# Performance Evaluation of Internet Routing Protocols in Wireless Mesh Networks

H R Ranganatha
[1]Research Scholar,
Jain University, Bangalore 560 027. INDIA

Shobha Rani A
Associate Professor, Department of Electronics and Communication Engineering,
Acharya Institute of Technology, Bangalore 560 107. INDIA.

T G Basavaraju
Professor, Department of Computer Science and Engineering,
Government SKSJ Technological Institute, Bangalore 560 001. INDIA.

**Abstract--Wireless Mesh Networks are considered as a feasible solution for transformation into next generation wireless network to offer Internet services for large variety of applications. These types of networks are used for providing enhanced services and extended coverage for scalable deployment. To support such services, an attempt is made to incorporate existing Internet Protocols into Wireless Mesh Networks and study their performance under different network scenarios. In this research contribution, a systematic investigation of proactive protocol Optimized Link State Routing (OLSR), two Internet Protocols Open Shortest Path First (OSPF) and Routing Information Protocol (RIP) are simulated in QualNet for Wireless Mesh Networks. The simulation results shows that OLSR provides better throughput and end-to-end delay in terms of number of nodes and OSPF has got clear advantage over link utilization when compared to OLSR and RIP.**

## I. INTRODUCTION

Wireless Mesh Networks have been gaining more visibility and special attention in the area of wireless networking [1]. It is a latest kind of multi-hop wireless network that consists of mesh clients and mesh routers [2]. Mesh clients are mobile or static and can access network through mesh routers directly or indirectly forming a perfect mesh network. Mesh routers provide back bone and power enabled support. WMN serve wide variety of rich set of application like transportation systems, home networking, and wireless community networks [3]. The design of routing protocols and associated metrics are mainly depend on the performance of WMN. The best routing metric is used by routing protocol to select best route between source and destination. The mesh networks are self organizing, self configuring and self healing network where users are able to deploy and maintain with limited knowledge. The higher reliable Internet access services are provided by WMN that can facilitate the deployment of public access wireless networks. Through ubiquitous access and reliable connectivity wireless enable advanced applications and services are available for users. To achieve better efficiency and bandwidth utilization the functionality of routing and forwarding is enhanced through IEEE 802.11s. External networks (Internet) are equipped with routing information updated and dynamic discovering by each node the network. The critical challenges of wireless mesh networks are evaluating different routing protocols of Internet.

The rest of the paper is organized as follows: The brief descriptions about the Internet routing protocols used in WMN are discussed in Section II. Section III describes the simulation environment and parameters. The simulation results are analyzed and discussed in Section IV. The conclusion for this work is done in Section V.

## II. INTERNET ROUTING PROTOCOLS FOR WIRELESS MESH NETWORKS

The popular three types of routing protocols have been considered for evaluation, namely Optimized Link State Routing (OLSR) [5], Open Shortest Path First (OSPF) [7] and Routing Information Protocol (RIP) [6]. In this section the mechanism of each routing protocols are explained briefly.

### A. Optimized Link State Routing (OLSR):

OLSR is a proactive link state routing protocol . At each node the information about the topology is updated periodically. In this protocol the low control and constant traffic overhead information about the topology is flooded to all the nodes in network thereby providing router immediately available irrespective of data load and the mobility of the node which may lead to the breakage of the link. There are three mechanisms in OLSR namely: a mechanism for sensing of the neighbor, a mechanism for efficient flooding of control traffic and a mechanism for how to select and send sufficient information of topology in the network thereby providing optimal router. The mechanisms are explained in detail.

(i) Sensing of neighbor: In this mechanism the node will be able to identify any changes in its neighborhood. In OSLR, a node keeps sending HELLO messages periodically and if any changes are present in the neighborhood that would be destroyed from the information present in these messages. The HELLO messages has the own address of the sending nodes the list of neighbors known to the node and status of link to each neighbors. A node in this way gives information to its neighbors with which neighbors and in what direction communication has been confirmed. Once the node receives the HELLO messages, it will gather info describing its neighborhood and also the link quality. The information got is maintained on each node and is valid for limited period of time. The validity of the information is obtained by periodical sensing.

(ii) Efficient message flooding: OLSR introduces efficient mechanisms for flooding control traffic to all the nodes in the network. It resends the control messages by using only the selected nodes. It reduces the number of retransmissions that is required to send a message to all the nodes in a network thereby by reducing the overhead. For calculating optimal routes from a node to the destination which is reachable, OLSR needs only partial link state to be flooded in order to find the route with shortest path. If topology information is present it can be used for redundancy purpose.

(iii) Information regarding topology: Sufficient information of topology has to be sent to all the nodes in the network. All the nodes with Multipoint Relay (MR) selector will periodically generate a topology control (TC) message. It will be sent to all the nodes in the network. The information in each node is valid only for a limited time and has to be sensed periodically for the information to be valid.

B. Open Shortest Path First (OSPF):

Internet has got Open Shortest Path First (OSPF) as routing protocol for IP Networks. The changes in the topology are detected due to link failures and coverage problems as early as possible. The Dijikstra's algorithm is used to compute the shortest path tree for each route in the network. The OSPF routing policies are governed by link cost factors for constructing a route table with each routing interface. The cost factors provide a dynamic process of traffic load between routes of equal cost. OSPF network is a structured or subdivided into routing areas to handle administration and optimize traffic and resource utilization easily. These areas are identified by 32-bit numbers expressed in hexadecimal or octet-based dot-decimal notation. OSPF does not use TCP or UDP and encapsulates the data with Protocol number 89 in IP datagrams. OSPF has own error detection and correction mechanisms. OSPF when working with IP traffic provide security between routers using variety of authentication methods. The version 3 of OSPF when running with IPv6 does not provide protocol-internal authentication and relies on IPv6 Protocol security (IPSec).

C. Routing Information Protocol

The Routing Information Protocol is one of the earliest distance vector routing protocols which uses hop count as routing metric. It eliminates the routing loops by implementing a threshold on the number of hops that can be allowed in a routing path from source to destination. The maximum number of hops that can allowed for RIP is 15 and this will limit the size of the networks that RIP could support. A hop count if 16 and above is considered as an infinite distance and the route is considered to be unreachable route. RIP implementation includes the split horizon, route poisoning and hold down mechanisms to avoid wrong routing information to be transmitted. Every RIP router that is transmitted will get updated for every 30 seconds. In the earlier deployments, the routing tables were so small that the traffic was not very significant. But as the networks grew in size, it became clear that there could be a severe traffic burst for every 30 seconds even if the RIP routers were initialized at random times. Most of the time RIP is not preferred for routing as its converge time and scalability are poor compared to internet routing protocols. But it is easy configure as RIP does not need any parameters like other protocols. RIP will use the User Datagaram Protocol (UDP) as its transport protocol and is assigned the prot number 520 that s reserved. In this work, we have used RIP version 1 [6].

## III. SIMULATION ENVIRONMENT

The simulation experiments are conducted using QualNet Simulator [25]. The standard IEEE 802.11s radio is adopted with the channel rate as 2 Mbps. The scenario with mesh of wireless routers for the backbone client nodes (fixed and mobile) connected to the each mesh routers. The transmission range is 250m and the carrier sensing range is around 600m. The client nodes have different mobility. These settings are maintained with real time wireless networks, in which the transmission range of a node is typically smaller than its interference range. The Random Waypoint model [27] is adopted for driving mobile hosts. In this model, each host starts its movement from a random location to a random destination with a randomly chosen speed uniformly distributed between 0 and a maximum speed. Once after reaching the destination, node will choose targeted another destination is selected. In this simulation study, the maximum speed is varied from 0 m/s to 20 m/s. Traffic sources are CBR (constant bit rate). For each CBR session, the packet size is 1024 bytes and packet rate is 4 packets per second. The number of session pairs is varied to change the traffic load transferred into the mesh network. In first set of experiments we need to evaluate the performance variation of the original OLSR, OSPF and RIP in comparison.

## IV. RESULTS AND DISCUSSIONS

A grid topology is considered, with 1500 X 1500 with 10, 15, 20 node. One of them is considered as a gateway. Each node uses the PHY802.11 model and 802.11s MAC protocol. Also a constant bit rate(CBR) traffic source with 1024-byte data packets is considered, and that all traffic of source randomly assumed that the link bandwidth is 2 Mbps. Simulations are run for 180 seconds. All packets sent by the routing layer are queued at the interface queue until they can be transmitted by the MAC layer.

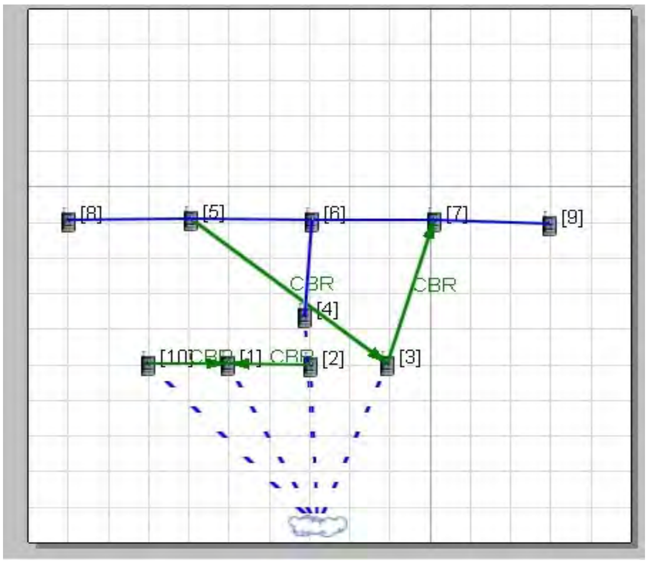



Figure 1. Qualnet Simulation Scenario of 10 nodes

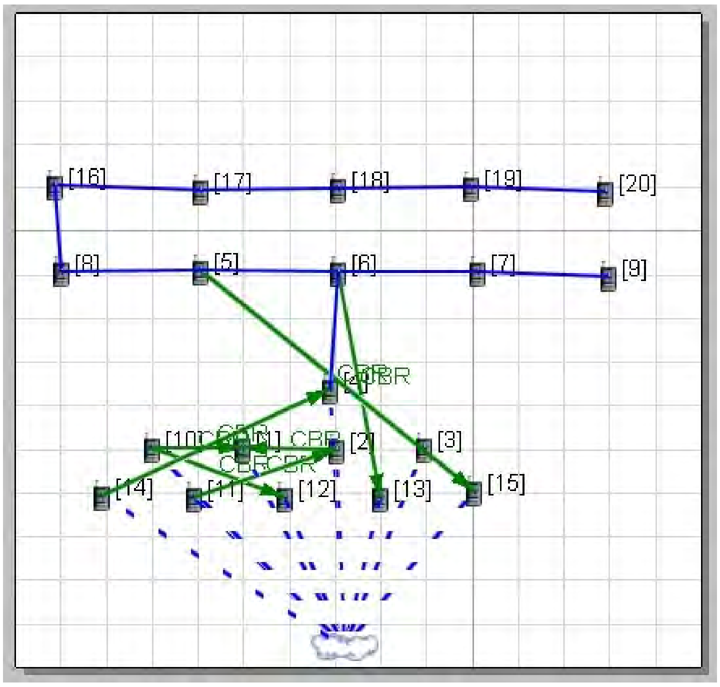



Figure 2. Qualnet Simulation Scenario of 20 nodes

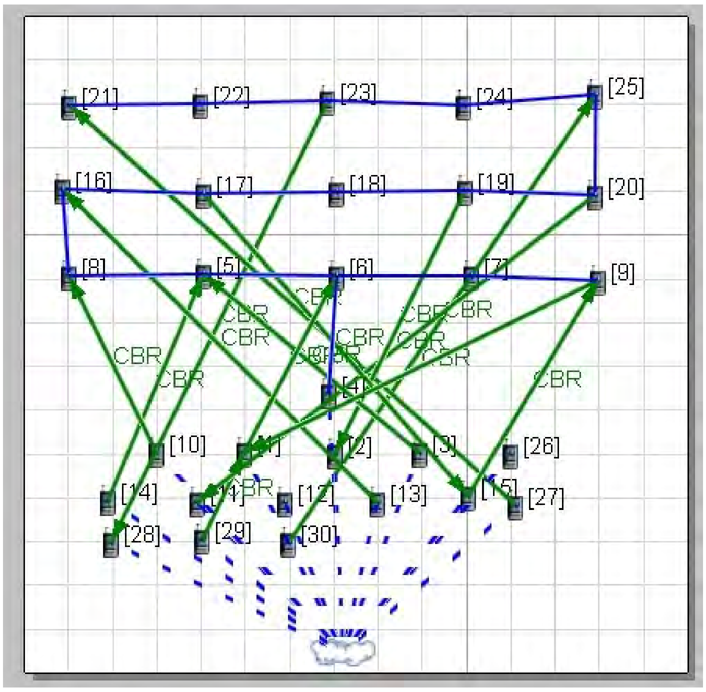
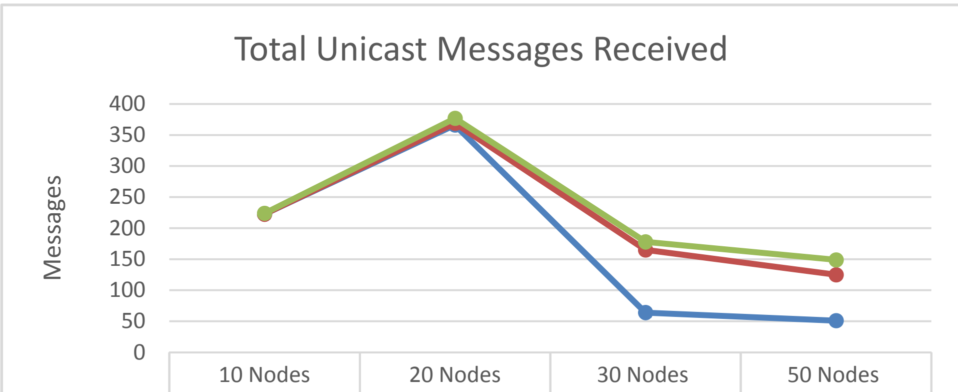



Figure 3 . Qualnet Simulation Scenario of 30 nodes

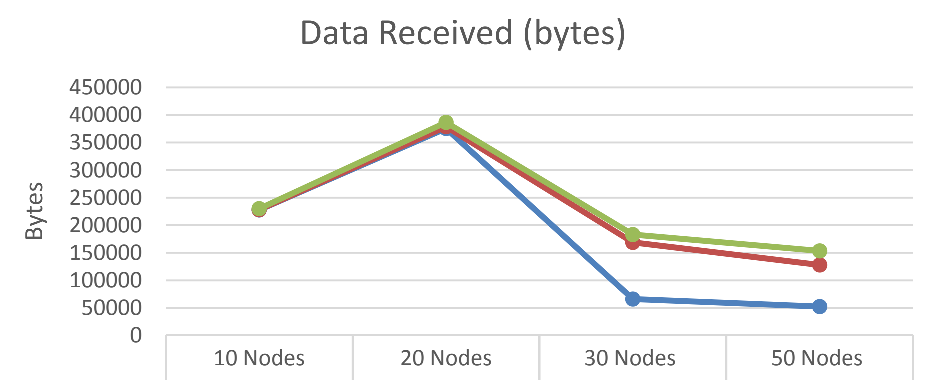
In figure 4, the total unicast messages received is plotted against varying the node density from 10 nodes up to 50 nodes. All the three protocols receives same number of messages during 10 nodes and due to connection setup in the beginning there is a sudden rise in received packets when the number of nodes increased to 20.




| | 10 Nodes | 20 Nodes | 30 Nodes | 50 Nodes |
|---|---|---|---|---|
| | Total Unicast Messages Received | | | |
| OSPF | 222.6 | 366 | 64 | 51 |
| RIP | 222.6 | 369 | 165 | 125 |
| OLSR | 224 | 377 | 178 | 149 |

Figure 4. Total Unicast Messages Received against node density

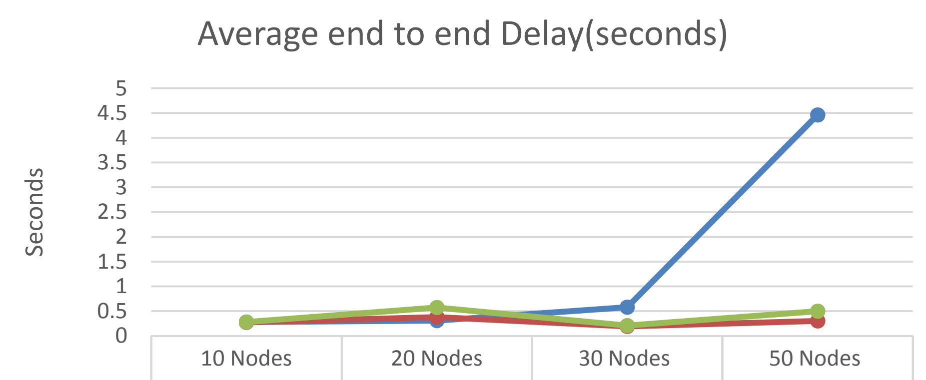
Further there is stability in the network depicts that OLSR outperforms other internet routing protocols RIP and OLSR. The similar behavior is observed in figure 5 for data received for varying nodes from 10 to 50 nodes. Once again OLSR perform better than RIP and OSPF.




| | 10 Nodes | 20 Nodes | 30 Nodes | 50 Nodes |
|---|---|---|---|---|
| | Total Unicast Data Received(bytes) | | | |
| OSPF | 228011 | 375603 | 66150 | 52565 |
| RIP | 228011 | 378675 | 168960 | 128000 |
| OLSR | 230059 | 386662 | 183125 | 153434 |

Figure 5. Data Received against node density

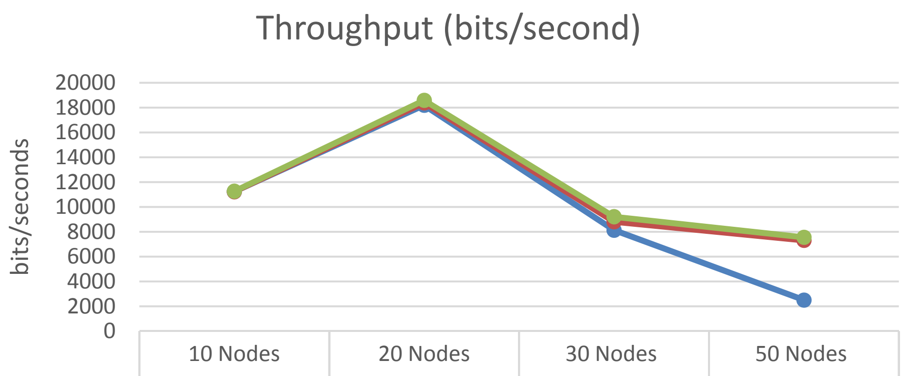
The average end to end delay against varying nodes from 10 to 50 nodes is depicted in figure 6. It clearly observed that initially all there protocols have consistent delay up to 30 nodes. The OSPF deviates with more end to end delay, due to it behavior of collecting link statistics for building routing table.




| | 10 Nodes | 20 Nodes | 30 Nodes | 50 Nodes |
|---|---|---|---|---|
| | Average end to end delay(seconds) | | | |
| OSPF | 0.28 | 0.31 | 0.58 | 4.46 |
| RIP | 0.274 | 0.38 | 0.192 | 0.301 |
| OLSR | 0.28 | 0.5733 | 0.21 | 0.5 |

Figure 6. Average End to End Delay against node density

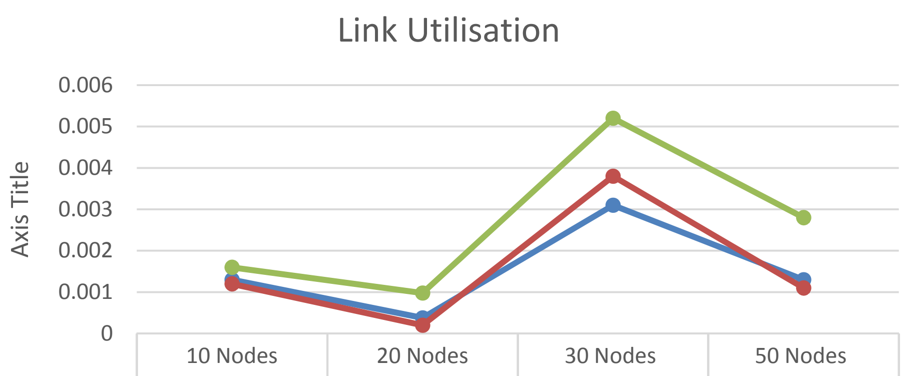
Since OSPF uses bandwidth and delay as metric where as RIP uses hop count. Both OLSR and RIP shows consistency throughout the simulation.




| Throughput | 10 Nodes | 20 Nodes | 30 Nodes | 50 Nodes |
|---|---|---|---|---|
| OSPF | 11236 | 18189 | 8130 | 2507 |
| RIP | 11228 | 18377 | 8807 | 7313 |
| OLSR | 11268 | 18588 | 9218 | 7564 |

Figure 7. Throughput against node density

In figure 7, the throughput is measured varying nodes from 10 nodes to 50 nodes. The throughput starts degrading when the node density is increased. RIP and OLSR shows consistency while OSPF under performs very poorly. This clearly shows that the existing internet routing protocols and OLSR will severely suffer from adoptability issues.




| Link Utilisation | 10 Nodes | 20 Nodes | 30 Nodes | 50 Nodes |
|---|---|---|---|---|
| OSPF | 0.0013 | 0.00038 | 0.0031 | 0.0013 |
| RIP | 0.0012 | 0.0002 | 0.0038 | 0.0011 |
| OLSR | 0.0016 | 0.00098 | 0.0052 | 0.0028 |

Figure 8. Link Utilisation against node density

The link utilization during node variation is depicted in figure 8. There is no consistency in all the three protocols due to overhead incurred during connection setup. RIP uses distance vector algorithm and OSPF uses shortest path fast algorithm to calculate the best path. The link state nature of OLSR consumes much bandwidth for maintenance of route between the nodes.

## V. CONCLUSION

In this research work, the performance of RIP and OSPF internet protocols along with OLSR protocol over different scenarios. All the three protocols are compared over varying network densities to study the behavior of the internet routing protocols in Wireless Mesh Networks. The data received, throughput, end to end delay and link utilization is measured and found that none of the protocols outperforms in all the cases. In most of the cases, OLSR and RIP has shown consistency but there is no clear winner in all the scenarios. The link state behavior of OLSR and OSPF accumulates much overhead to handle the network when its size grows. The distance vector concept limit allows RIP to handle complex routing table. The hop limit in RIP is 15, which restricts the size of the networks and does not support scalability. This study helps researchers to explore in developing or enhancing existing routing internet routing protocols for Wireless Mesh Networks. There is a need of designing and developing scalable hybrid internet routing protocol for Wireless Mesh Networks in near future.

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