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Pragmatic Implementation of Power Optimization in Wireless Sensor Networks

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Abstract— Energy efficiency in routing protocols has been major design goal for Mobile Ad Hoc Networks (MANETs) as the hosts are energy constrained. Essentially two actions are concerned in this notion: Finding an optimal routing path-ways and transferring the packets throughout an inter-network. The transmission process of packets way-through an inter-network is called packet switching which is straight forward and simple, but the path determination could be very difficult and complex. The routing protocols employed use many metrics as a benchmark measurement to compute the best path for routing the packets to its destination and that measurement could be number of hops, and are used by the routing technique to determine the optimal path for the packet to its destination. The process of path determination is through routing tables, which contain the total route information for the packet. Routing techniques are majorly classified into static-routing and dynamic-routing. The static routing method refers to the routing strategy which is done manually or statically in the router. The static routing technique maintains routing tables written by a networks administrator. The dynamic routing process refers to the routing policy that is being learnt by routing protocol and is used consequently. This type of routing basically depends on the state of the network.

***Keywords*— MANET, Routing, Protocols, Algorithms, Energy.**

I. INTRODUCTION

A. Routing in Mobile Ad hoc Networks

Mobile Ad-hoc networks are self-organizing and self-configuring multi-hop wireless networkswhere the structure of the network changes dynamically. This is basically due to the movement of the nodes. Nodes in these networks utilize the same random-access wireless channel, cooperating in an intimate manner to engaging themselves in multi-hop forwarding. The node in the network not only acts as hosts but also as routers that route data to/from other nodes in network. In mobile ad-hoc networks there is no infrastructure support as is the case with wireless networks, and since a destination node might be out of range of a source node transferring packets; so there is need of a routing procedure [][2][3][4][5][6].

II. RELATED WORK

A. Properties of Ad-Hoc Routing Protocols

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

- **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 [5].

- **Distributed Operation:** The protocol should be distributed. This is the case evenforstationary networks. It should not be dependent on a centralized controlling node. The dissimilarity is that the nodes in an ad-hoc network can enter or leave the network very easily and because of mobility the network can be partitioned [7][8].

- **Quality of Service Support:** The Qos should not be dependent on a centralized controlling node. 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 [6][7].

- **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 [9][0].

- **Demand based Operation:** This means that the protocol should react only when needed and should not periodically broadcast control information. To minimize the control overhead in the network and thus not misuse the network resources the protocol should be reactive.

➢ **Unidirectional link Support:** Utilization of these links and not only the bi-directional links improves the routing protocol performance [ ][2]. The radio environment can cause the formation of unidirectional links.

➢ **Security:** Authentication and encryption is the way to go and problem here lies within distributing the keys among the nodes in the ad-hoc network [3][4]. The radio environment is especially vulnerable to impersonation attacks so to ensure the wanted behavior of the routing protocol we need some sort of security measures.

B Problems in routing with Mobile Ad hoc Networks

➢ **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 over hear transmissions of other nodes and can corrupt the total transmission.

➢ **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 chaging their position within network

➢ **Dynamic Topology:** Since the topology is not contant; so the mobile node might move or medium characteristics might change. In ad-hoc networks, routing tables must somehw reflect these changes in topology and routing algorithms have to be adapted. For exmple in a fixed network routing table updating takes place for every 30sec. This updating frequency might be very low for ad-hoc networks [7].

C. Classification of Routing Protocols

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. 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. The routing protocols can be categorized into unicast routing protocols, multicast routing protocols and broadcast routing protocols[8]. The classification of routing protocols is shown in figure 1.

D. Proactive Routing Protocols

Proactive MANET protocols are also called as table-driven protocols and will actively determine the layout of the network. 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. Lastly, if the nodes transmit infrequently, most of the routing information is considered redundant. The nodes, however, continue to expend energy

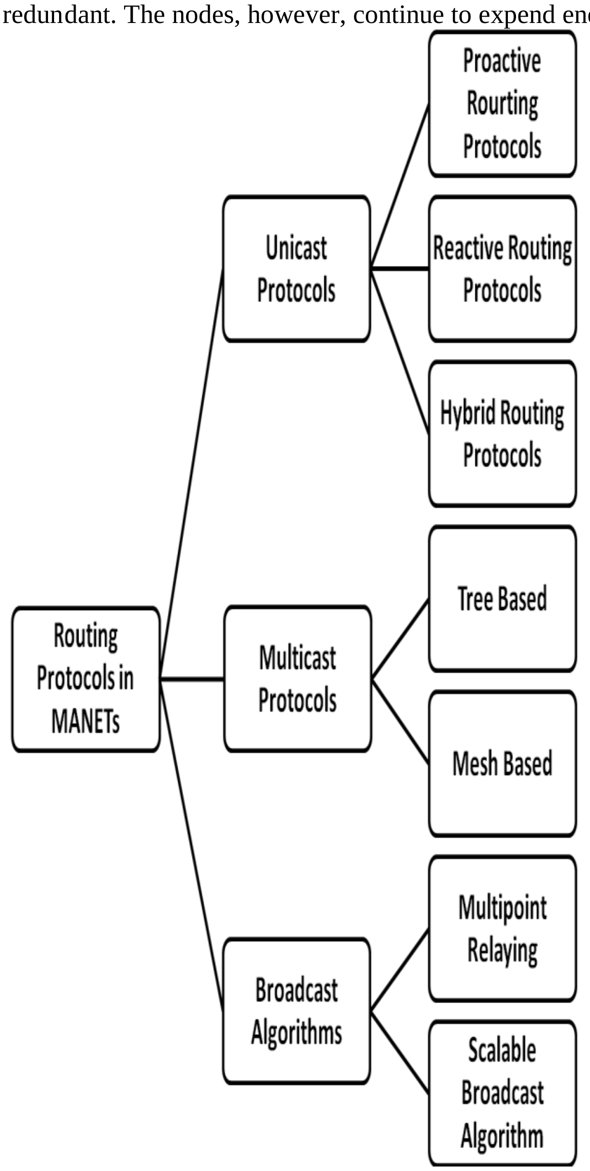

Fig. 1 Classifi cation of Routi ng Protoc ols in MANET.

by continually updating these unused entries in their routing tables as mentioned, energy conservation is very important in a MANET system design. Exmples 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)

E. Reactive Routing Protocols

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)

F. 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)

III. SIMULATION ENVIORNMENT AND RESULTS

A. Introduction to QUALNET

QualNet is a comprehensive suite of tools for modeling large wired and wireless networks.
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.

B. QualNet Key Features

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

- **Sped**
- **Scalability**
- **Model Fidelity**
- **Portability**
- **Extensibility**

C. 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 [8][9].

D. 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.
- 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. Figure 2 presents the process.

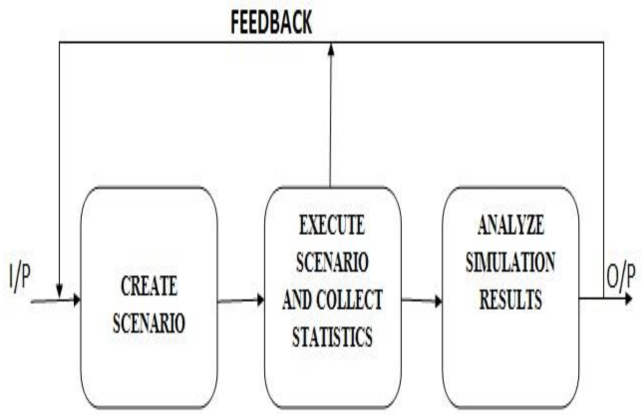

Fig. 2 Scenario Based Simulation

E. 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:**
- **Node placement file**
- **Applications configuration file:**

IV. PERFORMANCE METRICS

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

- **Packet Delivery Ratio**
- **Average end to end delay**
- **Throughput**
- **Jiter**

V. 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 falure of node can be easily detected and it gives the way for the accuracy in their performance. CBR traffic flows with 52 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. 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 00.
- Vary the pause time i.e. 5s, 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 0 simulation runs.

TABLE 1: Standard Parameters for overall Scenarios

DEVICE PROPERTIES	
No. of Nodes	00
Pause Time	30sec
Minimum Speed	0mps
Maximum Speed	20mps
Mobility Model	Random Waypoint
Traffic Application	CBR
Network Protocol	IPv4

VI. RESULT AND ANALYSIS

In the first three graphs the number of nodes has been varied as 50, 75, and 00 nodes and all other parameters are same as listed in above table .

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 00 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. 294 and OLSR shows the maximum value of throughput i.e. 402 when there are 50 nodes. Figure 3 presents a metric called end to end delay.

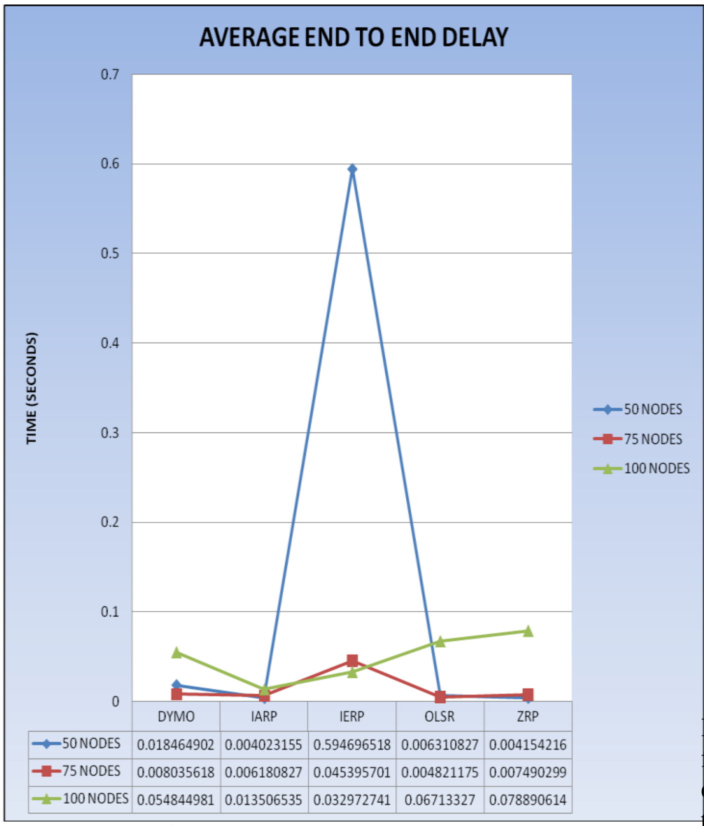

Figure 3. No. of Nodes v/s Average E nd to En d De lay (ETED)

The maximum value of ETED i.e. 0.59469658 is shown by IERP and minimum value of ETED i.e. 0.00402355 is shown by IARP when there are 50 nodes. IERP shows the maximum value of ETED i.e. 0.04539570 and OLSR shows the minimum value of ETED i.e. 0.00482 75 when there are 75 nodes. When there are 00 nodes, ZRP shows the maximum value of ETED i.e. 0.07889064 and IARP shows the minimum value of ETED i.e. 0.03506535.

IARP and ZRP show almost equal values of jitter in all the three cases. The maximum value of jitter i.e. 0.49328673 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. 0.00058005 is shown by OLSR and IERP shows maximum value of jitter i.e. 0.004240272 in case of 75 nodes. When there are 00 nodes, DYMO shows the maximum value of jitter i.e. 0.0689772 and IERP shows the minimum value of jitter i.e. 0.00345466. Figure 4 presents the jitter comparison.

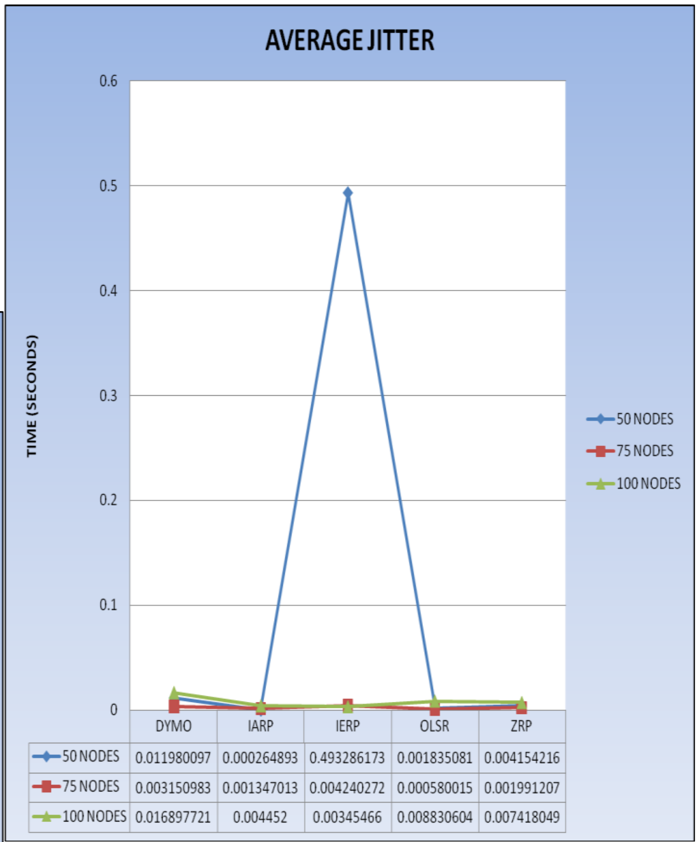

Fig. 4 No. of nodes v/s Average Jitter

VII. 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 deveopments 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 work total five, two On-demand routing protocols, namely, Dynamic Mobile Ad Hoc On-Demand Routing (DYMO) and Inter-zone Routing Protocol (IERP), two proactive routing protocols, namely, Optimized Link State Routing (OLSR) and Intra-zone 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 0 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).

It can be seen 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 mark 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.

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