Optimization of Location Aware Routing Protocol for Wireless Adhoc Tactical Networks

Noman Younis and Shoab Ahmed Khan
Department of Computer Engineering, National University of Sciences & Technology, CEME Rawalpindi Pakistan
Email: {nouman_younis, kshoab}@yahoo.com

***Abstract*—Mobile Adhoc Network (MANET) is a wireless technique which does not require any pre-existing infrastructure to function. It only requires wireless devices with sufficient battery to build the infrastructure dynamically. With the help of intermediate nodes, routes between source and destination are established by using any of the available Adhoc routing approaches. But due to high node mobility and frequent changes in routes, data transmission may break often, causing routes to recreate and update accordingly. Adhoc Routing Protocol we used in our thesis is Adhoc on Demand Distance Vector (AODV) which is a reactive protocol. AODV finds the route by broadcasting, which unnecessarily consumes bandwidth and processing at each node causing power constraints. Therefore, our thesis is focused on the optimization of AODV by using GPS to restrict packet broadcast and conserve power at nodes. Simulation environment used is Network Simulator 2. After simulation, results of Optimized AODV are then compared with traditional AODV and DSR for analysis purpose.**

***Index Terms*—LAR, AODV, DSR, GPS, location aided routing, optimization of adhoc on demand distance vector.**

I. Introduction

Mobile adhoc networks (manet) is a widely used field in world today because the need for rapid deployment of networks is needed in situations like natural disaster, war or any emergency and due to the sensitivity of situation, we cannot bear any delay in establishing the communication [1]. An example of mobile adhoc network is shown in Fig. 1. Mobile adhoc networks are used for warfare/tactical networks to help army to communicate in deserts or places where there is no pre-existing infrastructure of communication. There are different types of adhoc approaches i.e. proactive or reactive approach [2], [3]. In reactive approach, route is created / established when it is required to transmit data and when data transmission completes, the route is invalidated and is finally removed after some timeout period. Adhoc on demand distance vector routing protocol (aodv) is one of the examples of reactive approach. if we use adhoc approaches by using gps information of nodes then we call it location aided routing (lar) [4], [5].

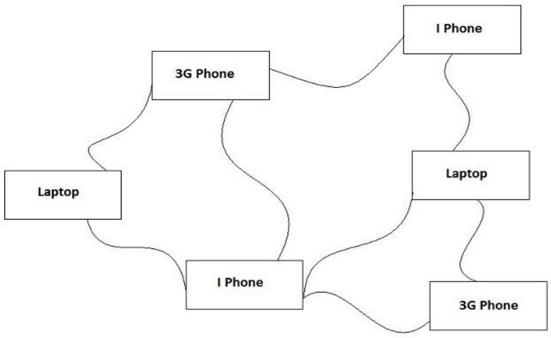

Figure 1. Example of MANET

II. Adhoc on Demand Distance Vector Routing

Adhoc on demand Distance Vector (AODV) is table driven, reactive approach which discovers route to destination by broadcasting the route request packet [2]-[4]. To avoid loops, destination node only responds to the first route request packet arrived and ignores the subsequent route request packets from the same sender node. When this route request reaches the destination it also keeps back track of source node so that in case of route reply it is easy to traverse back to source node as shown in Fig. 2. AODV keeps the routes in form of routing tables along with timers for validity of these routes. AODV is conservative type of protocol that is why only one route from source to destination is maintained because it keeps track of latest / fresh route by using sequence numbers. Each node also has information of predecessor nodes. When link from source to destination fails the route error is propagated back to source node, predecessor nodes and all other nodes which were involved in route creation.

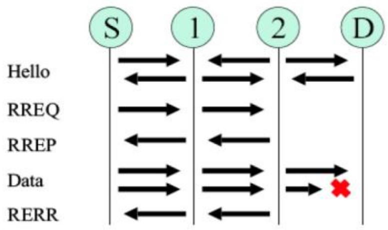

Figure 2. Send / Receive / error routing packets in AODV

III. Dynamic Source Routing

Manuscript received June 11, 2014; revised August 13, 2014.

doi: 10.12720/lnit.2.2.134-140

Dynamic Source Routing (DSR) is a reactive approach in which route caches are used to store the routes. It is based on the concept of source routing which means that source node knows the complete hop by hop route from source to destination [2]. This hop by hop route is attached inside packet header while sending data. Initially when source node does not know the route to destination then it broadcasts route request packet just like traditional AODV and destination node upon receiving the route request packet replies back to source node.

In DSR, destination node may receive multiple route request packets and it entertains all of them by sending route replies to all the requests therefore source node may receive more than one route to destination. During this process, source node also discovers routes to all other nodes within the route to destination and intermediate nodes in between source and destination also store routes to source and destination and to all other nodes within the route. There is also concept of promiscuous mode in which if nearby nodes have smaller route to destination then they may send gratuitous replies to source that it has smaller route to destination. There is an advantage of multiple routes from source node to destination because on failure of one route source may use alternate route stored in cache. But in some cases multiple route replies from destination may cause flooding. In case of link failure route error is propagated to source and nodes within route are also updated about the status of stale route. But route error is not propagated to nodes finding routes through promiscuous listening. In DSR, there is no concept of route timers for controlling the validity of routes. Neither concept of sequence numbers is used therefore multiple routes from source to destination may exist.

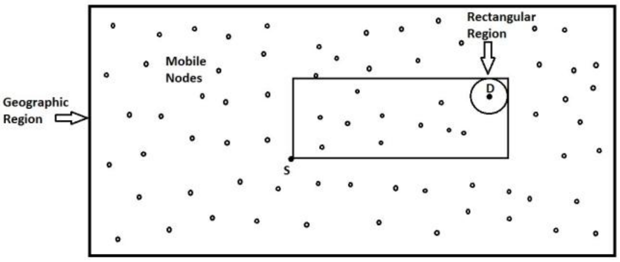

Figure 3. Type I LAR

IV. Location Aided Routing (LAR)

Our Thesis is focused mainly on LAR to optimize AODV for better performance. Basic challenge is to reduce flooding by reducing the generation of route request packets and their propagation to the network [2] [5]. For this purpose, we used Global Positioning System (GPS) to optimize the algorithm by reducing routing packets.

There are two types of Location Aided Routing which are as follows:

A. *Type I LAR*

This is a region based routing in which a smaller region or rectangle is calculated by knowing the coordinates of source node and destination node, which we may also say is a subset of bigger region [2]. GPS coordinates of source node and destination node help in creation of rectangle for reducing the number of routing packets. Whenever source node initiates route request, it broadcasts route request packet and the nodes which reside inside the rectangle accept this route request packet whereas nodes residing outside this rectangle simply discard it which is shown in Fig. 3.

B. *Type II LAR*

This type of routing works by using distance formula assuming GPS information at each node is known. Depending upon the distance of node from destination it senses whether it is moving towards destination or away from destination. Comparison of this distance of node with the previous node suggests whether it will receive the route request or not.

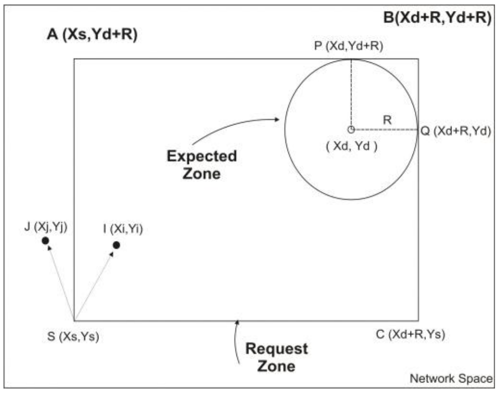

Figure 4. Rectangular Region comprising expected / request zone

V. Proposed Scheme

We have optimized the AODV protocol by reducing the number of control packets with the help of GPS coordinates thereby reducing power consumption [5], [6]. Initially source node does not know the coordinates of destination node therefore optimized AODV (LAR or O-AODV) algorithm broadcasts route request packet in an expanding ring search manner and when route request is received by destination node then it sends route reply along with its fresh coordinates, traversing the path back to source node. Now GPS coordinates of destination are available in the GPS table which may be referred if required in future. Based on GPS, rectangular region is made with source node at one corner of rectangle and destination node at other corner of rectangle as shown in Fig. 4. This rectangular region is further divided into request zone and expected zone. Expected zone is calculated based on the speed v of destination node which means that for next t seconds destination node is expected to be found in circle of radius $S = v/t$. If we subtract expected zone from rectangle then remaining region is request zone. We can easily understand route discovery process by using concept depicted in Fig. 4 in which we assume that source S has coordinates Xs and Ys whereas destination node has coordinates Xd and Yd. Source S now broadcasts route request packet which is received by both nodes denoted by J with coordinates Xj and Yj and I with coordinates Xi and Yi. Now coordinates of both nodes J and I are compared with coordinates of request zone. Node J coordinates is not within request zone coordinates it means that it is outside request zone and hence discards route request. Whereas node I receive route request because it is within request zone coordinates. This process continues and nodes outside request zone keep discarding the route requests whereas nodes inside request zone keep accepting the route requests until route request reaches destination D by traversing intermediate nodes. Destination node in return generates route reply traversing the same path back to source S.

A. *GPS table in AODV Protocol*

We added an additional table to store GPS coordinates for O-AODV [6]. This table has GPS timeout, to check the validity of coordinates. If GPS timeout is false then it fetches fresh coordinates. Some data fields of GPS table are given below:

- Node x-coordinate.
- Node y-coordinate.
- Node Velocity.
- GPS Expire.

B. *Optimized Route Reply Packet*

Since for first time source node S does not knows coordinates of destination therefore when destination node receives the route request message it generates route reply packet. This reply packet traversing the reverse path contains two additional parameters i.e. coordinates and velocity along with it shown in Fig. 5.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |R|A|    Reserved     |Prefix Sz|   Hop Count   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Destination IP address                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Destination Sequence Number                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Originator IP address                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Lifetime                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         X-coordinate                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Y-coordinate                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          V-velocity                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5. Optimized route reply packet

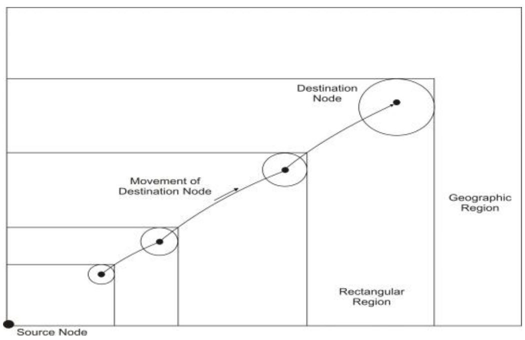

Figure 6. Variable rectangular region

C. *Variable Size of Rectangle*

It is possible that there are not enough intermediate nodes to transfer data from source to destination then algorithm will sense the problem and automatically increase size of rectangle accordingly as shown in Fig. 6. It will go on increasing rectangle size until there are enough intermediate nodes to send the data from source to destination.

VI. Simulation Results and Discussions

For simulation purpose, we have used Network Simulator 2 (NS2) in which basic AODV protocol is already available [7]. Hence we modified this basic AODV to cater for GPS enabled AODV or LAR for optimization purpose. Researchers in Berkley did intensive working and research for NS2. It is discrete type of Simulator which is used in research for various protocols including TCP, UDP etc. Fig. 7 shows different stages of NS2 form coding till output, which includes coding in C++ language and front end interfacing done in OTCL scripting for defining interface characteristics or parameters e.g. number of nodes, type of traffic, source node, destination node etc.

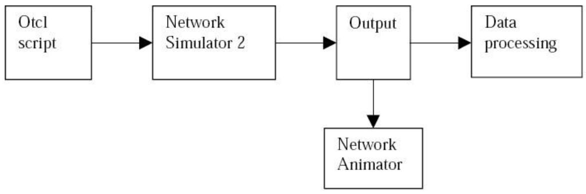

Figure 7. Work flow of network simulator 2

A. *Simulation Trace/NAM Files*

Simulation in ns2 normally includes mobility extension therefore input files [8] are as follows:

- Communication file that defines the pattern of movement of nodes.
- Trace file which defines different events e.g. when data is transferred or when route is broken etc.

Communication file can be created using available scripts which generate random movement pattern over a given period of time [7]. This file is then linked in the TCL script whereas OTCL provides linkage between TCL and C++ code, which after simulation generates trace output file. Using trace file important information is collected and then different performance parameters are analyzed. These parameters are then plotted in graphical form for understanding and comparison.

B. *TCL Script and Traffic Generation*

TCL Script is used to define the parameters of nodes like source node and sink or destination node etc. TCL script also provides option to select protocol e.g. in our case is optimized AODV and DSR is used. Communication file or movement of nodes is generated through setdest command which is built into NS2. Setdest command has arguments which can be no. of nodes, speed of nodes, total simulation time, pause time, x coordinate or y coordinate etc. After appropriately setting the arguments, output file is generated containing pattern for random movement of nodes encompassing simulation time. This output file is then imported into TCL script.

TABLE I. NETWORK SIMULATOR PARAMETERS

S. No.	Parameter	Value
1	Simulator	NS2 (Version 2.35)
2	Channel Type	Channel / Wireless Channel
3	Radio Propagation Model	Propagation / Two way ground wave
4	Network Interface Type	Phy / WirelessPhy
5	Mac Type	Mac / 802.11
6.	Interface Queue Type	Queue / Drop Tail
7.	Link Layer Type	LL
8.	Antenna	Antenna / Omni Antenna
9.	Data Packet Size	1040 Bytes
10.	Area (M X M)	1000X1000
11.	Simulation Time	200 sec
12.	No. of Nodes	20-60 Nodes (Pause=0 sec, v = 10 m/s)
13.	Speed of Nodes	10-50 m/s (Nodes=50, Pause=0 sec)
14.	Pause Time of Nodes	0, 2, 4, 6, 8, 10 sec (Nodes=50, v=25 m/s)
15.	Routing Protocol	O-AODV, AODV, DSR

C. Performance Parameters

Following are the performance parameters for which varying no. of nodes, speed of nodes and pause time of nodes are analyzed [4].

1) Packet Delivery Ratio (PDR)

This gives ratio of how many packets were sent divided by number of packets received by receiver.

2) Energy consumed

Energy consumed is the total amount of energy used by all the nodes during the total simulation time. It is a good parameter to calculate energy.

3) End-to-end delay

End to end delay is the time between when packet leaves source and reaches destination. When we add end to end delay of all packets and divide it by total time then it provides average end to end delay. Possible causes of delays are buffering when route discovery is going on, transmission delay at MAC layer etc.

4) Throughput

Throughput defines how fast packets are transferred from source to destination divided by time when last packet is received.

5) Packets dropped

It gives a measure of traffic generated and congestion because packets are dropped during congestion and effects overall packet transfer count.

D. Simulation Results

Simulation results are collected / analyzed by using the following NS2 parameters and creating three different scenarios which are described in following table.

1) Varying No. of nodes

Comparison of O-AODV, AODV & DSR is done with different no. of nodes i.e. 20, 30, 40, 50 and 60 with pause time of 0s and speed at 10m/s. Results are then plotted against above mentioned performance parameters. It is done firstly with O-AODV and then repeated with AODV and DSR as follows:

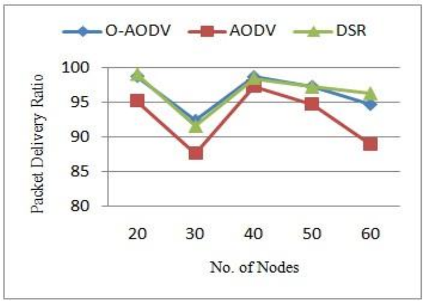

Figure 8. Varying no. of nodes vs PDR

We can see from graph in Fig. 8 that packet delivery ratio is more in O-AODV as compared to AODV or DSR and as we increase number of nodes O-AODV outperforms AODV.

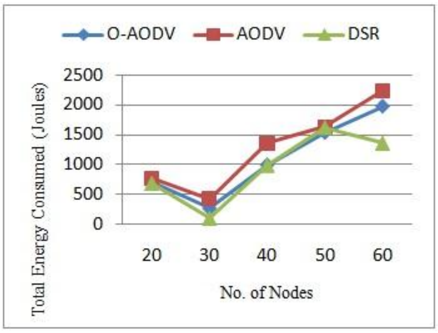

Figure 9. Varying no. of nodes vs total energy consumed

From Fig. 9 we can see that energy consumed is less in O-AODV as compared to AODV because routing packets are lesser in O-AODV whereas energy consumed in DSR is even lesser than O-AODV because of readily available routes in route cache.

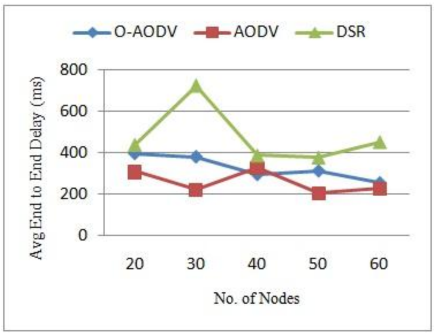

Figure 10. Varying no. of nodes vs Avg. End to End Delay

We can see from the graph in Fig. 10 that average end to end delay in O-AODV is more than AODV because in O-AODV calculations are involved for creating rectangle and GPS etc which increases the delay to some extent. End to end delay in DSR is even greater than O-AODV due to finding of multiple routes in DSR or due to lengthy route which after link failure, may be chosen as next available route.

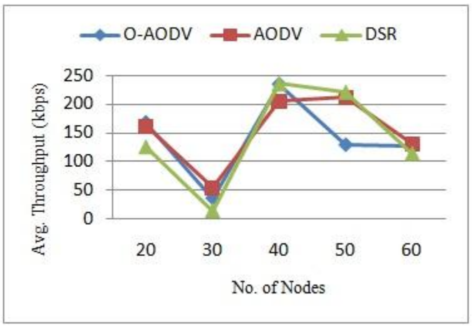

Figure 11. Varying no. of nodes vs Avg. throughput

From Fig. 11 we can see that average throughput of O-AODV and AODV remains almost same for up to 40 no. of nodes. But in between 40 and 50 no. of nodes throughput of O-AODV decreases whereas throughput of AODV remains almost constant with a slight increase and finally throughput of both AODV and O-AODV becomes equal at 60 no. of nodes. Throughput of DSR is less than both AODV and O-AODV which increases both AODV and O-AODV after 40 no. of nodes.

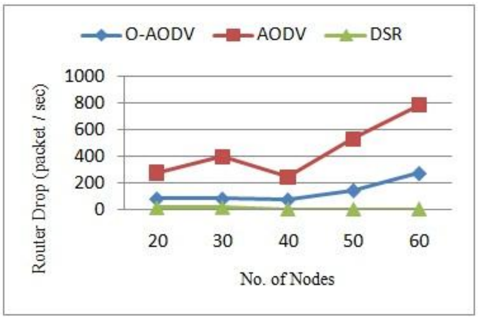

Figure 12. Varying no. of nodes vs Router Drop

From Fig. 12, we can see that router Drop of AODV is more than both O-AODV and DSR which increase after 40 no. of nodes. Whereas, router drop of O-AODV is less than AODV with slight increase after 40 no. of nodes. Router drop for DSR is least of both AODV and O-AODV and is almost equal to 0 because of availability of multiple routes.

2) Varying speed of nodes

In this case speed of nodes is varied whereas number of nodes and pause time is kept constant and are plotted against performance parameters. In graph DSR, O-AODV and AODV are plotted for comparison. Keeping number of nodes to 50 and pause at 0 s comparison graph for speeds 10, 20, 30, 40 and 50 m/s are as follows:

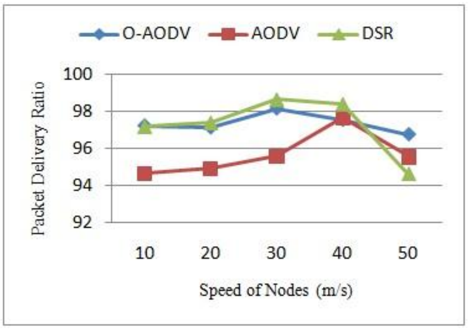

Figure 13. Varying speed of nodes vs packet delivery ratio

As seen from Fig. 13, PDR of DSR and O-AODV is almost same with sudden decrease of PDR in DSR after speed of 40 m/s. Whereas, PDR of AODV is less than both O-AODV and DSR but it increase slightly after 40 m/s when compared with DSR.

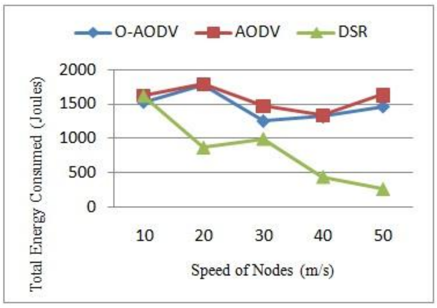

Figure 14. Varying speed of nodes vs Total Energy Consumed

Total energy consumed for O-AODV and AODV is almost same whereas total energy consumed by DSR decreases as speed increases.

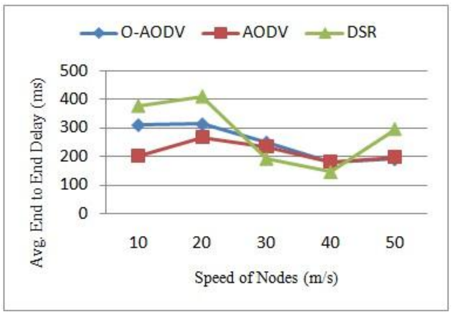

Figure 15. Varying speed of nodes vs Avg. End to End Delay

As shown in Fig. 15, average end to end delay of AODV is lesser than both AODV and O-AODV in the start average end to end delay becomes same for AODV and O-AODV after 30 m/s. Whereas, Average end to end delay for DSR is greater than both AODV and O-AODV which decrease than both AODV and O-AODV at 35 m/s and finally increase than both AODV and O-AODV after 45 m/s.

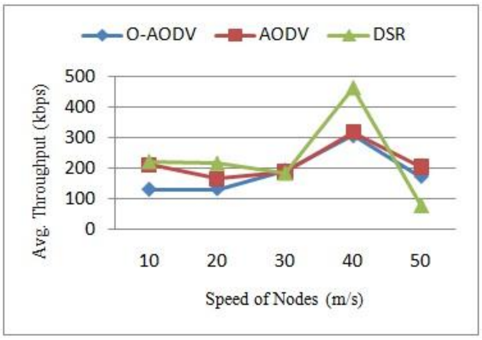

Figure 16. Varying speed of nodes vs Avg. Throughput

As shown in Fig. 16 throughput of O-AODV is slightly less than AODV in start i.e. between 10 m/s and 30 m/s which after 30 m/s becomes equal for both O-AODV and AODV. Throughput for DSR is more than both O-AODV and AODV which increases abruptly after 30 m/s and then decreases after 40 m/s.

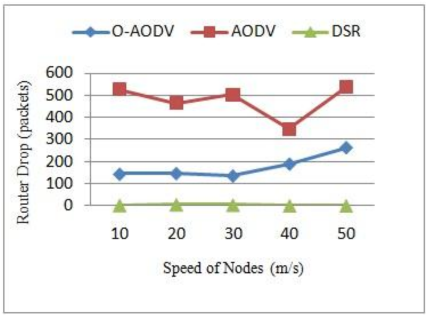

Figure 17. Varying speed of nodes Vs Avg. End to End Delay

As shown in Fig. 17, router drop for AODV is more than both AODV and DSR. Whereas, router drop for DSR is the least i.e. 0 router drop for all speeds.

3) Varying pause time of nodes

Now pause time is varied among 0, 2, 4, 6, 8 & 10 s whereas speed is constant at 25 m/s and number of nodes is kept constant at 50. It is plotted with above mentioned performance parameters for O-AODV, AODV and DSR.

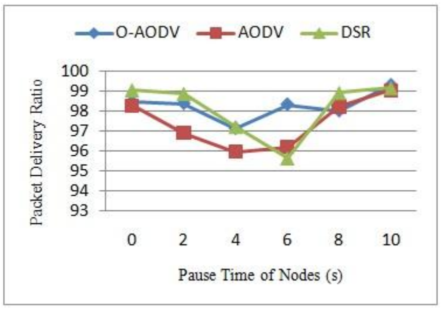

Figure 18. Varying pause time of nodes Vs packet delivery ratio

As shown in Fig. 18, PDR for O-AODV is better than both DSR and AODV. Whereas, DSR continuously decreases after pause time of 2 s and then increases at pause time of 6 s.

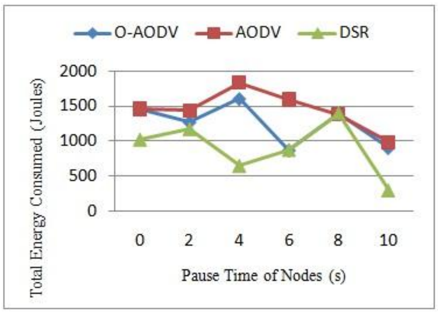

Figure 19. Varying pause time of nodes Vs Total Energy Consumed

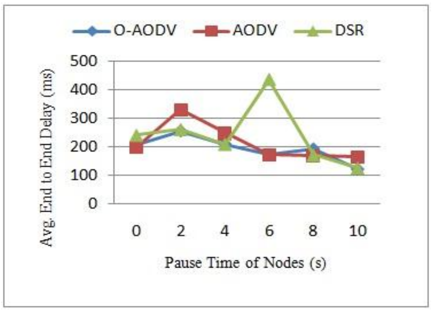

Figure 20. Varying pause time of nodes Vs Avg. End to end Delay

From Fig. 19 we can see that total energy consumed by AODV is more than both O-AODV and DSR whereas, DSR is lowest than both AODV and O-AODV.

As shown in Fig. 20, O-AODV is better than both AODV and DSR. Whereas, DSR has peak in between pause time of 4 s and 8 s.

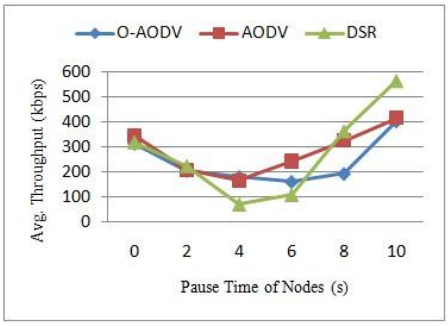

Figure 21. Varying pause time of nodes Vs Avg. Throughput

As shown in Fig. 21, throughput of AODV is better than O-AODV. Whereas, throughput of DSR is lowest at 4 s which gradually increases between 4 s and 6 s with a sudden increase at pause time of 6 s and goes on increasing up to 10 s.

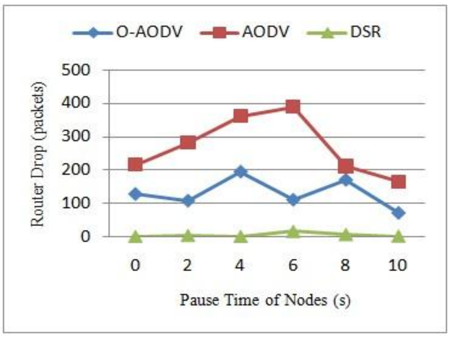

Figure 22. Varying pause time of nodes Vs Router Drop

Router drop for AODV is maximum whereas router drop for DSR is lowest. O-AODV has peaks in between 2 s and 6 s and then another peak in between 6 s and 10 s.

VII. Conclusions

In this thesis, Location Aware Routing Protocols along with tactical MANETs have been discussed. An optimized algorithm based on LAR has been designed and while evaluating and simulating, it has been observed that this optimized system reduces energy consumption at each node. LAR which we may also call as O-AODV outperforms AODV in packet delivery ratio and router drop whereas throughput and end to end delay of both O-AODV and AODV remained almost same due to calculations involved for finding coordinates in O-AODV. DSR when compared with O-AODV remained better in both router drop and energy consumed because of the advantage of source routing in which multiple routes to destination are readily available but in PDR, DSR remained almost equal to O-AODV.

References

[1] V. Kalpana, S. Kannan, and S. Karthik, “Performance evolution and comparison of geographical location aided routing and AODV routing in MANET,” *Internation Journal of Modern Engineering Research,* vol. 2, no. 4, pp. 2236-2241, Jul-Aug. 2012
[2] S. R. Das, C. E. Perkins, E. M. Royer, and M. K. Marina, “Performance comparison of two on-demand routing protocols for ad hoc networks,” Department of Computer Science, Texas A&M University, College Station, TX 77843-3112, USA, 2000.
[3] D. Espes and Z. Mammeri, “Adaptive expanding search methods to improve AODV protocol,” *IST Mobile and Wireless Communications Summit*, July 2005.
[4] G. Jayakumar and G. Gopinath, “Ad Hoc mobile wireless networks routing protocols–A review,” *Journal of Computer Science*, vol. 3, no. 8, pp. 574-582, 2007.
[5] A. M. Mohammad, “Energy effecient location aided routing protocol for wireless MANETS,” *International Journal of Computer Science and Information Security*, vol. 4, no. 1-2, 2009.
[6] H. Asenov and V. Hnatyshin, “GPS enhanced AODV routing, department of computer science,” Rowan University, Glassboro, NJ. 08028.
[7] P. Meeneghan and D. Delaney, “An introduction to NS, Nam and OTcl scripting,” Technical Report Series NUIM-CS-TR-2004-05.
[8] A. U. Salleh, Z. Ishak , N. Md. Din, and M. Z. Jamaludin, “Trace analyzer for NS-2,” in *Proc. 4th Student Conference on Research and Development*, Shah Alam, Selangor, Malaysia, 27-28 June, 2006.

Noman Younis originates from Wah Cantt Pakistan. He received his Bachelors of Computer Engineering in 2007 from Bahria University Islamabad Pakistan and is currently studying towards his Masters of Computer Engineering from National University of Sciences and Technology, CEME Rawalpindi, Pakistan. He remained employed in field of Computer Networks in Digital Processing Systems Islamabad from 2008 to 2009 and is currently employed in Pakistan Ordnance Factories since 2009 in the field of Computer Networks.

Shoab Ahmed Khan is Head of Department of Computer Engineering in National University of Sciences & Technology, CEME Rawalpindi. He received Ph.D. in Computer Engineering form USA and did research work in image processing, parallel processing and ASIC Design, microprocessor design, microcontroller design and Mobile Adhoc networks.