A new MIMC protocol to reduce message overhead in WLAN mesh networks

Chitender Kaur and Dr. Sandeep Singh Kang

Abstract— Wireless mesh networks provides a new area of technology set to play an important role in the next generation wireless mobile networks. With the increase of usage of wireless networks where the nodes are either stationary or minimally mobile, focus is on increasing the network capacity of wireless networks. WLAN mesh networks have been widely used for military scenarios, residential areas, campus/public access and remote areas. 802.11s is the standard of WLAN mesh network and it uses various channel and interfaces for fulfilling the requirement of users. Particularly, we have single interface, single channel (SISC) for communication. Moreover, multi interface, multi channel (MIMC) also provides huge resources now days. Using multi-interfaces and multi-channels (MIMC) is essential in increasing capacity and performance of emerging wireless mesh networks. In selecting path in mesh network, channel diversity is the prime factor for the better throughput of the path. Path selection algorithm basically utilizes the same path discovery mechanism of the HWMP. Channel diversity has been considered the prime factor in path selection as explained in related study. In this paper, we proposed a new MIMC routing protocol which is fully compatible with HWMP protocol and analyze the misbehavior of current SISC environment in the path selection process. Hybrid Wireless Mesh Protocol (HWMP) defined in 802.11s is a default path selection protocol for a wireless mesh network. In the simulation study, we will focus on the reduction of control message overhead by providing timely arranged intervals and we will control the flow of the communication with experimentation of Single Channel Single Interface and Multi Interface Multi Channel Schemes.

Index Terms— WLAN Mesh Networks, 802.11s, HWMP, Multiple-Interface and multiple-channel (MIMC)

1 INTRODUCTION

A WMN can provide gateways to the wired internet and other wireless services. 802.11s is an amendment being developed to the IEEE 802.11 WLAN (Wireless Local Area Networks) standard. It integrates mesh networking services and protocols with 802.11 at the MAC Layer. It helps small and medium mesh networks to become large networks by addition of large number of nodes. Due to its unique mesh structure, a WMN has an advantage over traditional MANET and wireless local area network in the areas of extensibility, reliability, data throughput and ant jamming. It also enables rapid deployment with lower-cost backhaul, ease to provide coverage in hard-to-wire areas, greater range due to multi-hop forwarding, and higher bandwidth due to shorter hops or better battery life due to lower power transmission [2]. With a limited transmit power; it has an ability to cover a wide geographic area. A WMN has several favourable features such as dynamic self-healing, self organizations, self configuration, with the nodes in the network automatically establishing and maintaining mesh connectivity among themselves (creating, in effect, an ad-hoc network). It provides easy maintenance, high scalability and reliable services.

Wireless mesh networks provides increased reliability, greater flexibility and improved performance over conventional wireless LANs. The main characteristic of wireless mesh networking is that nodes can communicate over multiple wireless hops on a meshed network graph. Efficient routing protocols can react to dynamic changes in the topology and provide paths through the wireless mesh, so that mesh nodes can communicate with each other even if they are not in direct wireless range. Intermediate nodes on the path will forward the packets to the destination [3].

WMN is different from adhoc networks although it has a lot of similar concepts. In WMN, nodes are enabled with wireless capacity are stationary in nature and show limited mobility. Thus, WMN has more or less static topology. Also, the nature of data flow in a WMN is also the same. For example in an enterprise, traffic mostly consists of internet usage by the nodes or communication between nodes for local file transfers. This provides an opportunity for optimisation of WMN's for certain traffic characteristics to improve efficiency. The traffic distribution in a WMN is also in fixed direction, generally to/from a wired/wireless backbone.

A WLAN Mesh Network consists of WLAN devices which relay functions that communicate directly with each other

- *Chitender Kaur is currently pursuing masters degree program in computer science engineering from CEC, Landran, PTU, India, E-mail: chinusaroya@yahoo.com*
- *Dr. Sandeep Singh Kang is working at CGC-COE, Landran as HOD (CSE) , India, E-mail: sskang4u1@rediffmail.com*

rather than communicating via base station. WLAN mesh networks have been widely used for military scenarios, residential areas, campus/public access and remote areas. They can be used to extend the coverage area of enterprise to achieve home network [7]. This technology is finding a better means of achieving broadband wireless communications and it is assumed to be an area of coming technical invocation especially in Quality of Service (QoS) technology and wireless high-speed techniques.

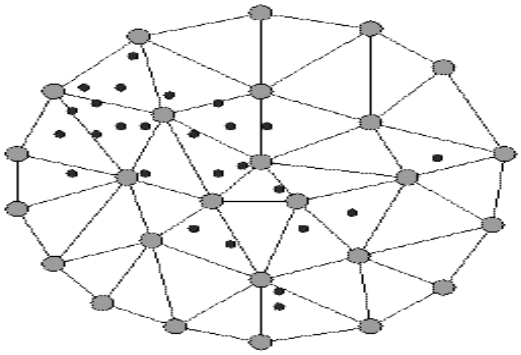

Fig 1. WLAN Mesh Network

In this paper, we reviews channel diversity is the prime factor for the throughput of the path. We implement a new routing protocol with the requisite parameters and path selection algorithm basically utilizes the same path discovery mechanism of the HWMP. We will focus on the reduction of control message overhead by providing timely arranged intervals according to the dijkstra's algorithm. The rest of the paper is organized as follows: Section II describes the HWMP Protocol, Section III discusses the multiple-interface and multiple-channel environment, Section IV presents proposed scheme, Section V contains simulation and results and in Section VI conclusions.

2 HYBRID WIRELESS MESH PROTOCOL (HWMP)

The Hybrid Wireless Mesh Protocol (HWMP) is the default routing protocol for IEEE 802.11s WLAN mesh networking. It is called hybrid routing protocol as HWMP contains both reactive routing components as well as proactive routing components [1]. It combines the features and flexibility of on-demand route discovery with efficient proactive routing to a mesh portal.

HWMP supports two modes:-

1. On-demand mode
   In this mode, it uses three different types of management frames: - Path Request (PREQ), Path Reply (PREP) and Path Error (PERR). Firstly, a source node that doesn't have a valid path to the destination node starts path request (PREQ) broadcasting. Upon receiving this message, the destination node sends a unicast path reply (PREP) back to the source [4]. All the intermediate nodes will update their path tables which have relay packets between source and destination.
2. Proactive tree building mode
   In this mode, one node in the mesh network acts as a root node. It maintains a tree path from the root node to all the other nodes. There are two sub-mechanisms of this mode:- Proactive PREQ mechanism and Proactive RANN. The first method begins with sending a proactive PREQ message periodically by the root node. Its target is to broadcast it to all the other nodes and every mesh node has to respond to the received PREQ by sending a PREP back to the root node. On the other hand, Proactive RANN mechanism, root node periodically broadcasts Root Announcement (RANN) messages to the entire network. Upon receiving a RANN, each mesh node can select whether or not it creates a path towards the root. A node that wants to create or refresh the path sends a unicast Path Request (PREQ) message back to the root node and in respond it receives a unicast path reply (PREP) message [7].

3 MULTIPLE-INTERFACE/MULTIPLE-CHANNEL (MIMC)

Wireless networks are used for various purposes now days where the nodes are either stationary or minimally mobile. WMN focus on increasing the network capacity of wireless networks. One such way is to use non-overlapping multiple channels provided by 802.11 by using multiple interfaces per node [1]. Multiple non-overlapped channels exist in the 2.4GHz and 5GHz spectrum.

As the mesh networks are extremely useful but it suffers from overheads of packet loss, packet errors, contention, low link-layer data rates and packet headers. It drastically reduces the actual good put available to the wireless network applications. With increasing distance between signal source and destination, the data rate also falls quickly. Interference from adjacent hops in a multi-hop network further decreases the available bandwidth [6]. By using multiple channels thus removes both of the problems – as it extends the available bandwidth and removes the problem of interference by providing simultaneous communication between adjacent hops on a non-overlapping channel.

Due to its wireless backbone, it is very challenging to improve the network capacity by providing the required quality of network services to as many users. A preferred solution is to integrate multiple radio interfaces into a mesh router. As different channels are assigned with multiple interfaces, it can simultaneously transmit packets without interference and provide better bandwidth [5].

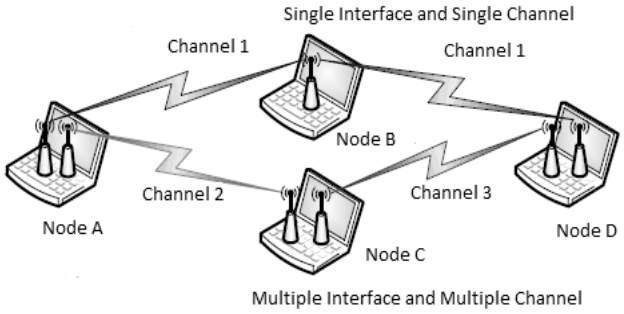

Fig 2. Comparison of SISC and MIMC path

We also need a channel assignment algorithm which provides schedules assignment and coordinates between the nodes. Specifically, the proposed CA schemes can be divided into three main categories- fixed, dynamic, and hybrid depending on the frequency with which the CA scheme is modified. In a fixed scheme the CA is almost constant, while in a dynamic scheme it is continuously updated to improve performance. A hybrid scheme combines the properties of both fixed and dynamic as it applies a fixed scheme for some inter-faces and a dynamic one for others [3].

4 Proposed Scheme

In this section, we will describe how a new HWMP routing protocol can reduce the overhead of control messages and also increase the network performance. The proposed new MIMC routing protocol is fully compatible with HWMP protocol for requisite selection of path on the basis of SISC and MIMC. The proposed path selection algorithm basically utilizes the same path discovery mechanism of the HWMP and the airtime link metric to maintain compatibility.

We arrange the mesh nodes in the particular fashion so that it can fulfill the requisite simulation of HWMP. Then we implement a new routing protocol with the requisite parameters and we will attach link cost and channel number at the end of PREQ/RREQ and PREP/RREP message format to improve the path throughput.

To reduce the control message overhead, we will increase the time interval of the PREQ/RREQ forwarding packets according to the dijkstra's algorithm which is based totally on the path selection of the neighbouring nodes and also depends upon the number of increased time intervals which we improved for our proposed HWMP routing protocol.

We will start with mesh networks implementation network analysis under NS2.

We introduce the communication in SISC environment as some of the user nodes can transmit packets using single channel and single interface to the destination. By this procedure, HWMP frequently changes the path and it lead to degradation of the throughput, which causes path instability problem of the HWMP. In the next step, we introduce the communication in MIMC environment as some of the other nodes can transmit packets using multiple channels and multiple interfaces to the destination. Here, we assume the proactive PREQ mechanism is utilized for the proactive tree building mode in the HWMP. First, we divide proactive PREQ messages into two types; PREQF and PREQR. Upon receiving a PREQF message, a node rebroadcasts it using every interface. On the other hand, when a node receives a PREQR message, the node rebroadcasts it by using only the necessary interfaces. We assign another bit in the flag field of the PREQ message for the root node to indicate the type of the proactive PREQ messages. The root node sends a PREQF message in every IF interval, but PREQR messages are transmitted in the other intervals. The Dijkstra's algorithm is implemented over the whole proposed routing protocol through which the actual communication and broadcasting can be done and further all requisite work maintained through the algorithm. As Dijkstra's algorithm is a graph search algorithm that solves the single-source shortest path problem for a graph with non-negative edge path costs, producing a shortest path tree. Dijkstra's algorithm is used to reduce the network overhead as it increases the time interval of the PREQF forwarding message, so packets drop will be reduced.

5 Simulation and Results

The performance of the proposed scheme can be evaluated by using NS2. NS2 is an open source simulator targeted for network research. It works at packet level and provides support for simulation of routing, multicast protocols and TCP over wired and wireless networks. It helps in verification of new protocols in less time.

Various parameters used in our simulation is given below:-

Table 1: Simulator Parameters

Parameter	Values
Simulator	NS-2
Simulation Duration	150 sec
Topology	1000meter X 1000 meter
No. Of nodes	100
Channel Number	50
Traffic type	FTP (TCP)
Routing protocol	HWMP
Channel Type	Wireless Channel
Link Cost	10

In our simulation model, we deployed 100 nodes in the 1000m x 1000m square area. Nodes are randomly deployed in the

mesh arrangement to fulfill the WMN criteria. We installed omni-antenna in each mesh node and data rate is fixed to 75 mbps. Our simulation is based on the Dijkstra's algorithm. We measure the TCP performance of the proposed scheme and the old scheme of HWMP with number of connections. In this paper, we measure the control packet overhead which results as the number of TCP connection increases and compare the results of proposed scheme with old scheme.

Control packet overhead: Maximum time taken by the packet transmission on the network. It reduces the overall transmission speed of the raw data. The overhead is measured in bytes. Lower the value of the packet overhead means better the performance of the protocol.

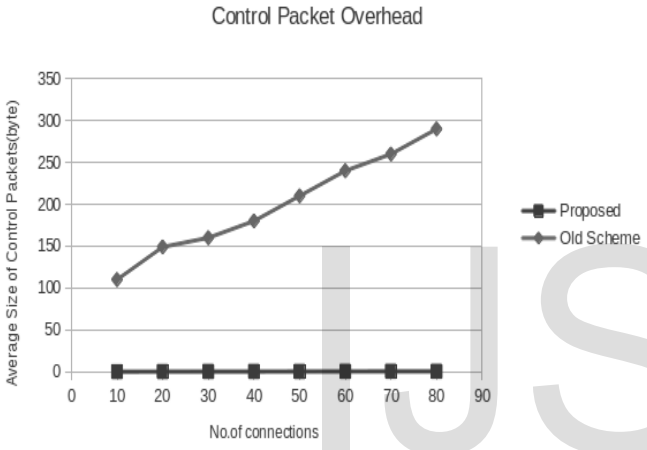

Fig 3. Comparison of packet overhead of proposed scheme with old scheme.

6 Conclusion

The IEEE 802.11s is an amendment being developed for realizing the WMN for future wireless infrastructure. But, the current standards do not focus on the reduction of control packet overhead in MIMC environment. In this paper, we have built a new routing protocol that works to reduce the control packet overhead by increasing the time intervals of the PREQ forwarding packet and also we include link cost and channel diversity according to the dijkstra's algorithm to attain better network performance than the previous work. Future works would introduce energy parameter so that we may calculate network lifetime in contrast to consumption of battery life for the forwarding packet nodes.

Acknowledgement

I express my sincere gratitude to the Punjab Technical University, Jalandhar for giving me the opportunity to work on the thesis during my final year of M.Tech.

First of all I am thankful to my project guide Dr. Sandeep Singh Kang, HOD, Computer Science and Engineering Department, CGC College of engg, Landran under whose guideline I was able to complete my thesis. I am wholeheartedly thankful to him for giving us their valuable time and attention and for providing us a systematic way for completing my project.

I must make special thanks of faculty members for their co-operation and assistance in solving problems. I would like to thank our Head of department, Mr. Rajwinder Singh, Computer Science and Engineering Department and all assistants for providing us assistance in various hardware and software problem encountered during course of our project.

Thesis work is an important aspect in the field of engineering. I would also like to thank my parents, friends etc who helped me in my thesis.

I would also like to thanks everyone who has knowingly & unknowingly helped me throughout my thesis. Last but not least, a word of thanks for the authors of all those books and papers which I have consulted during my thesis work as well as for preparing the report.

References

[1] A. P. Subramanian, M. M. Buddhiko, and S. Miller, "Interference aware routing in multi-radio wireless mesh networks," IEEE Workshop on Wireless Mesh Networks (WiMesh), 2006.

[2] M.J. Lee, J. Zheng, Y.B. Ko and D. M. Shrestha, "Emerging Standards For Wireless Mesh Technology," IEEE Wireless Communications, Vol.13, Issue 2, Apr. 2006, pp.56-63.

[3] H. Skalli et al. "Channel Assignment Strategies for Multiradio Wireless Mesh Networks: Issues and Solutions," IEEE Communications Magazine, Nov. 2007.

[4] P. Pandey, S. Satish, J. Kuri, and H. Dagale, "Design & implementation of IEEE 802.11s mesh nodes with enhanced features," Mobile Adhoc and Sensor Systems (MASS), 2009.

[5] D. Wu and P. Mohapatra, "From Theory to Practice: Evaluating Static Channel Assignments on a Wireless Mesh Network," IEEE Conference on Computer Communications (InfoCom) Mini-Conference, 2010.

[6] G.Qijun ,Y.Meng and Z.Wanyu, "Lightweight Attacks against Channel Assignment Protocols in MIMC Wireless Networks," IEEE Communications Society, 2011.

[7] Sung-Hee Lee, Young-Bae Ko, Youg-Geun Hong, and Hyoung-Jun Kim, "A New MIMC Routing Protocol Compatible with IEEE 802.11s based WLAN Mesh Networks," ICT Standardization program of MKE (The Ministry of Knowledge Economy), Vol.2, Issue. 4, pp. 33-39, May 2011.