

Impact of clustering in AODV routing protocol for wireless body area network in remote health monitoring system

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ABSTRACT

Proper selection of routing protocol in transmitting and receiving medical data in Wireless Body Area Network (WBAN) is one of the approaches that would help in ensuring high network performances. However, a continuous monitoring of health status through sensing of various vital body signals by multiple biosensors could produce a bulk of medical data and lead to the increase of network traffic. Occurrence of high traffic could result to network's congestion which have high tendency to loss some of important (critical) data and cause longer delay that would lead to false diagnosis of diseases. In order to analyze and validate this issue, Ad-Hoc On Demand Distance Vector (AODV) which is known as reactive routing protocol is evaluated in WBAN scenario through varying number of nodes and clusters. The presence of clustering helps in reducing the burden of the sink nodes in handling high traffics. The network's performances of this protocol are measured in terms of end to end delay, percentage packet loss, throughput and energy consumption using Network Simulator (NS-2). Based on the experimental results, the presence of cluster helps in improving network performances by achieving reduction in delay, packet loss and energy consumption. However, low throughput is achieved as number of clusters are increase due to low duty cycle of the nodes.

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1. INTRODUCTION

Wireless Body Area Network (WBAN) technology is specifically generated for healthcare application. This technology comprises of tiny and multiple biosensors which have high ability to continuously sense and sample medical data before transmitting them to the medical personnel through Internet connection [1]. These biosensors can be wearable on the garments or body as well as can be implanted in the human body as in [2-3]. In addition, this technology has been progressed as one of the Internet of Things (IoT) applications as mentioned in [4-5]. Although this technology is a subset of Wireless Sensor Network (WSN), there are still some major differences existing in both technologies. As WBAN technology is widely applied in medical application namely Remote Health Monitoring System (RHMS), the medical data generated can be divided into 3 kinds of traffics which are on-demand, emergency or critical data and normal [6]. Generation of various type of medical data from different biosensors would lead to congestion. Congestion in network would negatively affect the system's performance such as delay and packet loss. According to [7-9], longer delay in transferring the medical data as well as the loss of these critical data are not encourage in WBAN as it will

cause late in medical service and wrong in diagnosing diseases which could bring severe impact to the patient, thus increase mortality. Hence, this problem should be avoided through proper selection of routing protocol in WBAN during sending and receiving bulk of medical data.

The same concept of routing protocol in classic WSN which is known as ad-hoc network could be used in WBAN in order to set up the connection between various devices such as actuators, sensors, receivers and transceivers [7][10]. In [11], ad-hoc network refers to the interconnection of several nodes via router without a fixed structure and poses dynamic arrangement. There are 2 types of classifications in routing protocol which are reactive (on-demand) and proactive (table-driven) as stated in [10]. The well-known reactive protocol is Ad-Hoc On-Demand Distance Vector (AODV) and proactive is Destination Sequence Distance Vector (DSDV). In reactive routing protocol, discovery of route only happens based on the demand of a node in order to send and receive the data. In addition, AODV uses flooding mechanism during finding the route and message propagation. On the contrary, continuous route between pair of nodes is maintained in proactive routing protocol. Since WBAN works best in low data rate of 250kbps in IEEE 802.15.4 (Zigbee) as discussed in [12-13], AODV protocol has been chosen in this research to be tested since it is suitable in this environment [14]. However, since AODV uses flooding technique as mentioned earlier, there is a high possibility of network congestion would arise due to large number of biosensors involve in WBAN. In addition, these sensors could generate from low to high traffic of various medical data. Hence, presence of clustering in AODV would assist in improving network performances of WBAN by alleviating the burden of the sink node when receiving and processing these data.

The major concern of this paper is to investigate the impact of clustering in AODV protocol to the network performance of WBAN in terms of end to end delay, percentage packet loss, throughput and energy consumption. The aforementioned metrics are measured by varying the number of nodes and number of clusters in the simulation. The remainder of this paper is structured as follows. Section 2 delivers concept of AODV protocol and reviews current research on AODV in WBAN. Section 3 elaborates on method in conducting the simulation. Section 4 analyses and discusses the significant findings from collection of several performance metrics from this simulation. Section 5 concludes the paper and provides future works.

2. LITERATURE REVIEW

This section highlights the concept of Ad-Hoc On Demand Distance Vector (AODV) protocol and reviews significant existing researches on AODV especially in WBAN.

2.1. General Concept of Ad-Hoc On Demand Distance Vector (AODV) protocol

Ad-Hoc On Demand Distance Vector (AODV) protocol is mainly used in well-known applications of ad-hoc wireless networks such as in Mobile Ad-Hoc Network (MANET) and Wireless Sensor Network (WSN) as in [15-16]. This protocol uses concept of broadcast during route discovery and unicast in route reply message [17]. The term broadcast refers to the transmission of data to the multiple recipients at the same time. Conversely, unicast defines sending the data from one source to one destination.

Precisely, AODV is a reactive routing protocol which operates when any node (source) intends to send data by forming a Route Request message or termed as RREQ to find all the potential routes to arrive at the destination [18]. RREQ packet contains network address of the source and destination node, sequence number of source and destination and unique identification known as request ID as depicted in Figure 1.

RREQ ID	DESTINATION IP ADDRESS	DESTINATION SEQUENCE NUMBER	ORIGINAL IP ADDRESS	ORIGINAL SEQUENCE NUMBER
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Figure 1. Format of RREQ packet

Once the RREQ packet is received, neighboring nodes will check whether the data is intended for them or not. If yes, the Routing Response or known as RREP will be delivered to the source node. After receiving RREP message, a route from source to destination node would be established. Otherwise, the RREQ would be forwarded again to the intended node (destination) by creating a REPLY message that consist increment number of hops to the destination [10-11]. If there is any link is broken or the destination node is not active, the route request error (RRER) message would be received. The format of RREQ packet in AODV is reflected in Figure 2.

DESTINATION IP ADDRESS	DESTINATION SEQUENCE NUMBER	ORIGINAL IP ADDRESS	LIFETIME
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Figure 2. Format of RREP packet

In short, this protocol is energy-efficient since it invokes only when receiving request message during forwarding packet and utilizing small bandwidth based on [19]. However, longer delay might occur since not all of the nodes could quickly perform the route discovery process.

2.2. Existing researches on AODV in WBAN

Several researches have been carried out in evaluating the performances of AODV protocol with different number of nodes in [11], [20]. The performance of deployment multiple mobile sink nodes is analyzed in [14]. This work is intended for WSN and manage to conclude that using multiple mobile sink nodes has achieved reduction in delay. However, using multiple sink nodes could increase the energy consumption.

Another performance of mobility in AODV for WSN is reflected in [18]. This paper has discovered that random based mobility has effect on the performances of packet delivery ratio (PDR), throughput and latency. Although speed of the nodes is varied from 1m/s to 20 m/s, a steady increment reading of PDR and throughput are recorded. Meanwhile, decrement in latency in data transmission is also notified. But, this study does not cover the performance of energy consumption which is one of the measurements that need to be considered as nodes in WSN is known as battery-operated.

Another criterion in measuring performance of AODV protocol specifically for WBAN is analyzed under different transmission rate (100 and 250 kbps) and packet size (32, 64 and 128 Bytes) by [10] and has successfully concluded that AODV routing protocol is fitted for data transmission of human body by attaining low delay and packet loss rate compared to DSDV routing protocol.

Based on the aforementioned review of previous works, it could be notified that not much work has been done on clustering in AODV for WBAN. Although WBAN is a subset of WSN but it differs from WSN as it poses strict requirements in terms of low data rate, low latency in transferring the data and high security compared to WSN [7-8]. In addition, it could be simply concluded that the major consideration in analyzing the performance of WBAN are delay and packet loss since these two parameters have significant effects during the process of analyzing the collected medical data from continuous monitoring of health status of patients.

As discussed in Section 1, AODV uses flooding technique in dealing with transmission of bulk of medical data from multiple biosensors to search the route for sending the data to the intended destination. Based on this fact, it may be possible that the presence of several clusters would lessen the burden of the sink node in processing and receiving a bulk of medical data. This would directly reduce the chance of network congestion. High performance of AODV protocol in WBAN are measured in terms of reducing delay and packet loss. Also, this would ensure high data reliability of the system.

3. METHODOLOGY

In this paper, the performance of AODV protocol (without any modification) with the presence of cluster is assessed in WBAN scenario using Network Simulator (NS-2) with integration of Mannasim framework. The simulation environment using clustering in AODV of WBAN is illustrated in Figure 3.

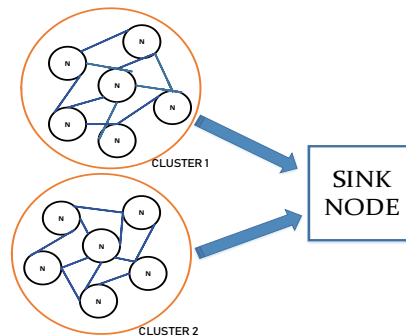


Figure 3. Simulation environment

According to [21-22], a suitable packet size of time-critical application should lie within 30 to 60 bytes. This is because bigger packet size would increase the chances of error packet and longer delay during sending the data. Hence, a packet size of 30 bytes is chosen to be tested. The performances of AODV protocol is evaluated in terms of end to end delay, percentage packet loss, throughput and energy consumption under different number of nodes which ranging from 10 to 50 and number of clusters from 0 to 2 with 200m x 200m area of deployment. The details of parameters setting in this simulation are tabulated as in Table 1.

Table 1. Settings of Parameters of WBAN

Parameters	Value
Packet size	30B
Queue Length	50
Data Rate	250 kbps
Number of Nodes	10 to 50
Number of Clusters	0 to 2
Area of Deployment	200m x 200m

4. RESULTS AND ANALYSIS

This section emphasizes on output analysis from the simulation in terms of end to end delay, percentage of packet loss, throughput and energy consumption based on AODV routing protocol with clustering in WBAN.

4.1. End to End Delay

End to end delay reflects the time taken for data transmission from source to destination. As depicted in Figure 4, there is a rapid increment in delay when the number of nodes are increased. But, as soon as clusters are introduced, there is a significant reduction in delay compared to no cluster. This has proven that the use of cluster can reduce the burden of the sink node which lessens the risk of congestion. Reduction in delay would lead to higher efficiency of data transmission and reception particularly dealing with critical packets.

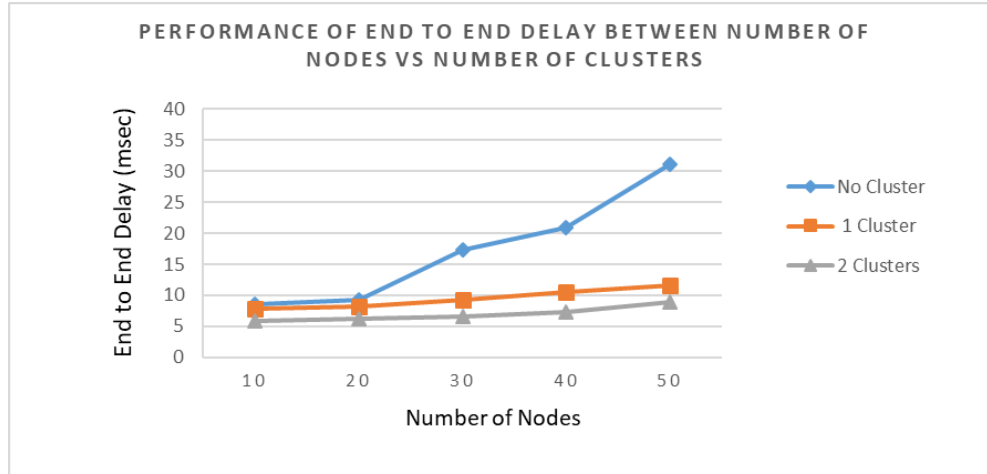


Figure 4. Graph of end to end delay versus number of nodes and clusters

4.2. Percentage Packet Loss

Percentage packet loss signifies number of loss packet during data transmission and reception. Referring to Figure 5, highest rate of percentage packet loss is recorded when there is absence of cluster is presented as number of nodes increase. However, there is a significant difference in loss of packets when number of nodes increased to 50 nodes together with the presence of 2 clusters. With this huge difference in packet loss, there is low possibility of congestion occurrence in this simulation. Low congestion brings positive impact to the network performances in terms of decrement in loss of packets. To be exact, the risk of losing critical medical is reduced which would lead to right diagnosing and provide quick medical treatment to the patients.

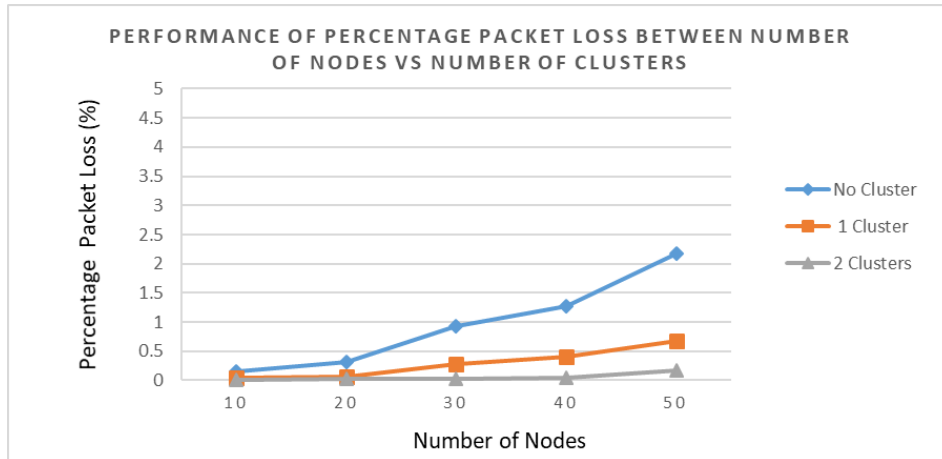


Figure 5. Percentage packet loss versus number of nodes and clusters

4.3. Throughput

Throughput defines the successful delivery of the total number of bits in a certain period of time. From Figure 6, high throughput is notified as the number of nodes are increased. However, as the clusters are introduced, the value of throughput is slightly decreased compared to when there is no presence of cluster. Theoretically, the value of the throughput should be higher as number of packet loss are reduced. This problem arises due to setting up of low duty cycle in the node. In general, duty cycle reflects the ratio of active period and full active period of a node. The nodes will be in active period once any activity or event is detected. Otherwise, the nodes will be in longer sleeping mode. Due to this reason, only few nodes are available to route the data in low duty cycle environment. Although longer sleeping mode promotes to energy saving but as a trade-off, the performance of throughput is decreased.

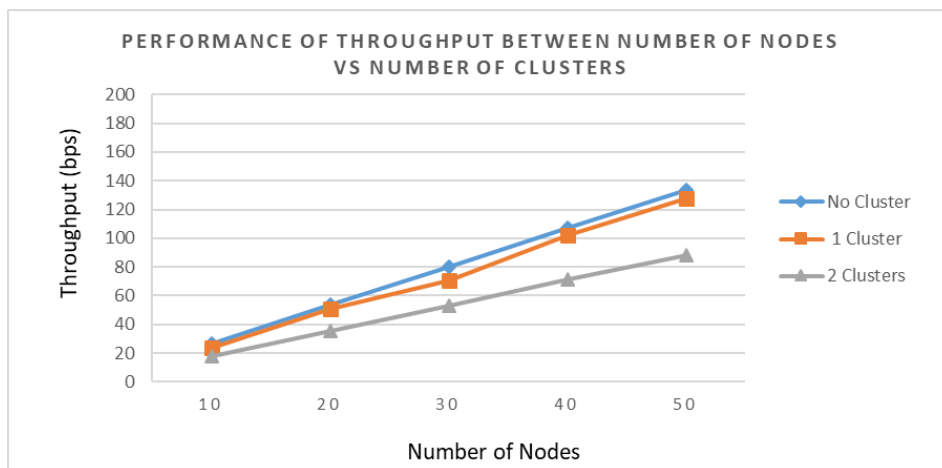


Figure 6. Throughput versus number of nodes and clusters

4.4. Percentage Energy Consumption

Percentage energy consumption refers to the amount of energy uses by the nodes during transferring and receiving data. Based on Figure 7, there is an increment in energy consumption when number of nodes increased. But, the energy is less consumed in the presence of two clusters compares to absence of clusters. This result has proven the ability of clusters to handle a successful delivery of the packets to the destination. In specific term, the number of packet retransmission is less since retransmission of packet consumes more energy. In addition, energy use in the node is related to the processing power as well.

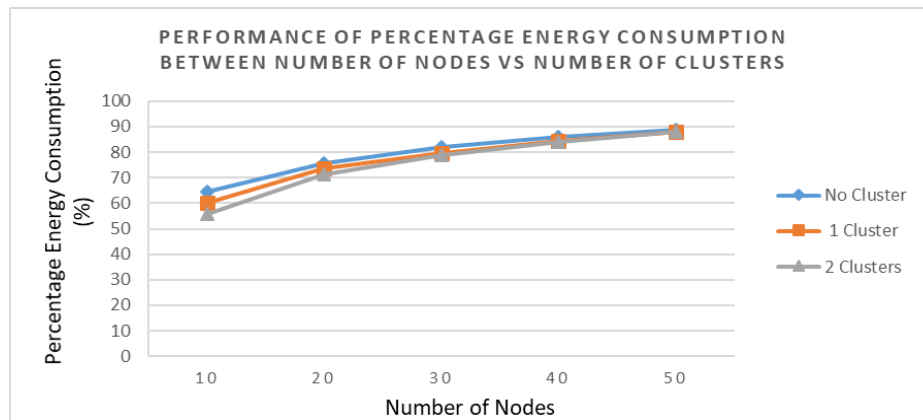


Figure 7. Graph of energy consumption versus number of nodes and clusters

5. CONCLUSION

In this paper, AODV protocol for WBAN with the presence of clusters is studied through varying number of nodes and clusters. The simulation results conveyed significant network performances by achieving reduction in end to end delay, percentage packet loss, throughput and energy consumption with the presence of cluster nodes. Presence of cluster has been a great help in reducing the burden of the sink node in processing and receiving medical data. Also, this would ensure low chance of network congestion. However, low throughput is recorded due to low duty cycle of the nodes. Therefore, some modifications are needed to handle this issue for improvement. In addition, by classifying the packets into different types of data (e.g: Normal, Critical and On-Demand) is believed to contribute to higher network performances as Critical data should be among the highest priority concerned for emergent data transmission compared to the Normal and On-Demand data in the future work.

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