Optimized Buffer Control Mechanism for Wireless LAN Mesh Networks

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ABSTRACT
In wireless mesh networks, the legacy stations lead to heavy congestions in network due to buffer overflow. Using buffer control mechanisms this drawback is achieved fairly as it services the high priority nodes first and lower priority nodes are kept waiting till back-off time period. In order to address this problem, this paper proposes an optimized congestion scheme for legacy nodes which will help to reduce the back-off time period of lower priority nodes and reduce congestion considerably.

Keywords
MHCCA (modified hybrid coordination function controlled channel access), MP(Mesh point), MPP(Mesh Portal), MAP(Mesh Access point),end-to-end delay.

1. INTRODUCTION:

Wireless Local Area Network (WLAN) mesh networking are easy to use , low cost and very flexible because of which they have become very popular [9]. A mesh network is generally set up different in location which have limited infrastructure in order to give connectivity in ubiquitous way. Wireless mesh networks consist of radio nodes organized in mesh topology. It consists of mesh clients, gateways and mesh routers. Any WLAN mesh network is consisted of MPs (Mesh points)to provide multi-hop connectivity using the wireless network interface so that it can be applied laptop computers and in consumer electronic devices [8].Cell phones, laptops and few other wireless devices are nothing but the wireless mesh clients. Mesh routers will forward the packets to wireless mesh routers which will in turn forward the traffic to gateways. These gateways may or may not be connected to the internet as shown in figure 1.This traffic flow is bi-directional. Generally a mesh network is reliable and but offers redundancy. When any node fails to operate, the rest of the nodes can still connect with each other, directly or indirectly through one or more intermediate nodes. 802.11, 802.15, 802.16, cellular technologies or combinations of more than one type of wireless technology are been used to implement wireless mesh networks.

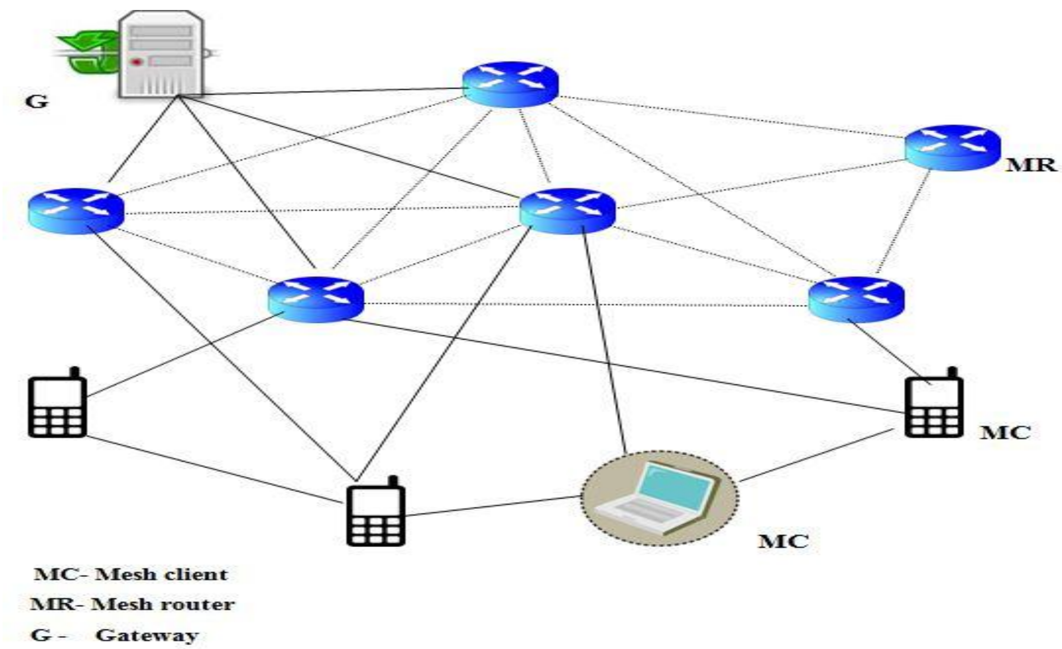

Figure 1 Wireless Mesh Networks

2. LITERATURE SURVEY:

Wireless LAN mesh networks are dynamically self-organized and self-configured. This paper [4] uses the following terminology as per IEEE standard 802.11.

1) Legacy stations (STAs): legacy stations are those nodes which exist in network but are not in use for a longer period.
2) Mesh Point (MP): MP is analogues to an access point that directs the frames on the basis of their MAC header information.
3) Mesh Access Point (MAP): MAP in a MP having wireless LAN functions for access points jointly with MP functions.
4) Mesh Portal (MPP): MPP is also a MP which is juxtaposed with mesh portal with a well-equipped gateway function in order to enhance the functionality of MP.

5) IEEE 802.11 e Enhanced distributed channel access:
   IEEE 802.11 e is a valid standard defined by IEEE that is specifically used for wireless LAN networks. EDCA protocol is a prolong form of IEEE 802.11. DCF (distributed co-ordination function) performs an effective use of CSMA/CA to provide channel access between multiple stations. EDCA [5] works upon priority levels or access categories.
6) IEEE 802.11 e Hybrid coordination function controlled channel access(HCCA):
   HCCF is the most advance and complex standard that is used for wireless mesh networks. It enhances the network with advanced traffic priority. It is well equipped with a hybrid controller (HC) i.e. medium controller.
7) IEEE 802.11 s:
   IEEE 802.11 s is reserved for mesh networks. It defines how actually a mesh network interconnected using mesh points. It can be used for both static as well mobile networks.

The IEEE 802.11 MAC layer provides two types access mechanisms: Distributed Coordination Function (DCF) and Point Coordination Function (PCF) [10]. PCF is a MAC with centralized working and so not applied in distributed mesh networks [7].While DCF is the basic access mechanism of the IEEE802.11 and it is based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). The MAC protocol of 802.11e which is the Hybrid Coordination Function (HCF) has supporting feature for both contention-based and controlled channel access [11].The Enhanced Distributed Channel Access (EDCA) mechanism implements HCF, which is nothing but an extension of the DCF mechanism which with the help of multiple access categories (ACs) enables distributed differentiated [6] access to various the wireless channel.

There is a smaller minimum contention window CW_{min} (minimum congestion window) for higher access category stations, hence have a higher probability than others to access the common channel. Thus, in IEEE 802.11, overall access time will be divided into Contention period (CP) and Contention free period (CFP).In EDCA, all stations will compete for accessing the media in CPby implementing different IFSs (Inter frame Space). But all the time only the highest priority will have the shortest random back-off window i.e. the shortest IFS. Hence the station successfully grabs the access media while the other longer IFS will have to wait for some time. In HCCA, it works in the CFP, where all stations will send their request to the [2] QAP (QoS Supportive Adaptive Polling)station who will grant the permission for each station in order to use the access media. But then, in HCCA mode, the CP will be used by implementing CAP (Controlled Access Phase).Because priority is not assigned amongst the accepted or requested stations.

In the HCCA, irrespective of their importance the QAP will serve all stations according to their arrivals .That is why, a very important role is played by admission control for both policies and mechanisms. Also since EDCA is designed for single-hop networks then using EDCA to multi-hop networks such as WLAN mesh network may lead to performance degradation. In WLAN mesh networks, [1] EDCA-compliant relay access points (APs) can lead to congestion because of the decrease in number of transmission opportunities. The legacy stations residing in wireless mesh networks sometimes tend to cause buffer overflow. This may lead to congestion control and degrades the performance of the network. In order to address this problem, a congestion control mechanism was adopted. However, few drawbacks were noticed in this buffer control mechanism. In order to resolve this, an optimized way of handling congestion control is been introduced in this paper.

3. PROPOSED WORK:

In wireless mesh networks, HCF (hybrid coordination function) controlled channel access (HCCA) can be used in a modified way alias M-HCCA i.e. modified HCCA. In this paper, an enhanced way of implementing HCCA in order to improve its performance is proposed.

In this M-HCCA, during a CAP, the Hybrid Coordinator (HC)—which is also the AP—controls the access to the medium. Whenever there is need to transmit packets, a mesh client will send request frame to HC. However, there is slight change in HCCA functioning. The nodes within the network can set an URG (urgent) flag if it requires sending the frames urgently to destined nodes. The HC will check for URG flag first to decide which frames to be send first. If HC finds such flag with the node's frame request it will send that frame first as shown in figure 2. Thus priority is set high due to URG flag. If URG flag is not assigned to particular node then those nodes will be buffered and will be sent to destined nodes later. For the buffered nodes, which are waiting to get serviced will be served according to scheduling mechanism. In order to keep high throughput, round-robin scheduling techniques for low priority nodes.

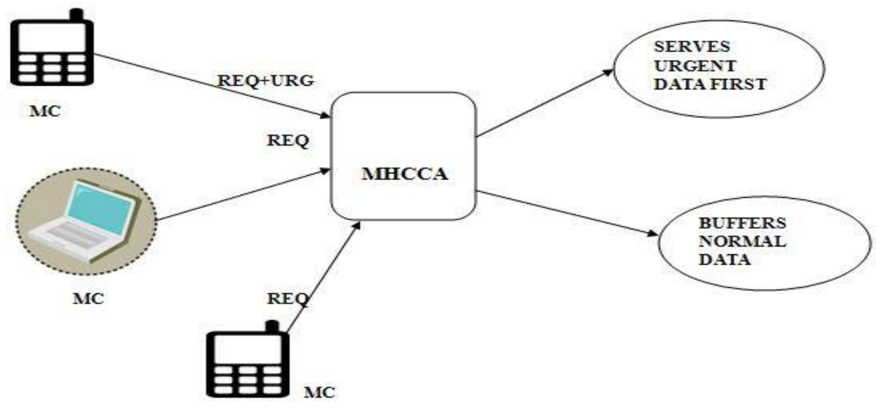

Figure 2 Mechanism of M-HCCA

can be implemented. In this technique, a specific quantum time slice is kept as shown in flowchart figure 3.

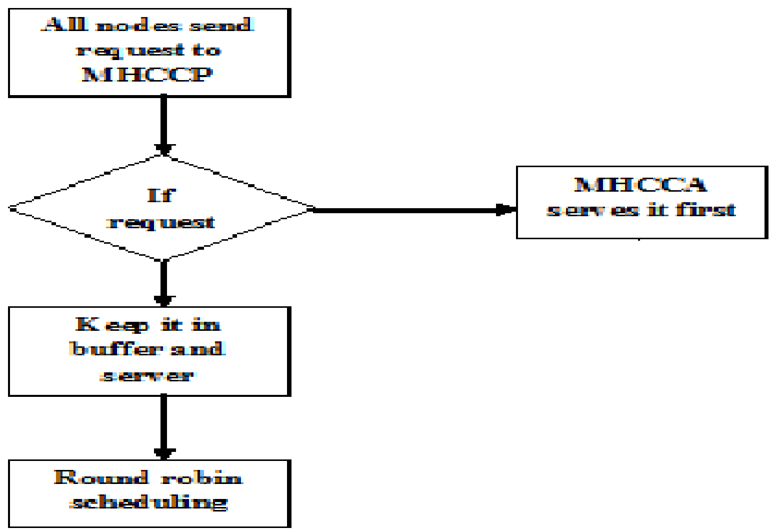

Figure 3 Flowchart

The nodes with lower priority are served in that quantum slice. Due to this, higher performance and higher throughput is achieved since fairness is achieved.

4. SIMULATION RESULTS:

4.1 Simulation Scenario:

The proposed scheme is simulated using Qualnet 4.5.1 [3] with simulation parameters mentioned in table 1. Table 2 and 3 show the AODV statistics and application statistics respectively. Table 4 shows CBR client and CBR server parameters. Figure 4 shows the network scenarios without the use of ROC. The simulation settings done to implement proposed scheme are shown in figure 5 and figure 6 shows the priority mechanism for the same. After the simulation is performed with required settings, figure 7 shows the network topology with the proposed scheme.

Table 1 Experimental parameters

Sr. No.	Parameter	Values
1	**Network protocol**	Internet Protocol (IP)
2	**Application**	FTP and Telnet
3	**Routing protocol**	AODV(Ad-hoc On Demand distance Vector routing protocol)
4	**Size of data to be sent (bytes)**	1024
5	**Number of packet**	512
6	**Start time (s)**	1
7	**End time (s)**	150
8	**Interval (s)**	0.25
9	**Simulation time(s)**	300

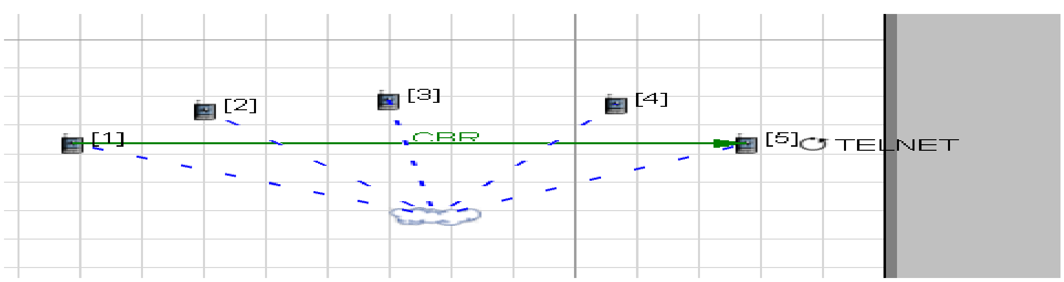

Figure 4 Network topology without ROC

Table 2 AODV statistics

Sr.	Parameters	Source	Destination

No.			
1	RREQ packets initiated	69	0
2	RREQ packets retried	49	5
3	RREQ packets initiated for local repair	0	0
4	RREQ sent for alternate route	0	0
5	RREQ received	111	77
6	RREQ discarded for blacklist	0	0
7	RREQ received by destination	6	66
8	RREP packet initiated at destination	6	66
9	RREP packet received	70	17
10	RERR packets initiated	0	0
11	RERR with n flags	0	0
12	RERR discarded	0	0
13	RERR packets received	100	4
14	HELLO message sent	0	0
15	HELLO message received	0	0
16	No. of routes selected	69	15
17	Total no of hop count	271	38

Table 3 Application Statistics

Sr.No.	Parameters	Client	Server
1	First packet sent	1.187572822	1.226521238
2	Last packet sent	579.3067829	0.000000000
3	Session status	closed	closed
4	Total bytes sent	3358	114
5	Total bytes received	114	3317
6	Throughput (bits/s)	24343	24432

Table 4 CBR Client and CBR Server

Sr.No.	Parameters	CBR Client	CBR Destination
1	Total bytes sent	51200	44544
2	Total packets sent	100	87
3	First packet sent at	1.00000000	1.405967005
4	Last packet sent at	25.75000000	25.768736070
5	Throughput (bits/s)	14624	14626

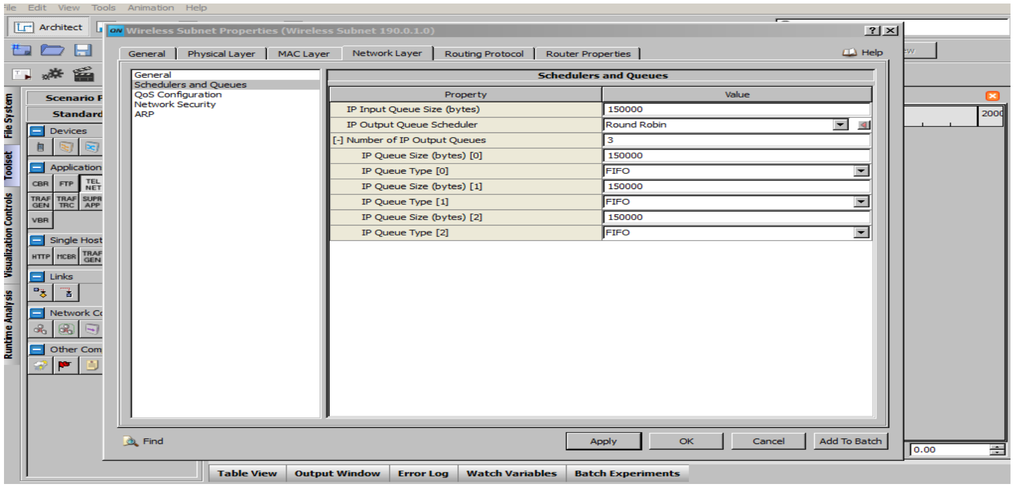

Figure 5 Settings for simulation

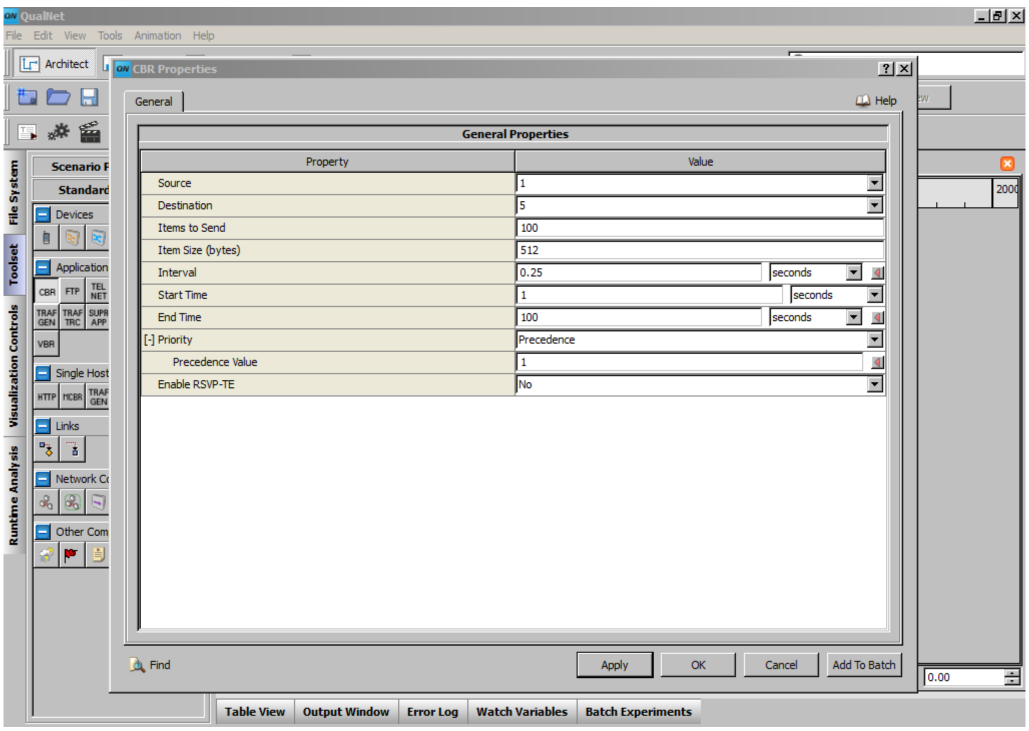

Figure 6 Priority mechanism

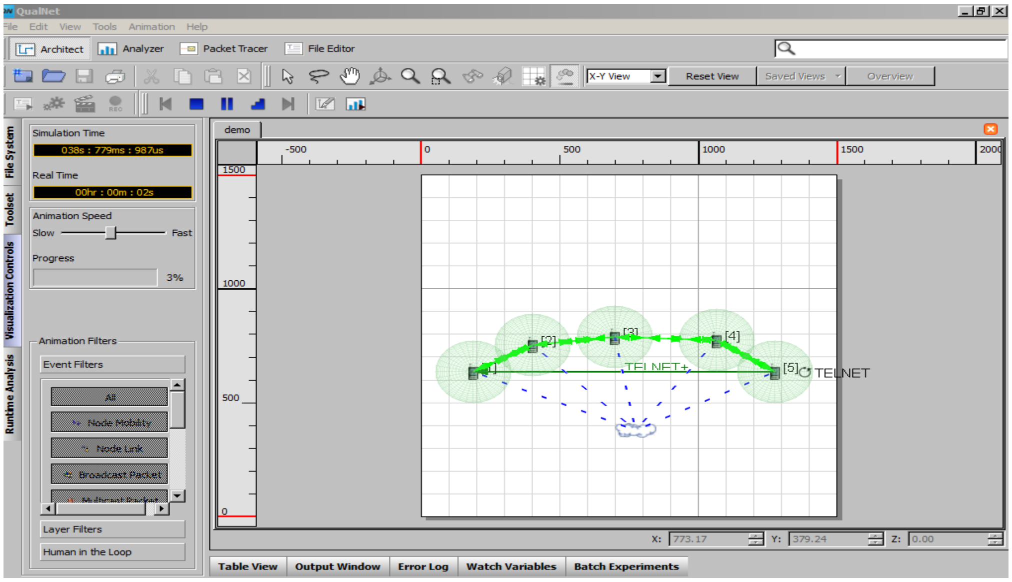

Figure 7 Network topology with proposed scheme

4.2Results and discussion:

Figure 8 and 9 depicts the total number of bytes received and throughput of the server respectively. Without the use of proposed scheme, the experiment results show that fairness is not achieved amongst lower priority nodes.

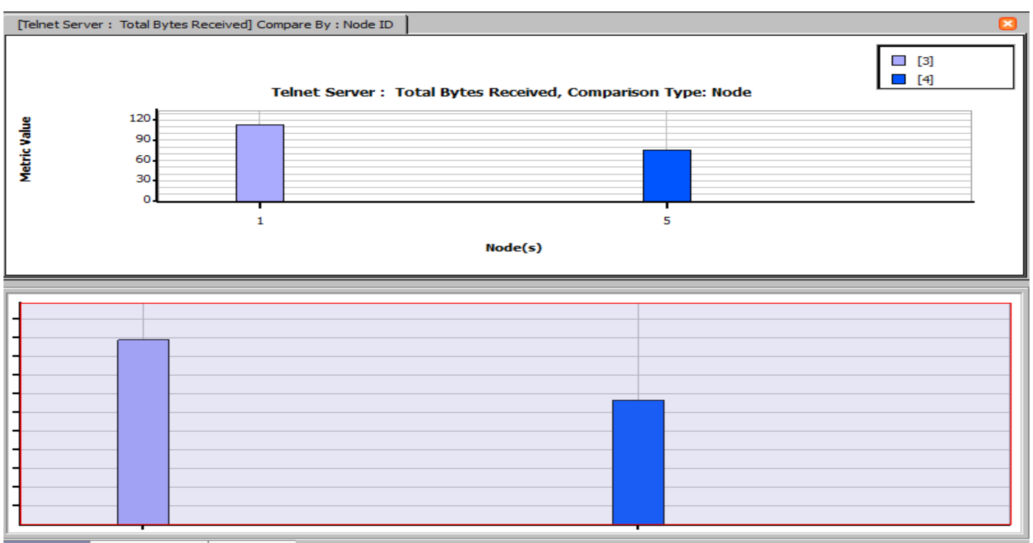

Figure 8 Statistics for total bytes received

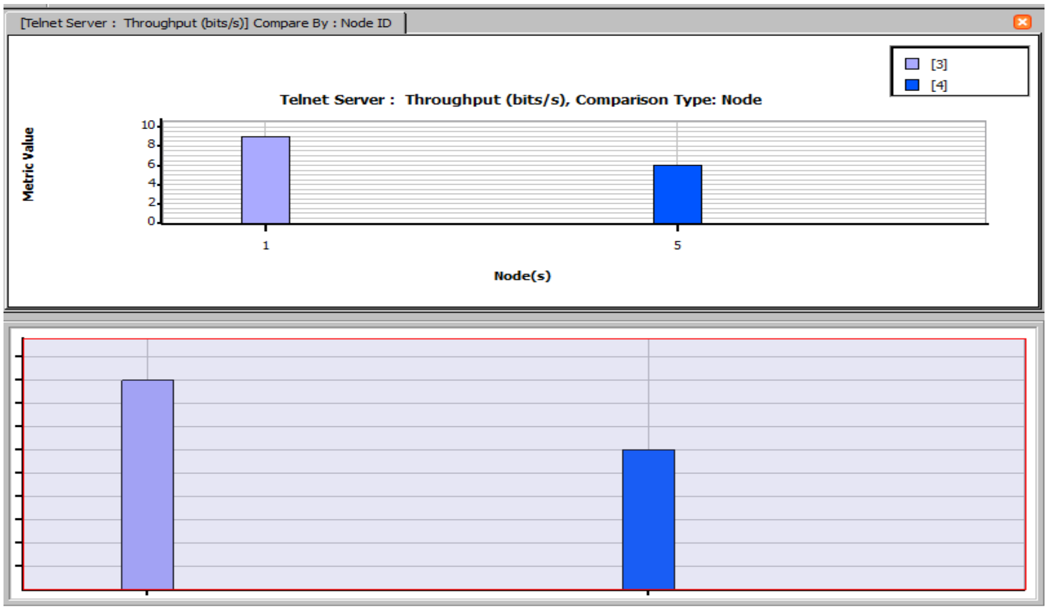

Figure 9 Throughput of network

However, as shown in figure 10 it's the comparative analysis of throughput where the overall throughput is improved when implemented using the proposed scheme where the lower priority nodes are served in round-robin mechanism instead of starving them.

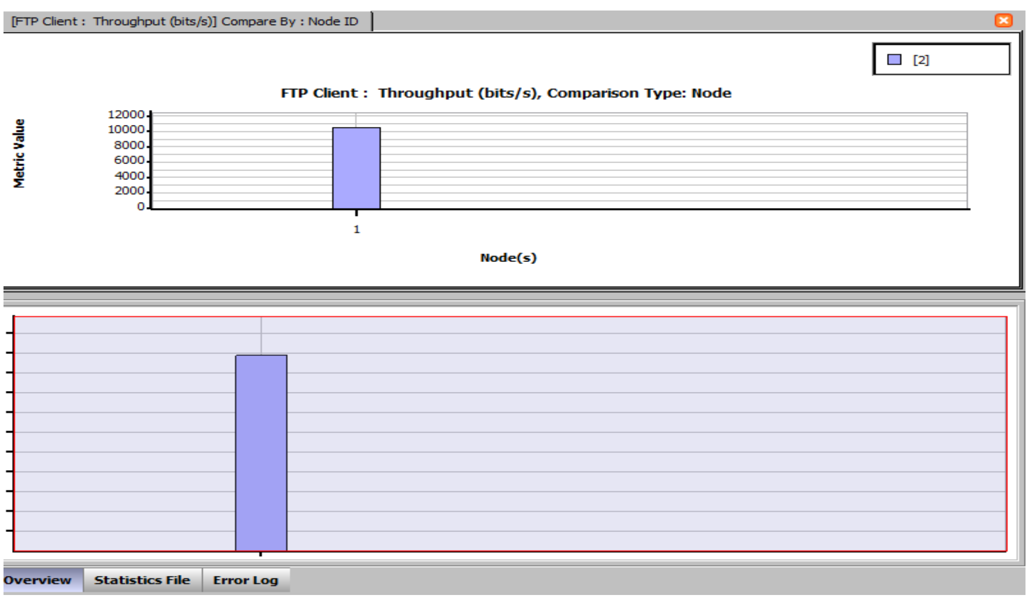

Figure 10 Comparative statistics of throughput

Finally it can be concluded that the proposed scheme of m-HCCA is helpful in improving throughput and efficiency of the network and thus achieves better network performance by providing fairness to the lower priority nodes.

6. ADVANTAGES:

1) Higher priority nodes are provided with fairness with the use of URG pointer.
2) Lower priority nodes are not starved and are served in round-robin fashion with specific time slice.
3) End-to-end delay is reduced.
4) Throughput and overall performance of network is improved.

7. LIMITATIONS:

1) Buffered nodes can further be served with better priority schemes.
2) Security of nodes with carrying URG pointer should be taken care against attacks.

8. CONCLUSION:

An effective, simple and modified way of implementing HCCA congestion control scheme for wireless mesh networks is been put forth n this paper. At first, the analysis of the reasons behind the inefficiency and unfairness on the nodes for transmission in wireless mesh networks was done. An experimental setup was done in order to analyze the results and applicability of this proposed work. The usage of URG pointer provides fairness to nodes with higher priority for transmission. Because of this the end-to-end delay and throughput of network is improved considerably. Thus the performance of network is enhanced. The upcoming work in this will be studying the behavior of network in more complex scenarios. Also the effect of variable time slice for lower priority nodes using round-robin scheduling can be studied and worked upon as the future scope.

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