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Research paper

Performance analysis of static wireless body area network for different routing protocols

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Abstract

Wireless body area network (WBAN) is a special type of wireless sensor network. It consists of sensors mounted on a human body to measure important body parameters. WBAN network uses different technologies such as IEEE 802.11, IEEE 802.15.4 and IEEE 802.15.6. In this paper, research outcomes focused on WBAN architecture design and performance analysis in a simulation environment for different routing protocols are done for IEEE 802.15.6. A comparative report is prepared for WBAN technology. Routing protocols are compared with each other based on energy consumption, throughput, and delay. For simulation purposes, a sensor network is designed by placing three sensors in a single hop star topology with a single central hub. The test run was successfully carried out to check the network configuration. A performance of three routing protocols for WBAN wireless technologies is investigated. These three routing protocols include AODV (Ad hoc On-Demand Distance Vector routing), DSDV (Destination Sequenced –Distance Vector routing) and DSR (Dynamic Source Routing). In three sets of simulation, the effect of various routing protocols on throughput, delay, and the energy consumption is calculated by increasing packet rate up to 2000 Kbps with an increment of 250 Kbps. Simulation results have shown that WBAN with AODV routing protocol is the most suitable to reduce power consumption and delay, and to increase throughput. Detailed analysis is discussed in the paper.

Keywords: *Wi-Fi; Blue Tooth; WBAN; Routing Protocol; Energy; Delay; Throughput.*

1. Introduction

Wireless Body Area Network (WBAN) is used extensively in the pervasive health monitoring and telemedicine to reduce the cost of hospitalization and also to ensure the comfort level of the patient. WBAN is a subset of the Wireless Sensor Network and considered as an effective tool for personal health monitoring [1-3]. Recently, it has gained importance with the development of wearable sensors. Sensors are used to sense and transmit the vital parameters of the body to the hub; which further sends these signals to the personal health monitoring system wirelessly [4,5]. Thus, wireless technology for signal communication must have the highest throughput with the least delay and the lowest possible energy consumption. The Wi-Fi, Zig-Bee and Blue tooth technologies are most widely used in personal monitoring. These technologies have some limitations which put the question on its use in personal health monitoring. Thus, to overcome these limitations, in recent years, IEEE 802.15.6 technology has been introduced. The motivation behind this research is to find out most suitable protocol for designed network for a static condition. The desirable protocol will give a higher throughout, less delay and also less power consumption. The outcome of this research is critical for guiding further planned research work in which we will analyze the performance of designed WBAN for dynamic conditions and under interference. The rest of the paper is divided into different sections in which previous studies are mentioned in section 2. The methodology and results are discussed in sections 3 and 4 respectively followed by the concluding remarks in section 5.

2. Literature review

This section is dedicated to some of the important studies done on the implementation of AODV (Ad hoc On-Demand Distance Vector routing), DSDV (Destination Sequenced –Distance Vector routing) and DSR (Dynamic Source Routing) in wireless technologies. AODV and DSDV protocol performances have been analyzed on the basis of the end to end delay, packet loss and throughput for WBAN. A network of ten sensors is designed and simulated in NS2 with 100 Kbps and 250 Kbps. It has been found that AODV is suitable for WBAN owing to its improved performance over DSDV [6]. In similar studies, WBAN of 12 nodes is been tested for improved DSR routing protocol which helped to reduce the energy consumption of the network [7]. In an NS2 experimental investigation, the number of nodes, its speed, and a communication range is varied to test the performance of AODV, DSR, and DSDV for IEEE 802.15.4 MAC Protocol. A 40 node network is tested and comparison is carried out on the basis of packet delivery ratio and average end-end delay. It is been concluded that both AODV and DSR protocols performed better than DSDV [8]. A Priority Queuing Algorithm for AODV is being tested in the NS2 simulator and found suitable to differentiate various types of traffic [9]. AODV and DSDV protocols have been tested the network model

on the basis of the end-to-end delay, packet loss rate, and throughput performance. Packet size is varied and performance analysis is carried out in the simulator. It is been found that AODV performed better than DSDV [10].
From the referred literature, it is understood that AODV, DSR and DSDV are being tested for their performances for IEEE 802.11 and IEEE 802.11.4 on the basis of delay, throughput and energy consumption. However, various protocols have not being tested sufficiently for IEEE 802.11.6. Also, performance analysis is limited to the single wireless technology and large number of nodes from 10 to 40. However, in practical situation, these many nodes cannot be carried by a human body. Thus, in this paper, we investigated performance of AODV, DSR and DSDV for IEEE 802.15.6. A practical human body network with three nodes and single hub in star topology is designed and tested. The performance analysis is done on the basis of delay, throughput and energy consumption. In the coming section, methodology used for this research is discussed.

3. Methodology

In this paper, in general, the following steps are followed. In the first step, WBAN architecture is designed and in the step 2 simulation analysis of designed WBAN is conducted for various routing protocols and in step 3 comparative study of performance is done on the basis of energy consumption, throughput, and delay. In the network, three sensors are placed at three different locations of the human body as shown in figure 1a. The node-1 is a heart rate sensor mounted close to heart, node - 2; a pulse rate sensor is mounted near to left-hand wrist and node - 3 is a temperature sensor near to right-hand wrist. Accordingly, the WBAN network is designed in NS2 (simulated environment) as shown in figure 1b. All nodes are connected with wireless links in a star topology. These three sensors nodes will be communicating with a single hub as shown in figure 1a. Figure 1b shows the simulation environment in NS2 (Network Simulator version 2). Accordingly, a program of four nodes is written.

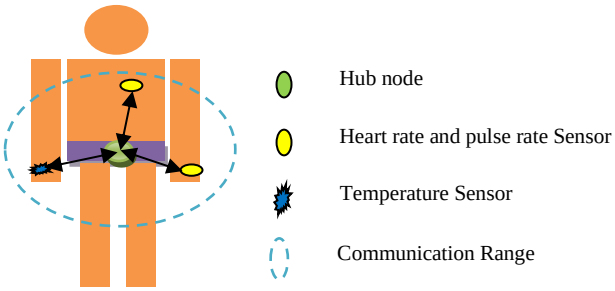

Fig. 1: a) WBAN Network Placed on Human Body.

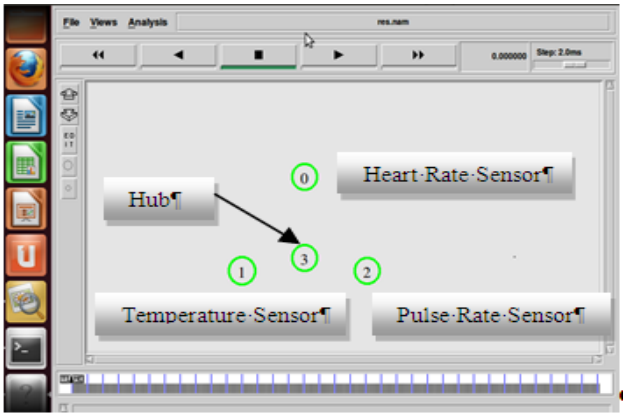

Fig. 1: b) Placement of the Sensor Node and Hub on the Body and Network in NS2.

Network design in NS2 contains a Frontend and a Backend structure. The frontend is used to design a WBAN. The designed network contains three nodes and one hub, thus four nodes are created. We assigned 50 second simulation time and MAC 802.15.6 protocol. We run the simulation for 50 seconds and then analyzed the results by applying the awk script to the output file of the program. We changed the data rates of sensors from 250 to 2000Kbps, and noted various values of throughput, delay and power consumption. A test run was carried out to check the network configuration. The designed network worked successfully and the desired output is obtained which confirmed that all nodes, hub and wireless links are working properly. The simulation results are obtained for three routing protocols AODV (Ad hoc On-Demand Distance Vector routing), DSDV (Destination Sequenced –Distance Vector routing) and DSR (Dynamic Source Routing). Simulation is carried out for three parameters viz. throughput, delay, and power consumption. Thus there are three routing protocols and three performance parameters. Overall, three sets of readings for each parameter are obtained. The first set of simulations is carried out for throughput analysis and three routing protocols. A similar analysis is carried for energy consumption and delay in the second and the third simulation. In all simulations, the packet rate is increased up to 2000 packets per second with an increment of 250 packets per second. Simulation environment parameters are as shown in table 1.

Table 1: Simulation Environment Parameters

Network Area	100 x 100m
MAC	802.15.6
Simulation Time	50sec
Initial Energy	100 nJ
Transmitter energy consumption	1 nJ
Receiver energy consumption	1 nJ
Number of traffic pairs	3
Type of traffic	CBR
Routing Protocols	AODV, DSR, DSDV

Data rate	250 to 2000 kbps
Mobility conditions	Static

4. Results

The results section is divided in the three sets of simulations; throughput analysis, energy consumption analysis and delay analysis. These results are discussed in this section .We changed data rates of sensors in the network and recorded Throughput, Energy consumption and Delay of designed network.

4.1. Throughput analysis

The throughput analysis is shown in Figure 2. In general, it is observed that as the packet rate increased throughput is also increased. For the IEEE 802.15.6 technology, it is observed that the AODV routing protocol has less throughput for data rate of 250bps than DSDV and DSR. However when data rate is increased throughput is also increased. DSDV protocol has more throughputs at lower data rate but for increasing data rates, throughput goes on decreasing as compared to AODV but DSDV has more throughput than DSR. For the DSR protocol we observed that it has very less throughput value than both protocols. These readings suggest that the performance of various prot0cols have similar trend that is when data rate is less, throughput is also less and as data rate increases the throughput increases. We can conclude that AODV protocol has better throughput than DSDV and DSR. So we can use AODV protocol which is more suitable for designed network.

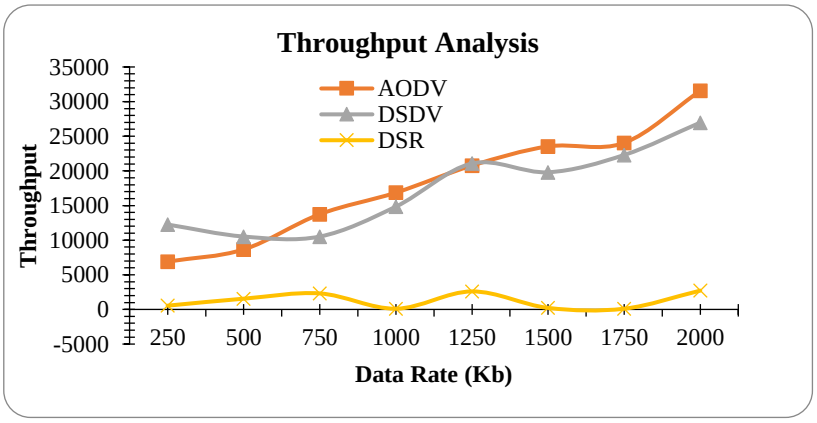

Fig. 2: Effect of Data Rate on Throughput.

Following table 2 shows variation in the throughput with increase in the data rate. DSR has shown lowest throughput at low data rate and a similar trend continued till the higher data rate. Initially at 250 Kb DSDV has shown better throughput than AODV. However, as the data rate increased to the higher values AODV has shown the highest values of the throughput.

Table 2: Variation in Throughput with Increase in the Data Rate

Data rate(Kb)	AODV	DSDV	DSR
250	6902.61	12253.77	542.26
500	8659.39	10518.18	1551.41
750	13745.18	10518.54	2312.41
1000	16859.42	14841.33	105.48
1250	20763.94	21068.2	2600.78
1500	23531.45	19799.26	219.21
1750	24043.07	22293.91	104.8
2000	31565.13	26967.58	2714.33

4.2. Energy consumption analysis

The energy analysis is shown in Figure 3. In general, it is observed that as the packet rate is increased, energy consumption is also increased. With these reading, it is observed that AODV protocol has less energy consumption as compared to DSDV and DSR protocol

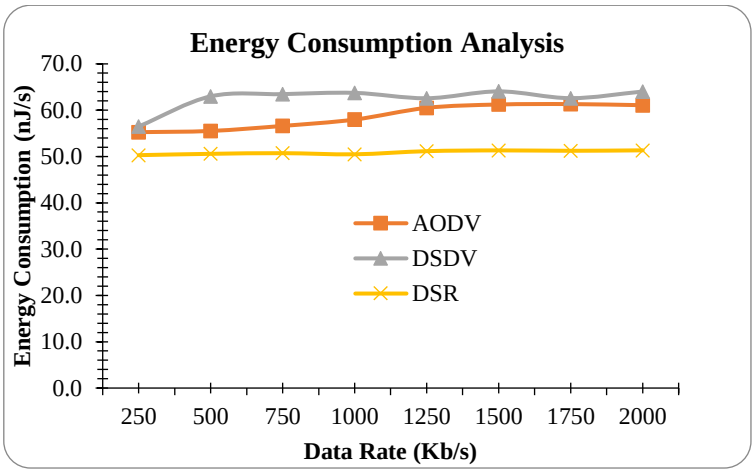

Fig. 3: Effect of Data Rate on Energy Consumption.

Following table 3 shows variation in the energy consumption with increase in the data rate. DSR has shown the lowest energy consumption at the low data rate and a trend continued till the higher data rate. Overall DSR has shown best performance as compared to all other protocols, for energy consumption. DSDV and AODV have shown almost similar trend with minor difference between energy consumption. AODV has shown better performance that DSDV at all data rates. At higher data rates, AODV and DSDV has shown similar trend.

Table 3: Variation in Energy Consumption with Increase in the Data Rate

Data rate(Kb)	AODV	DSDV	DSR
250	55.3	56.5	50.3
500	55.5	63.0	50.6
750	56.6	63.5	50.7
1000	58.0	63.7	50.5
1250	60.5	62.6	51.2
1500	61.2	64.1	51.3
1750	61.3	62.6	51.2
2000	61.1	64.0	51.3

4.3. Delay analysis

The delay analysis is shown in Figure 4. In general, it is observed that as the packet rate increased delay is also increased From reading we can conclude that for AODV protocol initially for lower data rate delay is very less but when data rate increases from 1000 Kbps , delay value goes on increasing . For DSDV protocol it is observed that delay value is very large compared than AODV and DSR. It is also observed that delay is more for all data rates. For DSR protocol delay is initially less, and increases for higher data rate. So we can conclude that AODV protocol is more suitable for designed network.

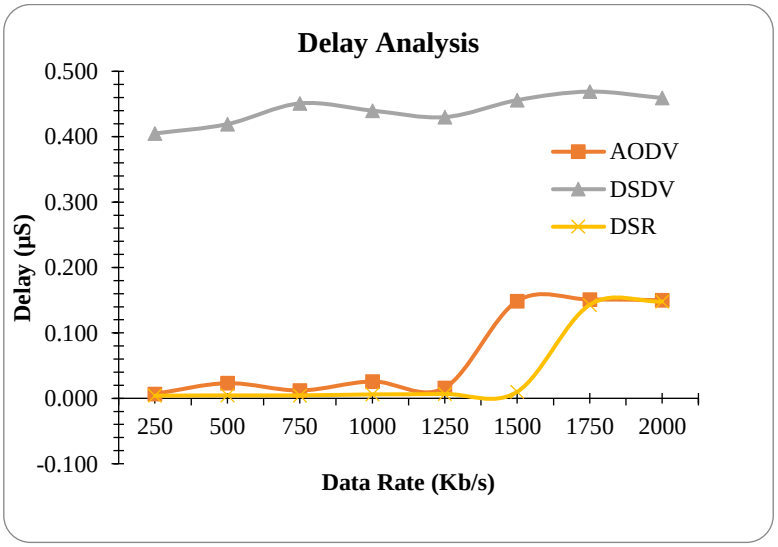

Fig. 4: Effect of Data Rate on Delay.

Following table 4 shows variation in the delay with increase in the data rate. DSR has shown the lowest delay at the low data rate and a trend continued till the higher data rate. Overall DSR has shown best performance as compared to all other protocols, for delay. DSDV and AODV have shown almost similar trend with minor difference between the delays. AODV has shown better performance that DSDV at all data rates. At higher data rates, AODV and DSDV has shown similar trend. This trend is similar to the energy consumption. Overall, DSR has shown least delay followed by AODV.

Table 4: Variation in Delay with Increase in the Data Rate

Data rate (Kbps)	AODV	DSDV	DSR

250	0.007	0.405	0.004
500	0.023	0.419	0.005
750	0.012	0.451	0.004
1000	0.026	0.440	0.006
1250	0.016	0.430	0.007
1500	0.149	0.456	0.010
1750	0.151	0.469	0.143
2000	0.150	0.459	0.148

5. Discussion

In the result section, various trends are plotted and explained. This section summarizes the results obtained above in the context of WBAN IEEE 802.15.6 requirements. In the WBAN, vital parameters of the patient is to be sensed and sent to the server for the further processing from the health services. Thus it is important that the network parameters such as energy consumption and delay must be minimum with maximum throughput. Accordingly, to facilitate a selection of the suitable protocol for the given application, descriptive statistical analysis is carried out. From the descriptive statistics mean values are extracted. Following table 5 shows mean values of performances of all protocols.

Table 5: Mean Values of Performance Parameters of All Protocols

Analysis Parameter	(AODV)	(DSDV)	(DSR)
Throughput	19881.08	17282.60	1268.84
Energy consumption	58.69	62.50	50.89
Delay	0.067	0.067	0.041

From the above table 5, it can be seen that mean value of throughput for AODV is more as compared to other protocols and DSR has lowest throughput. The mean value of the energy consumption is lowest for DSR followed by AODV. The mean value of the delay is the lowest for DSR followed by AODV. However, both have shown almost equal delay at higher data rates (referring fig.4 and Table 4). Thus, DSR is having less delay and power consumption, however it has considerably low throughput. Thus, DSR cannot be considered as a good choice for the WBAN. AODV has highest throughput at all data rates in all protocols, equal delay at higher data rate and moderate energy consumption. Thus, AODV can be considered as a best choice for the WBAN as it satisfied the network performance parameters. DSDV has highest delay and energy consumption at all data rates as compared to other protocols. It also has moderate throughput which is less than AODV and more than DSR. Thus, DSDV cannot be considered as a best choice for the WBAN as it does not satisfy the network performance parameters.

6. Concluding remarks

In this paper, a performance analysis for different routing protocols is carried out in a simulation environment for the static WBAN. In the simulation, results are obtained for three routing protocols AODV (Ad hoc On-Demand Distance Vector routing), DSDV (Destination Sequenced –Distance Vector routing) and DSR (Dynamic Source Routing).for WBAN. Simulation is carried out for three parameters viz. throughput, delay, and energy consumption. A comparative report of results is prepared and discussed in this paper. The effect of packet rate on throughput is analyzed and it is concluded that the packet rate should be maintained at higher levels for improving the throughput of the network. It is concluded that the increase in the packet rate has a marginal effect on delay for AODV and DSR and a greater impact on the delay of DSDV protocols. For Energy consumption it is observed that energy consumption of network goes on increasing as we increase data rates. AODV protocol has less energy consumption than DSDV and DSR. We conclude that AODV protocol is more suitable for the designed network, as AODV gives higher throughput, less energy consumption and less delay at higher data rate. In further research, AODV routing protocol will be tested under effect of interference.

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