A NEW PROPOSAL ERICA+ SWITCH ALGORITHM FOR TRAFFIC MANAGEMENT

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ABSTRACT
A new proposal to the Explicit Rate Indication for Congestion Avoidance+ (ERICA+) switch algorithm for traffic management is present. The new proposal can be used for enhancing quality of service of multimedia; the using of non_zero MCR is very useful for carrying multimedia over ATM network. We have adopted continuous event driven simulation methodology to evaluate performance of integrated video and data traffics on the ATM network when using ABR service. The study confirms that the system parameters (e.g., dynamic/constant queue control functions, ICRs for sources, number of video and data traffic intensity) have sensitive effects on the performance characteristics of the network. The method we have used depends on a separate queues for each traffic types to isolate them from overlapping, so the delay will reduce especially for video traffic, however, the new proposal algorithm gives better performance than the original algorithm, its promising enough.

KEYWORDS: *ERICA+ switch algorithm, ATM-ABR service, Performance of Video and Data traffics.*

I. INTRODUCTION

It is well known that ATM (Asynchronous Transfer Mode) has emerged as most promising technology which can provide high speed networks with the capability of sending all types of traffic including video and data, and provides high speed communications for different types of data [1]. ATM supports multiple Quality of Service (QoS), which include Constant Bit Rate (CBR), Variable Bit Rate (VBR), Available Bit Rate (ABR), and Unspecified Bit Rate (UBR). These services share a common link and thus not all of them can get the bandwidth they require. In ATM networks, the ABR service and UBR service are used to support non-delay sensitive data applications. ABR normally uses the available bandwidth. This is often the left-over of the higher priorities services, which are CBR and VBR. Though the current standards for ABR service do not require the cell transfer delay and cell loss ratio to be guaranteed, it is desirable for switches to minimize the delay and loss as much as possible. The ABR service requires network switches to constantly monitor their load and feed this information back to the sources, which in turn dynamically adjust their input into the network. This is mainly done by inserting Resource Management (RM) cells into the traffic periodically and getting the network congestion state feedback from the returned RM cells, which may contain congestion information reported by the switches and destinations. Depending upon the feedback, the source is required to adjust its transmission rate. Obviously, that the congestion control mechanisms are essential for the support of ABR service to provide efficient and fair bandwidth allocation among ABR applications [2-19].
Figure 1 shows an ABR traffic management model. The RM cell contains an Explicit Rate (ER) field. The switches along the path put some information to indicate the rate that the source should use after the receipt of the RM cell. ABR users are allowed to declare a Minimum Cell Rate (MCR), which is guaranteed to the Virtual Connection (VC) by the network. Most VCs use zero as the default MCR value. However, for an ABR with higher MCR, the connection may be denied if sufficient bandwidth is not available. Both ABR data traffic and the available bandwidth for ABR are variable.

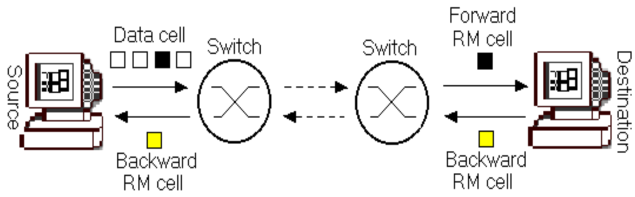


Figure 1 Traffic Model in ABR

If there is not enough buffer the bursty traffic (either from VBR, which requires more bandwidth), too many losses will result in low performance. This paper presents a new proposal algorithm to the switch depending on the General weighted Fair ERICA+ (GWFairERICA+) switch algorithm were described in [20,21]. As shown in Figure 2, we have considered two types of traffic (video and data), each traffic has n sources (Source 1,.,Source n) accommodates in one queue and the service of these queues occurs at different levels of priorities, that is to enhance throughput guarantees to support multimedia applications.

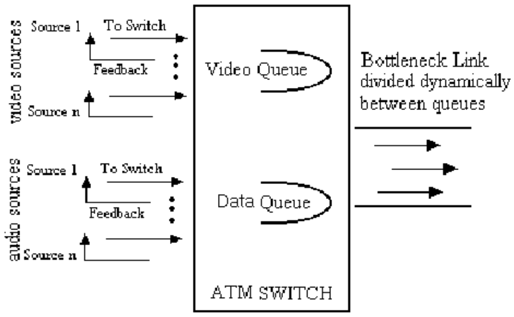


Figure 2

The output link bandwidth divided dynamically between these queues according to the level of priority. It is to mention here that the use of separate queues resulting in reduces the delay of the cells transmission. Also, we assume that the Average Interval (AI) period for each traffic type is different and depends on the RM cells, for example if RM cell of data source is sending every X period an data cell and RM cell of video source is sending every 50X period a video cell, that indicates that the AI for video sources much more than that of data sources 50 times, i.e., when one feedback arrives at video sources there are several feedback arrive at data sources.

The remaining of the paper organized as the following, section 2 gives brief overview of ERICA+ switch algorithm and then section 3 discusses the new proposal algorithm. In section 4 the configuration parameters, and simulation are discussed. The results are discussed in section 5. Section 6 gives discussion and finally section 7 presents the conclusion.

II. OVERVIEW OF THE ORIGINAL ERICA+ SWITCH ALGORITHM

At the beginning it is well known that the main advantages of ERICA are its low complexity, fast transient response, high efficiency, and small queuing delay [22-25], also, in ERICA, the time is divided into consecutive equal-sized slots called "switched averaging intervals" [26]. The ERICA+ algorithm is concerned with the fair and efficient allocation of the available bandwidth to all contending sources. Like any dynamic resource algorithm, it requires monitoring the available capacity and the current demand on the resources. There, the key "resource" is the available bandwidth at a queuing point. In most switches, output buffering is used, which means that most of the queuing happens at the output ports. Thus, the ERICA+ algorithm is applied to each output port. Assuming that measurements do not suffer from high variance, the above algorithm is sufficient to converge to efficient operation in all cases and to the max-min fair allocations in most cases [20, 27-32]. As mentioned above that the ERICA+ operates at the output port of a switch. It periodically monitors the load, active number of VCs and provides feedback in the backward RM (BRM) cells. The measurement period is called the "Averaging Interval". The measurements are done in the forward direction and feedback is given in the reverse direction. The complete description of ERICA+ algorithm and its performance in one of these references [20,33-35], and some related research in [36-44].

III. THE NEW PROPOSAL SWITCH ALGORITHM [45, 46]

In the new proposal switch algorithm, two types of traffic and two queues (as shown in Figure 2) are used instead of one type of traffic and one queue which have been developed in several switch algorithm to compute the feedback to be indicated to ABR sources in RM cells [31-33, 48, 49]. Also, the service of these queues depends on different levels of priorities that will enhance throughput guarantees to support multimedia applications and dividing the output link bandwidth between these queues dynamically depending on the traffic's priority level. The separate queues also protect each traffic type from overlapping , so the delay of both traffic will reduce.

When using more than one queue as shown in Figure 2, the treatment will be different because the case of one queue does not bother about the status of the traffic within the network, for example may be the video's queue is full and at the same time the data's queue is empty. Also, there are two functions of queue length, one for each traffic, Fq_v for video traffic, and Fq_D for data traffic. Each queue function defines the feedback for the source dealing with that queue and the queue functions are independent from each other.

We assume that the AI (Averaging Interval) period for each traffic type is different and depends on the Resource Management (RM) cells. Instead of using one queue function there are two queues and two functions which may be dynamic or static functions. These functions operate independently and the total bandwidth which divided on the active sources will depend on the two applied functions.

A simple choice is to use a Constant Queue control Function (CQF), where the queue Factor is set to a value less than one. The (1-Factor) is used for queue draining. Another choice is to use a Dynamic Queue control Function (DQF) [40]. In case of DQF, the Factor's value equals one for the short queue length and drops sharply by increasing of the queue length. ERICA+ switch algorithm uses a hyperbolic or inverse hyperbolic function for calculating the value of the DQF factor [49].

GWFairERICA+ and ERICA+ Switch algorithms were described in [20,21,26,50-52] using target ABR capacity which is obtained by multiplying the total available ABR capacity by a fraction term. Fraction amount of the link capacity is used to drain the queue[26]. Fraction can be either a constant less than one or dynamic function of the switch queue length (Fq). The using of one queue for all traffic with dynamic function of the switch queue length (Fq), resulting in the queue length will be very important to define the feedback for each active source and the status of the network depends on that queue, when the queue is full beyond threshold2 value (represents the transient point from steady state to over load) the network is congested and if between threshold1 (represents the transient point from under load to steady state) and threshold2 values, the network is in steady state and if less than threshold1, the network is under load.

The GWFairERICA+ Switch algorithm can operate with the new proposal because of the using of that algorithm to weight function which used to distribute the excess bandwidth among sources depending on their weights. In this paper we have followed the same general weighted function as in [48] with the new proposal

$$G_i = U_i + W_i (A-U) / \sum_{1}^{N} W_j \text{ ………… where } j = 1 \text{ to } N$$

G_i = GW fair allocation for connection i.
U_i = MCR of connection i.
W_i= Preassigned weight associated with the connection i.

U = Sum of MCRs of active connections Bottlenecked at this link.
A = Excess bandwidth, to be shared by Connections bottlenecked on this link.
N = total bottleneck sources.

Pseudo code of the New Proposal Algorithm

At the end of the averaging interval for data:
For data sources
(
target ABR data capacity = data factor × total ABR data capacity .
data input rate=sum of all inputs of data queue .
data over load factor = data input rate ÷ target ABR data capacity .
) ***repeat for video sources in case of the end of the AI for video***.

For each source
calculate weight (cost+ mcr) for each source .
End .
For each source
Excess fair share = target capacity× source_ weight ÷ sum of weights for certain traffic type.
End.
For each queue
Queue fair share = target capacity× sum of weights for sources dealing with this queue ÷ sum of weights for all traffic type.
End.
When a BRM is received:
For each source
virtual channel share (Vcshare)=max(0,source_ rate - mcr) ÷ over load factor .
explicit rate (ER) = mcr + max(Excess fair_ share, Vcshare) .
ER in RM cells=min(ER in RM,ER, Target rate).
End

The **main different** between the original GWFairERICA+ algorithm and the new proposal algorithm is the calculating of the variables of each traffic type independently and divide the available output link bandwidth dynamically among the queues depending on the sum of all weights of traffic types. Dividing the output link bandwidth among queues will happened at the end of the Averaging Interval period. We assume that only one feedback is given in each averaging interval to the sources. This avoids unnecessary conflicting feedbacks to the sources.
May be its very difficult to all sources to reach a steady state region at the same time because of the independency among queues but each source will obtain its need from the available bandwidth, and that will realize our main goals to maximize link utilization, minimize queuing delays, achieve fair allocation, reduce transient response time and achieve stable and robust operation.

IV. SIMULATION CONFIGURATION AND PARAMETERS

In this section, the simulation configuration and parameters are discussed. We use the common original configuration shown in Figure 3, to test the performance of the new proposal switch algorithm. We assume that the sources are greedy, i.e., they have infinite cells to send at Allowed Cell Rates (ACRs). In the configuration the traffic is unidirectional, from source to Destination. If bi-directional traffic is used, similar results will be achieved, except that the convergence time will be longer since the RM cells in the backward direction will travel along with cells from destination to source. In this configuration cells are traveling from the sources to the destinations through the two switches (SW1 and SW2) and the bottleneck link. We assume that only one feedback is given in each averaging interval to the sources, that is to avoid unnecessary conflicting feedbacks to the sources. The common original configuration is used to confirm that the new proposal switch algorithm can achieve the general fairness for different set of weight functions.

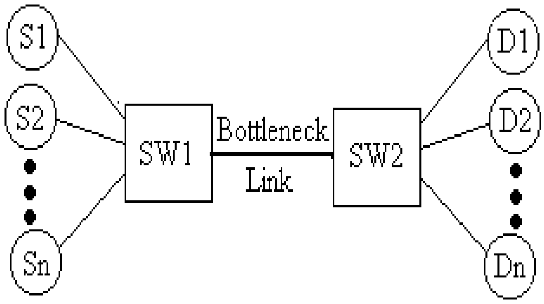


Figure 3 N Source – N Destinations Configuration

Definition of the Parameters within the Configuration

- *N* infinite sources sends to *N* destinations.
- The direction of the traffic is unidirectional.
- The Initial Cell Rate (*ICR*) values of all the sources are chosen randomly in the range between (*0*, *link rate*).
- All links are of length *1000 Km*, which correspond to the propagation delay of *5 ms*.
- All links have a bandwidth of *149.76Mbps*(*155.52Mbps* less the *S*ynchronous *O*ptical *NET*work S*ONET*) overhead).
- The sources start at random time in the range between (*0*, *RTT*), where *RTT* is the *R*ound *T*rip *T*ime. *RTT* = 30 ms for the mentioned above configuration.
- Hyperbolic function parameters for dynamic queues: *a = 1.15*, *b = 1.05*, where *a* and *b* are the parameters which control the degree of curvature of the hyperbolic function.
- *QDLF* (the *Q*ueue *D*rain *L*imit *F*actor) = *0.5*.
- *TCP M*aximum *S*egment *S*ize (*MSS*) of *512 bytes*.
- *Weight* = *Cost* + *MCR*.
- Using *M*otion *P*icture *E*xperts *G*roup (*MPEG*-2)[53] to generate video frames and using a Leaky Bucket shaper [54] to smooth out the traffic at the sources.

See the Simulator Flow chart at the end of the paper.

In the next section, we shall explore the simulation results of the new proposal algorithm. The performance studies of different rates, queue lengths and utilization are present. All the performance studies are done within the switch (*SW1*), our future research will look after the two switches (SW1 and SW2) within the configuration..

V. SIMULATION RESULTS

At the beginning the video and data queues at the switch grow depending on the Initial Cell Rates (ICRs). So the maximum queue depends on the Initial Cell Rates (ICRs) and Round Trip Time (RTT) and is independent of the queue control function used. Influence of ICRs appear only during first Round Trip Time. The feedback information reaches the sources and the sources adjust their rates accordingly.

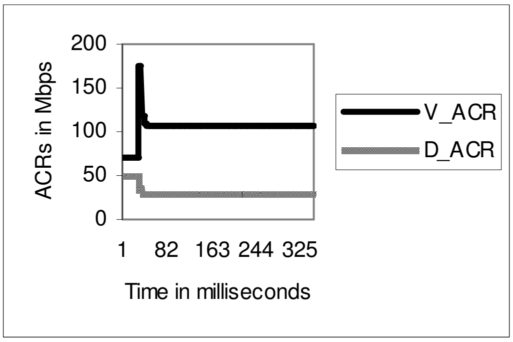
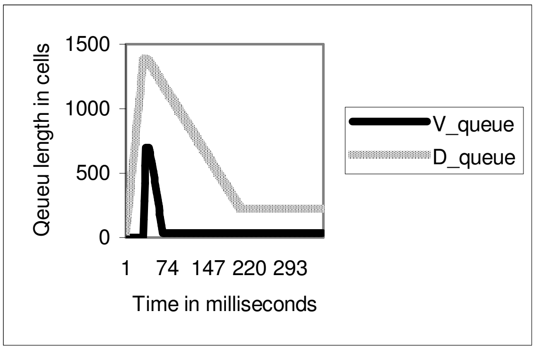


Figure 4: Video and Data ACRs Vs Time

Figure 4 shows the variance in rates for video and data traffics during 350 milliseconds where the initial cell rates are 70, and 50 Mbps for video and data sources respectively. In this case the sum of initial rates (70 + 50 = 120 < ABR capacity. Moreover the two sources achieve the General Weighted (GW) fairness rates. The weight function used in this case is Cost + MCR (25+30 for video traffic and 5+10 for data traffic). The left over capacity (149.76-30-10 = 109.76), is divided proportional to (55,15).

Hence the GW fair for each source is (30+55/70*109.76, 10+15/70*109.76) = (116.24,33.52) Mbps. All sources enter to a steady-state region during the first 100 milliseconds from the simulation period.



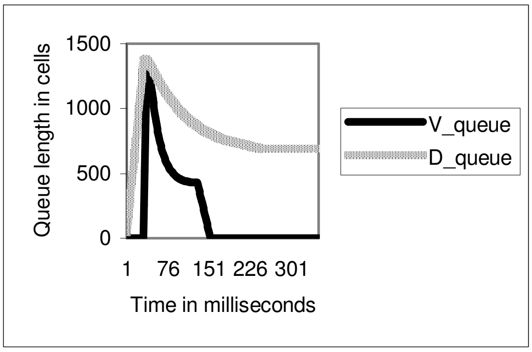
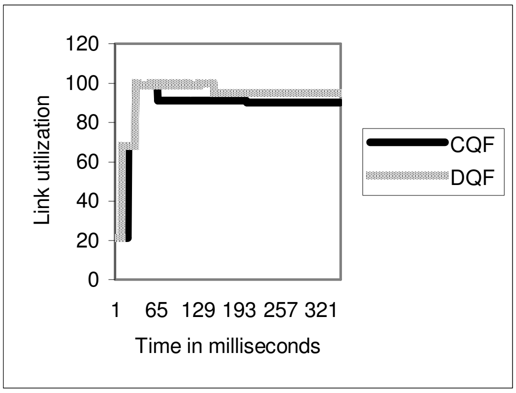


Figure 5 Video and data queues Vs Time using a CQF **Figure 6** Video and Data Queues Vs Time Using DQF

Figures 5 and 6 show the video and data queues lengths during 350 milliseconds respectively. Results here in two cases, when using a Dynamic Queue Control Function (DQF) and a Constant Queue Control Function (CQF). The GW fair for video and data sources are 116.24,and 33.52 Mbps respectively in case of using a DQF while when using a CQF are 104.47, and 30.31 Mbps respectively. All values and parameters like costs, weights, and ICRs used in this case is same as in figure 4. Comparing results when using a DQF with results when using a CQF, better values obtained in case of a CQF while the link utilization when using a DQF is better than a CQF (see Figure 7).



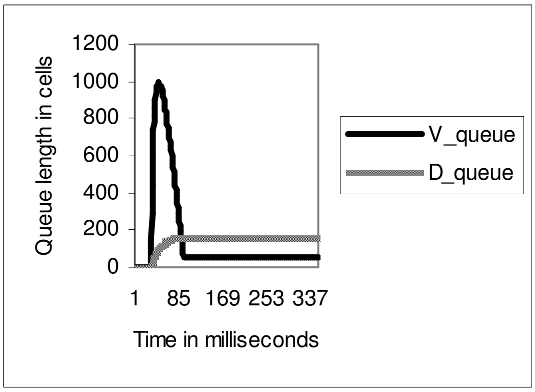


Figure 7: Link Utilization Vs Time **Figure 8:** Video and Data Queues Vs Time using a CQF

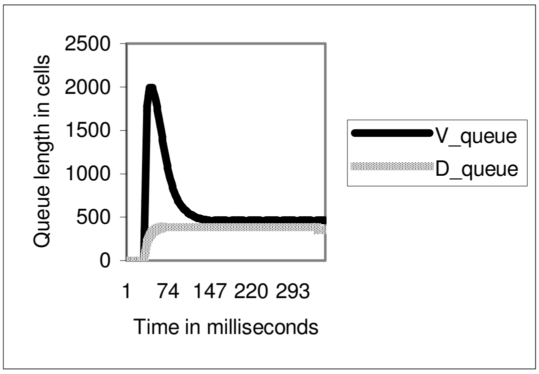


Figure 9: Video and Data Queues Vs Time using a DQF

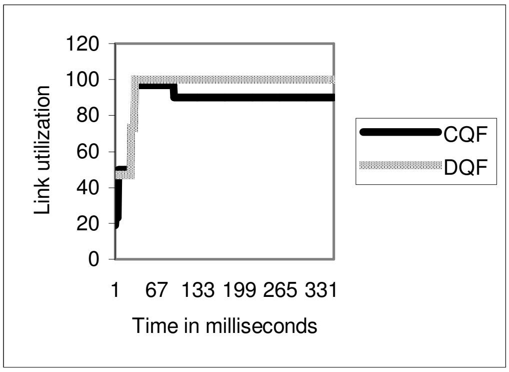


Figure 10: Link Utilization Vs Time

Figures 8, 9, and 10 show queues lengths and utilization when using a CQF and DQF if there are four active sources, two video sources and two data sources during 350 milliseconds. Where the initial cell rates are (35,40) Mbps for video and (15,20) Mbps data sources. The weight function used in this case is Cost + MCR (25+30, 25+35 for video traffic and 10+10, 10+15 for data traffic). When number of active video and data sources increased as in this case the performance is acceptable as seen in figures 8, 9, and 10. Also confirm that our proposed algorithm and simulator work efficiently**.**

VI. DISCUSSION

This section presents a comparison discussion between our proposal and previous algorithms. Most of the prior studies were used the ERICA+ switch algorithm with one queue carrying multimedia traffic over ATM-ABR service [49, 53, 54], but in our proposal we used separate queues. The main different between the prior studies results and our study results can be summaries in the following points:

1- In almost all studies each source obtains its fair share rate.
2- In our study the separate queues protect each traffic type from overlapping, so the delay reduces. However, the using of one queue for more than one traffic type resulting in the overlapping may be occurs, so the delay will be longer.
3- In case of three sources sending to ABR switch. Our results when using Constant Queue Function (CQF) are identical to that results when using GWFairERICA+ switch algorithm with one queue of multimedia traffic studied in [49]. But it is to mention here that, our results when using Dynamic Queue Function (DQF) are more steady than the results when using one queue of multimedia traffic studied in [49].
4- The weakness here is the cost in which it will increase by using several queues in ABR switch hardware.

VII. CONCLUSION

The paper has discussed a new proposal algorithm that can be used for enhancing quality of service of multimedia application when using ABR service in ATM network. Using a non_zero MCR was very useful for carrying multimedia over ATM network. The new proposal algorithm depends upon the use of an independent queue for each traffic type to protect the traffic from overlapping that makes sure for reducing the delay particularly for the traffics sensitive to the delay such as video and audio traffics. This is will be very good to the video cells which they are very sensitive to the delay resulting in continuity increases of the throughput of the switch. Also, the new proposal algorithm divides the output link bandwidth dynamically among different queues. This method depends on summing of all the weights of the sources which dealing with a specific queue and divide it on the total weight of all the active sources and the result will be the ratio of the bandwidth which the queue will use of it to transmit the cells. Dividing the output bandwidth among the queues will happen at the end of the averaging interval period which different for each queue type. The simulation results indicate that the using of general weighted fair ERICA+ switch algorithm (GWFairERICA+) with separate queues will maximize link utilization, minimize queuing delays, achieve stable and robust operation, achieve fair allocation, and reduce transient response. Obviously that, the ATM network using ABR service can effectively handle multimedia traffic in real-world network environment.

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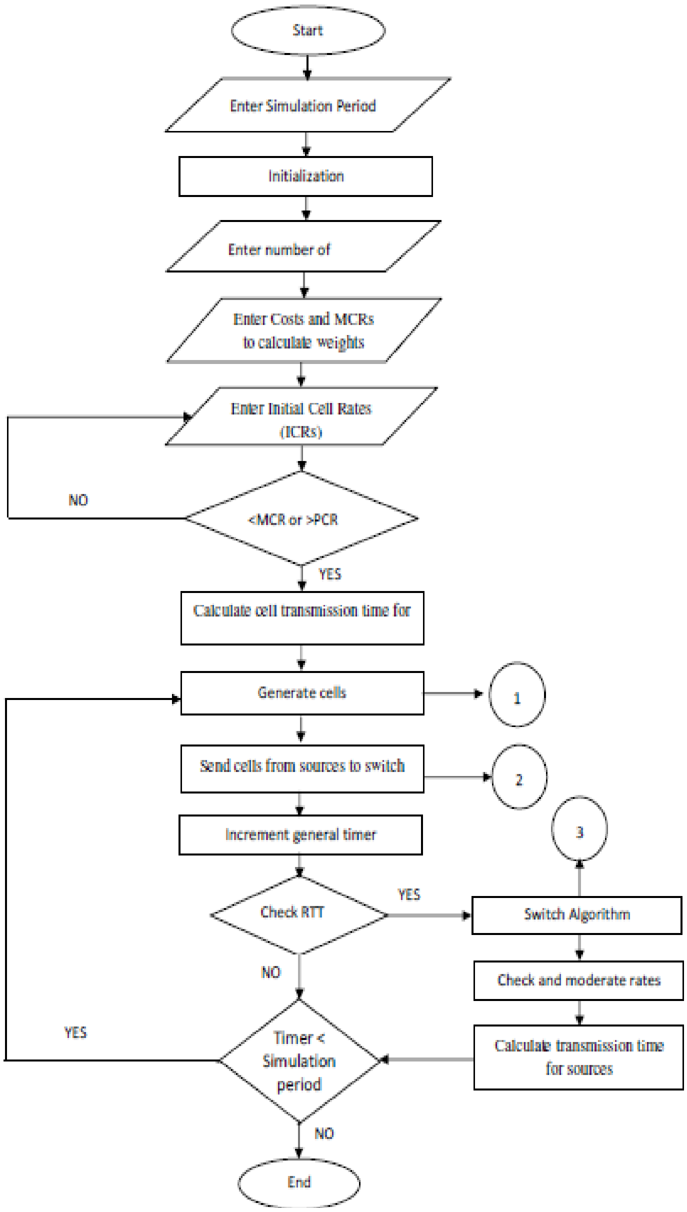
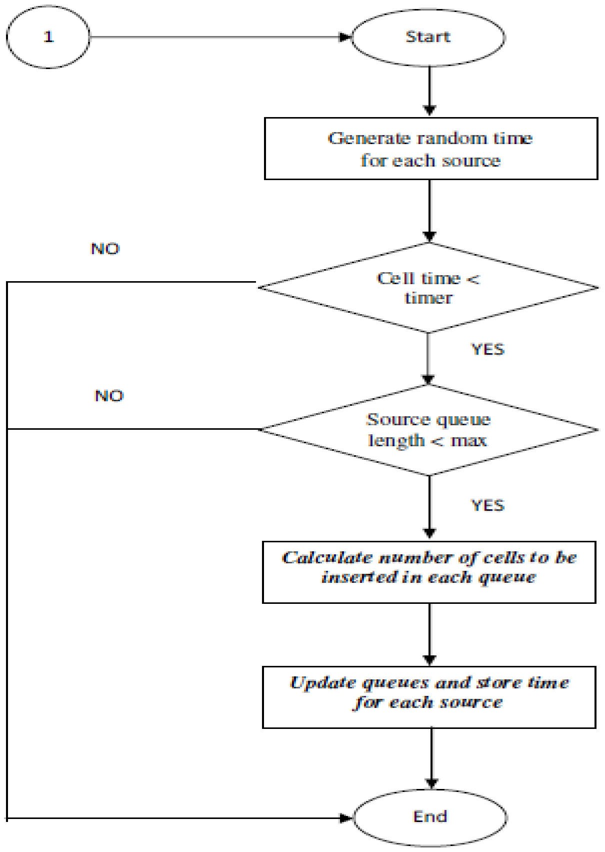
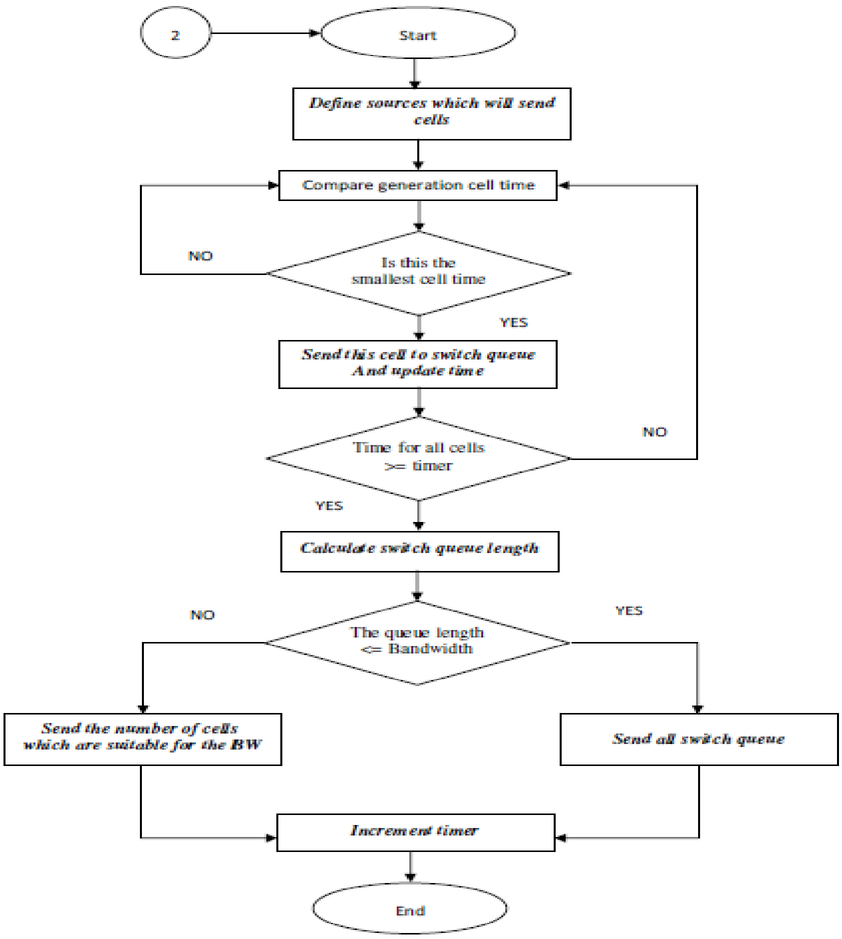
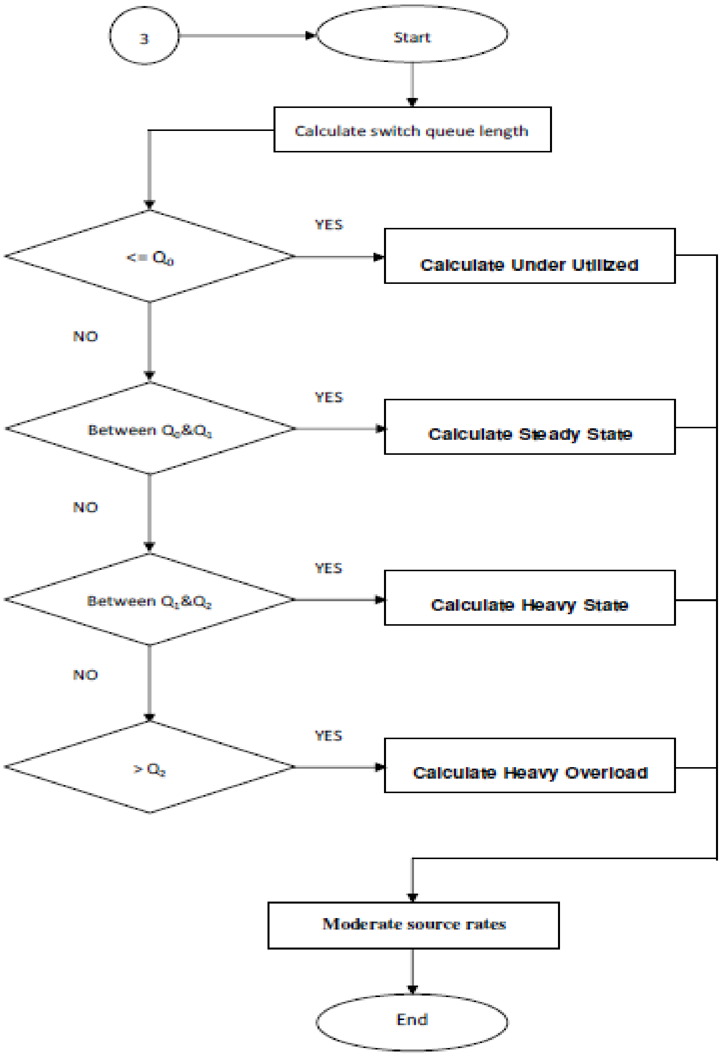
Flow charts




1
Start
Generate random time for each source
NO
Cell time < timer
YES
NO
Source queue length < max
YES
Calculate number of cells to be inserted in each queue
Update queues and store time for each source
End


2
Start
Define sources which will send cells
Compare generation cell time
NO
Is this the smallest cell time
YES
Send this cell to switch queue And update time
NO
Time for all cells >= timer
YES
Calculate switch queue length
NO
YES
The queue length <= Bandwidth
Send the number of cells which are suitable for the BW
Send all switch queue
Increment timer
End



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