PERFORMANCE STUDY OF ROUTING PROTOCOLS IN A MOBILE PATIENT MONITORING NETWORK

A Thesis submitted in partial fulfilment of the Requirements for the degree of

Master of Technology
In
Electrical Engineering
(Electronics systems and Communication)

By

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Under the Guidance of
Prof. Susmita Das

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Dedicated to…

My parents and my sisters

DEPARTMENT OF ELECTRICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA

ROURKELA – 769008, ODISHA, INDIA

Certificate

This is to certify that the work in the thesis entitled PERFORMANCE STUDY OF ROUTING PROTOCOLS IN A MOBILE PATIENT MONITORING NETWORK by Ravi Tiwari is a record of an original research work carried out by him during 2013 - 2014 under my supervision and guidance in partial fulfilment of the requirements for the award of the degree of Master of Technology in Electrical Engineering (Electronics System and Communication), National Institute of Technology, Rourkela.

Place: NIT Rourkela **Prof. Susmita Das**

Date: 22 May 2014 Professor

DEPARTMENT OF ELECTRICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA

ROURKELA – 769008, ODISHA, INDIA

Declaration

I certify that

a) The work contained in the thesis has been done by me under the general supervision of my supervisor.

b) The work has not been submitted to any other Institute for any degree or diploma.

c) I have followed the guidelines provided by the Institute in writing the thesis.

d) Whenever I have used materials (data, theoretical analysis, and text) from other sources, I have given due credit to them by citing them in the text of the thesis and giving their details in the references.

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Ravi Tiwari

22nd May 2014

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ABSTRACT

Patient monitoring and connected medical devices are dramatically changing for providing more care and health services. A WBAN is based on IEEE 802.15.6, allowing near field communication up to one-meter range from the human body. In patient monitoring, the physiological data is sensed by sensor and forward to the medical professional, where the received data is continuously compared with the original data base of a patient. In order to give more care to patients, it is necessary to monitor the patient when they are in motion. This gives a promising way to assist the medical professionals for improving their monitoring abilities. Mobile patient monitoring system detects the patient's situation when he/she is in motion and allows a patient to roam around the hospital without health professional.

For proper communication between the mobile nodes of the patient monitoring system, the IEEE standard WLAN and WPAN are to be implemented. When the patient is moving in the arbitrary trajectory a less predictable topology and link instability is formed, that make routing protocols an important task. Different routing algorithms such as AODV, DSR, DSDV, and AOMDV have been analysed in NS2 for different types of patient monitoring scenario. Most WLAN are based on IEEE 802.11 and provide wireless connection between the nodes for the communication. This gives users the ability to move around within a local coverage area up to hundred meter range and still be connected to the network. WPAN system is designed under IEEE 802.15.4 and provides interconnection of communicating devices. Also it can serve for different purpose such as allowing the surgeon and other team members to communicate during an operation inside the operation theatre. The simulation results shows that IEEE 802.11 is best suited for designed mobile patient monitoring network as it provides more coverage area to the patient.

CONTENTS

ABBREVIATIONS

WSN	:	Wireless Sensor Network
MANETs	:	Mobile Ad-Hoc Networks
WLAN	:	Wireless Local Area Network
IEEE	:	Institute Of Electrical And Electronics Engineers
AODV	:	Ad-Hoc On Demand Distance Vector
DSR	:	Dynamic Source Routing
DSDV	:	Destination Sequenced Distance Vector
NS2	:	Network Simulator 2
AOMDV	:	Ad-Hoc On Demand Multipath Distance Vector
WPAN	:	Wireless Personal Area Network
OLSR	:	Optimized Link Source Routing
WBAN	:	Wireless Body Area Network
IN	:	Infrastructure Network
RF	:	Radio Frequency
TCP/IP	:	Transmission Control Protocol/ Internet Protocol
LLC	:	Logical Link Control
MAC	:	Media Access Control
CSMA/CA	:	Carrier Sense Multiple Access/Collision Avoidance

FFD	:	Full Function Device
RFD	:	Reduced Function Device
RREQ	:	Route Request
RREP	:	Route Reply
RRER	:	Route Error
PDF	:	Packet Delivery Ratio
CBR	:	Constant Bit Rate
OTCL	:	Object Oriented Tool Command Language
NAM	:	Network Animator
CCU	:	Central Coordination Unit
PCU	:	Patient Coordination Unit

NOMENCLATURE

T_{ee}	:	End-to-end Delay
T_p	:	Processing delay
T_q	:	Queuing Delay
T_t	:	Transmission delay
T_{pr}	:	Propagation delay
N	:	Number of delivered packets
P_s	:	Packet size

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1

INTRODUCTION

Over the past few decades, there is an exponential growth in the field of information processing and wireless data transmission for patient monitoring system [23]. Wireless Body Area Network (WBAN) is a network which employing wireless sensor technology that forms a system to continuously monitor the patient situation. Specific sensors for each physiological data are placed near to the human body, but it limits the patient mobility. The wireless network is necessary to design for monitoring the mobile patient within specified area. This gives freedom to the patient to move without medical professional within the campus. This network is a wireless sensor network that provides the patient monitoring to anyone within coverage area. Mobile patient are moving and creates less predictable topology and link instability that's make routing an important task for mobile patient monitoring [30].

In the case of medical applications, the main requirement is to reduce the control overhead and reliable medical data transmission. A mobile patient monitoring network model is designed, and its performance has been analysed based on end-to-end delay and throughput using WLAN IEEE 802.11 standard under different routing protocols. Designing of network starts from the understanding of wireless networks and studying the concept of IEEE standards 802.11 WLAN and 802.15.4 WPAN, which can be employed on the network. This chapter describes the wireless network and IEEE standards [18] .

1.1 Wireless Network

The wireless network is the network which uses radio frequency for transmitting and receiving data on air. The most important benefit as compared to wired networks is to eliminate the problem of heavy cables and wireless network can be created easily and fast where we cannot wire the connection. This type of network gives more flexibility and easily adapts the changes in the network configuration. But wireless network is more susceptible to interference due to other radio frequency devices, and obstruction. Total throughput is also decreased when there are multiple connections [1]. The wireless network gives freedom to the devices, for forwarding data and takes part in communication without networking cables, which increase the mobility but decrease the range of communication. The wireless network structure is illustrated in the figure 1.1.

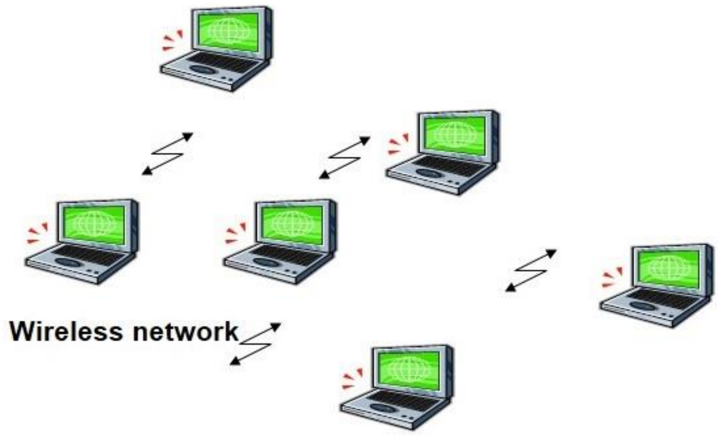

FIGURE 1-1: WIRELESS NETWORK

Wireless network is further classified into infrastructure and ad-hoc network:

1.2 Infrastructure Network (IN)

Infrastructure network can be defined as wireless network where communication takes place through access points only. This type of network is best suited where we can place an access point. The IN is depicted in the figure 1-2.

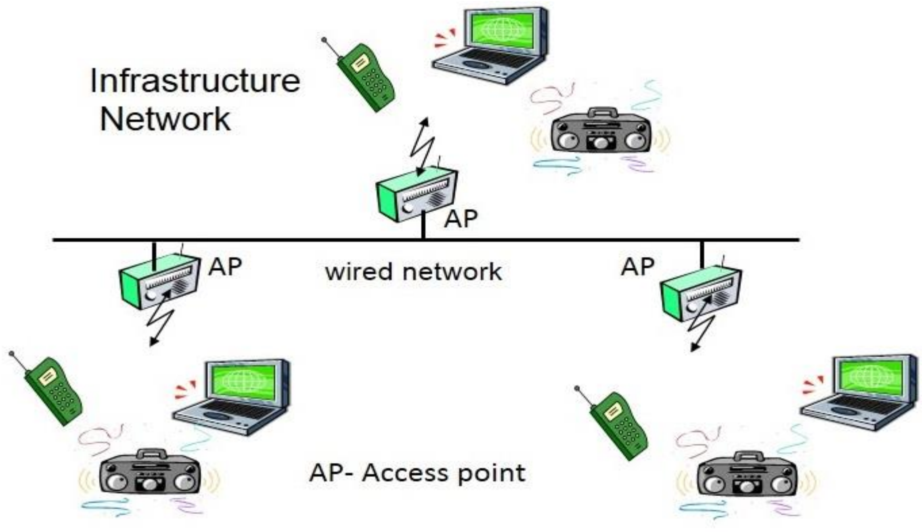

FIGURE 1-2: INFRASTRUCTURE WIRELESS NETWORK

1.3 Ad-hoc Network

A network without any fixed access point and also does not depend on pre-existing infrastructure that's why such network is called Ad-hoc. Wireless Ad-hoc network is made up of few to hundred numbers of nodes or device that are connected through a Radio Frequency (RF) of infrared interface and have a capability of communicating with each other by making connected in a decentralized manner [17]. All mobile nodes of the network have equal importance means any node of the network can be work as a host or router and can communicate by transmitting the data directly to any node or device on the network [18]. The control of the network is also distributed to every node of the network. As in wireless system all nodes or devices on the network are connected through the radio transmission path and because of that they are easily affected by noise, fading and interference. The Ad-hoc network is depicted in the figure 1-3.

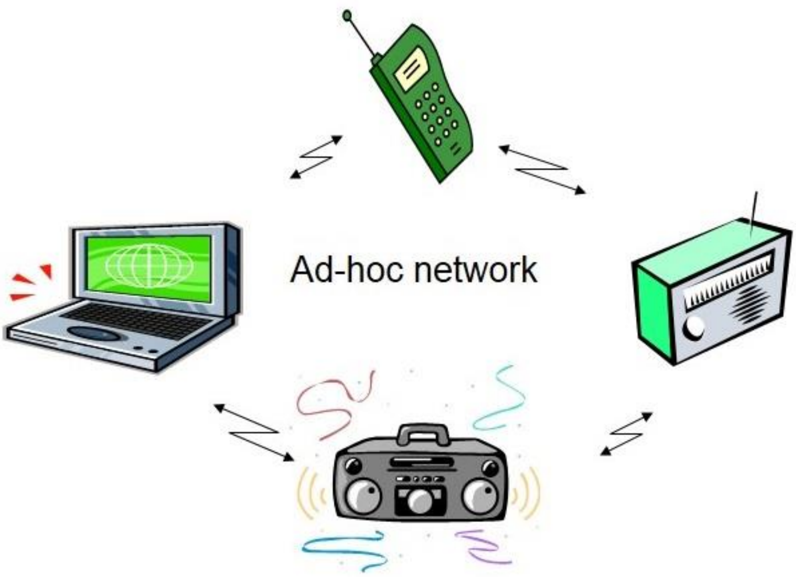

FIGURE 1-3: AD-HOC WIRELESS NETWORK

Wireless Ad-hoc network is having a number of sensor node spreads over a specified area [16]. Each node has a capability of signal processing and networking of the data. Some example of wireless ad-hoc network is as follows:

i) The network used to monitor the environment and detect environmental changes.
ii) The network used to detect and transmit data for military and defense purpose.
iii) Network used to sense and monitor vehicle traffic on the road.
iv) Network for surveillance sensor for providing security in any place.
v) Network for patient monitoring system to transmit data from ambulance to doctor and receive medical advice from a distance.

If every nodes of the network are moving, then structure of the network changes continuously and connectivity may break due to node movement that creates unpredictable topology and link stability. To overcome the problem of decreasing performance due to node mobility, routing protocol is very important necessity of mobile ad-hoc network. Routing protocol allows every device s or node to communicate over multi-hop paths to their intended node. Previously flooding mechanism is used to forward the data in mobile ad-hoc network. Main requirement of ad-hoc network is efficient routing protocol that's why routing protocol are getting attention by the researchers.

1.4 Overview of IEEE 802.11 WLAN Standard

IEEE standard 802.11 gives the MAC and physical layer specification for WLAN [8]. Which can be operated in 2.4, 3.6, 5, and 60 GHz band. Internet protocol suite is a group of communication protocols used in networking. Transmission control protocol (TCP), and

Internet Protocol (IP) were networking protocols gives total connectivity and specifies how the data should be addressed, transmitted, routed and received at its intended node [21]. The functionality of protocols is organized in four layers: Link Layer, Internet layer, Transport Layer and Application layer.

- **Link layer**

Link layer can be defined as a group of methods and communication protocol that operate on the link, where operated node is physically connected. The link is any interconnecting component, which is used to interconnect nodes of the network and link protocol is a group of methods, which operate only between adjacent nodes of the network. Link layer can also be seen as the group of data link layer and physical layer in OSI model.

- **Physical layer**

This is first stage of the TCP/IP, where data is physically moved across the network interface.

- **Data link layer**

It is a layer of TCP/IP model that forward data between adjacent nodes of the network over wide area network or transfer packet between nodes of the same WLAN [8]. It provides a functional way to transfer data between different nodes of network and also have a power to correct errors occur in physical layer. Ethernet of LAN protocol and Point to point protocol are the example of data link protocols [22]. Data link layer is further subdivided into two basic layer:

i) Logical link control

ii) Media access control

i) Logical link control

Logical link control is the top most layer of data link layer. Its function is to assign addressing, and control data link layer. It select which method is used for addressing over transmission medium and controlling data exchange between nodes. This layer may provide flow control, acknowledgement and error notification.

ii) Media access control (MAC)

Its function is to determine which node is allowed to access the media at that instant of time [22]. Distributed and centralized are two forms of MAC. MAC sub layer also synchronize the frame of the data by determining where one frame of data end and next frame starts. MAC sub layer synchronize the data by four methods they are:

- Time synchronization
- Character counting
- Byte stuffing
- Bit stuffing

1.5 Overview of IEEE standard 802.15.4 WPAN

It is IEEE standard, which is designed for low rate Wireless Personal Area network (WPAN). This IEEE standard comes under IEEE802.15 working group, which is mainly focused on low data rate low cost wireless network. Basically, WPAN network is used for providing communication under 10 meter range with a transfer rate not more than 250 kbps [7]. The main advantage of WPAN network is to provide low manufacturing and operation cost.

IEEE 802.15.4 protocol consists of physical layer, MAC layer, and higher layer. Higher layer are based on OSI model whereas lower layers are defined in this standard along with upper layer using IEEE 802.2 logical link control sub layer accessing the MAC through convergence sub layer. IEEE 802.15.4 protocol stack with protocol layers is shown in figure 1-4.

1.5.1 Physical Layer

It is a first layer of OSI reference model which provides data transmission services and interface to higher layer through physical layer management entity that maintain a database of WPAN. Physical layer manages the physical RF transceiver, energy and data communication. WPAN can be work in 2.4 to 2.483 GHz unlicensed frequency band.

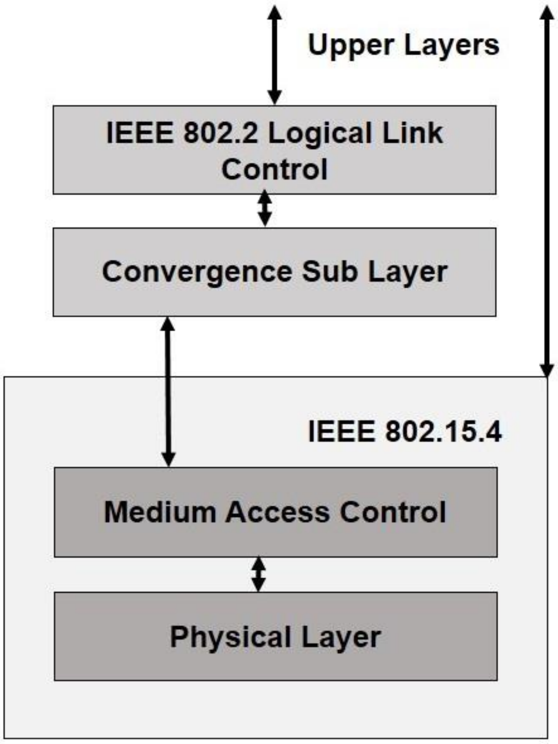

FIGURE 1-4: IEEE 802.15.4 PROTOCOL STACK

1.5.2 MAC Layer

It allows the forwarding of MAC frames through physical channel and manages accessing of physical channel and network beaconing. MAC layer provides time synchronization and frame validation. Mainly IEEE 802.15.4 standard supports maximum up to 127 bytes [6]. Higher Layers are not defined in this standard.

1.5.3 Network Model

Full Function Device (FFD) and Reduced Function Device (RFD) are two types of network node in personal area network. FFD serves as coordinators in the network which can relay message in network, whereas RFD is simple node or device and communicate only with FFD's and never work as coordinator.

1.6 Comparison of WLAN, WBAN and WPAN

The comparison WLAN, WBAN and WPAN are given in the table below [27]:

TABLE 1-1: COMPARISON OF WLAN, WPAN AND WBAN

	802.11b WLAN	802.15.4 LR-WPAN	802.15.6 WBAN
Range	**~ 100m**	**~ 10m**	**~ 1m**
Data rate	**11 Mbps**	**≤ 0.25 Mbps**	**≤ 20 Mbps**
Transmit Power	**250mW**	**0dBm**	**-41dBm**
Complexity and cost	**High**	**Low**	**Medium**
Bandwidth	**20 MHz**	**5 MHz**	**500MHz**
Frequency band	**2.4GHz**	**2.4GHz**	**3-10 GHz**

1.7 Objective of The Work

The basic objective of the research is to develop a wireless patient monitoring system where more flexibility is added by considering mobility of patients in different direction. The designed mobile are suggested to optimize throughput and end-to-end delay. To realize the objective, the following analysis and investigation are undertaken:

- The mobile patient monitoring network model has been designed using IEEE 802.11b WLAN standard and its performance has been analysed with AODV and DSR routing protocols. Where the facility of variable speed and different trajectory is provided by considering the patients movement inside the hospital.
- Study and analyse AODV, DSR, AOMDV and DSDV routing protocol under IEEE 802.11 WLAN and IEEE 802.15.4 Wireless Personal Area Network (WPAN).
- Implement AODV and DSR routing protocols for the designed Mobile Patient Monitoring Network under 802.11 WLAN

1.8 Literature Survey

The concept of patient monitoring system is explained in the paper “Implementation of wireless body area networks for healthcare system,” by **Mehmet R. Yuce** in year 2010 [27]. The patient monitoring is implemented in “ Real time monitoring of electrocardiogram through IEEE 802.15.4 network” under IEEE standard of WPAN and real time monitoring is explained by **Wei. Lin** in the year 2011 [29]. The concept of Ad-hoc network for patient monitoring system is explained by **Poramin Insom** et al in his paper “Implementation of a human vital monitoring system using Ad Hoc wireless network for smart healthcare”.

The routing is core issue for mobile patient system and the routing algorithm is discussed in the paper presented by **Wu Chunming Zheng** et al in 2010 [30]. The performance evaluation of different routing protocol is discussed by **V. K. Taksandde** et al in his paper “A simulation comparison among AODV, DSDV, DSR protocol with IEEE 802.11 MAC for grid topology in MANET” [4]. The simulation of routing protocols has been performed on network simulator NS2, introduction of NS2 is discussed by **Teerawat Issariyakul** et al in 2011 [2]. The brief description of AODV routing protocol is explained by **Tooska Dargahi** in 2008 [15]. It states that the AODV routing is reactive On demand routing protocol. DSR routing protocols explained in paper “Optimization and implementation of DSR route protocol based on Ad hoc network” by **Zhaohua Long** et al in 2007 [11]. AODV routing protocol is not performing well in highly dynamic network, to overcome this problem a derivative of AODV routing protocol, AOMDV came into light in paper “Ad-hoc on demand multipath distance vector routing” and described by **Marina** et al in 2006 [23].

1.9 Thesis Organization

The thesis has been organised into five chapters. The ongoing chapter gives the brief introduction to the network, Routing protocol, NS2 simulator setup and simulation analysis and discussion. The objective of the thesis has been addressed in the following subsections. The current subsection gives the brief discussion about IEEE 802.11 and IEEE 802.15.4 standard, explains the entire thesis organization and literature survey.

Chapter 2: The second chapter discusses the detailed description of routing protocols and the detail study of AODV, DSR, DSDV, and AOMDV routing protocols.

Chapter 3: This chapter gives the introduction to network simulator NS2. It also describes the setup of NS2 under different scenario used for the analysis with their parameters.

Chapter 4: The fourth chapter indicates result and discussion obtained by simulating different routing protocols with increasing speed and number of node scenario under IEEE 802.11. A detail description and result analysis by simulating routing protocols under IEEE 802.15.4 with increasing number of node scenario.

Chapter 5: This chapter explains the proposed mobile patient monitoring network and its simulation results has been analysed under AODV and DSR routing protocol.

Chapter 6: This chapter gives the conclusion to the entire thesis work carried out and the possible future work to the research with limitation of current work.

2

ROUTING PROTOCOLS

Routing protocols are defined as a group of rules by which nodes or router sending the packet of information from source to intended node. Whenever a path is needed from source to destination then routing protocols allows nodes or device of the network to find and maintain the routes up to intended nodes. Due to high mobility of mobile nodes, low bandwidth, and limited energy make routing protocol an important part in the mobile ad-hoc network.

2.1 CLASSIFICATION OF ROUTING PROTOCOLS

The routing algorithm mentions the procedure of communication between the routers. Figure 2-1 depicts the broad classification of routing algorithm with examples [4]. Routing protocol are classified into three basic groups depending on the fact that whether routing table is updated continuously or route request is required to send after the request from the source.

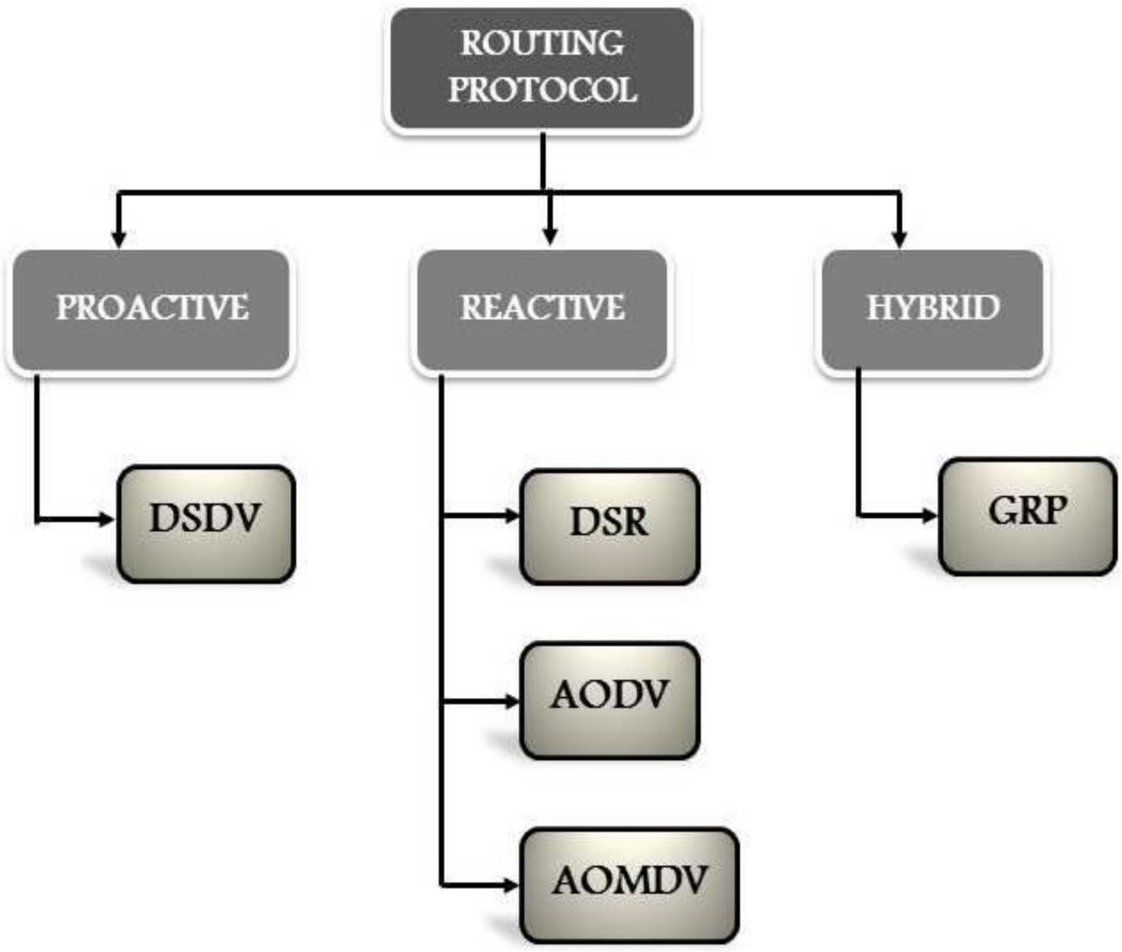

FIGURE 2-1: ROUTING ALGORITHMS CLASSIFICATION

2.1.1 Proactive Routing Algorithm

Proactive routing protocols can also be seen as table driven protocols. Table driven means every node or a device continuously updates the table containing routing information about every other node of the network. If due to mobility of nodes topology changes, then nodes of the network send a message to update routing table [13]. In proactive routing protocol, routing information of all the nodes is continuously updating and modify routing table. As the routing table has all the current routes of every node to any other node, so if any node wishes to send the packet of data to its intended node, then source node checks the current routing table information and find the path to the destination node.

Here latency delay is very less as the route from source to destination is updated and available in routing table before the actual communication requirement. When any source terminal wants to transmit packet of information to intended node, it has to just check for particular route from source to destination in routing table [14]. It performs better in slow speed of mobile nodes. Proactive routing protocols include Destination Sequenced Distance Vector (DSDV) and Optimized link source routing (OLSR). Description of DSDV routing protocol is given in section 2.2.3.

2.1.2 Reactive Routing Algorithm

Reactive routing protocols can also be seen as on demand protocols. In this type of routing algorithm, all mobile nodes contain the information of only active paths to the destination nodes. If any source terminal wants to send packet of information to its intended node or terminal, reactive routing will try to settle a route based on the request from the source. It indicates that here latency delay is high route discovery process is on demand, as the route from source to destination is settled after the request from the source terminal. It performs better in highly dynamic movement of mobile nodes of the network [4]. Reactive routing protocols include Ad-hoc on Demand Distance Vector (AODV), Ad-hoc on Demand Multipath Distance Vector (AOMDV), and Dynamic Source Routing (DSR).

2.1.3 Hybrid Routing Algorithm

Hybrid routing protocol is called as hybrid because this protocol is consolidation of above described two types of routing protocol along with a location identification routing algorithm and gives the advantage of both of it [14]. Hybrid routing protocol include Temporally Ordered Routing Algorithm (TORA), and Gathering Routing Protocol (GRP).

2.2 COMPARISON OF PROCESS FOR DIFFERENT ROUTING ALGORITHM

2.2.1 Dynamic Source Routing (DSR) Protocol

DSR based on 'on-demand theory' and supports unicast routing. It works on the source routing theory not hop by hop routing, it implies that, the source of sending packet will find out the complete sequence of the intermediate nodes by which the packet will reach up to intended terminal or node. In this routing protocol, when any source terminal or node wishes to send the packet of data to intended node, then the source will add that route sequence in the header of the transmitted packet [11]. The header contains the complete address of intended terminal and intermediate nodes of that route in the network. This routing protocol is used in multi hop wireless ad- hoc network. The DSR algorithm regulates and configures the communication by two mechanisms:

i) Route discovery mechanism

ii) Route maintenance mechanism

These two mechanisms allow the source of the data packets, to discover and maintain the path up to intended terminal in the network. In order to avert the memory overhead, the router maintains the list of recently used routes and route requests. Route discovery and route maintenance mechanism works completely on demand [12]. The Route Request (RREQ) and Route Reply (RREP) message are used to perform these mechanisms.

i) Route discovery mechanism

It is a process of finding the address of destination from source node. Route cache has all the information regarding the active routes from any mobile node to the destination node, therefore, if the node wants to send the information packet, it will search the route cache. If the route is available in route cache, then that path from source to destination terminal is used to send packet of information, otherwise the source node broadcasts the RREQ by flooding method in the network having a specific identification number and address of the transmitter and receiver node. When the in-between nodes in this process of broadcasting, receive the RREQ message, they will again send the same message to the nodes in its territory along with their own address [11]. As soon as the RREQ reaches its intended node for that packet of information, then that intended node will send back RREP with complete information about route to the source terminal.

The destination considers the shortest path for RREP by selecting the smallest route used by RREQ packet to travel from the transmitter to intended node for that message. Now as the source receives the route reply from intended node, source node assumes that it found the path to destination and source node start routing of packets.

The process of route discovery with an example of eight nodes is shown in figure 2-2. In this example source node (S) needs to sends the data to destination node (D). Then the source node (S) has to send complete route information along with information packet. Every in-between nodes resend message after adding their address in the header of the packet like here S, S to A etc. When any intermediate node receives the route request, initially it checks whether that request came earlier or not. If yes, intermediate node discards that request. Similarly in this example intermediate node (B) will discard the request from node (C) because node (B) got the same route request earlier from node (A). The process of route reply on the same network is shown in figure 2-3. When the route request reaches destination D, then destination node D will send route reply message with the full path like S-A-B-D and S-G-F-E-D. Source node catches all the paths form source to destination and select the shortest path. DSR is illustrated in the following figures:

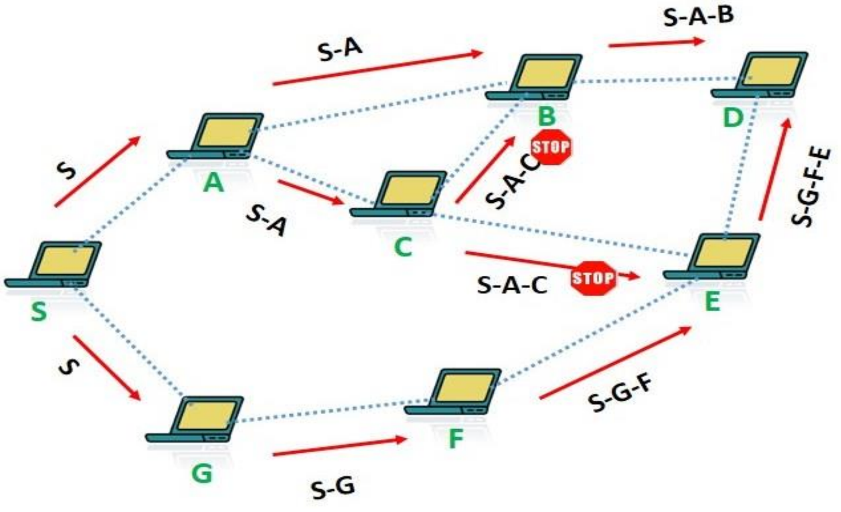

FIGURE 2-2: DSR ROUTE DISCOVERY PROCESS RREQ BROADCAST

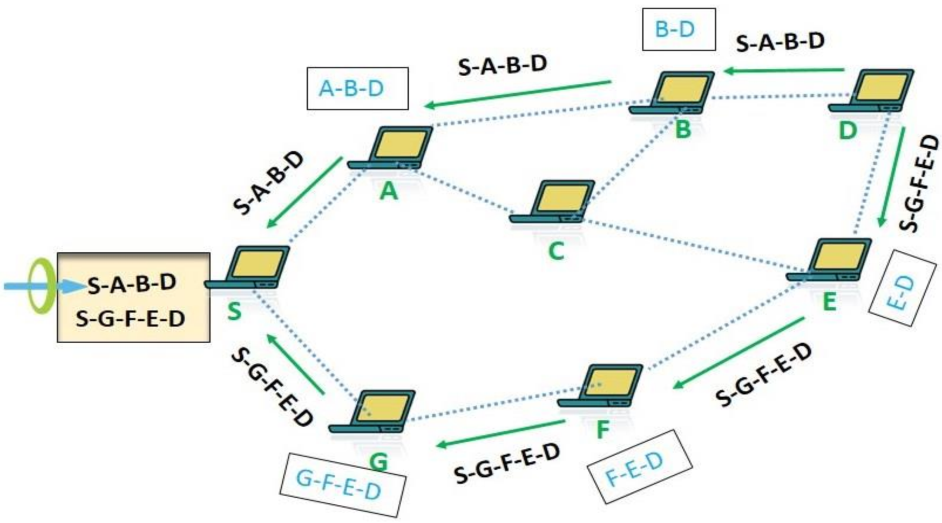

FIGURE 2-3: DSR ROUTE DISCOVERY PROCESS RREP

ii) Route maintenance mechanism

Route maintenance mechanism uses two messages for maintenance that are Acknowledgement (ACK) and Route Error (RERR) Message. When the packet of information reached successfully to their intended node, then it will send an ACK message to the source of that packet. If packet of information sent by the source does not reach successfully to their intended node, then it will send a RERR Message [12].

As DSR routing algorithm is basically designed for wireless mobile Ad-hoc network for multi-hop transmission from source to destination, the major disadvantage is its non-uniform packet size, because all wireless devices support uniform packet size and if sending packet is large in size it should be send after split into smaller parts. In case of the wireless medium it causes problem if smaller parts of the message will not receive in correct order.

2.2.2 Ad-Hoc On Demand Distance Vector (AODV)

The AODV is also based on ‘on-demand theory’ but applicable for both unicasting and multicasting routing. It is a reactive routing protocol so it frames routing paths between the node terminals only when the request came for the same from the source terminal. Once the routing path is establish between nodes it will remain exist for it lifetime [13]. Lifetime is associated with the entry in route table, if at all a path is idle for duration, then that path is black out from route table. The AODV assigns a destination sequence number to all route entry thus it is also called as destination based routing. AODV overcomes the existing problem in DSDV routing protocol by creating the path only on demand and thereby reduces the number of broadcast [14].

In order to find the route from source to its intended node, Source broadcast a RREQ and then in between nodes also broadcast that packet to their neighbor, this process is continued until it reaches intended node or any in between node which has a recent route information about the destination. RREQ in AODV carries the intended node address only, whereas in DSR it bears full routing data, it signifies that AODV routing algorithm, has probably lesser routing overhead. RREP in AODV, carries the intended node's IP address and destination sequence number, but unlike AODV in case of DSR routing algorithm it carries the information of the selected route, and at the same time it also carries the address of nodes coming in the selected path. Therefore AODV resolves the problem of potential overhead found in DSR [14].

Whenever any mobile terminal needs to transmit the information packet to the intended node, it broadcasts a RREQ in the network. When this RREQ message is received by the intermediate nodes, they create a reversal route towards the source node and then check for an accurate path in the route table, but if the requested route is not available, it will broadcast the RREQ message in the network again, and the process lasts until the node finds the suitable path.

As soon as the intended terminal gets the RREQ, immediately it generates RREP. It is also possible that the source node receives more number of RREPs, in this scenario the route with fewer numbers of hops will be chosen for transmission of information packets. It is expected that the information packet will reach the intended node with fewer number of hops, but in the case when the in-between devices fails to re-transmit the information packet towards the next node in the way due to any complication, it transmits the RERR message [15].

If during the process source node moves, then it has to reinitiate route discovery to the intended node and if in between node move then that node realizes a link failure to its neighbor, and process is continued until it reaches source and in that situation source node has to again restart the route discovery process.

The benefit in AODV routing is that, it can change in link situation very easily, but when the network size increases at the communication may suffer the high delays during route manipulation and require more bandwidth.

The processes of AODV routing protocol can be better understood by consider one Ad-hoc network shown in figure 2-4. This network is composed of ten nodes, where source node wishes to send the data to destination node. Firstly source node check whether the route to the destination is present in routing cache or not. If the path to the destination is available in route cache, source node will directly forward packet of information through that path [13].

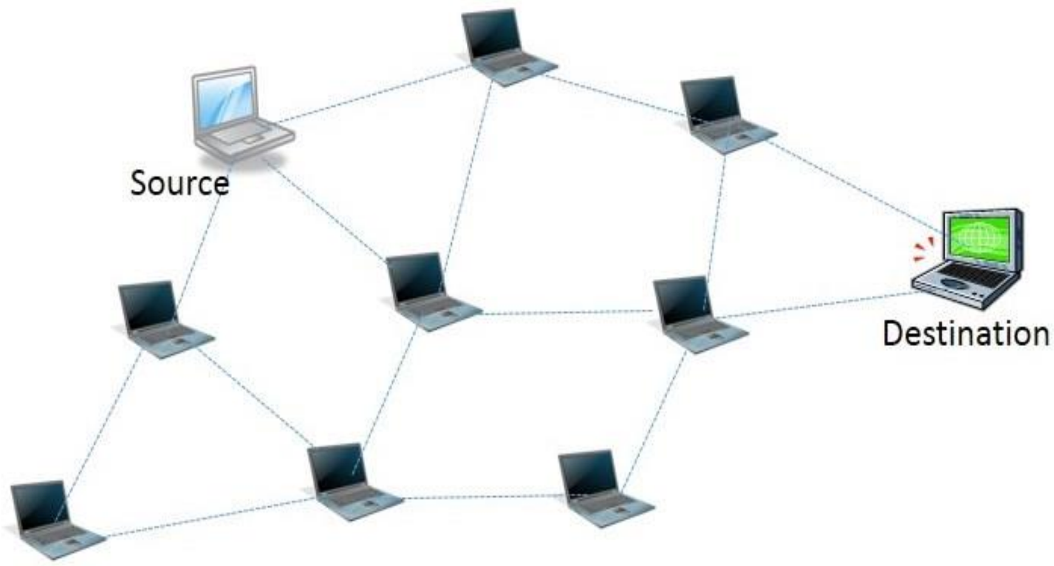

FIGURE 2-4: AODV SOURCE DESTINATION NETWORK

Figure 2-5 shows that if source node after checking in routing cache found that route to the destination are not there, and then source node broadcast RREQ in the network shown by red arrow in the network.

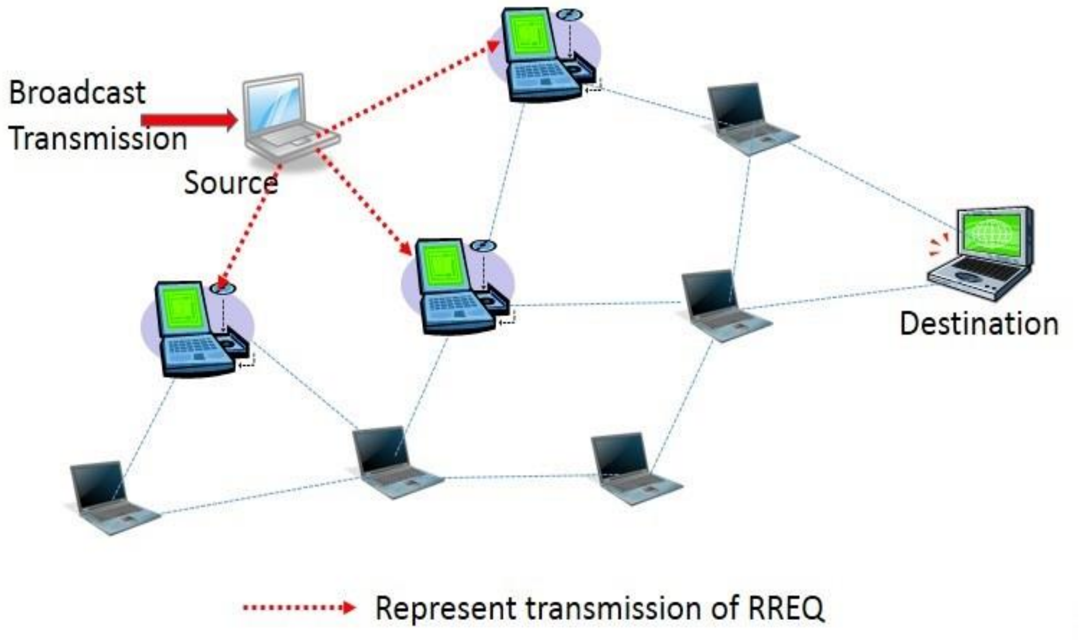

FIGURE 2-5: AODV RREQ BROADCAST

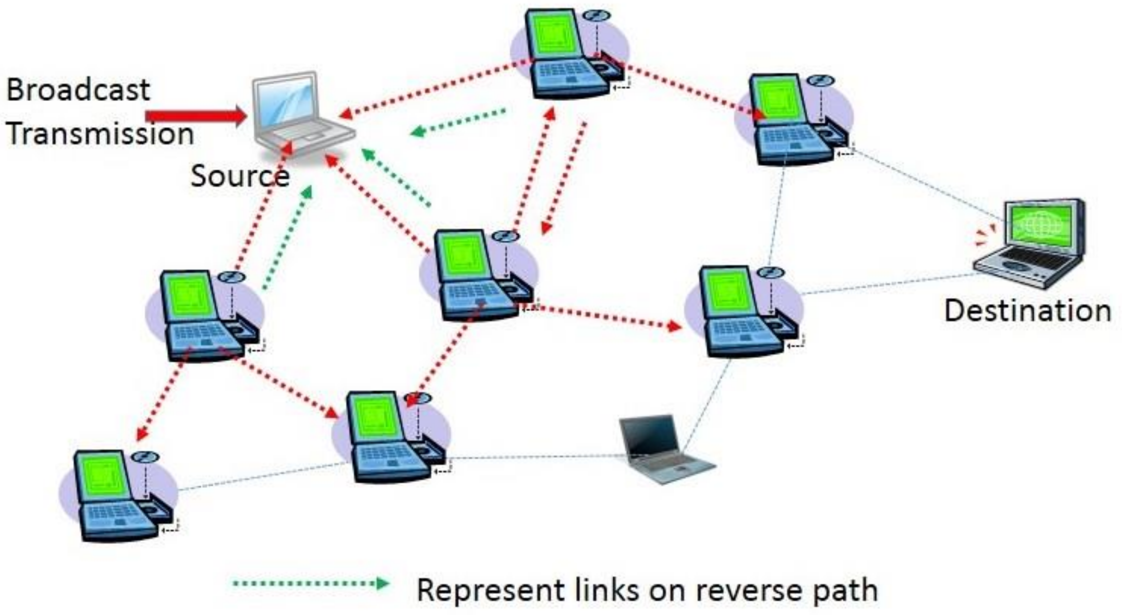

FIGURE 2-6: AODV RREQ MESSAGE PROCESSING

RREQ message contains the IP address of source and intended node with the current sequence number of source and last known sequence number of destination. In figure 2-6, it is shown that whenever any in between node receive the route request, it first check whether that request came earlier or not. If the same request came before, intermediate node will discard that request. Each node setup a reverse link and route entry in routing table. The process of forwarding RREQ is continued until it reaches the intended node for packet sent by source node that process is shown in figure 2-7.

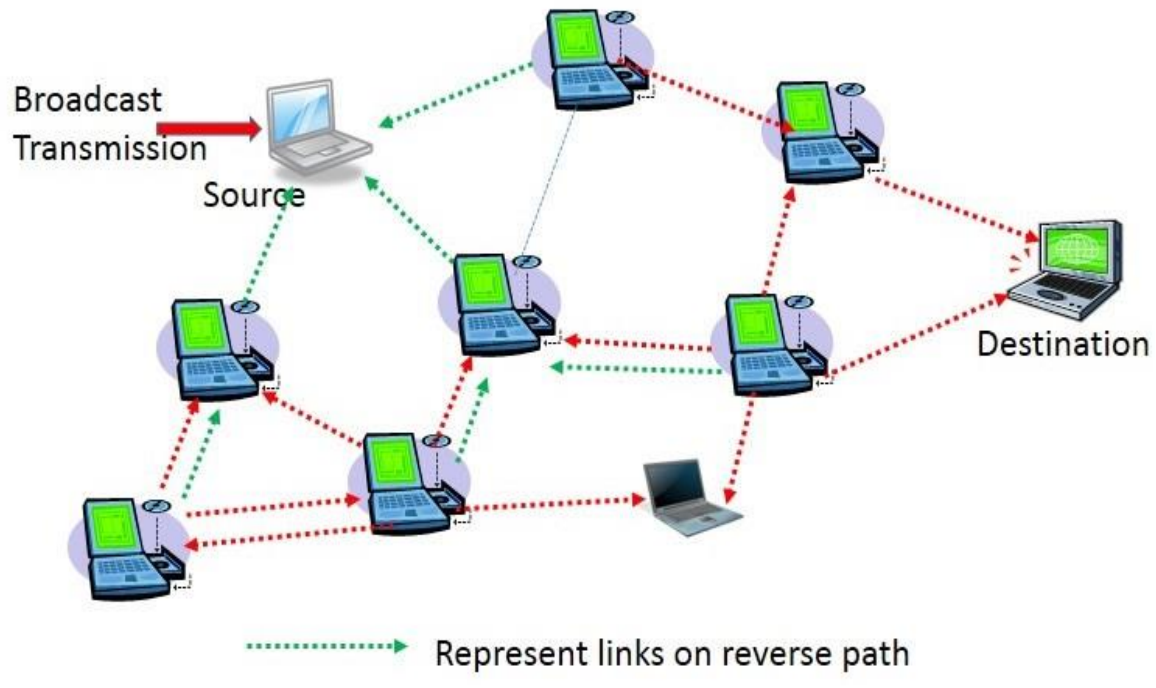

FIGURE 2-7: AODV REVERSE PATH SETUP

Figure 2-8 shows that destination node will not forward the RREQ message further in the network because the destination node is the intended target for the original packet of information being sent by source node. Each node forms a reverse path to source from it, and update in routing protocol.

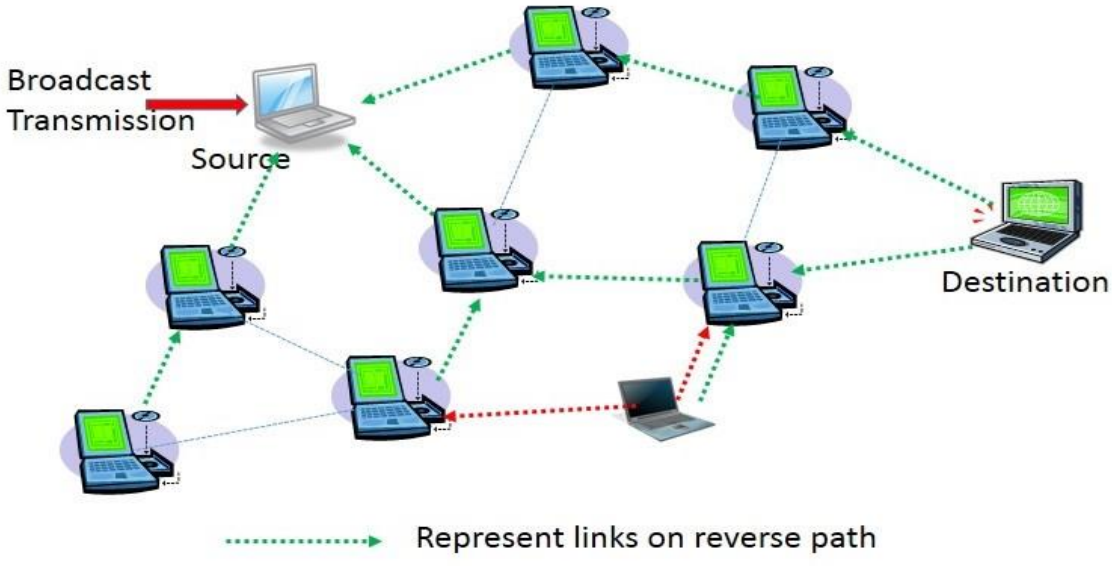

FIGURE 2-8: AODV REVERSE PATH SETUP UP TO DESTINATION

Figure 2-9 shows that forward links are setup when RREP message is reached up to source (shown in figure by yellow dotted line) traveling along the forward path. Now source can send packet of information through this forward link.

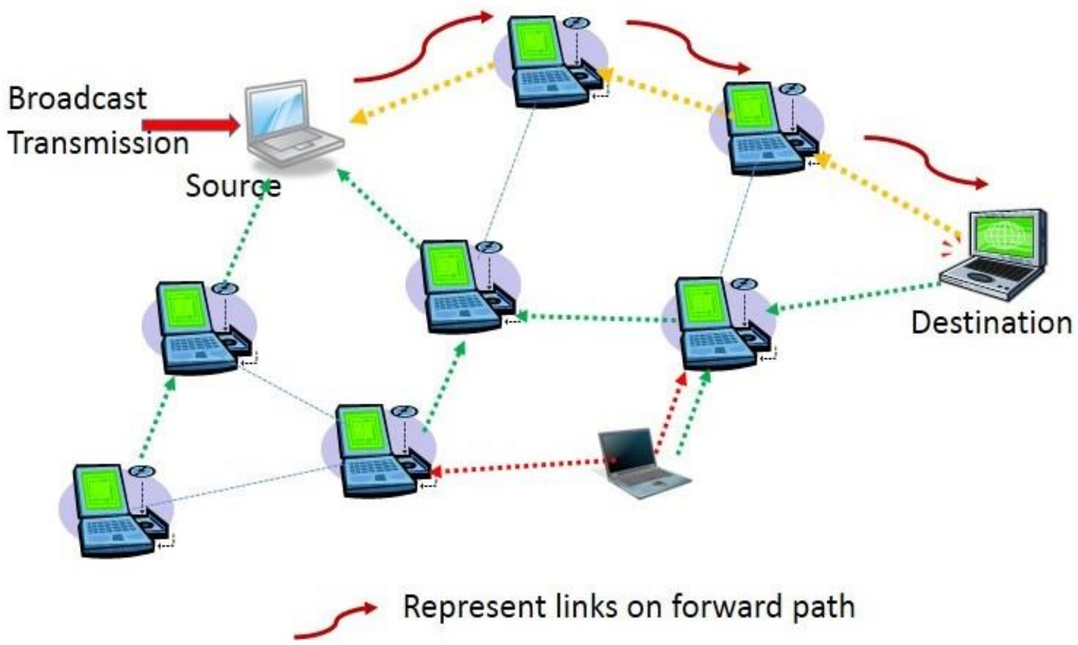

FIGURE 2-9: AODV FORWARD PATH SETUP

2.2.3 Destination Sequenced Distance Vector (DSDV)

It is a distance vector routing protocol, which indicates that in this routing protocol, each mobile node maintains a routing table by continuously broadcast routing update to their immediate neighbours. The routing table update is sending by two styles first by sending the complete routing table to their neighbours, but it will occupy many packets and the second style of sending the routing table update is by sending only those entries that have a change from initial routing table, and it will occupy less packets if some space is left in the packet then change in the sequence number is also included [5]. Generally second method of updating the routing table is used in case where network is stable and first method is used where speed of the node is very high. Routing table is updated by sending the route update packet with routing table information along with unique sequence number assigned by the sender. The route having the highest sequence number is preferred but in the situation of two or more routes containing the same sequence number then route with shortest path is chosen based on past memory [14]. Routing table contains paths of all available destinations and number of hop requires reaching the intended node with the sequence number appointed by destination node. The sequence number averts the formation of loops by differentiating stale routes from new ones.

Rule used by DSDV routing protocol can be understand by considering an ad-hoc network having eight mobile nodes shown in figure 2-10. Here source node (S) wishes to send the packet of information to destination node (D). Initially, source node (S) checks the route information about the destination in routing table, which is already updated with next hop node from source to destination like here for destination (D), next hop is the node (A). Then the source node (S) will forward message to node (A).

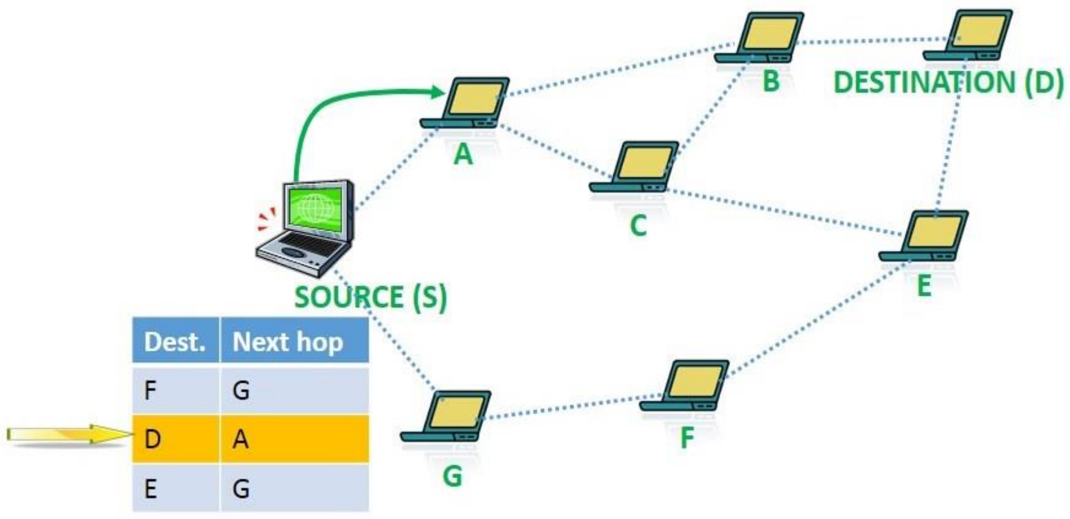

FIGURE 2-10: DSDV SOURCE DESTINATION NETWORK

Figure 2-11 shows that source node (S) checks the route information about the destination in routing table, which is already updated with next hop node from source to destination in intermediate node (A) and here it found that subsequent hop is the node (B) for destination D. Then source node (S) will forward message to node B.

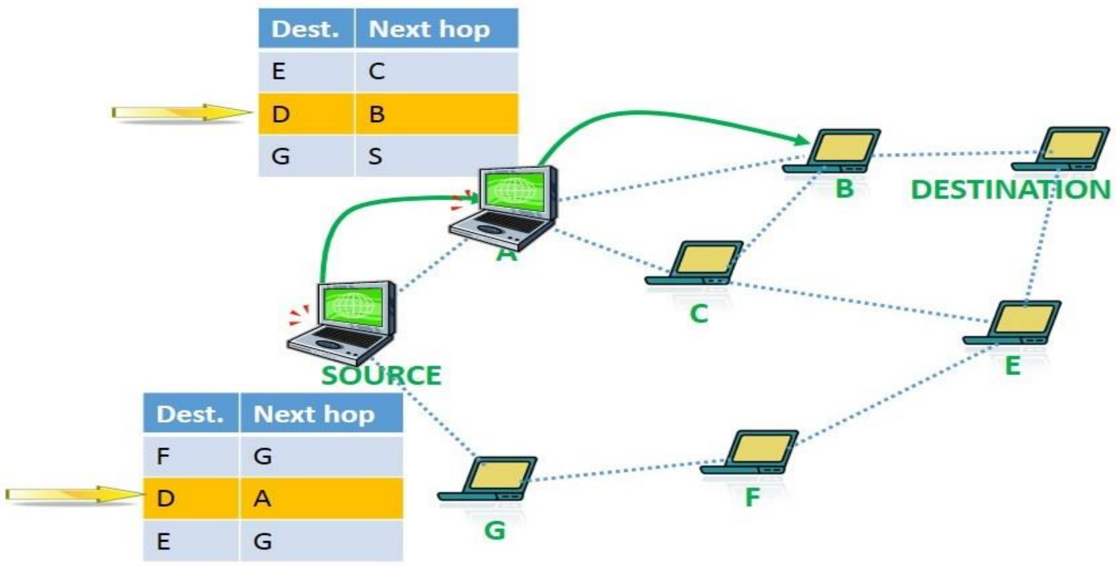

FIGURE 2-11: DSDV FORWARD MSG TO NODE A

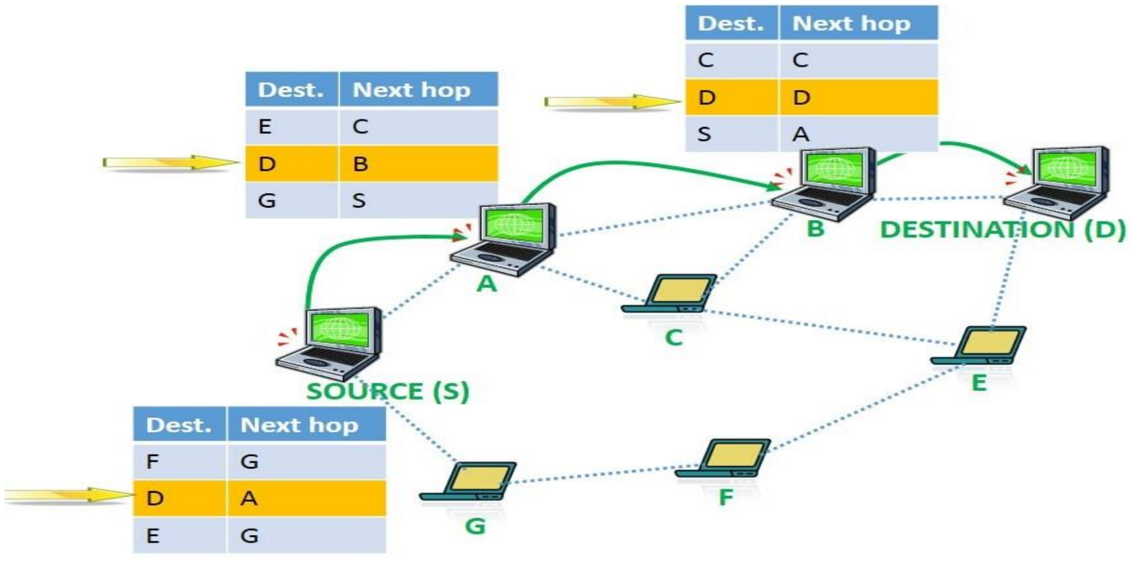

FIGURE 2-12: DSDV FORWARD MSG TO NODE B

Figure 2-12 shows that source node (S) checks the route information about the destination in routing table, which is already updated with next hop node from source to destination in intermediate node (B) and here it found that next hop is node (D) for destination D. Figure 2-13 shows that source node (S) will forward message to node D that is actually an intended node for that message from source node.

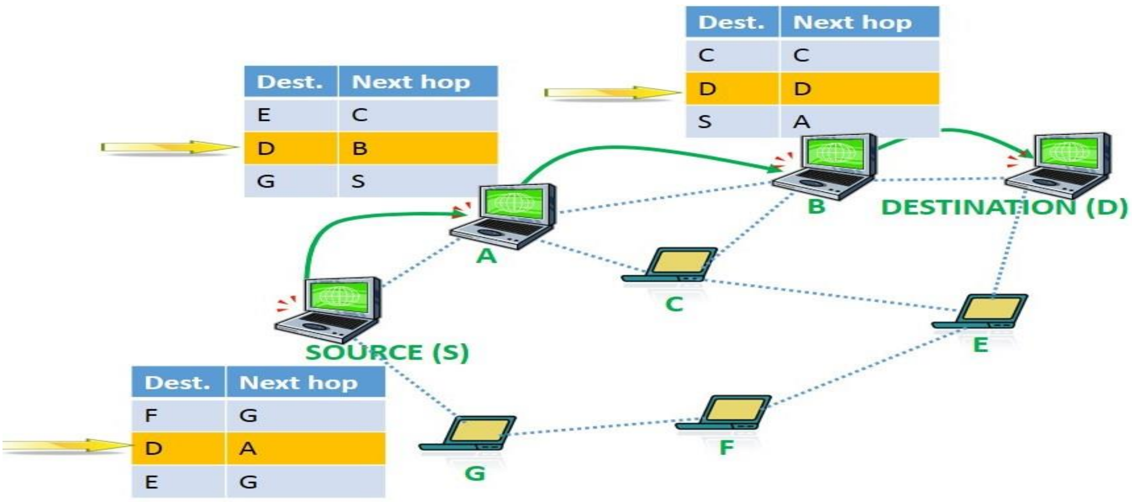

FIGURE 2-13: DSDV MSG REACHES DESTINATON

2.2.4 Ad-Hoc on Demand Multipath Distance Vector (AOMDV)

AOMDV is a derivative of AODV routing protocol. It is a multipath routing protocol because during one route discovery process, it can detect more paths from one node to another. AOMDV routing protocol is preferred in a network where speed of mobile nodes is very high and chance of link failure is more. In case of high dynamic situation, AODV always requires a new route discovery process once the link failure occurs. AODV will not have any other route from source to destination once link failure occurs [3]. A new route discovery process in AODV will add high overhead and latency. To overcome above problem in AODV, a new routing protocol derived from AODV routing protocol named as Ad-hoc on demand Multipath Distance Vector (AOMDV).

AOMDV routing protocol overcome above problem by discover more paths from source to destination so even in a network where mobile nodes are moving with high speed and a chance of link failure is more, AOMDV have another path to send the data from the transmitter to intended node in the network. In AOMDV, route discovery process is only needed when the entire path available in the route cache fails due to link failure.

In AOMDV route request is broadcast from transmitter to destination that establishes multiple reverse path and route reply is sent by the destination is coming through their reverse path and form multiple forward path. AOMDV provides the alternate path with reduced route discovery process [13]. AOMDV discovers multiple paths between one nodes to other in the network by two core issue: Multiple loops free path is calculated at every mobile node and finding of a link disjoint path.

Some rules for route update are modified in order to get multipath for one node to other. These modifications are done under the condition that it will compromise loop freedom. The list of next hop with hop count is listed at every destination. All the next hops have equal sequence number in order keeps the track of the path. AOMDV maintains the advertisement hop count for every node, which is actually a maximum hop count for all the paths, which is used to transmit route advertisement of the intended node. Every copy of route advertisement received at node will be an alternate path to the intended node. Loop freedom is certain for a mobile terminal by accepting alternate path to the intended node if it has a less hop count than advertised hop count.

The procedure of AOMDV loop free path is shown in figure 2-14. Node (S) is the source node and node (D) is destination node, source node has a two path to send the data to destination one with route S-A-B-G-E-D and second path S-G-D. Suppose source node advertises the path S-A-B-G-E-D to node (C) and path S-G-D to node (I). Then both nodes (C) and (I) have a path to destination node (D) through source node (S) with different hop count. In a further process if (S) node found five hop paths from, I (I-H-S-G-D) but at that time, the source node will not know about the node (I) whether it is upstream or downstream to itself because only hop count information is included in advertisement. Here in this network if source node (S) forms a path through (I) it will form a loop. This problem of loop came because the source node advertises shorter path S-G-D even when it has an alternate longer path S-A-B-G-E-D. So to remove this problem, never form a route at a downstream node via upstream node and for that, AOMDV forms some rules:

i) Sequence number rule: Select the route which is having highest sequence number and for each destination, multi path discovered by the node have the same destination sequence number. So when any advertisement received with a higher destination sequence number then all routes having an older destination sequence number are discarded [23].

ii) For the route having same sequence number: AOMDV will not advertise the shorter routes which is already advertised and will not accept a route longer than one already advertise.

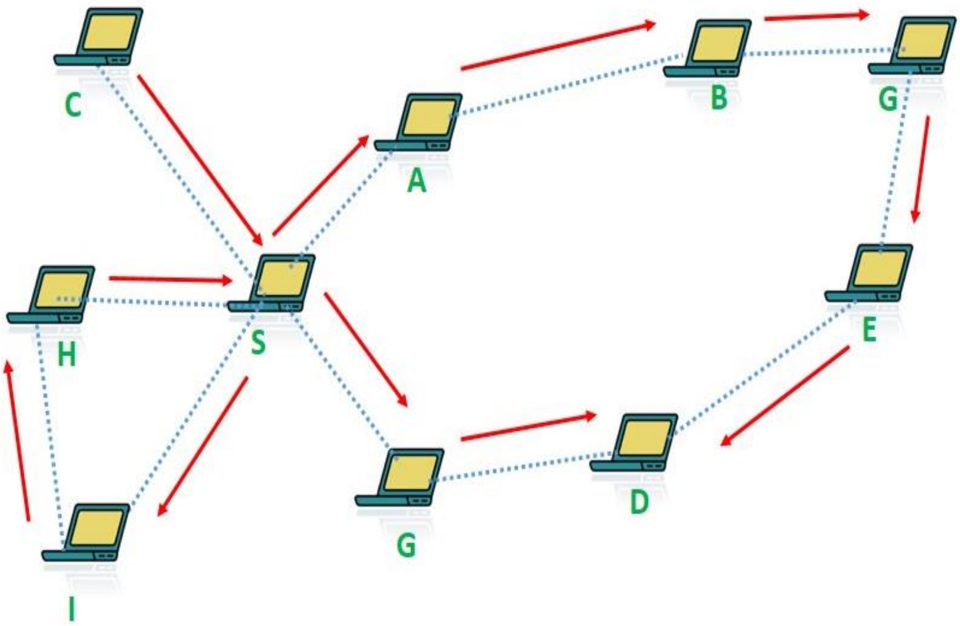

FIGURE 2-14: AOMDV MULTIPLE LOOP

In figure 2-15 any node wishes to send the packet of information to destination node (D). Path S-I-H-C-D, S-A-D and S-G-B-E-D are disjoint path whereas G-S-A-D and I-S-A-D is the joint path.

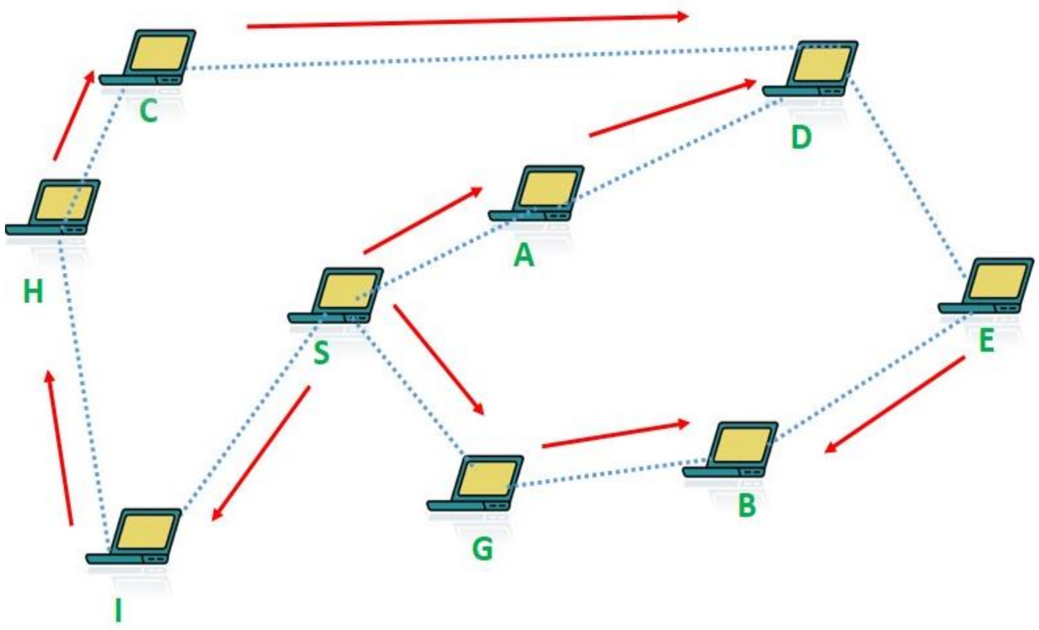

FIGURE 2-15: AOMDV DISJOINT PATH

But multiple paths are not worthy as it increases overhead proportional, so the solution of this problem is finding disjoint paths. Link disjoint path is selected by maintain last hop information in routing cache but after ensuring that next hops and last hops before destinations are same, for that route request message has to carry first hop information.

The chapter gives the details study of different routing protocols for mobile ad-hoc network. The DSDV routing protocol best performs with increasing number of nodes, but its performance degrades under the network having higher speed nodes. The AOMDV routing protocol is a derivative of AODV routing protocol and discover multipath from source to destination in one route discovery process so AOMDV routing protocol performs better in case of highly dynamic network. Whereas the DSR routing protocol have higher control overhead as compared to AODV routing protocol.

3

NS2: INTRODUCTION AND SIMULATION SETUP

3.1 Introduction to NS2

Network simulator (version 2) is usually known as NS2, it is a powerful simulator for studying dynamic nature of mobile wireless sensor network. NS2 supports simulation of a network from physical radio transmission channel to the application layer [2]. The NS2.35 simulator is used for simulation and was conducted under the Linux mint platform. In this thesis investigation of different routing like AODV, DSR, DSDV, and AOMDV protocols to have been performed based on different parameters with increasing speed and number of nodes on the network.

3.2 Traffic Connection in NS2

For the simulation, random data traffic connection Constant Bit Rate (CBR) and TCP have been provided in the network.

3.2.1 CBR traffic (constant bit rate)

CBR traffic indicates that the data are sent at constant rate and CBR data stream implies that the data is sending in a packet of fixed size with uniform interval [10].

3.2.2 TCP traffic

It is a connection based, and conforming transport protocol. In this type, data is only transmitting when establishment stage is over. TCP is having flow control and congestion control.

- Flow control works to avoid overloading at the intended node
- Congestion control is works to shape the traffic according to available network capacity.

The sender of TCP data is maintaining two windows for each intended node: a receive window represents the accessible capacity of the network and Congestion window defines the bounds of the receiver ability [9]. When the sender transmits a packet of information, the windows are reduced by an amount same as the size of information sent, when any of window reaches completely filled state.

3.3 NS2 Languages

NS2 is working on two key languages that are C++ and Object oriented Tool Command (OTCL). Now question is "**why NS2 uses two languages"** because both the languages have the own benefits like, OTCL runs slowly but easy to code whereas coding of C++ is difficult but execution is fast. NS2 utilizes benefits of both the languages so that anyone can vary the parameter and configure network very easily.

The internal program is written in C++ whereas OTCL is used for assembling and configuring the object and scheduling discrete events. The C++ and OTCL are combined by using TclCL after simulation and for getting the result graphically; Network Animator (NAM) and Trace file analyser is used. NAM (Network Animator) is an animation tool for NS2 used to visualize the network and packet of information tracing and Trace file (.tr) contains the overall network simulation information.

3.4 Steps For Getting Trace And NAM Files

In NS2, the steps for getting trace and NAM files after the simulation are as follows:

i) Writing of the program in Object Oriented Tool Command Language (OTCL) language. OTCL is used to write the program for generate a network, network environment, and trajectory of mobile nodes.
ii) Run the **.tcl** file on the terminal under the Linux mint platform.
iii) NS2 trace analyser is use to analyses trace file obtained during simulation and according to trace file generate the respective graphs.

Performance evaluation of different routing protocol is done on Network Simulator (NS2) which is installed on Oracle VM virtual box under the Linux mint platform. NS2 is a free simulator which provides the facility to set up network topology, configure and optimize the parameter according to the need of the application [9].

3.5 Network Simulator Setup For Simulation under IEEE 802.11

Comparative performance analysis of different routing protocol is done by considering different scenario. The parameter which is common to every case is shown in table 3-1.

TABLE 3-1: SIMULATION PARAMETER UNDER IEEE 802.11

PARAMETER	VALUE
Radio propagation model	Propagation/ Two ray ground
Network interface type	Physical/ wireless
MAC type	MAC/802.11
Interface Queue type	Queue/Drop Tail/ Pri Queue
Link layer type	CSMA/CA
Simulation time	60 sec
Area of the network	100*100
Traffic Type	CBR

3.6 Case Study

Analysis of routing protocol is done by considering the different case with increasing speed and number of node in the network. All cases with their parameters are as follows:

3.6.1 First Case With 10 Node Model Under 802.11

Network topology is set up with ten nodes connected through the wireless channel under IEEE 802.11 MAC layer. In this case consider all mobile nodes are moving in the 100*100 meter square area in two ray ground propagation forming Ad-hoc network shown in figure 3-1. Network consists of three sources and three destinations, which are given in table 3-2 and a TCP connection is setup between source to destination, and the size of the packet generated by TCP agent 1024 bit. CBR is set to generate 1024 bits. The exchange of packets takes place between these nodes until they are in coverage rage of each other, otherwise packets start getting drop.

TABLE 3-2: SOURCE AND DESTINATION IN TEN NODE NETWORK

SOURCE NODE	DESTINATION NODE
Node (2)	Node (3)
Node (5)	Node (4)
Node (9)	Node (6)

Energy model is also employed in the network by providing transmitter Power and receiver power to the router. Transmitter power specifies the strength of the signal that router is produce during the transmitting time similarly receiver power is the strength of the signal that router is produce during the receiving time. Receiver Power and Transmitter power of this particular network is 0.4 and 0.8 watt respectively. The trajectory of mobile nodes is defined arbitrary in the network. The speed of all ten mobile nodes is varied from 10 to 50m/sec. and analysis of this network is performed for 60 seconds based on different routing protocol like AODV, DSR, DSDV, and AOMDV routing protocols.

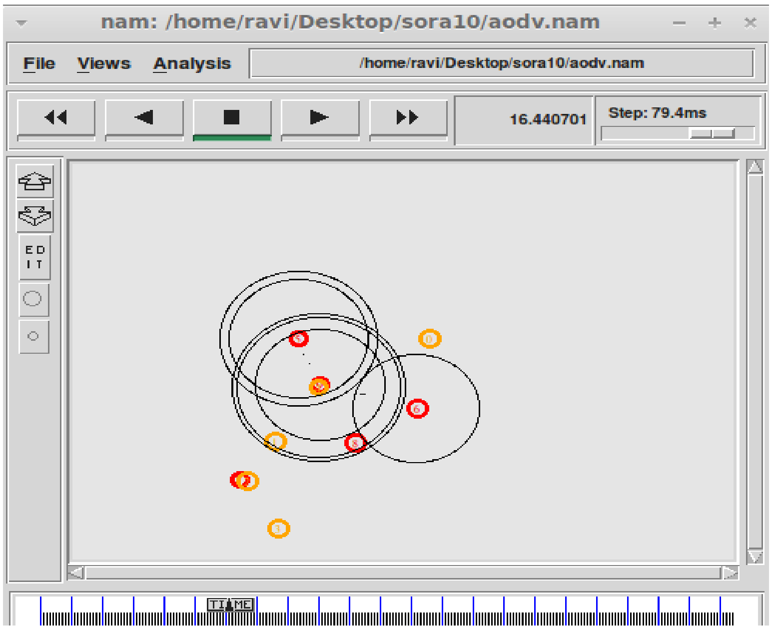

FIGURE3-1: TEN NODE MODEL IN NS2

3.6.2 Second Case With 20 Node Model Under 802.11

Network topology is set up with twenty nodes connected through wireless media under IEEE standard 802.11 MAC layer. In this case, it is assumed that all mobile nodes are moving in the 100*100 meter square area in two ray ground propagation forming Ad-hoc network shown in figure 3-2. Network consists of three sources and three destinations, which are given in table 3-3 and a TCP connection is setup between source to destination, and the size of the packet generated by TCP agent 1024 bit. CBR is set to generate 1024 bits.

TABLE 3-3: SOURCE AND DESTINATION IN TWENTY NODE NETWORK

SOURCE NODE	DESTINATION NODE
Node (12)	Node (3)
Node (15)	Node (4)
Node (4)	Node (16)

Energy model is applied in this network with initial energy, receiver power and transmitter power equal to 100 joule, 0.4watt and 0.8 watt respectively. Mobile node trajectory is defined arbitrary in the network. The speed of all mobile nodes is varied from 10 to 50 m/Sec and analysis of this network is performed for 60 seconds on the basis of different routing protocol like AODV, DSR, DSDV, and AOMDV routing protocols.

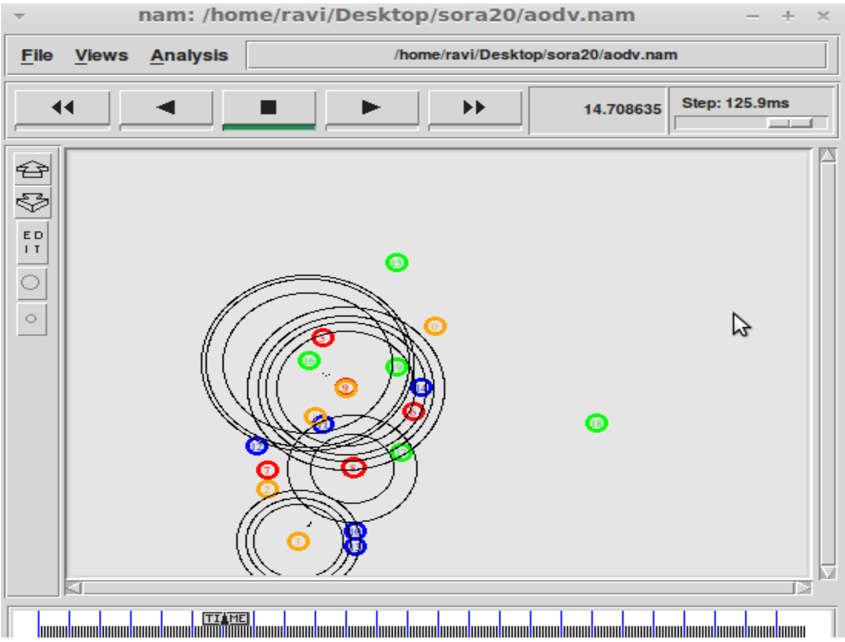

FIGURE 3-2: TWENTY NODE MODEL IN NS2

3.6.3 Third Case With 30 Node Model Under 802.11

Wireless media is used to connect thirty nodes of the Ad-hoc network, where all nodes can work in duplex mode under IEEE 802.11 MAC layer standard. In this case, it is assumed that all mobile nodes are moving in the 100*100 meter square area in two ray ground propagation forming Ad-hoc network shown in figure 3-3. Network consists of four sources and four destinations, which are given in table 3-4 and a TCP connection is set up between source to destination, and the size of the packet generated by TCP agent 1024 bit. CBR is set to generate 1024 bits.

TABLE 3-4: SOURCE AND DESTINATION IN THIRTY NODE NETWORK

SOURCE NODE	DESTINATION NODE
12	3
25	4
24	16
3	8

Energy model is applied in this network with initial energy, receiver power and transmitter power equal to 100 joule, 0.4watt and 0.8 watt respectively. Mobile node trajectory is defined arbitrary in the network. The speed of all nodes is varied from 10 to 50m/Sec. and analysis of this network is performed for 60 seconds on the basis of different routing protocol like AODV, DSR, DSDV, and AOMDV routing protocols.

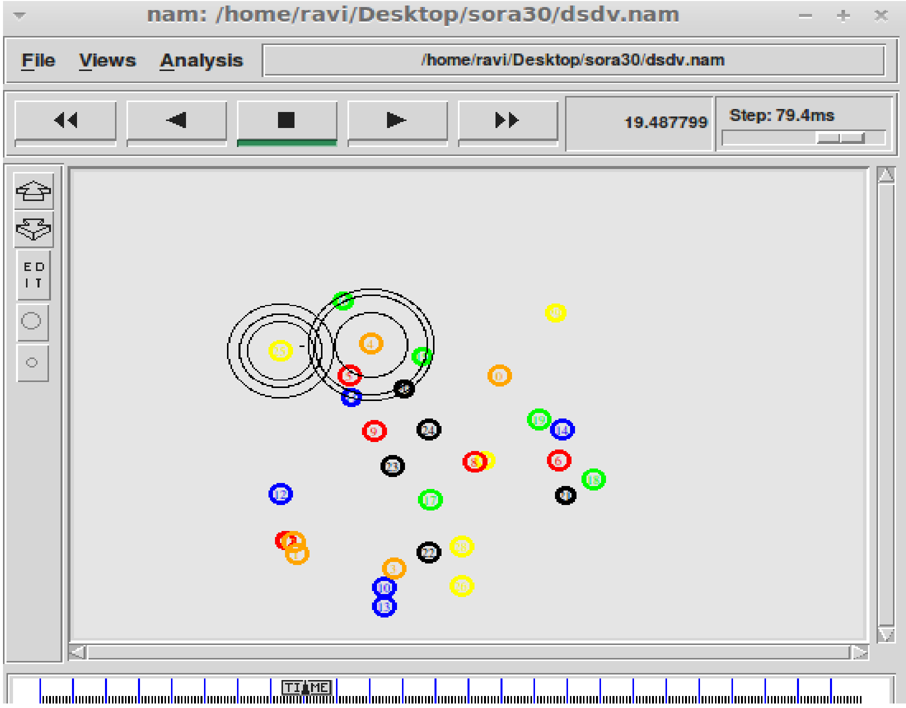

FIGURE 3-3: THIRTY NODE MODEL IN NS2

3.6.4 Fourth Case With 40 Node Model Under 802.11

Wireless channel is used to connect forty nodes of the Ad-hoc network, where all mobile nodes are work under IEEE 802.11 Mac layer. In this case, it is assumed that all nodes are moving in the 100*100 meter square area in two ray ground propagation forming Ad-hoc network shown in figure 3-4. Network consists of four sources and four destinations, which are given in table 3-5 and a TCP connection is set up between source to destination, and the size of the packet generated by TCP agent 1024 bit. CBR is set to generate 1024 bits. The exchange of packets takes place between these nodes until they are in coverage range of each other, otherwise packets start getting drop.

TABLE 3-5: SOURCE AND DESTINATION IN FORTY NODE NETWORK

SOURCE NODE	DESTINATION NODE
32	3
25	14
34	16
39	38

Energy model is applied in this network with initial energy, receiver power and Transmitter power equal to 100 joule, 0.4watt and 0.8 watt respectively. The trajectory of nodes is defined arbitrary in the network. The speed of all mobile nodes is varied from 10 to 50m/sec. and analysis of this network is performed for 60 seconds based on different routing protocol like AODV, DSR, DSDV, and AOMDV routing protocols.

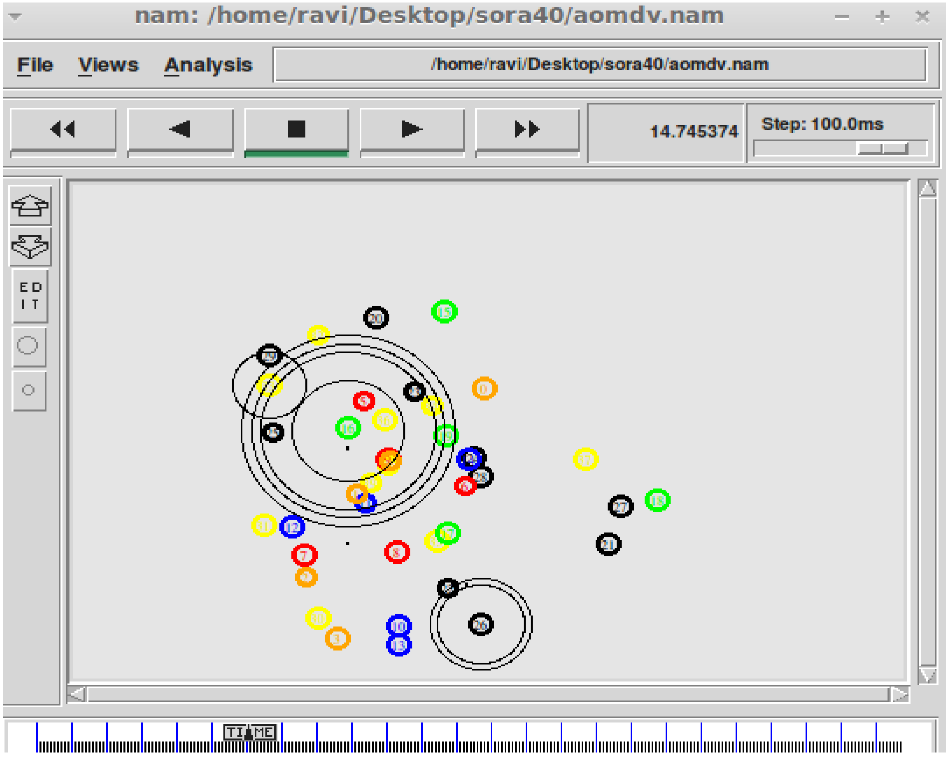

FIGURE 3-4: FORTY NODE MODEL IN NS2

3.6.5 Fifth Case With 50 Node Model Under 802.11

Wireless channel is used to connect fifty nodes of the Ad-hoc network, where all mobile nodes are under IEEE 802.11 MAC layer standard. In this case, it is assumed that all mobile nodes are moving in the 100*100 meter square area in two ray ground propagation forming Ad-hoc network shown in figure 3-5. Network consists of four sources and four destinations, which are given in table 3-6 and a TCP connection is set up between source to destination, and the size of the packet generated by TCP agent 1024 bit. CBR is set to generate 1024 bits. The exchange of packets takes place between these nodes until they are in coverage range of each other, otherwise packets start getting drop.

TABLE 3-6: SOURCE AND DESTINATION IN FIFTY NODE NETWORK

SOURCE NODE	DESTINATION NODE
42	3
25	14
34	16
49	48

Energy model is applied in this network with initial energy, receiver power and Transmitter power equal to 100 joule, 0.4watt and 0.8 watt respectively. The node trajectory is defined arbitrary in the network. The speed of all mobile nodes is varied from 10 to 50m/Sec. and analysis of this network is performed for 60 seconds.

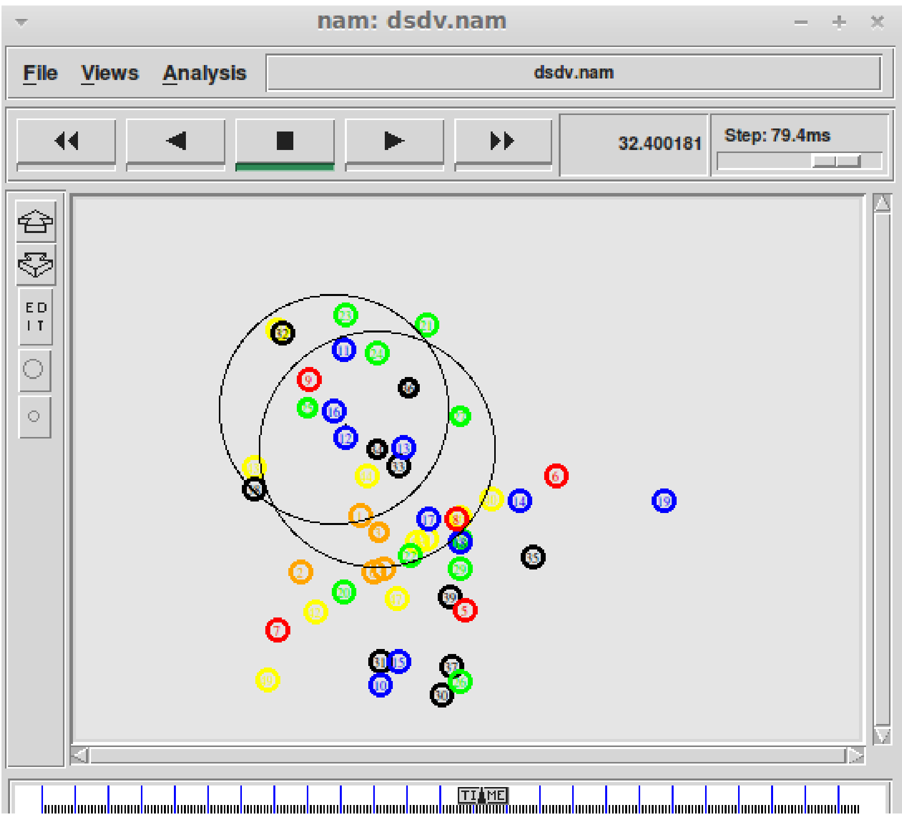

FIGURE 3-5: FIFTY NODE MODEL IN NS2

3.7 Network Simulator Setup For Simulation under IEEE 802.15.4

Comparative performance analysis of different routing protocol is done by considering the different scenario. Network topology is set up with twenty five nodes connected through the wireless channel under IEEE 802.15.4 MAC layer. In this case consider all mobile nodes are moving in the 30*30 meter square area with maximum speed of 2m/sec. in two ray ground propagation forming Ad-hoc network. WPAN network is shown in the figure 3-6 at time instant 0.147 seconds, where node nine is transmitting the data packet to node five indicated by red colour. Network consists of three sources and three destinations, which are given in table 3-7 and a TCP connection is set up between source to destination, and the size of the packet generated by TCP agent 60 bits. The exchange of packets takes place between these nodes within 10 meters of range, otherwise packets start getting drop.

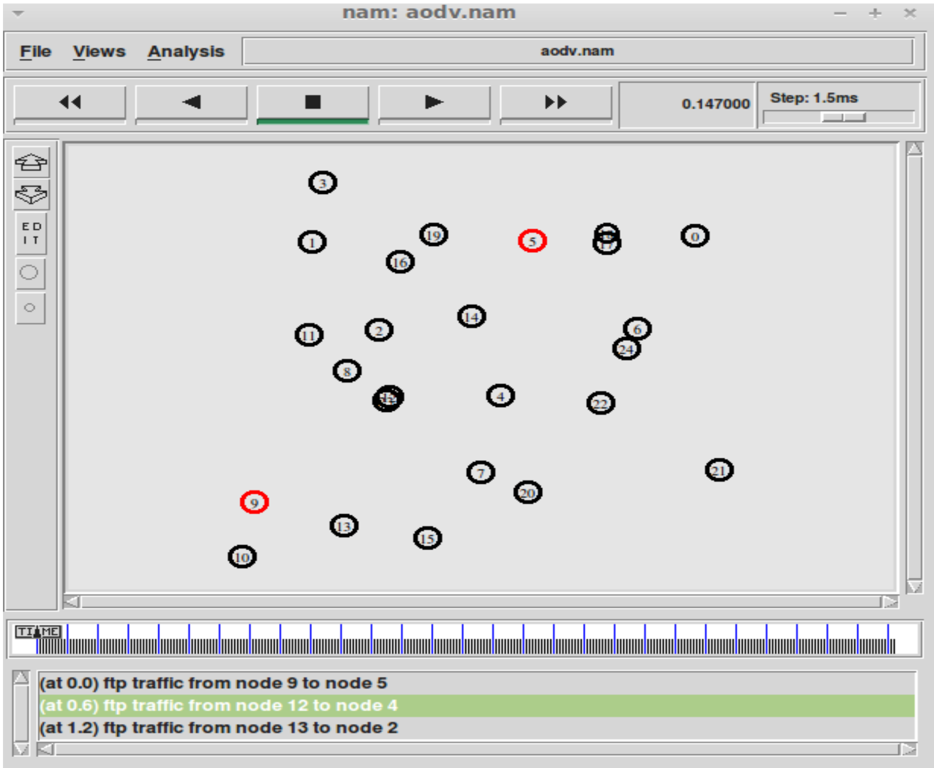

FIGURE 3-6: TWENTY FIVE NODE MODEL IN NS2 AT 0.147 SEC. OF TIME INSTANT

TABLE 3-7: SOURCE AND DESTINATION IN TWENTY FIVE NODE NETWORK

SOURCE NODE	DESTINATION NODE	APPLICATION TIME
9	5	0.0
12	4	0.6
13	2	1.2

Energy model is also employed in the network by providing transmitter power and receiver power to the router. Transmitter power specifies the strength of the signal that router is produce during the transmitting time similarly receiver power is the strength of the signal that router is produce during the receiving time. Receiver power and Transmitter power of this particular network is 0.3 and 0.3 watt respectively. Mobile node trajectory is defined arbitrary in the network. Analysis of this network is performed for 100 seconds based different routing protocol like AODV DSDV, and AOMDV routing protocols.

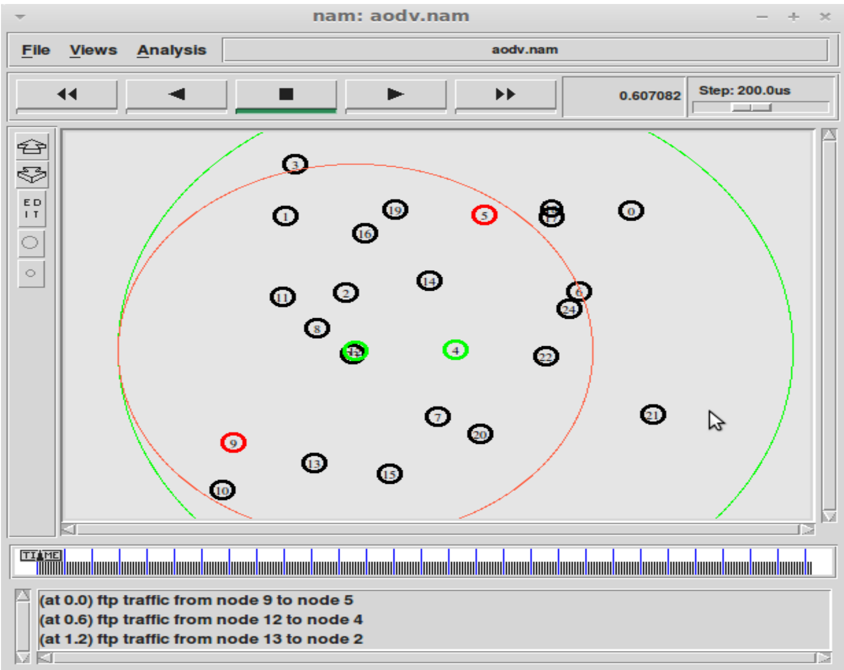

FIGURE 3-7: TWENTY FIVE NODE MODEL IN NS2 AT 0.607 SEC. OF TIME INSTANT

Figure 3-7 shows the (Wireless Personal Area) WPAN network at time instant 0.607 seconds, where node nine is transmitting the data packets to node five indicated by red colour along with node twelve is transmitting the data packets to node four indicated by green colour. WPAN is specified for low data rate, and it comes under IEEE 802.15.4 standard. This network is designed for very low cost communication by nearer node. Figure 3-8 shows WPAN network at time instant 1.2 seconds.

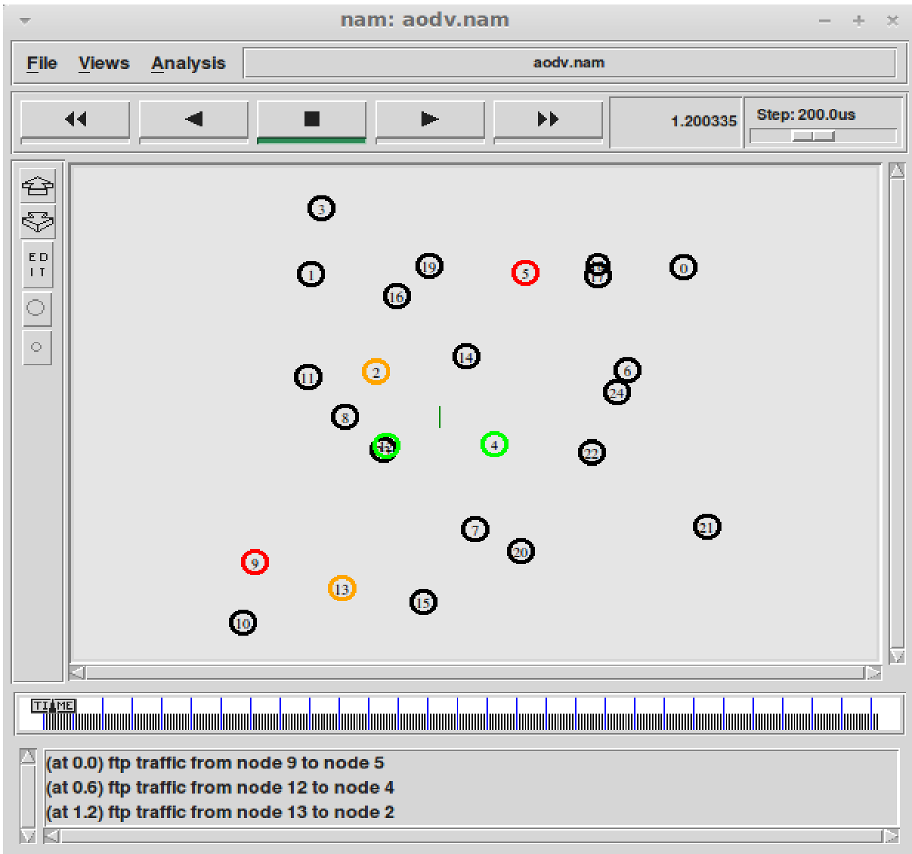

FIGURE 3-8: TWENTY FIVE NODE MODEL IN NS2 AT 1.20 SEC. OF TIME INSTANT

4

RESULTS OF ROUTING PROTOCOL UNDER 802.11 AND 802.15.4 SIMULATION IN NS2

4.1. Performance Parameter For Routing Protocols

Comparative Analysis of Routing Protocol has been performed under IEEE 802.11 and IEEE 802.15.4 MAC layer based on the end to end delay, Packet delivery ratio, and throughput. Brief description of the performance parameters is given below:

4.1.1 End to end delay ($\mathbf{T_d}$) :

This performance parameter represents an average delay and indicate the time taken by data bits to travel from source to intended node [14]. It include all delay caused by transmission at MAC, queuing at interface queue, processing and propagation delay. End to end delay is shown by equation (1).

T_{ee} = Processing Delay (T_p) + Queuing Delay (T_q)+ Transmission delay (T_t) + Propagation delay (T_{pr})…………………………………………..………………(1)

4.1.2 Throughput:

It represents the average rate of data packet received at the intended node. It is also defined as the total data packet reached at the intended node to the total time require by the bits of a data to reach the destination [13]. Higher value of throughput means routing protocol is performing better, and throughput is given by (2).

$$\boldsymbol{Throughput = \frac{N \times P_s \times 8}{T_s}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \ (\mathbf{2})$$

Where,

$\boldsymbol{N}$ = Number of delivered packets

$\boldsymbol{P_s}$ = Packet size

$\boldsymbol{T_s}$= Total duration of simulation

4.1.3 Packet Delivery Ratio (PDR)

It represents packet Delivery ratio in percentage and indicates the ratio of packet of data received at intended node to the packet generated by the source [5].

$$\boldsymbol{PDR = \frac{\text{Number of packet received}}{Number\ of\ packet\ send} \times 100} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ldots\ldots..(\boldsymbol{3})$$

The protocol will perform better, when the value of PDR is more.

4.2. Simulation Results And Discussion On Routing Protocols Under IEEE 802.11 Mac Layer

NS2 is chosen as the simulation software for this study. AODV, DSR, DSDV, and AOMDV routing protocols are simulated under IEEE 802.11 MAC layer for different cases. Distinct cases with their discussion are given below:

4.2.1 End To End Delay With Increasing Number Of Nodes In The Network

Figure 4-1 shows that AODV has a less delay as compare to AOMDV because whenever any link to intended node breaks, AOMDV tries to find any alternative path to the destination that results in extra delay in the total time require to reach the destination whereas AODV will not search for alternate path and packet drop, and it has to reinitiate route discovery process.

DSDV routing protocol outperform DSR, AODV, AOMDV in terms of the delay with increasing number of node scenario because in case of DSDV, updated route to the intended noded is always available whenever any node wishes to send the data to any other node.

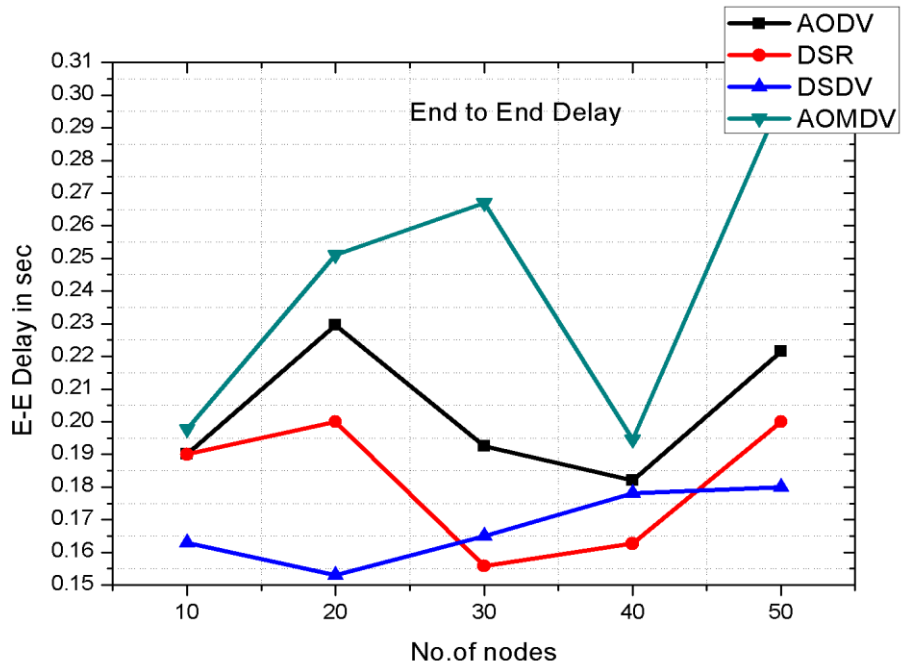

FIGURE 4-1: END TO END DELAY WITH INCREASING NUMBER OF NODES

4.2.2 End To End Delay With Increasing Speed Of The Node In The Network

Figure 4-2 shows that AODV as a less delay as compare to AOMDV in increasing speed of the node situation because whenever any link to intended node breaks, AOMDV tries to find any alternative path to the destination that results in extra delay in the total time require to reach the destination whereas AODV will not search for alternate path and packet drop, and it has to reinitiate route discovery process.

DSR routing protocol outperform DSDV and AMODV in terms of the delay because in case of highly dynamic network, DSDV fails to maintain complete routing table whereas DSR always initiates the route discovery process for one path when any node wishes to send the data to another node of the network.

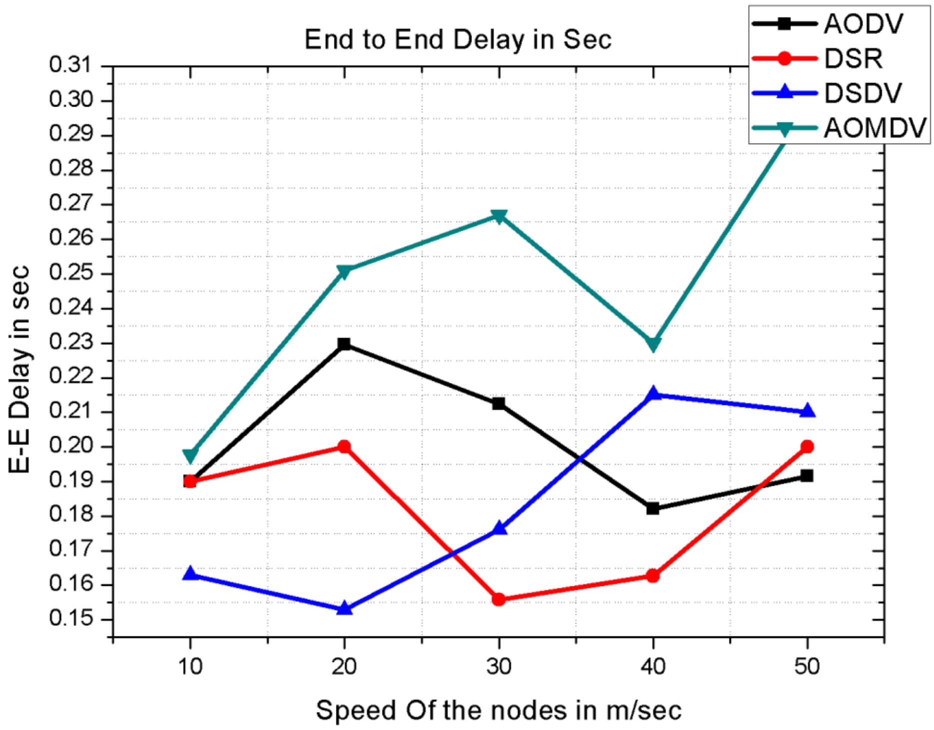

FIGURE 4-2: END TO END DELAY WITH INCREASING SPEED OF NODE

4.2.3 Packet Delivery Ratio (PDR) In Percentage With Increasing Number Of Nodes In The Network

Comparative performance analysis of different routing protocol has been performed with increasing number of mobile nodes where all nodes are moving with a speed of 10 m/sec. The simulation results in Figure 4-3 shows that DSDV routing protocol giving the best PDR because it has been up to date routing table and the speed of the mobile node is 10m/sec.

So the chance of link failure is also less. Whenever any node wishes to send the data to any other node it has to just find the path from source to destination in routing table and send the packet of information through that path. DSR routing protocol shows less PDR than DSDV and AOMDV routing protocol because with increasing number of nodes it increases the control overhead of data packet and increases the chance of dropping. AOMDV routing protocol shows higher PDR than AODV because AODV develop only one path in one route discovery process and if link failure occurs, it will drop that packet, and it has to reinitiate route discovery process for new path.

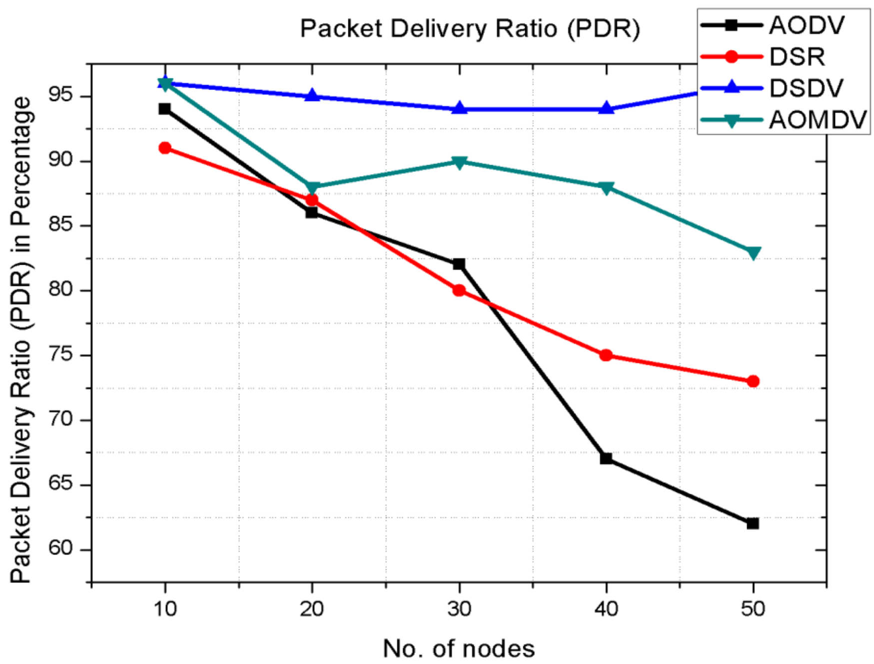

FIGURE 4-3: PDR IN PERCENTAGE WITH INCREASING NUMBER OF NODES

4.2.4 Packet Delivery Ratio (PDR) In Percentage With Increasing Speed Of Node In The Network

In figure 4-4 initially DSDV showing slightly higher PDR percentage than other routing protocol with the increase in speed of nodes because in DSDV is a table driven routing protocol and more reliable for slow speed of nodes but with increase in speed of nodes PDR reduces because the routing table will not rapidly update by broadcast route request message in the network. DSR routing protocol showing least PDR because it is on demand routing protocol and always search for a new path when the source wishes to send the data to its intended node by broadcasting the route request through the route discovery process but due to high speed of mobile nodes, there is always a chance of dropping the data packets. AOMDV showing higher PDR as compare to AODV protocol with increasing speed of node analysis. When speed of node’s increases, which also increase a chance of link failure. AODV develops one route from source to destination in one route discovery process whereas AOMDV develops multiple paths from one node to another in one route discovery process. When link failure occurs due to high dynamic nature of network, AODV routing protocol drop the packet and AOMDV routing protocol select other path in routing cache.

4.2.5 Throughput With Increasing Number Of Nodes In The Network

From figure 4-5 throughput in case of DSDV decreases with increasing number of nodes because DSDV routing protocol is table driven protocol and require more control overhead to maintain the route to every other node. Here AODV routing protocol showing best throughput with increasing number of node because in AODV routing protocol, routing table is established at every node, so there is no need to carry entire route information along with data packet that will decrease the control overhead. In case of DSR routing protocol, data packet has to carry complete route information with data packet. It will increase the control overhead as compare to AODV routing protocol.

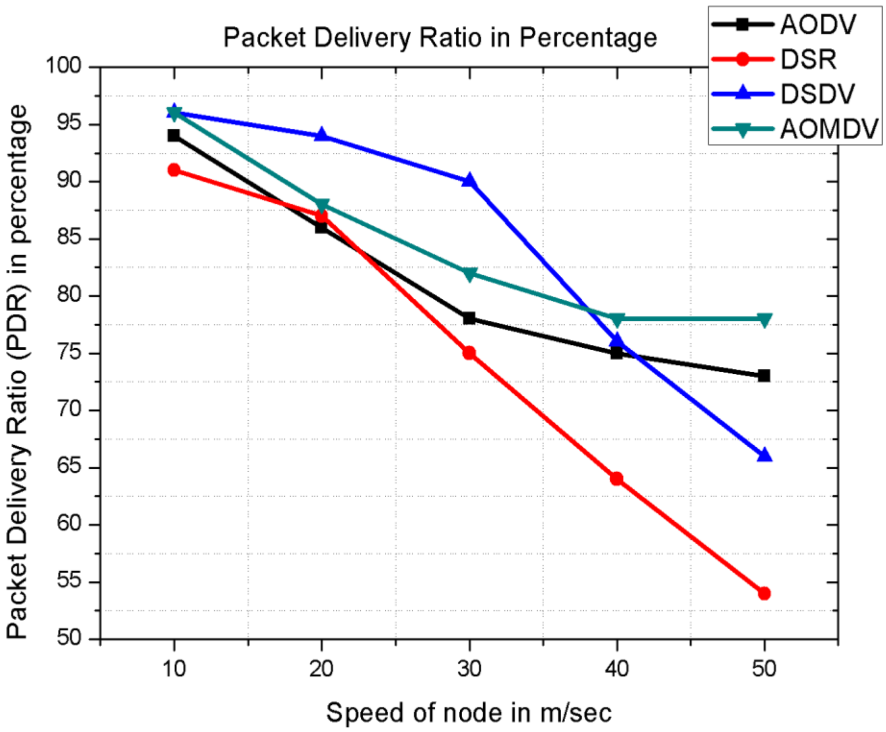

FIGURE 4-4: PDR IN PERCENTAGE WITH INCREASING SPEED OF NODE

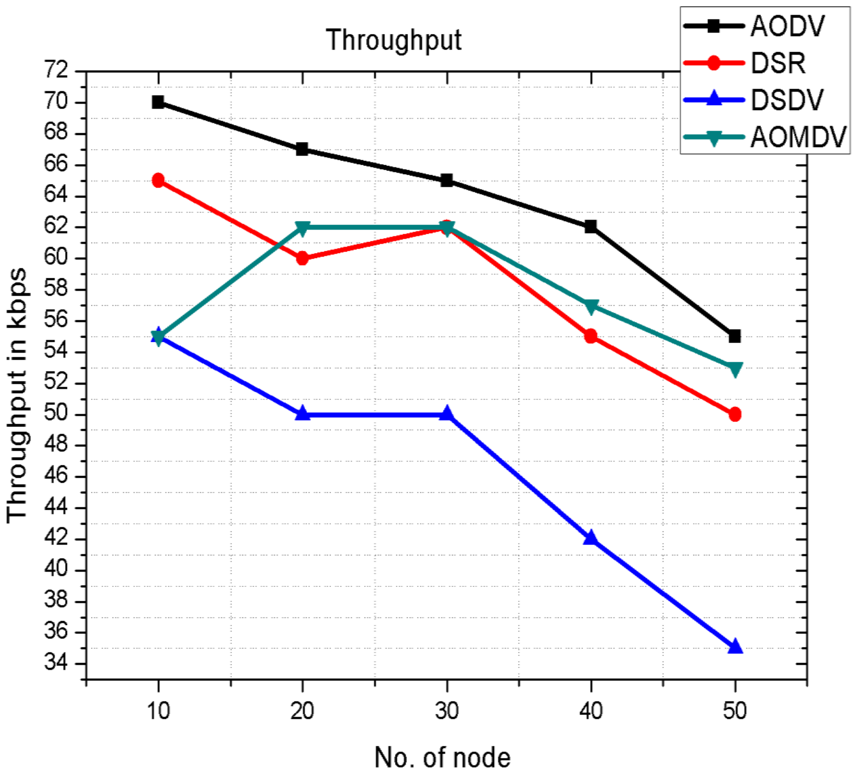

FIGURE 4-5: THROUGHPUT WITH INCREASING NUMBER OF NODES

4.2.6 Throughput With Increasing Speed Of Node In The Network

From figure 4-6 throughput in case of DSDV is least as compare to other routing protocol because the chance of link failure increases with an increase in speed of nodes, the routing table establishment becomes more difficult and it will increase the control overhead. In case of DSR routing protocol throughput decreases with increases in speed of nodes but even than throughput is more than AODV and DSDV routing protocol because in DSR, RREQ has to carry complete route information along with data packet. Throughput in AODV routing protocol is less than AOMDV routing protocol because with the increase in speed of mobile nodes, the chance of link failure is increase. As AODV develops only one path in one route discovery process and if link failure occurs, AODV has to reinitiate route discovery process that will increase the control overhead whereas in AOMDV there is multiple links from one node to other, so it has just select another path.

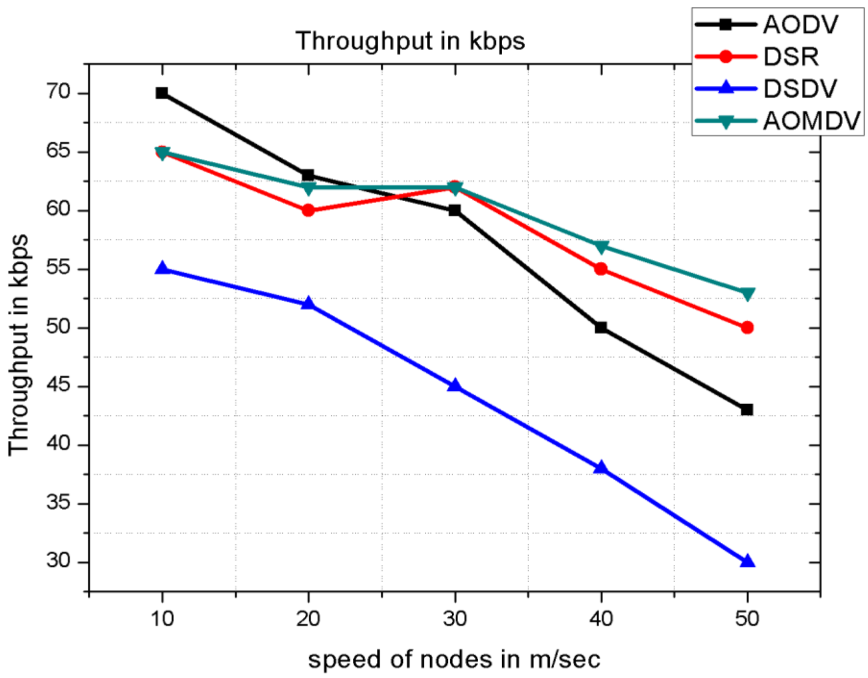

FIGURE 4-6: THROUGHPUT WITH INCREASING SPEED OF NODE

4.3. Simulation Results And Discussion On Routing Protocols Under IEEE 802.15.4 MAC Layer

NS2 is chosen as the simulation software for this study. AODV, DSR, DSDV, and AOMDV routing protocols are simulated under IEEE 802.11 MAC layer for different cases. Distinct cases with their discussion are given below:

4.3.1 End To End Delay With Increasing Number Of Nodes In The Network

Figure 4-7 shows that AODV has a less delay as compare to AOMDV because whenever any link to intended node breaks, AOMDV tries to find any alternative path to the destination that results in extra delay in the total time require to reach the destination whereas AODV will not search for alternate path and packet drop, and it has to reinitiate route discovery process. DSDV routing protocol outperform DSR, AODV, AOMDV in terms of the end-to-end delay with increasing number of node scenario because in case of DSDV, updated route to the destination is always available whenever any node wishes to send the data to any other node.

4.3.2 Packet Delivery Ratio With Increasing Number Of Nodes In The Network

The comparative analysis of different routing protocol has been performed with increasing number of mobile nodes where all nodes are moving with a speed of 2 m/sec. The simulation result shown in Figure 4-8 indicates that DSDV routing protocol showing the best PDR because it has up to date routing table and the speed of the mobile node is 2m/Sec so the chance of link failure is also less.

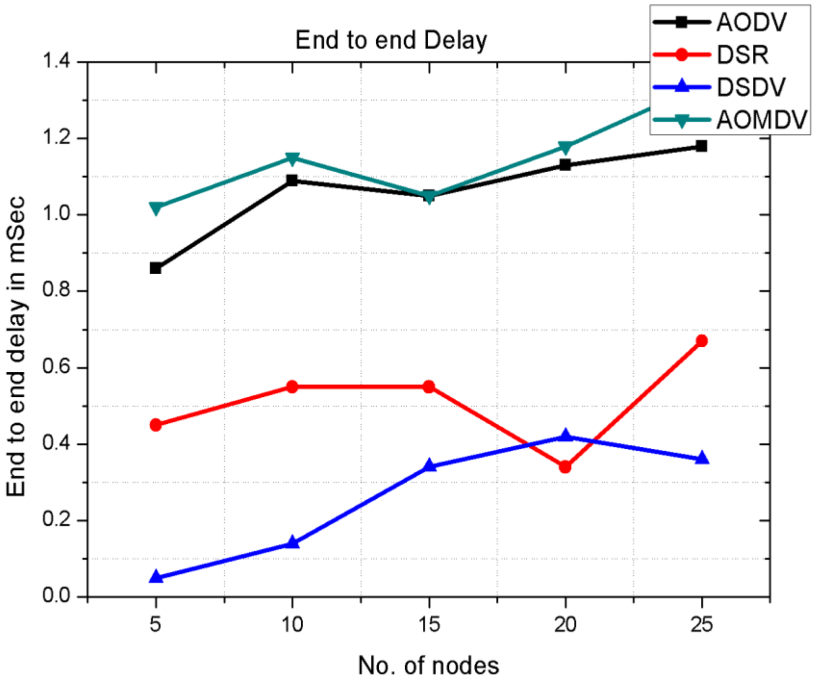

FIGURE 4-7: END TO END DELAY WITH INCREASING NUMBER OF NODES

Whenever any node wishes to send the data to any other node, it has to find the path from source to destination in routing table and send the packet of information through that path. DSR routing protocol shows less PDR than DSDV and AOMDV routing protocol because with increasing number of nodes, it increases the control overhead of data packet and creates the chance of dropping. AOMDV routing protocol shows higher PDR than AODV because AODV develops only one path in one route discovery process and if link failure occurs, it will drop that packet, and it has to reinitiate route discovery process for new path. Whereas in AOMDV, routing cache has multiple paths from source to destination, so in case of link failure, extra path from source to intended node is available and thereby reduce the chance of packet drop.

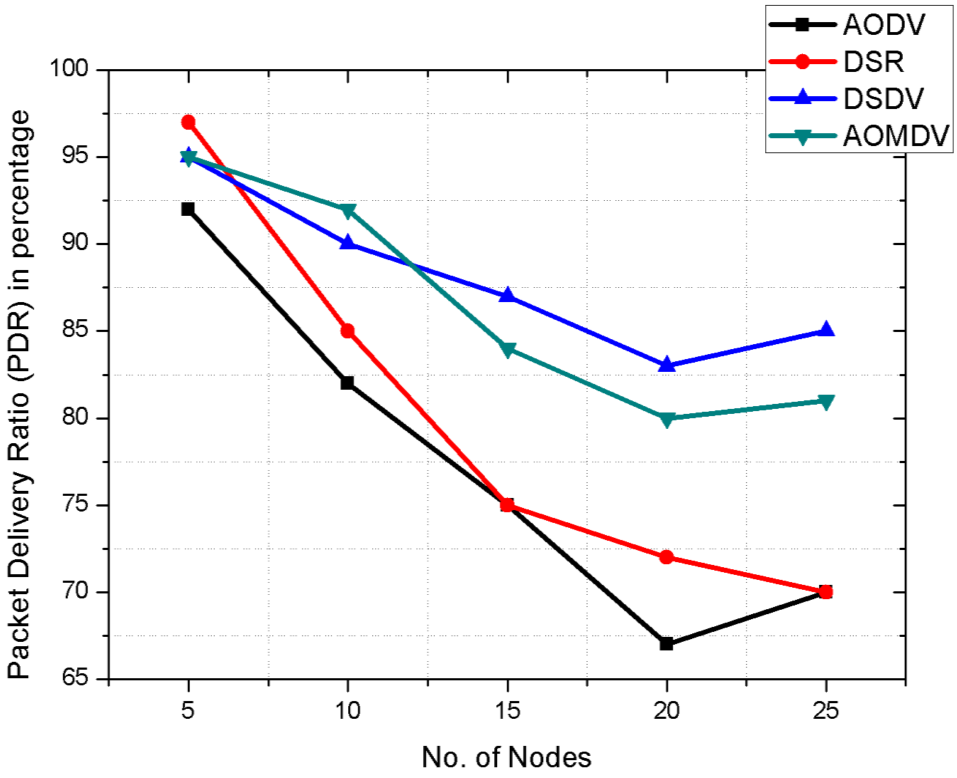

FIGURE 4-8: PDR WITH INCREASING NUMBER OF NODES

4.3.3 Throughput With Increasing Number Of Nodes In The Network

From figure 4-9 throughput in case of DSDV decreases with increasing number of nodes because DSDV routing protocol is table driven protocol and require more control overhead to maintain the route to every other node. Here AODV routing protocol showing best throughput with increasing number of node because in AODV routing protocol, routing table is established at every node, so there is no need to carry entire route information along with data packet that will decrease the control overhead. In case of DSR, data packet has to carry complete route information with data packet, it will increase the control overhead as compare to AODV routing protocol.

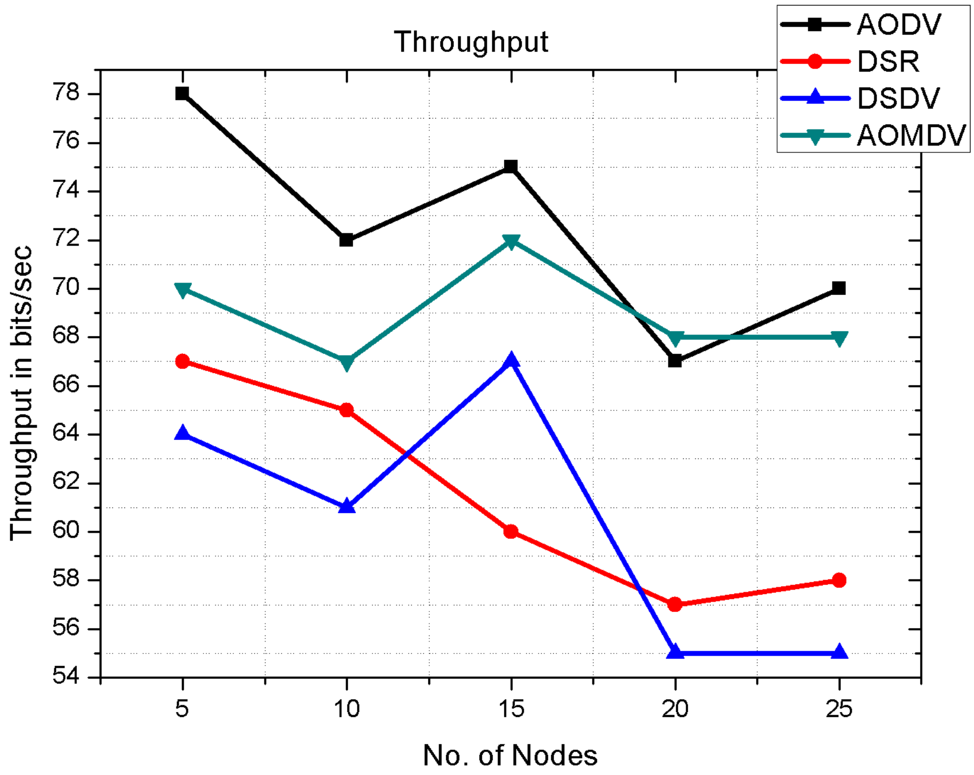

FIGURE 4-9: THROUGHPUT WITH INCREASING NUMBER OF NODES

The simulation has been done for different routing protocols under IEEE standard 802.11 and 802.15.4 in NS2. The results under IEEE 802.11 show that DSDV requires less time (delay) to forward data and performs better than other routing protocol with increasing number of node scenario whereas AODV outperforms other routing protocol with increasing speed of the node case. Packet delivery ratio of DSDV is higher than other routing protocols in increasing number of nodes, and AOMDV performs best in increasing speed of the node scheme. The average successful packet received at destination is high in AODV routing protocol with increasing node whereas AOMDV showing better output with increasing speed of the node case.

The simulation results under IEEE 802.15.4 show that the DSDV forwards packet with short delay than other routing protocol with increasing number of node. Packet delivery ratio of DSDV is higher than other routing protocols in increasing number of nodes. The average successful packet received at destination is high in AODV routing protocol with increasing node case. So here we can say that DSDV routing protocol performs better with increasing number of nodes and AOMDV routing protocol outperforms other in increasing speed of the node case.

5

NETWORK MODEL FOR MOBILE PATIENT MONITORING

5.1 Introduction

The patient monitoring system is a promising way to assist the medical professionals for improving their monitoring abilities. The numbers of medical professionals are limited and they are overburdened. The status of patient is evaluated by monitoring various physiological data such as heartbeat, temperature and blood pressure. Specific sensors for each physiological data are placed near to the patient body, which limit the patient mobility. The sensors works as a body area network and two or more sensors deploy in the network forming WPAN [29].

In the case where the patient condition is not very serious or have minor health problem, then the patient can roam around the hospital for example, patient has to go other area of hospital for medical counselling or test purpose. At that instant medical professional cannot directly monitor health condition, so based on above discussion mobile wireless network is necessary for patient monitoring.

Figure 5-1 shows the system architecture of mobile patient monitoring system. In this system, group of sensors are set nearer to the patient body, that's collect physiological data like temperature, pulse rate etc. These wireless sensors transmit sensed data to ZigBee router and it forwards to coordinator which permits family, and Doctor to continuously monitor the patient condition. This system also allows to forward data when the person is in mobile vehicle, and receive doctor advice. WBAN is an emerging technology, therefore IEEE formed a standard IEEE 802.15.6, working on the body area networks [28]. The WBAN sensors should be in coverage range of gateway always, to provide continuous monitoring. Ad-hoc wireless network formed among the patient can extend the range of the device to reach the coverage range of gateway; therefore this leads to improved networking support for patient monitoring.

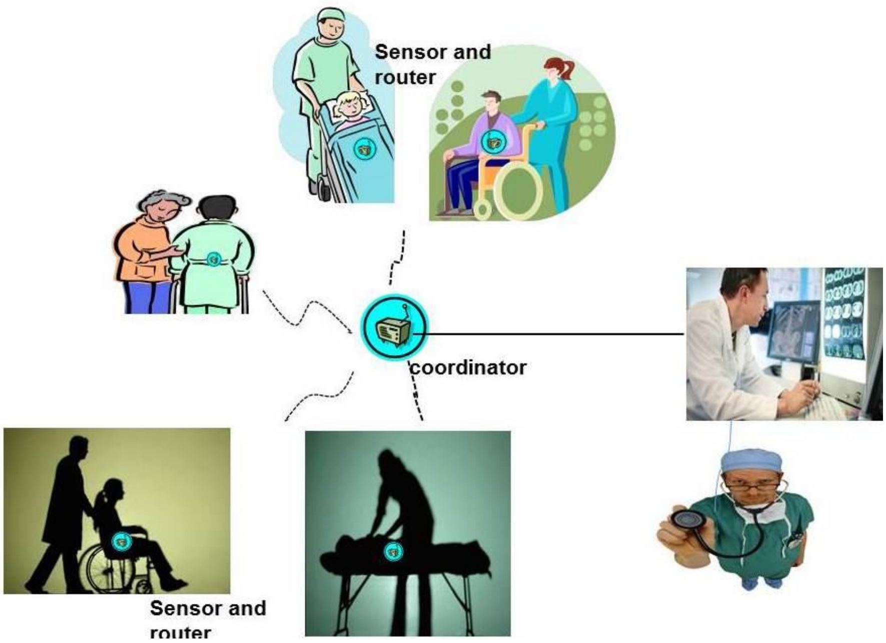

FIGURE 5-1: SYSTEM ARCHITECTURE OF MOBILE PATIENT MONITORING SYSTEM

The main objective of such a network is to assemble sensed data and transmit it to hospital center in the better way. This system allows the real time transmission of collecting data over the public wireless network to the health center, and patient will be able to receive medical advice from a distance. As the position and speed of the remote mobile patient are continuously changing, that creates unpredictable topology and link instability. Therefore, routing is a very important task in WBAN.

5.2 Mobile Patient Network model

The mobile patient monitoring wireless network designed using two subnet; CCU (Central Coordination Unit) and PCU (Patient Coordination Unit) shown in fiigure 5-2. The designed Mobile patient monitoring network is analysed by using network simulator and the development language used is C [30]. PCU aggregate’s sensor data and transmit them to a CCU located at a short distance. The Central coordination unit works as an intermediate network that forward the collected data to a hospital center. Figure 5-3 shows that, CCU has a WLAN Ethernet router and server, WLAN Ethernet routers are used to connect CCU with PCU [24], [25].

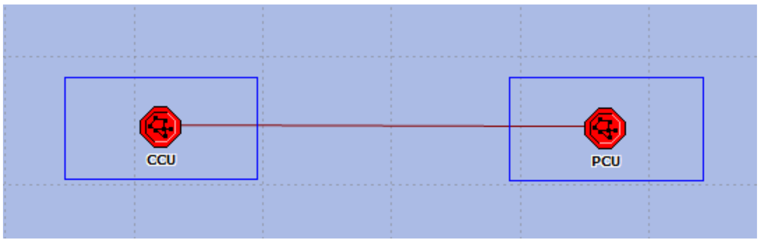

FIGURE 5-2: PATIENT MONITORING NETWORK MODEL

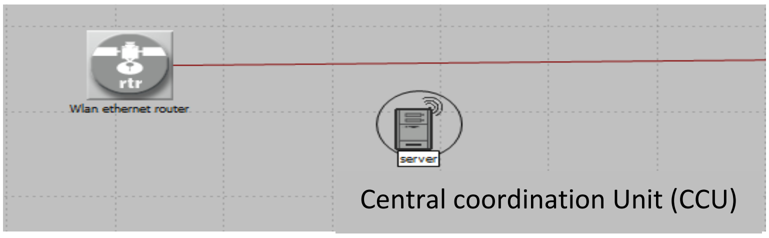

FIGURE 5-3: CENTRAL COORDINATION UNIT (CCU)

PCU contains seven mobile nodes moving with variable speed in their desired trajectory. Trajectory for a particular node is shown by the white line in figure 5-4. It can be seen as an ad-hoc network which allows to design and study wireless communication network with different routing protocols.

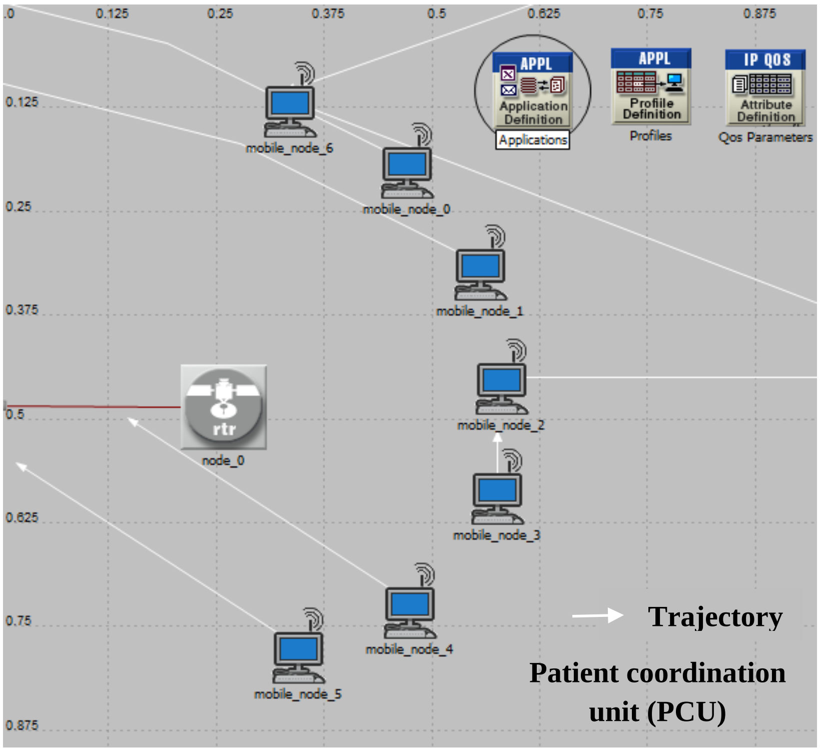

FIGURE 5-4: PATIENT COORDINATION UNIT (PCU)

Simulation has been performed by selecting unique arbitrary trajectory for every mobile node. In this type of model, the node are placed randomly within a 100m×100m area and nodes move in defined trajectory with arbitrary speed. The standard used is a WLAN IEEE 802.11b having 11 Mbits/sec data rate and transmission power 0.005 W. We have simulated this system in specified area with seven mobile nodes for 30 minutes; each node has a variable speed.

Figure 5-5 show that, the AODV has a smaller delay than DSR because in DSR, route discovery process require more time as compare to AODV routing protocol. Initially, total delay is more in both the routing protocols because routing cache is completely empty and after the small duration, the delay decreases as routing cache is establishing through the route discovery process. Once the route from one node to another is establish in the routing cache, then end to end delay become constant at 0.004 Sec for both the routing protocols.

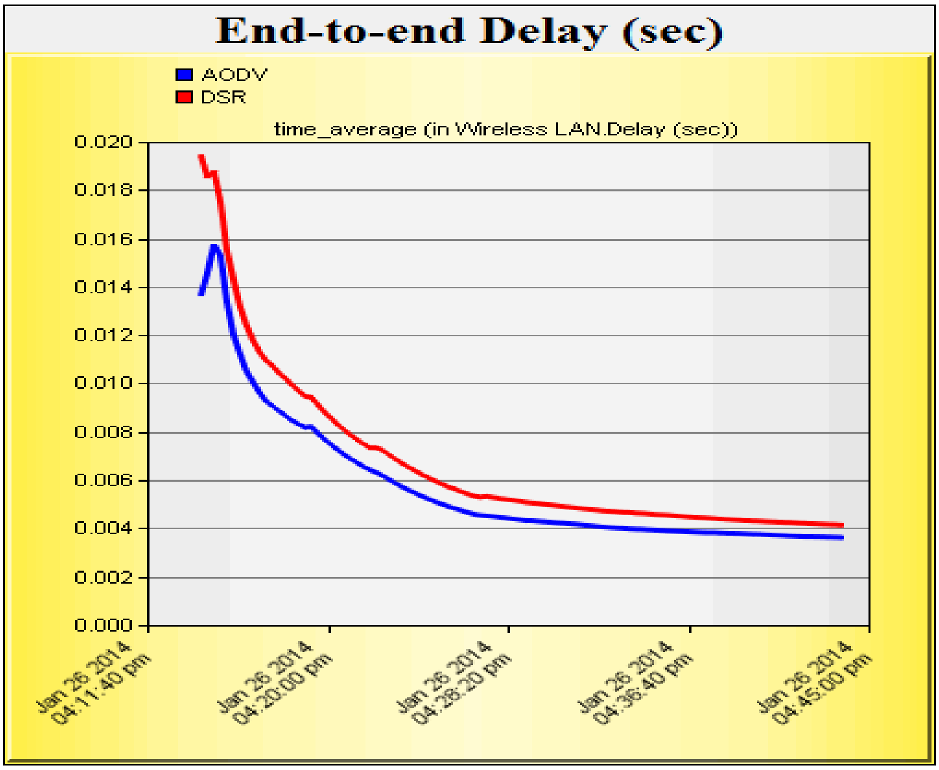

FIGURE 5-5: END TO END DELAY FOR PROPOSED NETWORK

Figure 5-6 the AODV routing protocol has a higher throughput as compared to DSR routing protocol because in case of AODV routing protocol there is no need to carry complete route information along with data packet that decreases the control overhead as compare to DSR.

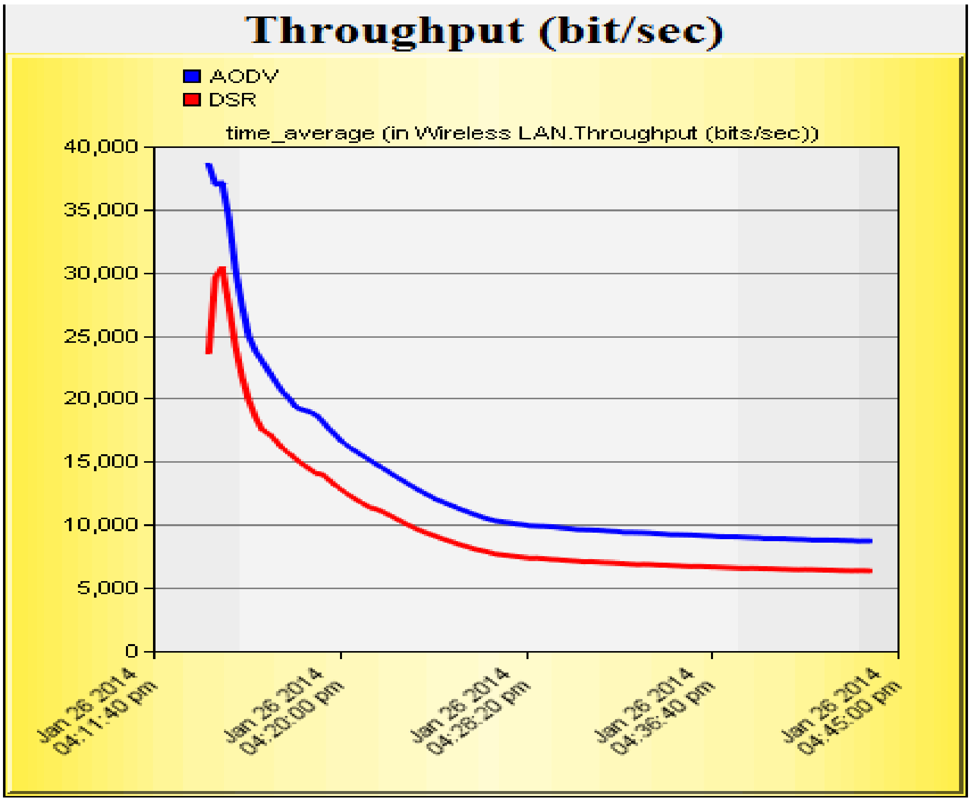

FIGURE 5-6: THROUGHPUT FOR PROPOSED NETWORK

In the initial phase of simulation throughput is zero because in the starting phase of simulation, routing cache was completely empty, and gradually it fills up the routing table through the route discovery process, then we can successfully transmit the information packet. Throughput decreases when mobile nodes move away from the server and become constant because their trajectory of the mobile node is limited within specified coverage area.

The proposed mobile network provides the facility to forward physiological data when patient is moving in their defined trajectory with variable speed. This mobile network is analyzed in context with existing routing protocols for mobile ad-hoc network and increases the range of the devices to reach the coverage range of gateway. With the implementation of the routing protocols the network performance is improved.

6

CONCLUSION AND FUTURE WORK

6.1 Conclusion

Nowadays, the growth in the field of information processing and wireless data transmission for patient monitoring system is in its peak. The physiological data like ECG, temperature, and pulse rate is collected via various sensors forming Wireless Body Area Network (WBAN). WBAN is a network which employing wireless sensor network technology that creates a system to continuously monitor the patient situation. In a case where the patient condition has to go for medical counselling, X-ray, MRI, Ultrasonography etc. Patient has to move around the hospital, but during that time medical professional cannot easily monitor the health condition of the patient, this makes mobile patient monitoring a core issue. The mobile patient forming unpredictable topology and link instability that’s make routing protocol important for mobile patient monitoring network.

For designing the patient monitoring system, evaluation of the four routing protocols under IEEE 802.11 and IEEE 802.15.4 standards has been done. The performance is evaluated in terms of the end-to-end delay, throughput, and Packet Delivery Ratio (PDR). The AODV, DSR, DSDV, and AOMDV routing protocols are implemented for both the standards. It is concluded that the WLAN 802.11b is best suited for designing a patient monitoring system because it provides better throughput and larger coverage area.

This dissertation proposed a mobile patient monitoring network model using WLAN environment, where all the patients are moving with changing speed and trajectory. The patient's movement makes unpredictable topology and results link instability. In order to overcome such problem, the AODV and DSR routing protocol has been implemented and their link performance has been analysed. It is found that under AODV routing protocol the throughput achieved is higher and the end-to-end delay is lesser as compared to DSR. It indicates that the AODV performs better for the proposed mobile patient monitoring network model.

6.2 Limitation and Future Work

The communication range of proposed network is according to WLAN standard i.e. 100m. It causes the performance degradation after this range. Thus, the work has to be extend further, in order to increase the coverage area. Every single routing protocol has its own advantages and disadvantages. No routing protocol can perform best in every type of network and scenario. So there is a need to develop new routing protocol, which could give higher performance under both IEEE 802.11 and 802.15.4 standards.

DISSEMINATION:

- Ravi Tiwari, Sonam Shrivastava and Susmita Das, **“Performance Analysis of Mobile Patient Network Using AODV and DSR Routing Algorithms,”** *IEEE International Conference on Green Computing, Communication and Electrical Energy (ICGCCEE’14),* Coimbatore 6th - 8th march 2014.
- Ravi Tiwari, Sonam Shrivastava and Susmita Das, **“Performance Analysis of Patient Monitoring System Under Different Routing Algorithm,”** *IEEE International Conferences for Convergence of Technology*, Pune, 6th - 8th April 2014. DOI 978-1-4799-3759-2/14/$31.00©2014 IEEE.

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Online Resources:

1. www.wikipedia.org

3. www.google.com – Search Engine for data and images