# Comparative Analysis of AODV, DSR, GRP, OLSR and TORA by varying Number of Nodes with FTP and HTTP Applications over MANETs

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## ABSTRACT
Recent years have witnessed an extreme growth in research and development in the field of Wireless Networks. The special focus has been on Ad-hoc Networks especially Mobile Ad-hoc Network (MANET). Mobile ad-hoc network is a dynamic instant mutihop radio infrastructure-less temporary network of wireless mobile nodes in which each participating nodes act as host and router at the same time. Routing is a crucial activity and plays an important role in the success of the communication in these structures. Many routing protocols have been presented for Mobile Ad-hoc network since last decade. The major difference between these protocols lies in the mechanism of searching, maintenance and recovering the route path. In the recent researches, there are numerous MANET routing protocols aiming to find the most suitable path from source to destination. In this paper, a simulation based comparative analysis is performed on various types of routing protocols over MANET. Ad Hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Temporally-Ordered Routing Algorithm (TORA), Optimized Link State Routing (OLSR) and Geographic Routing Protocol (GRP) has been considered for investigation in this paper based on throughput, delay, load and data dropped performance metrics using OPNET Modeler .

## Keywords
AODV, DSR, GRP, MANET Routing Protocols, OLSR, TORA

## 1. INTRODUCTION
In the recent decade there has been a step growth in the market of laptops, hand held devices and notebooks. These devices are battery operated with limited power but have the challenge of high processing capability. These mobile devices allow people to access internet or communicate with other devices by using wireless network. Wireless networks are cheaper and requires less effort as compared to wired networks and there is no requirement of any additional devices that need to be added at additional cost [1]. The continuous advancement in the field of wireless network has led to development of Ad-hoc Networks which allow the devices to communicate with each other directly without relying upon any base station. Routing plays an important role as the communication efficiency depends on the chosen route and the efficiency of the route [2]. Mobile Ad-hoc network (MANET) is further advancement in the field of Ad-hoc networks. In MANET the devices are called nodes which play a dual role by acting as host and router whenever required. The communication model used in MANETs is a multi-hop model. These temporary networks are dynamic in nature and can be set up randomly and when needed. Efficient route discovery and maintenance are key issues in MANETs. Routing has been the key field of choice for recent research activities [3].

In MANET all the nodes are mobile and range of each host is also limited so routing in such conditions is a bigger challenge. There are several types of routing protocols developed for tackling this challenge which are divided into various categories. The Table-driven (Proactive) and On-demand (Reactive) routing protocols are two main categories of routing protocol [4]. Apart from the two categories routing protocols can be categorized into hybrid routing protocols which constitute from the above two types. The Geographic position based routing protocols are also a key routing protocols of MANETs. The key difference among these protocols is the mechanisms to discover a route and then manage it until the packet is not delivered [5].

In various research papers performance of MANET routing protocols have been compared using various tools like NS-2, OPNET, GLOMOSIM and QUALNET. The results in all such papers shows a varying performance of various routing protocols when analyzed with changing scenarios, mobility patterns, traffic loads, area and number of nodes. In this paper, we have evaluated performance of AODV, DSR, TORA, OLSR and GRP routing protocols based on ftp and http applications with varying number of nodes and analyzed by means of throughput, delay, load and data dropped metrics by using OPNET Modeler 14.5.

The rest of paper is organized as follows: Section 2 presents brief overview of MANET routing protocols that we evaluate. Section 3 describes simulation environment. Section 4 shows simulation results and the discussion related to the results. Section 5 shows analysis of results. Finally, conclusion is drawn in section 6 followed by future work in section 7.

## 2. MANET ROUTING PROTOCOLS
The first three protocols are selected from Reactive category namely AODV, DSR and TORA and the fourth is selected from proactive category namely OLSR whereas the last protocol is selected from Geographic Position Information based routing namely GRP.

### 2.1 Ad-hoc On Demand Distance Vector
AODV is reactive routing protocol that creates routes only on-demand and reduce the number of broadcast. A route request message (RREQ) is broadcasted by the source until it reaches an intermediate node that contains recent route information or till it reaches the destination. The node which has the path to destination or the destination itself sends a route reply message (RREP) by constructing the reverse path. If in case there is some link failure or any other error then the node

sends an error message (RRER) so that the process of request is re initiated [6]. AODV is a hop by hop routing protocol which first checks to see if it has a valid route to destination before sending data. If a route exists then it sends data using that route otherwise it initiates route discovery process. The sequence number is used to determine the freshness of the route. A unique route request is generated with the help of the broadcast ID when used along with the node IP address [7].

## 2.2 Dynamic Source Routing

DSR is an on-demand routing protocol which follow the concept of source routing where the initiator knows the complete hop-by-hop route to the destination. Every node maintains the information of routes that it is knows in its route cache and continuously updates the entries whenever it knows about new routes. The route discovery process is initiated only when initiator find no route to the destination in its route cache. Route discovery process follows the concept of flooding the network with route request messages (RREQ). Each node receiving the RREQ message rebroadcasts it until it finds destination or the path to destination. The node which is destination or has a path to destination sends a route reply message (RREP) back to the initiator node. The route adopted by the RREP message is saved in the route cache for use in future. If any error occurs or the link in between the route is broken then the route error message (RRER) makes sure that the initiator is informed. DSR adopts a very intensive use of source routing and route caching mechanism. There is no special mechanism deployed to check for the route loops [8].

## 2.3 Optimized Link State Routing

OLSR is a point to point routing protocol which is based on the concept of traditional link state algorithm. The nodes maintain topology information about the network by exchanging link state messages periodically. The size of control messages and the number of rebroadcasting nodes during each route update is minimized by deploying the concept of Multi Point Relay (MPR). Each node selects a set of neighbors known as multipoint relays to transmit its packet whenever there is a change in topology. Any node that lies outside the range can only read and process each packet but cannot transmit it. Only multipoint relay (MPR) nodes are allowed to flood the topology control (TC) message. The mechanism of topology discovery or diffusion is followed by OLSR with the help of periodic and triggered Topology Control (TC) messages. [9].

## 2.4 Temporally-Ordered Routing Algorithm

TORA is a highly adaptive, efficient and scalable distributed on demand routing protocol for multi hop networks. TORA is source initiated routing protocol based on the concept of link traversal and is specially purposed for highly dynamic mobile, multi-hop wireless networks [10]. The concept of shortest path from source to the destination is not followed by TORA as it requires large amount of bandwidth. TORA algorithm forwards the packets to the destination by maintaining the "direction of the next destination" which means that the initiator contains one or two "downstream paths" to the destination node. The concept of "directed acyclic graphs" is used by this routing protocol to establish downstream paths to destination. Such a DAG is known as "Destination Oriented DAG" and a node marked as destination oriented DAG is the last node and no further link originates from it. TORA uses three messages: Query (QRY) message route creation, Update (UPD) message route maintenance, and Clear (CLR) message for route erasure [11]. TORA has a unique feature that it maintains multiple routes from source to the destination so that there is no reaction required when any topological changes occurs. The protocol reacts only when it loses all the routes to the destination [12].

## 2.5 Geographic Routing Protocol

GRP is classified as a position based proactive routing protocol. GRP uses the concept of Global Positioning System (GPS) to track the location of node. The entire network is divided into quadrants to optimize route flooding. The entire world is divided into quadrants ranging from Lat, Long (-90, -180) to Lat, Long (+90, + 180). The flooding position is updated on distance when a node moves and crosses the neighborhood. "Hello" messages are used to track the positions of the neighbors. When a node is unable or cannot send packet to the next node then it returns its packet to last node by using route locking mechanism [13]. GRP follows another approach apart from the concept of actual geographic coordinates received by the GPS. This approach is based on the concept of reference points in the fixed coordinate system. The major benefit of geographic routing protocol is that it prevents long network-wide searches for the destinations. The major disadvantage of GRP is that all the nodes must have access to their geographic coordinates at every moment. The speed of route update must be very fast due to the mobility of the nodes [14].

# 3. SIMULATION ENVIRONMENT

The simulations are performed using OPNET Modeler 14.5 with the nodes spread randomly over a square area of 1000 m x 1000 m. The mobility model used is "Random Waypoint Model" in which a node randomly chooses a destination, called waypoint and moves towards it in a straight line with a constant velocity [15]. The simulations are divided into scenarios with initially 30 nodes and then increasing the number to 60 and 90. The simulation was run for 600 simulation seconds with seed value of 128 using two application ftp and http. The pause time for the simulation is assumed to be constant. The speed varies uniformly from 0-10 m/s. The kernel mode is set to be optimized. The details are listed in Table 1.

**Table 1. Simulation Parameters**

| Simulation Parameter | Value |
|---|---|
| Number of Nodes | 30, 60 and 90 |
| Simulation Time | 600 sec (10 min) |
| Simulation Area | 1000 m X 1000 m |
| Routing Protocols | AODV, DSR, TORA, OLSR and GRP |
| Node Movement Model | Random waypoint |
| Data Rate | 11mbps |
| Application Name | ftp (High load) and http (image browsing) |
| Bandwidth | 2Mb/s |
| Simulator | OPNET Modeler 14.5 |

The performance of the simulation is analyzed according to different performance metrics. This quantitative measurement is useful for assessing the performance of network using different routing protocols. The following performance metrics are employed in this study:

(i) Throughput: Throughput is defined as the ratio of the total data that reaches a receiver from the sender.

(ii) Delay: Delay is the time of generation of a packet by the source up to the destination reception. So this is the time that a packet takes to go across the network.

(iii) Load: Load is represented in bit/sec and it is the total load submitted to WLAN layers by all higher layers in all WLAN nodes of the network.

(iv) Data Dropped: Data dropped shows how many packets successfully sent and received across the whole network. It also explains the number of packet dropped during the transmission due to interference from other devices.

## 4. SIMULATION RESULTS

In this section we analyze the performance of each routing protocol based on the results obtained after simulation experiments are conducted on each routing protocols. The main target of this paper is to evaluate the performance and behavior of each routing protocol with respect to the effect of varying the number of nodes for two different applications i.e. ftp (high load) and http (image browsing). The results are based on evaluation metrics of delay, load, throughput and data dropped. We have divided our study into three sets of experiments: the first set studies the performance of five protocols over a small number of nodes (30 nodes) followed by increase in number of nodes to 60 in second set and further increasing the number of nodes to 90 in third set of experiment. All the three sets shows the results for ftp with high load and http with image browsing separately.

### 4.1 Delay

The Fig. 1(a) shows the entire delay for 30 nodes using ftp. The AODV protocols show least delay followed by OLSR and GRP protocols. The TORA protocol show highest value of delay. The Fig. 1(b) shows entire delay for 30 nodes using http. The OLSR protocol show least delay followed by DSR and GRP. The TORA protocols show maximum value of delay.

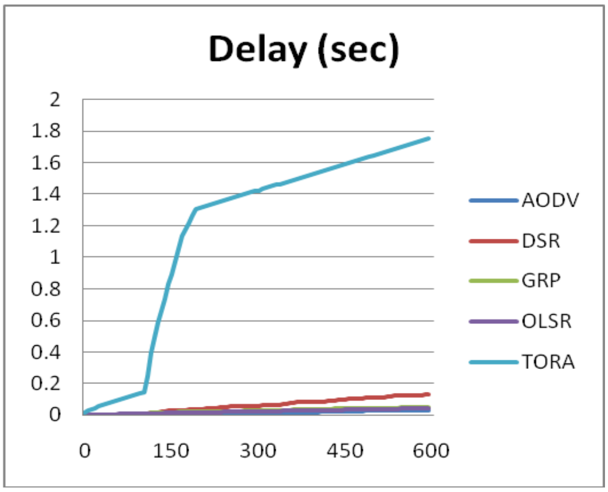


**Fig 1(a): Delay for 30 nodes using ftp**

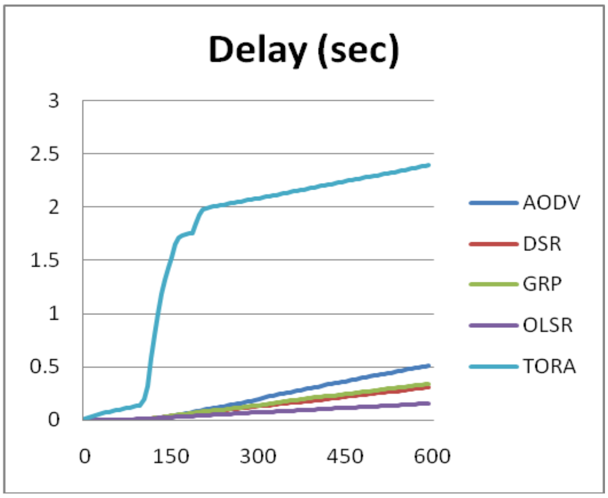


**Fig 1(b): Delay for 30 nodes using http**

The Fig. 2(a) shows the entire delay for 60 nodes using ftp. The GRP protocols show least delay followed by OLSR and AODV protocols. The TORA protocol show highest value of delay. The Fig. 2(b) shows entire delay for 60 nodes using http. The OLSR protocol show least delay followed by GRP and DSR. The TORA protocols show highest value of delay.

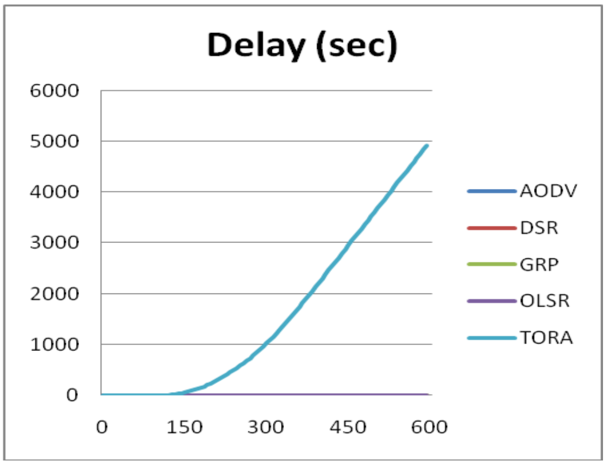


**Fig 2(a): Delay for 60 nodes using ftp**

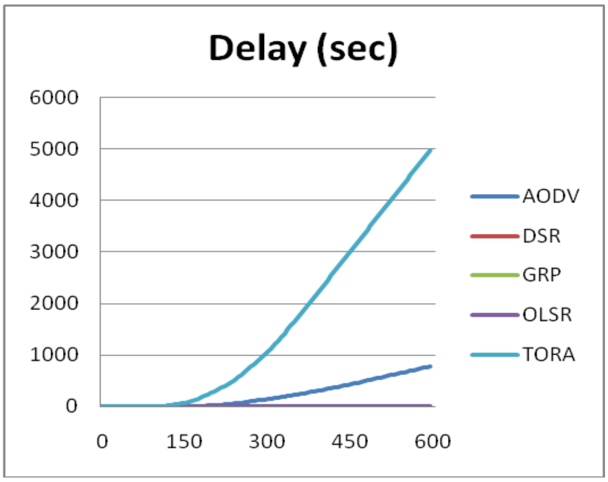


**Fig 2(b): Delay for 60 nodes using http**

The Fig. 3(a) shows the entire delay for 90 nodes using ftp. The GRP protocols show least delay followed by OLSR and AODV protocols. The TORA protocol shows highest value of delay whereas all the other protocols show almost negligible delay. The Fig. 3(b) shows entire delay for 90 nodes using http. The OLSR protocol show least delay followed by DSR and GRP. The TORA protocols show highest value of delay.

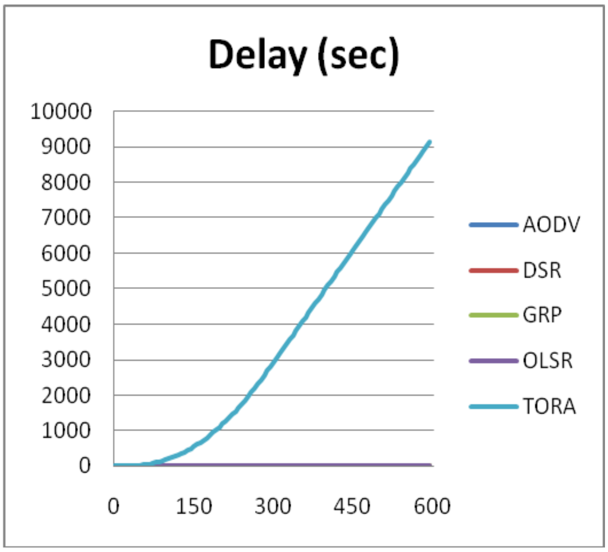


**Fig 3(a): Delay for 90 nodes using ftp**

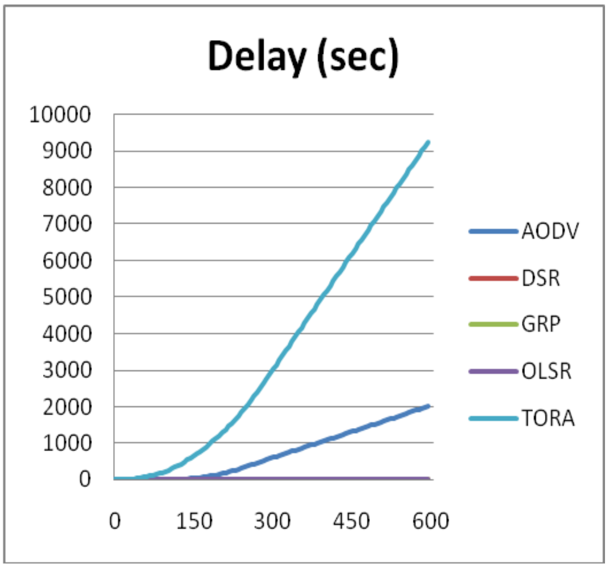


**Fig 3(b): Delay for 90 nodes using http**

## 4.2 Load

The Fig. 4(a) shows the entire load for 30 nodes using ftp. The AODV protocols show least load followed by DSR and GRP and OLSR protocols. Initially all the protocols move on with equal values. The TORA protocol show highest value of load. The Fig. 4(b) shows entire load for 30 nodes using http. The AODV protocol shows least load followed by DSR, OLSR and TORA protocols. TORA, DSR and OLSR protocols have almost similar performance whereas GRP protocols show highest value of load.

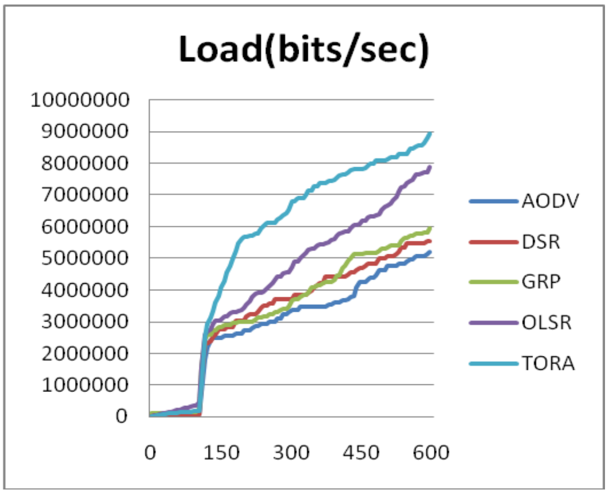


**Fig 4(a): Load for 30 nodes using ftp**

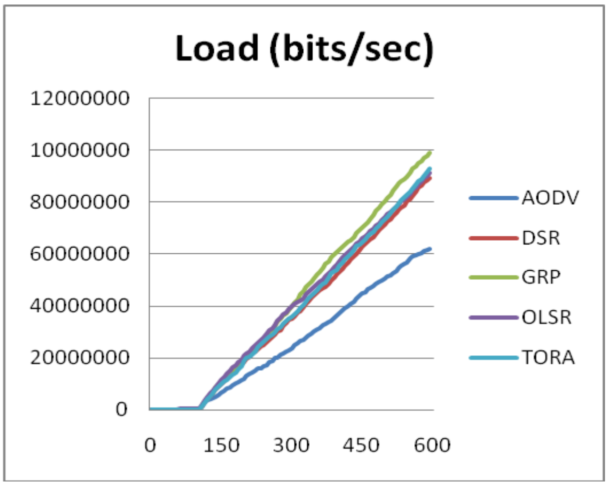


**Fig 4(b): Load for 30 nodes using http**

The Fig. 5(a) shows the entire load for 60 nodes using ftp. The GRP protocols show least load followed by DSR and AODV protocols. The TORA protocol show highest value of load. The Fig. 5(b) shows entire load for 60 nodes using http. The TORA protocol shows least load whereas OLSR protocols show highest value of load.

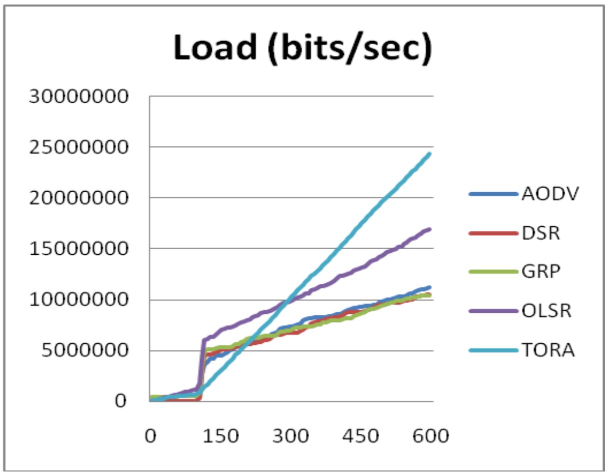


**Fig 5(a): Load for 60 nodes using ftp**

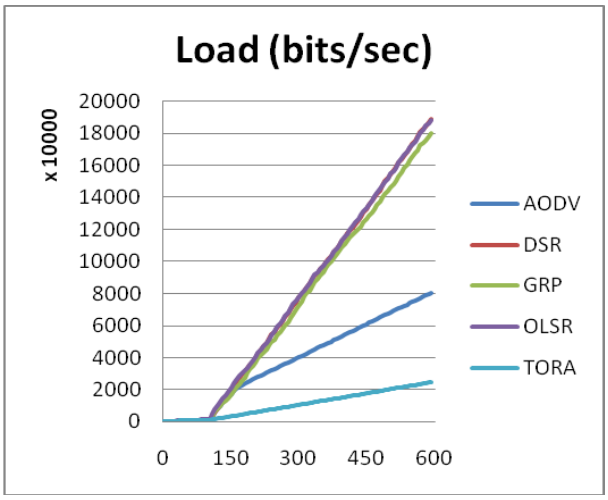


**Fig 5(b): Load for 60 nodes using http**

The Fig. 6(a) shows the entire load for 90 nodes using ftp. The DSR protocols show least load followed by GRP and AODV protocols. The TORA protocol show highest value of load. The Fig. 6(b) shows entire load for 90 nodes using http. The TORA protocol shows least load whereas OLSR protocols show highest value of load.

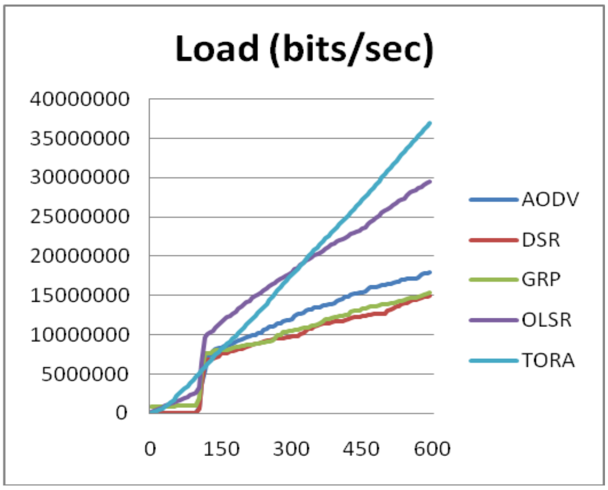


**Fig 6(a): Load for 90 nodes using ftp**

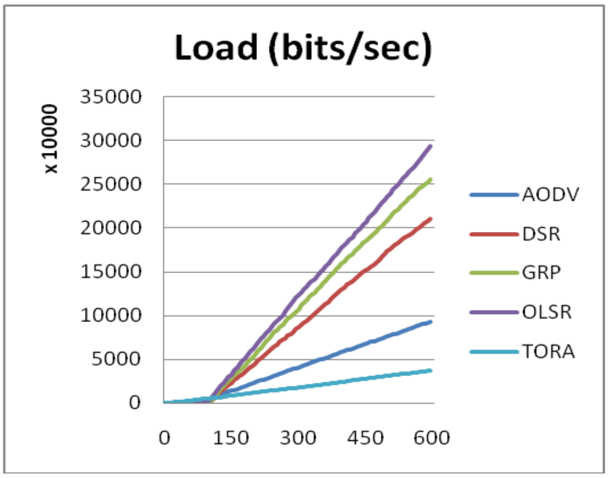


**Fig 6(b): Load for 90 nodes using http**

## 4.3 Throughput

The Fig. 7(a) shows the entire throughput for 30 nodes using ftp. The DSR protocols show least throughput followed by TORA, AODV and GRP protocols. The OLSR protocol show highest value of throughput which is 71107403 bits/sec. The Fig. 7(b) shows entire throughput for 30 nodes using http. The DSR protocol shows least throughput whereas AODV protocols show highest value of throughput which is 277992335 followed by OLSR

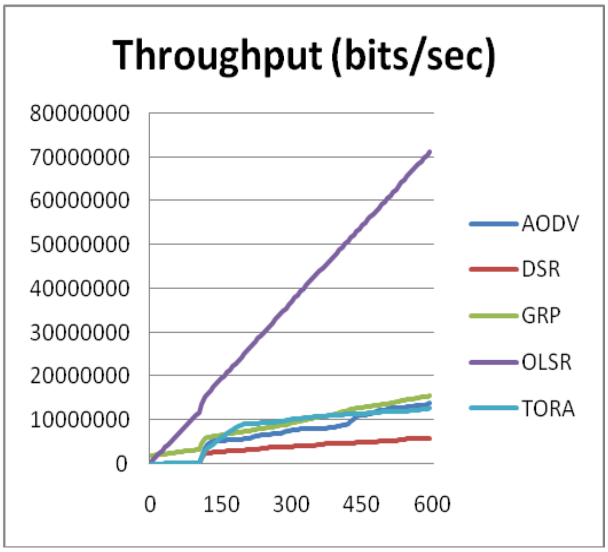


**Fig 7(a): Throughput for 30 nodes using ftp**

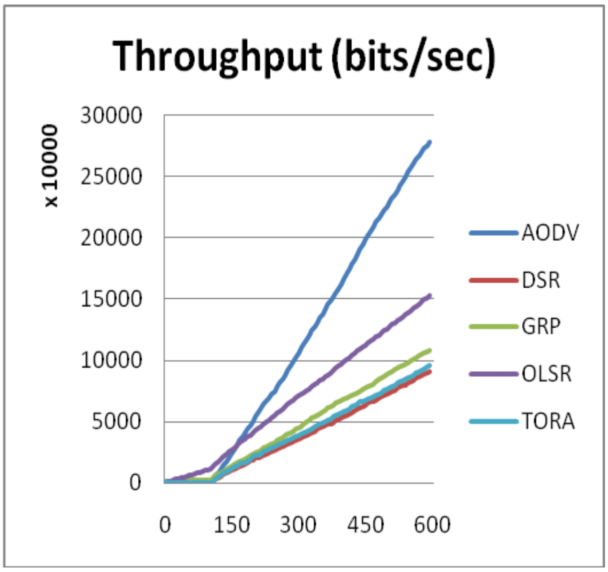


**Fig 7(b): Throughput for 30 nodes using http**

The Fig. 8(a) shows the entire throughput for 60 nodes using ftp. The DSR protocols show least throughput followed by TORA, GRP and AODV protocols. The OLSR protocol show highest value of throughput which is 442151477 bits/sec. The Fig. 8(b) shows entire throughput for 60 nodes using http. The TORA protocol shows least throughput whereas AODV protocols show highest value of throughput which is 1086252237 bits/sec followed by OLSR.

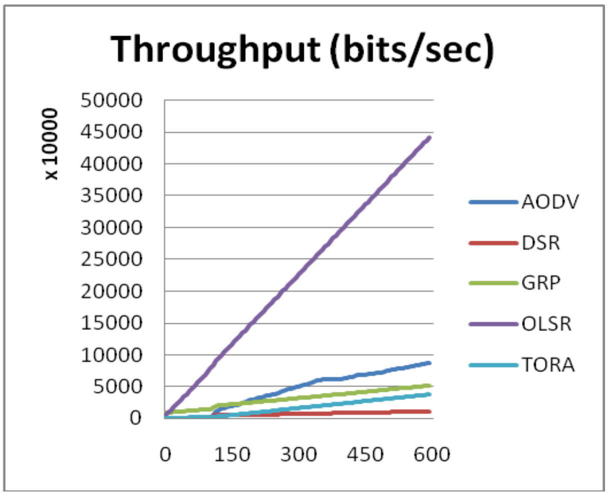


**Fig 8(a): Throughput for 60 nodes using ftp**

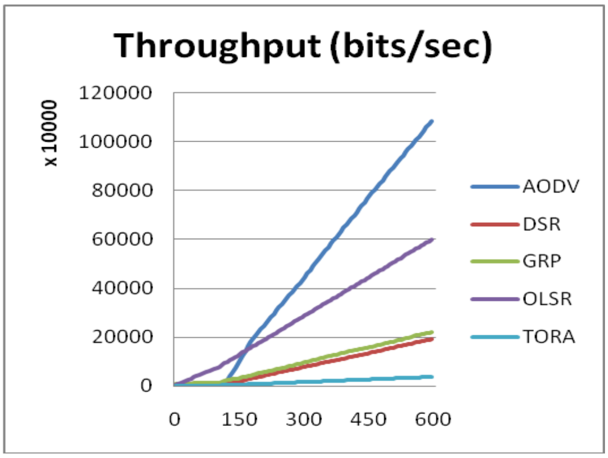


**Fig 8(b): Throughput for 60 nodes using http**

The Fig. 9(a) shows the entire throughput for 90 nodes using ftp. The DSR protocols show least throughput followed by TORA, GRP and AODV protocols. The OLSR protocol show highest value of throughput which is 1368500378 bits/sec. The Fig. 9(b) shows entire throughput for 90 nodes using http. The TORA protocol shows least throughput whereas OLSR protocols show highest value of throughput which is 1538299330 bits/sec followed by AODV.

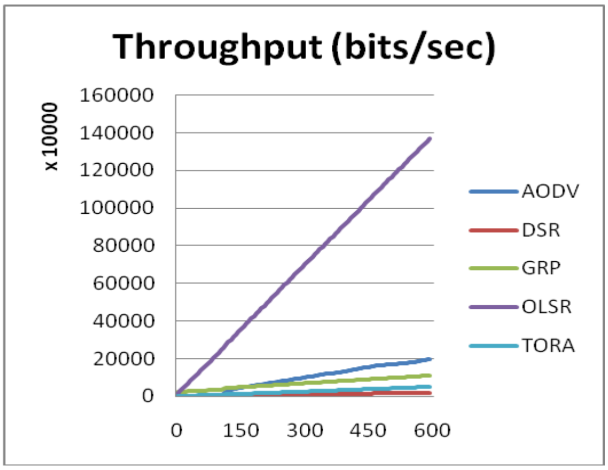


**Fig 9(a): Throughput for 90 nodes using ftp**

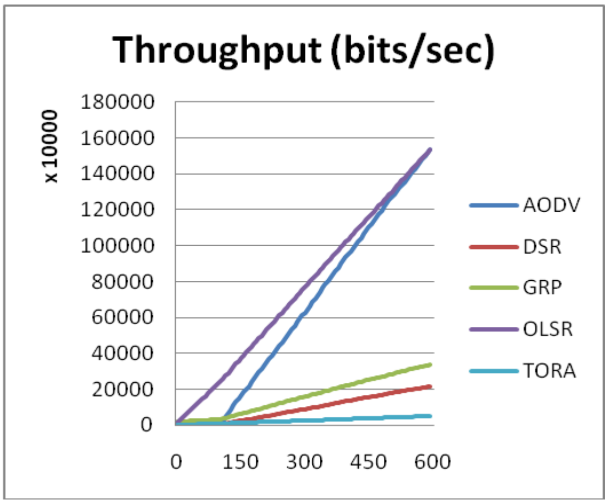


**Fig 9(b): Throughput for 90 nodes using http**

## 4.4 Data Dropped

The Fig. 10(a) shows the entire data drop for 30 nodes using ftp. The TORA protocols show highest data drop whereas the rest of protocols show almost no drop. The Fig. 10(b) shows entire data drop for 30 nodes using http. The TORA protocol shows highest data drop as compared to other protocols.

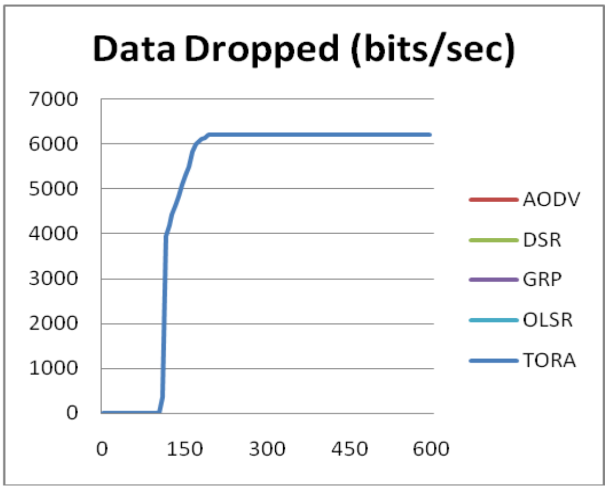


**Fig 10(a): Data Dropped for 30 nodes using ftp**

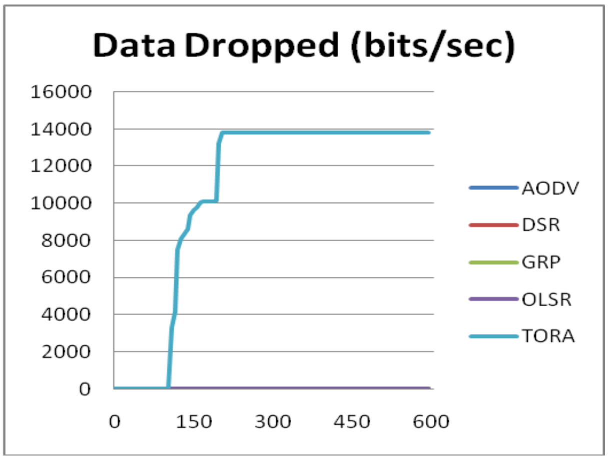


**Fig 10(b): Data Dropped for 30 nodes using http**

The Fig. 11(a) shows the entire data drop for 60 nodes using ftp. The TORA protocols show highest data drop whereas the rest of protocols show almost no drop. The Fig. 11(b) shows entire data drop for 60 nodes using http. The AODV protocol shows highest data drop whereas DSR protocols shows least data drop followed by OLSR protocol.

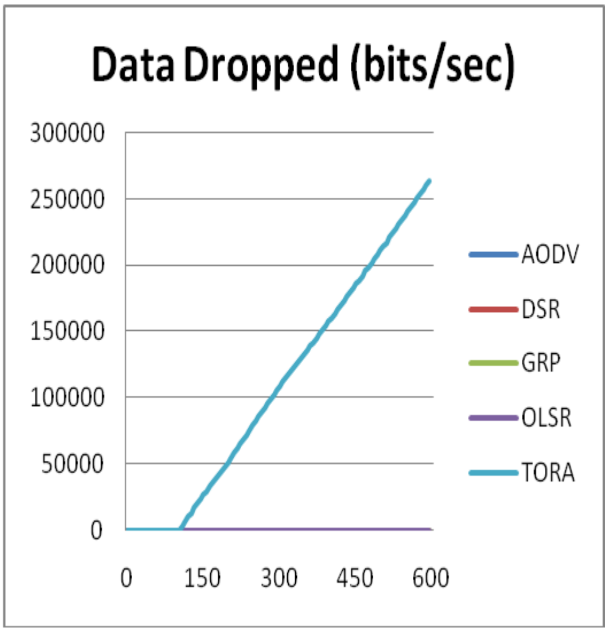


**Fig 11(a): Data Dropped for 60 nodes using ftp**

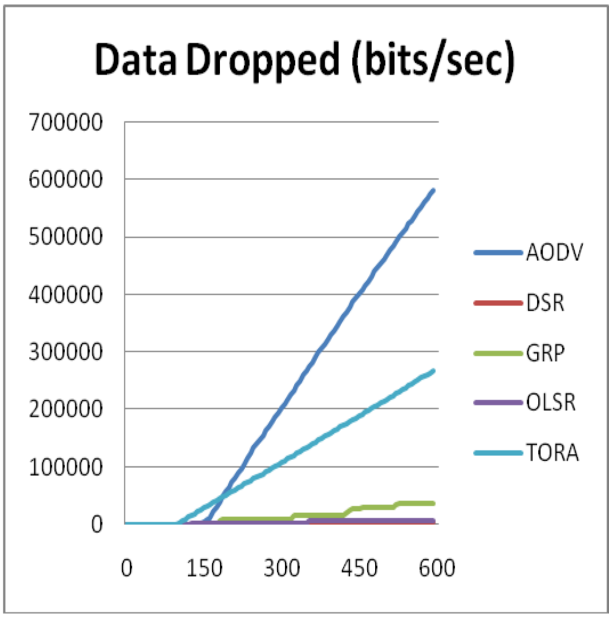


**Fig 11(b): Data Dropped for 60 nodes using http**

The Fig. 12(a) shows the entire data drop for 90 nodes using ftp. The OLSR protocol show no data drop followed by AODV. GRP and DSR shows average drop. TORA protocols show highest data drop. The Fig. 12(b) shows entire data drop for 90 nodes using http. The DSR protocol shows lowest data drop followed by OLSR and GRP. The AODV protocol shows highest data drop.

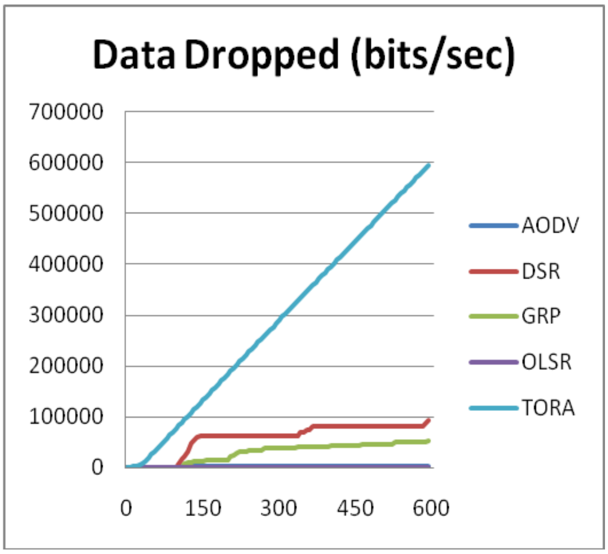


**Fig 12(a): Data Dropped for 90 nodes using ftp**

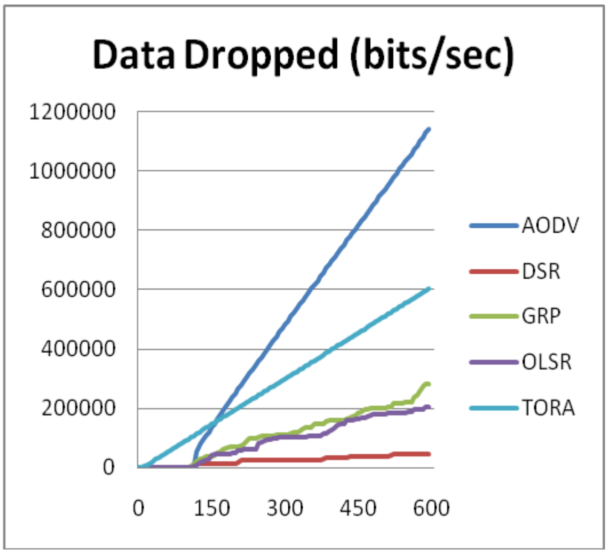


**Fig 12(b): Data Dropped for 90 nodes using http**

## 5. RESULT ANALYSIS

The result analysis of all the five protocols is shown in this section with the help of the simulation outputs with respect to the four performance metrics. The goal of this comparative study of AODV, DSR, GRP, OLSR and TORA routing protocols is to analyze the performance of protocols. OLSR in our simulation experiments show the overall best performance. The performance of OLSR protocol is best when we use ftp application but it shows degradation in performance when the application is changed to http. This means that changing traffic type change the performance of protocols. The effect of increase in the number of nodes is also clearly shown in the result tables shown below.

Table 2 shows the results of simulations for 30 nodes using ftp application.

**Table 2. Result for 30 nodes using ftp**

| Metrics | Delay (sec) | Load (bits/sec) | Throughput (bits/sec) | Data Dropped (bits/sec) |
|---|---|---|---|---|
| AODV | .30023 | 5215669 | 14016464 | 0 |
| DSR | .13301 | 5549605 | 5752144 | 0 |
| GRP | .50018 | 5965364 | 15553824 | 0 |
| OLSR | .40873 | 7894117 | 71107403 | 0 |
| TORA | 1.7504 | 8925712 | 12816811 | 6208 |

Table 3 shows the results of simulations for 60 nodes using ftp application.

**Table 3. Result for 60 nodes using ftp**

| Metrics | Delay (sec) | Load (bits/sec) | Throughput (bits/sec) | Data Dropped (bits/sec) |
|---|---|---|---|---|
| AODV | .11687 | 11256853 | 86946411 | 0 |
| DSR | .22458 | 10480245 | 11429963 | 0 |
| GRP | .04667 | 10438429 | 51225816 | 0 |
| OLSR | .05042 | 16910128 | 442151477 | 0 |
| TORA | 4923.3 | 24335899 | 38587499 | 263840 |

Table 4 shows the results of simulations for 90 nodes using ftp application.

**Table 4. Result for 90 nodes using ftp**

| Metrics | Delay (sec) | Load (bits/sec) | Throughput (bits/sec) | Data Dropped (bits/sec) |
|---|---|---|---|---|
| AODV | .22670 | 17998235 | 198891045 | 3136 |
| DSR | .39653 | 15042341 | 17310384 | 92442.67 |
| GRP | .05032 | 15377747 | 107945102 | 52224 |
| OLSR | .68883 | 29435291 | 1368500378 | 0 |
| TORA | 9141.6 | 36960309 | 51752261 | 593760 |

Table 5 shows the results of simulations for 30 nodes using http application.

**Table 5. Result for 30 nodes using http**

| Metrics | Delay (sec) | Load (bits/sec) | Throughput (bits/sec) | Data Dropped (bits/sec) |
|---|---|---|---|---|
| AODV | .5092 | 61855083 | 277992335 | 0 |
| DSR | .3097 | 89223169 | 90567373 | 0 |
| GRP | .3356 | 98921622 | 108475382 | 0 |
| OLSR | .1532 | 91271283 | 153535475 | 0 |
| TORA | 2.393 | 93075790 | 96193361 | 13816 |

Table 6 shows the results of simulations for 60 nodes using http application.

**Table 6. Result for 60 nodes using http**

| Metrics | Delay (sec) | Load (bits/sec) | Throughput (bits/sec) | Data Dropped (bits/sec) |
|---|---|---|---|---|
| AODV | 789.86 | 80204326 | 1086252237 | 580996 |
| DSR | .54815 | 188605831 | 191733426 | 4469 |
| GRP | .37896 | 179975398 | 219258648 | 37457 |
| OLSR | .21763 | 188061927 | 599222554 | 6144 |
| TORA | 4965.5 | 24460471 | 38658632 | 267381 |

Table 7 shows the results of simulations for 90 nodes using http application.

**Table 7. Result for 90 nodes using http**

| Metrics | Delay (sec) | Load (bits/sec) | Throughput (bits/sec) | Data Dropped (bits/sec) |
|---|---|---|---|---|
| AODV | 2000.6 | 92676694 | 1532746708 | 1140884 |
| DSR | 0.6257 | 210303461 | 214104413 | 45359 |
| GRP | 0.9479 | 255179871 | 340543902 | 282376 |
| OLSR | 0.4302 | 293499914 | 1538299330 | 203917 |
| TORA | 9256.6 | 36726480 | 51364656 | 604325 |

## 6. CONCLUSION

The simulation study helps to understand the behavior of AODV, DSR, GRP, OLSR and TORA routing protocols with respect to changing number of nodes and changing applications i.e. traffic. The results for ftp give us a clear picture that OLSR protocol performs best in all scenarios whereas the results for http application give us a mixed picture. OLSR performs overall best when we use http but some other protocols also show good results. The following points are concluded from our research:

- OLSR has highest throughput, least data drop almost negligible and low delay in all scenarios using ftp.
- TORA shows high delay, load and data drop in all scenarios for ftp.
- DSR shows least throughput in all scenarios using ftp.
- GRP shows least delay using ftp.
- OLSR shows least delay, low data drop and high throughput using http
- AODV protocol gives highest throughput when we use http but it goes down as number of nodes increase.
- DSR protocol has least data drop but it increases with the increase in number of nodes.

So the overall analysis shows OLSR as best protocol in all scenarios using both ftp and http. OLSR is undisputed winner in case of ftp application but it has been given good competition by some other protocols when we switch to http application.

## 7. FUTURE WORK

The future work suggested is the development of modified version of the selected routing protocols which should consider different aspects of routing protocols such as rate of higher route establishment with lesser route breakage and the weakness of the protocols mentioned should be improvised. The future work could be analyzing these protocols with varying area size, varying speed and varying mobility models. Here we used random waypoint model which can be replaced by trajectory based model.

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