2012 International Conference on Information and Network Technology (ICINT 2012)
IPCSIT vol. 37 (2012) © (2012) IACSIT Press, Singapore

An Optimized Network Performance Analysis Using Traffic Asymmetry Metric in IEEE 802.11s Wireless Mesh Networks

G.Merlin Sheeba[1 +] and Alamelu Nachiappan[2]

[1] ETCE Department, Sathyabama University Chennai, India
[2] EEE Department ,Pondicherry Engineering College, Puducherry, India

Abstract. Wireless Mesh networks (WMNs) are been extensively used in large mile broadband communications, surveillance systems etc. The key issues of neighbor discovery in WMN are link quality measurement procedures and their corresponding link quality metrics.IEEE 802.11s proposes multihop forwarding at the MAC level with Hybrid Wireless Mesh Protocol (HWMP) and Airtime as the default path selection protocol and metric which is a new approach for building WMNs.Link-layer measurement of wireless mesh networks involves the capture of traffic as it appears on the medium. In this paper we have designed a new Traffic Asymmetry Metric (TAM) which assigns a triggering time ratio for the real time scenario mesh nodes and the network performance is analyzed and evaluated. The primary metrics like packet delivery ratio and throughput which quantify the link quality of WMNs is analyzed. We have also observed that an optimized and normalized performance of the network is achieved by changing the Mesh Point (MP) Root announcement periods (RAP).

Keywords: WMNs, HWMP, TAM, MP, RAP.

1. Introduction

WMNs have gained tremendous popularity in both academia and industry due to its inherent properties like self-organization, self-configuration, and fault tolerance against network failures, easy maintenance and setup, low-cost and large coverage [1]. They provide reduced infrastructure costs for access networks.

Multihop forwarding can extend the coverage of wireless access points without the need of additional infrastructure.IEEE 802.11 is in the key position in developing city wide, campus and metropolitan deployments[2][3]. In this paper we have explored the concepts of IEEE 802.11s and have analyzed the network performance. We have defined a new link quality metric TAM to improve the throughput of the network which quantifies the link quality of the mesh cloud. In section II the architecture and the basic concepts of IEEE 802.11s is discussed.MAC frame format for multihop forwarding is discussed in section III.In section IV the related link quality metrics which is been contributed previously is discussed. A step wise procedure of TAM is given in section IV.The simulation results and their justifications are discussed in section V.Finally the paper is concluded with some ideas for future work.

2. IEEE 802.11s Architecture and Concepts

The 802.11s WLAN Mesh Networking integrates mesh networking services and protocols with 802.11 at the MAC Layer. The mesh infrastructure is formed with three types of static wireless nodes termed as Mesh Access Point (MAPs), Mesh Points (MP) and a Mesh Point Portal (MPP) [4].They can also be called as a mesh cloud. MAPs have the functionalities of both an access point and relay node, whereas, MPs act only as relay nodes and MPP is the gateway node that bridges the WMN to outer world (say Internet).The stations or

+ Corresponding author. Tel.: + 919487280011.
E-mail address: mersheeb@yahoo.com.

clients is a node that requests services but does not forward frames, nor participates in path discovery mechanisms.

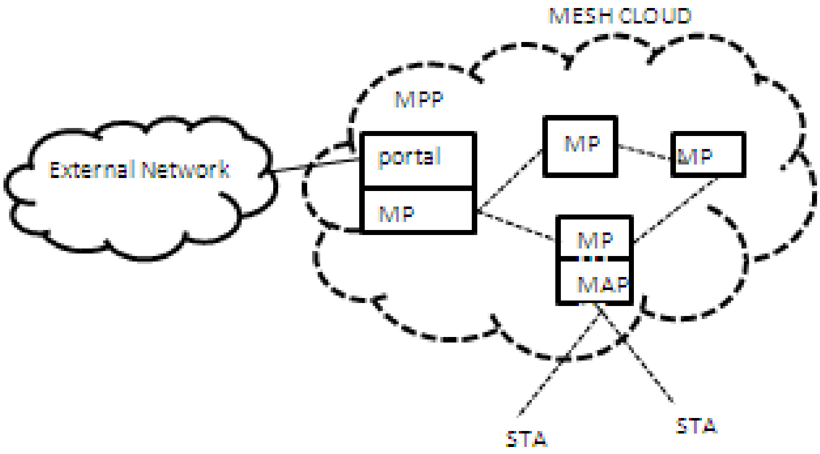

Fig. 1: IEEE 802.11s Mesh Architecture

2.1. Mesh creation

The mesh station's beacon carries information about the mesh and helps other mesh stations detect and join the mesh. Mesh stations detect each other based on passive scanning (observation of beacon frames) or active scanning (probe frame transmission). The mesh-specific beacon and probe frames contain a Mesh ID (the name of a mesh), a configuration element that advertises the mesh services, and parameters supported by the transmitting mesh station.

2.2. Mesh peer link creation

A Mesh Point shall create and maintain peer links to its neighbours. The mesh service enables the mesh stations to search for suitable peers. If the suitable peer is identified, a mesh station uses the Mesh Peer Link Management protocol to establish a peer link with the neighbour mesh station. Even when the physical link breaks, mesh stations may keep the peer link status to allow for quick reconnection.

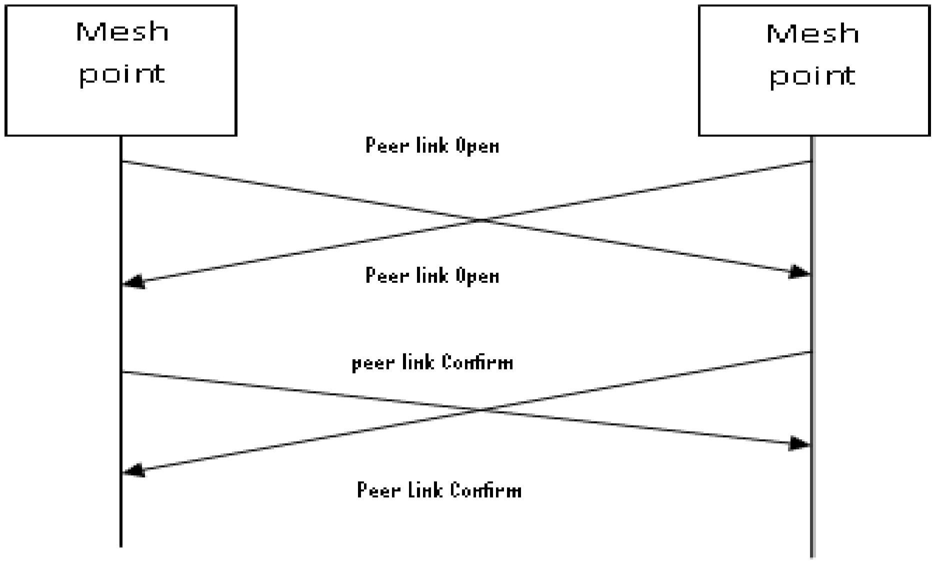

Fig. 2: IEEE 802.11s Mesh Peer Link creation

To establish a peer link, both MPs exchange Peer Link Open and Peer Link Confirm frames as shown in fig.2. Whenever an MP wants to close a peer link it should send a Peer Link Close frame to the peer MP.

2.3. Path selection protocol

The mandatory path selection protocol proposed by IEEE 802.11s is Hybrid Wireless Mesh Protocol (HWMP) [4]. The protocol can be configured to operate in two modes: on-demand reactive mode and tree-based proactive mode. On-demand mode is appropriate to establish a path between MPs in a peer-to-peer basis, while in proactive mode a tree-based topology is calculated once an MP announces itself as a root MP. Both the modes can be used concurrently.

3. Traffic Asymmetry Metric

The metric is illustrated below:

Step1: Traffic Symmetry ratio set G= {Tx: Tx; Tx} is selected

Step2: Selection of an Asymmetric ratio set G1= {Tx:Ty:Tz}

Step3: Analyse and comparison of network performance

Step4: Do iterations to optimize if tradeoff occurs between throughput and delay.

Step5: Optimized ratio set G1 = {Tx1:Ty1:Tz1} is selected.

4. Simulation Results and Discussion

In an effort to evaluate the performance of 802.11s WMN we have developed several simulation scenarios using Qualnet 5.0.We have designed the mesh backbone cloud with four Mesh Access Points (MAPs) and one root Mesh Point (MP). Six client stations are outside the mesh cloud, accessing the internet through the cloud. The scenario is shown in the following fig. 3.The traffic parameter constant bit rate (CBR) is used to evaluate the performance of the network. The performance is compared between three ways of traffic between the nodes:

1. Between station and root MP (Node7-Node 1)
2. Between root MP to Station (Node 1-Node8)
3. Between Station To Station (Node 6-Node 10)

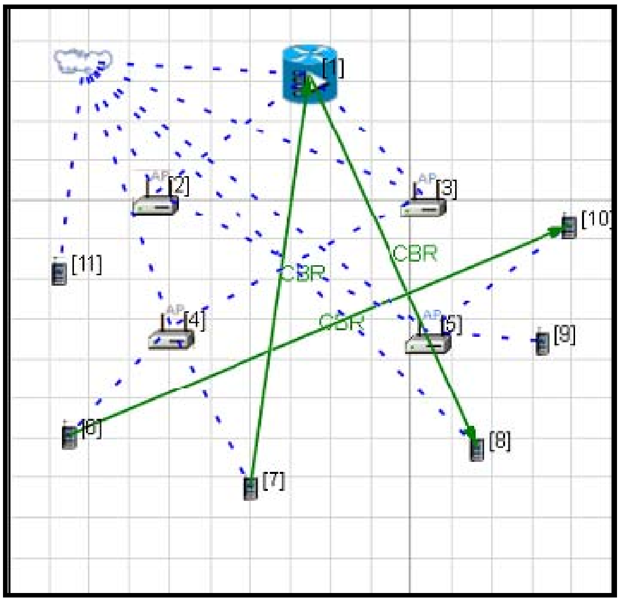

Fig. 3: Scenario of 802.11s Mesh Network.

The stations 6, 7 and stations 9, 10 are connected wirelessly to 4 and 5 MAPs respectively. The MP is connected to MAPs 2and 3.

Table. 1: Simulation Parameters.

PARAMETERS	VALUES
Terrain Dimension	1500 x1500
Channel frequency	2.4GHz
MAC protocol(Mesh cloud)	802.11s
Data rate	2Mbps
No. Of Bytes send	512

Traffic	CBR
MESH PARAMETER SETTINGS	
Station scan Type	Passive
Max channel Time TUs	400s
Path protocol	HWMP
Path Metric	Airtime

4.1. Network performance of traffic symmetry metric (TSM)

We have analysed the CBR Traffic between the devices in the mesh cloud and the stations. We observed that the throughput and Packet Delivery Ratio (PDR) of root MP to the station is very high than the other two traffics whereas the delay is also high. The traffic throughput between a station to station is very less and it is noticed in fig. 4 that for 200 packets the throughput has dropped more, because the packets where in queue for long time at root MP for about 13.8 seconds during the simulation.

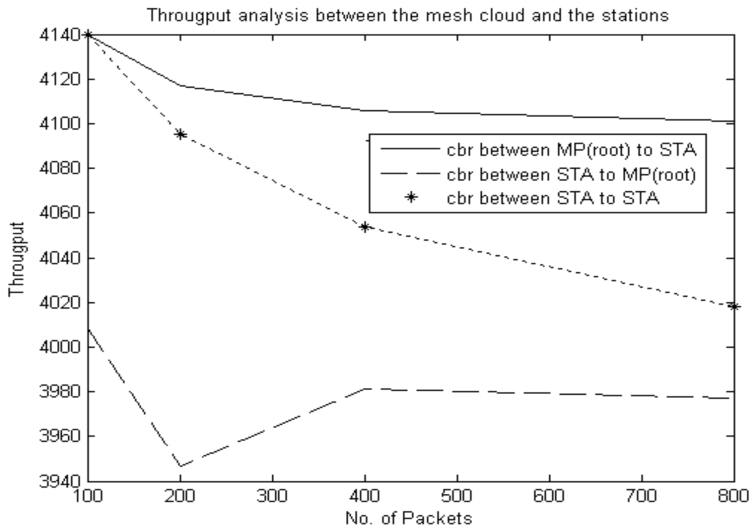

Fig. 4: Throughput Vs No. Of Packets with TSM

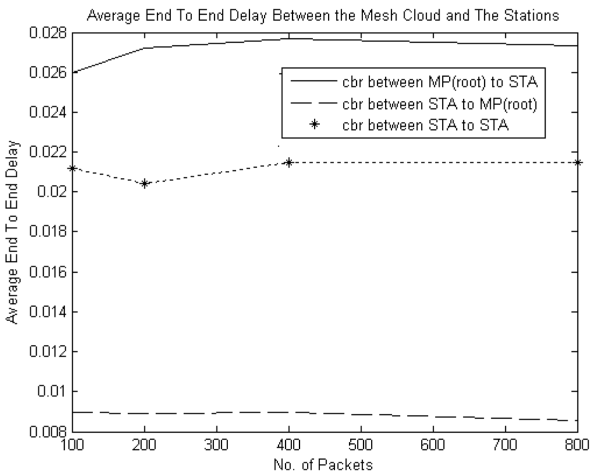

Fig. 5: Average End to End Delay vs No Of Packets

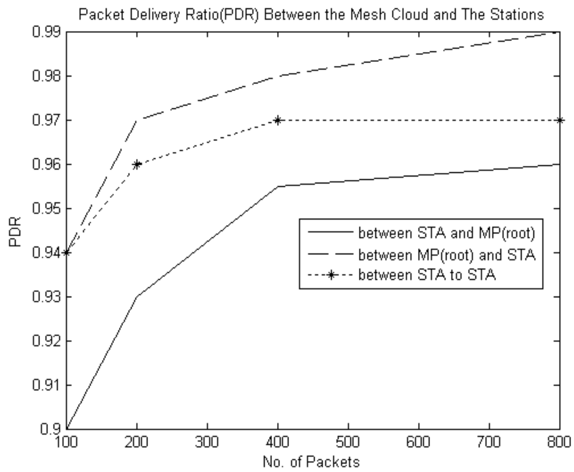

Fig. 6: PDR Vs No. Of packets with TSM

4.2. Comparison of network performance using TSM and TAM

In a real time scenario the triggering time of the nodes may vary for individual applications so we have simulated the network for a high traffic, say 800 packets and selected an asymmetric ratio of triggering time. Then we have compared the throughput and average end to end delay by using TSM set ratio G= {Tx: Tx: Tx} and TAM set ratio G1= {Tx: Ty: Tz}.We have observed that the overall throughput of network for all the three traffics has decreased by using the asymmetric triggering time for the nodes, whereas the average end to end delay has also decreased for the TAM. So a trade-off between throughput and delay has occurred, which is shown in fig 7 & 8.

To find a solution for this trade-off we have performed more iteration to finalize the asymmetric set G1= {Tx1: Ty1: Tz1}. Using the combination difference ratio set G1= {1:2:1} we have noticed that the overall throughput of the network for all three traffics has increased and delay had also decreased compared to other combinational time ratios.

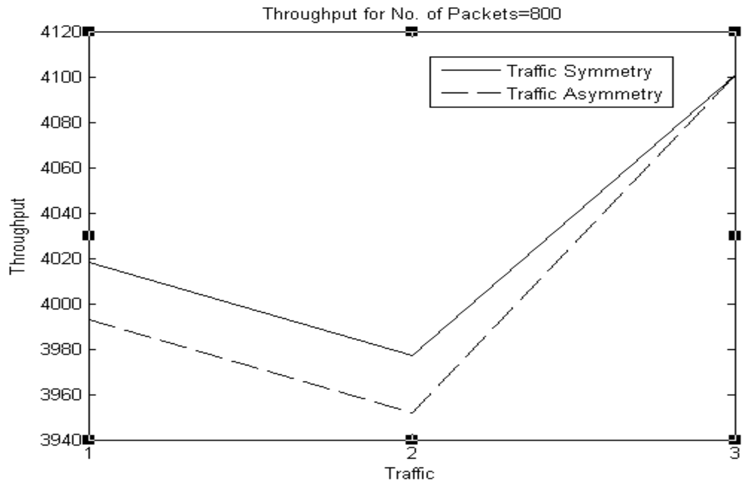

Fig. 7: Comparison of CBR traffics Vs Throughput using TSM and TAM

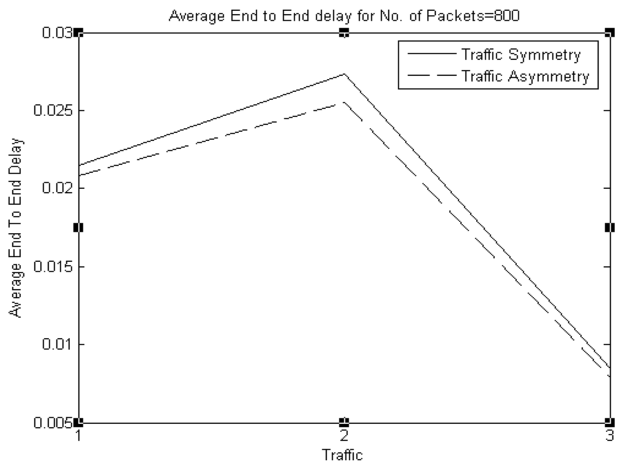

Fig. 8: Comparison of CBR traffics Vs Delay

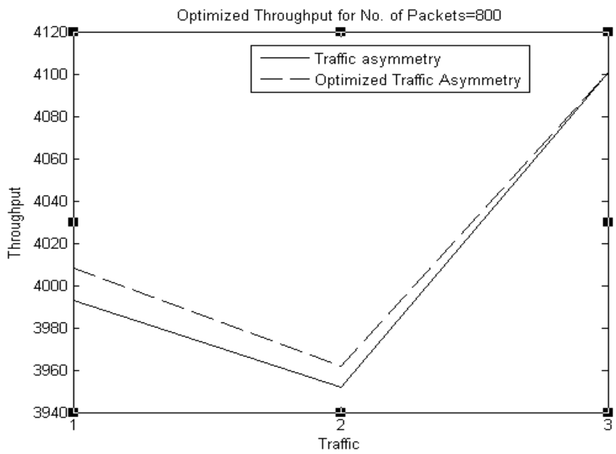

Fig. 9: Optimum Throughput using TAM

4.3. Optimized throughput by changing RAP of MP

The RAP is an interval between the announcements by a mesh point. This announcement propagates through the mesh. We have performed iterations for 4, 10, 20 and 25 seconds and observed that the overall throughput for 10secs (in fig 10) is found to be good and normalized for all three traffics.

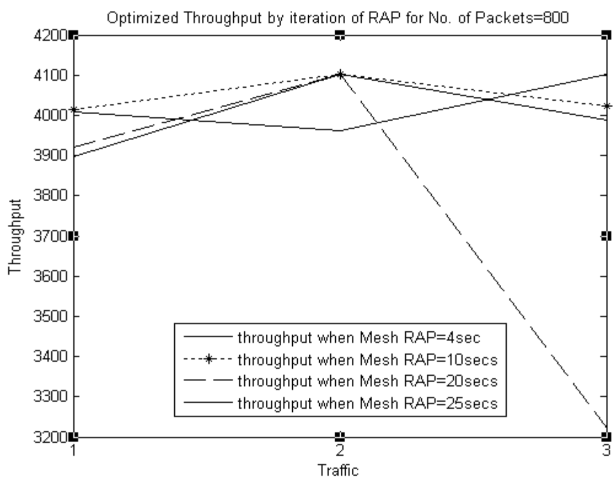

Fig. 10: Optimized Throughput when RAP=10secs

5. Conclusion

As throughput quantifies the link quality of any wireless network we have analyzed the network performance by using two triggering time ratio metrics symmetric and asymmetric. We have concluded that by using the TAM set G1= {1:2:1} and RAP 10secs a good overall and normalized throughput of the network is obtained for all CBR traffics. Our future work would be analyzing the network by adding mobility scenarios and interworking with other wireless networks.

6. References

[1] Ian F. Akyildiz, Georgia Institute of Technology Xudong Wang, Kiyon, Inc." A Survey On Wireless Mesh Networks", IEEE Radio Communication,Sep 2005.

[2] The IEEE 802.11s Extended Service Set Mesh Networking Standard Joseph D. Camp and Edward W. Knightly, 2008.

[3] J. Camp, E. Knightly, and W. Reed, "Developing and deploying multihop wireless networks for low-income communities," in Proceedings of Digital Communities, Napoli, Italy, June 2005.

[4] Multihop MAC Book,World Scientific Book,*Chapter 12,*April 2008.

[5] D. De Couto, D. Aguayo, J. Bicket, and R. Morris.High-throughput path metric for multi-hop wireless routing. In MOBICOM, Sep 2003.