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Evaluation of Ad-Hoc Routing Protocols on Body Area Networks

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***Abstract* – BANs (Body Area Networks) are networks which use different sensors for controlling status of patients. In these networks, according to type of disease, some medical cares' are done inside the hospital or at home. Sending information with the best quality is one of the most challenging tasks in BANs. Because of some real-time information in BANs, delay, packet loss and throughput are very important.**

In this paper, one hospital health care is considered that routing between nodes was carried out with the Ad-Hoc routing protocols namely OLSR, AODV and DSR. Results showed that AODV has a better performance than others for BANs and OLSR also is better than DSR. For simulation, opnet was used.

***Keywords* – AODV, OLSR, DSR, BAN.**

I. INTRODUCTION

With the growing requirement in ubiquitous communications and recent advances in low power wireless technologies, there has been interest in the development and application of wireless networks around human's body. A wireless body sensor network (BSN) or Body Area Network (BAN) is a radio frequency (RF)-based wireless networking technology that connects small nodes with sensor or actuator capabilities in a body of human. A sensor node is a device that gathers data, processes them and then sends them wirelessly. An actuator node is a device that acts according to data received from the sensors. The components of a sensor and actuator are: a power unit, a processor, memory and a receiver or transceiver. These devices can be ECG, blood pressure, pulse oximetry, respiratory, temperature and EEG as shown in Fig 1. These heterogeneous devices require different frequency rates and different transmission rates [1], [2], [3].

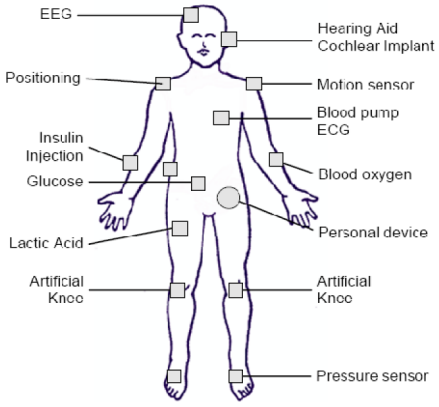

Fig.1. Sensors place on the body[4]

Body Area Network (BAN) communications architecture is divided to three components: Tier-1, Tier-2, Tier-3 communication design (Fig.2). They are included intra-BAN, inter-BAN, and beyond-BAN respectively[1]. There are some challenges and requirements in body sensor networks. These challenges and requirements include energy, Quality of Service, security, routing, reliability, mobility and privacy[5],[1],[6]. The issue of context-aware sensing in BSNs in [7] is addressed to allow long-term pervasive health care monitoring of patients.

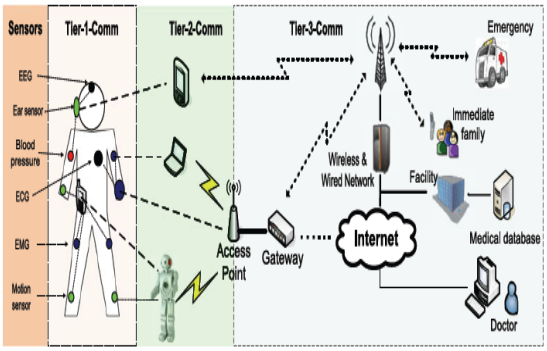

Fig.2. Architecture of the BAN

The overall routing protocol types responsible for transmission of packets between different mobile hosts in ad-hoc network falls into three broad categories[8]. The paper evaluates QoS with wireless sensor network routing protocols. The paper focused on three main protocols AODV, OLSR and TORA. Their work focused on routing performance with lower network congestion and with constants nodes. They discussed that OLSR is the most favorite proactive protocols and AODV are the most effective on-demand protocol within their environment. [9] presents Performance of Wireless Body Sensor based Mesh Network for Health Application. [10]presents a biomedical sensor network model and evaluates power consumption, packet reception ratio, network capacity, connectivity and delay. [11] presents a routing strategy for delay tolerant networks.

In the another paper the performance analysis of different routing protocols based on their effect on the QoS by using CBR application in Zigbee network using static IEEE 802.15.4 is studied. QoS parameters such as data packet delivery ratio, average end-to-end delay, jitter and throughput are evaluated as the metrics[12]. Some papers work on cluster based routing. In this kind of algorithms routing is done by node clustering. Each cluster has a cluster head. Cluster head selection is an issue, Cluster head selection can be done by energy

consuming[13]. The LEACH (Low Energy Adaptive Clustering Hierarchy) randomly selects nodes as a cluster head[14].

In this paper, we survey ad-hoc routing protocols for BAN in which some patients are equipped with sensors in a hospital area. This research is carried out using software known as OPNET Modeler version 14. It provides a parallel kernel to support the increase in stability and mobility in the network.

The nodes were randomly placed within certain gap from each other in hospital care for 5 patients and 10 patients and each person has 15 sensors. Every scenario in the network was configured to execute OLSR, AODV and DSR. The simulation time was set to 300s. Section II describes Ad-Hoc routing protocols. Section III is about performance metrics of the simulation and section IV discusses performance evaluation of the model and finally section V presents conclusion of the paper.

II. AD HOC ROUTING PROTOCOLS

A. DSR (Dynamic Source Routing)

DSR[15] is a reactive protocol i.e. it doesn't use periodic announcement. It finds the routes when necessary and then keep them. Source routing is a routing strategy in which the sender of a data identifies the sequence of nodes through which the data has to go through; the sender clearly lists the route in the packet's header, presenting each forwarding "hop" by the next node's address to which to transfer the packet on its path to the destination(Fig. 3).

DSR allows the network to be fully auto-organizing and auto-configuring, without the requirement for any network infrastructure or gateway. The protocol is made of the two main schemes of "Route Discovery" and "Route Maintenance', which work jointly to allow nodes to find and keep routes to arbitrary destinations in the network. All shapes of the protocol operate completely on DSR protocol include easily supported loop-free routing, operation with unidirectional connections; use the "soft state" in routing and very good recovery when paths in the network change. In DSR, Route Discovery and Route Maintenance each act completely "on demand"[16].

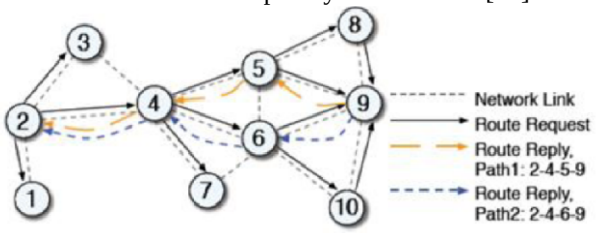

Fig.3. DSR routing protocol[17]

B. AODV (Ad Hoc On-demand Distance-Vector Protocol)

AODV offers good network utilization and uses destination sequence number to confirm loop freedom. It is a reactive protocol considering that it requests a path when required and it does not keep routes for the nodes which do not communicate actively with others[18], [19].

An important feature of AODV is that the timer related to states keeps in every node, due to utilization of routing table information. Every entry in a routing table is expired when do not use lately. A group of nodes is hold for routing table entries, while the neighboring nodes using the entry to route packets. The nodes are alarmed with RERR packets if the link is broken. Each predecessor node sends the RERR to its group of predecessors, while erasing all paths using the broken connection. RERR propagation in AODV can be seen as a tree whose root is the failure node and all sources using the failed connection as other leaves[20](Fig. 4).

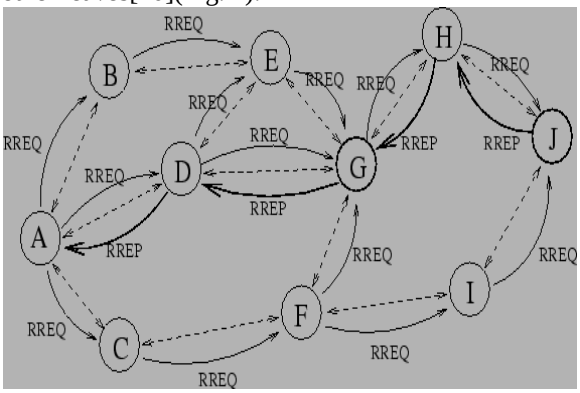

Fig.4. AODV routing protocol

C. Optimized Link State Routing Protocol (OLSR)

This protocol works in cooperation with other nodes while exchanging the topology information that is done periodically. To avoid retransmitting the packets, OLSR uses Multi Point Relays (MPR). In OLSR, a node broadcasts a packet to its neighbors periodically(Fig. 5). This is for computing the MPR set and exchanging information about the neighbors. From the neighbor's information, the node finds the minimum group of one-hop relay point which is required to get the two hop neighbors. OLSR is different from link state strategies in two factors. First is by construction i.e. the multi- point relay nodes can send packets to other nodes. Secondly the size amount of the link state of a node A is decreased because selected nodes are MPR nodes. Therefore it is conclude that OLSR decreases the Link state protocol. It can be used in the network that nodes are densely distributed. OLSR finds the shortest path in this networks to an arbitrary destination[21], [22].

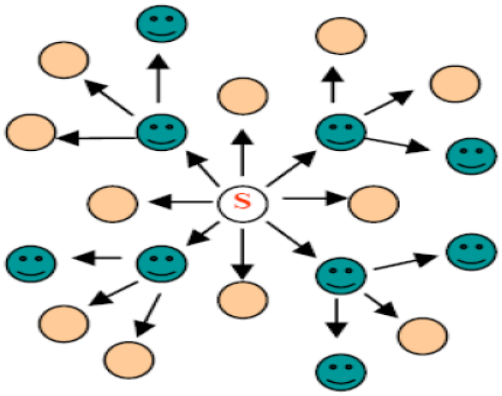

Fig.5. The MPR flooding mechanism of OLSR

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III. Performance Metrics

We evaluated key performance metrics for OLSR, DSR and AODV. We used the following parameters for performance evaluation. We use two models for our simulation. First model is included 5 patients with 15 sensors for each patient in a hospital center. This model is illustrated as fig 6.

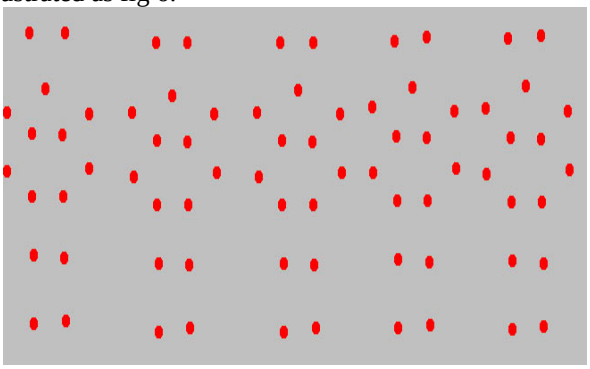

Fig.6. Proposed model for 5 patients

Second model is included 10 patients with 15 sensors for each patient in a hospital center. This model is depicted as fig 7.

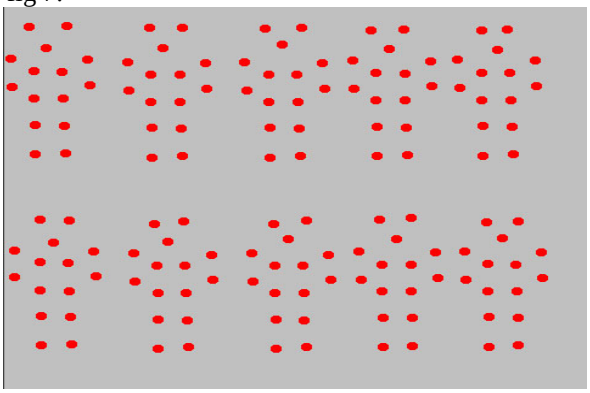

Fig.7. Proposed model for 10 patients

The network designed consists of basic network entities with the simulation parameters presented in table I.

Table I: Parameters of simulation

Parameters	**value**
Simulation time	300 s
Sensors	Heterogeneous
Number of patients	5,10
Data rate(bps)	2,5.5,11 mbps
Area	Hospital care
Routing protocols	Olsr, DSR and AODV
Performance parameter	Delay, packet loss, Throughput and number of hops

IV. Simulation and Discussion

The protocols evaluations are based on the simulation using OPNET simulator[23].

Simulated routing protocols are illustrated as below for 5 patients. First diagram is related to number of hops of the protocols(fig. 8).

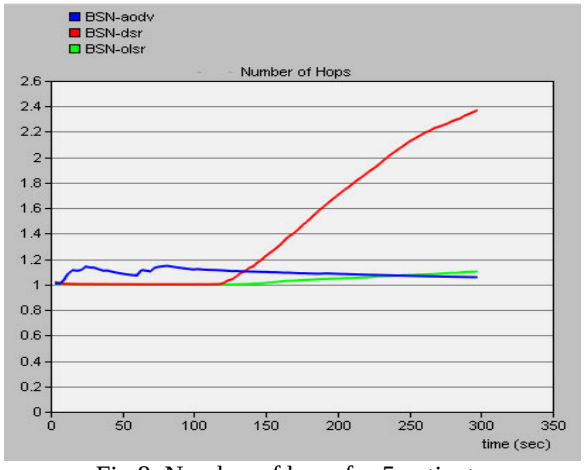

Fig.8. Number of hops for 5 patients

Number of hops for 10 patient are depicted as follows(fig. 9):

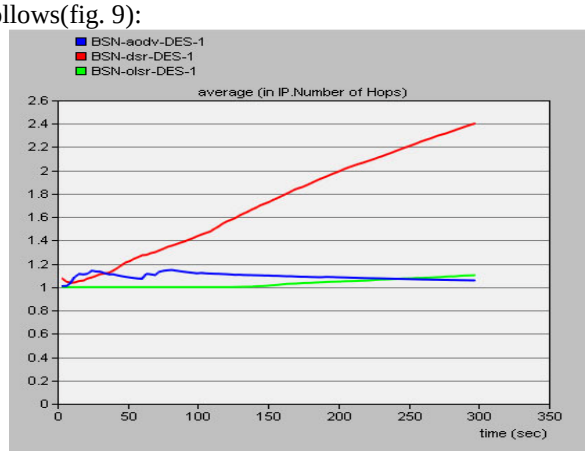

Fig.9. Number of hops for 10 patients

As we can show in the above diagrams number of hops in AODV protocols is less than two others. Number of hops related to DSR is the maximum. Packets drop rate is shown in the following diagram(fig. 10).

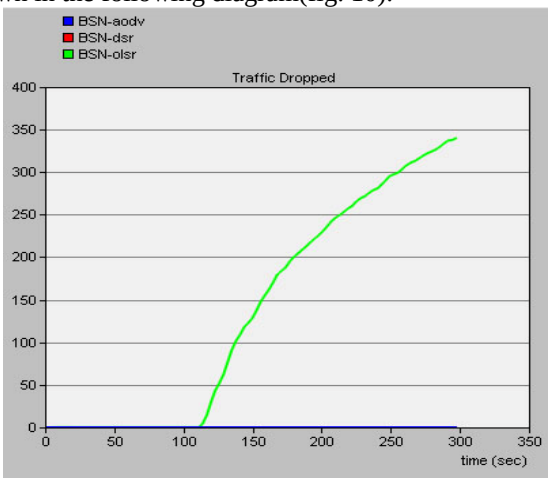

Fig.10. Packet drops for 5 patients

Above diagrams show the packet drops of the protocols. Packet drop of AODV and OLSR are near to zero, but DSR is average of 350 packets/s.

Packet delay for 5 patients are shown as below(fig. 11):

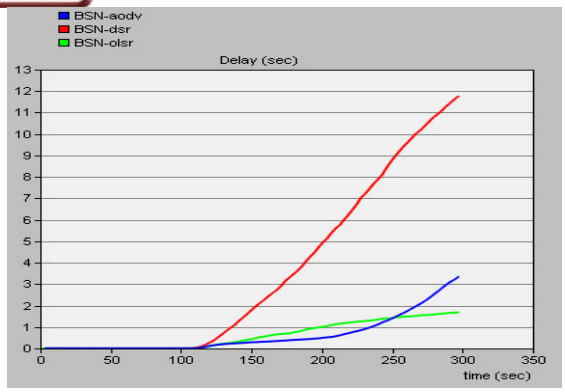

Fig.11. Delay of protocols for 5 patients

Packet delay for 10 patients is shown as follows(fig. 12):

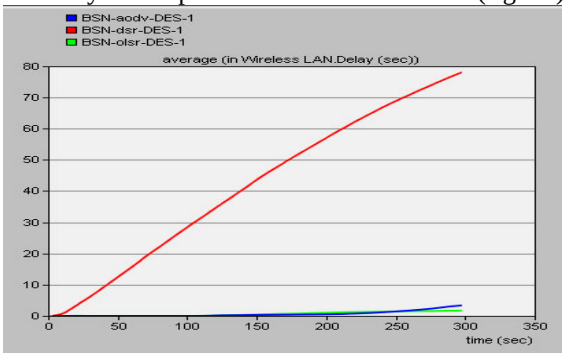

Fig 12. Delay of protocols for 10 patients

As we can show in the diagram, delay of AODV and OLSR are less than DSR. In the following diagram throughput of the protocols for 5 patients is shown(fig. 13).

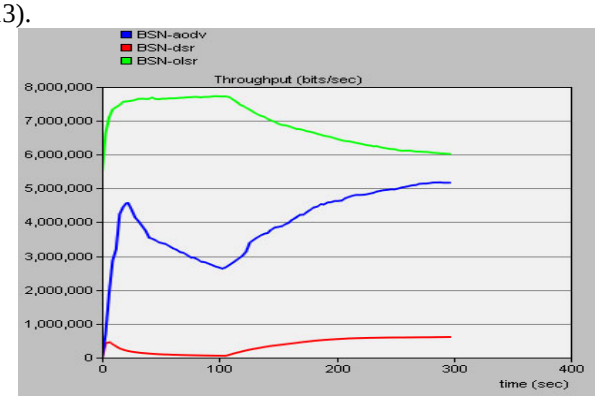

Fig.13. Throughput for 5 patients

Throughput of 10 patients is shown as follows(fig. 14):

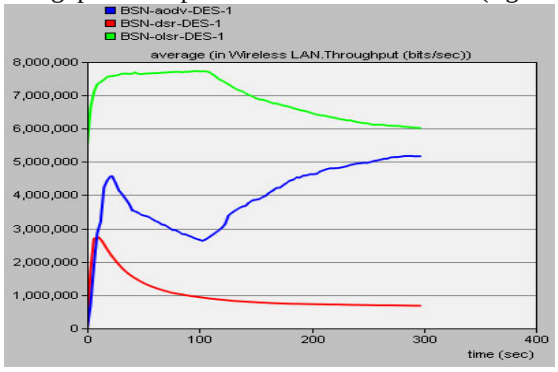

Fig.14. Throughput for 10 patients

Throughput of OLSR and AODV are more than DSR. Average of throughput for OLSR and AODV are nearly 550000 bits/sec, but for DSR is 50000 bits/sec.

Discussion

As we see from the above diagrams, AODV is the best related to the others from delay, number of hops, throughput and packet loss point of view. Because in AODV protocol, routing is done related to request and reply in which nodes selects the best path and also distance to the destination is considered to find a route. OLSR is the second protocol that works based on MPR nodes. Because nodes send packets to the MPR nodes, this protocol is good for dense networks. When the number of sensors in the network area increases, the OLSR works better. But DSR is not good for BANs because this protocol for routing use cache and when the cache become full , performance of the network get low. Therefore, number of hops, delay, packet loss and throughput of DSR with passing the time is worse than others because the cache becomes full.

V. Conclusion

In this paper, performance of AODV, DSR and OLSR were evaluated in BAN using OPNET modeler 14. The protocols were tested using the same parameters and sensors had different data rates such as human body. For simulation 5 and 10 patients were considered in a hospital environment.

Results showed that, with 5 and 10 patients AODV and OLSR are working better than DSR and AODV sometime is better than OLSR. Because AODV has better network utilization, it works better for body area and also OLSR selects MPR nodes that is caused good performance. But DSR uses cache and this is caused more delay, packet loss and number of hops because the cache becomes full.

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