DYNAMIC RESOURCE ALLOCATION SCHEME FOR AN ATM BASED ENTERPRISE –WIDE NETWORK

Ajibo Augustine, Igboeli Chukwudi, Ani Cosmas

Abstract— Asynchronous Transfer Mode (ATM) technology is the transfer mode for implementing a Broadband-Integrated Services Digital Network (B-ISDN). ATM as a technology is recommended as the transport vehicle for the B-ISDN, as it offers a great flexibility in the allocation of transmission bandwidth in order to accommodate diverse demands of multimedia connections. Dynamic Bandwidth Allocation (DBA) is a fundamental factor in network performance for an ATM-based bursty traffic. However, the fundamental problem in ATM network is defining the way available network resources are optimally allocated especially during period when the network experiences unpredictable bursty traffic. This work therefore, aims at developing an approach for determining the the optimum loading level and the associated QoS parameter values. A typical network was adopted, modeled and simulated in MATLAB environment using Simulink tool and results obtained were analyzed using Microsoft Excel.

Index Terms — B-ISDN, ATM, DBA, CLP, PRI, SLA, UBR, SNMP.

◆

1 INTRODUCTION

In digital communications, bandwidth as a concept has to do with the amount of data a link or network path can deliver per unit of time. For many multimedia applications, the available bandwidth has direct impact on the applications' performance. The terms bandwidth and throughput often characterize the amount of data that the network can transfer per unit of time [1]. Bandwidth plays a significant influence in several network communications. Several applications can benefit from knowing the bandwidth characteristics of their network paths. Network providers present lists of bandwidth bouquet from which interested users select and are billed. The customers' subscription to the service provider leads to traffic contract which will finally result in signing of Service Level Agreement (SLA). The rate of bandwidth utilization by various customers makes the providers to plan for capacity upgrade or expansion for the network to avoid congestion, traffic drop or total collapse of the network. It is a standard that bandwidth utilization of above 70% is an invitation to heavy congestion in which case various methods are encourage to avoid such state of congestion. Although network providers can effectively monitor bandwidth utilization through traffic policing and shaping, it is however not the same from the customers point of view. To achieve this network administrator with administrative privileges and access to the network devices such as routers or switches may connect to a link of interest in order to measure the bandwidth using the Simple Network Management Protocol (SNMP). However, such access is typically available only to administrators and not to end users. At times due to congestion which may lead to network failure, end users can estimate the bandwidth of their links or paths from end-to-end measurements to ascertain the quality of service delivery by the network provider, without any information from network routers due to lack of access. Even network administrators sometimes need to determine the bandwidth from hosts under their control to hosts outside their infrastructures, which make them to equally rely on end-to-end measurements. There are some bandwidth estimation tools which try to identify the bottlenecks that adversely affect the performance of the network communication. Some of the publicly available bandwidth measurement tools include the following: pathchar, pchar, nettimer, pathrate, and pathload, AppareNet and lots of other tools. Due to demand by various users, communication network providers, try to allocate bandwidth in order to optimize the network, enhance network performance and guarantee quality of service delivery to various users whose network demand defer [1].

The above scenario makes bandwidth allocation a very important issue in ATM networks, especially when there are random fluctuating demands for service and variations in the service rates. In order to make ATM reliable, ATM is designed to support not only a wide range of traffic classes with diverse flow characteristics such as Unspecified bit Rate (UBR) but also to guarantee these traffic classes Quality of Service (QoS) as well. The QoS may be measured in terms of cell loss probability and maximum cell delay [2]. The performance of a network is dependent on the behavior of the QoS parameters. However, the challenge is finding the best way to dynamically allocate network resources economically while maintaining low loss and delay [3]. This challenge has necessitated the need to investigate of the performance of Enterprise-wide network in order to ascertain the best way network resource (bandwidth and buffer capacity) can be dynamically handled while ensuring that the QoS of the different class of traffic is maintained.

2 NETWORK ARCHITECTURE

The adopted architecture for this research is that of a typical ATM based Enterprise-wide network connected to another Enterprise-wide network geographically separated linked via leases trunk line from public network which serves as its backbone network as shown in fig.1.

In high speed packet-switched network architectures such as ATM, several classes of traffic streams with widely varying traffic characteristics are statistically multiplexed and share common switching and transmission resources [4].A typical private ATM network is shown in Figure 3.2. As can be seen in the figure, at the interface to the network ATM multiplexers are used, firstly, to provide alternative user interfaces, secondly, to provide appropriate adaptation functions and, thirdly, cell multiplexing and demultiplexing to and from the duplex access circuit linking it to the site switch. The set of switches are interconnected by fixed-capacity leased trunk which provides backbone cell-switching for the network. Routing within the ATM backbone network is performed by using virtual path connections (VPCs) between sites. To transport various types of traffic between sites, virtual channel connections (VCCs) are used between source and destination adaptation interfaces at the end points of the VPCs. This means that a group of calls (VCCs) sharing a common path (route) through the backbone are multiplexed into a single VPC and all the related cells are switched using the same virtual path identifier (VPI) field at the head of each cell. Network management and traffic control actions can then be applied to VPCs instead of a large number of individual VCCs thus significantly reducing the control overheads. Also, a central management node can be used to make network-wide optimum allocations of network resources for each VPC [5].

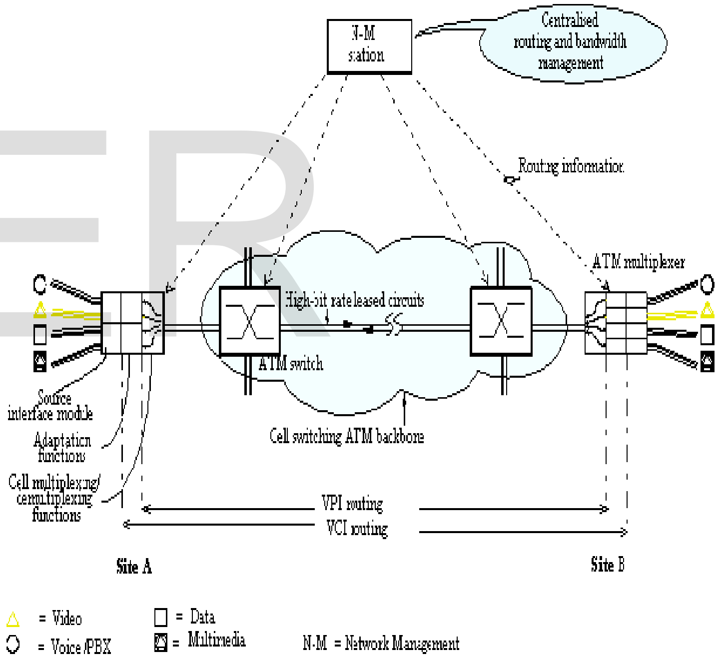

Figure1: Enterprise-wide network Architecture [9]

3. Simulation Model

In high speed packet-switched network architectures such as ATM, several classes of traffic streams with widely varying traffic characteristics are statistically multiplexed and share common switching and transmission resources. The proposed model for this paper is shown in fig 2. The model is divided into three modules: the traffic source module, the transmission facility module and the cell loss computing module.

3.1. Traffic source module: This module is comprised of voice, data and video traffic sub-modules. They were all modeled based on Markov modulated Poisson process (MMPP). MMPP traffic source was adopted as it account for the bursty nature of the various traffic type under consideration. Alternative to MMPP source is Bernoulli model. However, it cannot be used to characterize the bursty phenomenon of the services supported by enterprise-wide network.

3.2. Transmission Facility Module: This module comprise of a first-in-first-out (FIFO) transmission buffer queue with fixed capacity (ATM FIFO), an associated transmission link single server(ATM SERVER) as shown. The single server was used because ATM multiplexer was used for providing statistical multiplexing service for the BISDN service supported by the network and carried via a leased trunk.

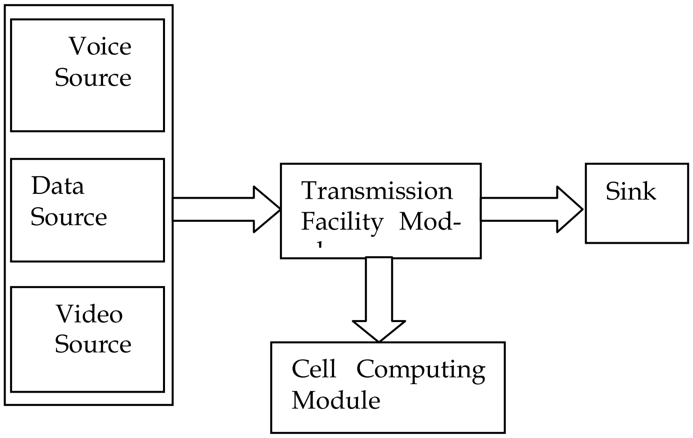

Figure 2: Simulation model for an Enterprise-wide network

3.3. Cell computing module: The cell loss rate predicting module carries out computation based on fluid-flow approximation approach. It assumes a uniform arrival and service process – continuous information flow instead of the discrete flow of cells. Fluid flow approximation compares favorably with other existing and popularly accepted methods [6]. This module performs the computation of cell loss rate for the different traffic (services) supported by the network. The module reads out minimum, mean and maximum cell arrival rate during the course of simulation every one second and reads in these values into the cell computing module.

Here, the cell loss is computed every second during the course of running the simulation. The average of the cell loss is at the end of the simulation obtained from this module.

The traffic source model generates cells at the rate of π cells per unit time during each burst period. The parameter π is expressed as:

$$\pi = \frac{1}{\delta}; \qquad (1)\ [5]$$

Where δ is the cell generation-period

For the period (Ts+τ) unit time, the mean rate of cell generation,λ, is expressed as:

$$\lambda = \frac{\text{average number of cells in a burst}}{Ts + \tau} \qquad (2)[5]$$

Hence a source model that generates cells at peak rate π and mean rate λ can be represented by the expression:

$$Ts = \tau*(1/\rho - 1) \qquad (3)[5]$$

Where ρ is the ratio of mean to peak rate and is known as the burstiness. This can also be expressed as a fraction of the on time by the expression:

$$\rho = \frac{\tau}{Ts + \tau} \qquad (4)[5]$$

Cell loss rate is calculated for buffer capacities from zero to the maximum buffer occupancy,κ, using the expression below:

$$\text{Cell loss rate} = \frac{\text{Num of cells rejected}}{\text{Num of cells through queue} + \text{Num of cells rejected}} \qquad (5)[5]$$

In the case of a single source (N=1) the cell loss probability, Pr, is given by:

$$\Pr = \psi * \exp.-(\varphi) \qquad (6)[5]$$

Normally, the factor ψ is approximated to unity and

$$\varphi = \frac{\pi(\mu - \lambda)\kappa}{\tau\mu(\pi - \lambda)(\pi - \mu)}$$

(7)[5]

For multiple sources, N, each independently emitting information, Pr(N) is evaluated using equation (8)

$$\Pr(N) = \Phi * \Theta * \exp.\left(Z_0 * \varepsilon\right) \qquad (8)[5]$$

Where:

$$\Theta = \prod_{i=1}^{N-[\mu/\pi]-1} \frac{Z_i}{Z_i - Z_0}$$

$$\Phi = \left[\frac{N\lambda}{\mu}\right]^N$$

$$\varepsilon = \frac{k}{\tau\pi}$$

Zo and Zi are eigenvalues; Zo is the largest and can be expressed explicitly as [14]:

$$Z_0 = -\frac{N(\mu - N\lambda)\pi^2}{\mu(\pi - \lambda)(N\pi - \mu)} \qquad (9)[5]$$

$Zi_{(i \neq 0)}$ can be numerically determined by solving the set of roots of a quadratic expression with constant values $A(i)$, $B(i)$ and $C(i)$:

$$A(i) \cong \left(\frac{N}{2} - i\right)^2 - \left(\frac{N\pi - 2\mu}{2\pi}\right)^2 \qquad (10)[5]$$

$$B(i) \cong 2\left(\frac{\pi - 2\lambda}{\pi - \lambda}\right)\left(\frac{N}{2} - i\right)^2 - N\left(\frac{\pi}{\pi - \lambda}\right)\left(\frac{N\pi - 2\mu}{2\pi}\right)^2 \qquad (11)[5]$$

$$C(i) \cong -\left(\frac{\pi}{\pi - \lambda}\right)^2\left\{\left(\frac{N}{2}\right)^2 - \left(\frac{N}{2} - i\right)^2\right\} \qquad (12)[5]$$

Expressions 10-12 are substituted into the expression:

$$A(i)z^2 + B(i)z + C(i) = 0, \quad i = 1,2,..,N \qquad (13)[5]$$

Expressions for $Z_{(1,2)}(i)$ are then obtained and the stable set used as negative eigenvalues.

4. Simulation Results and Analysis

In order to develop an approach for bandwidth estimation for an ATM based enterprise-wide network there is great need to take into consideration the QoS parameters relating to specific traffic load and transmission rates. These parameters were obtained by evaluating the performance of the queuing process at a node for a given buffer size at different transmission capacity.

The simulation was carried out with the range of values in mind for trunk capacity: 15Mbps, 20Mbps, 30Mbps and 40Mbps while for that of buffer capacity was varied in the range of: 5, 10, 15, 20 and 25. For the purpose of result generation, the simulation was run for 1000seconds. Readings were not taken for the first 20 seconds as the system gained stability at this point.

The above QoS parameters were taken into consideration and relationship established between them in the following order:

4.1 Cell loss rate and Delay as a function Traffic Intensity for varying Buffer Capacity for Homogeneous Traffic Source

In this case, the network was loaded with homogeneous type of traffic under consideration (voice) and the behavior of the network was observed in order to understudy its response in terms of the probability of the traffic been dropped and the delay variation experienced by the traffic when the buffer capacity of the ATM access node is varied and when the capacity of the leased trunk is varied. The set of results obtained are shown in Fig. 3 and 4, respectively. Figure 3 illustrates the obtained relationship between probability of cell loss and average traffic intensity for varying buffer capacity at the ATM access node, while fig 4 shows the obtained relationship between cell delay and traffic intensity for varying trunk capacity for the homogeneous traffic source.

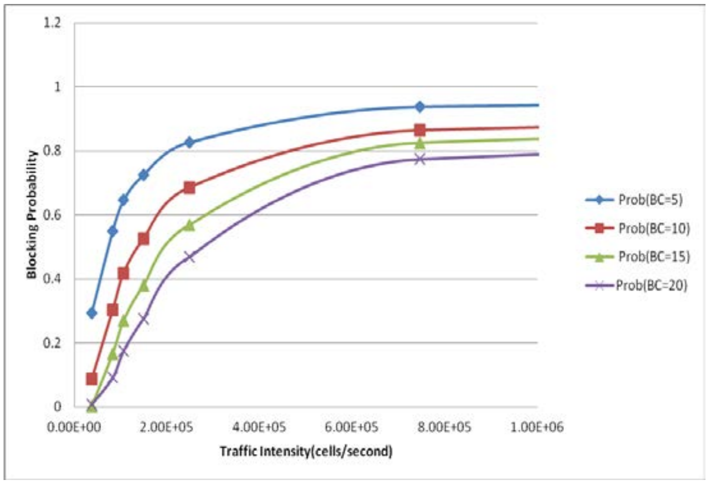

Figure 3:Probability of cell loss against Traffic intensity for Varying Buffer Size(BC) at different trunk capacity forhomogenious traffic source (voice).

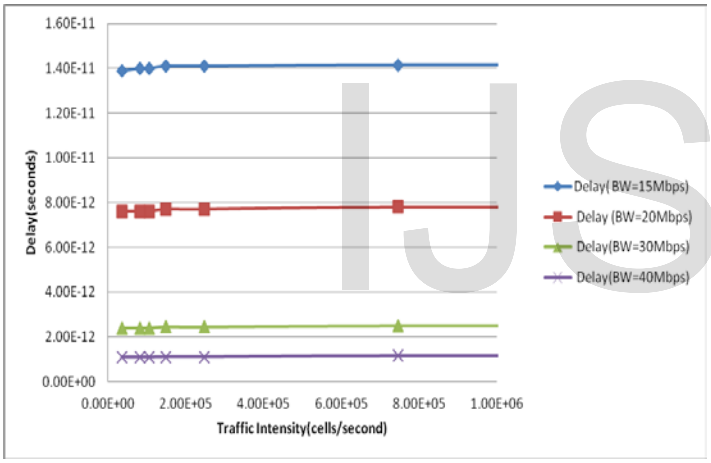

Figure 4: Cell Delay against Traffic intensity for Varying for varying trunk capacity for Homogeneous traffic source (i.e. either Data or voice or Video).

The obtained curves as shown in fig. 3, shows a rising mean/average cell loss rate with respect to traffic intensity for different buffer capacity. It is seen from the pattern of curves obtained that as the traffic intensity increase, the probability of traffic drop in the network (cell loss rate) also increases. Also it is seem from the set of curves obtained that as the capacity of the buffer at the ATM access node increases, the probability of traffic being dropped decreases. From the curve, it is seen that at traffic intensity between 5E5 and 1E6 that the probability of traffic been dropped for the different buffer capacity of 5, 10, 15 and 20 is given as 0.86, 0.72, 0.62 and 0.53 respectively. These set of results shows an increased probability of traffic being dropped as the capacity of the buffer becomes smaller. The observed behavior is attributable to the fact that as the buffer capacity of the ATM access node is increased, the network is able to accommodate more of the busty homogeneous traffic being transmitted in the network.

Similarly, fig. 4 shows a set of curve obtained from the investigation of cell delay against traffic intensity for different trunk capacity ranging from 15Mbps, 20Mbps, 30Mbps, and 40Mbps respectively. From the curves obtained, it is seen that the average delay experienced by the homogeneous traffic in the network lies within a constant value when the network is loaded with traffic of different intensity from the homogeneous traffic source at varying trunk capacity. From the family of curves obtained, it is seen that at a trunk capacity of 15Mbps, the average delay experienced by traffic in the network is 1.4 E-11 while for a trunk capacity of 20Mbps, the mean delay experienced by the traffic in the network is 7.6E-12. Also it is seen from the set of curves obtained that at a trunk capacity of 30Mbps, the average delay experienced by the traffic in the network is 2.49E-12 and finally, when the trunk capacity of the network was increased to 40Mbps, it is observed that the average delay experienced by traffic in the network is 1.08E-12.These set of results shows that the delay experienced by traffic in the network decreases as the capacity of the leased trunk acquired by the network is increased. This observed behavior is attributable to the fact that as the bandwidth of the trunk increases, traffic experiences less delay as there is little or no contention for available network resource during transmission.

4.2. Cell loss rate and Delay as a function Traffic Intensity for varying Buffer Capacity for Heterogeneous Source (combination of Data and Voice)

In this case, the network was loaded separately with the different combination of traffic under consideration (i.e. voice and data) and the behavior of the network was observed in order to understudy its response in terms of the probability of traffic been dropped and the delay variation experienced by these traffic when the buffer capacity of the ATM access node is varied and when the capacity of the leased trunk is varied. The set of results obtained as shown in fig 5 illustrate the relationship between probability of traffic drop in the network (cell loss rate) and average traffic intensity at varying buffer capacity for the heterogeneous source. Similarly, fig. 6 shows the set of curves obtained when the network was observed for traffic delay at varying traffic intensity at different trunk capacity under consideration.

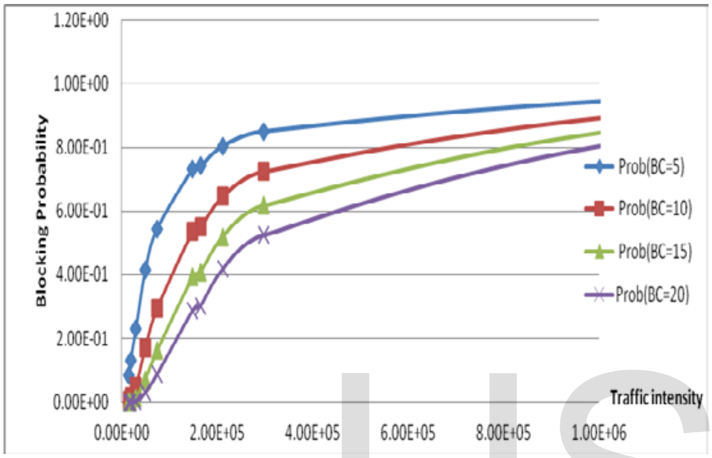

Figure 5: Blocking Probaility against Traffic intensity for Varying Buffer Capacity(BC) for varying trunk Bandwidth for Heterogenious Traffic Source (voice & Data)

The obtained curve as shown in fig. 5 shows a rising mean/average cell loss rate with respect to traffic intensity for different buffer capacity. It is seen from the pattern of curves obtained that as the traffic intensity increase, the cell loss rate also increases. Also it is seem from the set of curves obtained that as the capacity of the buffer at the ATM access node increases, the probability of traffic being dropped decreases. From the curve, it is seen that at a traffic intensity of 3.0E05 that the probability of traffic being dropped for the different buffer capacity of 5, 10, 15 and 20 is given as 0.84, 0.73, 0.60 and 0.53 respectively. These set of results shows an increased probability of traffic being dropped as the capacity of the buffer becomes smaller. The observed fact is attributable to the fact that as the buffer capacity of the ATM access node is increased, the network is able to accommodate more of the traffic being transmitted in the network.

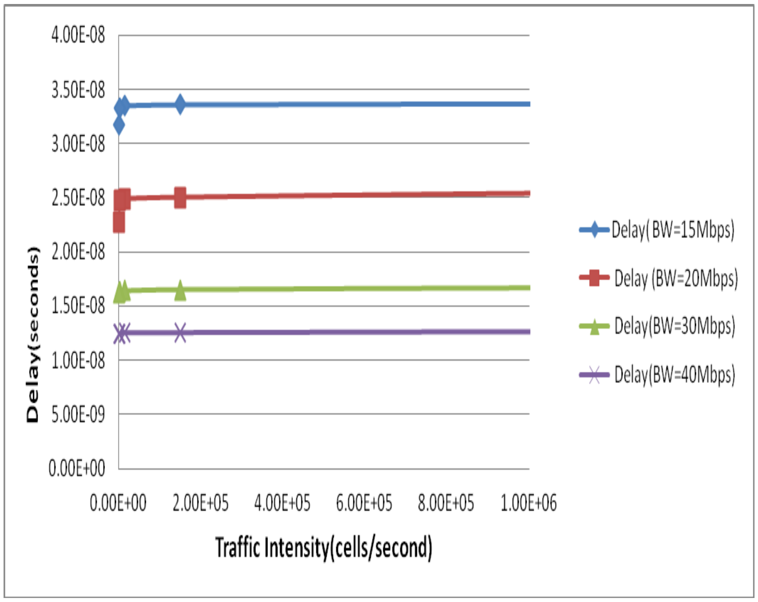

Figure 6: Delay against Traffic intensity for Varying Buffer Capacity(BC) for varying trunk Bandwidth for Heterogenious Traffic Source (voice & Data).

Similarly, fig 6 shows the set of curves obtained from the investigation of cell delay against traffic intensity for different trunk capacity ranging from 15Mbps, 20Mbps, 30Mbps, and 40Mbps respectively. From the family of curves obtained, it is seen that at a trunk capacity of 15Mbps, the average delay experienced by traffic in the network is 3.4E-08 while for a trunk capacity of 20Mbps, the mean delay experienced by the heterogeneous traffic in the network is 2.5E-08 Also it is seen from the set of curves obtained that at a trunk capacity of 30Mbps, the average delay experienced by the traffic in the network is 1.6E-08 and finally, when the trunk capacity of the network was increased to 40Mbps, it is observed that the average delay experienced by traffic in the network is 1.25E-08.These set of results shows that the delay experienced by traffic in the network decreases as the capacity of the leased trunk acquired by the network is increased. This observed behavior is attributable to the fact that as the bandwidth of the trunk increases, traffic experiences less delay as there is little or no contention for available network resource.

4.3 Cell loss rate and Delay as a function Traffic Intensity for varying Buffer Capacity for Heterogeneous Source (Data, Voice and Video)

In this case, the network was loaded separately with the different combination of traffic under consideration (i.e. voice, data and video) and the behavior of the network was observed in order to ascertain the networks response in terms of the probability of traffic been dropped and the delay variation experienced by these traffic when the buffer capacity of the ATM access node is varied and when the capacity of the leased trunk is varied. The set of results obtained as shown in fig 7 illustrate the relationship between probability of traffic drop in the network (cell loss rate) and average traffic intensity at varying buffer capacity for the heterogeneous source. Similarly, fig.8 shows the set of curves obtained when the network was observed for traffic delay at varying traffic intensity at different trunk capacity under consideration.

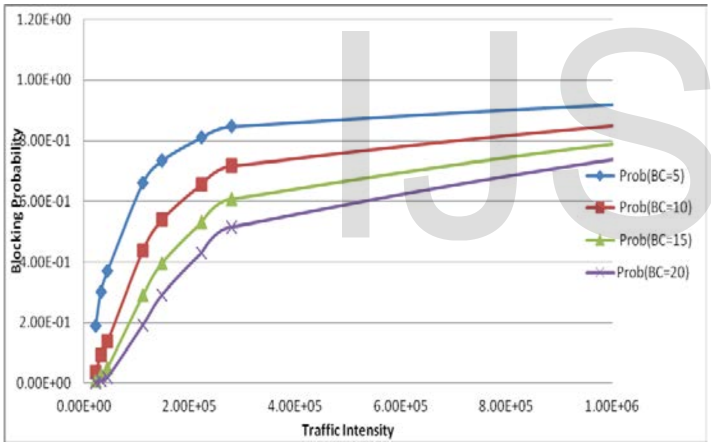

Figure 7: Blocking Probaility against Traffic intensity for Varying Buffer Capacity(BC) for varying trunk Bandwidth for Heterogenious Traffic Source (Voice, Data & Video)

The obtained curve as shown in fig. 7 shows a rising mean/average cell loss rate with respect to traffic intensity for different buffer capacity. It is seen from the pattern of curves obtained that as the traffic intensity increase, the cell loss rate also increases. Also it is seen from the set of curves obtained that as the capacity of the buffer at the ATM access node increases, the probability of traffic being dropped decreases. From the curve, it is seen that at a traffic intensity between 2.0E6 and 2.5E6 that the probability of traffic being dropped for the different buffer capacity of 5, 10, 15 and 20 is given as 0.84, 0.73, 0.61 and 0.53 respectively. This set of result shows an increased probability of traffic being dropped as the capacity of the buffer becomes smaller. The observed fact is attributable to the fact that as the buffer capacity of the ATM access node is increased, the network is able to accommodate more of the busty traffic being transmitted in the network.

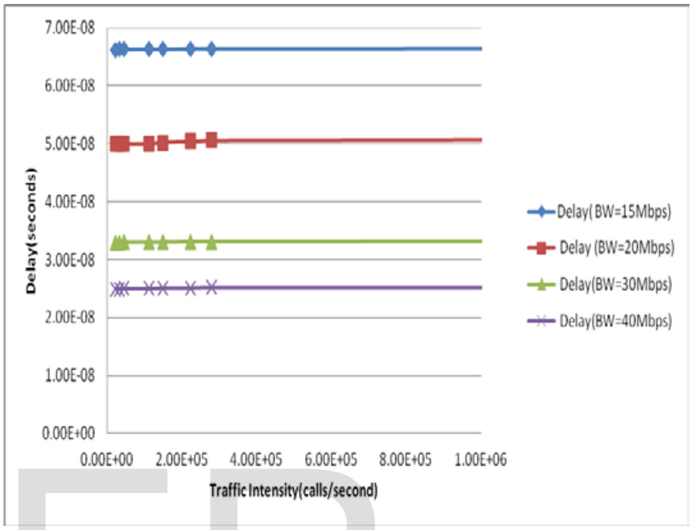

Figure 8: Delay against Traffic intensity for Varying Buffer Capacity(BC) for varying trunk Bandwidth for Heterogenious Traffic Source (voice, Data & Video).

Similarly, fig. 8 shows a set of curve obtained from the investigation of cell delay against traffic intensity for different trunk capacity ranging from 15Mbps, 20Mbps, 30Mbps, and 40Mbps respectively. From the family of curves obtained, it is seen that at a trunk capacity of 15Mbps, the average delay experienced by traffic in the network is 6.7E-08 while for a trunk capacity of 20Mbps; the mean delay experienced by the heterogeneous traffic in the network is 5.0E-08. Also it is seen from the set of curves obtained that at a trunk capacity of 30Mbps; the average delay experienced by the traffic in the network is 3.2E-08 and finally, when the trunk capacity of the network was increased to 40Mbps, it is observed that the average delay experienced by traffic in the network is 2.5E-08. These set of results shows that the delay experienced by traffic in the network decreases as the capacity of the leased trunk acquired by the network is increased. This observed behavior is attributable to the fact that as the bandwidth of the trunk increases, traffic experiences less delay as there is little or no contention for available network resource.

4.4 Cell Loss Rate as a function of Buffer Capacity at varying Traffic Intensity for the different Traffic Source.

In this case, a comparison is done to ascertain the behavior of the network in terms of cell loss rate and buffer capacity when the network is loaded separately with the different combination of traffic sources under consideration (i.e. homogeneous & heterogeneous sources) for a given traffic intensity. The comparison was done by loading the network with the different traffic types at given traffic intensity and observing its effect on the probability of traffic drop in the network (cell loss rate or blocking probability) as the capacity of the buffer at the ATM access node is varied in the range of 5, 10, 15 and 20. The set of curves obtained at this different traffic intensities are shown in figures 3, 4 and 5respectively for the different traffic sources under consideration.

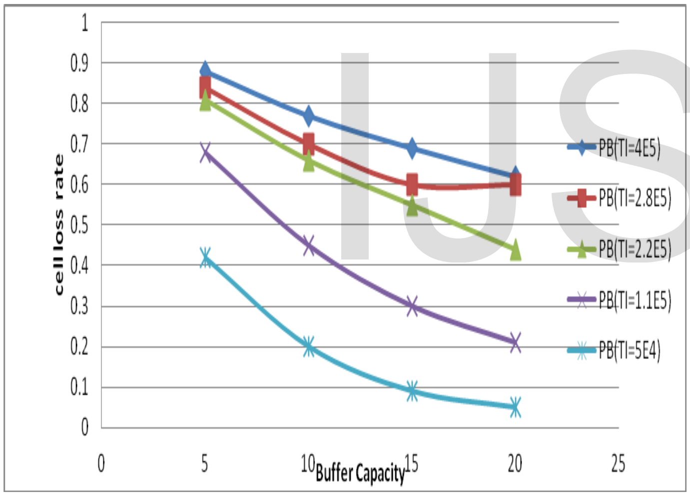

Figure 9: Blocking Probability against Buffer Capacity for homogeneous source at varying traffic intensity.

The family of curves shown in fig. 9 represents the observed behavior of the network in terms of cell loss rate and buffer capacity when the network was loaded with traffic from the homogeneous source at varying intensity in the range of 5.00E04, 1.10E05, 2.20E05, 2.80E05 and 4.00E5cells/second respectively.

The set of curves obtained as shown in figure 9, shows that there is an inverse relationship between cell loss rate and buffer capacity for a given traffic intensity i.e. as the buffer capacity becomes smaller the network blocking probability of cells increases. This is attributable to the fact that as the buffer capacity at the ATM access node reduces, it becomes unable to accommodate more of the busty traffic generated by the homogeneous source at a given traffic intensity, and as such drops some of this traffic in the network.

The set of curves obtained, it can be easily decided what buffer capacity will support a particular traffic intensity at a given QoS value (i.e. cell loss rate values). If we consider a buffer capacity of 10, one can easily determine from the set of plots the individual QoS value for each traffic intensity under consideration. It is seen from the plots that at a traffic intensity of 5.00E04, and at an access node buffer capacity of 10, the QoS value the network will provide at this point is 0.20. While at a traffic intensity of 1.10E05, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.45. Similarly, at a traffic intensity of 2.20E05, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.65. Furthermore, at a traffic intensity of 2.80E05, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.70. Finally, at a traffic intensity of 4.0E5, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.74.

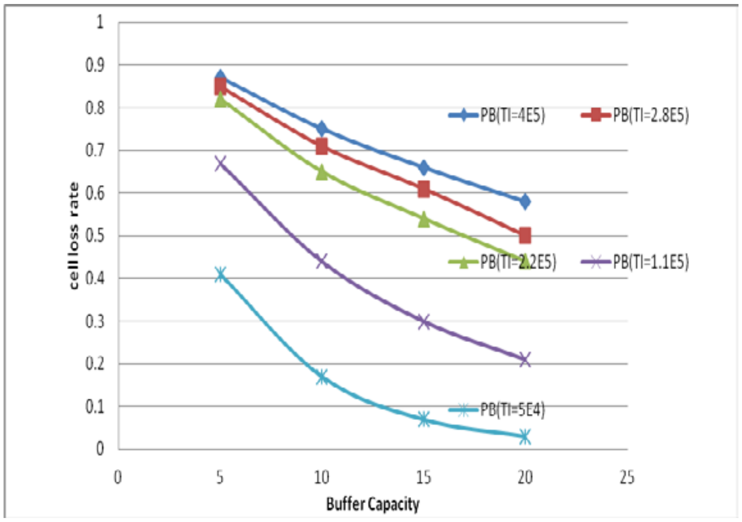

Figure 10: Blocking Probability against Buffer Capacity for heterogeneous

source (Voice & Data) at varying traffic intensity.

The family of curves as shown in fig.10 represents the observed behavior of the network in terms of cell loss rate and buffer capacity when the network was loaded with traffic from the heterogeneous source (i.e. data and voice) at varying intensity in the range of: 5.0E04, 1.1E05, 2.2E05, 2.8E05 and 4.0E5cells/second respectively.

The set of curves obtained as shown in fig.10, it is seen that there is an inverse relationship between cell loss rate and buffer capacity for a given traffic intensity i.e. as the buffer capacity becomes smaller the probability of traffic drop in the network (blocking probability/cell loss rate) increase. This observed behavior is attributable to the fact that as the buffer capacity at the ATM access node becomes small, it becomes unable to accommodate more of the busty traffic generated by the heterogeneous source (i.e. data and voice source) at specific traffic intensity, and as such drops some of these traffic in the network.

From the set of curves obtained, one can be easily decided what buffer capacity will support a particular traffic intensity at a given QoS value (i.e. cell loss rate) in the network. For example if we consider a buffer capacity of 10, one can easily say from the set of plots the individual QoS value for each traffic intensity under consideration. It is seen from the plots that at a traffic intensity of 5.00E04, and at an access node buffer capacity of 10, the QoS value the network will provide at this point is 0.26. While at a traffic intensity of 1.10E05, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.44. Similarly, at a traffic intensity of 2.20E05, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.65.

Furthermore, at a traffic intensity of 2.80E05, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.70. Finally, at a traffic intensity of 4.00E5, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.80.

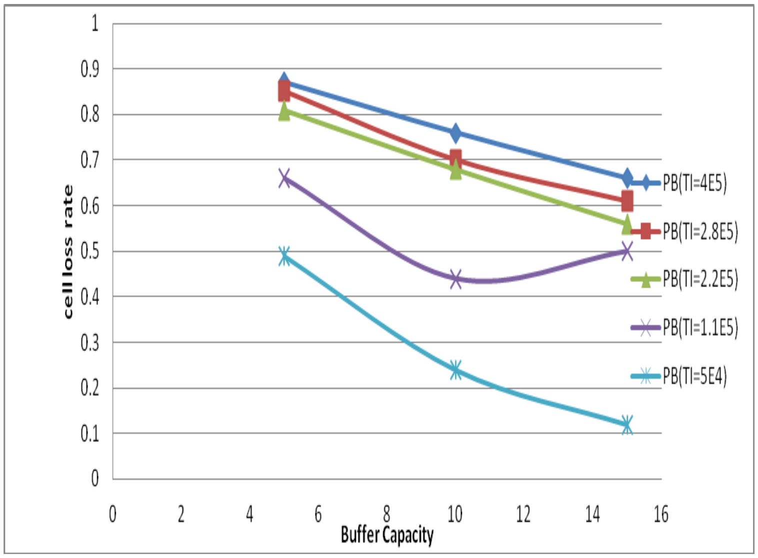

Figure 11: Blocking Probability against Buffer Capacity for heterogeneous source (Voice, Data & Video) at varying traffic intensity.

The family of curves as shown in fig.11 represents the observed behavior of the network in terms of cell loss rate and buffer capacity when the network was loaded with traffic from the heterogeneous source (i.e. data, voice and video) at varying intensity in the range of: 5.0E04, 1.1E05, 2.2E05, 2.8E05 and 4.0E5cells/second respectively.

From the set of curves obtained as shown in fig. 11, it is seen that there is an inverse relationship between cell loss rate and buffer capacity for a given traffic intensity i.e. as the buffer capacity becomes smaller network blocking probability of cells increases. This observed behavior is attributable to the fact that as the buffer capacity at the ATM access node reduces, it becomes unable to accommodate more of the busty traffic generated by the heterogeneous source (i.e. data, voice and video source) at specific traffic intensity, and as such drops some of these traffic in the network.

The set of curves obtained, one can be easily decided what buffer capacity will support a particular traffic intensity at a given QoS value (i.e. cell loss rate) in the network. For example if we consider a buffer capacity of 10, one can easily say from the set of plots the individual QoS value for each traffic intensity under consideration. It is seen from the plots that at a traffic intensity of 5.00E04, and at an access node buffer capacity of 10, the QoS value the network will provide at this point is 0.24. While at a traffic intensity of 1.10E05, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.44. Similarly, at a traffic intensity of 2.20E05, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.68. Furthermore, at a traffic intensity of 2.80E05, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.70. Finally, at a traffic intensity of 4.00E5, and at an access node buffer capacity of 10, the QoS value the network will provide will be 0.86.

5. CONCLUSION

From the simulation carried out as seen in the set of curves obtained as described above, it is seen that there is a relationship between probability of cell loss and traffic intensity of the network as is seen in literature. It is also seen that there is relationship between transmission bandwidth and delay experienced by traffic across the network. It is observed that as the available bandwidth needed for the different class of traffic carried across the network is increased, the delay experienced by traffic in the network as well as the probability of traffic been dropped in the network is decreased. It is also observed that in the case where the network is limited in terms of the available bandwidth for transmission, it is see that with increasing the buffer capacity at the access node, the probability of traffic loss is greatly ameliorated. The set of results obtained so far will be of great assistance in policing the networks as an understanding of the results from the research will better equip Enterprise-wide network managers on the best way to better allocated the network limited resource at their disposal to efficiently support the different class of service at their desired QoS that their network support. From the evaluation carried out, it is also seen from the set of results obtained after comparing the different sources with respect to average utilization of the network resources shows that the heterogeneous source (i.e. data, voice and video) better utilize the network resource (bandwidth and access node buffer capacity) as compared to the homogeneous source when the network is loaded with traffic of varying intensity. From the charts obtained so far, it becomes much easier for network managers to adequately dynamically allocate these limited network resources as they can easily tell at any point in time the minimum network resource requirement needed to support different traffic class supported by the network at different traffic intensity.

6. Acknowledgments

Ajibo wishes to thank the University for the Privilege to embark on this research work especially the Department of Electronics Engineering. My appreciation also goes to my family the' AJIBO'S'for their spiritual and moral support.
Igboeli wishes to express his profound gratitude to Ministry of Foreign Affairs (Research Department) for sponsoring part of this research and also his family for their moral support.
Finally, our sincere appreciation goes to our supervisor, Prof. Cosmas Ikechukwu Ani for being instrumental to the completion of this research work. His technical knowledge in the research field and supervisory role were exceptional.

REFERENCES

[1]M. Kawarasaki and B. Jabbari,"B-ISDN architecture and protocol", IEEE J selected Areas in communication, 9,(9),1405-1415(1991).

- *Ajibo Augustine is currently pursuing masters degree program in Telecommunication Engineering at the University of Nigeria Nsukka. E-mail: augustine.ajibo@unn.edu.ng*
- *Igboeli chukwudi is currently pursuing masters degree program in Telecommunication Engineering at the University of Nigeria Nsukka. E-mail: sncigboeli@gmail.com*
- *Cosmas Ani is currently a Professor of Communication Enginereingat the University of Nigeria Nsukka. E-mail:cosmas.ani@unn.edu.ng*

[2]Achille Pattavina, “Switching Theory Architectures and Performance in Broadband ATM Networks”, John Wiley & Sons Ltd (1998).

[3]Bijan Jabbari and Ferit Ycgcnoglu. "An efficient Method for Computing Cell Loss Probability for Heterogeneous Bursty Traffic in ATM Networks", International Journal of Digital and AnalogCommunication Systems, vol.5, 1992. 39-48

[4] C. l. Ani & Fred Halsali, "Simulation Technique for evaluating Cell-Loss Rate In ATM Networks"; The Society for Computer simulation. SIMULATION Journal California; Vol. 64, No.5: May 1995; pp. 320-329.

[5]C.I. Ani, Fred H. and Riaz A, “Methodology for Derivation of Network Resources to Support Video Related Service in ATM Based Private WAN” IEEE Proc-Commun., Vol 142, No. 4 August 1994

[6] C. l. Ani & Fred Halsali, "Simulation Technique for evaluating Cell-Loss Rate In ATM Networks"; The Society for Computer simulation. SIMULATION Journal California; Vol. 64, No.5: May 1995; pp. 320-329.

[7] Sykas D, et. al., "Congestion Control – Effective Bandwidth Allocation in ATM Networks", High Performance Networking. IV (C-14), IFIP, Belgium, 1993, pp.65-80.

[8] Roch Guerin, Hamid Ahmadi and Mahmoud Naghshineh, "Equivalent Capacity and its Application to Bandwidth Allocation in High Speed Networks" IEEE Journal on Selected Areas in Communications. Vol. 9 .No. 7, September 1991 pp.968-981.

[9] Ani C.I., “Determination of optimum number of trunk line for corporate network backbone in Nigeria”, Nigerian Journal of Technology, Vol. 23, No. 1, March 2004.

[10] Song C, San-qi Li and Joydeep G, “dynamic bandwidth allocation for effective transport of real time vbr video over ATM”, University of Texas at Austin IEEE 1994.