A Study on Bandwidth Provisioning Mechanism using ATM Shortcut in MPLS Networks

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Abstract: This paper addresses how to be connected with end-to-end shortcut using ATM Switched Virtual Connection (SVC) in ATM-based Multi-Protocol Label Switching (MPLS) Networks. Without additionally existing ATM Ships-in-the-Night (SIN) mode, when the stream is continuously transmitted at the same destination with the lapse of determined aging time, the connection is changed with end-to-end shortcut connection using ATM signaling. An ATM direct short circuit is performed an IP and ATM effective integration. An ATM shortcut has a number of advantages, like higher throughput, shorter end-to-end delay, reduced router load, better utilization of L2 Quality of Service (QoS) capabilities, and route optimization. In particular between other MPLS domains, this can be efficiently improved the performance of networks.

1. Introduction

Until now, the Internet, which is growing very fast, struggles to cope with an ever-increasing number of users and traffic volume, only provides Best Effort Service and isn't satisfied with user's various Quality of Service (QoS). While ATM networks has the advantage of various QoS supports but don't take an interest in users for service absences. In order to supplement these defects, researches on IP transmission service technologies using ATM switching and high-speed layer 2 switching technology were in progress. As the result of these researches, Multi-Protocol Label Switching (MPLS) technology is emerged.

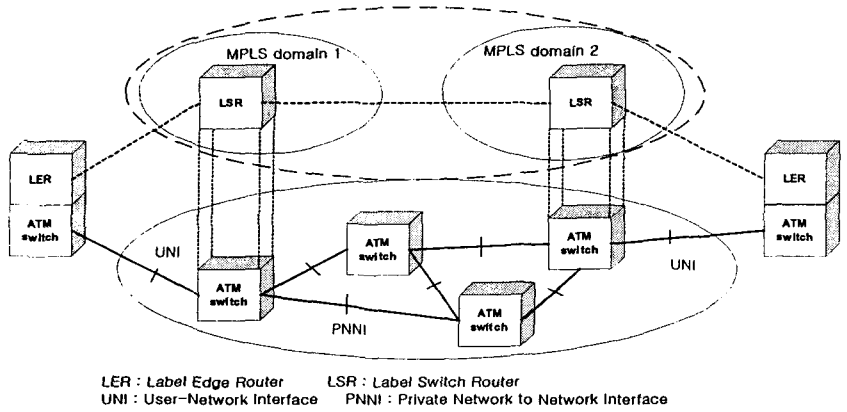
MPLS is the best solution so as to be able to integration IP connectionless routing and ATM connection-oriented switching functions. Namely, through MPLS, IP layer deals with destination address disposition operations and then, through ATM switching, ATM shortcut is used for the best path selection with the address. An ATM shortcut refers to the ability to forward network layer packets (L3) directly at the link layer (L2), regardless of the existing network boundaries. This has a number of advantages, like higher throughput, shorter end-to-end delay, reduced router load, better utilization of L2 QoS capabilities, and route optimization. [1] Also, ATM switch using User-to-Network Interface (UNI)/Q.2931 signaling and MPLS switch using Constraint-Based Label Distribution Protocol (CR-LDP) is together integrated in the same switch fabric architecture. In the end, expectation effects are enlarged.

MPLS is the convergence of the Internet's routing and label switching paradigm. As a result, it has many advantages of performance improvement, scalability, flexibility, QoS support. While it is propagated through hop-by-hop routing and causes looping problems, so it is restricted in routing and causes the sequence problems. ATM can effectively merge IP using a direct short circuit and high-speed cell switching functions. While it has a problem in IP address mapping, but insufficient Virtual Connections (VCs) problem can be solved with MPLS flow concepts. Without additionally existing ATM Ships-in-the-Night (SIN) mode [2], when the stream is continuously transmitted at the same destination with the lapse of determined aging time, like the Broadcast Unknown Server (BUS) of LAN Emulation [3], an initial connection between Label Edge Router (LER) and Label Switch Router (LSR) is changed with end-to-end shortcut connection using ATM Switched Virtual Connection (SVC). This method can be easily connected in shortcut without additional address resolution process.

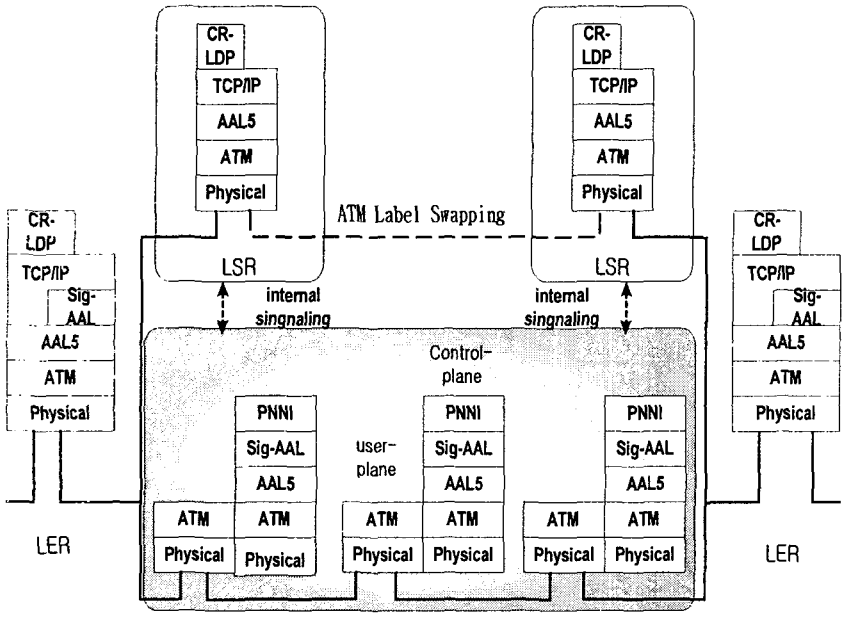
This paper explains MPLS network model and protocol reference model for a direct shortcut connection in section 2. Section 3 addresses the system architecture and operation procedure in suggested networks. Section 4 presents many implementation problems, considerations, expectation effects, the future study directions, and so on. Finally, our conclusion and a summary are in presented in section 5.

2. MPLS Network Model and Protocol Reference Model

Routers are at the very core of the Internet, handling millions of packets per second. Nevertheless, the future Internet will need much more forwarding capacity than today's routers can handle. So, the author regards shortcut routing as an appropriate solution to the bottlenecks already being encountered on the Internet. To achieve shortcut connection, it must be replaced the ATM-based core router with IP router based. ATM is a connection oriented switching networking technology. Paths are established between end points by reserving resources along the switching path. ATM technology is more complex and more expensive than IP routing, and does not interact well with other networking technologies, because it is designed assuming that only ATM equipment will be used and it is therefore not flexible. Some telecom operators have however made huge investments in ATM switching equipment, and many efforts to achieve flexible deployment of ATM networks in the Internet, using IP as a network layer technology have been made. MPLS arises from this problem, and presents a simple solution to the integration of different transport technologies with different network layer protocols [4].



(Figure 1) MPLS network model for ATM shortcut connection



(Figure 2) MPLS network protocol reference model

(Figure 1) illustrates the general network model of MPLS/ATM core network. ATM switch-based MPLS networks are composed of Label Edge Routers (LERs) and Label Switching Routers (LSRs). The LER is located at the edge of the ATM core network as MPLS aware ingress/egress router. The LER performs full functions of Layer 3 and label binding based on LIB (Label Information Base) generated by running CR-LDP. The LER is connected to interior LSRs. The LSR performs label swapping based on LIB. LSP (Label Switched Path) between LERs or LER and LSR is set up using CR-LDP. The LSR also reserves the resources for QoS and holds packet-handling information. [5]

Between LSRs, Label swapping using ATM SVC/Permanent Virtual Connection (PVC) is performed. If end-to-end shortcut routing algorithm, which is the best optimized method to configure a forwarding bypass route and can be directly forwarded IP packets at link layer without neighborhood conditions of networks, is used, can especially optimize network performance and resource utilization between other MPLS domains.

(Figure 2) illustrates the reference model for shortcut communication flows using ATM signaling. It must have the mechanism that can be mutually interfaced between existing MPLS protocol and ATM signaling, and QoS mapping functions and additional internal signaling between LSR and ATM signaling.

To achieve traffic engineering requirements and inter-operability in a multiple service provider and vendor environment, ITU-T choose CR-LDP signaling method as a standard. It is an extension from LDP and uses the same messages and mechanisms as LDP for peer discovery, session establishment and maintenance, label distribution and error handling. Also it runs on the reliable TCP transport and is readily scaleable and resembles ATM architecturally and is targeted towards Differentiated Services (DiffServ). [6]

Individually, MPLS domain uses IP routing protocol, but ATM uses Private Network to Network interface (PNNI) [7] routing algorithm for shortcut routing. Afterward if Integrated PNNI (I-PNNI) witch can be used IP router and ATM switch simultaneously is used, it may be operated a little more easily.

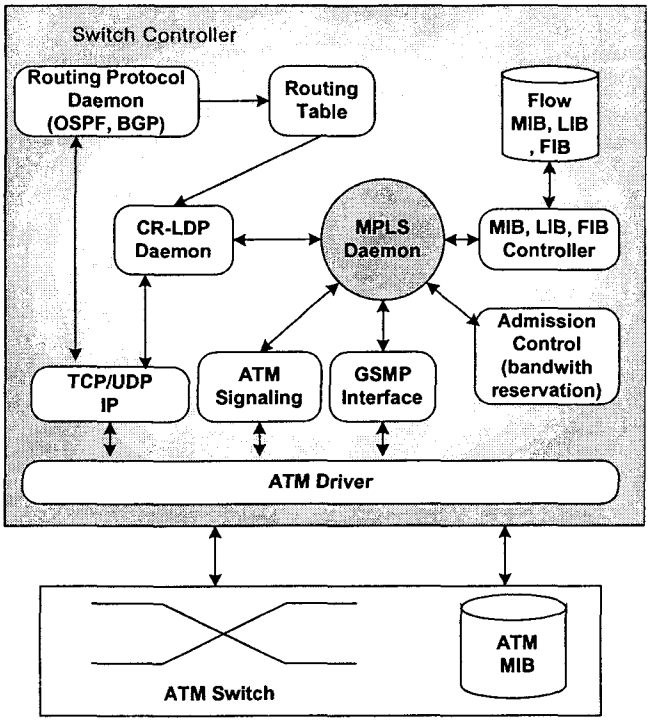
3. MPLS System Architecture and Operation Procedure

MPLS router system architecture is illustrated in (Figure 3). In order to accommodate ships-in-the-night mode, ATM switch based MPLS router system is made up of existing ATM signaling protocol and MPLS daemon which are the heart of this system. After when MPLS networks are composed, the routing table is built in Routing Information Protocol (RIP), Open Shortest Path First (OSPF), Border Gateway Protocol (BGP), etc. Thereafter label is assigned/distributed with CR-LDP daemon. The CR-LDP daemon maintains the mapping information of ingress label and egress label as Label Information Base (LIB) table, forwarding engine generate routing table based Forwarding Information Base (FIB), exchange LDP Protocol Data Unit (PDU) with peer LDP in base of LIB table which is created with FIB and LDP, and interface to the MPLS daemon.

Flow Management Information Base (MIB) is the database for maintaining flow related information, such as pre-flow traffic statistics and path information for aggregated flows. This information is needed for resource management. Flow MIB controller is responsible for monitoring the LSR and its flows. It collects statistics which are useful for evaluating the local resources.

Switch controller is required to manage and control the ATM switch which forms part of the ATM LSR. Functions such as VC establishment and release, dynamic QoS negotiation, request of switch statistics and configuration information, etc, need to be supported. For

this purpose, some kind of general purpose management protocol must be used. An example of such a protocol is Ipsilon's General Switch Management Protocol (GSMP). The MPLS router use GSMP interfaces for the purpose of controlling ATM switch.



(Figure 3) MPLS Router System Architecture [8]

Admission control is used to find out whether available resources are sufficient to supply the requested QoS. It needs additional agent functions in order to connect in shortcut.

So as to connect in ATM shortcut in MPLS networks, we propose the following method. In a short-lived flow, it is used a label swapping using CR-LDP. In a long-lived flow which remains at the same destination for some time, it is translated to end-to-end shortcut circuits thorough ATM SVCs using ATM signaling. The proposed method can enlarge the performance of networks. In particular, the above ATM shortcut gets rid of the delay resulted from label swapping between other MPLS domains.

In ATM based MPLS networks, a call setup is made up of cell switching using VPI/VCI values which are the resources of Label Control-ATM (LC-ATM) allocated to be based on admission control according to forwarding information. It uses connection-oriented TCP sessions to distribute the forwarding information between LDP peers. At this time, when the stream is continuously transmitted at the same destination with the lapse of determined aging time, LER sets up an end-to-end shortcut connection using SVC and transmits a LC-ATM release massage through the new configured paths. This procedure changes from existing MPLS call to ATM shortcut call connection, and updates the VC table. The call conversion massage procedure uses interfaces between CR-LDP and ATM signaling function through MPLS daemon.

MPLS call release processes are executed in the following situations, that is, when LDP session is closed due to LDP peer eliminations, timer expires or errors, and when FIB route information changes due to FEC changes, and when label release massages are received. Also it may be released due to release commands through network managements. The ATM shortcut follows an inherence ATM signaling procedure.

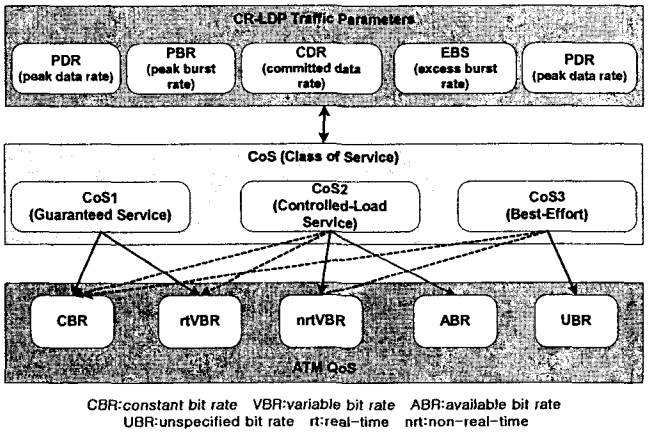
4. Implementation Concerns

4.1 Mutual Interfaces

In the side of mutual interfaces in the proposed networks, MPLS uses the label, which is a physical interface, as VPI/VCI, which is the logical interface of ATM. That is, MPLS inherits the ATM hardware label (VPI/VCI) switching. So ATM switch resources (VPI/VCI, bandwidth, etc) must be divided and shared fairly without mutual interference between MPLS and ATM. So MPLS daemon must have a resource management mechanism and can be solved it using switch partitioning functions.

4.2 QoS (Quality of Service)

From the viewpoint of QoS, CR-LDP has five traffic parameters [9] in order to be applied to traffic engineering as illustrated in (Figure 4). So this technology delivers the traffic engineering capability and QoS performance to enable the support of differentiated service. Also Through mapping Class of Service (CoS) to ATM traffic class and bandwidth allocations, this can easily guarantee a complete QoS with ATM shortcut. At this time, a selected ATM Transfer Capability (ATC) must be satisfied with traffic parameter requirements and allocated bandwidths according to flow traffic characteristics



(Figure 4) ATM QoS mapping relation

4.3 Data Transmission

When it is connected with end-to-end shortcut in LER, it may occur sequence problems between the data transmitting through LSP via LSRs and the data transmitting through the new configured paths, that is, shortcut paths. In order to prevent this problem, it needs data integrations between MPLS using transmission through LSP and ATM using transmission shortcut paths, and must be guaranteed the data pureness to protect packet loss due to cell interleaving.

4.4 Operation

CR-LDP has primitives needed call setup/release and ATM also has primitives so as to communicate thorough ATM signaling. Accordingly, it needs primitive mappings and parameter conversions between CR-LDP and ATM.

A call release after data transmission using CR-LDP occurs the following cases. First, with the lapse of some time, operations are stopped on account of interrupts and unused states. Second, when the stream is continuously transmitted at the same destination with the lapse of determined aging time, a connection is changed with ATM shortcut. The last, the resource table is overflow. We must consider when to close the connection in ATM shortcut with resource table shared.

4.5 Address Resolution

In the side of addressing, dynamic address resolution isn't required because this already determined through registration steps during ATM switch installing. But the future, for the purpose of supporting mobility, it is required additional functions in order to bind between Home Agent (HA) and Foreign Agent (FA).

4.6 Virtual Private Network (VPN) Service

In the side of service, The VPN service is the foundation service used for deploying or administering value-added services including applications and data hosting network commerce, and telephony services to business customers. This service has QoS support and multicast requirements in order to solve high costs, ineffective management problems in existing private networks, and widely used on large scale in an enterprise, and also has a bright prospect as one of major application services in a next generation gap. As a result, this can use QoS routing which is one of MPLS major advantages, provide a connection oriented service, be made up of flexible VPN logical networks using dynamic tunneling functions. [6]

To provide VPN service using ATM shortcut, it is required the security of data holding existing private network, tunneling in order to protection user group, user authentications, and resource controlling functions.

4.7 Network Management

In the side of network management, MPLS system is controlled by Telecommunication Management Network (TMN) management system for ATM switch and General Switch Management Protocol (GSMP) interface. So it needs a resource management system to control several systems simultaneously

4.8 Performance Analysis

From the viewpoint of performance analysis, when mapped IP flow to ATM connection, it need to study bandwidth reservation algorithms and traffic control methods using Connection Admission Control (CAC) and scheduling.

5. Conclusion

In my opinion, MPLS networks are the best solution for integration IP and ATM from the viewpoint of scalability, flexibility and QoS support. As suggested by this paper, A shortcut connection in ATM based MPLS networks supplements a weak point of MPLS and ATM, and the same time, provides bandwidths through the ATM signaling between other MPLS domains and consequently give a number of advantages, like higher throughput, shorter end-to-end delay, reduced router load, better utilization of L2 QoS capabilities, and route optimization. Many points of view, this paper presents many implementation problems and considerations. It must be founded the solutions about the above points

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