications Magazine, June2004.
- [8] V. Gungor, G. Hancke, —Industrial wireless sensor networks: challenges, design principles, and technical approaches, IEEE Transactions on Industrial Electronics 56 (10) (2009) 4258– 4265,doi:10.1109/TIE.2009.2015754.
- [9] I. Akyildiz, T. Melodia, K. Chowdhury, —A survey on wireless multimedia sensor networks, Computer Networks 51 (4) (2007) 921–960, doi:10.1016/j.comnet.2006.10.002.
- [10] S. Soro, W. Heinzelman, —A survey of visual sensor networks, Advances in Multimedia 2009 (2009) 1–22.
- [11] Yadav, P., Performance Comparison and Analysis of Table- Driven and On-Demand Routing Protocols for Mobile Ad-hoc Networks ,(2008), available online at: <http://citeseerx.ist.psu.edu/viewdoc/download>.
- [12] Parul Kansal, P. Kansal, D and Balodi, A,—Compression of Various Routing Protocol in Wireless Sensor Network”, International Journal of Computer Applications (0975 – 8887) Volume 5– No.11.
- [13] Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate Wireless Personal Area Networks (WPANs), IEEE Std. 802.15.4, 2003.
- [14] A. Adane, “Active communication energy efficient routing protocol of mobile ad hoc networks(Manets)”, M. Eng. thesis, Addis Ababa University, Ethiopia, April 2008.
- [15] Network Simulator 2, available online at: <http://www.isi.edu/nsnam/ns>.
- [16] Cui Xiaoyan, Chen Mengxiao, Zheng Wei, YaoYan. Research on routing improvement based on ZigBee. 2009 IEEE.