Performance analysis of QOS-Oriented Distributed Routing Protocols for Wireless Networks using NS-2.35

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List of Acronyms

- **EAODV: Enhanced Ad-hoc on demand distance vector routing**
- **QOD:QOS oriented dynamic routing protocol**
- **DSR: Dynamic source routing**
- **AS: Access Point**
- **UDP: User datagram protocol**
- **CBR: Constant bit rate**
- **TX: Transmission**
- **QOS: Quality of service**
- **AODV: Ad-hoc on demand distance vector routing protocol**
- **RSVP: Resource Reservation Protocol**
- **S:Source**
- **MANET: Mobile ad-hoc network**
- **RREQ: Route request packet**
- **NS: Network Simulator**

Abstract

Wireless technologies are becoming an essential part of our daily life. These technologies are expected to provide a wide variety of real-time applications; hence, there is a vital need to provide quality-of Service (QoS) support. The emergence and the envisioned future of real time and multimedia applications have stimulated the need of high Quality of Service (QoS) support in wireless and mobile networking environments. In this project I will be simulating the energy based enhanced AODV (AD-HOC On-demand distance vector routing) and QoS-Oriented Distributed routing protocol (QOD) and comparing their performance on the basis of different parameters such as throughput and transmission delay.

Keywords: Quality of service, Energy based -EAODV, QOD, Wireless

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Chapter 1

1.1 Motivation

I wanted to evaluate the performance of energy based enhanced AODV (AD-HOC On-demand distance vector routing) and QoS-Oriented Distributed routing protocol (QOD) used to provide quality of service (QOS) in wireless network because this work relates to my Co-op position for spring 2016: Quality Engineer. This helped me in understanding the nuances of the quality of service required for wireless communication and will certainly going to help me in making judicious decision while implementing them in future projects. Second reason for choosing hybrid wireless network is because of its worldwide popularity.

The number of Wi-Fi capable cell phones including tablets and handheld gadgets (e.g. cell phone and PDA) has been expanding quickly. The number of wireless Internet users has tripled world-wide in the recent three years, and the number of smartphone users has increased from 7.4 million in 2003 to190 million in 2010 and estimated 300million in 2013 [3]. The emergence and the envisioned future of real time and multimedia applications have stimulated the need of high Quality of Service (QoS) support in wireless and mobile networking environments.

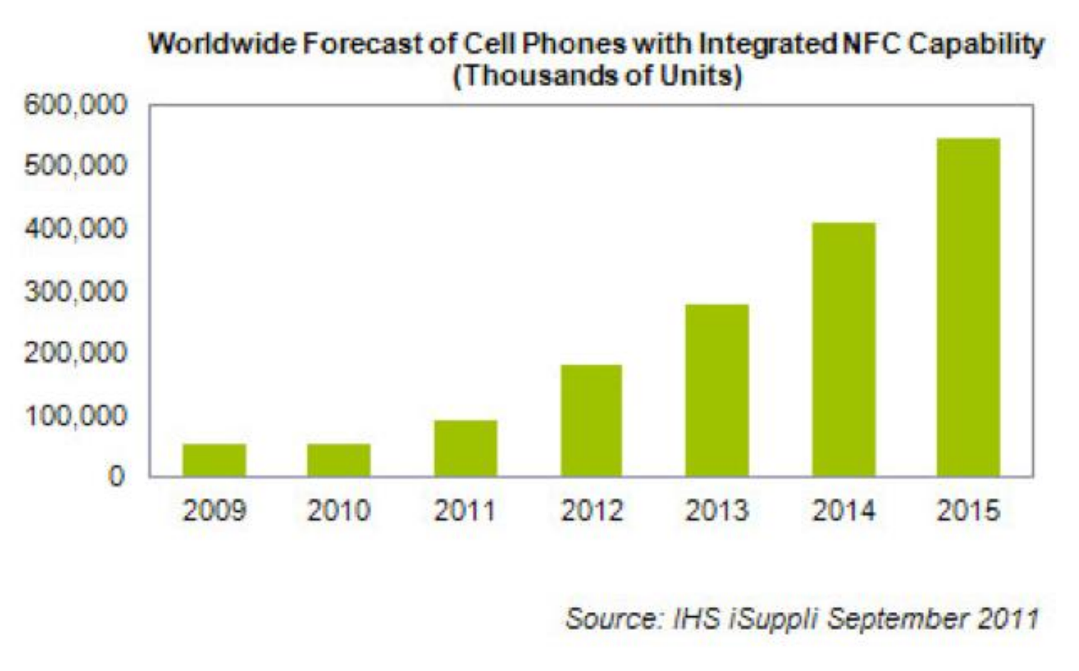


Fig.1:Cell phone market trend[4]

Chapter 2

2.1. Introduction:

Hybrid wireless network: A hybrid wireless network is a network, where mobile host or source may connect to an access point (AP) or destination using multi hop wireless routes via other mobile hosts or neighboring hosts. The APs are configured to operate on one of multiple available channels. Hybrid Wireless facilitates the effective and efficient integration of microwave transport networks, communications infrastructure components and high capacity broadband technologies, focusing on Internet Protocol (IP). [5]

Next-generation wireless systems are expected to support a wide range of advanced services: Support both data and voice traffic Cellular systems: 1G focused on efficient frequency usage for voice transmission.2G focuses on efficient spectrum usage for voice transmission.3G focuses on efficient data traffic. Hybrid wireless networks have emerged as a promising solution, allowing mobile clients to achieve higher performance and service access in a seamless manner independent of their existence in wireless LAN (WLAN) communication range [5]. In this paper I analyzed the performance of routing protocol used in providing the QOS support in hybrid wireless network.

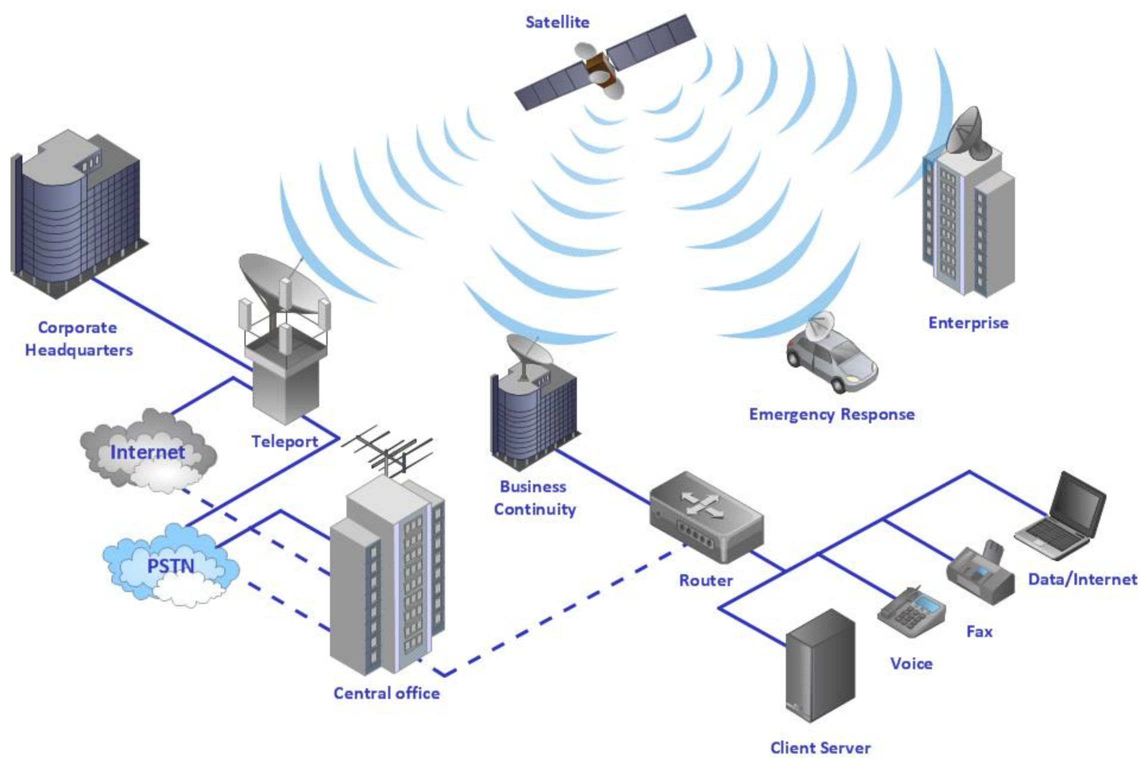


Fig.2. Hybrid Wireless Network [6]

Chapter 3

3.1. **Overview**:

3.1.1. **Ad-Hoc**: network is a peer to peer based network, which consists of at least two wireless station. Ad-hoc LAN are normally less expensive because it follows decentralized approach ,which does not require dedicated computer to store applications and data [8].Nodes can move randomly and in any directions and nodes must communicate with one another to forward packet to its final destination. Limitation of ad-hoc network is that it does not perform well in large networks.

Fig 3: Ad-hoc based network [7]

3.1.2. Literature review: A number of routing algorithm has been proposed for the mobile ad-hoc network. Traditional routing algorithms cannot be used for ad-hoc network. Routing protocols for ad-hoc network classified as: on-demand driven, pro-active, reactive and hybrid.

3.1.2.1. Ad-hoc on Demand Distance Vector Routing: "A node does not have to discover and maintain a route to another node until the two need to communicate unless the former node is offering its services as an intermediate forwarding station to maintain connectivity between two other nodes" [9].The each mobile node become aware of the other nodes in its neighborhood by the use of several techniques, including local broadcasts known as hello messages and routing cache mechanism. The routing tables of the nodes within the neighborhood are organized to optimize response time to local movements and provide quick response time for requests for establishment of new routes [10].

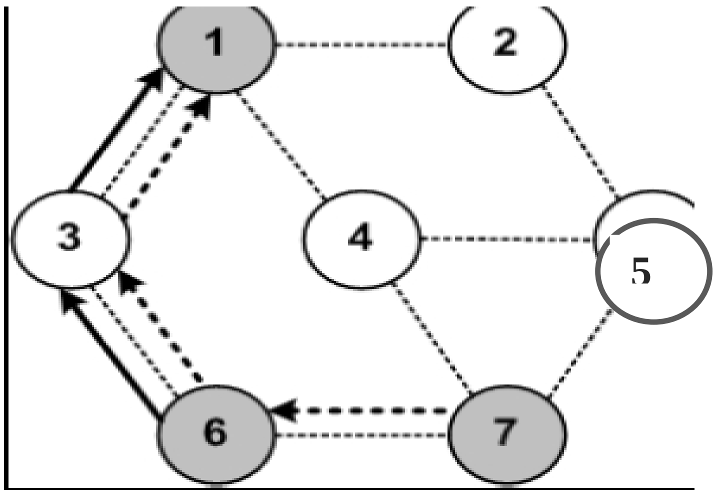


Fig.4: Ad-hoc routing protocol [10]

- **Advantages:** Broadcast discovery packets only when necessary (reactive).
- **Disadvantages:** Mechanism to ensure the reliability of data delivery has not been invoked.

3.1.2.2. The Dynamic Source Routing Protocol (DSR): DSR is a typical routing protocol for MANETs [11]. When a source node wants to find a route to another one, the source node initiates a route discovery it broadcasts a Route Request(RREQ) to the entire network till either the destination is reached or another node is found with a fresh enough route to the destination and each node add its own identifier when forwarding RREQ.[11]

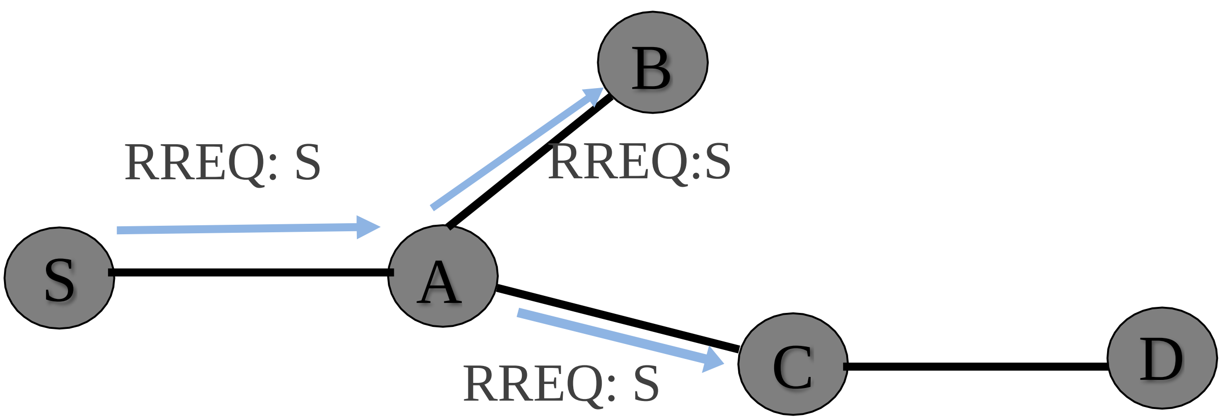


Fig: 5 Dynamic source routing [14]

- **Advantages:** The use of source routing allows packet routing to be loop-free and avoids the need for up-to-date routing information in the intermediate nodes through which packets are forwarded.
- **Disadvantages:** Stale caches will lead to increased overhead [11]

3.1.2.3. Resource Reservation Protocol: The Resource Reservation Protocol (RSVP) is a network-control protocol that enables Internet applications to obtain differing qualities of service (QoS) for their data flows.

Some traditional application require reliable delivery of data but not timeliness delivery but on the other hand newer application such as videoconferencing, IP telephony, and other forms of multimedia communications require: Data delivery must be timely but not necessarily reliable. Thus, RSVP was intended to provide IP networks with the capability to support the divergent performance requirements of differing application types [12]

- **Advantages:** RSVP enables network to accommodate IP videoconferencing traffic which not only requires significant bandwidth but also protection from the packet loss without degrading the performance of other applications in the network [12].

Problems is providing Quality of services: Some of the challenges in providing quality of service in hybrid networks are

- **Energy constraint:** Each mobile node runs on a battery and because of that limited power is available (transmission power) thus limited communication range. The processing power of each node must be considered, especially because each node acts as an individual router that performs network control.[13].This has been addressed by EAODV protocol
- **Constrained bandwidth:** "Nodes need to forward or transmit packets of other nodes as well as their own packets, which creates scarce bandwidth" [13]. This has been addressed by quality of service based routing protocol.
- **Node mobility:** In wired networks, as nodes are stationary, routing protocols are successful to efficiently transmit data between two endpoints and data transfer is reliable. However, this is not possible in mobile ad hoc networks because mobility of the nodes causes frequent link failures, which in turn decrease the performance of the network.[13]

Chapter 4

4.1. EAODV:

Many enhancements to AODV routing protocol have been proposed [15, 16, 17] till now .I am going to discuss energy based enhanced ad-hoc routing protocol.

E-AODV: is a resource reservation-based routing protocol for QoS routing in MANETs [16]. This protocol extends AODV by adding information of the maximum delay and minimum available bandwidth of each neighbor in a node's routing table [17]. To apply E-AODV in hybrid networks, let a source node search for the QoS guaranteed path to an AP. A node always forwards a packet to a next hop node that has small buffer usage than itself and high remaining energy until the packet reaches an AP [17].

In MANET as mobile nodes relies on battery for a power and in case battery let down then this leads to the problem of delay in transmission resulting in more packet loss and lesser overall throughput. In EAODV the source nodes chooses neighbor node on the basis of available power to reach the AP and who has small buffer as comparison to itself [17].

EAODV uses a selective route cache mechanism in the route discovery procedure and select the node on the basis of the available energy.

Basically in route cache mechanism let say path between node 6 to node 1 is saved in route table using route caching mechanism and then if node 7 needs to talk with node 1 then it might use node 6 to connect to node 1 or it will choose path node 4 to connect to node1 as shown in figure below. [10]

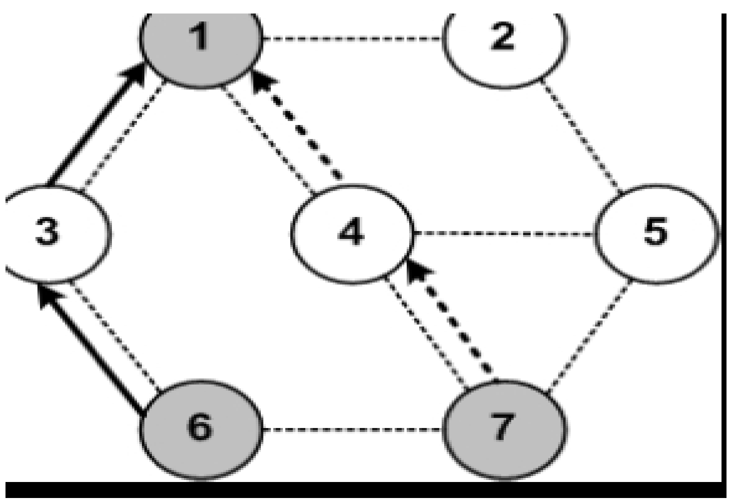


Fig.6: Selective route mechanism [10]

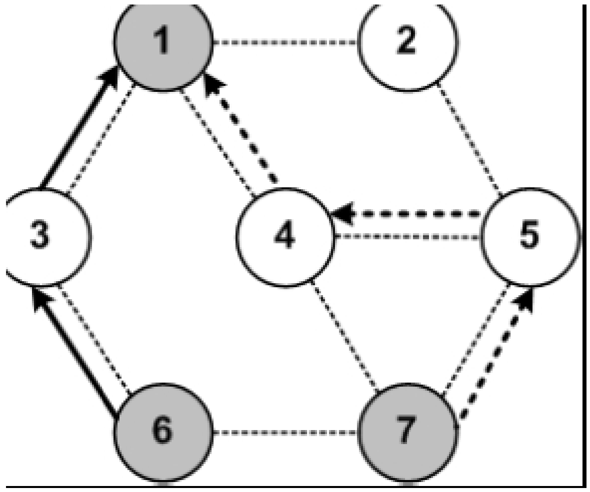


Fig: 7: Selective route mechanism [10]

“Here node 7 broadcasts an RREQ with TTL=1 to find a route to node 1 for data transmission, although node 6 has the route to node 1 by the previous route discovery procedure, node 6 does not reply to the received RREQ by the selective route cache mechanism. Since nodes 4 and 5 do not have a route to node 1, they cannot also reply to the RREQ. Then node 7 broadcasts an RREQ with TTL=3 again. The RREQ will be propagated to node 1 and node 1 will reply to the RREQ and then node 7 will going to connect to node 1 through node 4 depending upon power availability and buffer size” (Kim, B.C, IEEE, 2005).

4.2. QOD:

QOD: Usually, a hybrid network has widespread base stations. The data transmission in hybrid networks has two features. “First, an AP can be a source or a destination to any mobile node. Second, the number of transmission hops between a mobile node and an AP is small”(Li.Z,IEEE,2012). Taking full advantage of the two features, QOD transforms the packet routing problem into a dynamic resource scheduling problem.

In QOD, A source node selects nearby neighbors if AP is not within range that can provide QoS support in hybrid network to forward its packets to base stations in a distributed manner. The source node schedules the packet streams to neighbors based on their buffer size and bandwidth availability [2].

The QOS of the direct transmission between a source node and an AP cannot be guaranteed, the source node sends a request message to its neighbor nodes. After receiving a forward request from a source node, a neighbor node n_i with space utility less than a threshold replies the source node [5].QOD uses three algorithm to provide quality of service: QOS-Guaranteed Neighbor Selection Algorithm [2] which is used to choose qualified neighbor. Distributed packet scheduling algorithm [2] [21] schedule packet routing and reduce transmission delay. Packet resizing algorithm [2] adaptively resizes the packet according to neighbor mobility [5] .QOS guaranteed neighbor selection algorithm is used to choose qualified neighbor

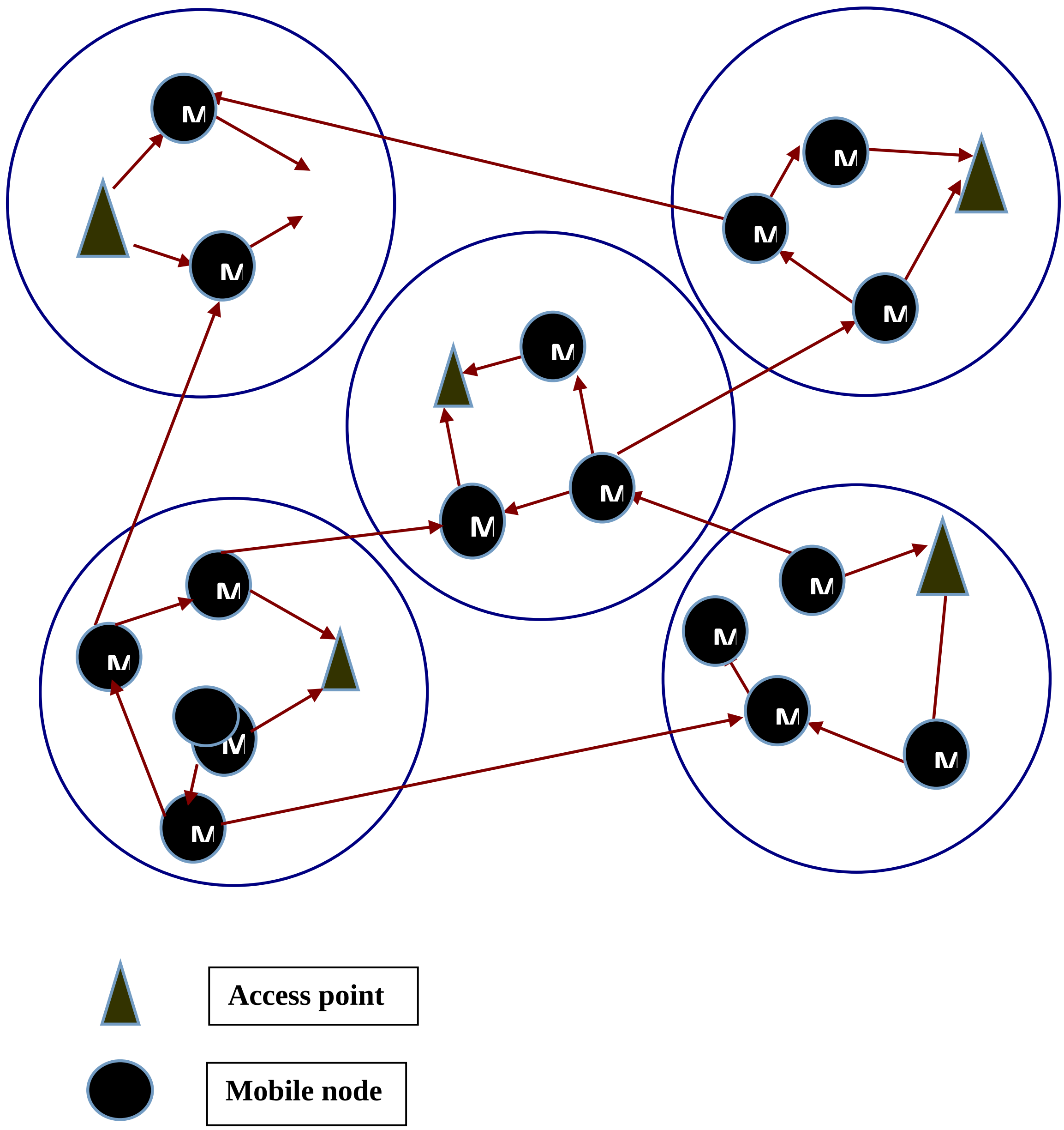


Fig 8: The network model of the hybrid networks. [2]

The objective of simulating the energy based EAODV and QOD is to find out the performance in

- Supporting QoS routing in hybrid networks.
- To further reduce the packet transmission time during the transmission.
- To enhance scheduling to achieve fairness in packet forwarding scheduling when some packets are not scheduling feasible.
- To guarantee the routing QoS in a highly mobile environment.
- To provide high QoS performance in terms of overhead, transmission delay, mobility-resilience, and scalability.

Chapter 5

5.1. Project Implementation:

5.1.1. Network Simulator-2.35: NS-2.35 is network simulation tool**.** Ns is a discrete event simulator targeted at networking research. Ns provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks. [18]

“The ns simulation core supports research on both IP and non-IP based networks. However, the large majority of its users focuses on wireless/IP simulations which involve models for Wi-Fi, WiMAX, or LTE for layers 1 and 2 and a variety of static or dynamic routing protocols such as OLSR and AODV for IP-based applications.

NS also supports a real-time scheduler that facilitates a number of "simulation-in-the-loop" use cases for interacting with real systems”. (*nanam.org retrieved on Apr.19,2016*)

5.1.1.1. System requirement:

Simulator	:	NS version 2.35
Language	:	TCL and AWK script
Operating System	:	Windows 7 (Cygwin) / Ubuntu

Table [1]. System requirements for ns-2.35

5.1.2. Network simulator architecture Design: To simulate the performance analysis of enhanced ad-hoc routing protocol and quality of service based distributed routing protocol in hybrid wireless network, the model is created in network simulator using standard libraries and models. The simulations are carried to obtain results and at end after careful analysis of the results conclusion is made. The simulation results may vary depending upon the chosen scenarios.

5.1.2.1. Network model Implementation: In this section the implementation detail of the project is discussed. The simulating parameters used for implementing are given below.

SIMULATOR	Network Simulator 2
NUMBER OF NODES	30
TOPOLOGY	Fixed Access point ,mobile users
INTERFACE TYPE	Phy/WirelessPhy
MAC TYPE	802.11
QUEUE TYPE	Droptail Queue
QUEUE LENGTH	50 Packets
ANTENNA TYPE	Omni Antenna
PROPAGATION TYPE	Two ray Ground
TRANSPORT AGENT	UDP
APPLICATION AGENT	CBR
SIMULATION TIME	50seconds

Table [2]. Simulation parameters

The queue type used is drop tail queue and user datagram protocol is used as transport layer protocol and constant bit rate is used as traffic generator. In this network implementation the topology chosen is such a way that the access points (APs) are stationary and rest are mobile nodes .Mobile nodes act as a source nodes and AP act as a destination nodes .If AP is within the range of source node then it makes the connection directly with AP, If not then it chooses neighbor nodes for reaching destination while ensuring quality of service depending upon the routing protocol.

The reason for choosing the topology:

- It is a simple topology to simulate the ad-hoc network routing protocols[17]
- This topology satisfies the requirement for testing the EAODV and quality of service based distributed routing protocol.[2][17][5]

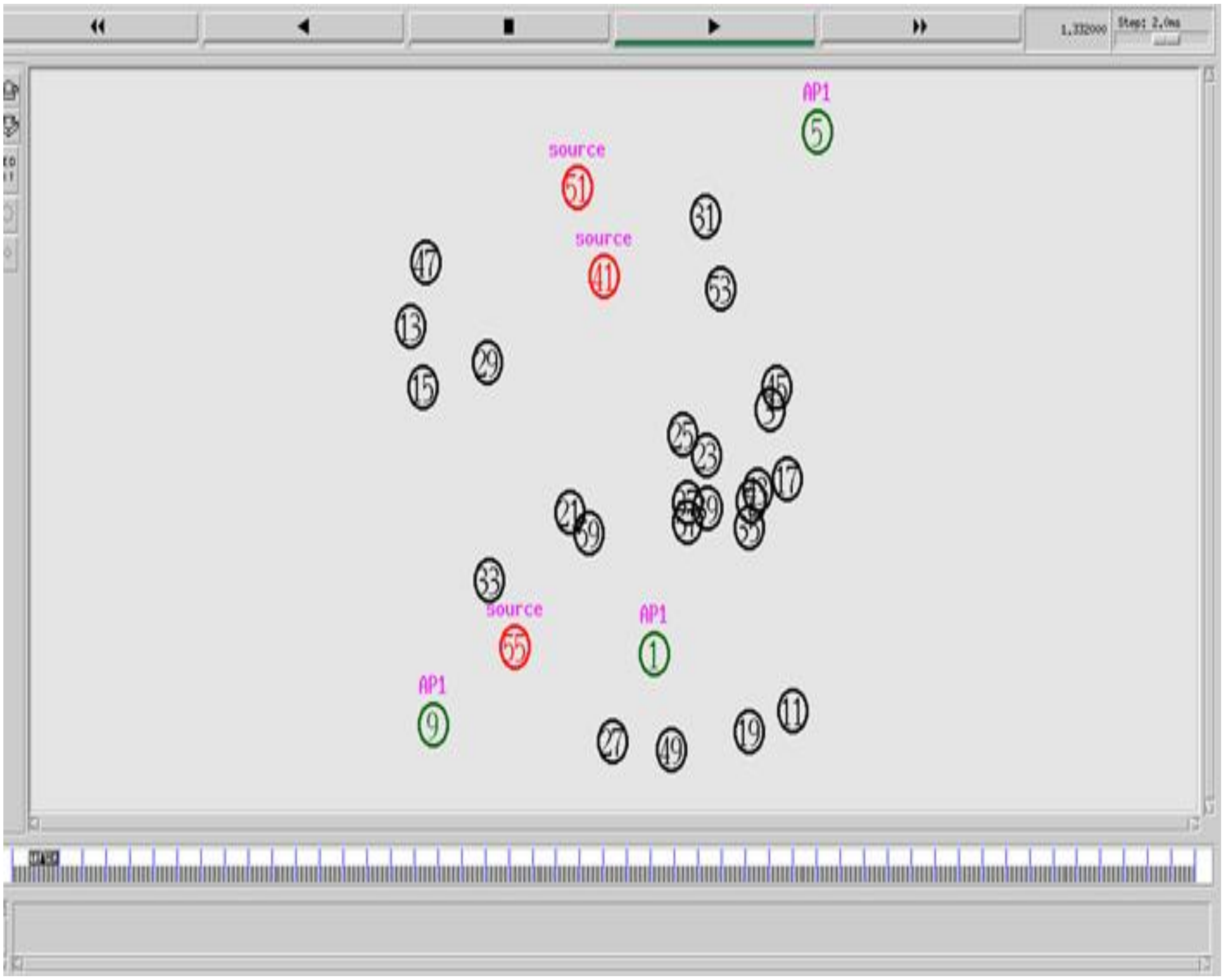


Fig. 9: The network simulation model

Here nodes with the notation AP and green color circles are access points. The nodes with the black color circles are mobile nodes and the nodes with the red color circle are mobile source nodes. If source node needs to reach the destination and the destination AP is not within the range of coverage then it sends the beacons signal to the neighbor nodes and select the neighbor node to reach destination.

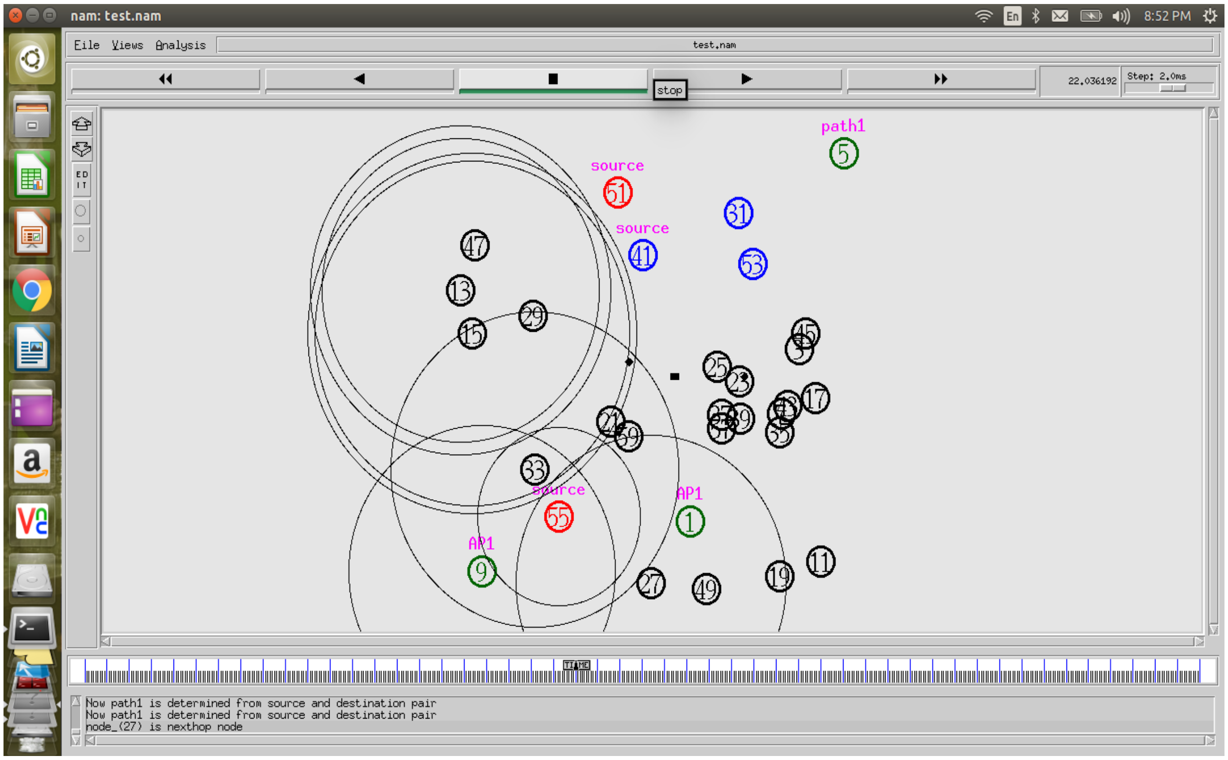


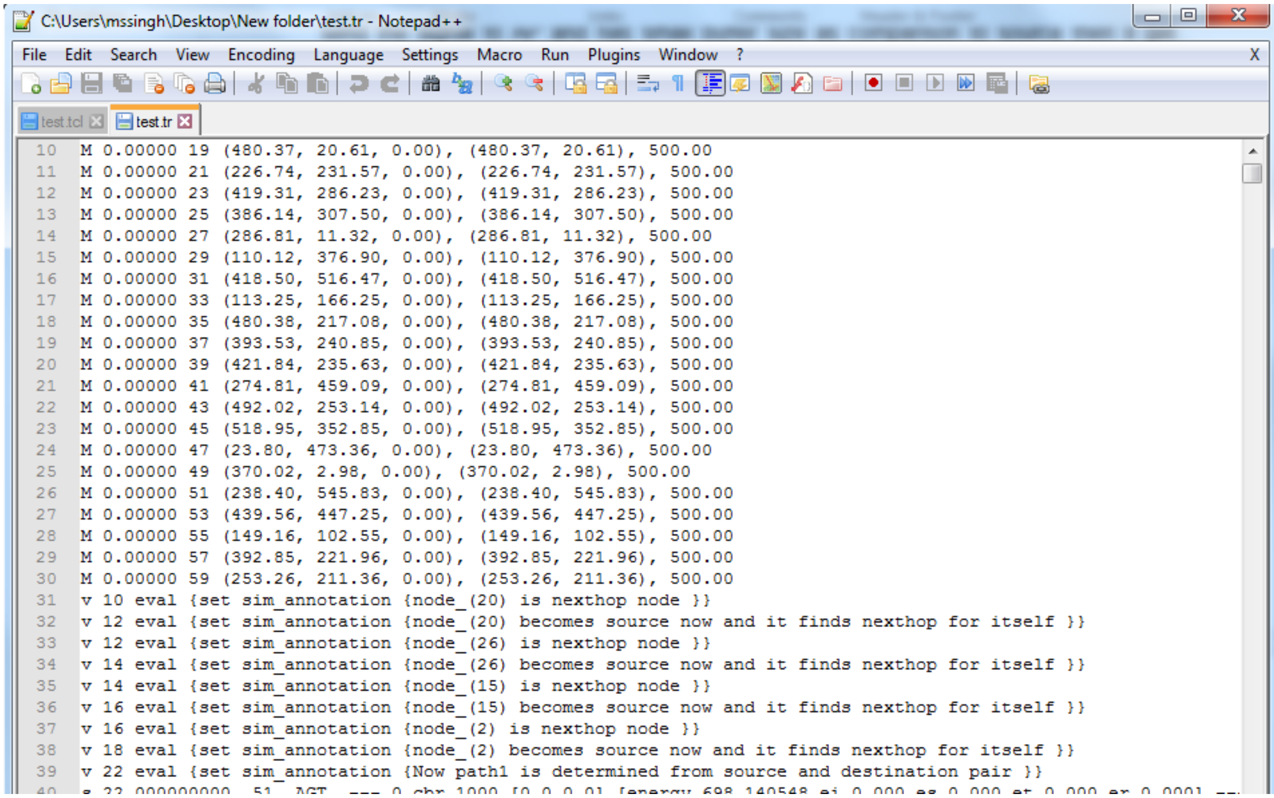
Fig 10: Source node searching for intermediate node

5.1.2.2. Energy based EAODV node selection criterion:

In case of energy based enhanced ad-hoc on-demand distance routing protocol it checks for power availability and buffer of intermediate nodes and if intermediate node has enough power to send the signal to AP and has small buffer size as comparison to source then it get selected [5]. For implementation of this protocol I used AODV protocol which is available in network simulator and the enhancement on the basis of energy is implemented on top of it and the reference for it is taken from [17][19][20]

It is a resource reservation-based routing protocol for QoS routing in MANET. This protocol extends AODV by adding information of the maximum delay and minimum available bandwidth of each neighbor in a node's routing table.

To apply energy based E-AODV in hybrid networks, let a source node search for the QoS guaranteed path to an AP. A node always forwards a packet to a next hop node that has small buffer usage than itself and high remaining energy until the packet reaches an AP. Data is transmitted via the router that leads to minimum delay and high remaining.




```
M 0.00000 19 (480.37, 20.61, 0.00), (480.37, 20.61), 500.00
M 0.00000 21 (226.74, 231.57, 0.00), (226.74, 231.57), 500.00
M 0.00000 23 (419.31, 286.23, 0.00), (419.31, 286.23), 500.00
M 0.00000 25 (386.14, 307.50, 0.00), (386.14, 307.50), 500.00
M 0.00000 27 (286.81, 11.32, 0.00), (286.81, 11.32), 500.00
M 0.00000 29 (110.12, 376.90, 0.00), (110.12, 376.90), 500.00
M 0.00000 31 (418.50, 516.47, 0.00), (418.50, 516.47), 500.00
M 0.00000 33 (113.25, 166.25, 0.00), (113.25, 166.25), 500.00
M 0.00000 35 (480.38, 217.08, 0.00), (480.38, 217.08), 500.00
M 0.00000 37 (393.53, 240.85, 0.00), (393.53, 240.85), 500.00
M 0.00000 39 (421.84, 235.63, 0.00), (421.84, 235.63), 500.00
M 0.00000 41 (274.81, 459.09, 0.00), (274.81, 459.09), 500.00
M 0.00000 43 (492.02, 253.14, 0.00), (492.02, 253.14), 500.00
M 0.00000 45 (518.95, 352.85, 0.00), (518.95, 352.85), 500.00
M 0.00000 47 (23.80, 473.36, 0.00), (23.80, 473.36), 500.00
M 0.00000 49 (370.02, 2.98, 0.00), (370.02, 2.98), 500.00
M 0.00000 51 (238.40, 545.83, 0.00), (238.40, 545.83), 500.00
M 0.00000 53 (439.56, 447.25, 0.00), (439.56, 447.25), 500.00
M 0.00000 55 (149.16, 102.55, 0.00), (149.16, 102.55), 500.00
M 0.00000 57 (392.85, 221.96, 0.00), (392.85, 221.96), 500.00
M 0.00000 59 (253.26, 211.36, 0.00), (253.26, 211.36), 500.00
v 10 eval {set sim_annotation {node_(20) is nexthop node }}
v 12 eval {set sim_annotation {node_(20) becomes source now and it finds nexthop for itself }}
v 12 eval {set sim_annotation {node_(26) is nexthop node }}
v 14 eval {set sim_annotation {node_(26) becomes source now and it finds nexthop for itself }}
v 14 eval {set sim_annotation {node_(15) is nexthop node }}
v 16 eval {set sim_annotation {node_(15) becomes source now and it finds nexthop for itself }}
v 16 eval {set sim_annotation {node_(2) is nexthop node }}
v 18 eval {set sim_annotation {node_(2) becomes source now and it finds nexthop for itself }}
v 22 eval {set sim_annotation {Now path1 is determined from source and destination pair }}
```

Fig 11: Trace file for the EAODV intermediate node selection

5.1.2.2. QOD node selection criterion:

1. “The source node requests a number of qualified neighbors that can guarantee the QoS of packet transmission to assist the packet forwarding to base stations” (Li, Z, IEEE, 2012).After receiving request form the source node the neighbor node with space utility less than the neighbor node reply to source node [2].The parameters for selecting the neighbor nodes are the available bandwidth and the delay. The reply message contain information about neighbor node such as channel capacity and queue size and based on the reply source node chooses the intermediate node. The reference for implementation of it is taken from [21] [21] [2].

The node selection is done by QOS guaranteed neighbor section algorithm. The selected node periodically update the source node which confirms the network connectivity and feasibility. Before sending the packets the packet size and queue delay is also considered to avoid the transmission delay. The distributed packet scheduling algorithm is used to schedule packet routing and reduce transmission delay [5] [21]. The mobility based resizing algorithm manages the packet size adaptively on the basis of mobility of intermediate nodes [5]

Node 0 Initial available bandwidth = 2.1392073617965019

Node 1 Initial available bandwidth = 3.6581297138045215

Node 2 Initial available bandwidth = 4.1860999125922564

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Node 29 Initial available bandwidth = 2.4614738400380469

It search for the neighbor nodes by sending the beacon signal after finding the neighbor node it selects the node on the basis of the bandwidth availability.

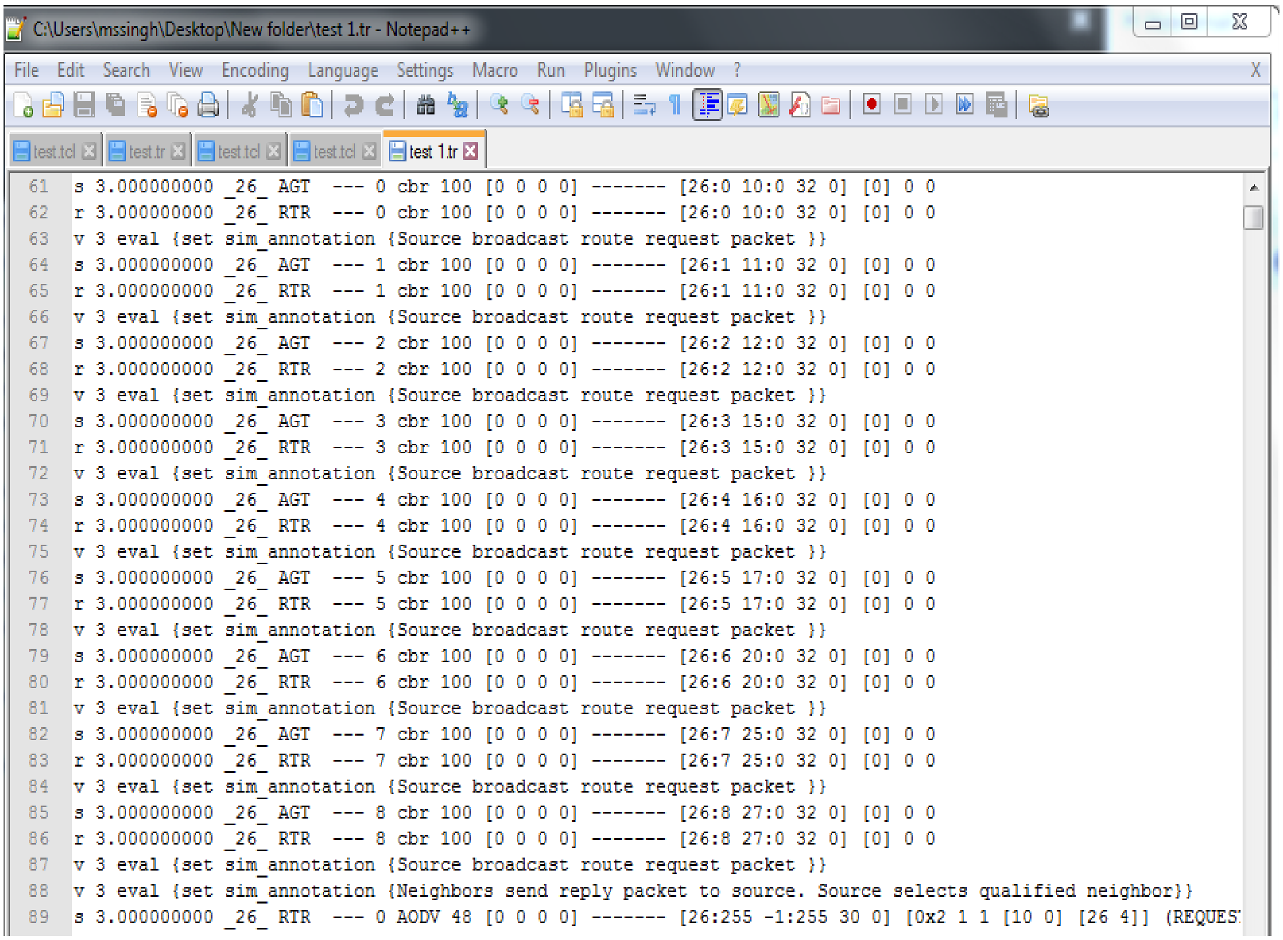

Fig 12: Trace file for the QOD neighbor node selection

Chapter 6

6.1Simulation results and analysis:

6.1.1. Throughput: Throughput is the measurement of the number of packets passing through the network over a unit of time.

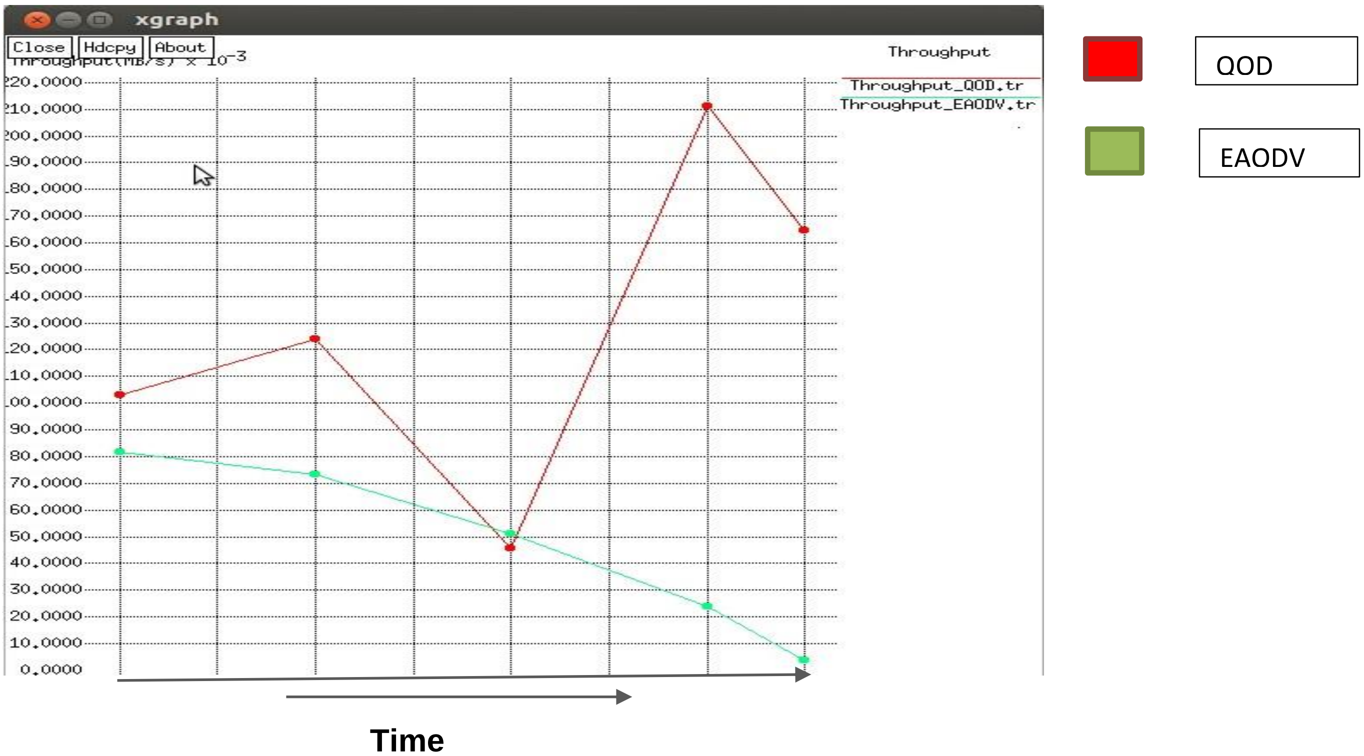

Fig: 13: Throughput

The results may vary according to the scenario chosen. In this simulation the throughput of energy based enhanced ad-hoc on demand routing protocol decreases and for QOD it somewhat diminishes first and then increase, as the mobile nodes start moving. “It is because in EAODV the link is reserved for the QOS traffic. In a mobile network the reserved link constantly breaks down which forces the source node searches for new path to the base station”(Li, Z, IEEE, 2012). The delay due to path searching degrades the energy based EAODV quality of service therefore the EAODV does not perform well in the highly dynamic nature [2]. On the other hand as we know that in QOD rather than reserving paths, nodes sends periodically updates about the queue status to the source nodes .In QOD Source node accordingly adapt to the packet size in order to compensate change in mobility and not to overflow the neighbor queue[2][5]. The somewhat decrease in the QOD throughput is because of increase in overhead.

6.2.2. Overhead: Overhead is defined as total number of beacon update messages involved in the communication.

Overhead = Number of messages involved in beacon update process.

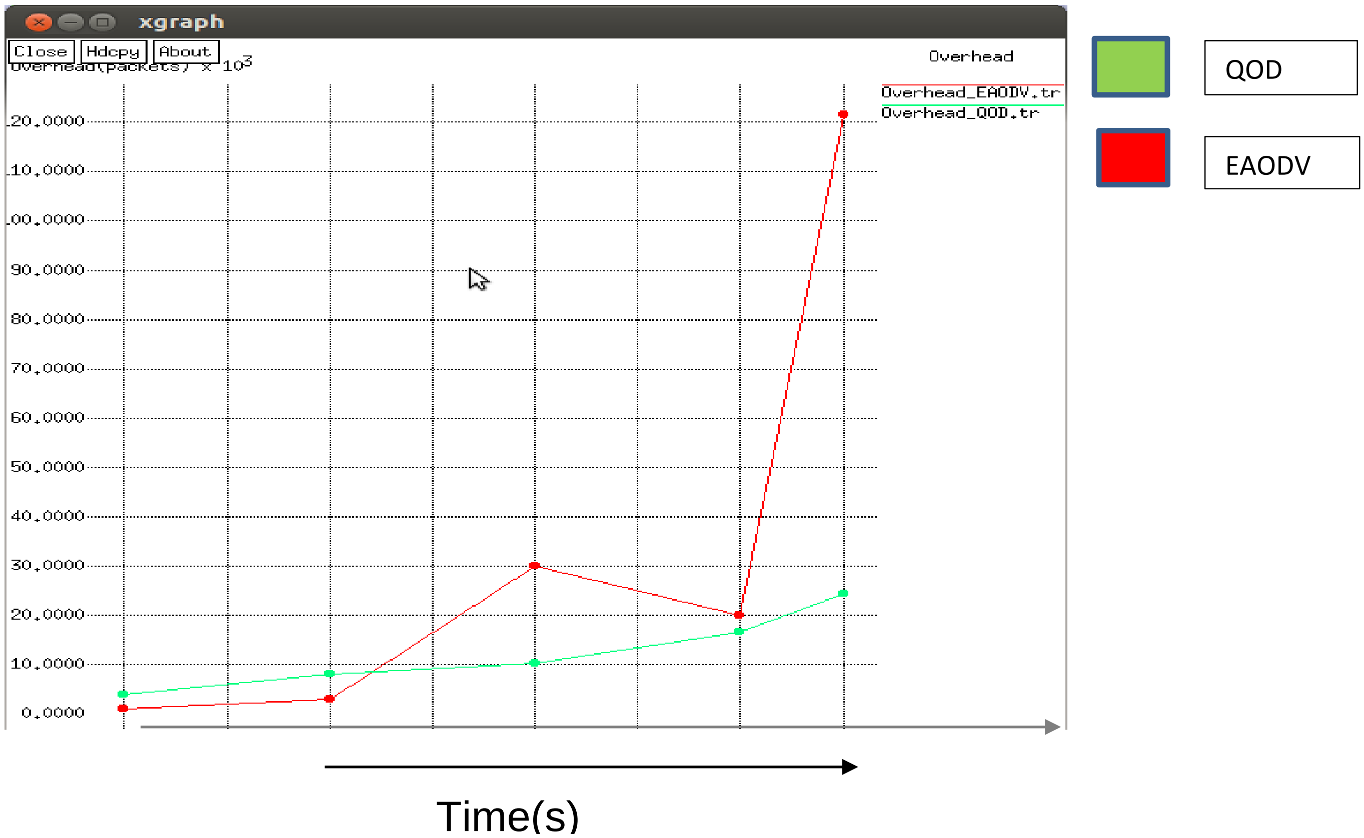

Fig: 14: Overhead

At start of the simulation the overhead in QOD is higher than energy based EAODV but as simulation progress with increase in mobility the overhead in case of EAODV increases. In EAODV the overhead is because of route cache mechanism, with mobility the connection breaks down and then source need to find path again and cache it which leads to increase overhead in energy based EAODV. In QOD the overhead is because of two reason: First reason is due to the periodic updates neighbor nodes send back to source node about queue status [5].

Although these are the updates exchanged only when source nodes has to send some packet but still in low mobility environment overhead is higher in QOD as comparison to EAODV. The second reason for the overhead in QOD is packet headers [2], when mobility increases packets are resized accordingly, which means more packets needed to complete the transmission which increase the packet header size and that's why there is an somewhat increase in overhead in QOD with mobility.

6.3.3. Transmission delay: Transmission delay is the time taken for a packet to reach the destination from the source node.

$$\text{Transmission delay (ms)} = \frac{\sum \text{(Delay of each entities data packet)}}{\text{Total number of delivered data packets}}$$

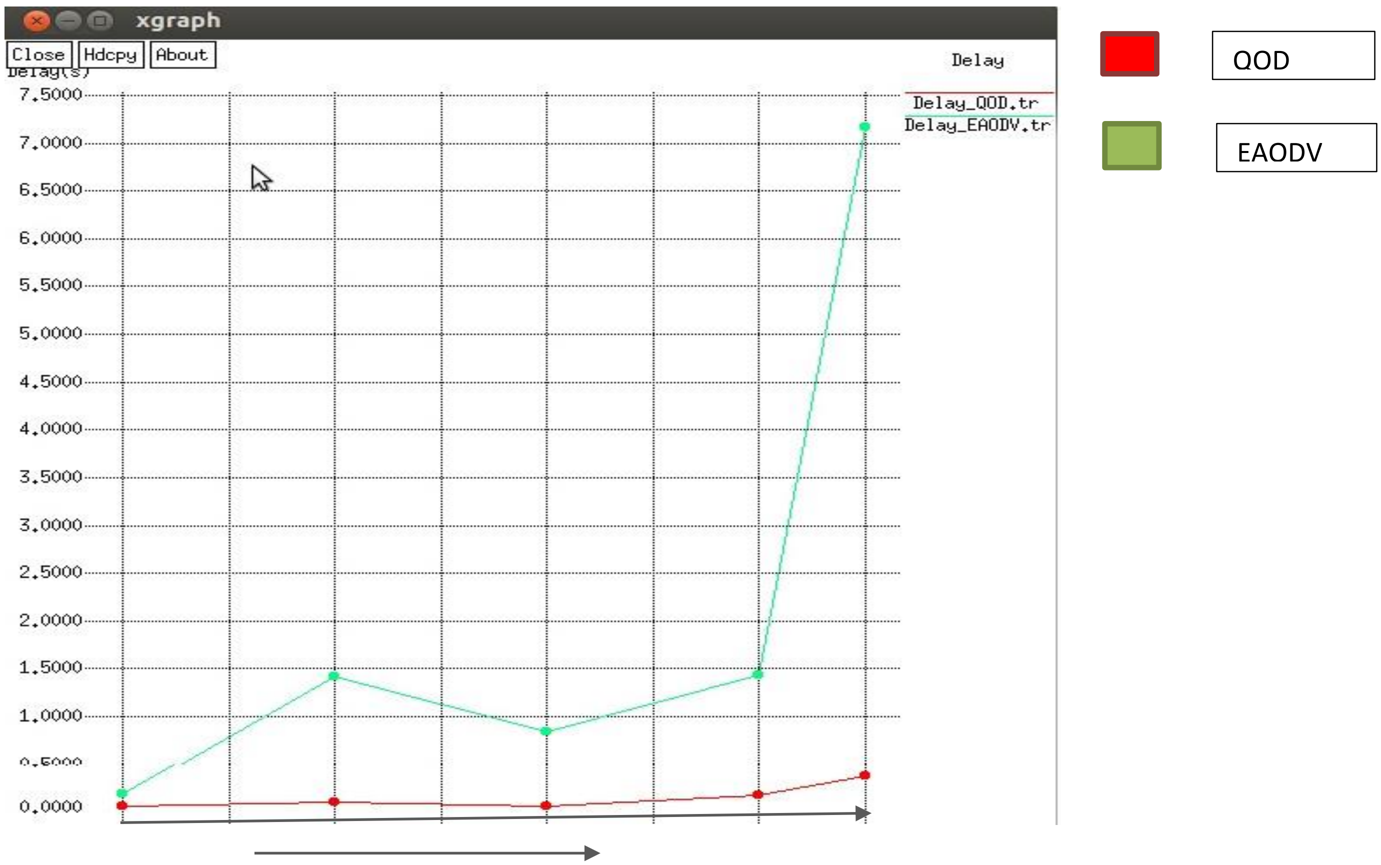

Fig: 15: Transmission delay

The transmission delay is higher in EAODV as comparison to QOD. This is because as load increases (source node increases),the possibility of two or more QOS routing reserves the same resources nodes also increases leading to the race condition problem[23] which led to increase in transmission delay in EAODV[2].

Since QOD doesn't cache the route, but send periodic updates about the feasibility of the connection and queue system, there is a less transmissions delay in this case.

Chapter 7

7.1. Conclusion: Direct adoption of the QoS routing techniques in MANETs into hybrid networks inherits their drawbacks [5]. Energy based enhanced ad-doc on demand distance vector routing protocol oriented distributed routing protocol (QOD) for hybrid networks proven to be a better than AODV [10], DSR [11] and RSVP [12] routing protocol. The QOD protocol seems to be performed better in the high mobility environment as comparison to EAODV in term of throughput, transmission delay and overhead but in low mobility environment QOD has higher overhead as comparison to EAODV.

“The mobility-based packet resizing algorithm resizes packets and assigns smaller packets to nodes with faster mobility to guarantee the routing QoS in a highly mobile environment” (*Ms.Nanthini, IJET, 2014*).The result of this simulation are valid for only this scenario, results may vary depending upon the topology chosen[2], load[2] and mobility speed[2] of the nodes.

7.3. Challenges:

- Understanding network simulator
- Learning about AVOD, Energy based EAODV and QOD routing protocols.

7.2. Future work:

- Implementation of QOS based quality of service on demand routing protocol in highly dynamic environment and with different topologies
- Comparison of QOD and EAODV in higher load and different mobility speed.

7.4. Related work

[1].Agarwal, K., & Awasthi, L. K. (2008, December), Enhanced AODV routing protocol for ad hoc networks, In *Networks, 2008. ICON 2008. 16th IEEE International Conference* IEEE, 2008.

- Only AODV and EAODV is compared

[2]. Li, Ze, and Haiying Shen. "A QoS-oriented distributed routing protocol for hybrid networks." *Mobile Adhoc and Sensor Systems (MASS), 2010 IEEE 7th International Conference* IEEE, 2010.

- QOD routing protocol is discussed and simulate

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