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Bandwidth Guarantee using Class Based Weighted Fair Queue (CBWFQ) Scheduling Algorithm

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ABSTRACT

In this paper class based weighted fair queue (CBWFQ) algorithm with generic traffic shaping mechanism were simulated on an IP router for applications bandwidth guarantee. IP Telephone, Voice, and HTTP are the traffic classes generated in the network. CBWFQ scheme classify packets, assign bandwidth to each packet class and, queued packets in a buffer for transmission. Network simulation environment consisted of two students each carries IP Telephone, Voice and HTTP traffic was constructed using OPNET Modeler, simulation software. Simulation results was studied and analyzed. Graphical results show that each traffic class met with the minimum bandwidth guaranteed and, classes get shaped according to their specified traffic rate (bits/sec). This paper contribution can be used by an organization (Universities) and enterprises as traffic management scheme for better QoS.

KEYWORDS

Guaranteed Bandwidth, Internet Traffic, Quality of Service, Simulation Results, OPNET Modeler.

1 INTRODUCTION

This study presented the used of class based weighted fair queue scheduling algorithm for IP network applications to met their bandwidth requirement. According to [2] almost 850 million end systems are attached to the internet. Cisco virtual networking index [6], predicted that about 3.6 billion users will be connected to the internet and, 1.4 zettabytes of global traffic increases. Bandwidth is one of the QoS performance measures on the internet. Its scarcity degrades applications performance.

Queuing scheduling discipline (QSD) is one of the most frequent mechanisms used to control congestion in a network. Stored packets temporarily in a queue before transmission.

However CBWFQ enforce fairness in sharing bandwidth among different traffic classes in the network. Traffics are served based on their application type requirement. Considering each traffic class, the remaining bandwidth is shared to the low priority traffic classes. This study contributed the use of CBWFQ on an IP-based network to guarantee applications bandwidth requirement.

2 RELATED WORKS

Many studies and projects have been done in the area of QoS performance measures, computer network modeling, simulation and verification [1], [4], [5]. [5] of these proposed a simulation model that evaluated bandwidth performance in a corporate network. Presented how wider bandwidth increases network performance, using OPNET Modeler. The paper [4] developed policy based model of bandwidth management, simulated using graphic network simulator version 3 (GNS3). Bandwidth performance improvement was recorded. The other research study [1] modeled small office / home office (SOHO) network using OPNET, pointed out that upgrading link data rate will not necessarily be economically feasible. The study [3] implemented a universities policy based on bandwidth management in Zimbabwe. Analysis was recorded during the study.

Our study differs from the previous research studies through constructing an Ethernet simulation model using OPNET Modeler for an application bandwidth guaranteed.

Simulation of CBWFQ algorithm with generic traffic shaping and policing mechanism were implemented on IP router. The applications modeled in the network met their QoS requirement.

3 QUEUING SCHEDULING DISCIPLINE

3.1 Class Based Weighted Fair Queuing (CBWFQ)

CBWFQ scheduling scheme guaranteed bandwidth to each class of service in a network during the period of congestion. However uses the scheduling techniques of weighted fair queue (WFQ) to assign a weight to a different class of service based on their QoS, as shown in figure 1. Packets in classes, get services in a round-robin fashion based on their virtual finish time (VFT). This algorithm dropped packet when the buffer is filled. Priority is given to certain traffic, mostly real time applications (Voice and Video) over non real time applications (Email, HTTP and FTP). Fairness is enforced in sharing the remaining bandwidth among classes.

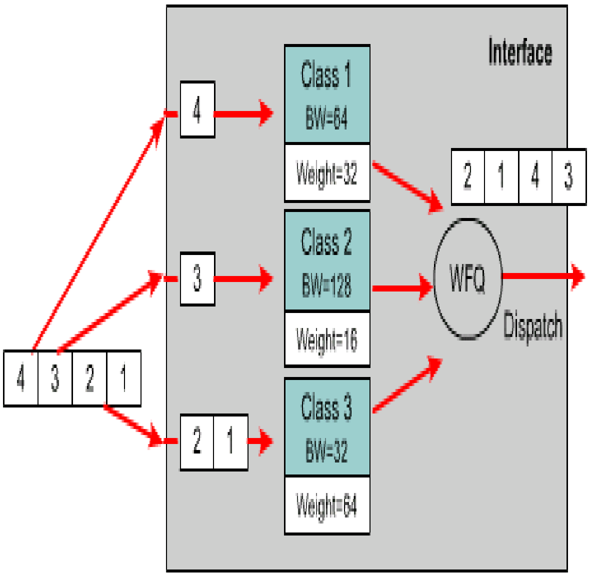

Figure 1. Class-Based weighted fair queue

For each number of packets within WFQ scheduler a weight is assign using equation 1

$$Wi = Wj; \qquad (1)$$

$$Bi = {}^{Wi}/_{\sum_{i=1}^{n} Wi} \times B \qquad (2)$$

Equation 2 is used to calculate the bandwidth of each link based on an assigned weight and interface bandwidth (data rate) B. Within each class packet get service based on their virtual finish time, packets with lower finish time get higher priority than any other packets in the queue.

$$Vf(i) = \max\big(A(i), F(i+1)\big) + \frac{length(i)}{Wi} \qquad (3)$$

$$\sum_i Bi - B \qquad (4)$$

Congestion occurs when the requested bandwidth is greater than the available bandwidth. As such packet will get dropped as stated in equation 4.

3.2 Priority Queuing (PQ)

Priority queuing scheduling discipline assigned the priority of high, medium, normal and low to different packets classes based on their delay requirement. Priority queueing is the traditional queueing techniques used to service real-time application (delay in tolerant applications). However high priority are asiggn to real-time applications which consume all the available bandwidth and starve non-real time applications.

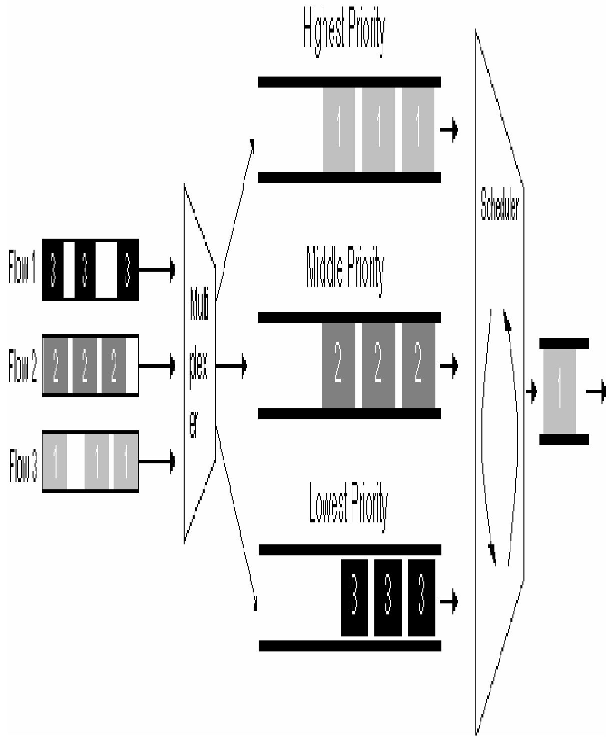

Figure 2.Priority Queue

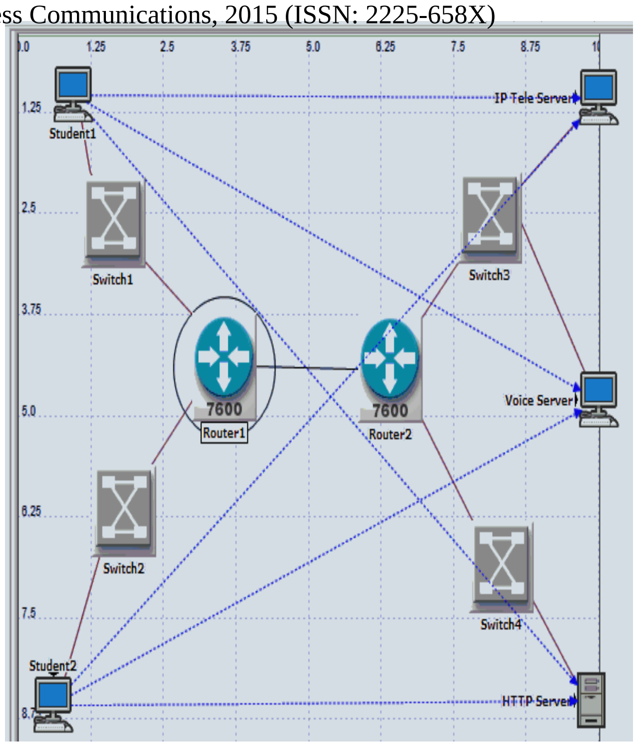

Figure3. Simulation Topology

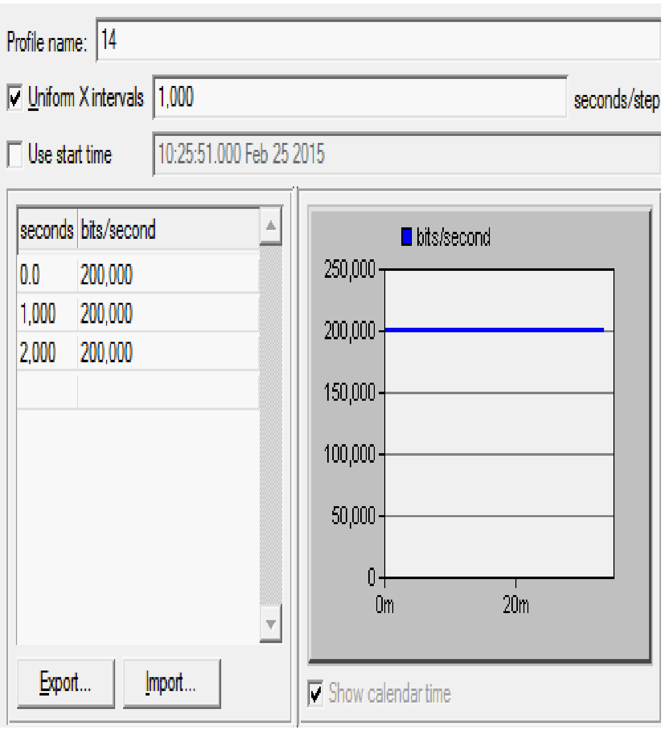

Figure 4. Student 1 HTTP Traffic

3.3 General Processor Sharing (GPS)

In GPS scheme packets are served in a queue based on their arrival time and length. Packets arrived first on the queue have higher priority of service than late arrived packets. the packets virtual finish time (VFT) determine the packets service processes.

4 SIMULATION EXPERIMENT

The network simulation environment constructed consist of 4 Ethernet workstations, 4 Ethernet switches, 2 Cisco 7600 routers, all link in the network are connected through 10 Mbits/sec data rate. The bottleneck link between Router1 and Router2 has data rate of T1 as shown in figure 3. Similarly student1 and student2 generate IP-Telephone, Voice and HTTP traffic respectively. The implementation of the algorithm, traffic classification and policing is on the bottleneck router (Router1). Each class was assigned a minimum amount of traffic to be forwarded in bit/sec as depicted in figure 4 and 5 for Voice and HTTP traffic generated by student1.

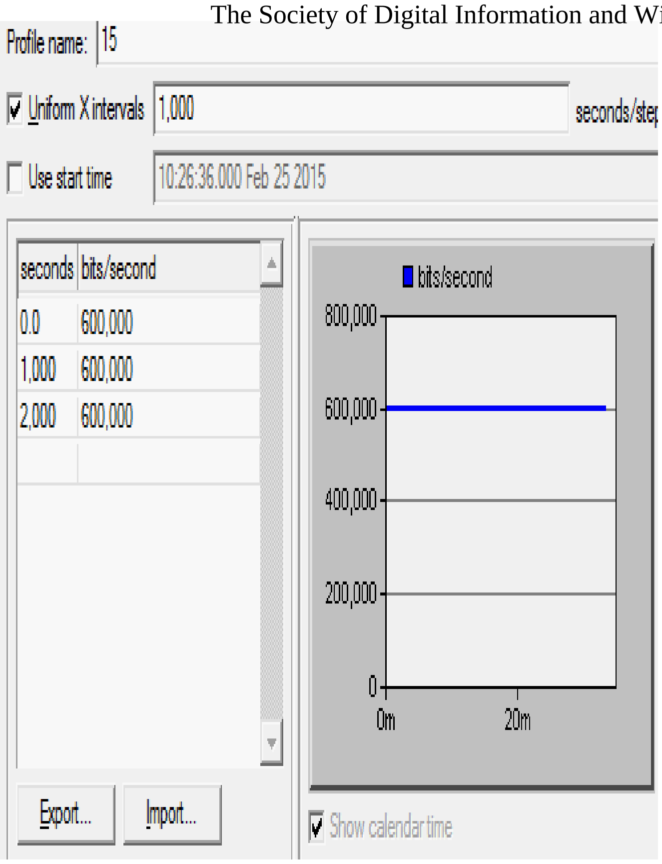

Figure 5.Student1 Voice traffic.

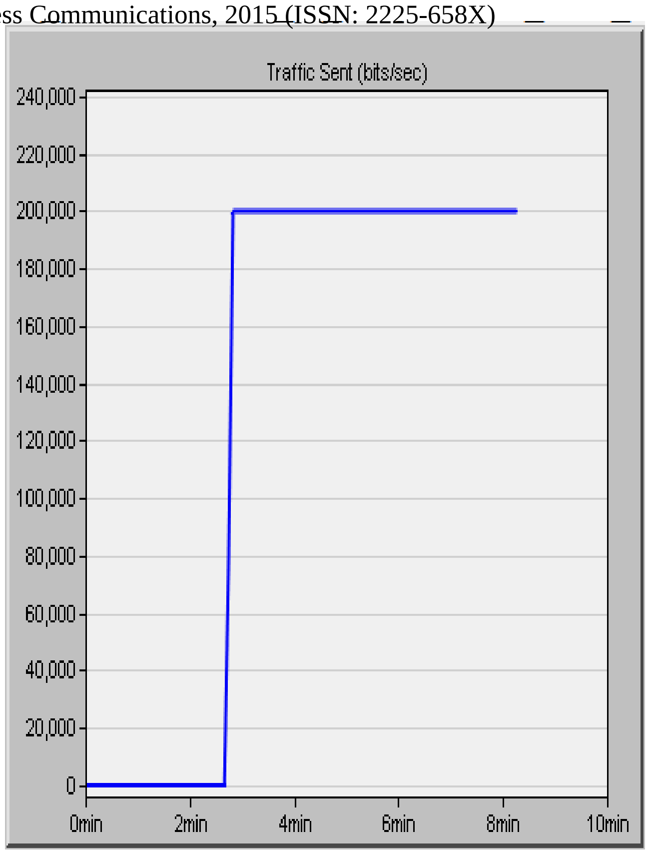

Figure 5.Student 1 HTTP Traffic Sent

5 SIMULATION RESULT

At 500 seconds simulation duration a discrete event statistics (DES) was collected and different simulation results were studied and analyzed.

Results for different network including traffic sent and traffic received were obtained graphically. The graph depicted in figure 6, shows student1 HTTP traffic received of 200Kbits/sec at time 2 minutes as guaranteed and minimum shaping requirement of 182Kbits/sec respectively.

The overall graphs for different traffic generated by student1 and student2, during the experiment show that all applications met their minimum bandwidth requirements and, each class gets shaped to their specified rate. Admittedly simulation result highlights the impact of CBWFQ on IP router discipline for guaranteed QoS. CBWFQ is an important scheduling discipline that has been implemented on IP router which governed the transmission of a packet in a network.

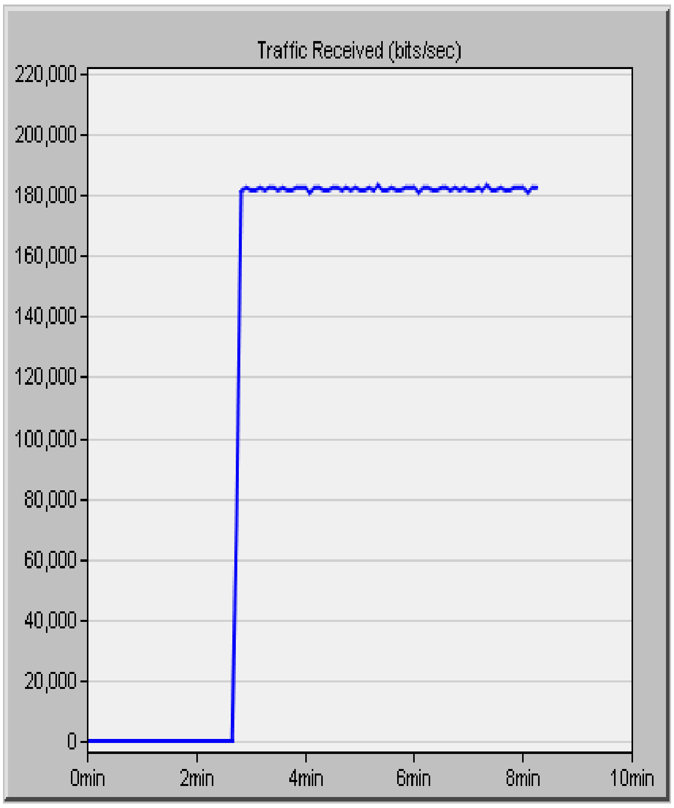

Figure 6.Student 1 HTTP Traffic Received

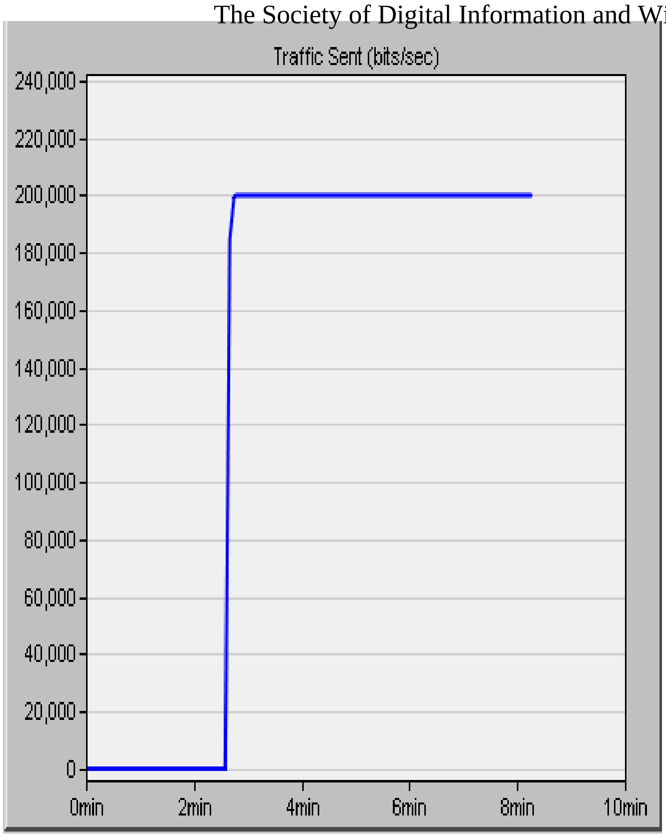

Figure 7.Student 1 IP Tel Traffic Sent

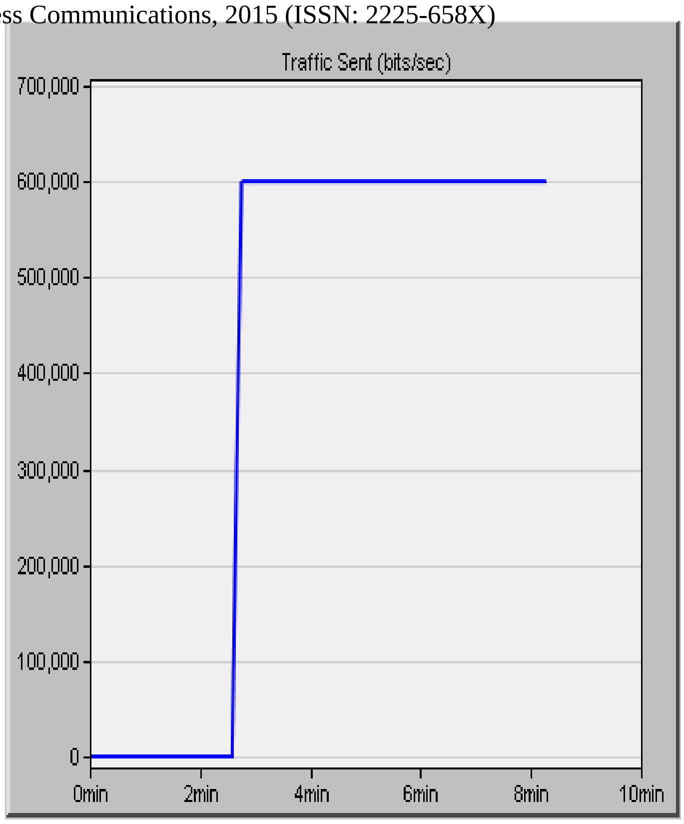

Figure 9.Student 1 Voice Traffic sent

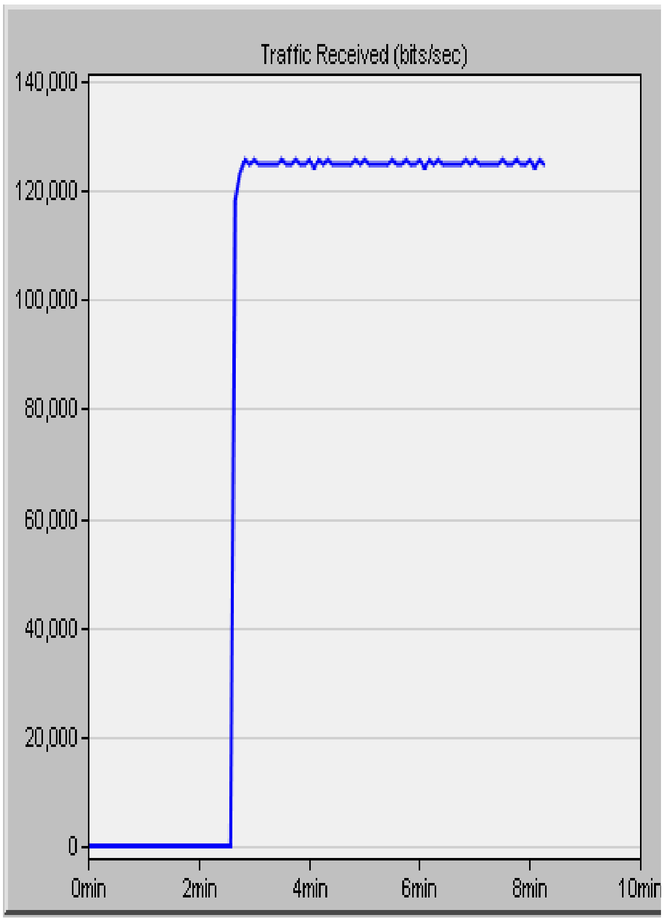

Figure 8.Student 1 IP Tel Traffic Received

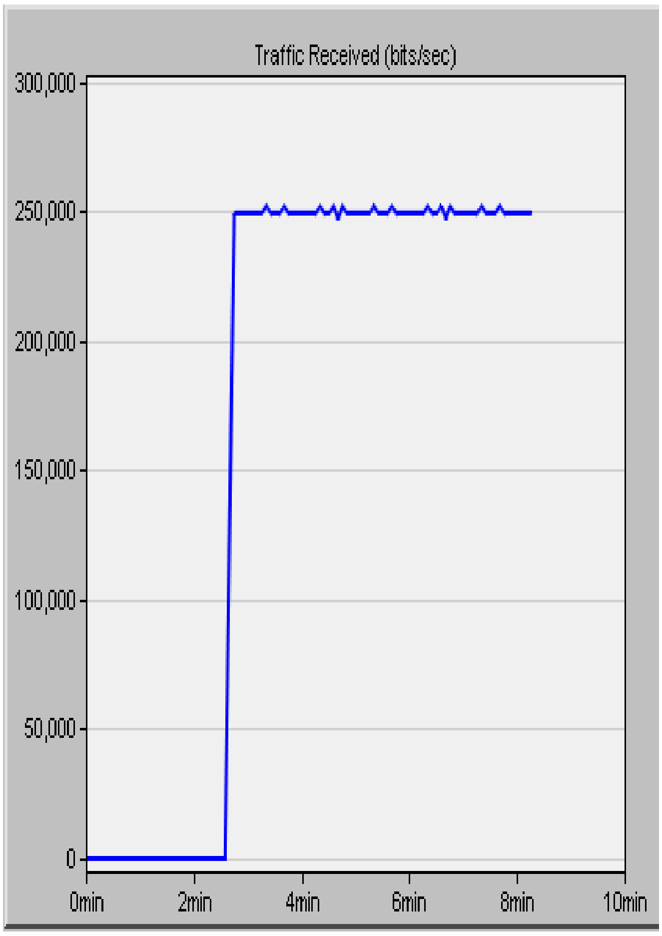

Figure 10.Student1 Voice Traffic Received

6 CONCLUSION

This research contributed the use of CBWFQ in an organization enterprises or (universities) IP based Network router for efficient QoS. The simple-Ethernet network model the implementation of class-based weighted fair queue (CBWFQ) with generic traffic shaping mechanism on a cisco router. HTTP, Voice and IP-Telephone were the traffic generated.

Simulation results show that the minimum bandwidth guaranteed to each traffic is met and classes get shaped to their specified value. Further researches can be carried out to investigate the effect of changing the traffics generation by the clients and traffic type respectively.

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