Buffer Capacity Allocation: A method to QoS support on MPLS networks

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Abstract

This paper describes an optimized model to support QoS by mean of Congestion minimization on LSPs (Label Switching Path). In order to perform this model, we start from a CFA (Capacity and Flow Allocation) model. As this model does not consider the buffer size to calculate the capacity cost, our model- named BCA (Buffer Capacity Allocation)- take into account this issue and it improve the CFA performance. To test our proposal, we perform several simulations; results show that BCA model minimizes LSP congestion and uniformly distributes flows on the network.

1. Introduction

Today, the Internet growth and the convergence of services such as voice, data and video, involve more network requirements such as Quality of Service (QoS) support, which is an important topic into the scientific world today. However, the IP protocol was not designed to support QoS. Therefore, when several fails on packet forwarding occurs, the IP protocol does not provides control mechanisms to reduce the impact of issues such as excessive delays, dropped packets and throughput degradation. A solution to improve the network performance is given by the Traffic Engineering (TE) theory [1]. TE reduces congestion effects on networks by mean of resource optimization methods and then, it obtains a more distributed and efficient use of all network links. Also, TE provides support to several types of user traffic by mean of several services types [2, 3].

Currently, Traffic Engineering on Internet is based on MPLS, which is a high performance technology to transport IP packets. MPLS allows traffic classification by mean of the Forwarding Equivalence Class (FEC) concept. Also, MPLS offers a high speed switching, scalability and QoS support. As a result, MPLS is a useful solution to the services convergence on networks [4, 5].

When congestion occurs on IP networks and TCP and UDP protocols are used by several users on the same network, a great variety of problems arise due to the different behaviors of these protocols on congestion situations. A congestion state of a network occurs when the load volume to support by the network is more than the network capacity. An approach commonly used to model and control the congestion state is known as "Generalized Shortest Path" (GSP), which is based on the "shortest path" criteria to search a path for packets on the network. The shortest path algorithm finds a packets path which obtains the minimum cost for a parameter. Also, this path should reach minimum conditions for flow conservation [6]. GSP models are linear because are independent of load conditions. On the other hand, there exist other models which are dependent of load conditions; these are not linear models and are used to control congestion situations on "quasi-static" topology networks [7].

On the other side, IP networks are considered dynamic networks because topology changes occur frequently. Then, the use of non-linear models is bounded on IP networks due to traffic oscillations [8]. Due to these issues, models developed to IP networks are linear, and consequently they not have QoS support capability. As a result, non-linear models implemented on MPLS have been studied recently. This is possible because MPLS supports QoS on IP networks by mean of Label Switched Paths (LSPs) optimization [7].

One goal of this paper is to propose a new model to minimize links congestion. Thus, our approach allows QoS support by mean of congestion control. Also, we performed an analysis of flow optimization based on traffic and restrictions requirements. Another main goal of this paper is to propose a non-linear model to give solution to the capacity and flow allocation problem on the LSPs. Our approach is based on the Capacity and Flow Assignment (CFA) model. Several studies using CFA model and stochastic traffic have previously performed [9, 10]. However, CFA model have not considered the buffer size to calculate capacity cost for each LSP. Therefore, we propose a model that improves this deficiency of CFA model. Our model is named Buffer Capacity Allocation (BCA) and it takes into account the normalized buffer size. As a result, BCA optimizes flows assignment on links and minimizes costs of each LSP.

This paper is organized as follows, section 2 describes MPLS technology and presents our congestion links optimization model; section 3 describes CFA model. Section 4 details our BCA model and compares it respect the CFA model. Section 5 presents simulations results and finally, conclusions and future work are detailed on section 6.

2. MPLS: Optimization Model

In this section we will analyze the main characteristics of MPLS to provide TE in flow control in IP network packets and optimization of congestion model in the LSP.

2.1. Description MPLS

The devices that participate in the MPLS protocol mechanisms can be classified into label edge routers (LERs) and label switching routers (LSRs). An LSR is a high-speed router device in the core of an MPLS network that participates in the establishment of LSPs using the appropriate label signaling protocol and high-speed switching of the data traffic based on the established paths. An LER is a device that operates at the edge of the access network and MPLS network. LERs support multiple ports connected to dissimilar networks (such as frame relay, ATM, and Ethernet) and forwards this traffic on to the MPLS network after establishing LSPs, using the label signaling protocol at the ingress and distributing the traffic back to the access networks at the egress. The LER plays a very important role in the assignment and removal of labels, as traffic enters or exits an MPLS network, (Fig. 1).

The forward equivalence class (FEC) is a representation of a group of packets that share the same requirements for their transport. All packets in such a group are provided the same treatment en route to the destination. As opposed to conventional IP forwarding, in MPLS, the assignment of a particular packet to a particular FEC is done just once, as the packet enters the network. FECs are based on service requirements for a given set of packets or simply for an address prefix. Each LSR builds a table to specify how a packet must be forwarded. This table, called a label information base (LIB), is comprised of FEC–to-label bindings [4].

A label, in its simplest form, identifies the path a packet should traverse. A label is carried or encapsulated in a Layer-2 header along with the packet. The receiving router examines the packet for its label content to determine the next hop. Once a packet has been labeled, the rest of the journey of the packet through the backbone is based on label switching. The labels values have significance only locally, meaning that they pertain only to hops between LSRs. Labels are bound to an FEC as a result of some event or policy that indicates a need for such binding. These events can be either data-driven bindings or control-driven bindings. The latter is preferable because of its advanced scaling properties that can be used in MPLS.

In MPLS to improve used routing metrics as: the maximum velocity of data transmission, capacity reserve, packet loss rate and link propagation delay. It is necessary to increase and to optimize the capacities of the routing protocol or to develop new one [3].

A routing algorithm that considers the requirements of traffic for several flows and resources availability throughout several jumps and through several nodes, it is denominates routing based on restrictions algorithm. In essence a network that uses this type of routing algorithm use the utilization percentage of links of the existing capacity, although it agree services to the network. In the next section we will analyze an optimization model based in the characteristics indicated before.

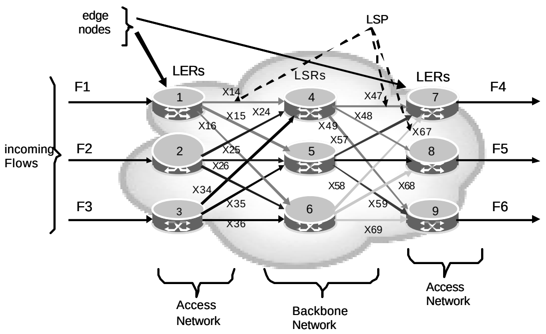

Figure 1: Network MPLS

2.2. Tunneling Optimization

Multiprotocol label switching (MPLS) is a recent technique to provide controlled traffic engineering for flow of packets for different service/user (traffic) classes in core IP networks. Roughly speaking, this is done by assigning end-to-end "virtual paths"(called Tunnel) of predefined capacity to different demand streams corresponding to different services classes associates with certain user groups, with local networks connected by the core IP networks, etc, that require differentiated quality of service (QoS) [11]. In this way a much more flexible packet routing can be achieved as compared to the link-metric dependent shortest-path type of routing which id identical for all service/user classes.

MPLS achieves control over packets flows (and thus can performs traffic engineering in a flexible way) through a concept called label switching. For different classes tunnels can be established that use the concept of label switching between label-edge routers (LER) where ingress and egresses traffic (fig. 1). The communication between routers to set up such labels can be performance either by using the label distribution protocol (LDP) or the resource reservation protocol (RSVP)[4].

The tunnels in the network can have a certain bandwidth assigned to them, although it should be noted that an MPLS network does not by itself provide QoS. On the other hand, for traffic class, if the bandwidth needed to meet a certain QoS can be determined, then a tunnel (or multiple tunnels, id this is allowable) that can carry this bandwidth demand can be established. In other words, QoS requirements can be met indirectly if the bandwidth determination process takes into accounts QoS requirements.

While tunneling is a nice concept with great traffic engineering potential and allows separation of diverse traffic of different service/user groups in different tunnels, there is an inherent difficult since only a limited number of tunnels can be handled by any MPLS router without unduly overloading the router. Furthermore, from a manager point of view, it may also be desirable to limit the number of tunnels [12] .

Here we will use the identifier d to denote a demand (associated with a node pair and a traffic class) that requires bandwidth h_d to be routed in the network. We assume that the demand h_d can be carried over multiple tunnels from ingress to egress MPLS label-edge-router (LER). We denote the different possible tunnels for demand d by Pd and the fraction of the demand volume for d to be carried on tunnel p as X_{dp}. We then have the demand constraint:

$$\sum_p x_{dp} = 1 \qquad d=1,2,\ldots\ldots,D$$

Since it is possible to select a flow with a very small fraction, we want to put a lower bound on the fraction of a flow on a path, this is also desirable since we want to minimize the number of tunnels on the link. Thus, if we use a positive quantity e to be the lower bound on fraction of flow on the tunnel (path) and use the binary variable $u_{dp}=1$ to denote selection of a tunnel if the lower bound is satisfied (and 0, otherwise), we have the following two relations:

$$e u_{dp} \le h_d x_{dp} \qquad d=1, 2, \ldots,D \qquad p = 1, 2, \ldots\ldots.,Pd$$

$$x_{dp} \le u_{dp} \qquad d=1, 2, \ldots.,D \qquad p = 1, 2,\ldots\ldots\ldots.,Pd$$

The first one states that if a tunnel is selected, then the tunnel must have at least the fraction of flow which is set to e, the second one state that if a tunnel is not selected, then the flow fraction associated with this tunnel should be forced to be equal to 0. Let d_{edp} be the link-path indicator, meaning it takes the value 1 if the router p for demand d uses the link e, otherwise it is 0. We have the capacity feasibility constraint

$$\sum_d h_d \sum_p d_{edp} x_{dp} \le c_e \qquad e = 1, 2, \ldots\ldots\ldots E$$

Now, the number of tunnels on link e will be

$$\sum_d \sum_p d_{edp} u_{dp} = r$$

Since our goal is to reduce "tunnel congestion", i.e., total number of tunnels, we want to minimize a number r that represents the maximum number of tunnels over all links. Thus, our entire problem can be formulated as:

Minimize $\quad F = r \qquad$ (1)

Subject to $\quad \sum_p x_{dp} = 1 \qquad d=1,2,\ldots\ldots.,D \qquad$ (2)

$$\sum_d h_d \sum_p d_{edp} x_{dp} \le c_e \qquad e = 1, 2, \ldots\ldots E \qquad (3)$$

$$x_{dp} \le u_{dp} \qquad d=1, 2,\ldots.,D \qquad p = 1, 2,\ldots\ldots,Pd \qquad (4)$$

$$e u_{dp} \le h_d x_{dp} \qquad d=1, 2,\ldots,D \qquad p = 1, 2,\ldots\ldots,Pd \qquad (5)$$

$$\sum_d \sum_p d_{edp} u_{dp} = r \qquad e = 1, 2,\ldots\ldots E \qquad (6)$$

Where

- **r** Maximum number of tunnels over all links.
- **R** Congestion in each link without optimizing.
- x_{dp} The fraction of the demand volume for d to be carried on tunnel p.
- d Demand (associated with a node pair and a traffic class) that requires bandwidth hd.
- D Total number of the demand.
- h_d Bandwidth to be routed in the network.
- d_{edp} Link-path relation: is 1 if link e belongs to path p for demand d, 0 otherwise.
- c_e Capacity the link e.
- E Total number the links in the network.
- P_d Different possible tunnels for demand d.
- u_{dp} Binary variable to denote selection of a tunnel if the lower bound is satisfied (and 0, otherwise).
- e The lower bound on fraction of flow on the tunnel.

It is possible to be verified that this problem has continuous variables as much as discreet, whereas the objective function and the restrictions are linear. This model of optimization will allow us to minimized the congestion of the connections in a network MPLS. In the following section we will study advantage and deficiencies of model CFA for the analysis of the capacities and the trajectories of the LSP.

3. CFA Model

In this section we will study the path capacities. Also, we will study CFA model issues and functions. Thus, we will complete the optimization tools needed to reduce the network links congestion.

3.1. Path Capacity

Communication Network Analysis defines a network as a set of nodes and links. This set can be represented as a G= (N, L) graph, where N is the nodes set, and L is the links set. A graph can be expressed as a matrix composed by ones and zeros. This matrix, named Incidence matrix, gives a relationship between nodes and links. Several models, on communication network analysis, assign quantitative entities to nodes and links. Some examples of these are transmission links capacities (trajectory capacities) and traffic flows. A great variety of networks can be developed by combining several entities types. Conventional models are modeled with:

• Deterministic parameters or the first and second moments of stochastic parameters;
• Load-independent parameters, or equivalently, linear programming formulations;
• Link-node incidence;
• Single traffic class.

Solutions using stochastic parameters were proposed by Liu in [13]. On the other hand, our model uses load dependent parameters because they are non-linear; therefore, they have necessary conditions to support QoS. By definition, CFA model takes the path capacities as design parameters. This point of view looks natural for MPLS networks because path capacities concept can be mapped to LSPs in a direct way. This issue allows on MPLS networks to use optimization concepts studied above on section 2. Thus, path congestion reduction can be performed. Next section, will describe the CFA model by mean of path capacities.

3.2. Load Dependent Parameters

From the mathematical viewpoint all generic network models can be interpreted as the shortest path problem. The realization of a generic model can be linear or nonlinear. If the network parameters are load independent, e.g. the cost per unit flow or the geographical length of links, then the resulting model usually takes the form of linear programming (LP). If the network parameters are load dependent, e.g. the mean or variance of delay, then the model may take the form of nonlinear programming (NLP). In modern packet switching techniques, there are two main paradigms: datagram and virtual circuit. For datagram paradigms like IP networks, the use of nonlinear models is limited since they are liable to cause oscillations in terms of load distribution and congestion. The root reason is that the link parameters used for generalized distances are updated much more frequently than the circuit paradigm, the situation is different. Therefore, nonlinear models may play role in MPLS networks.

3.3. CFA model Functions

The main goal of CFA model is to optimize one of two index types: Function Index (FI) and Capital Index (CI). FI is the packets delay. Also, FI could be the total number of packets of the system. CI is the capacities cost. Capacities and traffic flows are fitted to network links as the entities. Then, they are the design variables. Any index, CI or FI, can be established as the objective function and the restriction respectively. On practice, election depends on the objectives priority and values bounds. If CI is selected as objective function, the design problem can be treated as a generalized shortest path problem. For this case, the assigned distance could be the geographic distance, the flow cost unit or the link use. For example, on an Incidence node-link model, the flows cost function can be:

$$U = \sum_{e=1}^{N} g_e x_e \qquad (7)$$

Where N is the links number, g_e is the flow unit cost and x_e is the flow on the link. On the other side, if the model is an Incidence node-path model, the cost function can be expressed by the same equation (7), but in this case N is the trajectories number, g_e is the flow unit cost and x_e is the flow on the trajectory [7, 13].

4. Buffer Capacity Allocation (BCA): Proposed Model

In the following analysis we considered the situation where to each node we will add a buffer for each path. Thus BCA model, based on equation 7 will have a flow x_p, path capacity y_p, and the size of the variable buffer z_p as of design. The following equations show the analysis of the proposal:

$$U = \sum_{p \in b} \sum_{p \in P_p} (a_p y_p + b_p z_p) \quad (8)$$

Subject to $x_p / y_p \leq q_p$ (9)

$$\sum_{p \in P_p} x_p = g_b \quad (10)$$

$$x_p, y_p, z_p \geq 0 \qquad \forall p \in P_b, \; b \in B$$

Where

U Function of cost of flows.

$\boldsymbol{x_p}$ Path flows.

$\boldsymbol{y_p}$ Path capacities.

$\boldsymbol{z_p}$ Buffer sizes.

B The set of all OD pairs.

P_b The set of all paths connecting OD pair ß.

$\boldsymbol{a_p}$ The unit capacity cost of path p.

$\boldsymbol{b_p}$ The unit buffer cost of path p.

$\boldsymbol{q_p}$ The upper bound of congestion of path p.

q_b Limit superior of the congestion of a pair OD belongs to B.

g_b External traffic requirement associated to OD pair ß.

Equation 8 represents the incidence node - link model of the proposed model, the first term of this equation symbolizes the cost by the capacity of the each LSP, in this equation introduces a second term where the cost by the size of the buffer in each trajectory is considered.

Equation 9 represents the restriction of the congestion of the tunnel and equation 10 the restriction of the requirements of external traffic in each tunnel. It is possible to be observed that if $q_b = q_p$ for all the paths of pair OD, the restrictions (9) and (10) implies other restrictions as well, thus we have:

$$\sum_{P \in P_b} \frac{x_p^2}{y_p} \leq q_b g_b \quad (11)$$

$$\sum_{P \in P_b} y_p \geq \frac{g_b}{q_b} \quad (12)$$

Equation 11 can be interpreted as the expression of the paradigm nonlinear of the shortest path with dependent parameters of the load x_p / y_p. Equation 12 indicates the relation between the capacities associated to the requirements of the external traffic of a pair ß pertaining to OD.

Exist diverse forms to elaborate a model based on model CFA, however, the key for its design depends on the formulation of $q_ß$ since the discarding of packages is one of the main consequences of congestion in networks of commutation of packages and is very common to use probability distributions to construct $q_ß$

This process needs information the profile of the process of the incoming traffic, the process of transmission, as large as the buffer and of the disciplines of the tails. Our model will be based on a scene with the following characteristics: there are N constant rate sources, the packets size is variable, the buffer size is z_p packets and the queuing discipline is FIFO.

Under these characteristics the upper bound of congestion q_p can be expressed like an approach of the model of queue ND/D/1 proposed by Vitarmo in [14], as follows:

$$q_p = \frac{2j\, z_p}{2z_p (j - z_p) - j \ln(a)}$$

Where a is specified packet discard probability. Therefore, the model considers the space priority. If j is very great in relation to the size of the buffer, then the above model becomes the simplified form:

$$q_p = \frac{2z_p}{2z_p - \ln(a)} \quad (13)$$

With these approaches proposed BCA model must be solved by technical of programming nonlinear procedure, because the equation 13 depends on the factor nonlinear $\ln(a)$.

The CFA Model has some interesting characteristics for an additional analysis; it is defined by a set of separable constraints. If we used the equality constraint to replace the inequality of equation 9, then x_p can be expressed in terms y_p and q_p. Consequently, we have obtained a reduced capacity assignment model; here capacity includes also the buffer size. Furthermore, if we are able to decompose g_b into each path, denoted as g_p, then an analytical solution is available. The details are presented as follows:

Minimize $U_p = a_p y_p + b_p z_p$ (14)

Subject to $x_p / y_p = q_p$ (15)

$x_p = g_p$ (16)

Substituting 13,15 and 16 into 14

$$U_p = a_p g_p \left(1 + \frac{|\ln(a)|}{2z_p}\right) + b_p z_p$$

Let the derivative of Up be zero, and then we have the optimal solution:

$$y^* = g_p + \sqrt{\frac{b_p g_p |\ln(a)|}{2a_p}} \quad (17)$$

$$z^* = \sqrt{\frac{a_p g_p |\ln(a)|}{2b_p}} \quad (18)$$

The normalized forms are:

$$\frac{y^* - g_p}{\sqrt{g_p}} = \sqrt{\frac{b_p |\ln(a)|}{2a_p}} \quad (19)$$

$$\frac{z^*}{\sqrt{g_p}} = \sqrt{\frac{a_p |\ln(a)|}{2b_p}} \quad (20)$$

Where

- a The specified packet-discard probability.
- y* Optimal capacity of path p.
- z* Optimal buffer size.
- φ Constant sources.
- x Percentage variation the congestion.

5. Results

In this section, we evaluated the link congestion in the proposed model and we compared it with the conventional model.

5.1. Tunnel congestion

One of our objectives is reduce the congestion in the LSP in MPLS network, that is to say, minimize r that represents the maximum number of tunnels on all links. In order to obtain this objective we evaluated the model proposed in section 2 in the network shown in the fig 3, which has 20 nodes and 39 links. The capacity of each link will be limited between 0 y 5 ∀ i, j. The ingress flows F1, F2, F3, F4 and F5, will be respectively: 5, 2, 3, 4, 1 and the egress flows F6, F7, F8, F9 and F10 will be: -4, -3,-3, -2, -3. To analyze theoretically the optimization levels we used "Integrated Development Environment (GAMS)" program version 2, which is a tool that helps to solve equations of linear programming (LP) and no linear programming (NLP).

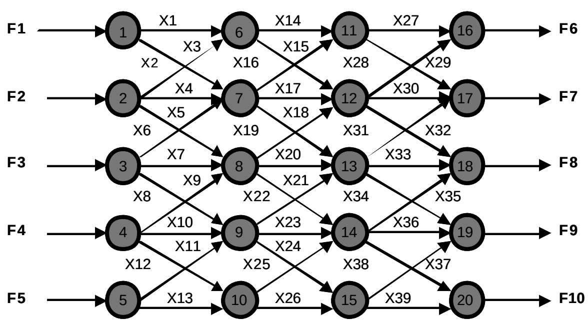

Figure 3: MPLS Network

Table 1 shows normalized congestion values order in each network link without optimizing (R) and optimized with the proposed model (r). Threshold to indicate if one link is congested or not is 1, all the links with values equal or superior to it have congestion.

In fig 4 you can to observe that there are 6 connections that exceed the value of the threshold (X5, X8, X9, X16, X22 and X25), what indicates that several resources of the network to evaluate are congested, therefore, traffic delays take place as well as the loss of packets. As a consequence the network services experiment reduction of prediction capacity.

When implementing the proposed model we verified a reduction of the congestion between 15% and 78 %, in the 6 links mentioned before.

Table 1
Congestion in each link

e	r	R	x (%)	e	r	R	x (%)	e	r	R	x (%)
X1	*0,921	0,723	-27,426	**X14**	0,203	0,772	73,737	**X27**	*0,202	0,160	-26,231
X2	*0,738	0,603	-22,421	**X15**	0,200	0,384	48,255	**X28**	*0,672	0,448	-49,822
X3	0,176	0,498	64,626	**X16**	0,604	1,152	47,591	**X29**	*0,838	0,728	-15,029
X4	*0,405	0,366	-10,846	**X17**	0,272	0,872	68,784	**X30**	0,196	0,756	74,071
X5	0,835	1,049	20,367	**X18**	0,198	0,494	59,781	**X31**	*0,681	0,444	-53,238
X6	*0,617	0,383	-61,070	**X19**	0,215	0,893	75,903	**X32**	0,379	0,690	45,016
X7	0,410	0,921	55,474	**X20**	*0,748	0,421	-77,176	**X33**	*0,831	0,541	-53,553
X8	0,893	1,165	23,296	**X21**	0,445	0,527	15,684	**X34**	0,502	0,537	6,3687
X9	0,257	1,188	78,293	**X22**	0,932	1,120	16,819	**X35**	*0,709	0,426	-66,549
X10	0,352	0,946	62,719	**X23**	0,466	0,820	43,171	**X36**	*0,428	0,375	-14,313
X11	*0,813	0,526	-54,483	**X24**	*0,419	0,255	-64,092	**X37**	*0,404	0,354	-14,294
X12	0,120	0,598	79,949	**X25**	0,846	1,010	15,9766	**X38**	0,189	0,460	58,832
X13	0,139	0,256	45,911	**X26**	0,525	0,754	30,391	**X39**	0,193	0,819	76,406

In the table 1 we can observe (marked with one *) increase of load in 19 links between 10 % and 77 %. The negative sign near the percentage of congestion (x) indicates that when applying the model of optimization in that connection the load increases respect to its original value.

This is consequence of a better balance of load in links that were being underutilized, without getting to congest them, see Fig.4.

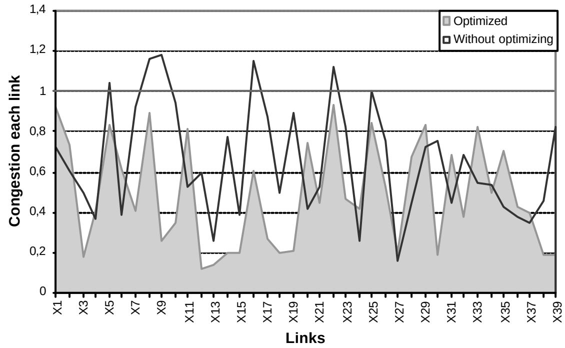

Figure 4: Congestion in each link

5.2. Distribution of the Capacities

In order to calculate the capacity and the optimal distribution of the flow in network links of figure 3 ACB model was implemented in GAMS. Fig 5 shows the results of the normalized optimal distribution of the path capacity (y*) based on the relation of cost ap / bp. We can emphasize that the path capacity gets to be insensible at the variation of quotient ap / bp when this is greater of 1, indicating the capacity decreases scarcely rate that stays almost constant in relation to the costs. This is due the cost relation begins to increase when the probability of losses of packets (a) begins to increase slightly and in this way the path capacity stay almost at constant level.

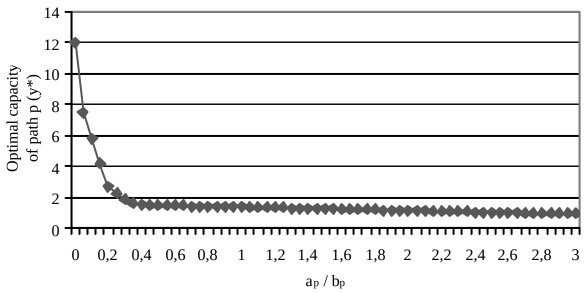

Fig. 5 Distributions of optimal path capacities in functions ap / bp

Fig 6 shows the optimal size of the normalized buffer (z*). When ap / bp relation begins to increase, the optimal distribution the capacities also begins to increase, which implies that it's less expensive than path transmission, this behavior is a indicative that probability of loss diminish and therefore it will require a great buffer size, reason why has facility for the allocation of the flow in the links, this behavior is a indicative of improvement in the QoS.

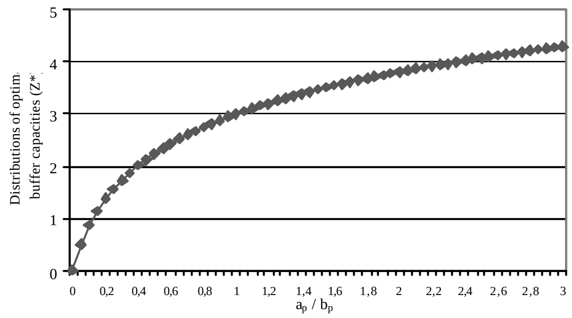

Fig. 6 Distributions of optimal buffer capacities in functions a_p / b_p.

Fig 7 shows the capacity of the optimal path normalized (y*) in function the probability of discarding a packet. In this figure it is deduced a capacity increase in proportion with that increases the neperian logarithm of losses probability, which indicates that the congestion in the connections diminishes until the capacity arrives at the maximum value, the number of the path in the network, taking into account the restriction that not exceeding the maxima capacity of the link.

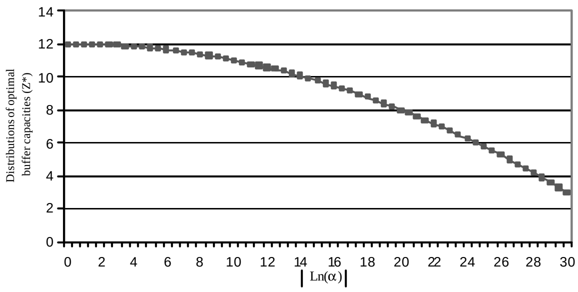

Fig. 7 Distribution of optimal path capacities in functions of loss probability.

Fig 8 shows an opposite behaviour, since the optimal distribution capacities of the normalized buffer (z*), begins to diminish as the neperian logarithm of the probability of loss of packets begins to increase, this must the traffic flow in the links begins to distribute of uniform way in all the network, which is a indicative of the minimization of the congestion, because the proposed model adds improvements to model CFA.

Another advantage that offers model ACB is the appropriate approach to obtain the optimal configuration of the LSP. It is possible to be formed the routes and optimized the resources of the network in real time whenever one becomes in the incoming node of the network. Despite for implementations in real time, the time of processing must be shortest possible. To grief that proposed objective function in the model considers the parameter of the capacities of the trajectory and the single buffer, the diminution in the time of the calculation is also an important solution in the propose technique.

Simultaneous optimization of multiple constraints generally increases the complexity of the routing algorithm to high levels. It has been shown that finding an LSP based on two or more constraints (i.e. delay and jitter) on any of the likely combinations, generates a NP-complete problem.

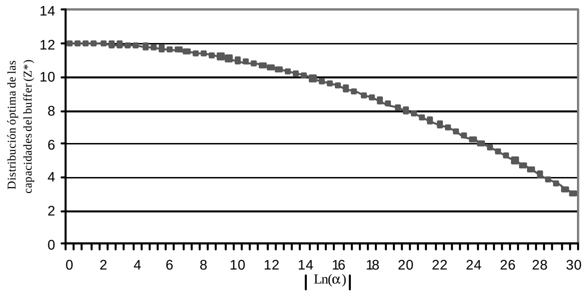

Fig. 8 Distributions of optimal buffer capacities in functions of the probability of losses.

6. Conclusions

MPLS technology is a good approach to solve current data network problems because it has high performance, scalability and QoS management by mean of congestion reduction based on Traffic Engineering concepts. This article presents an Optimization model which support QoS by mean of congestion minimization on the MPLS network LSPs. Our proposed BCA model reduce costs on path capacities by mean of buffers and take into account the buffer size for the analysis. Simulation results show that under our model, traffic flows on links are uniformly distributed on the network. As a result, we obtain a congestion reduction. Therefore, our model improves the CFA model.

As future work, we want to use this model for multi-classes traffic to distinguish priorities of trajectories based spaces. These spaces attach the same origin-destination couple. Under this assumption, we want to analyze the congestion minimization, the costs and calculation time by mean of the inside point algorithm.

7. Acknowledgments

This work was supported by CICYT Project grant TIC2003-08129-C02.and under a Grant from the Spanish Educational Ministry and the European Commission EuroNGI Network of Excellence, cost 293.

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