A Solution for Integrating MPLS over ATM[1]

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Abstract. *Multiprotocol Label Switching* (MPLS) is an advanced forwarding scheme, which allows the network to achieve the *Traffic Engineering* (TE) objectives. When two or more MPLS nodes are connected via an ATM backbone merely composed of ATM switches, it is necessary to add some mechanisms to allow the label distribution and allocation between both nodes. In this paper a new solution is proposed to allow the PNNI capacities to be used as a topology transport protocol. Along with the use of the Proxy PAR, it will be possible to transport the MPLS labels through an ATM cloud until they reach the border nodes connected to MPLS domains.

1 Introduction

The Internet must support a lot of different data from different users, all having very diverse characteristics and needs. With the current growth in communications, some new technologies have appeared that enable users to get certain services from the net, such as videoconferences and, in general, all the services that need real time traffic, and which are supported by the old net structure.

To be able to access these new services we need to develop some mechanisms that allow us to ensure certain *Quality of Service* (QoS) on the net. Generally, we can understand this as the allocation of concrete values, for several parameters, in the data path from the transmitter to the receiver, in order to get a good performance. To make it possible it is necessary to both, find the data path and have mechanisms in place to perform the values allocation.

When we analyze the first issue carefully we realize that, up to now, the routing decisions have been taken without considering the QoS required by the application nor even the available resources on the network. Thus, it is necessary to setup mechanisms to make the path selection according to the QoS required by the application. This is known as the QoS routing.

Finally, to carry out the value allocation it is necessary to solve two problems:

- all the nodes in the path must have some mechanisms to support the QoS,
- we need a protocol to achieve the QoS end-to-end.

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To solve the first problem, different classes of services exist. Actually, these only specify the appropriate parameters needed to get the desired QoS. To solve the second problem, we have different protocols. Currently, there are two models: *Integrated Services* [1] and *Differentiated Services* [2]. The *Resource Reservation Protocol* (RSVP) [3] is the protocol used in the Integrated Services framework. RSVP is useful, but it has a major problem: it is not a scalable protocol for managing a great number of flows. However, it would be a good mechanism to be used as a signaling protocol.

The IETF has defined one more method to solve the QoS problem*: Traffic Engineering* (TE) [4]. TE is the mechanism used to control the traffic flow to achieve both, the optimization of the network performance, and the resource utilization, so that the network will never be congested. Consequently, if there is no congestion in a network, its performance may be good.

It might be thought that with an important handling of the routing metrics, it could be possible to control the traffic distribution, but this could only be possible in small networks. Therefore, TE is more important in networks where multiple alternative paths are available.

Multiprotocol Label Switching (MPLS) [5] is an advanced forwarding scheme which allows the network to achieve the TE objectives.

There are some works on the interface between MPLS and the different protocol architectures currently established such as ATM [6,7] or Frame Relay [8]. In these references, the label distribution and allocation are analyzed according to different link levels. When the MPLS sends a message requesting a label for a flow through a network, it is routed based on the routing algorithm placed in it. Nevertheless, if the network topology is ATM, to make it possible every switch must be under a router, which allows the IP routing to be done.

A problem exists when two MPLS nodes are connected via several switches ATM. Since there are no routers, the connectivity via MPLS between both MPLS nodes is not possible. Therefore, in order to achieve MPLS connectivity, it is necessary to add some mechanisms to allow the label distribution and allocation between both nodes. A new mechanism based on ATM protocols is proposed in this paper. The *Private Network-Network Interface* (PNNI) [9] is the standard routing protocol over ATM, defined by the ATM Forum, and that the *PNNI Augmented Routing* (PAR) [10] is an extension of the last one. Moreover, an additional set of optional protocols called Proxy PAR has been defined to allow a client that is not PAR-capable to interact with a server that is PAR-capable and thus obtain the PAR capabilities. The server acts as a proxy for the client in the operation of PAR. The client is able to register its own services, and query the server to obtain information on compatible services available in the ATM network.

With the solution offered in this paper, the PAR will work as a *Label Distribution Protocol* (LDP)[11].

The remainder of this document is organized as follows. In section 2, we propose a new solution that allows the PAR to be used as a LDP. In section 3, we are going to view an example where our suggestions are implemented. Section 4 shows the results obtained from the simulations carried out. Finally, in section 5 we present the conclusion and future works.

2 The ProxyPAR-Label Switching Router Solution

In order to set up a *Label Switched Path* (LSP), a mechanism is necessary to allow the label distribution along the path, known as LDP. However, this makes sense only when the domain is completely MPLS, i.e., all the devices are Label Switching Router (LSR), which are capable of supporting a signaling protocol such as RSVP, running as an LDP. Therefore, when this is not the case, the LDPs that are used in a completely MPLS domain, cannot be used, e.g. an ATM backbone merely composed of ATM switches and ATM SVC. In this paper, a new solution is proposed to allow the PNNI capacities to be used as a topology transport protocol. Along with the use of the Proxy PAR, it will be possible to transport the MPLS labels through an ATM cloud until they reach the border nodes connected to MPLS domains.

Firstly, the border node architecture will be defined. This node is named *Proxy PAR Capable Label Switching Router* (PPAR-LSR) and it is composed of (Fig.1):

– an LSR performing both the routing functions of the network layer and the typical MPLS functions. A Proxy PAR client is added to register and to obtain information about the Proxy PAR server,
– an ATM switch utilizing the PAR protocol, with the Proxy PAR server installed,
– a forwarding table setting up the relationship between MPLS labels and ATM outgoing interfaces.

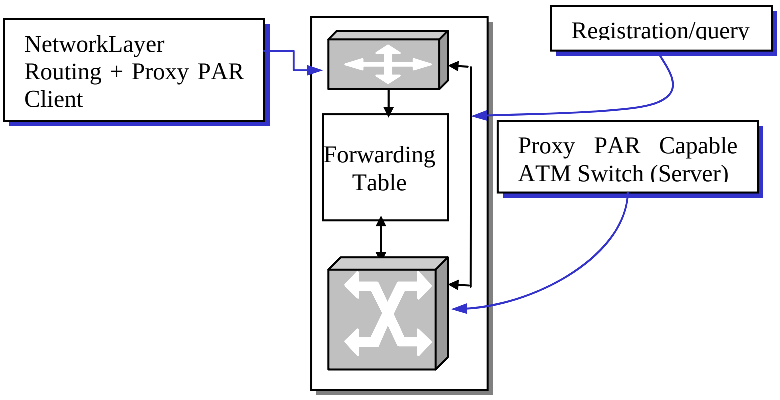

Fig. 1. PPAR-LSR architecture

PAR SPECIFIC IG. The Information Groups to set up the communication between PAR-capable devices are described in [10]. Table 1 summarizes the Information Group types used. The list only includes the IG types used by PAR. The types of IGs defined for PNNI can be found in [9].

The addition of a new type is proposed: type 792 named PAR MPLS Services Definition IG needed in the PAR Services IG (768) which is defined in Table 1.

Table 1. Information Group Summary

C	IG Name	Nested in
768	PAR Service IG	PTSE (64)
776	PAR VPN ID IG	PAR Service IG (768)
784	PAR IPv4 Service Definition IG	PAR VPN ID IG (776) / PAR Service IG (768)
792	**PAR MPLS Services Definition IG**	**PAR Services IG (768)**
800	PAR IPv4 OSPF Service Definition IG	PAR IPv4 Service Definition IG (784)
801	PAR IPv4 MOSPF Service Definition IG	PAR IPv4 Service Definition IG (784)
802	PAR IPv4 BGP4 Service Definition IG	PAR IPv4 Service Definition IG (784)
803	PAR IPv4 DNS Service Definition IG	PAR IPv4 Service Definition IG (784)
804	PAR IPv4 PIM-SM Service Definition IG	PAR IPv4 Service Definition IG (784)

PAR MPLS Service Definition IG. In order to distribute information about MPLS services, the MPLS Service Definition IG has been proposed in Table 2. The IG contains all necessary information about the MPLS (IP address Destination and label) and a bitmask to indicate the protocols and services bound to MPLS. It is expected that some IGs may be defined in the future that can be embedded in the PAR MPLS Service Definition IG.

This new PAR IG will be loaded into a *PNNI Topology State Element* (PTSE) and, along with the rest of the PTSEs, will set up a *PNNI Topology State Packet* (PTSP). This PTSP will be flooded through the ATM topology.

Table 2. PAR MPLS Service Definition IG

Offset	Size (bytes)	Name	Function/Description
0	2	Type	Type=785 (PAR MPLS Service Definition IG)
2	2	Length	
4	4	IP address	The IP address or IP address prefix Dest.
8	4	MPLS Label	
12	8	Service Mask	Bitmask of registered services.

3 Scenario

We are going to view an example where our suggestions are implemented. In Figure 2 a scenario is shown. Two Autonomous Systems, a terminal and a Local Area Network (LAN) are all connected to an ATM backbone formed by only one hierarchy level (level 40). BR1, BR2, BR3 and BR4 are the PPAR-LSRs proposed above. The PAR is used in the ATM cloud only as topology information protocol. The MPLS is implemented in both the border routers of the ASs and the terminals. A label distribution between BRs is intended so that an LSP can be setup from or to any point of the scenario, as if it were an MPLS topology. Firstly, the clients have to execute a registration sequence as follows:

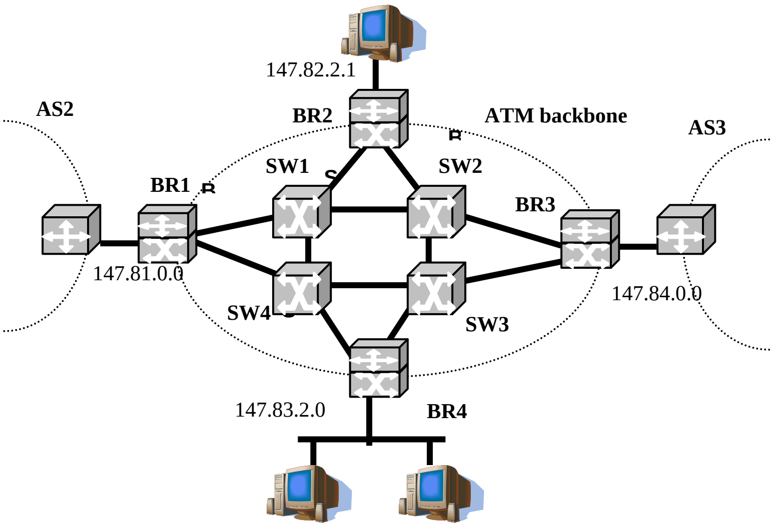

Fig. 2. MPLS over ATM Backbone

1. BR1 registers MPLS protocol with label 0.20 and destination address prefix 147.81.0.0.
2. BR2 registers MPLS protocol with label 0.50 and destination address 147.82.2.1.
3. BR3 registers MPLS protocol with label 0.40 and destination address prefix 147.84.0.0.
4. BR4 registers MPLS protocol with label 0.30 and destination address prefix 147.83.2.0.

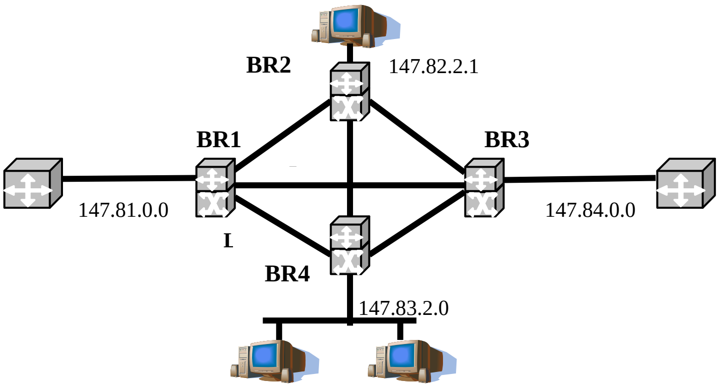

Fig. 3. MPLS topology

Each server bundles its state information in PTSE. PTSEs are encapsulated within PTSP and this is sent to a neighboring peer. The PTSE contains the PAR MPLS Services Definition IG with MPLS label and IP address. Each server side generates an MPLS topology database with the information received.

Each client uses the query protocol to obtain information about services registered by other clients. The result is as shown in Figure 3. The MPLS database will be made up of the following (table 3):

– FECs (Forwarding Equivalence Classes): each one is an IP address reachable by the node,
– interface out: the ATM address of a PPAR-LSR,
– label out: each one is associated with an FEC. These labels should be piggybacked on the packets at the precise instant in which they are forwarded.

Table 3. Routing tables of network elements

	@IP Dest	**@ATM**	**Label Out**		**@IP Dest**	**@ATM**	**Label Out**
BR1				BR3			
	147.82.2.1	@BR2	0.50		147.82.2.1	@BR2	0.50
	147.84.0.0	@BR3	0.40		147.81.0.0	@BR1	0.20
	147.83.2.0	@BR4	0.30		147.83.0.0	@BR4	0.30
BR2				BR4			
	147.81.0.0	@BR1	0.20		147.82.2.1	@BR2	0.50
	147.84.0.0	@BR3	0.40		147.84.0.0	@BR3	0.40
	147.83.2.0	@BR4	0.30		147.81.0.0	@BR1	0.20

In this way, when an LDP used to perform the label distribution reaches a BR, only a new input label associated with an input interface should be generated. This new label is bound with both the required destination address and, of course, the corresponding output label.

4 Results

Once the PTSEs are grouped to form PTSPs, they are flooded throughout the peer group. All nodes in one peer group will have identical topology database consisted of a collection of all PTSEs received, which represent that node’s present view of the PNNI routing domain. In particular the topology database provides all the information required to compute a route from the given node to any address reachable in or through that routing domain.

In order to know when the database topology stability is reached, i.e. the state where each of the PNNI routing protocols have reached an operating mode, some simulations are performed. We have used the ATM PNNI Routing Protocol Simulator (APROPS) [12] and we assume the following:

- Each node has the same node processing time for the same packet type, and each physical link has the same delay. The default node processing time for Hello packet, Database Summary packet, PTSE Request packet, PTSP packet are 0.1, 0.3, 0.5 and 0.5 second, respectively. The default link delay is 0.0001 second. The default Hello interval value is 15 seconds.

- One PTSP bundles all database information stored in a node; each node has the same PTSE refresh interval. PTSE refresh interval is 1,800 second.
- All nodes and links are active at once, and the starting global clock is 0.0 seconds
- All topologies have a single peer group with no routing hierarchy.

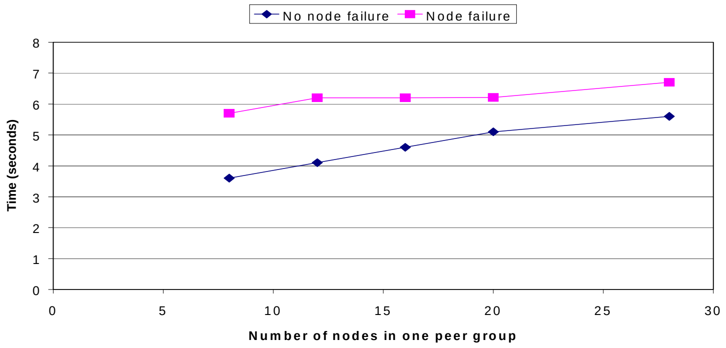

Fig. 4. Database Synchronization

The time required to complete the database synchronization, based on the number of nodes within a single peer group, is shown in Figure 4. We have simulated two cases: 1) a node failure occurs and is then restored (failure time: 1 sec. Restore time: 2 sec.) and 2) node failure does not exist.

The amount of data required to complete the database synchronization is shown in Figure 5, where the two cases presented above are considered.

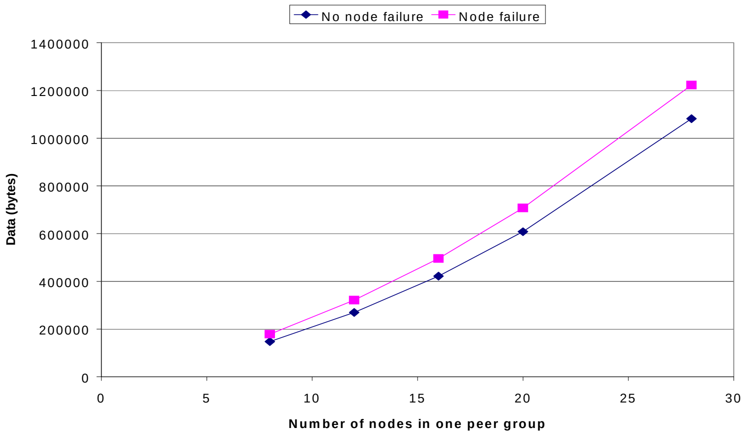

Fig. 5. Total Data

5 Conclusions and future works

Up to now, an MPLS node has always been performed as an ATM-LSR, i.e. a *Label Switching Router* (LSR) with an ATM switch in the link layer. It only carries out level 2 functions.

This paper has proposed a solution to running MPLS through ATM cloud where all the internal nodes are ATM switches without LSRs. In order to achieve our aims, the *Proxy PNNI Augmented Routing-LSR* (PPAR-LSR) border node has been introduced. Switches and PPAR-LSR make use of *Private Network-Network Interface* (PNNI) flooding in order to distribute MPLS information. Proxy PAR and PAR provide automatic discovery and therefore a simplified configuration facility. With this suggestion, the encapsulation and transport of a signaling protocol (e.g.. RSVP) used as an LDP through an ATM cloud is avoided. The labels will be in the PPAR-LSRs when the LDP requests it.

A future work will be the mapping between FECs of MPLS and ATM service classes to guarantee that the data flow forwarded through an ATM cloud has the Quality of Service requested.

References

[1]Shenker, S., Wroclawski, J. “General Characterization Parameters for Integrated Service Network Elements”, RFC 2215, September 1997

[2]Blake, S. Et al. “An Architecture for Differentiated Services”, RFC 2475, December 1998

[3]Braden, R et al., “Resource Reservation Protocol (RSVP)-Version 1, Functional Specification”, RFC 2205, September 1997.

[4]Awduche, D.O., et al. “Requirements for Traffic Engineering Over MPLS”, RFC 2702, September 1999.

[5]Rosen, E., et al. ”Multiprotocol Label Switching Architecture”, Internet draft< draft-ietf-mpls-arch-05.txt>, April 1999.

[6]Bruce Davie et al. “MPLS using LDP and ATM VC Switching”, Internet draft<draft-ietf-mpls-atm-02.txt>, April 1999.

[7]Wimer, W. “MPLS Using RSVP and ATM VC Switching”, ”, Internet draft<draft-wimer-mpls-atm-rsvp-00.txt>, June 1999.

[8]Conta, A., et al. “Use of Label Switching on Frame Relay Networks”, Internet draft<draft-ietf-mpls-fr-03.txt>, November 1998.

[9]ATM Forum. “Private Network-Network Interface Specification Version 1.0”, af-pnni-0055.000, March 1996.

[10]ATM Forum. “PNNI Augmented Routing (PAR) Version 1.0”, af-ra-0104.000, Jan. 1999.

[11]Anderson, L., et al. “LDP Specification”, Internet draft<draft-ietf-mpls-ldp-05.txt>, June 1999

[12]Song, Y., “The NIST ATM PNNI Routing Protocol simulator (APRoPS), Operations and Programming Guide”, December 1998.