IMPLEMENTING POWER OPTIMIZATION IN WSN USING A PRAGMATIC APPROACH

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ABSTRACT

Routing involves transferring data from one point to another within a network of interconnected devices. During the transmission of data, there is at least one middle node that is encountered in the network. Essentially, this concept includes two main tasks: finding the best routing paths and sending packets across a network. The process of moving packets across an internetwork is known as packet switching, and while it is direct, determining the path can be quite complicated. Routing protocols utilize various metrics as a standard to determine the best path for routing packets to their destination, which may include the number of hops used by the routing algorithm to find the most efficient path to the packet's destination. Routing algorithms are responsible for discovering and managing routing tables, which store all the necessary route details for the packet in the path determination process. The details of the route differ depending on the specific routing algorithm. The routing tables contain entries that include the IP address prefix and the corresponding next hop. There are two main classifications of routing: static routing and dynamic routing. Static routing is when the routing scheme is set manually in the router, rather than dynamically. Static routing involves the creation of a routing table typically established by a network administrator. Dynamic routing is when an interior or exterior routing protocol is learning the routing strategy. The routing is mainly determined by the network's condition, meaning the routing table is influenced by how active the destination is.

Key Words: WSN, Power efficiency, Networking, Routing Protocols

INTRODUCTION

Routing in Mobile Ad hoc Networks

Mobile Ad-hoc networks are wireless networks that are able to self-organize and self-configure through multiple hops. Networks that have a dynamic structure where the network changes constantly. This is primarily because the movement of the nodes. Nodes within these networks make use of identical random access. cooperating closely in a wireless channel to participate in multihop communication sending on. The node in the network performs both hosting and routing functions. transferring data between different nodes within the network. In mobile ad-hoc networks, there is no infrastructure support like in wireless networks, so when a destination node source node transferring packets may be too far away for reception, requiring a routing solution to establish connectivity. process. This is constantly prepared to locate a route in order to forward the packets correctly. from the starting point to the ending point. In a cell, a base station has the ability to communicate with all mobile devices nodes in typical wireless networks that do not use routing through broadcast. When it comes to ad-hoc situations In networks, every node needs to have the ability to route data for other nodes. This results in extra opportunities. issues along with the challenges of dynamic topology that is difficultto predictalterations in connectivity.

I. LITERATURE REVIEW

Properties of Ad-Hoc Routing protocols

The properties that are desirable in Ad-Hoc Routing protocols are:

- Distributed operation: The protocol should be distributed. It should not be dependent on a centralized controlling node. This is the case even for stationarynetworks. Thedissimilarity is that the nodes in an ad-hoc network can enter or leave the network very easily and because of mobility the network can bepartitioned.
- Loop free: To improve the overall performance, the routing protocol should assurance that the routes supplied are loop free. This avoids any misuse of bandwidth or CPU consumption.
- Demand based operation: To minimize the control overhead in the network and thus not misuse the network resources the protocol should be reactive. This means that the protocol should react only when needed and should not periodically broadcast control information.
- Unidirectional link support: The radio environment can cause the formation of unidirectional links. Utilization of these links and not only the bi-directional links improves the routing protocol performance.
- Security: The radio environment is especially vulnerable to impersonation attacks so to ensure the wanted behavior of the routing protocol we need some sort ofsecurity measures. Authentication and encryption is theway to go and problemhere lies

within distributing the keys among the nodes in the ad-hoc network.

- Multiple routes: To reduce the number of reactions to topological changes and congestion multiple routes can be used. If one route becomes invalid, it is possible that another stored route could still be valid and thus saving the routing protocol from initiating another route discovery procedure.
- Quality of Service Support: Some sort of Quality of service is necessary to incorporate into the routing protocol. This helps to find what these networks will be used for. It could be for instance real time traffic support.

1.1 Problems in routing with Mobile Ad hoc Networks

- Asymmetric links: Most of the wired networks rely on the symmetric links which are always fixed. But this is not a case with ad-hoc networks as the nodes are mobile and constantly changing their position within network
- Routing Overhead: In wireless ad hoc networks, nodes often change their location within network. So, some stale routes are generated in the routing table which leads to unnecessary routing overhead.
- Interference: This is the major problem with mobile ad-hoc networks as links come and go depending on the transmission characteristics, one transmission might interfere with another one and node might overhear transmissions of other nodes and can corrupt the total transmission.
- Dynamic Topology: Since the topology is not constant; so the mobile node might move or medium characteristics might change. In ad-hoc networks, routing tables must somehow reflect these changes in topology and routing algorithms have to be adapted. For example in a fixed network routing table updating takes place for every 30sec. This updating frequency might be very low for ad-hoc networks.

1.2 Classification of Routing Protocols

Routing is the exchange of information from one station of the network to other. The major goals of routing are to find and maintain routes between nodes in a dynamic topology with possibly unidirectional links using minimum resources. A protocol is a set of standard or rules to exchange data between two devices. Classification of routing protocols in mobile ad hoc network can be done in many ways, but most of these are done depending on routing strategy and network structure. The routing protocols can be categorized into unicast routing protocols, multicast routing protocols and broadcast routing protocols. Unicast forwarding means one-to-one communication, i.e. one source transmits data packets of a single destination. This is the largest class of routing protocols found in Ad Hoc networks. Multicast routing protocols comes in to play when a node needs to send the same message, or stream of data, to multiple destinations. Broadcast is the basic mode of operation over a wireless channel; each message transmitted on wireless channel is generally received by all neighbors located within one hop from the sender. The classification of routing protocols is shown in figure 2.1.

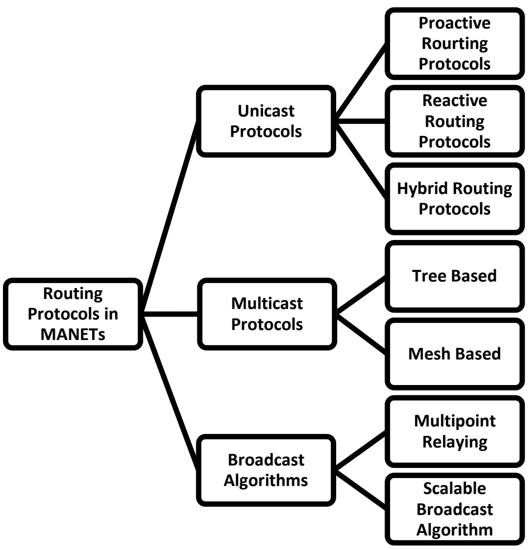


Figure 3.1: Classification of Routing Protocols in MANET.

There are several unicast routing protocols such as proactive routing protocols or table driven routing protocols, reactive routing protocols or on-demand routing protocols and hybrid routing protocols.

1.2.1 Proactive Routing Protocols

Proactive MANET protocols are also called as table-driven protocols and will actively determine the layout of the network. Through a regular exchange of network topology packets between the nodes of the network, at every single node an absolute picture of the network is maintained. There is hence minimal delay in determining the route to be taken. This is especially important for time-critical traffic.

When the routing information becomes worthless quickly, there are many short-lived routes that are being determined and not used before they turn invalid. Therefore, another drawback resulting from the increased mobility is the amount of traffic overhead generated when evaluating these unnecessary routes. This is especially altered when the network size increases. The portion of the total control traffic that consists of actual practical data is further decreased. Lastly, if the nodes transmit infrequently, most of the routing information is considered redundant. The nodes, however, continue to expend energy by continually updating these unused entries in their routing tables as mentioned, energy conservation is very

important
in a MANET system design. Therefore, this excessive expenditure of energy is not desired. Thus, proactive MANET protocols work best in networks that have low node mobility or where the nodes transmit data frequently. Examples of Proactive MANET Protocols include:

- Destination Sequenced Distance Vector (DSDV)
- Intra zone Routing Protocol (IARP)
- Distributed Bellman-Ford (DBF)
- Wireless Routing Protocol (WRP)
- Cluster-head Gateway Switch Routing (CGSR)
- Fisheye Routing Protocol (FISHEYE)
- Source Tree Adaptive Routing (STAR)
- Optimized Link State Routing (OLSR)
- Landmark Ad Hoc Routing Protocol (LANMAR)
- Hierarchical State Routing (HSR)

1.2.2 Reactive Routing Protocols

Portable nodes- Notebooks, palmtops or even mobile phones usually compose wireless ad-hoc networks. This portability also brings a significant issue of mobility. This is a key issue in ad-hoc networks. The mobility of the nodes causes the topology of the network to change constantly. Keeping track of this topology is not an easy task, and too many resources may be consumed in signaling. Reactive routing protocols were intended for these types of environments. These are based on the design that there is no point on trying to have an image of the entire network topology, since it will be constantly changing. Instead, whenever a node needs a route to a given target, it initiates a route discovery process on the fly, for discovering out a pathway.

Reactive protocols start to set up routes on-demand. The routing protocol will try to establish such a route, whenever any node wants to initiate communication with another node to which it has no route. This kind of protocols is usually based on flooding the network with Route Request (RREQ) and Route reply (RERP) messages .By the help of
Route request message the route is discovered from source to target node; and as the
target node gets a RREQ message it send RERP message for the confirmation that the route has been established. This kind of protocol is usually very effective on single-rate
networks. It usually minimizes the number of hops of the selected path. However, on multi-rate networks, the number of hops is not as important as the throughput that can be

obtained on a given path. Some of the reactive protocols are:

- Ad Hoc On-Demand Routing (AODV)
- Dynamic Mobile Ad Hoc Network On-Demand Routing (DYMO)
- Associativity Based Routing (ABR)
- Dynamic source Routing (DSR)
- Inter zone Routing Protocol (IERP)
- Cluster Based Routing Protocol (CBRP)
- Signal Stability Routing (SSR)
- Temporally Ordered Routing Algorithm (TORA)
- Relative Distance Micro Discovery Ad Hoc Routing (RDMAR)
- Caching and Multipath Routing (CHAMP)
- Ant-based Routing Algorithm (ARA)

1.2.3 Hybrid Protocols

Since proactive and reactive protocols each work best in oppositely different scenarios, hybrid method uses both. It is used to find a balance between both protocols. Proactive operations are restricted to small domain, whereas, reactive protocols are used for locating nodes outside those domains. Examples of hybrid protocols are:

- Zone Resolution Protocol (ZRP)
- Hybrid Wireless Mesh Protocol (HWMP)
- Order One Routing Protocol (OORP)
- Wireless Ad Hoc Routing Protocol (WARP)
- HAZY Sighted Link State Routing Protocol (HSLS)

2 SIMULATION ENVIORNMENT AND RESULTS

2.1 Introduction to QUALNET

QualNet is commercial software that runs on all common platforms (Linux, Windows, Solaris, and OS X) and is specialized in simulating all kind of wireless applications. It has a quite clear user interface compared to other solutions while also offering an easy to use command line interface.

QualNet is a comprehensive suite of tools for modeling large wired and wireless networks. It uses simulation and emulation to predict the behavior and performance of networks to improve their design, operation and management. QualNet provides a comprehensive environment for designing protocols, creating and animating network scenarios, and analyzing their performance.

QualNet is composed of the following tools:-

- QualNet Architect- A graphical experiment design and visualization tool. Architect has two modes: Design mode, for designing experiments, and Visualize mode, for running and visualizing experiments.

- QualNet Analyzer- A graphical statistics analyzing tool.
- Packet Tracer- A graphical tool to display and analyze packet traces.
- File Editor- A text editing tool.
- QualNet Command Line Interface- Command line access to the simulator.

2.2 QualNet Key Features

The key features of QualNet that enable creating a virtual network environment are:-

- Speed-QualNet can support real time speed to enable software-in-the-loop, network emulation, and hardware-in-the-loop modeling. Faster speed enables model developers and network designers to run multiple "what-if" analyses by varying model, network, and traffic parameters in a short time.
- Scalability- QualNet can model thousands of nodes by taking advantage of the latest hardware and parallel computing techniques. QualNet can run on cluster, multi-core, and multi-processor systems to model large networks with high fidelity.
- Model Fidelity- QualNet uses highly detailed standards-based implementation of protocol model. It also includes advanced models for the wireless environment to enable more accurate modeling of real-world networks.
- Portability- QualNet and its library of models runs on a vast array of platforms, including Windows XP, and Linux operating system, distributed and cluster parallel architectures, and both 32 and 64-bit computing platforms. Users can now develop a protocol model or design a network in QualNet on their desktop or laptop Windows XP computer and then transfer it to a powerful multi-processor Linux server to run capacity, performance, and scalability analyses.
- Extensibility- QualNet can connect to other hardware and software applications, such as OTB, real networks, and third party visualization software, to greatly enhancing the value of the network model.

2.3 Scenarios-based Network Simulation

In QualNet, a specific network topology is referred to as a scenario. A scenario allows the user to specify all the network components and conditions under which the network will operate. This includes terrain details, channel propagation effects including path loss, fading, and shadowing, wired and wireless subnets, network devices such as switches, hubs and routers, the entire protocol stack of a variety of standard or user-configured network components, and applications running on the network. Most of these are optional; you can start with a basic network scenario and specify as much detail as necessary to improve the accuracy of your network model. [44]

2.3.1 General Approach

In general, a simulation study comprises the following phases:-

- The first phase is to create and prepare the simulation scenarios based on the system description and metrics of interest.

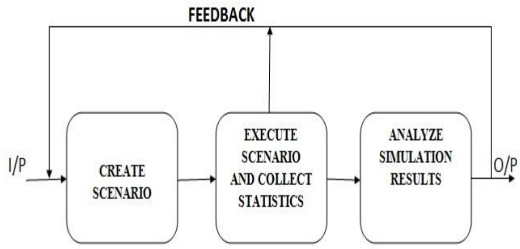


Figure 4.1 Scenario Based Simulation

- The next step is to execute, visualize, and analyze the created scenarios and collect simulation results. Simulation results can include scenarios animations, runtime statistics, final statistics, and output traces.
- The last step is to analyze the simulation results. Typically, users may need to adjust the scenarios based on the collected simulation results.

2.3.2 Files Associated with a Scenario

Input to the QualNet simulator consists of several files. For the command line interface, the input files are text files. The main input files for command line are-

- Scenarios configuration file: This is the primary input file for QualNet and specifies the network scenarios and parameters for the simulation. The file usually has the extension ".config".
- Node placement file: This file is referenced by the scenarios configuration file and specifies the initial position of nodes in the scenario. (The node placement file may also contain the future positions of nodes.) This file usually has the extension ".nodes".
- Applications configuration file: This file is referenced by the scenarios configuration file and specifies the applications running on the nodes in the scenarios. This file usually has the extension ".app".

In addition to the above three files, QualNet may use other input files. These additional files depend upon the models specified in the configuration file and are referenced by the configuration file. These input files are text files, which can be created using any text editor. When using the command line interface, the user has to create these files manually. When the user creates a scenarios in Architect, the major input files representing the scenario (scenario configuration, node placement, and application configuration files) are automatically created by Architect.

The primary output file generated by a QualNet simulation run is a statistics file, which has the extension ".stat". This file contains the statistics collected during the simulation run. Other output files that may be generated by QualNet include the trace file (which has the extension ".trace") which records packet traces, and the animation file (which has extension ".anim") which records the animation trace of a scenario when the scenario is run in Architect. Both the statistics and traces files are text files, which can be viewed using any text editor. In addition, Analyzer can be used to view the contents of the statistics file in a graphical, easy to analyze manner.

2.4 Performance Metrics

The following are the performance metrics used to evaluate the performance of different routing protocols:-

2.4.1 Packet Delivery Ratio

Packet Delivery Ratio is defined as the ratio of total packets received at the destinations to those generated by the CBR sources. It specifies the packet loss rate, which limits the maximum throughput of the network. The better the delivery ratio, the more complete and correct is the routing protocol. In the world of MANET, packet delivery ratio has been accepted as a standard measure of throughput. [42]

2.4.2 Average end to end delay

It is the average time it takes a data packet to reach the destination. This metric is calculated by subtracting time at which first packet was transmitted by source from time at which first data packet arrived to destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times. This metrics is significant in understanding the delay introduced by path discovery. [40]

2.4.3 Throughput

Throughput is the average rate of successful message delivery over a communication channel. It is defined as the amount of data successfully delivered from the source to the destination in a given period of time. It is the amount of data per unit that is delivered from one node to another via a communication link. The throughput is measured in bits per second (bit/s or bps). [43]

2.4.4 Jitter

It is the average amount of variation in the end to end packet transit time. Jitter is the variation in the time between packets arriving, caused by network congestion, timing drift, or route changes. It should be less for a routing protocol to perform better. [41] It becomes a matter of concern if it is more than the threshold value, which is different for each type of transmission as data, voice or video.

This chapter presents a comprehensive study of MANET routing protocols using simulation and emulation. Simulation results comparing different routing protocols briefly and describes the integration and inter-operability of different MANET protocols and applications.

2.5 Design of the simulation

The network designed as randomly a square topology where the mobile nodes placed starting from the center point and the links were made by wireless link. The QualNet Simulator was used which has a scalable network libraries and gives accurate and efficient execution. The simulations were performed with different node mobility speed and CBR (Constant bit rate) traffic flow. By this proposed topology, the failure of node can be easily detected and it gives the way for the accuracy in their performance. CBR traffic flows with 512 bytes were applied.

A two-ray path loss model was applied to avoid random path loss component. Simulations were made in different speed utilization with IEEE 802.11 Distributed Coordination Function (DCF) ad hoc mode and the channel frequency is 2.4 GHz and the data rate 2mbps. The network protocol here applied was Internet Protocol version four (IPv4). The study has been done to compare the efficiency of five different unicasting routing protocols in Mobile Ad Hoc Networks. For the performance comparisons between DYMO, IARP, IERP, OLSR, and ZRP protocol the following parameters has been varied and comparisons has been made:-

- Vary the number of nodes i.e. 50, 75, and 100.
- Vary the pause time i.e. 15s, 30s, and 60s.
- Vary the environments i.e. Grid, Uniform, and Random.

Using the QualNet network simulator comprehensive simulations are made to evaluate the protocols explained above. QualNet provides a scalable simulation environment for multi-hop wireless ad hoc networks, with various medium access control protocols. The tool used is QualNet 5.0, the QoS parameters are First Packet Sent at (s), Last Packet Sent at (s), Total Packets Sent, Total Bytes Sent, Total Bytes Received, Throughput, Average end to end delay, and Average Jitter. The performance of all five routing protocols is carried out and results are compiled. Each data point in the graphs is an averaged over 10 simulation runs.

Table 4.1: Standard Parameters for overall Scenarios

DEVICE PROPERTIES	
No. of Nodes	100
Pause Time	30sec
Minimum Speed	0mps
Maximum Speed	20mps
Mobility Model	Random Waypoint
Traffic Application	CBR
Network Protocol	IPv4
WIRELESS SUBNET PROPERTIES	
MAC Protocol	802.11
Network Protocol	IPv4
SCENARIO PROPERTIES	
Simulation Time	100sec
Dimensional Area	1500X1500
Coordinate System	Cartesian
No. of Channels	1
Channel Frequency	2.4 GHz
Data Rate	2Mbps
Item (Packet) Size	512 bytes
Path loss Model	Two Ray
Shadowing Model	Constant
Fading Model	None

3. RESULT AND ANALYSIS

In the first three graphs the number of nodes has been varied as 50, 75, and 100 nodes and all other parameters are same as listed in above table 5.1.

All the clients have 4274bps throughput. The maximum throughput is shown by DYMO, IARP and OLSR. ZRP shows the least value of throughput i.e.662 in case of 100 nodes but for this hybrid protocol the value of throughput is maximum i.e. 4273 in case of 75 nodes as shown in the above graph. IERP shows the least value of throughput i.e. 4097 and OLSR shows the maximum value of throughput i.e. 4300 when there are 75 nodes. IERP shows the minimum value of throughput i.e. 2914 and OLSR shows the maximum value of throughput i.e. 4102 when there are 50 nodes.

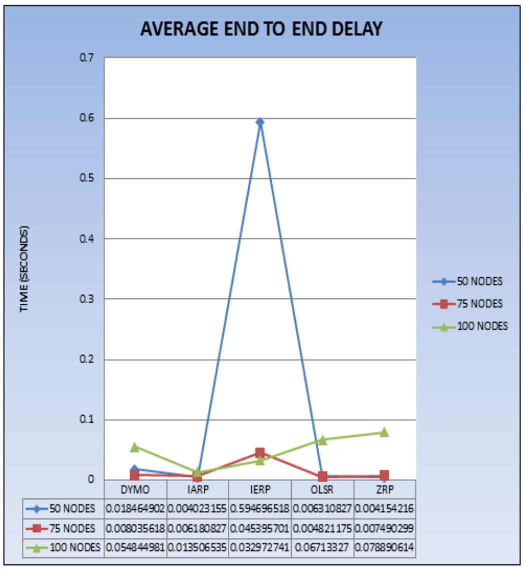
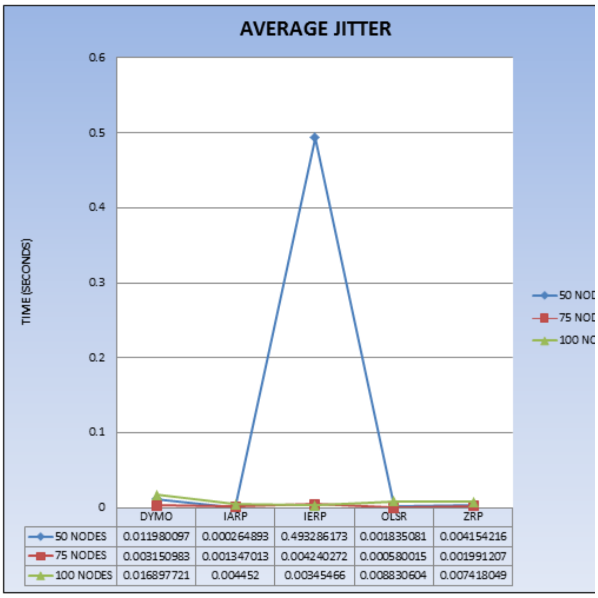


Figure 4.7 No. of Nodes v/s Average End to End Delay (ETED)

The maximum value of ETED i.e. 0.594696518 is shown by IERP and minimum value of ETED i.e. 0.004023155 is shown by IARP when there are 50 nodes. IERP shows the maximum value of ETED i.e. 0.045395701 and OLSR shows the minimum value of ETED i.e. 0.004821175 when there are 75 nodes. When there are 100 nodes, ZRP shows the maximum value of ETED i.e. 0.078890614 and IARP shows the minimum value of ETED i.e. 0.013506535.



	DYMO	IARP	IERP	OLSR	ZRP
50 NODES	0.011980097	0.000264893	0.493286173	0.001835081	0.004154216
75 NODES	0.003150983	0.001347013	0.004240272	0.000580015	0.001991207
100 NODES	0.016897721	0.004452	0.00345466	0.008830604	0.007418049

Figure 4.8 No. of nodes v/s Average Jitter

IARP and ZRP show almost equal values of jitter in all the three cases. The maximum value of jitter i.e. 0.493286173 is shown by IERP and IARP shows the minimum value of jitter i.e. 0.000264893 when there are 50 nodes. The minimum value of jitter i.e. 0.000580015 is shown by OLSR and IERP shows maximum value of jitter i.e. 0.004240272 in case of 75 nodes. When there are 100 nodes, DYMO shows the maximum value of jitter i.e. 0.016897721 and IERP shows the minimum value of jitter i.e. 0.00345466.

In the next seven graphs the pause time has been varied as 15sec, 30sec, and 60sec and parameters are same as listed in table 5.1.

4. CONCLUSION

In the recent time, there has been a lot of interest in the field of wireless networks. The fast moving world demands seamless communication facilities, so former types of connectivity like wired networks, radio waves are fast becoming obsolete. One of the recent developments in the world of wireless technology is the use of mobile ad hoc networks, which was initially developed for military applications but now has expanded to include many commercial applications. The rapid use of MANET has resulted in the identification of several problems and this has become the area of potential interest.

In this thesis work total five, two On-demand routing protocols, namely, Dynamic Mobile Ad Hoc On-Demand Routing (DYMO) and InterzoneRouting Protocol (IERP), two proactive routing protocols, namely, Optimized Link State Routing (OLSR) and Intrazone routing protocol (IARP) and one hybrid routing protocol, namely, Zone routing protocol (ZRP) has been compared by varying different parameters. The simulation of these protocols has been carried out using QUALNET 5.0. In these experiments, some problems are faced like communication stoppage for short durations; difference in simulation times for same scenarios conditions (of course was solved by running the simulator for more than 10 times). The problem of switching off the scenario was also faced for higher node densities. It might be due to the processor capability (RAM usage). I believe that our work could be more intuitive for researchers for protocol selection and their suitability of application in real time scenario analysis in ad hoc networks.

From the above results, it is concluded that in each case the best performance in terms of packet delivery ratio (PDR) and throughput is shown by on demand protocols (DYMO and IERP). ZRP shows least values of throughput and PDR in each case. IARP shows the least values for average jitter and end to end delay. The maximum values of average jitter and ETED is shown by OLSR and IERP. DYMO and ZRP show moderate values of jitter and delay. When varying the environment as GRID, UNIFORM and then RANDOM, for all the protocols the numbers of packet sent are more when there is GRID and UNIFORM environment but it is less when the environment is RANDOM. Regretfully ZRP was not up to the task and it performed poorly throughout all the simulation sequences, hence putting itself out of competition. Hence, the overall best performance is shown by DYMO in each case. IERP perform poor in more stressful circumstances.