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Performance Evaluation of ad hoc Wireless Local Area Network in Telemedicine Applications

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Abstract

The presented paper evaluates and compares the performance of routing protocols in Wireless Ad Hoc network and also discusses the application of ad hoc mode of wireless local area network (WLAN) in emergency health services for a hospital. The vital data of patients within a hospital are monitored and communicated to doctors within the hospital. The proposed scenario helps in managing any emergency situation to a great extent and reduces the delays which may be crucial for such emergency situations. In the proposed study, the doctors and patients are assumed to be mobile so as to mimic the real situation. However, the movement of patient and doctors are confined to a limited range.

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Keywords: *WLAN, Telemedicine, Ad Hoc network, Performance Evaluation*

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1. Introduction

The past decade has witnessed mammoth developments in the field of communication and network technology. Health services are one such area, which can have a high impact of these advancements. The evolution of mobile telemedicine has made possible to transfer vital sign of a patient across any geographical areas in a flash, thus minimizing even the slightest lapse of critical time and saving the patient's life in many cases. However, despite being a normal practice for hospitals in US and other developed nations, these telemedicine technologies still do not find much application in developing nations due to multiple reasons such as cost, lack of infrastructure, etc. Therefore, to promote telemedicine in these nations, more studies and research are needed to establish the suitability of such applications in the context of current communication and network technologies.

There are wide ranges of communication technologies that have been employed in telemedicine. Wireless Local Area Network (WLAN) based on the IEEE.802.11 family of standards is the first and the oldest technology to be used in medical applications [1]. WLAN still remains a popular option because of its ease of use and economic viability. Further, it supports mobility of users (up to a few meters) and provides a reasonable amount of bandwidth. Hence, WLAN seems to be the best suited network that can be used in areas which do not have extended network infrastructures.

In addition, the non-infrastructure oriented WLAN or Ad Hoc WLAN is best suitable for temporary connections and short duration transmission and can play a vital role in case of emergency applications. As WLAN chosen as the network for analysis, this paper aims to analyze performance of routing protocols, namely Ad hoc On-Demand Distance Vector (AODV) and Destination-Sequenced Distance-Routing (DSDV) and their application in remote healthcare services. Based on the result the study will be extended to other protocols.

Section II explains the basic information of wireless routing protocols, which are being used. In the Section III, the designed scenario and simulation for the proposed paper has been discussed. The section IV lists out the parameters on which the two protocols are evaluated. The network design in the simulation environment is discussed in Section V followed by the simulation results and discussions in Section VI. Finally, the conclusions are discussed in Section VII.

2. Wireless Routing Protocols for Health Services

WLAN networks fall under two major categories, infrastructure-oriented and Ad Hoc Networks [2], which are non-infrastructure oriented [3]. In infrastructure oriented networks the nodes are connected to an access point which act as a central point of communication. Whereas, in Ad Hoc networks, the mobile nodes form a decentralized network, which work without any access point [4].

However, the Infrastructure based networks are more efficient than Ad Hoc networks. In general, they do not account for much when additional nodes (or patients in this case) are to be added immediately as required in case of an emergency. Hence, in this paper, we have focused on using the Ad Hoc network for implementing patient monitoring systems as in many situations, the establishment of the infrastructure based network is not possible due to the nature of the problem and time limitations. Routing protocols in Ad Hoc networks [3, 5] are classified into three categories: Table Driven, On Demand [6] and Hybrid [7].

In Table-Driven routing protocols [8], the routing tables are present at each node which is updated periodically and the routing that occurs is done on the basis of data from these tables. In On-Demand Routing Protocol routes are decided on demand by flooding the network with route request packets (RRPs). The combination of reactive and proactive protocols known as the hybrid protocol is presented in [7, 9]. The routing protocols discussed in this paper are AODV and DSDV, which are an example of On-Demand and Table-Driven routing protocol, respectively [10].

2.1 Ad Hoc On-Demand Distance Vector

Ad-Hoc On-Demand Distance Vector (AODV) [4, 11] is a protocol which creates route on the demand basis. AODV uses messages such as route request (RREQ), route reply (RREP) and route error (RRER) to maintain transmission and discover links for route establishment [12]. In AODV, the communication between two nodes occurs by finding the best possible route with the help of other existing nodes.

2.2 Destination-Sequenced Distance Routing

Destination-Sequenced Distance Routing (DSDV)is often described as an improvement to the classical Bellman-Ford Routing Algorithm [13]. The DSDV is basically a hop to hop protocol [4]. The DSDV is an example of table-driven type protocol. In this, each node maintains a table with the data about next hop and the number of hops to all the nodes that are accessible from that particular node. The main advantage of DSDV is the less delay in the set-up process due to availability of paths to every node [15].

3. Scenario for WLAN Implementation

Since, WLAN allows only a limited amount of mobility to its users, they are mainly used in indoor applications where the movement of the user remains confined. Keeping this in consideration, we assumed a scenario, as shown in fig 1, in which the network is inside a hospital and the communication occurs among the nodes within the area of the hospital.

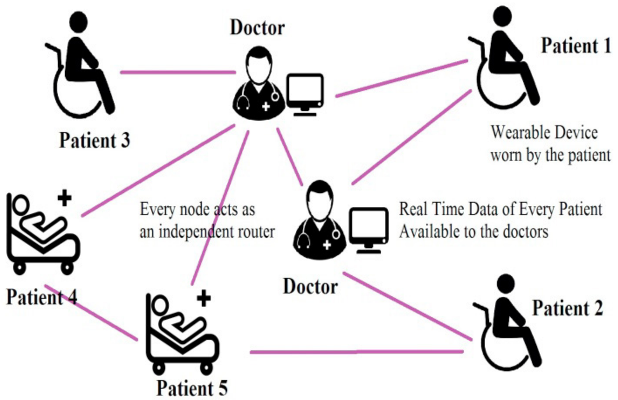

Fig. 1 System Architecture for proposed Scenario

In this specified situation, we assumed that every patient within every department is connected through an ad hoc network. The wearable devices worn by the patients constantly measure the vital signs [14] such clinical parameters representing a data can be sent to any doctor present in the network at any location of the hospital. The proposed study takes into account the mobility of both the patients as well as the doctors. Body parameters of the patients like ECG, heart rate, oxygen saturation level, etc. can be monitored by any doctor without having to visit the patient physically.

The property of adding nodes and the ease of monitoring through an ad hoc network can be of great help in the different scenario, where a large number of patients need immediate tending and the number of staffs available may not be enough. In such a case, the nodes can be immediately added in an ad hoc network and the body parameters of the patients (victims) can be provided to all the doctors present. Based on vital signs, priorities can be defined for the patient who needs the medical help first. This not only prioritizes the work for the staff, but also minimizes the delays caused by taking up the the vital parameters on the patient physically. The important aspect in such situation is the reliability of a network and its Quality of service. The network qualitycan be judged taking into consideration the different quality parameter associated with a network[17,18]. However, in such situation it is important to analyse the successful packet received by a node and the time required to receive a packet [16]

4. Performance Parameters

The evaluation of the performance of the two routing protocol was done on the basis of the following parameters:
Packet Delivery Ratio – It is the ratio of actual packets delivered to the number of packets sent
Throughput – It is the total number of packets delivered.
End-to-End Delay – It is the average time it takes a data packet to reach the destination

5. Proposed Network Design

The network simulator (NS2) was chosen as the simulator due to its availability and easy to use for the network design [19]. Simulations were done for two different cases: in the first case, by keeping the speed of the node constant (50 ms) and varying the number of nodes, while in the second case, by keeping the number of nodes (10 nodes) constant and varying the speed of nodes. For the simulation, the number of nodes was varied from 30 to 40 then to 50 and the speed of nodes is varied with pause times of 5ms, 10ms and 20ms. This resembles the varying number of patients in the hospital at any time that is being monitored at any given time. The same condition is also applied for the speed if the patient is moving. Fig 2 shows the setup and the simulation of the network in NS2 and table 1 lists all the proposed parameters for the simulation.

Fig.2 Network Set up and Simulation

Table 1. Simulation Parameters

Parameter Name	Propagation	Simulator and Version	Packet Size	Antenna	Link Layer	Mac Protocol	Routing Protocols	Performance Parameters
Parameter Value	Two Ray Ground	NS2 (NS-allinone-2.35)	512 bytes	Omni Antenna	LL	802_11	AODV, DSDV	Packet Delivery Ratio, Throughput, End-to-End Delay

6. Simulation Results and Discussions

The value of simulated parameters is obtained in the two cases. In the first case, the number of nodes was varied as shown in table 2(a), table 2(b) and table 2(c), while in the second case, the speed of the nodes was varied as shown in table 3(a), table 3(b) and table 3(c).

Table 2(a). Parameter Values by Varying Number of Nodes (30 nodes)

Parameter Measured	No. of Packets Sent	No. of Packets Received	Packet Delivery Ratio	Delay	Throughput	No. of Packets Dropped
AODV	557	549	98.56	0.0329	239.84	8
DSDV	578	351	60.72	0.01044	153.77	227

Table 2(b). Parameter Values by Varying Number of Nodes (40nodes)

Parameter Measured	No. of Packets Sent	No. of Packets Received	Packet Delivery Ratio	Delay	Throughput	No. of Packets Dropped
AODV	573	567	98.95	0.01011	247.66	6
DSDV	555	390	70.27	0.00762	170.57	165

Table 2(c). Parameter Values by Varying Number of Nodes (50 nodes)

Parameter Measured	No. of Packets Sent	No. of Packets Received	Packet Delivery Ratio	Delay	Throughput	No. of Packets Dropped
AODV	568	565	99.47	0.00929	246.91	3
DSDV	562	497	88.43	0.007	217.41	65

Table 3(a). Parameter Values by Varying Speed of Nodes (5ms)

Parameter Measured	No. of Packets Sent	No. of Packets Received	Packet Delivery Ratio	Delay	Throughput	No. of Packets Dropped
AODV	579	576	99.4819	0.01163	251.701	3
DSDV	558	494	88.5305	1.19433	216.07	64

Table 3(b). Parameter Values by Varying Speed of Nodes (10ms)

Parameter Measured	No. of Packets Sent	No. of Packets Received	Packet Delivery Ratio	Delay	Throughput	No. of Packets Dropped
AODV	570	566	99.298	0.57243	247.28	4
DSDV	561	347	61.85	1.7492	151.72	214

Table 3(c). Parameter Values by Varying Speed of Nodes (20ms)

Parameter Measured	No. of Packets Sent	No. of Packets Received	Packet Delivery Ratio	Delay	Throughput	No. of Packets Dropped
AODV	557	550	98.74	0.9545	240.67	7
DSDV	559	367	65.65	1.7002	160.38	92

The simulated results show that the performance of the two protocols fluctuates when either the number of nodes or speed of the nodes is varied. These changes represent the cases where the number of patients in the hospital changes. The proposed study gives the real picture that how the system will behave in such an environment. The purpose of varying the speed of the nodes is simulating an instance when any patient is being relocated or a doctor is on move. Our aim is to find a routing protocol, which can effectively transmit data during such scenario, so not even a fraction of pre-operative time lapses in doctor to come and do the diagnosis based on the vital parameters of a patient. The comparisons of various performance parameters for the proposed AODV and DSDV protocols are presented in the following sub-sections.

A. Packet Delivery Ratio

Fig. 3(a) shows the packet delivery ratio (PDR) of AODV and DSDV when number of nodes are varied, while fig. 3(b) shows the same, when the speed of the nodes is varied.

As shown in fig 3(a), the PDR remains constant for AODV and varies with the number of nodes. The PDR of AODV and DSDV are fairly comparable, when larger number of nodes is considered. However, when less number of nodes is considered, the PDR for DSDV is less effective as compared to AODV and AODV have 62.31% better packet delivery ratio performance than DSDV.In case of varying speed, as shown in fig 3 (b), the PDR of AODV yet again remains constant, whereas it varies in the case of DSDV. When the speed of the node is less, the PDR of DSDV is almost as much as that of AODV butthe performance of DSDV deteriorates with increasing the speed and reaching a minimum PDR value, which is 38.02% less than the AODV. Hence, it can be concluded that PDR of AODV remains same throughout the cases, while the PDR of DSDV is best used in the case of higher number of nodes and lesser speed of nodes.

B. Throughput

Fig 4 (a) represents the throughput of AODV and DSDV calculated at the destination, when the number of nodes is varied while keeping the other parameters constant. Fig 4 (b) represents the throughput of AODV and DSDV calculated at the destination, when the speed of the nodes is varied.

From fig.4 (a), it is observed that the throughput of AODV is much higher and more reliable than DSDV. The throughput of AODV, like its PDR, almost remains constant except for the slight decrease, when either the number of nodes or speed of nodes is increased to higher levels. The throughput of DSDV increases with increasing the number of nodes and degrades when the speed of nodes is increased. It is observed that AODV have better throughput performance up to even 77.09% in the case of varying the number of nodes.

Hence, it can be concluded that AODV has better throughput performance than DSDV. AODV is suitable for use in any emergency case, while the DSDV works best when the number of nodes is high and the speed of nodes is less.

C. End to End Delay

When the number of nodes is varied, the end to end delay of AODV and DSDV are calculated and shown in Fig 5(a). Fig 5(b) represents the calculation of end to end delay of AODV and DSDV, when the speed of the nodes is varied.

As observed from the figs., AODV shows higher delay than DSDV, when the numbers of nodes are varied. This is due to the less set-up time required in DSDV. The delay in AODV is especially high when the numbers of nodes are low. When the speed of the nodes is varied, the delay shown by DSDV is more than the delay shown by AODV.

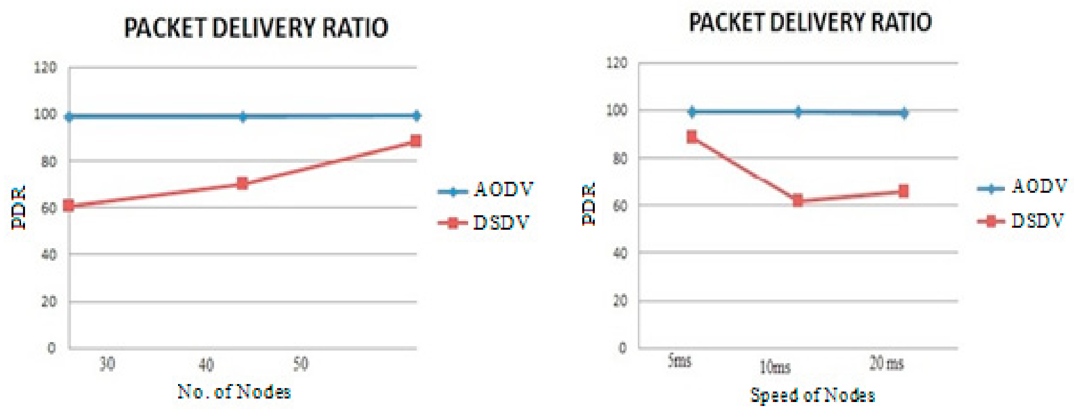

Fig. 3. (a) Packet Delivery Ratio with Varying No. of Nodes; **(b)** Packet Delivery Ratio with Varying Speed of Nodes

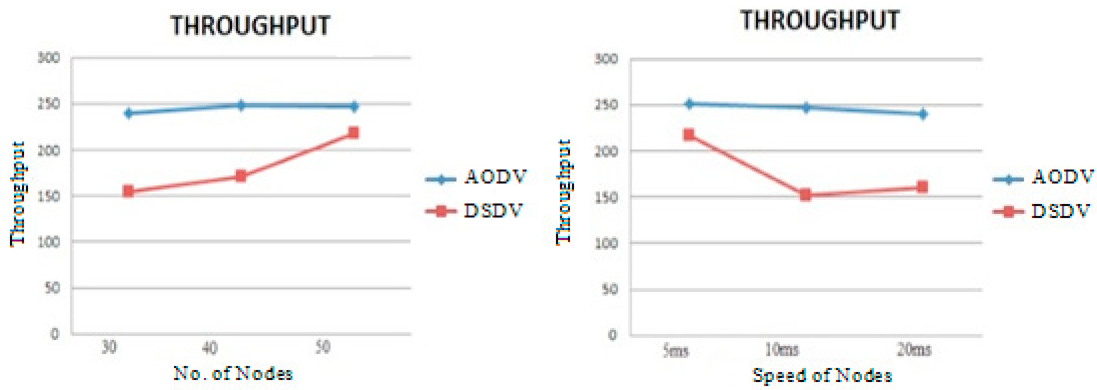

Fig.4. (a) Throughput with Varying No. of Nodes; **(b)** Throughput with Varying Speed of Nodes

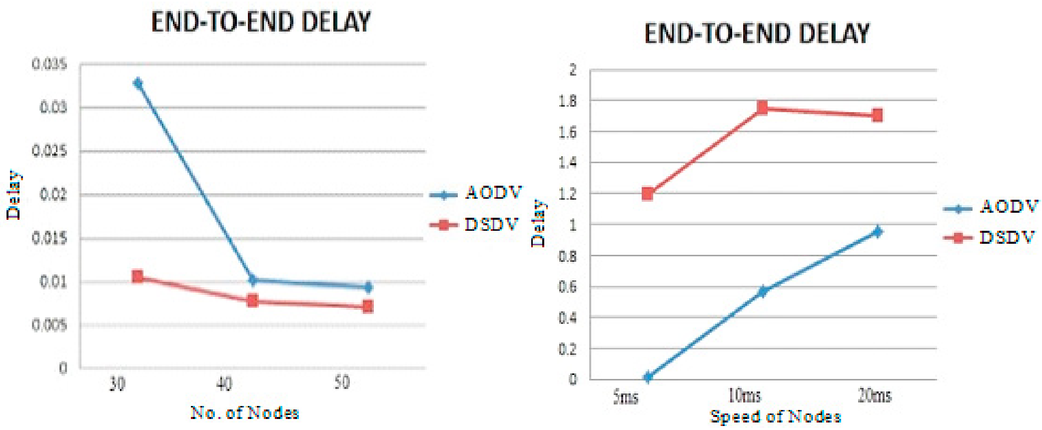

Fig. 5. (a) End to End Delay with Varying No. of Nodes; **(b)** End to End Delay with Varying Speed of Nodes

7. Conclusion

This paper presents the performance evaluation and comparison of the routing protocols in wireless Ad Hoc network. The paper also discusses the application of ad hoc mode of wireless local area network in emergency healthcare services for a hospital. The performance of different parameters of AODV and DSDV is illustrated for different number and speed of nodes and discussed in detail. From the simulated results, it is concluded that the DSDV showed fair performance when delay was considered, while AODV turned out to be more efficient when the packet delivery ratio and throughput was considered.Although in the case of medical data, delay cannot be suffered to a high extent, the priority is to successfully transfer data with minimum packet loss. Therefore, in telemedicine applications, we are giving more priority to throughput and packet delivery ratio. Hence, from the results, we can conclude that AODV is a better choice as it outperforms DSDV routing protocol for such applications.

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