Design of an Energy Efficient and Delay Tolerant Routing Protocol for Wireless Body Area Network

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Abstract— **The Wireless Body Area Network provide continuous health monitoring and real-time feedback to the medical personnel. The devices used for WBAN have limited energy resources. For most devices it is impossible to recharge or change the batteries. Low power is needed to provide long lifetime to the devices. All devices are equally important and devices are only added when they are needed for an application. The data mostly consists of medical information. Hence, high reliability and low delay is required. Cluster topology and Dynamic Source Routing Protocol provides high packet delivery ratio, low delay and low energy consumption. In this paper, a modification in the DSR routing protocol has been proposed. The modified DSR named as EDSR (Efficient Dynamic Source Routing), reduces the delay by reducing the average end to end delay for the node and reduces the number of packets dropped thereby increasing packet delivery ratio. Energy consumption in EDSR is decreased by 16.73% when compared to DSR. This protocol reduces the energy consumption and delay by reducing the time needed for route discovery process. EDSR achieves high residual battery capacity which eliminates the need for recharging the batteries thereby ensuring long lifetime of the devices.**

Keywords- WBAN; EDSR; Energy Efficiency; Patient monitoring (key words)

I. INTRODUCTION

The wireless sensor networks are an enabling technology for the application domain of unobtrusive medical monitoring. This field includes continuous cable-free monitoring of vital signs in intensive care units ,remote monitoring of chronically ill patients ,monitoring of patients in mass casualty situations , monitoring people in their everyday lives to provide early detection and intervention for various types of disease, computer-assisted physical rehabilitation in ambulatory settings and assisted living for the elderly at home[5].IEEE 802 has established a Task Group called IEEE 802.15.6 for the standardization of WBAN(Wireless Body Area Network). The purpose of the group is to establish a communication standard optimized for low-power in-body/on-body nodes to serve a variety of medical and non-medical applications. The standard defines a Medium Access Control (MAC) layer supporting several Physical (PHY) layers[11]. The devices used for WBAN have limited energy resources. The transmitted data mostly consists of physiological information. This information has to be communicated efficiently to the medical server. The routing protocol take its significant role in transmitting these information. The routing protocols proposed for the Mobile Adhoc networks will not suit body area networks. The energy efficient communication is major concern here. The medical information is inherently delay sensitive. Hence the objective of this work is to design an energy efficient and delay tolerant Routing Protocol for Wireless Body Area Network.

The rest of the paper is organized into four sections. The section I bring the picture of various research works that have been done in the field of Wireless body area network related to routing. The section II presents the proposed routing methodology. Section III analyzes the performance of the proposed routing protocol with the existing one. The final section concludes our work with useful remarks.

II. RELATED WORK

The study of the work done in the Mobile ad hoc network is very useful in the design of the Efficient Routing Protocol for Wireless body area network. This section gives a brief analysis of various research works and also analyses why energy requirements and delay play an important role in the Wireless body area network.

The requirements of Wireless Body Area Network (WBAN) for medical application are explained by Jamil Y Khan [1]. It explains the requirements for the design of the Wireless Body Area Network and patient monitoring system considering the multi-patients in one room and evaluates the performance of the Wireless Body Area Network based on Reliability, Power efficiency and Scalability. The performance of low rate wireless technologies for Medical Applications has been analyzed by Golmie N [2]. It explains in detail about the wireless technologies that can be used for medical applications and how well they perform in a healthcare or hospital environment. They consider the emerging low rate Wireless Personal Area Network technology as specified in the Institute of Electrical and Electronics Engineers 802.15.4 standard and evaluate its suitability to the medical environment focusing on scalability issues. They also evaluate the performance of 802.15.4 devices under interference conditions caused by other devices.

The performance of DSR is evaluated by using a Novel Approach by Setti S P [7]. This paper proposes a Routing based on Best First Search Technique (RBFS) to improve the performance of Dynamic Source Routing for mobile ad-hoc wireless networks. The proposed scheme tries to reduce broadcasting of Route Requests during routing. The Performance of Quality of Service Parameters for IEEE 802.15.4 in the Star Topology using MANET routing [8] is explained in detail by Sanatan Mohanty. It analyses the quality of service parameters for WSN based on IEEE 802.15.4 star topology beacon enabled mode. From the simulation results of the studies and analysis, it is concluded that on an average DSR performs better than DYMO and AODV at low traffic loads, which suits WSN applications; but at high traffic loads all three routing protocols nearly behave same. They investigated the QoS metrics namely, Average jitter, Average end-to-end delay, Packet delivery ratio and throughput in various simulation scenarios by varying network size. Energy-efficient routing for delay sensitive applications is given by Ranganathan D in wireless sensor networks [10]. It gives the mathematical formulation for finding energy-efficient paths that satisfy the delay constraints in sensor networks

From the above analysis, it can be concluded that each and every routing protocol has its own pros and cons. The efficiency of choosing a routing protocol for the Wireless Body Area Network depends on the type of topology and network size used. The various factors which come into picture when deciding the protocol include throughput, delay in the transmission, time needed for Route Discovery process, time needed for data exchange and energy consumed.

III. PROPOSED METHODOLOGY

The several routing protocols available in the literature have been investigated. Among these DSR protocol with cluster topology is well suited for Body Area Network application. Hence DSR is modified into an Energy efficient and Delay-tolerant routing protocol termed as EDSR (Efficient Dynamic Source Routing) protocol.

Efficient Dynamic Source Routing protocol is an on-demand routing protocol. EDSR builds routes only on-demand by flooding Route Request packets if a sender wishes to send data to a destination with no known route. In addition to the on-demand algorithm, EDSR implements a set of modifications to attempt to route packets more efficiently, and reduce the control overhead. The basic structure is same as DSR. It has the following features.

A. Route Discovery Features

During the route discovery route is set up on-demand. It consists of five steps namely route request, route reply, caching overheard routing information, replying to route request using cached routes and route request hop limits.

B. Route Maintenance Features

The route maintenance monitors an established connection during a communication between nodes. It involves packet salvaging, automatic route shortening and increased spreading of route error messages.

C. EDSR Additional Functions

EDSR protocol is based on DSR protocol. In addition to the DSR the following new features are included in EDSR:

- Starting time and Ending time of the Route request packet.
- Path Selection Time of the route.
- Trust Time for the route.

In EDSR the node which has data packets to send checks the route cache if it has the route to the destination. If it has a route it sends data packet through that route otherwise it initiates the route discovery process by broadcasting the RREQ packet to other nodes. The node which receives the RREQ packets checks its destination address with its node address. Trust time depends on Route request period, Route cache time and Broadcast jitter. If the node address is equal to the destination address the processing time for the RREQ packets is calculated for the route. The node sends RREP only if the processing time of the route is found to be less than the trust route. The route which has the processing time greater than the trust time is discarded. The route for which the processing time is less than the trust time is the efficient route as it reduces the time needed for routing the packets. The routes for which the processing time is greater than the trust time takes more time to route the packet leading to increased energy consumption.

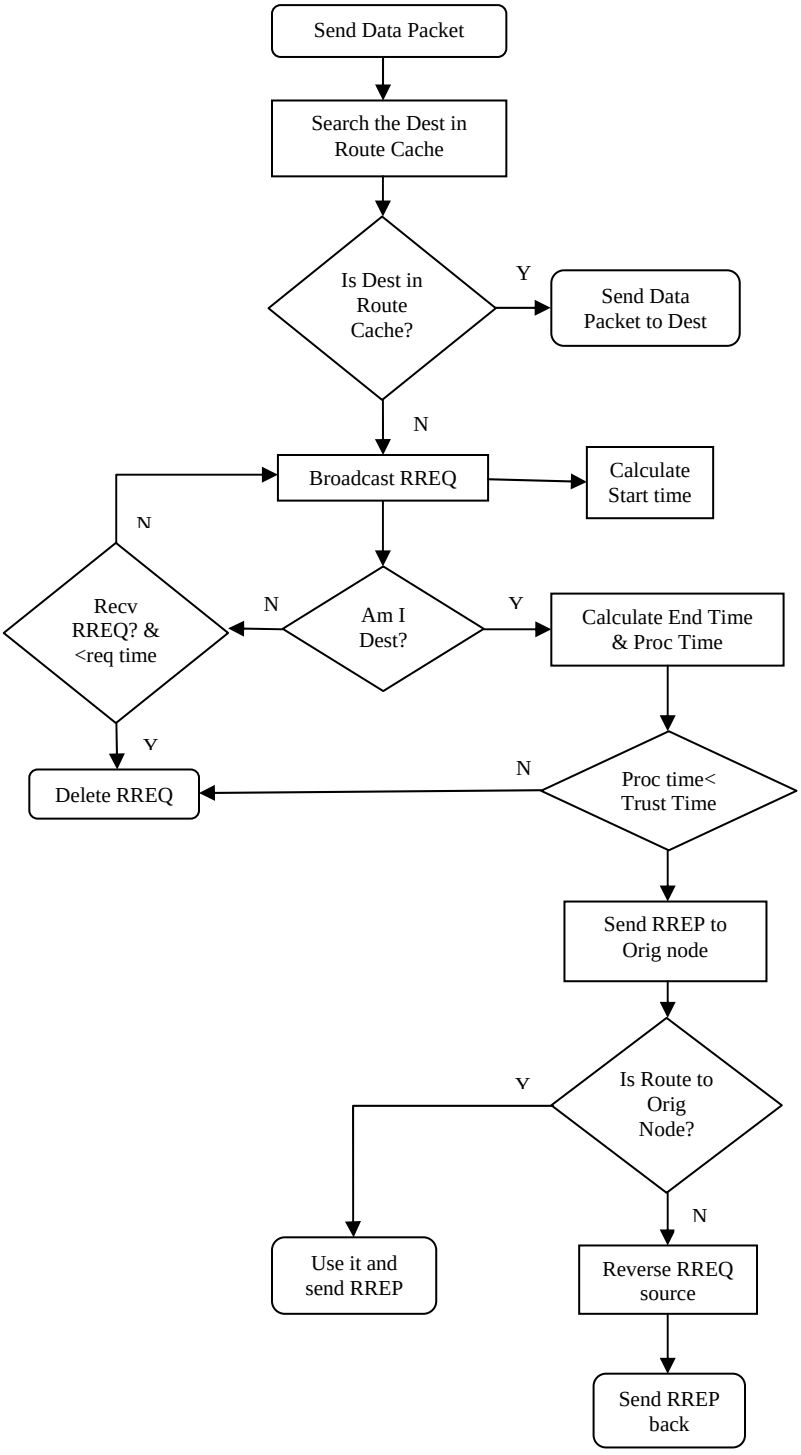

Figure 1. Route Discovery in EDSR

IV. SIMULATION RESULTS

The main objective of this simulation study is to evaluate the performance of Efficient Dynamic Source Routing Protocol and compare it with the existing Dynamic Source Routing protocol on static IEEE 802.15.4 for various traffic loads, for different types of traffic and for various nodes. The simulations have been performed using QualNet 5.0, software that provides scalable simulations of wireless networks. In the simulation model, one PAN Coordinator is deployed in an area of 5mx5m. PAN is static main powered device placed at the centre of the simulation area. Only the uplink traffic i.e. devices to PAN Coordinator are considered in the simulations which suits WBAN application where a large number of devices communicates to a single sink for data delivery and processing. The simulation parameters are listed in Table I. The Scenario for the WBAN shown in Fig. 2 consists of one PAN coordinator and other 32 nodes sending packets to it.

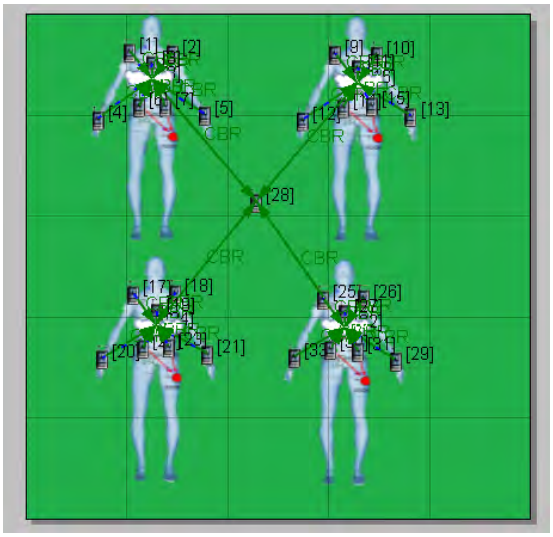

Figure 2. Scenario for WBAN

The CBR traffic with the following average packet rates: 0.1 packet per second (pps), 0.2 pps, 1 pps, 5 pps and 10 pps are used. The Cluster topology with four clusters is created in the scenario. Each Cluster is identical to the single person and the nodes are placed according to the need of the person in specific locations with each cluster having a single cluster head. These Cluster heads from each cluster forward the data to the PAN coordinator. The number of nodes can be increased for critically ill patients. The simulation has been carried out by increasing the number of nodes and results are verified in this section.

TABLE I. SIMULATION PARAMETERS

Parameters	Values
Nodes	33
Terrain Area	5m*5m
Simulation Time	60 M
TX-Power	0dBM
Path Loss Model	Two Ray Model
PHY and MAC Model	IEEE 802.15.4
Energy Model	MICAZ Mote
Battery Model	Simple Linear,1200mAhr
No. of Items	100
BO and SO	5
Payload size	50 bytes
Precedence	0 to 7

The performance of EDSR is analyzed by varying the traffic load. This is done by varying the packet generation interval for the traffic. For the packet generation interval of 100 milliseconds ten packets are sent in one second, it is said to be heavy traffic. Similarly for the packet generation interval of 10 seconds only 0.1 packets is sent in one second, it is said to be light traffic. The scenario shown in fig 2 is used for evaluation based on traffic load and the results for packet delivery ratio Fig. 3, average jitter Fig .4, average end to end delay Fig .5, throughput Fig .6, is observed. The results obtained for the EDSR is compared with that of the results obtained for DSR.

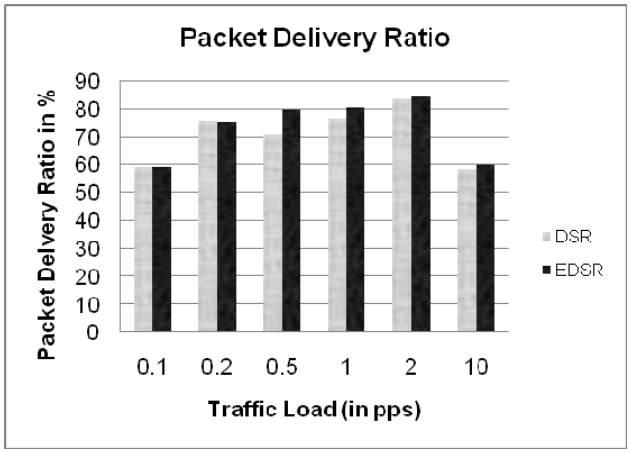

Figure 3. Packet Delivery Ratio based on Traffic Loads

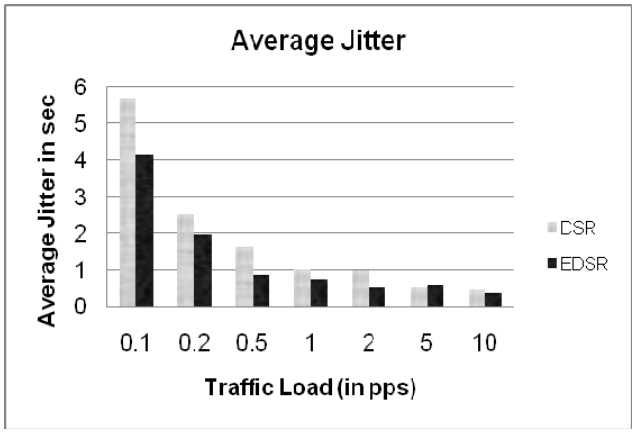

Figure 4. Average Jitter based on Traffic Loads

The Packet delivery ratio decreases for the heavy traffic due to collision of the packet leading to packet drop, whereas the packet delivery ratio decreases for the light traffic due to the increase in delay leading to packet drop. When performance of the EDSR and DSR are considered, both the results follow the same pattern for various traffic load but the packet delivery ratio of EDSR is 12.73 percent higher than that of packet delivery ratio of DSR. The average jitter value is low for light traffic and high for heavy traffic. But when the EDSR and DSR are compared the value of the average jitter of the EDSR reduces to about 28.56 percent.

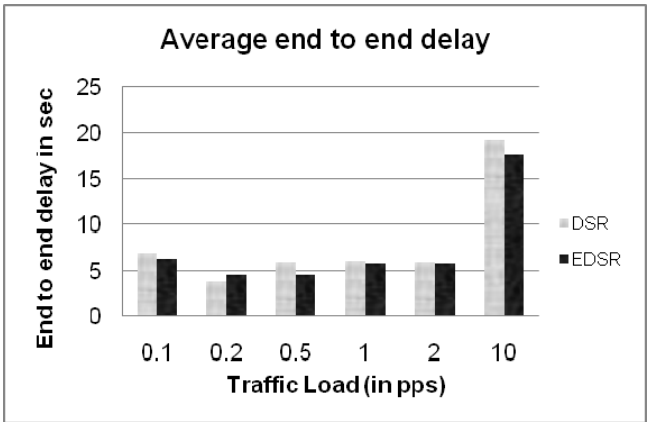

Figure 5. Average End to End Delay based on Traffic Loads

The average end to end delay is low for heavy traffic as increase in the packet generation rate reduces delay. The average end to end delay is high for heavy traffic, this is because the packet generation rate decreases the delay also increases. The average end to end delay increases exponentially as the traffic load increases. When EDSR and DSR are compared the value of the average end to end delay of the EDSR reduces to about 9.64 percent.

The throughput is low for heavy traffic as increase in the packet generation rate reduces delay.. The throughput increases exponentially as the traffic load increases. When EDSR and DSR are compared the value of the throughput of the EDSR reduces to about 13.65 percent.

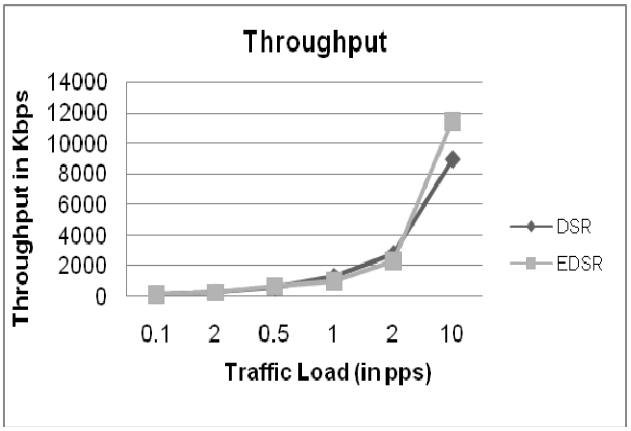

Figure 6. Throughput based on Traffic Loads

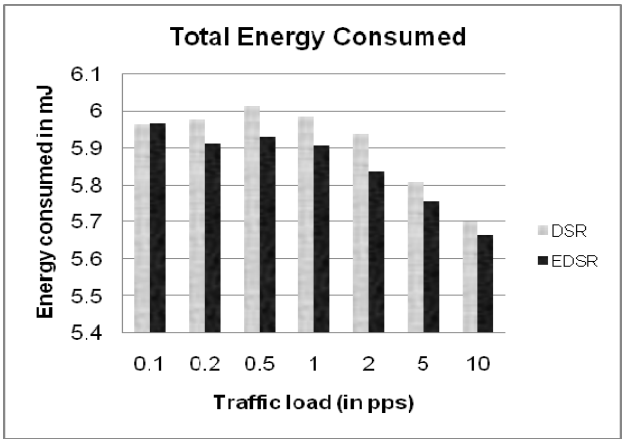

Figure 7. Total Energy Consumption based on Traffic Loads

The energy consumption is more for light traffic and less for heavy traffic. The energy consumption is also good for the EDSR when compared to the DSR. Energy consumed decreases exponentially as the traffic load decreases. Only 89 percentage of the energy needed for DSR is sufficient for EDSR in the transmit mode and only 87 percentage of the energy needed for DSR is sufficient for EDSR to operate in receive mode. On the whole the energy consumed in the EDSR decreases to about 11.56 percent when compared to DSR.

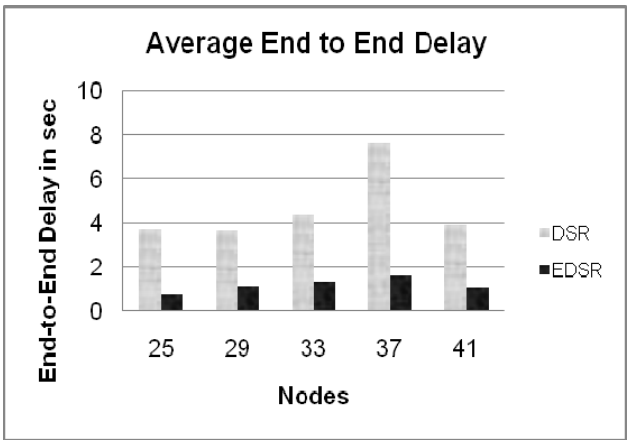

Figure 8. Average End to End Delay based on Nodes

The performance of EDSR is analyzed by varying the number of nodes in the scenario. This is done to ensure that the proposed routing protocol EDSR provide better performance even when the network scales in size. By varying the number of nodes in the scenario the results for average end to end delay Fig. 8, throughput Fig. 9, and energy consumption Fig .10 is obtained. The delay also decreases to about 28.75 percent in the EDSR when compared to DSR. Throughput in the EDSR is higher than the throughput in DSR this is because of the increase in the packet delivery ratio. The raise in the throughput is about 11.47 percent.

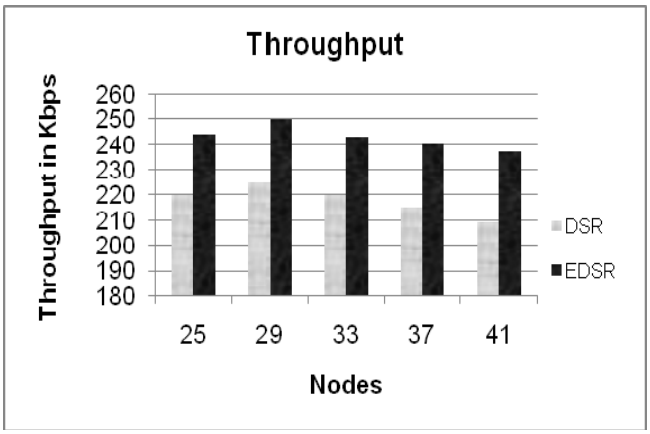

Figure 9. Throughput based on Nodes

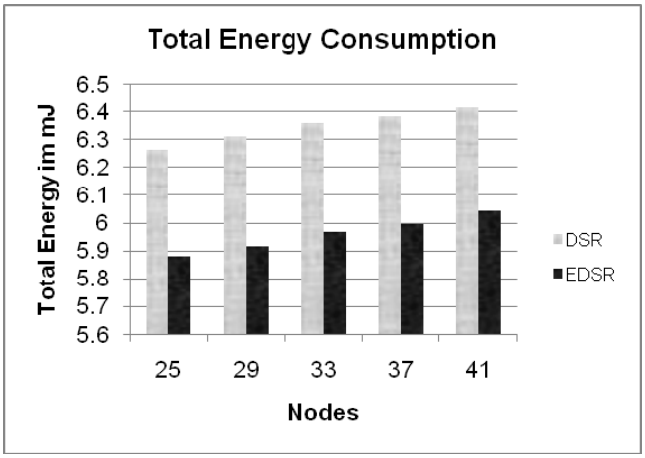

Figure 10. Total Energy Consumption based on Nodes

The Energy consumed in EDSR is less when compared to energy consumed in DSR. From the above results it is clear that the proposed routing protocol perform well even when the number of nodes are increased. This increases the residual battery capacity ensuring the longer life of the batteries.

V. CONCLUSION

In this paper the Efficient Dynamic Source Routing protocol had been designed to support the multi patient health care monitoring system. The results compare the performance of EDSR with DSR under different traffic loads by varying inter arrival time and number of nodes. From these results, it is observed that EDSR achieve low delay and low energy consumption with high packet delivery ratio and throughput, when compared to DSR. Thus it proves that EDSR is an Energy Efficient Delay Tolerant Routing protocol for wireless Body area network. Having proposed an energy efficient and delay tolerant routing protocol the next step for the future work would be to implement the protocol in a real time environment for healthcare monitoring.

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