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Analyzing the effect of node density and CBR traffic on AODV, OLSR and ZRP for a realistic scenario in MANET using Qualnet

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Abstract - Mobile Ad Hoc Networks (MANET) are wireless networks which do not require any infrastructure support for transferring data packet between two nodes. Mobile ad-hoc network have the attributes such as wireless connection, continuously changing topology, distributed operation and ease of deployment. Routing in these networks is highly complex as nodes are host and router both. It can be used for various applications areas. In this paper, we have considered a National Park scenario to setup a MANET. Since number of people in park is not constant, we have evaluated the performance of AODV (Reactive), OLSR (Proactive) and ZRP (Hybrid) routing protocols with respect to different node densities. The case of variable CBR connections is also considered to study the effect of variable load traffic. A detailed simulation has been carried out in QualNet Simulator 7.1. The performance analysis is based on different network metrics such as Average End to End delay, Average Jitter and Packet Delivery Ratio.

Keywords: AODV, OLSR, ZRP, CBR, Mobile Ad-hoc networks (MANET), QualNet 7.1.

I. INTRODUCTION

With applications ranging from civilian use to emergency rescue sites and in battlefield, MANETs [13, 8] have gained momentum because they help realize network services for mobile users in areas with no preexisting communications infrastructure [12]. A lot of work is going on in this field. The major issue for use of MANETs in any scenario is use of best possible routing protocol. In realistic scenarios, topology continuously changes thus varying node density. This leads to varying performance by routing protocols in different scenarios [1, 9]. So before we use MANETs in any realistic scenario we must decide on which routing protocol to use for that particular scenario.

In this paper we have considered a National Park. These locations are mostly in areas without any cellular connections. Whenever we visit such places the guides and other officials are not able to give us all the information that we look for. But we can get all the information using MANET from internet [12]. MANET [13] in such area can also monitor movement of tourist [8]. Since number of tourists (nodes) is most important factor in such a scenario, in this paper we address the following research question: What impact do different routing protocols (AODV, OLSR, and ZRP) have on a typical 802.11 MANET for different node densities? To answer the question posed we carry out a systematic performance analysis (by simulation) for AODV (Reactive), OLSR (Proactive) and ZRP (Hybrid) routing protocols. These routing protocols were selected based on published results, and interesting characteristics and features. The performance analysis for variable CBR connections is also included in this paper to get a better understanding of loading on MANET.

The remainder of this paper is structured as follows. Section II reviews literature, representative of that MANET routing protocols. Overview of MANET routing protocols considered in this paper, is given in Section III. Section IV describes simulation environment and network parameters. The comparative analysis and simulation results of three routing protocols are presented in Section V. The conclusion is given in Section VI.

II. LITERATURE REVIEW

Numerous studies have been carried out in past to analyze the performance of MANETs by varying different network parameters. In [1], authors have compared AODV, OLSR and ZRP routing protocols for 20 nodes. They have shown that for OSLR nears performance of AODV and ZRP is outperformed by both AODV and OSLR. It is so because of proactive and reactive natures of AODV and OLSR respectively. But they haven't considered a high density network. Similarly, authors have compared DSR, OLSR and ZRP in [9]. Their network has more density with maximum 100 nodes. They have concluded that DSR's performance is the best considering its ability to maintain connection by periodic exchange of information. But they have not considered AODV. In [2], extensive research is done on ZRP. They have established that ZRP is not up to the task and performs poorly in all simulation sequences. In [4] and [6] they have discussed the working and detailed analysis of OLSR for Ad-hoc networks. They have done performance analysis by proving route optimality and broadcast performance. But no simulations are done in [4]. Similarly, in [10], the author has compared AODV and OLSR without simulation. Author concludes here that OLSR protocol is more efficient in networks with high density and highly sporadic traffic as OSLR requires that it continuously have some bandwidth in order to receive the topology updates messages. As already seen in [1] OLSR is outperformed by AODV in low density networks for the same reason.

III. ROUTING PROTOCOLS IN MANET

Routing protocols in MANETs are divided into three categories based on how and when routes are discovered [7], but all find the shortest path to the destination.

Proactive routing protocols are table-driven protocols, they always maintain current updated routing information by sending control messages periodically between the hosts which update their routing tables. When there are changes in the structure then the updates are propagated throughout the network. The proactive routing protocols use link-state routing algorithms which frequently flood the link information about its neighbours. Optimized Link State Routing Protocol (OLSR) [4, 6, 10] is one such routing protocol.

Reactive routing protocols or on demand routing protocols are ones which create routes when they are needed by the source host and these routes are maintained while they are needed. Such protocols use distance-vector routing algorithms, they have vectors containing information about the cost and the path to the destination. When nodes exchange vectors of information, each host modify own routing information when needed. Ad-hoc On Demand Distance Vector (AODV) [3, 10, 11] is one such routing protocol.

Hybrid routing protocols combine the advantages of proactive and of reactive routing. The routing is initially established with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding. The choice for one or the other method requires predetermination for typical cases. Zone Routing Protocol (ZRP) [2, 9] is one such protocol.

Ad hoc On Demand Distance Vector (AODV) [3] is an on-demand routing protocol used in ad hoc networks. This algorithm, like any other on-demand routing protocol, facilitates a smooth adaptation to changes in the link conditions. In the case a link fails, notifications are sent only to the affected nodes. This information enables the affected nodes invalidate all the routes through the failed link. It has low memory overhead, builds unicast routes from source to the destination and network utilization is minimal. It uses Destination Sequence Numbers (DSN) to avoid counting to infinity. This is one of the distinguishing features of this algorithm [11].

Optimized Link State Routing (OLSR) [4, 6] is a proactive routing protocol, providing the advantage of having routes immediately available in each node for all destinations in the network. It is an optimization of a pure Link State routing protocol [14]. This optimization is based on the concept of multipoint relays (MPRs) [4]. First, using multipoint relays reduces the size of the control messages, rather than declaring all links, a node declares only the set of links with its neighbours that are its "multipoint relays". The use of multipoint relays also minimizes flooding of control traffic. Indeed only MPRs forward control messages. This technique significantly reduces the number of retransmissions of broadcast control messages.

Zone Routing Protocol (ZRP) [2] is one of the hybrid routing protocols, it takes advantage of proactive approach by providing reliability within the scalable zone, and for beyond the scalable zone it looks for the reactive approach. It (ZRP) uses the proactive and the reactive routing according to the need of the application at that particular instance of time depending upon the prevailing scenario. In this separation of nodes, local neighborhood from the global topology of the entire network allows for applying different approaches and thus taking advantage of each technique's features for a given situation. These local neighborhoods are called zones (hence the name) each node may be within multiple overlapping zones, and each zone may be of a different size. Size is given by a radius of length α where α is the number of hops to the perimeter of the zone [9].

IV. SIMULATION SCENARIO AND NETWORK PARAMETERS

In this paper we have considered a setting up a MANET in a National Park. It can provide internet access to tourist using servers placed at local offices of forest department [8]. In such a case we can also monitor tourist movement using MANET. In this scenario topology changes mostly due to changing number of tourist inside park accessing internet. So we have considered the performance of AODV, OLSR and ZRP for variable node density and increasing the number of

CBR connections. Traffic source used was CBR (constant bit rate). The packet size was 512 bytes with sending rate of 500 packets per second. We have used QualNet 7.1 [15] for simulation of these routing protocols in this scenario. The realistic scenario is configured with a main receiving node at the top, the four static substation nodes in their respective quarters and a group of free mobile nodes spread randomly over the simulation area. The CBR connections have been set up between these mobile nodes and the main receiving server. The corresponding simulation screenshot is as follows:

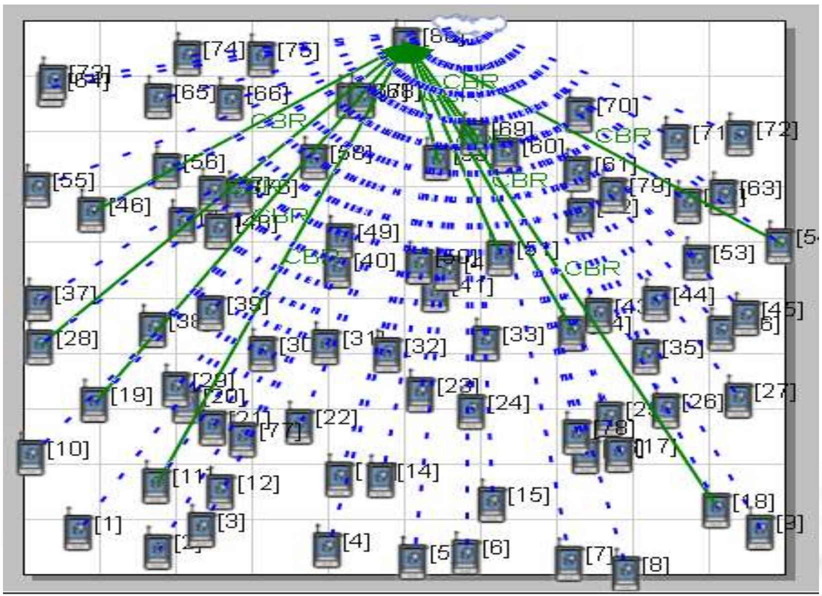

Figure 1: Simulation Scenario

Table I: Simulation Parameters

Simulation Parameter	Values
Dimension	1000mx1000m
No. of nodes	50,75,100,125,150,175,200
No. of CBR connections	10,15,20,25,30
Node placement strategy	Random
Mobility model	Random Waypoint
Mobile nodes Speed	1-5m/s
Traffic source	CBR
Packet size	512 Bytes
Packets per seconds	500
Simulation time	600sec
Channel frequency	2.4GHz
Data Rate	6Mbps
Path Loss Model	Two Ray Model
Physical layer radio type	IEEE802.11a/g
MAC Protocol	IEEE802.11
Antenna model	Omni-directional

V. SIMULATION RESULTS AND ANALYSIS

In order to evaluate the performances of three MANET protocols, several metrics need to consider. These metrics reflect how efficiently the data is delivered. According to the literatures [1, 5, 7, 9, 10] some of these metrics are suggested by the MANET working group for routing protocol evaluation are:

Average End-to-End Delay: It is defined as the average time taken by data packets to propagate from source to destination across a MANET.

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Average Jitter: It is the variation in the time between packets arriving at sink node, caused by network congestion, timing drift, or route changes.

Average Throughput: It is the rate of successfully transmitted data packets in a unit time in the network during the simulation.

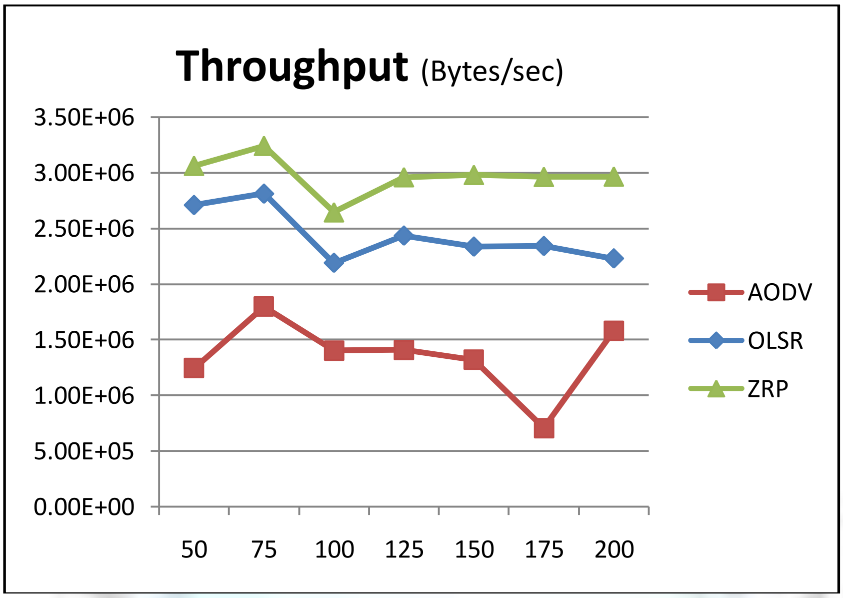

Figure 2: Throughput versus number of nodes

The variation of throughput against number of nodes shows that ZRP outperforms OLSR and AODV. The variation shows that the network performance increases for all the protocols up to 75 nodes, after which it experiences a small dip, which remains constant with the increasing nodes up to 200. In terms of throughput ZRP & OLSR perform better than AODV for the given scenario. The results suggest that ZRP is better in terms of throughput.

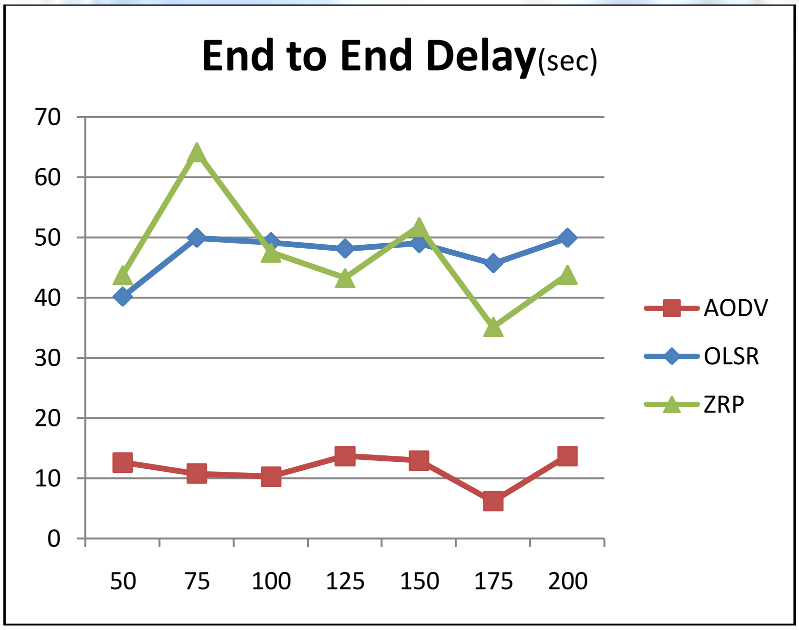

Figure 3: End-to-End Delay versus number of nodes

Figure 3 represents the end to end delay with the variation in number of nodes. Here it can be clearly seen that AODV has significantly low clearly than OLSR & ZRP. This can be attributed mainly to its reactive nature which leads to low delay. On the other hand ZRP & OLSR having higher delay indicates their proactive nature which results in higher overhead in the network. ZRP takes time for intercommunication between IERP and IARP, maintaining the routing table of their local zone, which adds unnecessary traffic in the network.

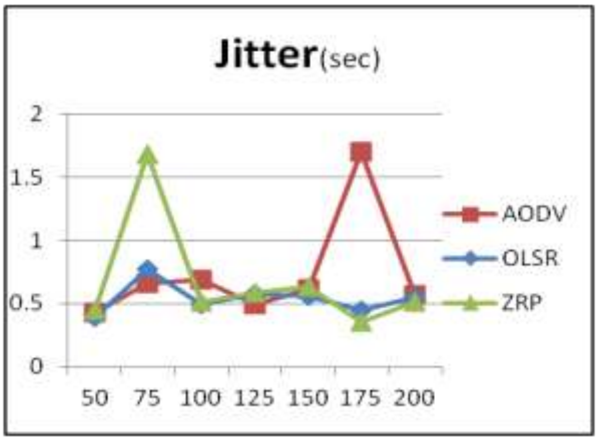

Figure 4: Jitter versus number of nodes

Figure 4 represents the variation in jitter. Jitter signifies variation in delay with which packets reach the destination. Although the variation is almost same but on average OLSR performs well in terms of jitter compared to AODV & ZRP. Further the variation in number of active CBR connections was plotted with total nodes fixed.

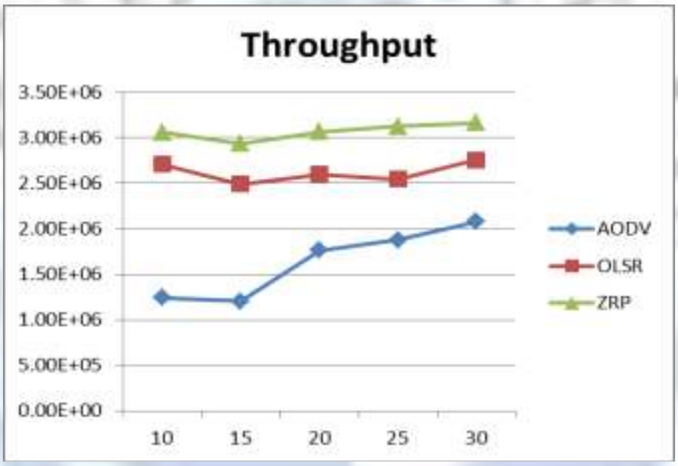

Figure 5: Throughput versus No. of CBR sources

Figure 5 depicts variation of throughput versus number of active CBR connections. This follows the previous result with variation in number of nodes. ZRP performs well even with the increasing number of connections. ZRP and OLSR both have almost constant performance with increasing connections. AODV however experiences a significant increase in the throughput with increasing active connections.

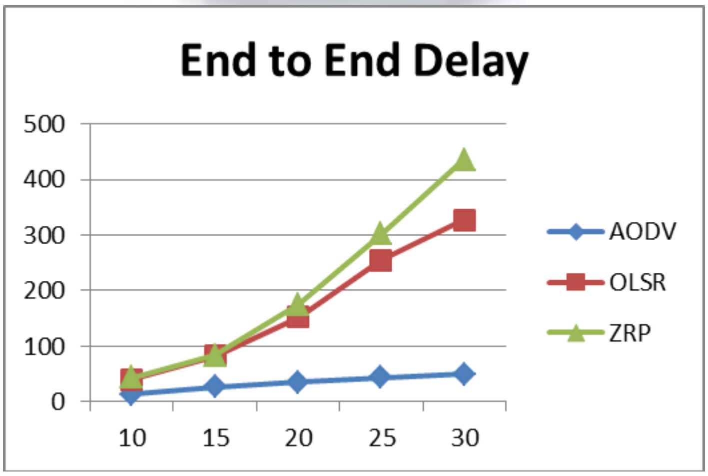

Figure 6: End-to-End Delay versus No. of CBR sources

As evident from figure 6, performance of ZRP and OLSR degrades almost exponentially. End to end delay for ZRP and OLSR rises too much from normal values. Large end to end delay signifies congestion in the network or less efficient routing mechanism for the given network. This delay can be attributed to proactive nature of these routing protocol which results in higher amount of control overhead for each active CBR connection. Higher number of connections is creating a large number of control packets.

On the other hand, AODV has significantly less delay and increase in delay with the increasing connections is not much. This signifies that AODV is a much faster protocol than ZRP and OLSR for the given scenario. AODV uses hop by hop routing mechanism while constantly updating the shortest possible source destination path. Also the amount of information that may add up to network overhead is very less. So lower control overhead and maintenance of shortest path with dynamically changing network, end to end delay is less in AODV.

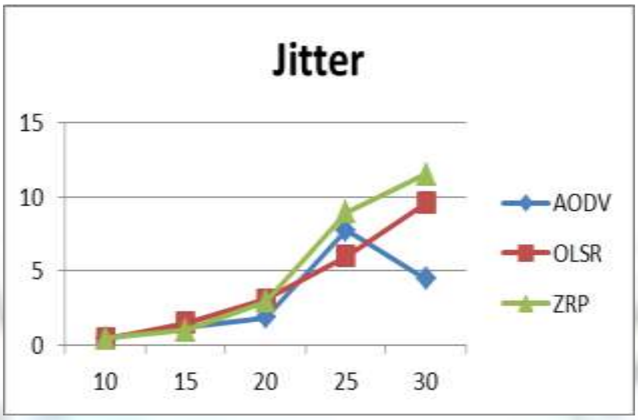

Figure 7: Jitter versus No. of CBR sources

Jitter signifies the variation in time between the packets arriving at the destination caused by network congestion. With the increase in number of active CBR connections the average jitter in network rises for all the protocols as expected. AODV shows average performance in terms of jitter, however at higher density its performance improves in terms of jitter. With fewer connections OLSR has lower jittering than the other two, owing to its proactive nature the protocol uses its multipoint relaying technique to efficiently flood its control messages in network with dynamic topologies.

CONCLUSION

QualNet simulations can be configured to accurately model some of the most realistic scenarios in the field with good correlation on the end to end statistics. These simulations can then be extended or re-run with different parameters, to provide the modeler with the ability to answer additional questions about network performance and optimization, without resorting to costly and time-consuming actual real time exercises.

These simulations show that performance of routing protocols varies and depends on the performance metrics on which they are measured. For the given scenario ZRP gives the best throughput but has significantly higher delay for almost all simulations. OLSR gives almost at par results with ZRP but higher than AODV in terms of throughput. Low throughput in AODV is seen compared to ZRP and OLSR for almost all the simulations. This is possible due to expiry of an optimal route due the mobility in nodes. This mobility may create congestion or may result in fluctuating characteristics of the wireless links.

However in terms of throughput ZRP outperforms OLSR and AODV. The dual nature of ZRP is a possible explanation. It updates the routing table inside the proactive zone and for paths outside, it uses reactive component, thus combining the advantages of both reactive and proactive protocols. Its performance can be further maximized by determining the optimal zone radius. Also higher end to end delay suggests its failure in terms of speed. This can be due to the suboptimal routes between source and destination. So AODV with minimal delays can be regarded as on optimized protocol for the particular scenario. Its response is faster to the topological changes in the network and updates only those nodes which are required for communication. Control overhead is also low which keeps the unnecessary congestion low in the network.

It is important to note that these results are specific to the particular network. It provides a good indicator of how suited each protocol is, by default, to this type of real time simulations.

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