Simulation of energy consumption analysis of multi-hop 802.11 wireless ad-hoc networks on reactive routing protocols

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ABSTRACT

In this paper we compare energy consumption in multi-hop IEEE 802.11 wireless ad-hoc networks using different routing protocols and various TCP/IP topologies. The performance costing of three MANET routing protocols: such as STAR, RIP and OLSR based on multi-hop IEEE 802.11 through simulator. When a source node has data to send to a destination node, if does not have the same route, than it will initiate a broadcast route-query process. The implementation was achieved over a real-world considering some vital metrics with application, MAC and physical layer model to define the performance effectiveness of routing protocols. Performance is analyzed and compared on performance measuring metrics like average jitter, throughput, average end to end delay, Energy consumed (mjules) in transmit, received and ideal modes, in different mobility models with varying CBR traffic load and then their performance is compared using QualNet 5.0 network simulator.

Keywords - Ad hoc network, STAR, RIP, OLSR QualNet 5.0

I. INTRODUCTION

The Wireless Sensor Networks are a valuable technology to support countless applications in different areas, such as: monitoring, environmental, habitat, surveillance, indoor climate control, structural monitoring, medical diagnostics, mapping and disaster management and so on. All of above defined as special type of multi-hop ad-hoc networks (MANETs) [1], since they share a number of common characteristics. MANETs are wireless networks also known as"networks without a network" since they do not use any fixed infrastructure. Participating nodes in these networks are typically battery operated, and thus have access to a limited amount of energy. Besides being power constrained, network nodes often have exhibit additional constrains, e.g., they typically have a limited processing, storage and communications capabilities [2].The mobile hosts depends on the assistance of the other node in the network to forward a packet to the destination in case the destination node is multi-hop away from the source. Thus each node here acts as a router when the situation demands. In an ad hoc network, one of the major concerns is how to decrease the power usage or battery depletion level of each node among the network so that the overall lifetime of the network can be stretched as much as possible. So while the data packets are sent from source to destination, special routing strategies need to be adopted to minimize the battery depletion level of the intermediate nodes. This paper addresses the comparison of different routing protocols at physical layer of TCP/IP in network layers using omni directional antenna and considers the battery power of each node as important criteria while determining the route for data packet transmission. We focus on the energy performance measuring metrics like Energy consumed (in mjules) in transmit mode, Energy consumed (in mjules) in recived mode, Energy Consumed (in mjules) in ideal mode in different mobility with varying CBR traffic load depletion of the nodes.

Evaluating the winner performer among on demand routing protocols STAR, RIP and OLSR based on IEEE 802.11 through simulation different mobility models and varying CBR nodes results are scrutinized to provide qualitative assessment of the applicability of the protocols. The mobility model uses the File, Group and random waypoint model in a rectangular field where 30 nodes are placed randomly over the region of 1500m x1500m. To test competence and effectiveness of all three routing protocols comparison is done by means different mobility models varying number of Nodes and different mobility.

A. Factors affecting performance of MANET

Bandwidth constraints and variable link capacity: Wireless link usually has lower capacity than wired link. Due to multi path fading, noise and signal interference, wireless link is very unstable. Obstacles in environments also affect the wireless link. Error always bursts on wireless link as opposed to flat bit error rate on wired link [3].
Dynamic topology: [4] [5] Because of node mobility a node can join, stay and leave the network. So network topology should be adaptive to current

location of nodes. Depletion of battery capacity can also cause node failure. As all nodes adjust their power level dynamically, some new links between two nodes are established and some old ones are broken. Thus the network topology should be constructed on the fly depending on all these facts. Topology management is a hard issue in MANET.
Mobility: The mobility of the nodes affects the number of average connected paths, which in turn affect the performance of the routing algorithm, node density and length of data paths. Density is increased the throughput of the network shall increase [6].

Energy constraints: The major affects energy because nodes are battery operated and to minimize the total energy consumption of the nodes. Performance of the nodes increases when minimize the total energy consumption as well as minimize the total number of collision [7].

Multi-hop communication: Another issue because of transmission power limit, a node will communicate with the nodes outside its transmission range via intermediate nodes [8].

Limited physical security: Wireless network is less secure than wired network in natural. Lacks of central authority and there are limited computation and power capacity in each node [8] [9].

This paper compares the performance of reactive routing protocols under the effect of mobility. To find the effect of Reactive routing protocols in various mobility model such as group, file and random waypoint mobility models are considered. The rest of this paper is organized as follows: in section II brief introductions related work to various routing protocols techniques is discussed. In section III Simulation setup and platform used in this work is discussed. In section IV the results of the performance evaluation are thoroughly discussed. Conclusion and Future work of paper given in section V.

II. RELATED WORKS AND OVERVIEW OF ROUTING PROTOCOLS

Although energy consumption is agreed to be of importance in the design of MANET routing protocols, there is no work that examines the energy consumption of well-known protocols. In fact, very little has been published about the energy consumption of wireless network interfaces. The values used here are based on experiments reported in [10] and extended in [11].

Most proposed energy management strategies for wireless networks rely on base station support [3] [5]. Low level energy management strategies that explicitly or implicitly assume that the mobile node communicates only with a resources base station are often not applicable in the MANET environment. High-level energy management strategies supporting common applications such as email and web browsing also make assumptions that are inappropriate for the MANET environment.
One exception is that analyzes an energy conserving MAC protocol for ad hoc networks. In simulation, the protocol provides energy savings of 10–70%. Further work [6].

A. OVERVIEW OF ROUTING PROTOCOLS

Routing is the process of finding a path from a source to some arbitrary destination on the network. The broadcasting [10] [11] is inevitable and a common operation in ad-hoc network. It consists of diffusing a message from a source node to all the nodes in the network. Broadcast can be used to diffuse information to the whole network. It is also used for route discovery protocols in ad-hoc networks. The routing protocols are classified as follows on the basis of the way the network information is obtained in these routing protocols.

1) Table Driven Routing Protocols:

It is also known as proactive routing protocols. In these protocols the routing information is stored in the form of tables maintained by each node. These tables need to be updated due to frequent change in the topology of the network. These protocols are used where the route requests are frequent. For example Destination sequenced Distance vector routing (DSDV), Source Tree Adaptive Routing (STAR), RIP, OLSR etc [12].

2) On Demand Routing Protocols:

It is also known as reactive protocols. These protocols start the routing process whenever a node requires otherwise the network is ideal. These are generally considered efficient, where the route discovery is required to be less frequent. This makes them more suitable to the network with light traffic and low mobility. For example Ad-Hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR) etc [9].

3) Hybrid Routing Protocols:

This protocol combines the advantages of the two routing protocols in order to obtain higher efficiency. In these a network is divided in to the zones, if the routing is to be carried out within the zone than table driven routing is used otherwise on demand routing is preferable. For example Temporally ordered routing algorithm (TORA), Zone Routing Protocol (ZRP) [9] [13].

These classes of routing protocols are reported but choosing best out of among them is very difficult as one may be performing well in one type of scenario the other may work in other type of scenario. In this paper it is observed with the simulation of STAR, RIP and OLSR routing protocols. These three protocols are briefly described below. The characteristic summary of these routing protocols is also presented in this paper in table 2.

III. ROUTING PROTOCOLS UNDER CONSIDERATION

A. Optimized link state Protocol (OLSR):

It is a proactive non-uniform Link State routing approach. In OLSR, every node transmits its neighbor list using periodical beacons. So, all nodes can know their multi-hop neighbors. OLSR uses an extraction algorithm for multipoint relay (MPR) selection [6]. The multipoint relay set of a node P is the minimal (or near minimal) set of P's one-hop neighbors such that each of P's two-hop neighbors has at least one of P's multipoint relays as its one-hop neighbor. In OLSR, each node selects its MPR independently and only the knowledge of its two-hop neighbors is needed. When a node broadcasts a message, all of its neighbors will receive the message. Only the MPRs, which have not seen the message before, rebroadcast the message. Therefore, the overhead for message flooding can be greatly reduced.

B. Routing Information Protocol (RIP):

It is an Interior Gateway Protocol used to exchange routing information within a domain or autonomous system. It is based on the Bellman-Ford or the distance-vector algorithm. This means RIP makes routing decisions based on the hop count between a router and a destination. RIP does not alter IP packets; it routes them based on destination address only. A router in the network needs to be able to look at a packet's destination address and then determine which output port is the best choice to get the packet to that address. The router makes this decision by consulting a forwarding table [8][13].

C. Source Tree Adaptive Routing (STAR):

This Protocol for ad-hoc network is a proactive table driven routing protocol. This protocol works on below mechanism [10].

a) Route Discovery & Maintenance

Each node builds a shortest path tree (source tree) and stores preferred path to destination and so each node discovers and maintains information related tonetwork topology. STAR protocol uses two different techniques to neighbor discovery using hello or update messages. It is energy saving protocol in the sense that every node of it updates about only the changes to its source routing tree when they found changes or breakage in the links. If over a given period of time a node doesn't receive any such message, it assumes that either node is out of its range (node may be dead) or link is broken. Within the finite time frame all the changes like link failures, new neighbor notifications etc. are processed and send to neighbors in their order of occurrences and one at time.

a) Different Operating Modes;

The STAR routing protocol operates in two different mechanisms but chooses one at a time. It may work either in the Optimum Routing Approach (ORA) mode or, Least Overhead Routing Approach (LORA) mode this routing protocol attempts to update routing tables as quickly as possible to provide paths that are optimum with respect to a defined metric whereas in LORA mode it tries to provide shortest route as per performance and delay metrics [13].

IV. SIMULATION ENVIRONMENT AND METHODOLOGY

The simulator used in this paper is QualNet 5.0, [14] this is developed by Scalable Network Technologies. The simulation parameters are as shown in Table.1. It consists of total 30 number of nodes in the Terrain area of 1500 m *1500 m, the CBR of packet size is 512, the simulation time chosen over here is 30 seconds, the mobility is File, Group, Random way point. Further increase in these values increases the time taken for completing simulation, to a limit which is not feasible due to various constraints. It shows the performance of various protocols such as STAR, RIP and OLSR with respect to physical and application layer model to define the performance effectiveness of routing protocols. Performance is analyzed and compared on performance metrics of average jitter, throughput, average end to end delay, energy consumed in transmit, received, and ideal modes. In this simulation we performed by increasing the no. of node 1 to 30 in equal 29 simulation linearly with in the simulation area 1500x1500. The source nodes transmit 1000 byte data packets per second at a constant bit rate (CBR) across the established routefor the entire simulation time 30 second. Fig 1 shows the snapshot of running scenario of 30 nodes using STAR routing.

Table 1 Simulation Setup Parameters

Parameters	Value
Simulator	QALNET 5.0
Number of Nodes	30
Simulation Time	30s
Simulation Area	1500 X 1500
Mobility Model	File Mobility Group Mobility Random Waypoint Mobility
Energy Model	Mica-Motes
Traffic Type	Constant-Bit Rate
Node Placement Model	Random
Battery Model	Linear Model
Antenna Model	Omni direction
Total packet sent	24
Packet Size	12288 Bytes

A. Snapshot

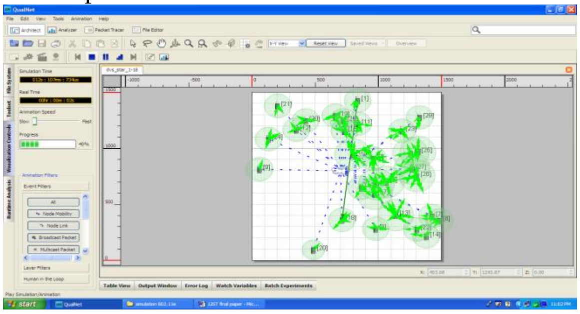

Fig. 1 Snapshot of simulation scenario 30 nodes for STAR routing

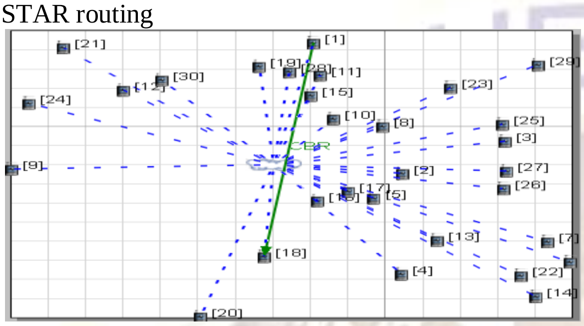

Fig. 2 Snapshot of simulation scenario representing CBR between nodes 1 to node 18.

V. RESULTS AND DISCUSSION

A. Impact on Average Jitter

Average Jitter: It is the alteration in arrival time ofthe packets and caused due obstruction, topology changes. It is measured in second (s).

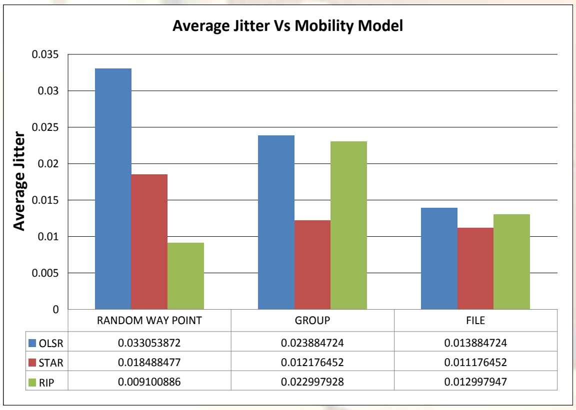

Fig. 3 Average jitter for different routing protocols vs. using mobility models.

Fig. 3 shows the impact of mobility models on the Average Jitter taking routing protocol as parameter. Following assumption can be made:

- The OLSR presents highest values of Average Jitter for Random waypoint and group mobility.
- The RIP presents least value of the average jitter for all three mobility models.

B. Impact on Average End to End Delay

End-to-End Delay: Delays due to buffering during the interface queues, route discovery process, and transfer the channel. It measured in second.

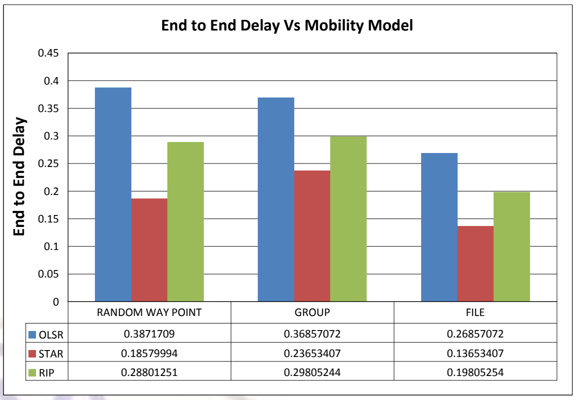

Fig. 4 End to End Delay for different routing protocols vs. mobility's.

Fig. 4 shows the impact of mobility models on the End to End Delay taking routing protocol as parameter. Following assumption can be made:

- The OLSR presents highest values of End to End Delay for Random waypoint as well as Group mobility.
- The RIP presents least value of End to End Delay for all three mobility models.

C. Impact on Throughput

Throughput: Average rate of successful data packets received at destination is called throughput. It is precise in bps (bit/s)

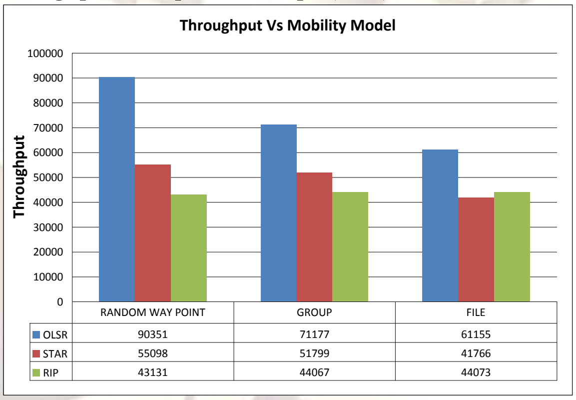

Fig. 5 Throughput for different routing protocols vs. using different mobility models.

Fig. 5 shows the impact of mobility models on the Throughput taking routing protocol as parameter. Following statement can be made:

- The OLSR presents highest values of Throughput for Random waypoint, File and Group mobility models.
- The RIP presents least value of the average jitter for all three mobility models.

D. Impact on Energy consumed in Transmit Mode:

The mobility, effective scalability, efficiency, lifetime, sampling frequency and response time of nodes, all these parameters of the

MANET depend upon the power. In case of power failure the network goes down break therefore energy is required for maintaining the individual health of the nodes in the network, during receiving the packets and transmitting the data as well.

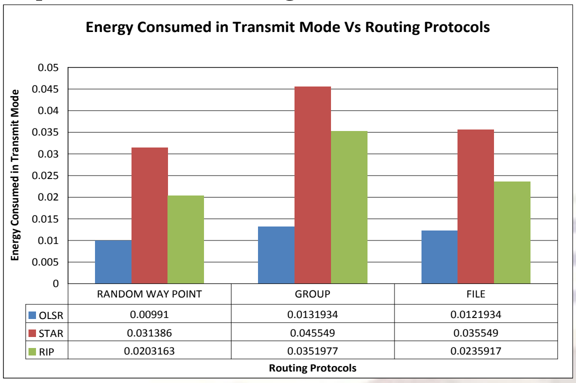

Fig. 6 Energy consumed in transmit mode for different routing protocols using different Mobility models.

Fig. 6 shows the impact of different mobility models on the Energy Consumed in Transmit Mode taking routing protocol as parameter. Following interferencecan be made:

- The STAR presents highest energy consumed in all mobility models.
- The RIP consumes moderate energy for all three mobility models.
- The OLSR consumes least energy in Random waypoint, File and Group mobility models.

E. Impact on Energy consumed in Received Mode:

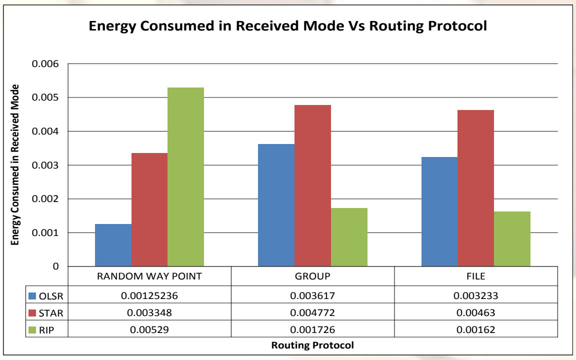

Fig. 7 Energy consumed in received mode for different routing protocols using Mobility models.

Fig. 7 shows the impact of mobility models on the Energy Consumed in Received Mode taking routing protocol as parameter. Following interference can be made:

- The RIP presents highest energy consumed in received mode in Random waypoint mobility model.
- The STAR consumes moderate energy for all three mobility models.
- The OLSR consumes least energy in Random waypoint mobility model.

F. Impact on Energy consumed in Ideal Mode:

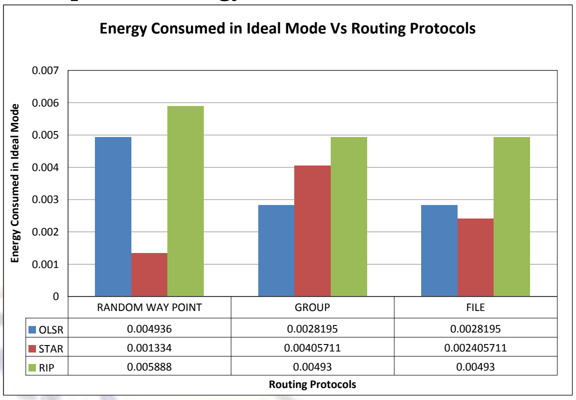

Fig. 8 Energy Consumed in Ideal Mode for different routing protocols using different Mobility models.

Fig. 8 shows the impact of mobility models on the Energy Consumed in Ideal Mode taking routing protocol as parameter. Following interference can be made:

- The RIP presents highest energy consumed in Ideal mode in Random waypoint mobility model.
- The OLSR consumes moderate energy for all three mobility models.

TABLE II OVERALL COMPARISION OF OLSR, STAR AND RIP ROUTING PROTOCOLS

Performance Metrics	OLSR Routing Protocol	STAR Routing Protocol	RIP Routing Protocol
Average Jitter	Efficient	Good	Worst Constantly Low
Average End to End Delay	Good	Average	Low
Throughput	Constantly Good	Good	Efficient Decreases at Random way point & Group
Energy consumed in Transmit Mode	Most efficient	Average	Poor
Energy consumed in Received Mode	Good at random way point low at file & group mobility	Average	Good at random way point average at file, group mobility
Energy consumed	Efficient	Good	Average

in Ideal Mode			

VI. CONCLUSION

The above result shows a major impact of mobility on the performance metric of OLSR, STAR and RIP protocols. Simulation results have indicated that the comparative ranking of routing protocols may depend upon mobility model which we have used and analyzed performance shown in table II. The comparative ranking also depends on the node speed as the presence of the mobility implies repeated link failures and each routing protocol reacts differently during link failures. Table II shows the overall comparison of the three reactive routing protocols. The results can be very useful for researchers while designing a new routing protocol for MANET.

Future work proposed in a mobility model where the nodes are forced to move along predefined pathways the different on demand routing is observed to generate less control traffic in comparison with the RWP, File and Group mobility and pattern.

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