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Network Density Based Analysis of MANET Routing Protocols using Client-Server and Peer-to-Peer Architecture based Applications

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Abstract
Mobile Ad-hoc Network (MANET) is a network with structure less self organizing an autonomous system of mobile nodes which are connected by wireless links. In mobile network every mobile node functions as transmitter, router and data sink. Due to dynamic natured topology of network mobile nodes, MANETs are facing many deployments, routing, security, adaptability etc challenges. Among the various challenges that are getting explored in these days in field of MANETs, network density, such that number of nodes in a Mobile Ad Hoc Network (MANET) is also a big challenge in designing the routing protocols. In this work an attempt has been made to compare the performance of three MANET Routing Protocols, such that Pro-active Routing Protocol: OLSR (Optimized Link State Routing Protocol), Reactive Routing Protocol: AODV (Ad-Hoc on Demand Distance Vector), Hybrid Routing Protocol: GRP (Geographic Routing Protocol) by using two different applications i.e. High Definition Video Conferencing and High Load FTP generating different types of data in the networks under different nodes densities (20, 40, 60 and 80) in the networks. All the networks are simulated by using a discrete event simulator OPNET 14.0 and results are gathered by using different performance evaluation metrics. After the intensive simulation, it has found that the hybrid protocols (GRP) outperforms both reactive (AODV) and proactive (OLSR) protocols.
Keywords*: MANET, AODV, OLSR, GRP*

1. Introduction

MANET is an acronym for Mobile Ad Hoc Network. A MANET is a type of ad hoc network that can change its locations and configure itself on the go. This can be a standard Wi-Fi connection, or another medium, such as a cellular phones or satellite transmission [8].Because MANETS are for mobile devices, they use wireless connections to connect to the various networks. Most research in this field is based on simulation studies of the routing protocols of interest in arbitrary networks with certain traffic profiles. However, the simulation results from different research groups are not consistent. This is because of the lack of consistency in MANET routing protocol models and application environments including networking and user traffic profiles.

1.1 Types of routing protocols in MANET

Based on the method of delivery of data packets from the source to destination, classification of the MANET routing protocols could be done as unicast, multicast or geocast routing protocols.

1.1.1 Unicast Routing Protocols: The routing protocols that consider sending information packets to a single destination from a single source.

1.1.2 Multicast Routing Protocols: Multicast is the delivery of information to a group of destinations simultaneously. Multicast routing protocols for MANET use both multi-cast and unicast for data transmission. Multicast routing protocols for MANET can be classified again into two categories: tree-based and mesh-based multicast routing protocols. Mesh-based routing protocols use several routes to reach a destination while the tree-based protocols maintain only one path. Tree-based protocols ensure less end-to-end delay in comparison with the mesh-based protocols.

1.1.3 Geocast Routing Protocols: The routing protocols aim to send messages to some or all of the wireless nodes within a particular geographic region. Often the nodes know their exact physical positions in a network, and these protocols use that information for transmitting packets from the source to the destination.

1.2 MANET Routing Protocols

Several routing protocols have been proposed for the successful deployment of Mobile Ad Hoc Networks (MANETs). The protocols differ in terms of routing methodologies and the information used to make routing decisions. On the behalf of their different working methodologies, these routing protocols are divided into three different categories: i) Reactive Protocols, ii) Proactive Protocols and iii) Hybrid Protocols.

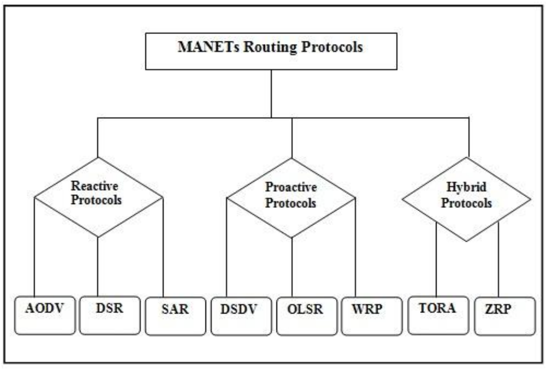

Figure 1: Categories of MANET routing protocols

1.2.1 Reactive Protocols

Reactive Protocols are also known as On Demand Routing Protocols because they establish routes between nodes only when they are required to route data packets. When a route required by a source node to a destination for which it does not have route information, it starts a route discovery process, which goes from one node to another node until it arrives at the destination or a nodes in-between has a route to the destination[1].

Ad Hoc on Demand Vector Routing Protocol (AODV)

AODV is described in RFC 3561 [5]. The Ad Hoc on Demand Vector Routing Protocol (AODV) enables multi hop routing between participating mobile nodes wishing to establish and maintain an ad-hoc network. AODV is based upon the distance vector algorithm. AODV only requests a route, when needed and does not require nodes to maintain routes to destinations that are not actively used in communication. The algorithm uses different messages to discover and maintain links. Whenever a node wants to try and find a route to another node, it broadcasts a Route Request packet (RREQ) to all its neighbors[14]. The RREQ packet propagates through the network until it reaches the destination or a node with a fresh enough route to the destination. Then the route is made available by unicasting a RREP back to the source.

1.2.2 Proactive Protocols

Proactive Protocols are also known as Table Driven Protocols. These protocols maintain constantly updated topology of the network. Every node in the network knows about the other nodes in advance keeping it simple, the whole network is known to all the nodes making that network. All the routing information is usually kept in number of different tables. Whenever, there is a change in the network topology, these tables are updated according to the changes. The nodes exchange topology information with each other, so that they can have route information any time when they needed.

Optimized Link State Routing Protocol (OLSR)

Optimized Link State Routing Protocols is a proactive protocol, in which each node to build a global view of the network topology. The periodic nature of the protocol creates a large amount of overhead. In order to reduce the overhead, it limits the number of mobile nodes that can forward network wide traffic and for this purpose it uses Multi Point Relays (MPRs), which are responsible for forwarding routing messages. Mobile nodes which are selected as MPRs, can forward control traffic and reduce the size of control message [18].

1.2.3 Hybrid Protocols

Hybrid Routing Protocols combine proactive protocols with reactive protocols. They use distance-vectors for more precise metrics to establish the best paths to destination networks, and report routing information only when there is a change in the topology of the network [12]. Each node in the network has its own routing zone, the size of which is defined by a zone radius, which is defined by a metric, such as the number of hops. Each node keeps a record of routing information for its own zone.

GRP (Gathering based routing protocol): GRP protocol is source initialized protocol in MANET routing protocol in which all the routing path is created by source node in Mobile Ad-hoc network. In this protocol, source node collects all the information about the route to the destination. In this procedure, source node sends a destination Query toward the destination through network. When NIG packet reached at a router, router gives it all the information about the network and its resources. There are many nodes called Effective Outgoing Links (EIL) where NIG packet does not riches, routers send this information to these EILs. At last NIG reaches at source node and source node get all the information [8].

1.3 Objectives

1. To study the working of various existing routing protocols for MANETs.
2. To analyze various MANET networks with varying nodes densities and configuration of the networks will be done by using MANET routing protocols.
3. Various performance evaluation metrics will be chosen to evaluate the networks.

2. OPNET MODELER

OPNET (Optimized Network Engineering Tool) provides a comprehensive development environment for the specification and performance analysis of communication networks.

2.1 Modeling and Simulation Cycle: OPNET provides powerful tools to assist user to go through three out of the five phases in a design circle [5].

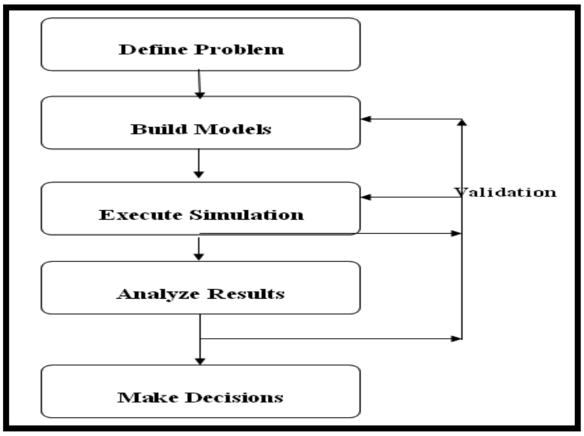

Figure 2: Modeling and Simulation Cycle

2.2 Hierarchical Modeling: OPNET employs a hierarchical structure to modeling. Each level of the hierarchical describes different aspects of the complete model being simulated.

2.3 Specialized in Communication Networks: Detailed library models provides support for existing protocols and allow researchers and developers to either modify these existing models or develop new models of their own.

2.4 Automatic simulation generation: OPNET models can be compiled into executable code. An executable discrete-event simulation can be debugged or simply executed, resulting in output data.

2.5 Network Model

Network Editor is used to specify the physical topology of a communications network, which define the position and interconnection of communicating entities, i.e. node and link. A set of parameters or characteristics is attached with each model that can be set to customize the node's behavior. A node can either be fixed, mobile or satellite

2.6 Node Model

Communication devices created and interconnected at the network level, need to be specified in the node domain using the Node Editor as shown in Figure 5. These modules can be grouped into two distinct categories. The first set is modules that have predefined characteristics and a set of built-in parameters[5]. Examples are packet generators, point-to-point transmitters and radio receivers. The second group contains highly programmable modules.

Each node is described by a block structured data flow diagram. Each programmable block in a Node Model has its functionality defined by a Process Model. Modules are interconnected by either packet streams or statistic wires. Packets are transferred between modules using packet streams. Statistic wires could be used to convey numeric signals.

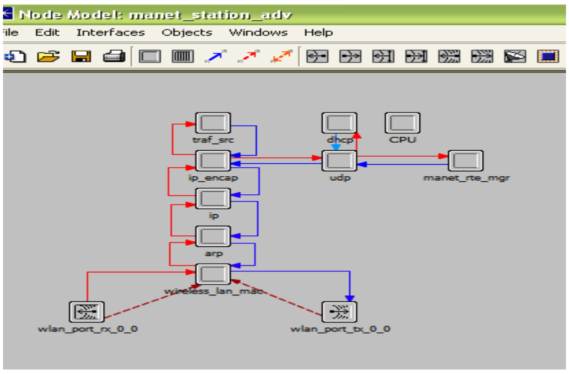

Figure 3: Example of a Node Model

2.7 Process Model

Figure 6 shows a Process model, created using the process editor, are used to describe the logic flow and behavior of processor and queue modules [5]. Communication between processes is supported by interrupts. Process models are expressed in a language called Proto-C, which consists of state transition diagrams (STDs), a library of kernel procedures, and the standard C programming language. The OPNET Process Editor uses a powerful state-transition diagram approach, to support specification of any type of protocol, resource, application, algorithm, or queuing policy. States and transitions graphically define the progression of a process in response to events. Within each state, general logic can be specified using a library of predefined functions and even the full flexibility of the C language. Process may create new processes (chi1d process) to perform sub-tasks and thus is called the parent process.

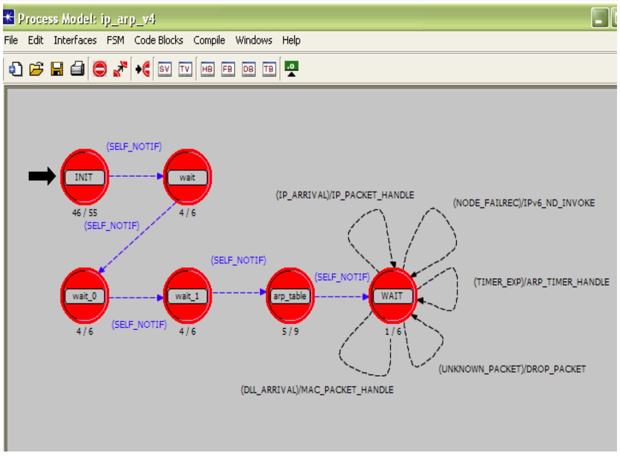

Figure 4: Example of a Process Model

3. PERFORMANCE EVALUATION AND NETWORK DESIGN

3.1 Performance Evaluation of MANET routing protocols

In this chapter different metrics are considered in performance evaluation of different MANET routing protocols. The brief discussion has done of all the performance evaluation metrics that are considered in the comparison.

3.1.1 Data Dropped (Buffer Overflow): The routers might fail to deliver or drop some packets or data if they arrive when their buffer are already full. Some, none, or all the packets or data might be dropped, depending on the size of the higher layer packet, which is greater than the maximum allowed data size defined in the IEEE 802.11 standard. The unit of Data Dropped is bits/sec.

3.1.2 Delay: The time from the beginning of a packet transmission at a source node until packet delivery to a destination. This includes delays caused by buffering of data packets during route discovery, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.

3.1.3 Load: Represents the total load (in bits/sec) submitted to wireless LAN layers by all higher layers in all WLAN nodes of the network.

3.1.4 Throughput: Throughput is defined as the ratio of the total data reaches a receiver from the sender. The time it takes by the receiver to receive the last message is called as throughput. Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec) [5].

3.2 Simulation model (environment) and parameters

The simulation is focused on the performance of MANET routing protocols, when node density is changed. For the simulation 1000x1000 meter campus network has used in which nodes are randomly placed within an environment with a fixed WLAN application server. Numbers of nodes are configured by using reactive protocol (AODV), proactive protocol (OLSR), and hybrid protocol (GRP) by setting different parameters provided by OPNET. To generate data in the network video conferencing and high load FTP applications are configured by using application node provided by MANET module in the OPNET simulator. To support the application, two fixed servers are configured and all the nodes in the network are configured according to the servers. Profiles for the configured application are defined by using profile definition node.

Network design with 20 nodes: 20 mobile nodes has used in this Network environment. The trajectory used in this environment is vector.

Network design with 40 nodes: In Figure.8, for simulation 40 mobile nodes are used in a network environment. Only number of nodes is changed in this simulation model.

Network design with 60 nodes: In Figure.9, 60 mobile nodes are used in network model for simulation. Only numbers of mobile nodes are increased.

Network design with 80 nodes: In Figure.10, 80 mobile nodes are used in network model for simulation. Only number of nodes is increased in this simulation model.

4. SIMULATION RESULTS AND ANALYSIS

4.1 Introduction

To make the research more optimized various MANET routing protocols and network density based analysis of routing protocols have been studied, to choose better among the existing routing protocol, it is required to design a few network model, to evaluate the performance of routing protocols. At the end of this chapter, results obtained from various simulations in the form of graphs are presented. Future scope on the basis of this research is also suggested.

4.2 Simulation Results and Analysis:

Simulation based analysis of different MANET routing protocols with varying number of nodes in a network environment. Used number of nodes is: 20,40,60,80.

4.2.1 Result of AODV Protocol: The Analysis of AODV routing protocol have done with varying (20, 40, 60, 80) number of nodes. AODV protocol was simulated in all the four scenarios by using all the four parameters such as: Data Dropped (Buffer Over Flow), Delay, Load, Throughput.

4.2.1 (a) Data Dropped (Buffer Over Flow)

From the Figure 5, it can be shown that bits\sec data dropped rate is maximum for 40 mobile nodes. Data dropped rate for 20 nodes firstly increases and then decreases till the time of 255 sec. The value of data dropped rate for 60 nodes is constant at the time of 40 sec after that it decreases till the time of 95 sec then data dropped value increases till the time of 150 sec and then gradually decreases till the time of 270 sec. The value for data dropped for 80 nodes firstly decreases constantly then after the interval of 70 sec value of data dropped rate is increases till the time of 160 sec after that data dropped rate starts decreases and value of data dropped rate for 80 nodes is merge into the decreasing rate of 20 mobile nodes. It is concluded that bits\sec data dropped rate is maximum for the 40 nodes than 40, 60 and 80 nodes.

Table 1: Data Dropped (Buffer over flow)

Time (sec)	AODV_20	AODV_40	AODV_60	AODV__80
0	1.66E+09	3.45E+09	4.51E+09	5.43E+09
30	7.75E+09	1.58E+10	4.16E+09	4.71E+09
60	8.34E+09	1.65E+10	2.18E+09	3.14E+09
90	8.58E+09	1.68E+10	1.47E+09	6E+09
120	8.7E+09	1.71E+10	3.34E+09	7.97E+09
150	8.77E+09	1.71E+10	5.83E+09	9.07E+09
180	7.33E+09	1.43E+10	4.87E+09	7.61E+09
210	6.3E+09	1.23E+10	4.2E+09	6.57E+09
240	5.52E+09	1.08E+10	3.69E+09	5.77E+09
270	4.94E+09	9.57E+09	3.31E+09	5.17E+09

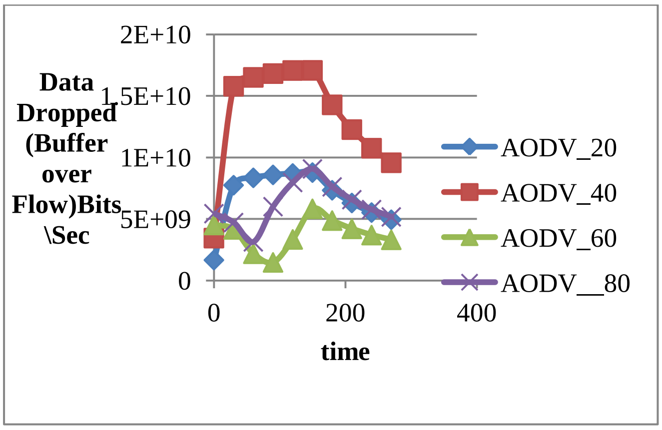

Figure 5: Data dropped (Buffer Over Flow) of AODV

4.2.1 (b) Delay:

In Figure 6, shows delay in sec. The x-axis denotes time in min and y-axis in sec .The value for Delay of 20 mobile nodes is increases till the 80 sec. The peak value of delay is 110 sec. for 40 mobile nodes the value of delay is increases till the maximum value of delay that is 110 sec. The value of delay for 60 mobile nodes is increases till the value of 90 sec. The value of delay for 80 mobile nodes is increases gradually till the value of 70 sec. It is concluded that the value of delay is more for 40 mobile nodes, so 40 mobile nodes have maximum delay than 20, 60, and 80 mobile nodes.

Table 2: Values for Delay of AODV

Time (sec)	AODV_20	AODV_40	AODV_60	AODV__80
0	0.286882	0.152513	0.095178	0.055452
30	14.23254	13.65149	11.01833	6.523601
60	27.92033	28.39191	21.85376	13.47845
90	39.39513	42.92395	33.16224	19.35738
120	49.44391	56.49983	44.20742	27.41211
150	61.02711	68.80446	55.38814	35.26211
180	69.85744	79.16509	64.93007	44.06242
210	75.66507	90.0669	74.75326	53.32372
240	79.79057	100.5737	85.23071	61.60947
270	79.04856	107.2168	94.08742	69.67018

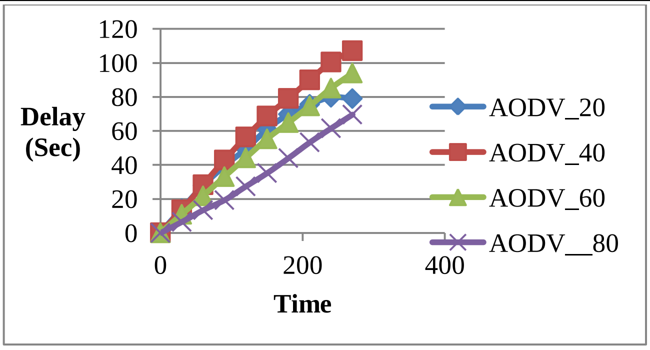

Figure 6: Delay of AODV

4.2.1 (c) Load

In Figure 7 shows load in bits\sec. the x-axis shows time in sec and y-axis shows load in bits\sec. load for 20 mobile nodes firstly increases up to the time period of 40 sec then load decreases till the time of 260 sec. load for 40 nodes increases up to 45 sec then shows constant load then after the completion of 150 sec load decreases gradually 280 sec. For 60 mobile nodes network feels minimum load. For 80 mobile nodes load decreases up to the time period of 60 sec then load increases when simulation reached up to 150 sec. then value gradually decreases. It is concluded that network with 40 mobile nodes shows more load than 20, 60, 80 mobile nodes.

Table 3: Values for load of AODV.

Time (sec)	AODV_20	AODV_40	AODV_60	AODV__80
0	2.28E+09	4.44E+09	5.91E+09	6.84E+09
30	7.82E+09	1.59E+10	4.3E+09	4.86E+09
60	8.4E+09	1.66E+10	2.25E+09	3.22E+09
90	8.63E+09	1.69E+10	1.53E+09	6.08E+09
120	8.73E+09	1.71E+10	3.4E+09	8.03E+09
150	8.8E+09	1.71E+10	5.88E+09	9.12E+09
180	7.36E+09	1.43E+10	4.92E+09	7.65E+09
210	6.32E+09	1.23E+10	4.24E+09	6.61E+09
240	5.54E+09	1.08E+10	3.73E+09	5.8E+09
270	4.96E+09	9.59E+09	3.34E+09	5.2E+09

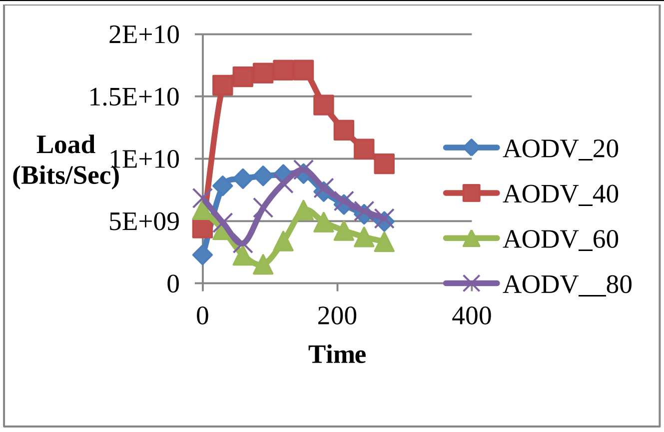

Figure 7: Load of AODV

4.2.1 (d) Throughput:

In Figure 8, shows throughput of 80 mobile nodes is increases till 20000000 bits\sec but after that it decreases. Throughput of 60 mobile nodes is increases till 18000000 bits\sec than after 5 sec its value decreases down. Throughput of 20 mobile nodes is increases up to the value 19000000 bits\sec. Throughput of 40 mobile nodes is increases till the value of 18000000 bits\sec. Throughput for 40 and 60 mobile nodes is same till the time period of 150 sec after that the value for 40 mobile nodes increases and throughput of 60 mobile nodes decreases. From the graph it is concluded that with the increases of number of mobile nodes in a network throughput decreases. So throughput for 20 mobile nodes in network has more throughput than 40, 60, 80 mobile nodes. AODV performs better with lesser network density.

Table 4: Values for throughput of AODV

Time (sec)	AODV_20	AODV_40	AODV_60	AODV__80
0	6362688	5458901	8146371	11533157
30	18545391	17636369	17731626	19580178
60	19150175	18079545	18138900	19452222
90	19345533	18246007	18149425	19149623
120	19434962	18329276	18166065	18949771
150	19293089	18541503	18357698	18990599
180	19190640	18709244	18293439	18869750
210	19129709	18807540	18206399	18754078
240	19113026	18815802	18205156	18719798
270	19149772	18829778	18190830	18659737

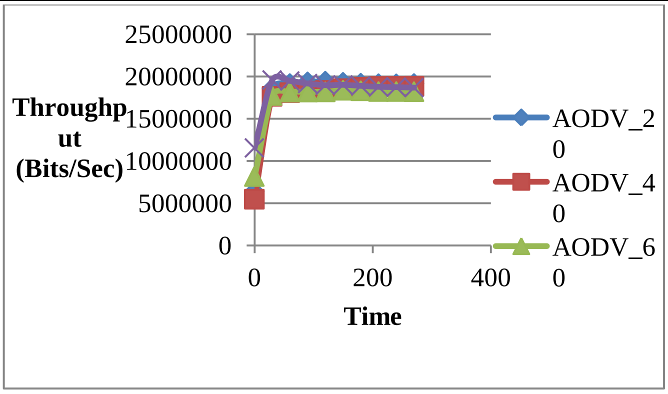

Figure 8: Throughput of AODV

4.2.2. Results of OLSR

The Analysis of OLSR routing protocol have done with varying (20, 40, 60, 80) number of nodes. OLSR protocol was simulated in all the four scenarios by using all the four parameters such as: Data Dropped (Buffer Over Flow), Delay, Load, Throughput.

4.2.2 (a) Data dropped (Buffer Over Flow):

In Figure 9, shows that data dropped rate for 40 mobile nodes is maximum till the time period of 150 sec, after this time interval value of data dropped rate comes down till the end of the simulation. Total time has taken for simulation by all the scenarios are 270 sec. Value of date dropped rate for 80 mobile nodes decreases till the time period of 50 sec and then sudden changes in the value happens till the end of simulation. With decrease in number of mobile nodes in a network data dropped value is also decreases. With increase in network load in a network scenario data dropped rate is also increases.

Table 5: Values for Data Dropped (Buffer Overflow) of OLSR

Time (sec)	OLSR_20	OLSR_40	OLSR_60	OLSR_80
0	0	2.33E+09	4.51E+09	5.43E+09
30	2.56E+09	8.6E+09	4.16E+09	4.71E+09
60	2.59E+09	9.59E+09	2.18E+09	3.14E+09
90	2.5E+09	1.07E+10	3.34E+09	7.97E+09
120	2.49E+09	1.04E+10	1.47E+09	6E+09
150	2.48E+09	1.06E+10	5.83E+09	9.07E+09
180	2.07E+09	8.84E+09	4.87E+09	7.61E+09
210	1.82E+09	7.63E+09	4.2E+09	6.57E+09
240	1.72E+09	6.73E+09	3.69E+09	5.77E+09
270	1.76E+09	6.03E+09	3.31E+09	5.17E+09

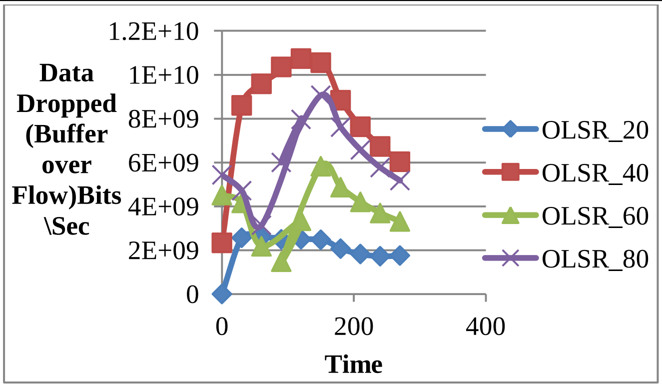

Figure 9: Data dropped (Buffer Over Flow) of OLSR

4.2.2 (b) Delay:

In Figure 10, shows delay in sec. The x-axis denotes time used for simulation and y-axis shows delay in sec. The peak value of delay during simulation is 95 sec. Maximum delay occurs in 60 mobile nodes scenario. Maximum value of delay for 80 mobile nodes is 70 sec. In OLSR routing protocol for delay it is concluded that in heavy networks there is more delay rate. With lesser number of nodes in a network there is less delay occurs.

Table 6: Values for delay of OLSR

Time (sec)	OLSR_20	OLSR_40	OLSR_60	OLSR_80
0	7.72E-05	0.177465	0.095178	0.055452
30	11.47311	10.67995	11.01833	6.523601
60	20.20214	22.90302	21.85376	13.47845
90	24.04017	34.72374	33.16224	19.35738
120	26.89106	45.54152	44.20742	27.41211
150	28.15267	57.19551	55.38814	35.26211
180	28.87615	68.12377	64.93007	44.06242
210	27.17299	76.49346	74.75326	53.32372
240	25.50701	79.93936	85.23071	61.60947
270	25.29279	79.69134	94.08742	69.67018

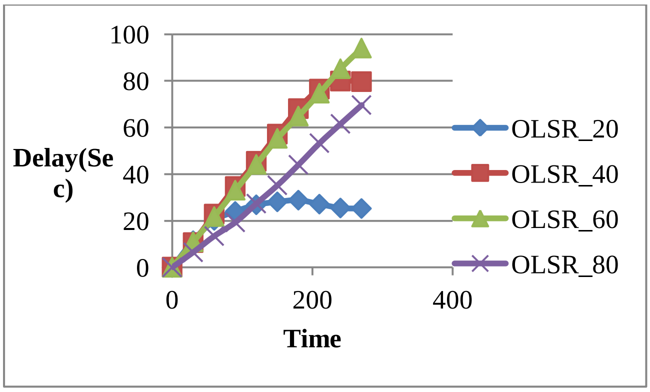

Figure 10: Delay of OLSR

4.2.2 (c) Load

In Figure 11, shows load in bits\sec. x-axis shows the simulation time and y-axis shows the load in bits\sec. Network with 40 mobile nodes is shows maximum load during execution. During simulation at the time period of 150 sec network density with 40, 60 and 80 mobile nodes is shows maximum load. In scenario network density with 20 mobile nodes is shows minimum load during simulation.

Table 7: Values for Load of OLSR

Time (sec)	OLSR_20	OLSR_40	OLSR_60	OLSR_80
0	10581.33	2.85E+09	5.91E+09	6.84E+09
30	2.6E+09	8.71E+09	4.3E+09	4.86E+09
60	2.62E+09	9.65E+09	2.25E+09	3.22E+09
90	2.52E+09	1.04E+10	1.53E+09	6.08E+09
120	2.52E+09	1.08E+10	3.4E+09	8.03E+09
150	2.5E+09	1.06E+10	5.88E+09	9.12E+09
180	2.09E+09	8.87E+09	4.92E+09	7.65E+09
210	1.85E+09	7.66E+09	4.24E+09	6.61E+09
240	1.75E+09	6.75E+09	3.73E+09	5.8E+09
270	1.78E+09	6.06E+09	3.34E+09	5.2E+09

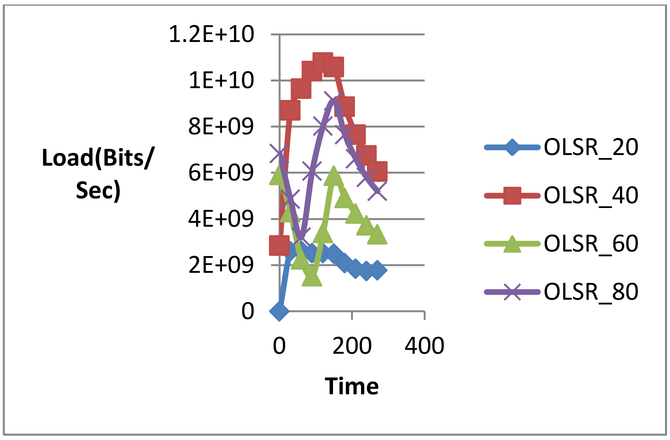

Figure 11: Load of OLSR

4.2.2 (d) Throughput:

In Figure 12, shows that network density with 80 mobile nodes shows maximum throughput at rate of 20000000 bits\sec after that throughput value for this scenario gradually decreases till end of simulation. Network density with 60 mobile nodes shows minimum throughput. Network density with 40 mobile nodes is also shows minimum throughput than network scenario with 20 mobile nodes, but it shows maximum throughput than scenarios with 60 and 80 mobile nodes. OLSR routing protocol performs better with lesser network density. Network density with 20 mobile nodes shows maximum throughput than 40, 60 and 80 mobile nodes.

Table 8: Values for Throughput of OLSR

Time (sec)	OLSR_20	OLSR_40	OLSR_60	OLSR_80
0	203008	7040747	8146371	11533157
30	18401690	17850494	17731626	19580178
60	19264798	18299053	18138900	19452222
90	19530001	18387607	18149425	19149623
120	19870544	18484972	18166065	18949771
150	19902837	18522796	18357698	18990599
180	19947152	18638937	18293439	18869750
210	20020318	18657440	18206399	18754078
240	20072100	18789679	18205156	18719798
270	20052460	18873666	18190830	18659737

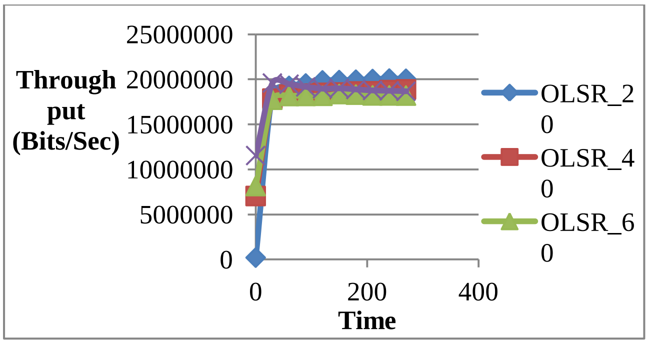

Figure 12: Throughput of OLSR

4.2.3. Results of GRP

The Analysis of GRP routing protocol have done with varying (20, 40, 60, 80) number of nodes. OLSR protocol was simulated in all the four scenarios by using all the four parameters such as: Data Dropped (Buffer Over Flow), Delay, Load, Throughput. These four parameters can be checked in all the 20, 40, 60, 80 mobile nodes.

4.2.3 (a) Data dropped (Buffer Over Flow):

In Figure 13, shows that network density with 40 mobile nodes is shows maximum data dropped rate than network density with 80 and 60 mobile nodes. In scenario with 20 mobile nodes shows a minimum date dropped rate than scenarios of 40, 60 and 80 mobile nodes.

Table 9: Values for Data Dropped (Buffer Overflow) of GRP

Time (sec)	GRP_20	GRP_40	GRP_60	GRP_80
0	0	0	0	0
30	0	0	0	0
60	0	0	0	0
90	0	0	0	0
120	0	0	0	0
150	0	0	0	0
180	0	2505.661	4217.923	3613.596
210	346.1408	14495.4	17861.78	20064.15
240	3257.514	32549.14	44202.04	39539.75
270	4813.158	53727.65	66115.75	62275.6

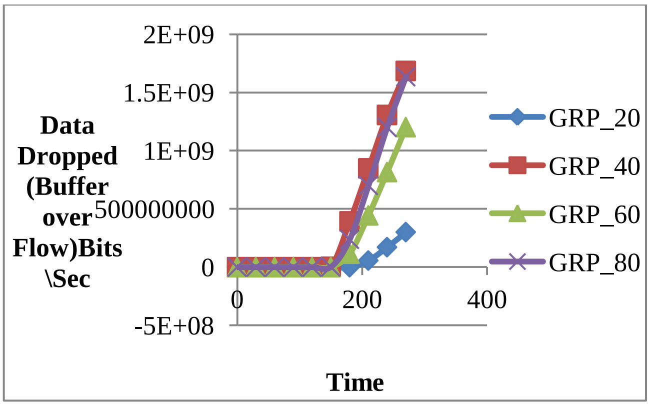

Figure 13: Data dropped (Buffer Over Flow) of GRP

4.2.3 (b) Delay:

From the given results in Figure 14, shows that more delay is occur in network density with 40 mobile nodes. It shows maximum delay at 13 sec. network density with 80 mobile nodes is showing the delay at 9 sec. Network density with 60 mobile nodes shows increase in delay after it reaches simulation of 150 sec than the value of delay abruptly increases till end of simulation. Network density with 20 mobile nodes shows minimum delay. Network with minimum number of nodes shows minimum delay with increase in number of mobile nodes value of delay increases.

Table 10: Values for Delay of GRP.

Time (sec)	GRP_20	GRP_40	GRP_60	GRP_80
0	0.001458	0.002072	0.002181	0.00176
30	0.000354	0.000492	0.00049	0.000427
60	0.000198	0.00028	0.000279	0.000246
90	0.000146	0.000204	0.000203	0.000181

120	0.00012	0.000165	0.000164	0.000148
150	0.000105	0.007837	0.000141	0.006603
180	9.84E-05	1.939468	0.519562	0.978176
210	0.487388	5.217337	1.888889	2.57258
240	1.75033	8.876084	4.105053	5.416583
270	4.045211	12.79461	7.57869	9.035522

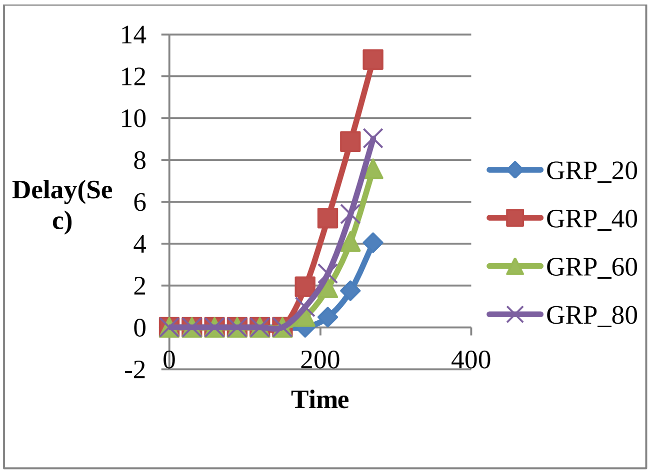

Figure 14: Delay of GRP

4.2.3 (c). Load:

In Figure 15, shows that network density with 40 mobile nodes shows maximum load. Load can be measure in bits\sec. with increase in number of mobile nodes load increases network density with 20 mobile nodes shows minimum load.

Table 10: Load of GRP

Time (sec)	GRP_20	GRP_40	GRP_60	GRP_80
0	69813.33	199920	519973.3	1134013
30	10853.33	38029.09	81689.7	140166.1
60	6146.032	20800	44088.89	75138.41
90	4475.699	14686.45	30746.67	52064.09
120	3620.163	11555.12	23912.85	40245.53
150	3100.131	5208279	19758.95	4036731
180	3231.956	4.02E+08	1.21E+08	2.46E+08
210	59994563	8.6E+08	4.55E+08	7.14E+08
240	1.78E+08	1.32E+09	8.29E+08	1.21E+09
270	3.09E+08	1.7E+09	1.22E+09	1.65E+09

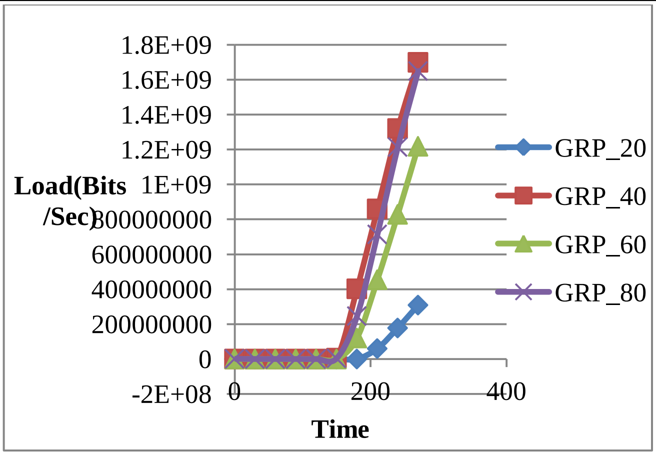

Figure 15: Load of GRP

4.2.3 (d) Throughput:

Table 11: Throughput of GRP

Time (sec)	GRP_20	GRP_40	GRP_60	GRP_80
0	512720	1094347	2263040	3264453
30	92826.67	271993.9	517593.9	668837.6
60	58303.49	178553	350362.5	489509.2
90	46053.33	145396.6	291022.4	425876.6
120	39778.86	128414	260628.6	393284.2
150	35964.97	244227.8	242154	500116.2
180	33882.89	3477101	3328747	3745856
210	1841104	5770319	5620397	5975384
240	4097568	7426272	7258384	7635171
270	5848642	8685505	8541376	8924070

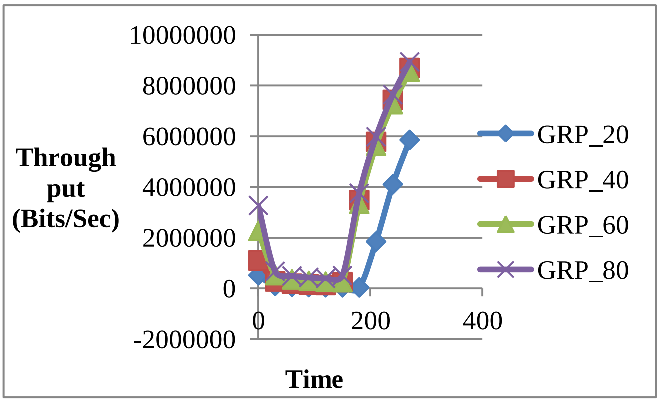

Figure 16: Load of GRP

From the given results in Figure 16, shows that network density with 80 mobile nodes shows maximum throughput than 60, 40, 20 mobile nodes. With increase of mobile nodes in a network throughput also increases in case of GRP routing protocols. Because of the hybrid nature, protocol decides it's working according to the zones. For the nodes present in the range of a specific zone, the hybrid protocol behaves like a reactive protocol and for the nodes present out of the range, protocol behaves like a proactive protocol. With every increment of the node density, it has seen that there is a steep increment in the throughput of the networks.

5. CONCLUSION

5.1 Conclusion

A simulation based analysis of one reactive protocol, AODV, one proactive protocol, OLSR and one hybrid routing protocol, GRP has done under varying node densities by using different types of applications, such that High Definition Video Conferencing and High Load FTP. After running intensive simulations, it has been concluded that as the number of nodes increases in the network, throughput of the network configured by using a hybrid protocol, GRP increases proportionally, such that the throughput has increased by approximately 32% with each increment of nodes due to its boundary resolution feature in which, for a specific range protocol works like a reactive protocol and beyond the range, protocol begins to work like a proactive protocol. Though, increment has also seen in the throughputs of other two protocol, AODV and OLSR, but in comparison to the hybrid protocol, the increment in less. Among the reactive protocol, AODV and proactive protocol, OLSR, the OLSR protocol outperforms the AODV protocol.

5.2 Future Scope

There is always a scope of improving the results of work done by increasing the number of nodes and by configuring other present MANET routing protocols or by running the simulations for longer duration. Different performance evaluation metrics could be chosen to make the concluded results more justified.

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Author Profile

This is to certify that this dissertation entitled **"Network Density Based Analysis of MANET Routing Protocols using Client-Server and Peer-to-Peer Architecture based Applications"** embodies the work carried out by **Preeti Sharma** pursuing M.Tech degree in Computer Science & Engineering at RPSGOI Mahendragarh, Haryana, India Affiliated from Maharshi Dayanand University, Rohtak-124001, Haryana, India under Ms. Komal Garg (Assistant Professor at Computer Science & Engineering Deptt.) and that it is worthy of consideration for the award of M.Tech degree.