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APPLICATION NUMBER: 60/197,006**FILING DATE: April 13, 2000****PRIORITY
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PROVISIONAL APPLICATION COVER SHEET

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This is a request for filing a PROVISIONAL APPLICATION under 37 CFR 1.53(c).

DOCKET NO.		P05101US00		TYPE A PLUS SIGN (+) INSIDE THIS BOX →		+	
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TITLE OF THE INVENTION (280 characters max)							
NETWORK RESOURCE OPTIMIZATION METHOD AND APPARATUS							
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STATE	VA		ZIP CODE	22202		COUNTRY	USA
ENCLOSED APPLICATIONS PARTS (check all that apply)							
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X	A check in the amount of \$150 to cover the filing fee is enclosed.			Check No. 16506		PROVISIONAL FILING FEE	\$150
	The Commissioner is hereby authorized to charge the filing fee and credit Deposit Account No.:			25-0120			

☒ Additional Inventors are being named on separately numbered sheets attached hereto.

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

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April 13, 2000

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1. Name of the Invention

Network resource optimization method and apparatus

2. Inventor(s)

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3. Background

Within the Internet community there are several initiatives towards improving different aspects of the Internet. Some of the major issues are: (1) extending the service model, (2) routing and forwarding efficiency and scalability, and (3) operations and management.

All of these are important to the continued growth and success of the Internet. This document describes a combination of two emerging technologies, Multiprotocol Label Switching (MPLS) [5], [10] and Bandwidth Brokers (BB), which have great potential in the context of all three mentioned issues.

This section briefly describes the two technologies. MPLS is undergoing standardisation in the IETF while there is currently no formal effort to standardise Bandwidth Brokers. Today, Bandwidth Brokers with diverse functionality are developed by researchers and participants in the Internet2 QBone project[6].

3.1 MPLS

The MPLS working group of the IETF was started in response to the label-switching trend among router vendors back in 1997. At the time, there existed several proprietary implementations and the need for standardisation was identified.

MPLS is a method which integrates the label-switching forwarding paradigm with network layer routing. In MPLS, connection-oriented switching is provided based on IP routing and control protocols.

In short, MPLS operates as follows:

- Labels are associated with specific streams of data (known as Forwarding Equivalence Classes, or FECs).
- The labels and their FEC bindings are distributed across the network, that is the MPLS domain, to establish a label switched path.
- Entering the domain, packets are assigned one or more labels (a stack of labels).
- Passing through the domain, packets are forwarded based on labels.

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Core components of MPLS are semantics of labels, forwarding methods and label distribution methods.

3.2 Bandwidth brokers

The cost-efficiency of IP networks is partly achieved through the connection-less traffic model resulting in efficient resource-sharing. However, this model does not allow for quality guarantees, without additional functionality for service differentiation in network devices. In recent years such functionality has become common, and static QoS (Quality of Service) configurations with it. By introducing a bandwidth broker into the network QoS policy management can be handled in a more flexible way.

A bandwidth broker is an entity in a network domain that manages policies for bandwidth resources. By maintaining a database of the domain's resources it provides admission control decisions on QoS service requests. It is also responsible for configuring the network to meet the granted policies. It may be able to communicate with bandwidth brokers in neighbouring domains, allowing QoS services spanning several domains.

For further information on Bandwidth Brokers please refer to [9].

4. State of the Art

This section gives a brief overview of how MPLS and Bandwidth Brokers are used today, and what can be achieved by using them.

4.1 MPLS

Using label switching techniques such as MPLS, network operators have powerful tools at hand to create efficient network engineering solutions. For example, label switched paths (LSP) can be set up based on traffic patterns to achieve load sharing on multiple links where destination based routing would have used one single link.

The LSPs are set up by distributing labels throughout the domain. Within the IETF, a protocol called Label Distribution Protocol (LDP) [1], is standardised for this purpose. LDP is used between two neighbouring MPLS routers to exchange information on the label bindings they each have made.

Using the core components of MPLS with methods available today, the major advantages lie in forwarding efficiency and the ability to clearly separate inter- and intra-domain routing (by using stacks of labels). Separating inter- and intra-domain routing is an important issue to many network operators since it greatly simplifies operations and management of the intra-domain routing infrastructure.

The following subsections describe efforts which combines MPLS with other technologies to achieve greater benefits.

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resources available in the interior of the network. Today, there are two main approaches for provisioning:

- A top-down approach, in which the network administrator studies the network topology and traffic routing and computes the provisioning requirements. This requires explicit knowledge of the network topology.
- Use signaling to automate the process. For example, RSVP messages could be launched along the paths that will be followed by submitted quantitative traffic. This is however not feasible with reservations in advance.

5. Problem

There are some major limitations in the currently available best practices using MPLS and Bandwidth Brokers. In the MPLS case the problem lies in selecting the paths for setting up LSPs, while Bandwidth Brokers are limited to managing resources on paths as selected by network layer routing.

Looking at the MPLS issue, achieving high resource utilisation by setting up LSPs requires good knowledge of the state of the network. It is very hard to make the decisions on how to aggregate data streams into FECs and how to set up LSPs to achieve optimal resource utilisation.

The Bandwidth Broker problem is that even though it has the information needed to compute alternate paths for flows which cannot be admitted along the network layer routing paths, it lacks the mechanism to set up such paths.

6. Solution

5 Solutions

A topology-aware Bandwidth Broker, which keeps track of admitted resources and the per-link resource usage has the detailed overall view of the domain needed to select paths for MPLS LSPs. MPLS, on the other hand, provides the means for a Bandwidth Broker to set up alternate paths through the domain.

The combination of the techniques has great potential in making each of the two components much more powerful in a complete QoS system.

6.1 Using MPLS for route pinning in QoS networks

When using a topology-aware Bandwidth Broker that does admission control per link in its domain, the Bandwidth Broker knows exactly how much resources that are admitted on every link. In normal operation when a path-sensitive Bandwidth Broker receives a

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request for admission it will compute the path through the network based on the source and destination address and the routing protocol in use. If there is not enough resources left over on one or more links along the default network layer routing path, a Bandwidth Broker using MPLS can provide alternative paths through the domain. If an alternative path with enough resources is available, it can use the "route pinning" functionality of MPLS to set up the new path through the domain for this traffic. Through this method traffic can be distributed over several parallel paths, to increase throughput. It can also be used to balance the load over several paths, i.e., load balancing. Notice that a Bandwidth Broker with support for advance reservations can set up the MPLS paths in advance to the reservation start time.

6.2 Using Bandwidth Brokers for path selection in MPLS

The path selection methods used by a network operator is at the core of producing high quality services for customers, while still maintaining cost-efficiency in the network. Keeping this simple assessment in mind, it is clear that path selection methods will need to be based on good knowledge of the network as well as traffic patterns.

A resource management system with the capabilities to set up and manage LSPs in an MPLS domain has the potential of being a very important component for network operators. The solution proposed herein is to use a Bandwidth Broker, such as described by [11], as the path-selecting entity in MPLS domains. The Bandwidth Broker is equipped with the means to engage LSP set up (that is, label distribution) and the available information in it is used for traffic engineering purposes in addition to admission control. It must also be informed of the amounts of traffic in each FEC entering the domain.

Knowing the topology and the set of LSPs, the Bandwidth Broker is the one node which can keep track of resource usage on a per-link basis. Having this knowledge in one node provides great benefits in optimising overall resource utilisation. It can, ahead of time, compute alternate paths through a domain and by doing so anticipate the need to distribute traffic load on several paths. It is also possible to re-route existing LSPs as the result of increased load or other changes in resource usage. Another great benefit is that the Bandwidth Broker can make use of recent history to set up LSPs ahead of time.

7. Merits of the Invention

The Invention will optimize the network usage due to the combination of MPLS and Bandwidth Brokers.

8. Enclosures

[1] Andersson et al, LDP Specification, <draft-ietf-mpls-ldp-05.txt>, Internet draft, June 99.

[2] Awduche et al., Extensions to RSVP for LSP Tunnels, Internet draft, <draft-ietf-mpls-rsvp-lsp-tunnel-05.txt>, February 2000.

[3] Blake et al, An Architecture for Differentiated Services, RFC 2475.

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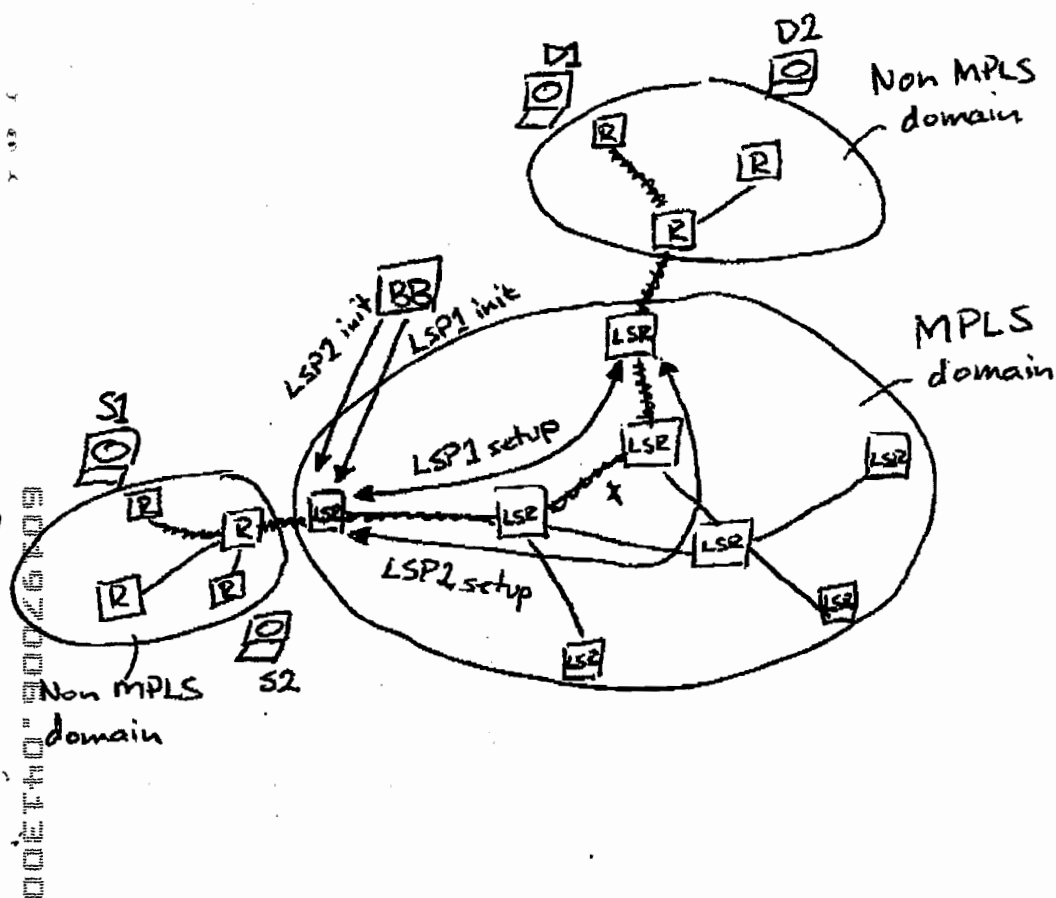
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1. An LSP, LSP1, is set up for a QoS data stream between S1 and D1. The network-layer routing path is used for this LSP. The path used between S1 and D1 is marked in the figure.
2. S2 and D2 wishes to set up a QoS data stream between their sites. The BB, which has all the information, needs to set up LSP2, which does not share all the links with LSP1, in order to meet the request. The BB computes the alternate path for LSP2 and makes sure the labels are distributed.