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25. MULTIMEDIA TRAFFIC ENGINEERING IN NEXT GENERATION NETWORKS

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Abstract

Due to high speed Internet and Multimedia applications, future wireless communication are expected to support multimedia traffic such as voice, video and text with a variety of Quality of Service (QoS) requirements and make efficient use of radio resources. Such kind of traffic requires high level of QoS guarantees. Traffic management is a process of regulating the traffic over network. Since, multimedia traffic is more sensitive, therefore it requires special measures while transmission, especially in wireless networks. There are different queuing disciplines which are used to police the traffic, the Priority Queue and RIO (RED with In/Out) are queuing disciplines, PQ is used to prioritize the traffic, and the later is used to drop the lower priority packets at the time of congestion. Proposed solution is the integration of Priority Queue with RIO, which will serve as a classifier to prioritize the traffic and then it will also serve as a scheduler by dropping lower priority traffic when the congestion state occur. Simulation results show that by applying proposed Traffic Management Strategy (PriRIO), it assigns stable bandwidth to the Multimedia Traffic Flow and enhances its throughput. It also shows that Packet Losses for Multimedia Traffic are very minor, that is, equivalent to none. Further, delay values for Multimedia traffic also remain below the Best Effort traffic flows. Thus, on the basis of these simulation results and analysis, PriRIO outperforms significantly, as compare to other Traffic Management Strategies..

Keywords

Multimedia, Quality of Service, Traffic Management, Wireless Networks, Queueing Discipline, Priority Queueing, RIO

1. Introduction

Wireless is a ubiquitous technology, and is a universal remedy. Due to high speed Internet and Multimedia applications, future wireless communication are expected to support multimedia traffic such as voice, video and text with a variety of Quality of Service (QoS) requirements and make efficient use of radio resources.

The Internet, web applications and wireless communications are dominating and have overcome the barriers of time and space in teaching and learning. The importance of distance learning has significantly improved in the past few years, as both students and educators have become more comfortable with the technology. An important issue in distance learning using wireless LAN related to QoS is the support for Multimedia Services; many scheduling strategies have been identified by (A. Iffat et al. 2008) to carry out multimedia traffic.

In the recent years there has been growing propagation of multimedia traffic and telecommunication technologies. Multimedia Traffic management techniques need to be purified, as the future wireless system are supposed to support the multimedia traffic. When multimedia traffic is transported over a network, then audio/video type traffic requires more bandwidth, then the text data. Therefore such kind of traffic requires high level of QoS (Quality of Service) guarantees.

Traffic management refers to regulating the traffic over network, so that to best utilize the network and provide satisfactory QoS to the user at low service cost. Traffic shaping and rate control, congestion control, bandwidth allocation, flow control, and video scalability are some of the technical challenges to be considered in managing multimedia traffic over ATM networks (Zheng, B. 1999)

Data packets can be characterized as Real-Time (RT) and non-Real Time (nRT). The real-time data is time dependant, therefore requires highly guaranteed Quality of Service for such applications containing Real time data. Real time traffic includes Voice, Video and Non-Real Time traffic involves text and graphics. The real-time traffic is delay sensitive where as non-real time traffic is error sensitive. The different service applications of such multi-class traffic differ in their bandwidth and resource management.

Support for traffic with QoS requirements is currently being addressed by the IEEE 802.11e Task Group. In order to deliver guaranteed QoS, however, 802.11e is only a QoS enabling mechanism that requires some higher level management functionality. (Davis, M. 2004)

The Embedded Markov Chain and supplementary variable methods are used by (D. Choi et al. 2006) to obtain the queue length distribution as well as the loss probability and the mean waiting time for each type of customer for the purpose of Traffic Control. Referring to an infrastructure wireless access network by (P. Fiengo et al. 2007), it focuses on managing downlink traffic in both wireless ATM and WiFi scenarios, where a central coordinator takes scheduling decisions for the mobile users in its cell. A queue-based approach by (L. Chisci et al. 2008) is adapted to efficiently control the power in Wireless Systems. Their proposed solution involves power control algorithm which adopts the Queue Size as control variable.

Our proposed solution performs significantly better than previous approaches used for traffic management. The proposed solution can prioritize the multimedia traffic over best effort traffic (data), therefore, high priority traffic gets fairer access of bandwidth as compare to lower priority traffic. Congestion Avoidance is accomplished by dropping lower priority traffic. Similarly, it involves lower end-to-end delays and minimum packet losses for multimedia traffic.

In the SECTION-II related work is described; SECTION-III illustrates proposed solution; SECTION-IV portrays Simulation analysis and its results; whereas, SECTION-V discusses the overall results and comparative analysis and finally SECTION-VI concludes the proposed solution and enlists future trends.

2. Related Work

CDMA transmission policies in conjunction with traffic monitoring high level protocols have been discussed in work presented by (Anthony, B. et al. 1997), so that to accommodate the multimedia traffic in wireless networks. The proposed scheme achieves the low rejection and capacity waste rates, as well as low delays.

A signaling and transmission algorithmic system proposed by (Burrell, A. et al. 2001) for wireless digital networks, is evaluated, in conjunction with a Traffic Monitoring Algorithm (TMA) for dynamic capacity allocation in multimedia ATM environments. As the admission delay constraint weakens, this proposed signaling technique even then maintains performance.

Different techniques are proposed related to multimedia traffic management, like, (Choi, S. et al 2000) proposes an adaptive bandwidth allocation scheme that dynamically determines the changing traffic parameter. Some of the work already has been done in providing differentiated treatment to multimedia traffic flows in the context of QoS in wireless networks.

Traffic management techniques may include traffic scheduling, traffic prediction and bandwidth allocation or some strategies so that the delays can be reduced to provide Quality of Service (QoS) in the delivery of Multimedia Contents. Algorithm which reduces the waiting time of delay for multimedia wireless environment is also introduced by (Benny, B. et al 1999).

To manage a single connection for multi-priority traffic over ATM (Seckin, G. et al. 2000) proposes *multi-priority traffic management model* for ATM traffic. The proposed solution consists of priority cell mapping algorithm, priority based bandwidth allocation approach, adaptation layer definition and multi-priority buffer access control algorithm. The aim is to develop the protocol stack that can support multi-priority real-time video traffic transmission over ATM networks. Proposed model controls the loss of video packets on priority basis. Thus in this way the loss effects due to congestion are controlled.

(Baamrani, K. et al. 2007) Presents the new multi-user rate adaptive resource allocation for OFDM downlink transmission. The presented algorithm assigns one bit at a time to the user which has minimum total power in the sub-carrier. Their simulation result shows that the sum capacity is allocated more fairly among users.

A TDMA-based ad hoc network system is considered in (Li, Y. et al. 2007) and proposes an algorithm for joint power control, scheduling and routing. This article is based on cross layer design to improve the performance in terms of delay and throughput. It considers the coupling of routing in the network layer and bandwidth allocation in the MAC layer.

IEEE 802.16 based Wireless Mesh Networks (WMN) utilize TDMA as the access method. To provide high Quality of Service (QoS) for multimedia services in such environment, (Han, B. et al. 2007) proposes a collision-free scheduling algorithm. In a transmission tree, they have designed a relay strategy for mesh node, so that to improve the performance in terms of link scheduling. Fairness, channel utilization and transmission delay are such factors which are considered for their proposed solution. This solution is based on maximizing the spatial reuse of the available bandwidth as well as eliminating the possibility of collisions.

Traffic control consists of some traditional elements (SourceForge, Inc. 2008); *Shaping* is the mechanism by which packets are delayed before transmission in an output queue to meet a desired output rate. *Scheduling* is the mechanism by which packets are arranged (or rearranged) between input and output of a particular queue. *Classifying* is the mechanism by which packets are separated for different treatment, possibly different output queues. *Policing*, as an element of traffic control, is simply a mechanism by which traffic can be limited. *Dropping* a packet is a mechanism by which a packet is discarded. *Marking* is a mechanism through which the packet is altered.

Some research community proposes Queuing System to control the traffic and provide guaranteed QoS. The FIFO/DropTail Queuing discipline is the primitive queue type. In FIFO Queuing Discipline all packets are treated equally and are placed into a single queue. Then each packet is served in the same order. The RED (Random Early Detection) uses only one queue and one dropping probability, where as the GRED (Generalized RED) has 16 levels of dropping thus 16 virtual queues with their own parameter settings. RED & GRED are used for congestion avoidance (SourceForge, Inc. 2008).
RIO (RED In/Out) queue discipline includes two types of data packets, “In” and “Out” packets, which basically utilizes two delivery classes. Packets are marked with OUT, if the packet arrival rate exceeds a predetermined target rate. Otherwise, packets are marked with IN. “IN” packets have the preference over “OUT” packets; therefore, “OUT” packets can be dropped in congestion states (S. Floyd et al. 1993).

In classic Priority Queuing, packets are first classified by the system and then placed into different priority queues. Within each of the priority queues, packets are scheduled in FIFO order. It contains an arbitrary number of classes of different priority (SourceForge, Inc. 2008), thus, high priority traffic gets fair access. Class Based Queuing (CBQ) divides user traffic into a hierarchy of classes, on the basis of any combination of IP addresses, protocols and application types. It contains shaping elements as well as prioritizing capabilities. Shaping is performed using link idle time calculations based on the timing of de-queuing events and underlying link bandwidth (Peter K. et al) The queuing model presented by (Doo, C. I. et al 2007), extends the existing scheduling policies and includes these policies as special cases, which presents the loss probability and the mean waiting time by deriving the queue-length distribution.

Thus, to provide guaranteed QoS (Quality of Service) in wireless networks, it is important and hot issue to manage the network traffic, especially multimedia traffic. Since some traffic classes requires more bandwidth utilization and some traffic classes are under-utilized, therefore we can manage the traffic by providing bandwidth according to traffic classes.

3. Proposed solution

In the recent years there has been growing propagation of multimedia traffic and telecommunication technologies. Multimedia Traffic management techniques need to be purified, as the future wireless system are supposed to support the multimedia traffic. When multimedia traffic is transported over a network, then audio/video type traffic requires more bandwidth, than the text data. Therefore such kind of traffic requires high level of QoS (Quality of Service) guarantees.

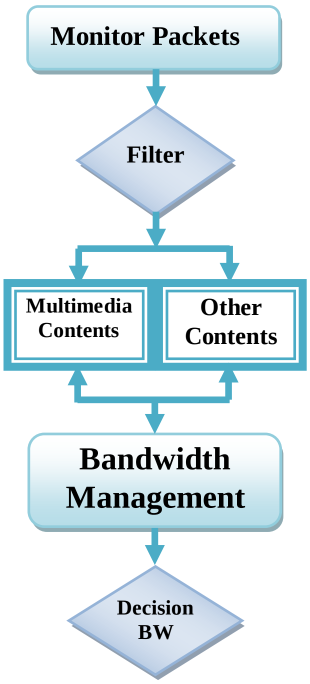

Figure.1. Proposed Model (Generic) Proposed by (A. Iffat et al. 2008)

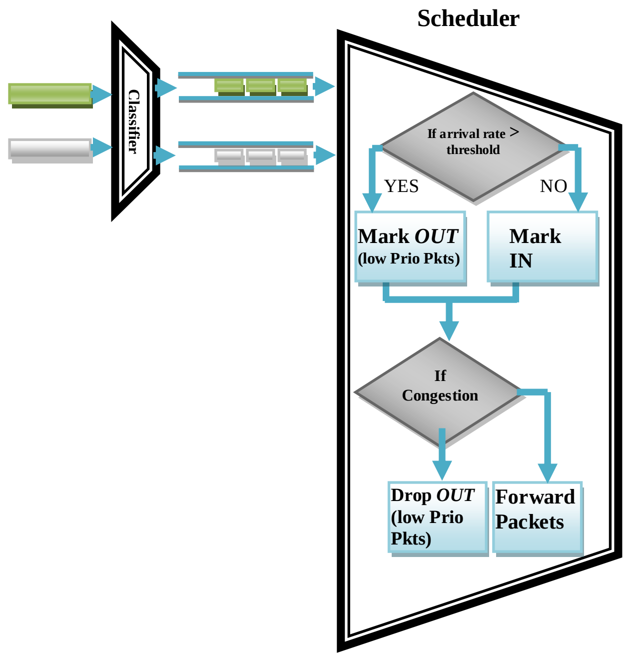

Figure.2. Proposed Model (Technical)

The proposed model is represented in two forms: Generic Model and Technical Model. In the generic model, the concept is represented in the pictorial form, whereas, in the technical model the actual flow of work is represented pictorially. In the proposed solution, data is monitored and differentiated on the basis of multimedia traffic and other data (best effort traffic). Then, on the basis of type of data, bandwidth is allocated. Like, multimedia traffic gets more bandwidth and best effort traffic gets lower bandwidth comparatively. Same thing can be said in a way that, multimedia traffic gets stable bandwidth. The generic model/architecture is pictorially represented above in Figure 1.

The proposed model consists of multiple queuing disciplines. Technically, this model works in the second layer of OSI Model, that is, Data Link Layer. Basically the input of the second layer is in the form of packets. When the packets arrive in the second layer, they are classified according to their type, that is, multimedia contents or best effort traffic. Then, packets are prioritized according to their classified type.

The multimedia traffic is given high priority over other traffic. Then, after prioritizing traffic, the packets are sent to another queuing discipline RIO (RED with In/Out), which is basically the inherited form of RED Queuing discipline. It is basically used to limit the traffic rate and drop the lower priority packets in congestions. Therefore, this combination of queuing disciplines is used for congestion control as well as for efficient bandwidth utilization. The pictorial representation of technical model is given in figure 2.

As multimedia traffic needs high priority, because it is sensitive traffic and requires less delay and more bandwidth for better Quality of Service, therefore proposed solution fulfils its requirements. In the previous solutions, only priority was assigned to the traffic, no such effective difference was present there for multimedia traffic. Whereas, in the proposed solution, by prioritizing traffic, there are less packet drops of multimedia traffic as compare to other traffic (Best Effort traffic).

Furthermore, no packet dropping mechanism was used, whereas, in the proposed solution, lower priority traffic packets are dropped in congestion states. Therefore, proposed solution also acts as a congestion avoidance mechanism, while keeping the Quality of Service issues in consideration for multimedia traffic.

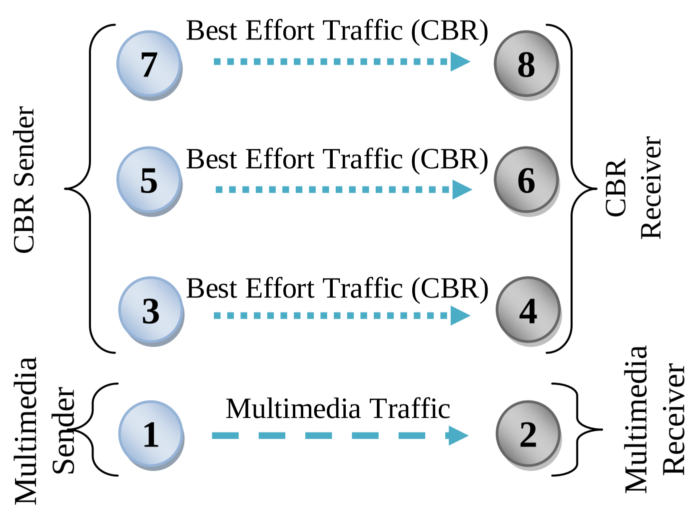

Figure.3. Simulation Topology

Thus, by using priority queuing discipline, multimedia traffic can be prioritized over best effort traffic (non- real time data). Furthermore, high priority traffic can get fair access to bandwidth. The drawback of using priority queuing alone is that, when incoming traffic rate is high and outgoing traffic rate is low, congestion avoidance is complicated. RIO queuing discipline is used to avoid the congestions by dropping the packets. Therefore, by using the RIO queuing discipline along with priority scheme can eliminate this drawback of priority queues. The drawback of using RIO queuing discipline alone is that packets are lost due to dropping mechanism, without considering the sensitivity of the contents/data. Thus, proposed solution can be best suited as multimedia traffic management strategy; same is verified by the simulation in the subsequent section.

4. Simulation & results analysis

4.1 Simulation Topology

Simulation topology is demonstrated in Figure.3. There are four sending nodes and four receiving nodes. One node is sending multimedia traffic over multimedia based UDP and other nodes are sending CBR traffic over UDP Agent. First node start sending application data at 1.4 second, 2nd application starts at 10.0 seconds, 3rd application start at 20.0 Second and finally 4th application starts transmission at 30.0 seconds. The QoS Parameters measured are delay, packet loss and throughput. For each of the traffic, these parameters are measured.

4.2 Simulation Scenario-I

The simulation running time was 80 second; the queue length was set to 50. The IEEE 802.11e standard is used at MAC layer. There are total of eight nodes. Network interface type is Wireless/WirelessPhy and OmniAntenna type is used. DSDV routing protocol is used. Queue types used are proposed solution that is, Priority with RIO (PriRIO).

4.2.1 Results for Scenario-I

For each transmission, statistics of delay, packet loss and throughput is measured and analyzed. In figure 32, no such traffic management strategy has been used and all flows are entertained equally. In the X-axis, time is represented in the seconds, whereas, on Y-Axis, throughput values have been presented in terms of bandwidth utilization. Figure.4, shows that bandwidth is equally distributed.

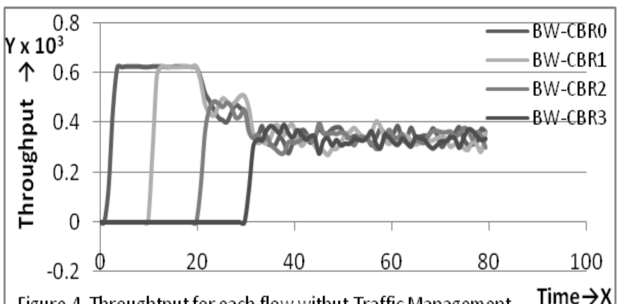

Figure.4. Throughtput for each flow withut Traffic Management

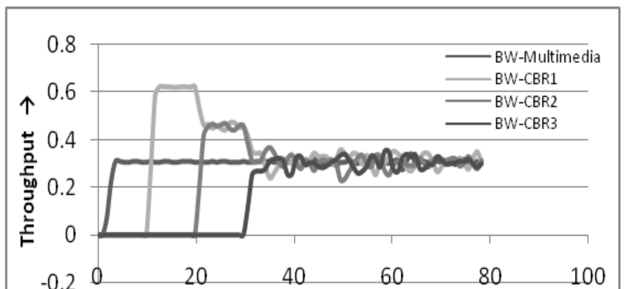

Figure.5. Throughtput for each flow with PriRIO

In the figure.5, throughput is presented with applying the proposed traffic management strategy, that is, PriRIO. Here, it clearly shows that the throughput for the multimedia traffic is very stable and gets almost average bandwidth, whereas, other application traffic gets un-stable bandwidth. Since, Multimedia traffic is more sensitive; therefore, bandwidth stability here shows its effectiveness.

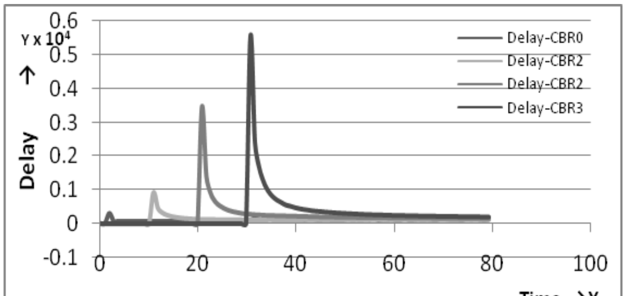

Figure.6. Delay for each flow without Traffic Management

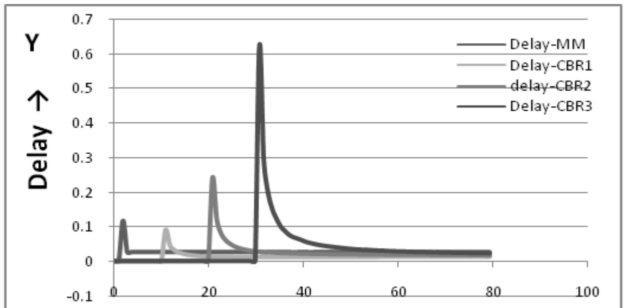

Figure.7. Delay for each flow with PriRIO

In the figure.6, delays are represented, while no such traffic management strategy is applied. Here it can be shown clearly that all of the traffic has almost equal values of delays after its transmission initiation.

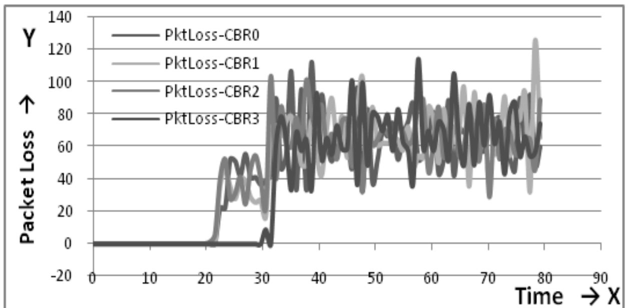

Figure.8. Packet Losses for each flow without Traffic Management

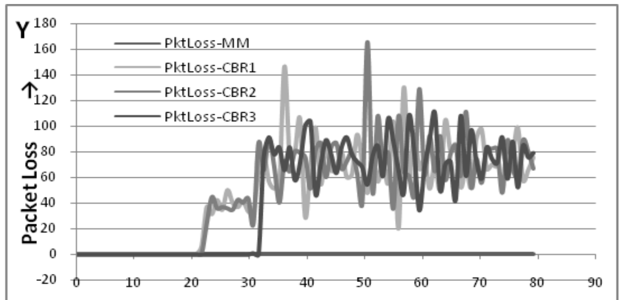

Figure.9. Packet Losses for each flow with PriRIO

In Figure.7, end-to-end delays are represented, even though in the graphs little bit delay values are increased, but it does not impact Quality of Service up to that extend, Quality is almost same, because other parameters have very good values, that stable bandwidth utilization as well as no packet losses.

In figure.8, packet losses are pictorially represented. Graph shows that it almost equally treats all of the flows, and packet loss values for each of the flow are very close to each other.

Whereas, in figure.9, when proposed traffic management strategy is applied, it significantly reduces the packet loss values, that is, almost representing none for multimedia traffic, this shows an excellent achievement of the proposed solution. Thus, it shows that only lower priority packet will be dropped in the time of congestions, and high priority traffic such as Multimedia traffic will be get affected in the situation of congestions.

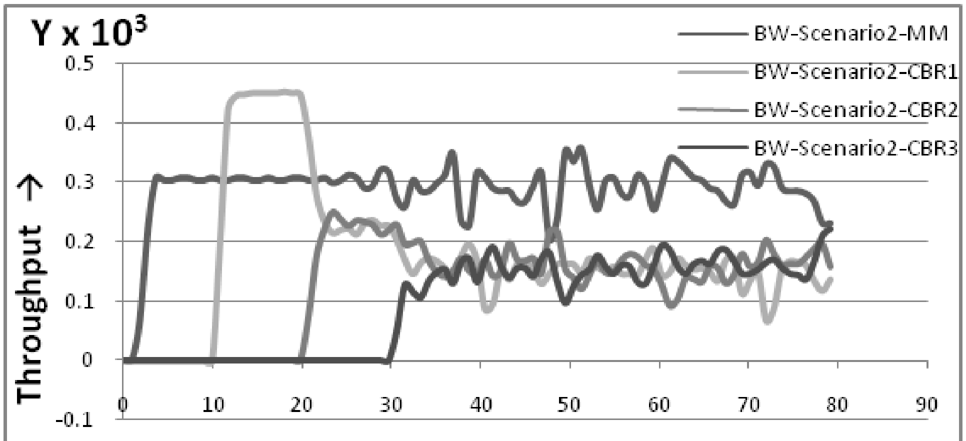

Figure.10. Throughtput for each flow with PriRIO

4.3 Simulation Scenario-II

In the second scenario, if we lower the data transmission rate, as in under developed countries, bandwidth is low, therefore, data transmission rate is also low, in such scenario, how our proposed solution works is demonstrated in this section. Here, instead of 2MB, I have used 1MB for data transmission:

4.3.1 Results for Scenario-II

In figure.10, PriRIO Traffic Management strategy has been used. In the X-axis, time is represented in the seconds, whereas, on Y-Axis, throughput values have been presented in terms of bandwidth utilization. Figure shows that more bandwidth is assigned to Multimedia traffic instead of other CBR Traffic.

In the figure.11, delays are represented, when PriRIO Traffic Management strategy is applied in lower data transmission rates. Here it can be shown clearly that Multimedia Traffic remains below as compare to other CBR traffic.

In Figure.12, packet losses are pictorially represented when PriRIO is applied on lower data transmission rate. Graph shows that packet losses for Multimedia traffic are minor as compare to other CBR traffic.

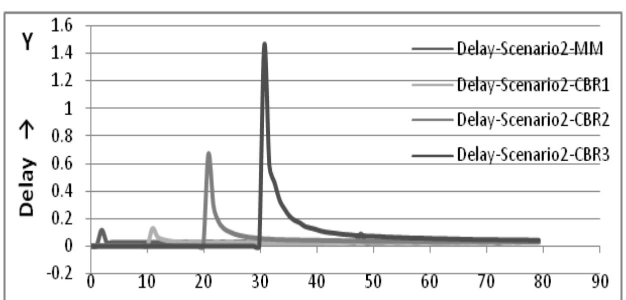

Figure .11. Delay for each flow with PriRIO

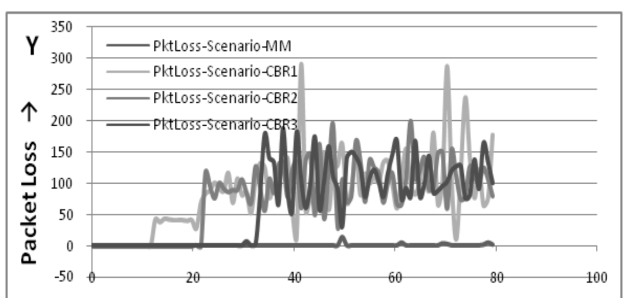

Figure.12. Packet Losses for each flow with PriRIO

5. Discussion

In the recent years there has been growing propagation of multimedia traffic and telecommunication technologies. Multimedia Traffic management techniques need to be purified, as the future wireless system are supposed to support the multimedia traffic. When multimedia traffic is transported over a network, then audio/video type traffic requires more bandwidth, than the text data. Therefore such kind of traffic requires high level of QoS (Quality of Service) guarantees. Traffic management refers to regulating the traffic over network, so that to best utilize the network and provide satisfactory QoS.

Priority Queue Scheme is also widely used, because in this scheme traffic can be prioritized according to the needs. RED In/Out (RIO) Queues can play significant role in congestion avoidance. It can drop lower priority packets, thus, enhancing the Quality of Service for high priority traffic. Thus, if we integrate both solutions, they can eliminate the cons of each other and can significantly enhance the quality of service in terms of decreased end-to-end delays, fair access to bandwidth and less packet drops for high priority traffic (that is multimedia traffic).

6. Conclusion & Future Trends

Traffic Management plays important role in providing QoS for Multimedia Traffic in Wireless Networks. There are different traffic management strategies: Queuing management is one of them. Further, Queuing Disciplines are also categorized. Priority Queues prioritize the traffic according to traffic attribute, whereas, RIO Queue are used for congestion control.

The proposed solution is PriRIO (Priority with RED In/Out), which basically prioritizes the traffic as Real Time (Multimedia Traffic) and non-real time (best effort traffic). Then, if congestion state occurs, it drops lower priority traffic and maintains QoS for high priority packets, that is, multimedia traffic. PriRIO significantly increases the bandwidth utilization for Multimedia traffic in the form of throughput. Even though little bit delay values are increased, but it does not impact overall, such values can be ignored, because these values are very minor and very much lower than the acceptable values. Finally, it significantly reduces packet losses for Multimedia Traffic.

Future trends include the enhancements in more queuing disciplines to be deployed in Wireless Networks. Most of the Queueing disciplines perform well in Wired-Line networks, but they are not supported in Wireless Systems. There is a need to introduce some rate limiting schemes and policing in wireless networks as well, instead of using simple DropTail or Priority Queue. In my proposed simulations, there is no such significant difference in delays; therefore, some other efficient strategies can be introduced to decrease the delays.

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