Bandwidth Allocation and Traffic attention in BISDN

G. Isern, M. Villapol*

Universidad Central de Venezuela
Grupo de Investigación en Redes, Arquitectura y Sistemas
E-mail: isern@reacciun.ve, mvilla@reacciun.ve,

Keywords: BISDN, ATM, , bandwidth allocation, virtual connection, classes of traffic.

Abstract

This paper deals with the problem of bandwidth allocation in BISDN. We evaluate some combinations of bandwidth allocation strategies and traffic attention strategies. Bandwidth allocation is accomplished over the virtual connections, more specifically over VPCs. The solution to the bandwidth allocation problem is based in the following aspects: a) the Broadband network is composed by access node (VC/VP switch) and intermediate node (VP/VC switch), b) there is one server in each node which attends the different classes of traffic and allocate bandwidth c) discrete event simulation is used to evaluate the different strategies d) the performance in terms of rejected call is evaluated using a software package developed for that purpose.

I. Introduction

Broadband Integrated Services Digital Network (BISDN) is a set of services, capabilities and interfaces supporting an integrated network and user interfaces at high speed. It was issued by CCITT as part of its I-series of recommendations in 1988. The ITU-T decided to develop BISDN using the Asynchronous Transfer Mode(ATM). ATM defines switching and multiplexing forms. It provide two oriented connections services, Virtual Paths(VPs) and Virtual Channels(VCs) [18].

The resource reservation is an important aspect in Broadband Integrated Networks, such as BISDN, because these networks were created to support different classes of traffic, for example, videoconference, file transfer, telephony,. etc.. For this reason, It is necessary to control and to guarantee the requirements of quality of service and traffic.

Resource reservation should be accomplished in three levels, network or VP level, call or VC level and Cell level [6], [7], [10], [11], [12] and [25]. Bandwidth allocation is a resource allocation form which permits to reserve bandwidth during a connection or during a burst. In this document, we only work over bandwidth allocation during the whole connection. These levels are described afterwards:

a) Network or VP Level: it deals with the Network Resource Management (NRM) [15]. These functions are accomplished in the VPs and they include bandwidth allocation for a period of time [10].

b) Call or VC Level: it deals with the admission of the calls to the network. A call can be admitted if it exists enough resources to guarantee the required parameters of traffic and quality of service [26]. The acceptance is based on, descriptor of traffic, available bandwidth on the set of VPs which compose the path between the origin and destine

* Current address : Monash University, Melbourne , Australia.

node, the route between origin and destine node and required QOSs.

c) Cell Level: it is responsible to maintain the traffic negotiation which was established between the user and the network during the whole connection. the main purpose of Cell level is to protect network resources from malicious as well as unintentional misbehavior which can affect the QOS of other already established connections [15]. These functions are named Usage Parameters Control (UPC) and Network Parameters Control (NPC) [15].

The network level and the call level deal with the bandwidth allocation problem over VP an VC respectively. The VP level decided how the classes of traffic share the available bandwidth over the VPCs (Virtual Path Connections) [5]. This information is given to the VC level. It uses this information and the parameters of QOSs and traffic to decide whether a call will be accepted. The bandwidth allocation is accomplished over a VC. So we only concentrate over these levels.

I-A. Bandwidth Allocation Strategies

We have divided the bandwidth allocation strategies in two categories, bandwidth management and traffic attention strategies. There are five classes of service, Constant Bit Rate (CBR) traffic, Variable Bit Rate (VBR) - Real Time (RT) traffic, Variable Bit Rate (VBR) - Non Real Time (NRT) traffic, Available Bit Rate (ABR) traffic and Unspecified Bit Rate (UBR) traffic [1]. We grouped these traffic according the bandwidth reservation process in the following categories, a) no reserved bandwidth, b) CBR reserved connection bandwidth, c) VBR reserved connection bandwidth, d) ABR reserved connection bandwidth and reserved burst bandwidth [26]. We deal only with the reserved connection bandwidth category of service, such as, CBR, VBR and ABR services.

ITU defines the traffic and QOS parameters [1], [16], [26]. But we only use the Peak Cell Rate (PCR). It defines the maximum instantaneous rate at which the user will transmit [16]. Bandwidth allocation is accomplished using this parameter.

The traffic attention strategies are: firsts input first output (FIFO), cyclic and priority. We considered that there are many queues, one for each class of traffic (reserved connection bandwidth category of traffic). Using FIFO strategy, the first call arriving is attended. The server which accomplishes bandwidth allocation functions at the admission moment tries to allocate the demanded bandwidth. Using Cyclic strategy, the server attends one call of each class of service on each cycle, in other words, all of the defined classes of service have the same priority. And using Priority strategy, the server attends the calls according the value of their priority which must have been defined previously. Each class of service has some priority level. We considered only five levels of priority and a priority level equal zero is the highest level.

We also studied three management bandwidth strategies. These strategies are: complete sharing (CS), movable boundary (MB) and routing according to bandwidth

Management bandwidth strategies/ Traffic attention strategies	Complete share	Movable boundary
Static routing:		
Firsts Input Firsts Output (FIFO)	applicable	applicable
Priority	applicable	applicable
Cyclic	applicable	applicable

Table 1: Relationship between management bandwidth and traffic attention strategies.

available. We considered the bandwidth allocation over virtual connection, specifically over VPCs. A PVC is a set of VPs between two points which are defined as VP/VC switches [5]. So we only work with VP/VC switches.

The complete sharing strategy uses the whole available bandwidth on a VPC and it tries to allocate the demanded bandwidth (the value of the PCR) for a call. This strategy is simple but the available bandwidth is used for all of classes of services. So the traffic which requires more bandwidth has to compete with the traffic which necessitates less bandwidth.

The movable boundary strategy [12] and [19] divides the available bandwidth in partitions of bandwidth which can have equal or different sizes. The sum of the sizes of these partitions must be less or equal to the maximum available bandwidth. The size of partition must be defined and which partitions can be used for what classes of traffic These strategy is more complex than the complete sharing strategy, but is more flexible than it because it is possible to assign more or less partitions for the different classes of traffic. This decision should be supported on the PCR required in average for each classes of traffic.

The last strategy is a combination of a dynamic routing and bandwidth allocation strategy. The route is set according to available bandwidth over the VPCs which compose the route between origin and destine node. In this case, we should use Bell-Ford or Dijkstra's algorithm to find the shortest path [26] from a source node to destine node. In this case, *the weight* of the links (VPCs) should be the allocated bandwidth. This is the most complex strategy, but it permits to obtain the best route according the available bandwidth. However, it is possible to use the complete sharing or movable boundary schemes to allocate the bandwidth with the routing according to available bandwidth.

We implemented only the two firsts strategies in this stage of the whole project. The table 1 shows a relationship between the management bandwidth and the traffic attention strategies. We only consider static routing, in other words, the routing tables are loaded at the network initialization moment and are kept while the network is working. We can use the simple static routing (only one route exists) or the alternate static routing (many routes exist) [26].

Bandwidth allocation problem over integrated networks which support multiple classes of traffic has been studied since the middle of the 80's [10], [20], [24] and [25].

Some of these studies have dealt with the problem over integrated networks in general [24], [25], others have been based in analytical models [10], [24], and others have studied the performance characteristics of bandwidth allocation strategies over circuit-switched networks [8]. This work is accomplished using a simulation program which permits to do many test of bandwidth allocation strategies over different configurations of network. In addition, we concentrated on bandwidth allocation over virtual connections as well as they have been defined by ITU and ATM FORUM [18], [21].

The objective of this research is to evaluate the different combinations of strategies which are showing in the table 1. The performance in terms of the rejected call in function of the traffic load is obtained using a software program developed for that purpose. This evaluation permits to give some recommendations that should improve the performance of the network in terms of the bandwidth utilization and numbers of rejected calls.

This paper is organized as follows. In section II, we present the set of steps which were followed for us to resolve the problem of evaluation of the different combinations of bandwidth allocation strategies as well as it was described in the section I-A on this paper. The queuing model is described in the section II-A. In the section II-B, we describe the simulation process. We use the software program to evaluate the different combinations of bandwidth allocation strategies, this program is described in the section II-C. In the section III, we use an integral example to show the performances of the different strategies of bandwidth allocation in terms of rejected calls in function of the traffic load. The output parameters of our simulations are given in the section III-A While, the results of our simulation are presented in the section III-B. Section IV summarizes our conclusions.

II. Evaluation of bandwidth allocation strategies

Evaluation of the bandwidth allocation strategies described in the previous section is accomplished based on the following steps, the network configuration, the queuing model, the simulation process and the software program. As respects the network configuration, we considered that an integrated service digital network is composed by access and intermediate nodes which accomplish functions of a VP/VC switch. The follows steps are described in the next sections.

II-A Queuing Model

Each access node has multiple queues, one for each class of traffic. In each access node, there is a server which accomplishes functions of admission control and network resource management as well as we explained in the previous section. On the other hand, in each intermediate node, there is a server which accomplishes functions of network resource management, in other words, it will try to allocate the bandwidth over the respective VPC. The VPC over which the bandwidth is allocated is chosen according to the table of routes. So, we use one server queuing model for each access or intermediate node.

Each access node receives many call arrivals. Call arrivals are assumed to be Poisson and holding times (i.e. the expected duration of a connection) exponentially distributed. So a traffic type *i* is characterized by a call arrival rate λi calls/ time units, a mean holding time $1/\mu i$, and an peak Cell rate PCR (i.e. peak bit rate).

II-B Simulation Process

Evaluation of bandwidth allocation strategies is accomplished using event-discrete simulation [2]. The different events for node (access and intermediate node) which were considered are described as follows, for access node:

a. *Call arrival:* a call of *i* traffic is arriving at access node *j*.

b. *End bandwidth allocation:* the server of an access node ends to allocate bandwidth for call of *i* traffic and it can attend another call of *j* traffic.

c. *End a connection:* the holding time of a call connection is finished.

All of previous events can be succeeded at an intermediate node except for a call arrival.

On the one hand when a call arrives at an access node, the server attends it if it is free at that moment, in other case, the call is queued in order to wait for the server attention. On the second hand, when a server of a node ends to allocate the bandwidth for a call, it takes another call from one of the multiple queue. The call is taken following an attention strategy as well as we explained in section I. The bandwidth allocation process could be finished successfully which implies that the server found some available bandwidth over the set of VPCs which compose the route, or unsuccessfully which implies that the server could not allocate the demanded bandwidth over the route. In this case, the call is re-queued at origin access node if and only if another route exists. If another route does not exist, the call is rejected. Finally, the liberation of a connection implies that the allocated bandwidth will be liberated over the whole route (over the set of VPCs which compose the route).

II-C Bandwidth Allocation Evaluation Program

We developed a software program in order to evaluate the different combinations of bandwidth allocation strategies (see section I). This tool is an event simulation program and is based in one server queuing model. Other important characteristic of this software is that it is able to support single and alternate static routing.

This program accepts multiple classes of traffic given to it by the user . All these classes are of the type reserved connection bandwidth traffic. In addition, the software allocates the bandwidth over a set of VPCs which composed a route between origin and destine node.

The most important aspects that characterize the computational model are summarized as follows; it accomplishes call admission control functions based on demanded bandwidth for each class of traffic; the available bandwidth is always checked by the program in order to respond to the requirements of bandwidth; it controls the available and busy bandwidth over each VPC; all of the combinations of bandwidth allocation strategies which are shown on the table 1 are supported; it maintains a register of the number of rejected and accepted calls for node and classes of traffic; multiple queues of traffic (one for each class of traffic) are supported; multiple priority levels can be supported by the program; multiple partitions over each VPC can

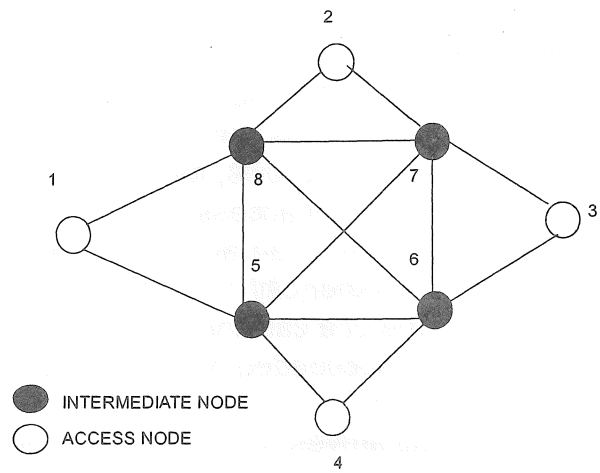

Fig. 1: Network configuration of the example.

be defined and they can have different sizes as if as the sum of these size will be less than maximum available bandwidth in each VPC; it supports many configurations of an integrated Broadband network in terms of numbers of node and topology; and, it may accept other call arrival and holding time distributions. A detailed description of this program is done in [26].

III. Evaluation Results

We choose an integral example to show how the program works using the different combinations of bandwidth allocation strategies based on the queuing model and simulation process , as they were described in section II.

III-A Output parameters

The parameters took in count for this bandwidth allocation strategy evaluation are; total numbers of calls which arrived to the network, total numbers of call which entry the network, in other words, they were queued in the access node; total numbers of processed calls, they are the calls for which demanded bandwidth tried to be allocated; total numbers of call which were rejected because there was not enough available bandwidth over the route; total numbers of calls which were accepted, in other words, demanded bandwidth was allocated over the route; percentage of rejected call; percentage of accepted calls; a traffic *i* is characterized by offered traffic, $Ai = \lambda i / \mu i$ in Erlangs; and the *i* traffic load as $Si = Ai * PCRi$. The total traffic load Sj generated at a network node *j* is defined as follows :

$$Sj = \sum_{i=1}^{\text{number of classes of traffic}} Sji$$

Network Topology		
Length of each trunk:	100 Kms.	
Route		
Number of routes:	2	
VPC		
Maximum Available Bandwidth for each VPC:	1500 Mbps	
Number of partitions	10	
Traffic		
	Mean holding time in sec.	PCR (Mbps)
Traffic type 0:	60	1
Traffic type 1:	60	10
Traffic type 2:	60	100
Traffic		
Priority level of traffic type 0:	2	
Priority level of traffic type 1:	1	
Priority level of traffic type 2	0	

Traffic /Partitions	0	1	2	3	4	5	6	7	8	9
T0	-------	-------	-------	-------						
T1				-------	-------	-------	-------			
T2							-------	-------	-------	-------

Table 2: Input parameters and traffic types.

and the total x traffic load Sx generated at the whole network is defined as

$$Sx = \sum_{j=1}^{\text{number of access node}} Sjx$$

We registered all of this parameters for traffic, node and for whole network.

III-B An example

The following example represents only a case which is used to show how the queuing model and the simulation process can be applied and what results can be obtained using our simulation program with the different combination of bandwidth allocation strategies. The configuration of the network is shown in the fig. 1 and the table 2 shows the input parameters.

The performance in terms of rejected call in function of total i traffic load at the network is obtained using the program developed for that purpose.

The fig. 1 to fig. 6 show the results obtained for each combination of bandwidth allocation strategies. First, observe that traffic 0 which demands the less bandwidth is favored by FIFO strategy with it is combined with complete share strategy. This situation is improved when the cyclic or priority strategies are used. In these case, the performance of traffic type 1 and 2 is improved. The principal reason is that the traffic type 1 and 2 have the higher priority than the traffic type 0 do.The fig. 4, fig. 5 and fig. 6 show the results when we use movable boundary strategy (3 instances of the same experiment). The different size of each partition are shown on the table 2 as well as the traffic assignation for each partition. In this case, the performance is less than the performance obtained previously. The reason is that the size of each partition and the

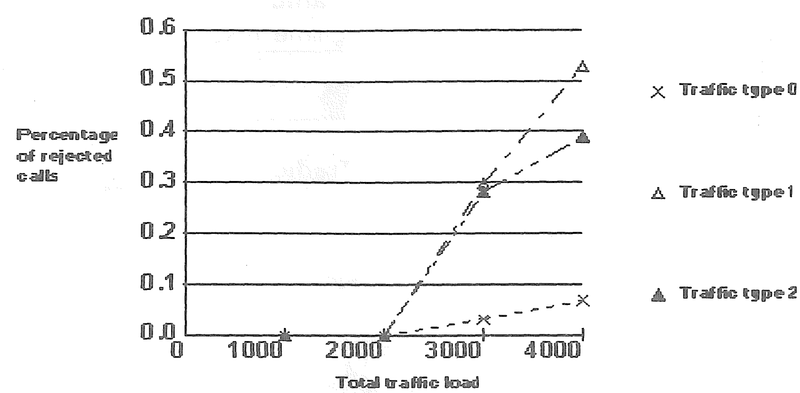

Fig. 1: Percentage of rejected calls versus total traffic load for the complete sharing and FIFO strategies.

traffic assignation do not favor the higher bandwidth demands, such as, traffic type 1 and 2. However, the cyclic and priority strategies improve this performance again. In this case, it is recommendable to assign more quantities of partitions for the traffic which demands more bandwidth[26]. It would also be interesting to have a more pragmatic approach and explain how determine the different traffic types and to which application/media they correspond but this will be part of another work.

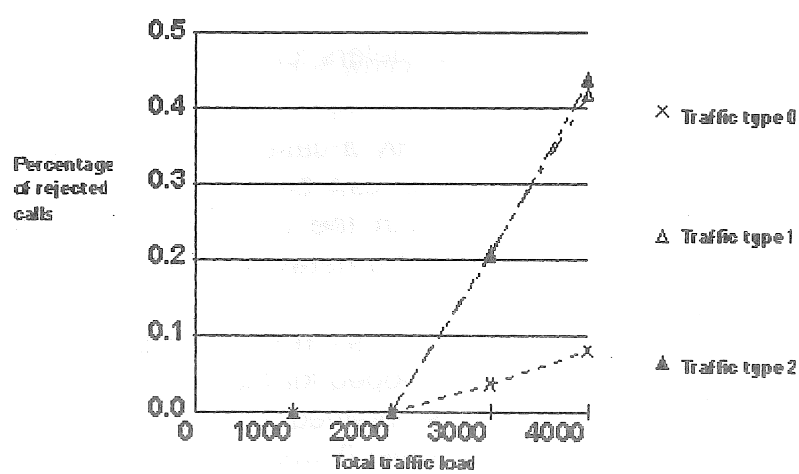

Fig. 2: Percentage of rejected calls versus total traffic load for the complete sharing and cyclic strategies.

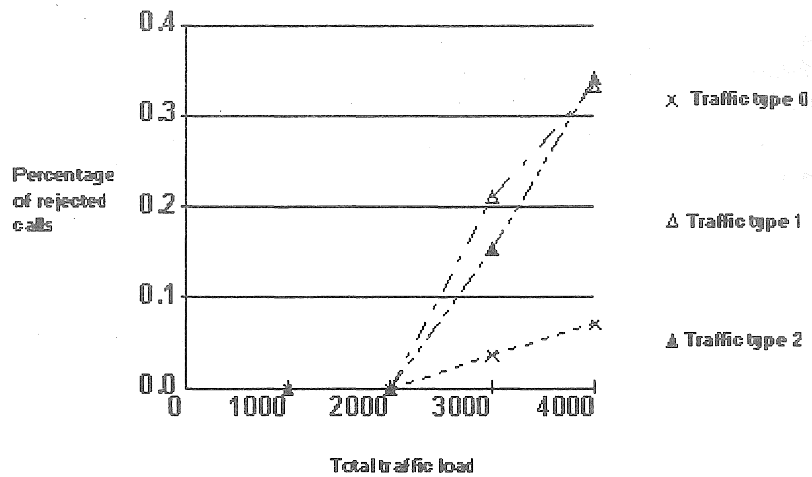

Fig. 3: Percentage of rejected calls versus total traffic load for the complete sharing and priority strategies.

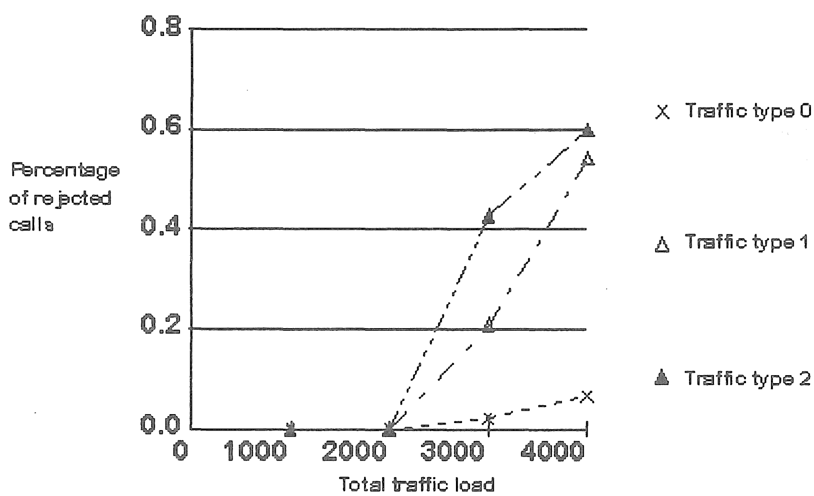

Fig. 4: Percentage of rejected calls versus total traffic load for the movable boundary and FIFO strategies.

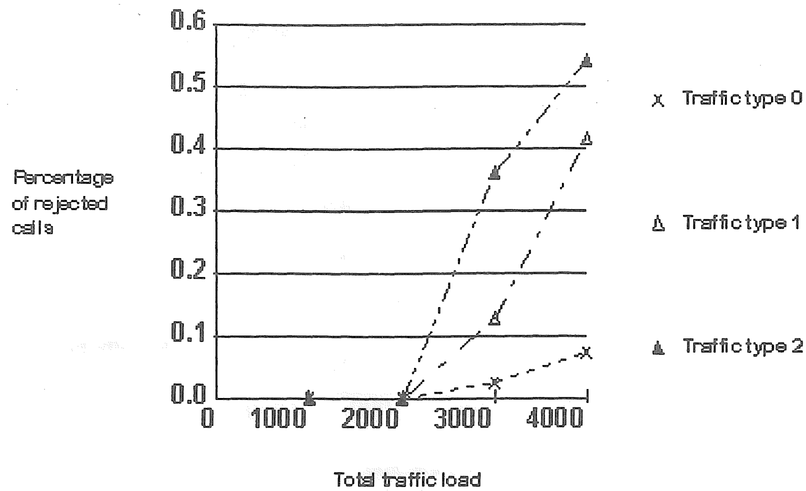

Fig. 5: Percentage of rejected calls versus total traffic load for the movable boundary and cyclic strategies.

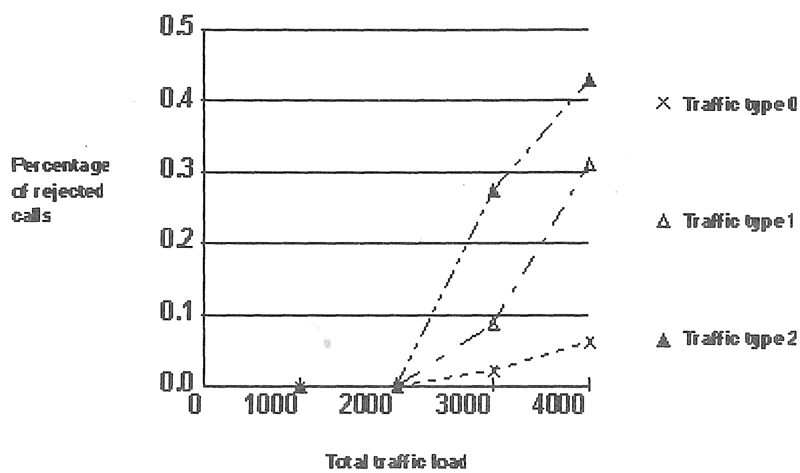

Fig. 6: Percentage of rejected calls versus total traffic load for the movable boundary and priority strategies.

IV. Conclusions

In Integrated Broadband networks, such as BISDN, which supports many classes of traffic and count with a great account of bandwidth (it support transmission rates over 150 Mbps), it is necessary to count with strategies which permit to regulate the call admission in the network and management the network resources, such as bandwidth. The different classes of traffic have different demands of bandwidth, as is described in section III. So, this work concentrates in proposing a set of combination of bandwidth allocation and traffic attention strategies which may improve the performance in terms of rejected call in a Broadband network.

The principal advantage of this work is that permit to change the network configuration (number of node, topology of the network, routing table, etc.), input parameters (peak Cell rate, call interarrival time and holding time) and classes of traffic supported in order to prove the different strategies over different networks. Other works, such as [10], [24] are based over analytical model for which they are less flexible.

Other important characteristic of this work is that the bandwidth allocation is accomplished over virtual connections, more specifically over VPCs, as well as it is described ITU's recommendations [18].

The developed program evaluates the combinations of bandwidth allocation strategies and it is based in the one server queuing model and event-discrete simulation. It supports multiple classes of traffic, multiple routes between origin and destine nodes, works over VPCs, and combines the bandwidth allocation strategies and traffic attention strategies.

References

[1] A. ALLES. *ATM Networking*. Cisco Systems, Inc. May 1995.

[2] J. A. BELTRAO, J. P. SAUVE, W. F. GIOZZA, J. F. MARINHO. *Redes Locales de Computadoras, Protocolos de alto nivel y evaluación de prestaciones*. McGraw-Hill. 1989.

[3] D. BERTSEKAS, R. GALLAGER. *Data Networks*. Prentice Hall, 1992

[4] J. BURGIN, D. DORMAN. *Broadband ISDN Resource Management : The Role of Virtual Paths*. IEEE Communications Magazine, September 1991.

[5] T. M. CHEN, S.S. LIU. *Management and Control Functions in ATM Switching Systems*. IEEE Networks, July 1994.

[6] L. A. CRUTCHER, A.G. WATERS. *Connection Management for an ATM Networks*. IEEE Networks , November 1992.

[7] A.E. ECKBERG. *B-ISDN/ATM Traffic and Congestion Control*. IEEE Network, September 1992.

[8] A. GERSHT , K J. LEE. *Virtual-Circuit Load Control in Fast Packet-Switched Broadband Networks*. GTE Laboratories. 1988.

[9] A. GERSHT, K LEE. *A Congestion Control Framework for ATM Networks*. IEEE Journal on Selected Areas in Communications, Vol. 9, No 7, September 1991.

[10] A. GERSHT, A. SHUIMAN, J. VUCETIC, J. KELISON. *Dynamic Bandwidth Allocation, Routing, and Access Control in ATM Networks*. GTE Laboratories, March 1994.

[11] H. GILBERT, O. ABOUL-MAGD, V. PHUNG. *Developing a Cohesive Traffic management Strategy for ATM Networks*. IEEE Communications Magazine, October 1991.

[12] I.W. HABIB, T. SAADAWI. *Controlling Flow and Avoiding Congestion in Broadband Networks*. IEEE Communications Magazine, October 1991.

[13] D. HONG, T. SUDA. *Congestion Control and Prevention in ATM Networks*. IEEE Network Magazine, July 1991.

[14] J. Y. HUI. *Resource Allocation for Broadband Networks*. IEEE Journal on Selected Areas in Communications, Vol. 6, No 9, December 1988.

[15] ITU-T. Recommendation I.371. *Traffic Control and Congestion Control in BISDN*. Geneva. March 1994.

[16] R. JAIN. *Congestion Control and Traffic Management in ATM Networks: Recent Advanced and A Survey*. Department of Computer and Information Science, The Ohio State University. January 1995.

[17] B. KUMAR .*Broadband Communications*. Mc-Graw Hill 1994.

[18] D. E. MCDYSAN, D. L. SPOHN. *ATM, Theory and Application*. Mc-Graw-Hill, 1994.

[19] D. LIOU, A. LIU. *A Model for Dynamic Channel Allocation in an ISDN*. Proceedings of the IEEE, Vol. 79, No 2, February 1991.

[20] A. PATTAVINA. *Multichannel Bandwidth Allocation in a Broadband Packet Switch*. IEEE Journal on Selected Areas in Communications, Vol. 6, No 9, December 1988.

[21] M. De PRYCKER. *Asynchronous Transfer Mode, Solution for Broadband ISDN*. ELLIS HORWOOD. 1993.

[22] W. SATALLINGS. *Data and Computer Communications*. MacMillan Publishing, 1995.

[23] K-I SATO, S. OHTA, I. TOKIZAWA. *Broad-Band Network Architecture Based on Virtual Paths*. IEEE Transactions on Communications, vol. 38, No 8, August 1990.

[24] B. KRAIMECHE, M. SCHWARTZ. *Bandwidth Allocation Strategies in Wide-Band Integrated Networks*. IEEE Journal on Selected Areas in Communications, Vol. SAC-4, No 6, September 1986.

[25] E.D. SYKAS, K.M.VLAKOS, I.S. VENIERS, E. N. PROTONOTARIOS. *Simulative Analysis of Optimal Resource Allocation and Routing in IBCNs*. IEEE Journal on Selected Areas in Communications, Vol. 9, No 3, April 1991.

[26] Villapol M.E. *Asignación del Ancho de Banda en BISDN: una evaluación a nivel de conexiones virtuales*. Universidad Central de Venezuela. Escuela de Computación. Caracas, Mayo 1996.