STUDY OF QoS ISSUES FOR ROUTING PROTOCOLS in IEEE 802.11s

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Abstract

This paper focuses on the two routing protocols proposed by IEEE 802.11s for Wireless Mesh Networks. Towards this goal, this paper contributes in several areas of Routing and Quality-of-Service provisioning in IEEE 802.11-based wireless mesh networks. It compares the variety of routing protocols that could be used for Wireless Mesh Networks and later we specially focus on the recommended routing protocols HWMP and RA-OLSR by IEEE 802.11. We simulated using ns3 simulator under various parameters and observed how the two protocols reacted with changes in these parameters. From these observations, we have been able to study and compare few QoS of the routing protocols of Wireless Mesh Networks.

***Keywords*: Wireless Mesh Networks, Routing, IEEE 802.11.**

1. Introduction

Wireless Mesh networks have gain enormous attention because of their capability of providing broadband wireless coverage to large areas without infrastructure requirements[16]. Free of any infrastructure requirements, nodes can be added as the situation demands, thus offering excellent flexibility. The network can span miles, providing wireless “last-mile” IP connectivity to hundreds of users. The mesh network acts as a common backhaul network providing interconnection between ranges of heterogeneous networks as well as providing eventual access to the Internet. A survey on wireless mesh networks can be found in [3]. An overview on routing in WMNs is given in [5]. The QoS described in the paper can be used to select the most appropriate routing protocol depending upon the requirements and the vendors providing these for Wireless Mesh Network.

2. Review of Literature

A number of reviews of literature concerning Wireless Mesh network has been provided by the researcher and offered very useful comments and insights into WMN’s users and vendors. Michael Bahr in his paper “Proposed Routing for IEEE 802.11s WLAN Mesh Networks” (2006), describes in details about the describes the proposed routing for IEEE 802.11s WLAN mesh networks based on the current draft standard D0.01 from March 2006. IEEE 802.11s defines a new mesh data frame format and an extensibility framework for routing**.**

Akyildiz, I. F., Wang, X, and Wang, W. brought forward “Wireless mesh networks: a survey. *Computer Networks”*, vol. 47, no. 4, March 2005,which has been a revolutionary to the world of WMNs. A complete review on the Physical layer, MAC layer, Network layer and Transport layer implementation of WMNs is given. Moreover, network security and network capacity and congestion are topics are taken into deep consideartions.

Usman Ashraf ,Qos in Routing Protocols(Qualité de Service et Routage dans les Réseaux Maillés Sans Fil), 5 May 2010, in his thesis, described WMNs, Route selection by different Routing metrics and compared many protocols that are used in Wireless multi-hop networks. He also reviewed the QoS and route maintenance and proposed a “Efficient Route Maintenance (ERM)”.

3. Objective of the study

The objective of the paper was to study the routing protocols and their quality-of-services(QoS) of the Wireless Mesh Networks, especially the recommended(by IEEE 802.11s) protocols, i.e., Hybrid Wireless Mesh

Networks(HWMP) and Radio-Aware Optimized Link State Routing. We will compare and state their QoS so that they can be extended further, as one of them will be good in one or other sense.

Network simulator version-3(ns3) is used as the simulator for experimental analysis.

4. Protocols for Wireless Mesh Networks

4.1 HWMP

The Hybrid Wireless Mesh Protocol (HWMP*)* [25] is the default routing protocol for IEEE 802.11s WLAN mesh networking. As a hybrid routing protocol, HWMP contains both reactive routing components as well as proactive routing components.

Reactive Routing in HWMP:The main characteristic of reactive routing is that a path is computed only if one is needed for sending data between two mesh points. The HWMP uses the route discovery process well-known from AODV and DSR.

Generation & Processing of Route Request Messages: The source mesh point S checks in its routing table whether it has a valid path to D or not, if not, source node creates a RREQ. If the mesh point processing the RREQ is not the requested destination, it will broadcast the updated RREQ to all its neighboring mesh points, if a path to S has been created or updated and the TTL is greater than 0.

Generation & Processing of Route Reply Messages : A requested destination D will always be allowed to generate a RREP messages to the source mesh point S. A RREP sets forward path from the originator S to the Destination D.

Proactive Extensions of HWMP:Proactive Routing is used where a large proportion of traffic is anticipated for only one or only a few mesh points. A mesh point, usually a mesh portal, has to be configured to periodically broadcast mesh portal announcements called RANN.

Non-registration Mode: The intention of the non-registration mode is a “lightweight” HWMP topology formation where the routing overhead for the proactive extension is kept at a minimum.

Registration Mode: Mesh Points that receive a root portal announcement from the root portal are registered proactively at the root portal in registration mode.

4.2 RA-OLSR

The Radio-Aware Optimized Link State Routing protocol (RA-OLSR) [25] is an optional proactive routing protocol of the emerging IEEE 802.11s framework. It is an adaptation of the well-known Optimized Link State Routing Protocol (OLSR) [10] to the IEEE 802.11s environment. RA-OLSR follows closely the original specification of OLSR [6].

Multi-Point Relays**:** An optimized broadcast mechanism is the core concept of RAOLSR. Each mesh point selects so-called Multi-Point Relays (MPRs) among its direct neighbors, so that every 2-hop neighbor of a mesh point will receive broadcast messages even if only the MPRs forward the broadcast message. This can reduce the number of broadcast messages. Each mesh point selects its MPRs independently and solely based on the received information about its 2-hop neighborhood. The only requirements are that the complete 2-hop neighborhood receives broadcast messages if only MPRs forward them, and that only neighbors with symmetric links and willingness to forward are considered.

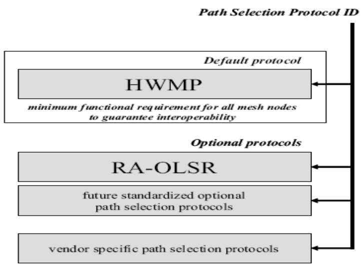

Fig 1: Extensibility of IEEE 802.11s with respect to path selection protocols [25]

5. AIRTIME ROUTING METRIC (802.11s Standard Metric):

The proposed IEEE 802.11s amendment [1] defines a default radio-aware routing metric for basic interoperability between IEEE 802.11s devices. The airtime link metric is a measure for the amount of the consumed channel resources when transmitting a frame over a particular wireless link.

$$\mathbf{C_a = [O_{ca} + O_p + B_t/r] / 1 - e_{fr}}$$

This equation is used for the calculation of the airtime cost C_a of each link. The path metric is the sum of the metrics of all links on the path. The channel access overhead O_{ca}, the MAC protocol overhead O_p, and the number of bits B_t in a test frame are constants. Their values depend on the used IEEE 802.11 transmission technology such as IEEE 802.11b or IEEE 802.11g. The transmission bit rate **r** in Mbit/s is the rate at which the mesh point would transmit a frame of size B_t with frame error rate e_{fr}, based on the current conditions of the radio environment.

6. Experimental Results and Analysis

6.1 Scalability

Scalability is an important issue in WMNs, just like any other multi-hop networks, where with the increase of the network size, the network performance degrades significantly.

In **HWMP:** we found that for a single root mesh portal optimal number of nodes are around 30, after which performances degrade dramatically.

In **RA-OLSR**: scalability is not a hindrance because with the increase of nodes, more multipoint relay(MPR) nodes are selected which can efficiently transport packets.

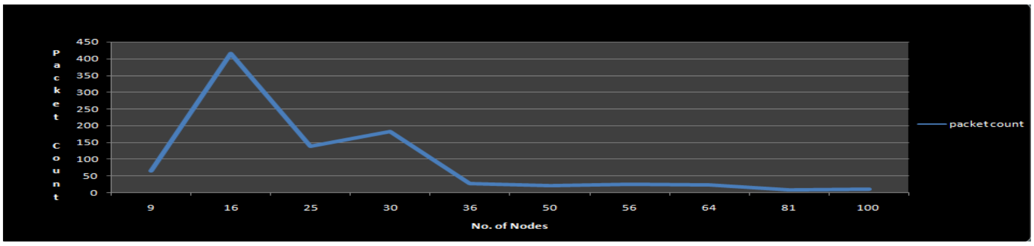

Fig 2: Packet counts at different number of nodes using HWMP

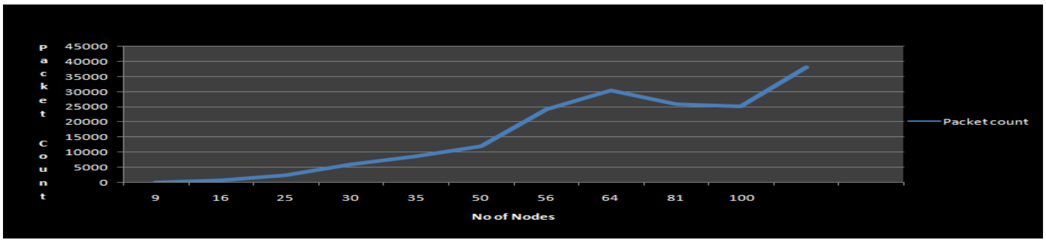

Fig 3: Packet counts at different number of nodes using RA-OLSR

6.2 Load Balancing

Given that two or more channels coexist between a pair of nodes, if one channel is close to congestion, another channel should be used.

With our experiments by taking different packet size and playing with packet interval to increase the traffic and load distribution in the nodes, we observed that HWMP withstands the load and the mesh root portal is able to handle the overhead with minimum loss and delay.

For RA-OLSR, load balancing requires frequent routing table update with the increase of load in the nodes to select optimum path (all MPRs involved in routing).

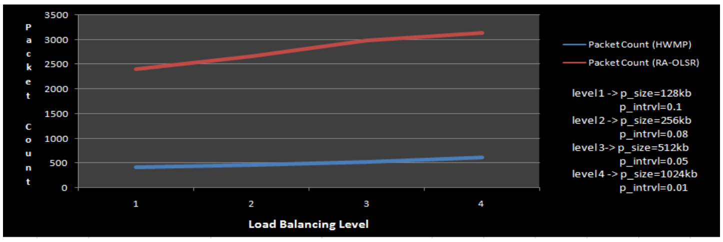

Fig 4: Packet count of HWMP and RA-OLSR for different values of packet size and packet interval.

7. FINDING THE OPTIMUM PACKET SIZE AND NUMBER OF RADIO INTERFACES

For our topology with 16 nodes, Area of operation = 25446.90 m^2 , Random mobility speed = 1 m/s and *Wi-Fi* as radio interface, we found the optimum number of radio interfaces and packet size to get optimum packet counts in our configured mesh root portal so to optimize the traffic and load in the root.

HWMP:

Table 1: Comparison of 512 bytes with different number of radio interfaces

Nodes	Packet Size-512, radio inetrfaces=1 Packet Counts	Packet Size-512, radio inetrfaces=2 Packet Counts	Packet Size-512, radio inetrfaces=3 Packet Counts
0	350	307	263
1	32	23	20
2	0	0	0
3	31	22	19
4	31	22	19
5	1	25	22
6	0	26	22
7	31	22	19
8	32	25	20
9	0	0	0
10	32	23	20
11	31	22	19
12	31	22	19
13	32	23	20
14	31	22	19
15	31	24	19

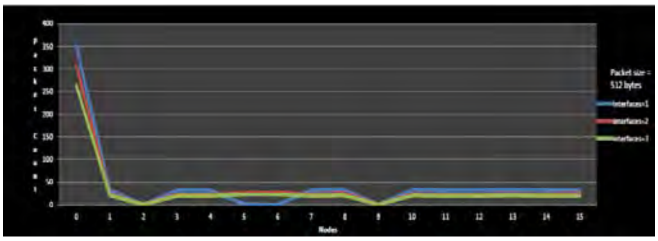

Fig 5: Comparison of 512 bytes with different number of radio interface

Table 2: Comparison of 1024 bytes with different number of radio interfaces

Nodes	Packet Size=1024, radio inetrfaces=1 Packet Counts	Packet Size=1024, radio inetrfaces=2 Packet Counts	Packet Size=1024, radio inetrfaces=3 Packet Counts
0	368	195	292
1	35	0	24
2	0	1	23
3	34	30	18
4	34	23	20
5	1	22	17
6	0	27	21
7	34	26	21
8	35	0	18
9	0	0	21
10	35	0	20
11	34	24	22
12	34	19	18
13	35	23	21
14	34	23	19
15	34	0	18

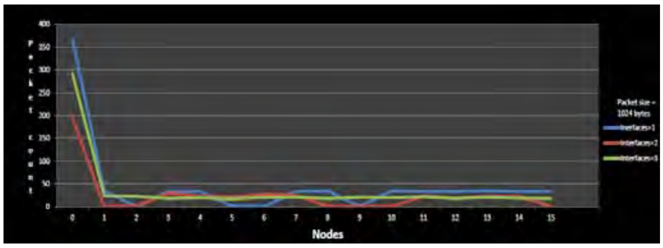

Fig 6: Comparison of 1024 bytes with different number of radio interfaces

Table 3: Comparison of 2048 bytes with different number of radio interfaces

Nodes	Packet Size-2048, radio inetrfaces-1 Packet Counts	Packet Size-2048, radio inetrfaces-2 Packet Counts	Packet Size-2048, radio inetrfaces-3 Packet Counts
0	347	225	303
1	35	0	24
2	0	1	16
3	34	22	21
4	34	24	18
5	1	3	20
6	0	20	23
7	33	28	24
8	14	0	15
9	0	0	0
10	35	0	20
11	34	27	17
12	34	23	20
13	35	28	15
14	34	24	21
15	34	22	20

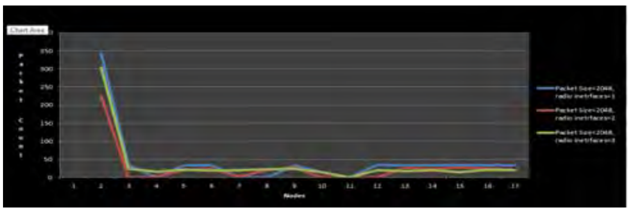

Fig 7:Comparison of 2048 bytes with different number of radio interfaces

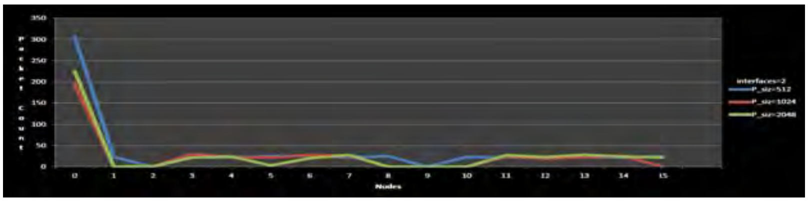

Fig 8: Optimum result- interface=2 with packet size=1024 bytes

RA-OLSR:

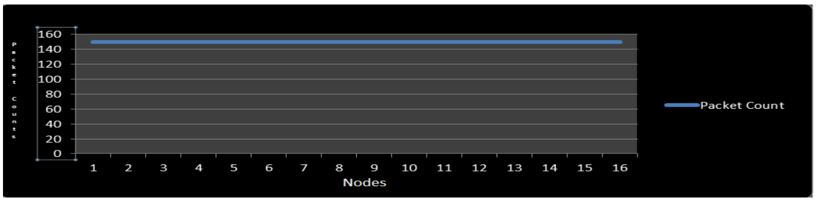

Fig 9: Packet count for radio interface=2 and packet size= 1024 bytes in RA-OLSR

We observed that for the topology of 16 nodes used, optimum results are achieved with packet size = 1024 bytes and number radio interfaces = 2 in HWMP.

The same optimum parameters are applied in RA-OLSR and found that the packet count is constant for all different values of parameters used.

8. CONCLUSION

From our results that we have intercepted from NetAnim, we see that the root mesh portal have to do the bulk of the packet sending work for route discovery and routing messages have to be periodically broadcasted to the other mesh nodes. Thus the root mesh portal requires a lot of power (battery power) especially during the mobility of nodes in our topology. This also increases route congestion in the root. We henceforth, look to optimize the packet count in the mesh root portal. Also we see that interference occurs with the further increase in number of radio channels due to inter-channel interference. From the observation of the graph, we can conclude that a packet size=1024bytes, radio interfaces=2 and radio channels=2 give us the optimum result of packet count. Also the implementation of RA-OLSR protocol in our mobile wireless mess network topology was a success and the network was stable. It could be implemented as an alternative routing protocol to HWMP.

In HWMP, we found that for a single root mesh portal optimal number of nodes are around 30, after which performances degrade dramatically. In RA-OLSR, scalability is not a hindrance because with increase of nodes, more multipoint relay nodes are selected which can efficiently transport packets With our experiments by taking different packet size and playing with packet interval to increase the traffic and load distribution in the nodes, we observed that HWMP is withstands the load and the mesh root portal is able to handle the overhead with minimum loss and delay. For RA-OLSR, the comparative packet counts declines with the same load balancing strategy we applied.

9. FUTURE WORKS

The message complexity is a very important aspect in both HWMP and RA-OLSR, especially from the vendor perspective, a lot could be analyzed to found out which has lower complexity. Distribution of the mesh roots in HWMP for large number of nodes in a topology to increase their scalability and reliability of packet delivery
Cross layer design and layer 2 routing. Cross layer design can enhance the efficiency of routing and thus improve the performance of a routing protocol. It also helps to ensure the scalability of WMNs, since scalability depends on collaboration of all protocols layers. So far most research in routing has been focused on network layer functionality only. Merging major functions of MAC and routing is now becoming a favorable approach.
There remain several open issues where throughput–delay tradeoff is concerned. First, hybrid networks with infrastructure support can help improve the capacity of multihop wireless networks, which is a typical case in WMN. However, the delay performance in such networks is still unknown and no research work has been carried out to study this problem. Besides delay, there are other performance metrics that are critical for users.

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