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Implementation of Multiple protocol Label Switching in FreeBSD

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ABSTRACT

In the case of traditional IP network the packet may take any path to reach its destination but MPLS allows the integration of IP to layer 2 technologies(such as ATM) by overlaying a protocol on top of IP networks. Network router equipped with special MPLS software process MPLS labels contained in the Shim Header. Raw IP traffic is presented to the LER, where labels are pushed; these packets are forwarded over LSP to labels and successfully delivers the IP packets to the desired destination.

MPLS is networking protocol used for routing information quickly and efficiently which is extensively used in internets backbone networks. basic functionality of sending and receiving packets in an efficient manner along with label swapping is the main goal of the project.

2.1 Introduction to Multi Protocol Label Switching

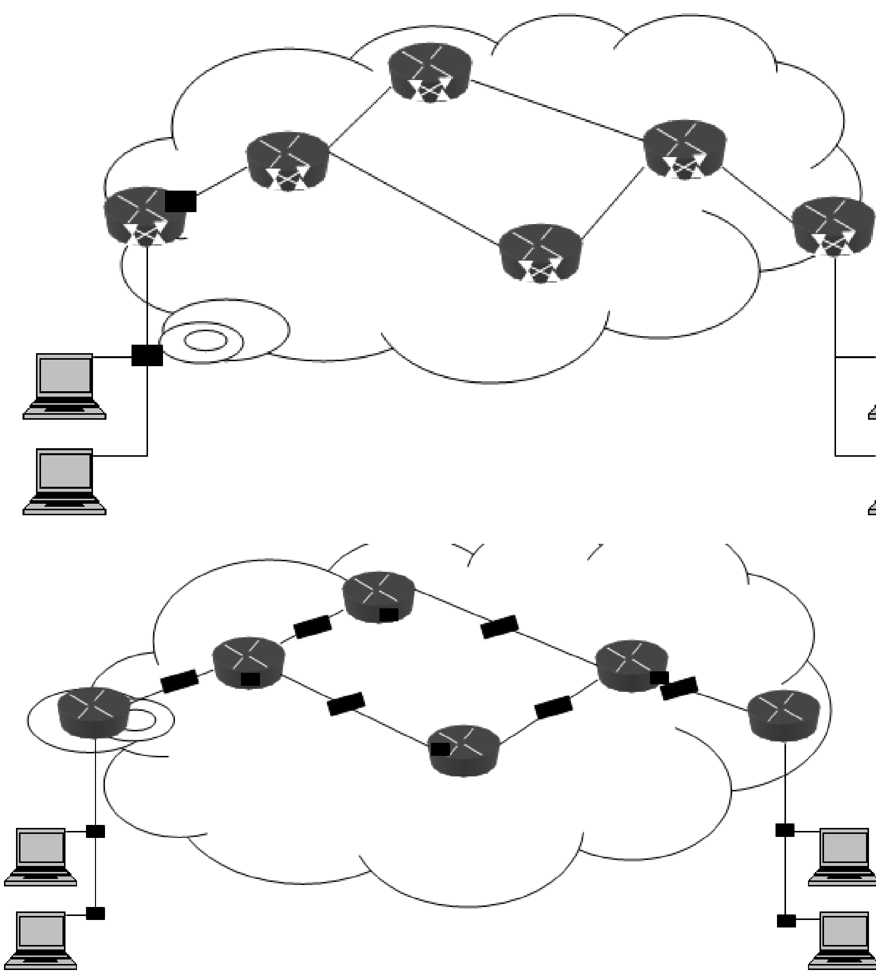
MPLS allows for the integration of IP to layer 2 technologies (such as ATM) by overlaying a protocol on top of IP networks. Network routers equipped with special MPLS software process MPLS labels contained in the Shim Header. Raw IP traffic is presented to the LER, where labels are pushed; these packets are forwarded over LSP to LSR where labels are swapped. At the egress to the network, the LER removes the MPLS labels and marks the IP packets for delivery.

2.1.1 The Construction of an MPLS Network

In an IP network, you can think of routers as post offices or postal sorting stations. Without a means to mark, classify, and monitor mail, there would be no way to process different classes of mail. In IP networks, you find a similar situation. Figure 1 below shows a typical IP network with traffic having no specified route.

Figure 1: An IP Network

In order to designate different classes of service or service priorities, traffic must be marked with special labels as it enters the network. Special routers called LER (Label Edge Routers) provide this labeling function (Figure 2). The LER converts IP packets into MPLS packets, and MPLS packets into IP packets. On the ingress side, the LER examines the incoming packet to determine whether the packet should be labeled. A special database in the LER matches the destination address to the label. An MPLS shim header (Figure 3) is attached and the packet is sent on its way.



IP with an with

Figure 2: Network LERs and IP packet Shim header attached

To further explain the MPLS shim header, let's look at the OSI model[13]. Figure 3 (a) shows OSI layers layer 7 through layer 3 (L7-L3) in black and layer 2 (L2) in white. When an IP packet (layers 2-7) is presented to the LER, it pushes the shim header (b) between layers 2 and

3. Note that the shim header is neither a part of layer 2 or layer 3 but however, it provides a means to relate both layer 2 and layer 3 information.

The Shim Header (c) consists of 32 bits in four parts – twenty bits are used for the label, three bits for experimental functions, one bit for stack function, and eight bits for time to live (TTL). It allows for the integration of ATM (a layer-2 protocol) and IP (a layer-3 protocol).

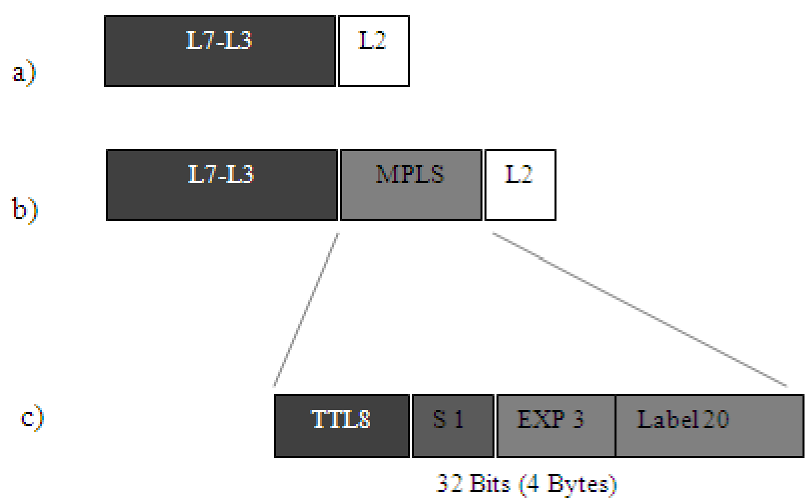


Figure 3: The MPLS Shim Header and Format

A shim-header[5] is a special header placed between layer two and layer 3 of the OSI model. The shim header contains the label used to forward the MPLS packets. In order to route traffic across the network once labels have been attached, the non-edge routers serve as LSR (Label Switch Routers). Note that these devices are still routers. Packet analysis determines whether they serve as MPLS switches or routers. The function of LSR is to examine incoming packets. Providing that a label is present, the LSR will look up and follow the label instructions, and then forward the packet according to the instructions. In general, the LSR performs a label swapping function. Figure 4 shows LSR within a network.

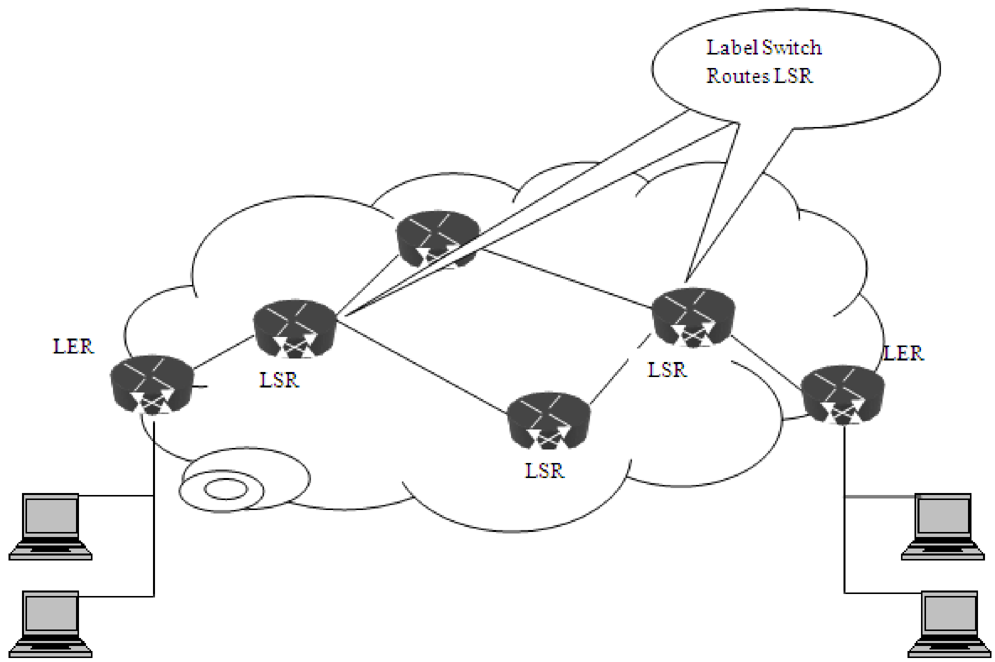


Figure 4: LSR (Label Switch Routers)

Paths are established between the LER and the LSR. These paths are called LSP (Label Switch Paths). The paths are designed for their traffic characteristics. The traffic-handling capability of each path is calculated. These characteristics can include peak traffic load, inter-packet variation, and dropped packet percentage calculation.

Figure 5 shows the LSP established between MPLS-aware devices. Because MPLS works as an overlay protocol to IP, the two protocols can exist in the same cloud without interference.

In the construction of an MPLS network, the LER adds and/or removes (pops or pushes) labels. The LSR examines packets, swaps labels, and forwards packets, while the LSP are the pre-assigned, pre-engineered paths that MPLS packets could take. With

MPLS, we can have the LER sort your packets and place only your highest priority traffic on the most expensive circuits, while allowing your routine traffic to take other paths.

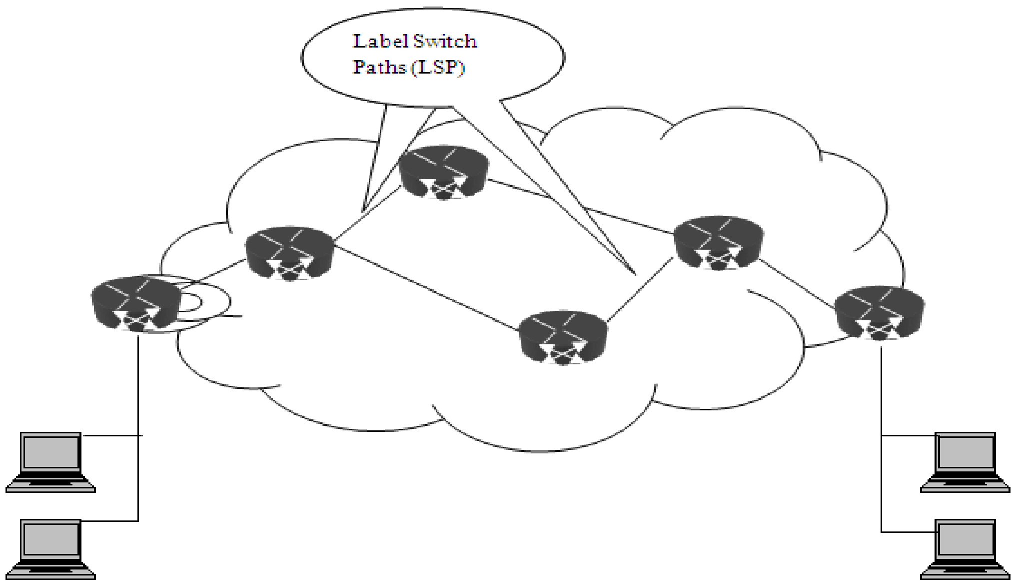


Figure 5: LSP (Label Switched Paths)

2.2 MPLS Label Distribution

The MPLS switches must also be trained – they must learn all the rules and when to apply them. Two methods are used to make these switches. One method uses hard programming; it is similar to how a router is programmed for *static routing*. Static programming eliminates the ability to dynamically reroute or manage traffic. Modern networks change on a dynamic basis. To accommodate this need, many network engineers have chosen to use the second method: dynamic signaling and label distribution. Dynamic label distribution and signaling can use one of several protocols, with each its given advantages and disadvantages

At a minimum, MPLS switches must learn how to process packets with incoming labels. Sometimes this is called a *cross-connect table*. For example, label 101 in at port A will go out port B with a label swapped for 175. The major advantage of using cross-connect tables instead of routing is that cross-connect tables can be processed at the "data link" layer, where processing is considerably faster than routing. We will start our discussion using a simple network with four routers. Each router has designated ports. For the sake of illustration, the ports have been given a simple letter a, b, s, h, a, and e. These port identifications are router specific. The data flows from the input a of r1 to the input of r4. This basic network diagram will be enhanced as we progress through MPLS signaling.

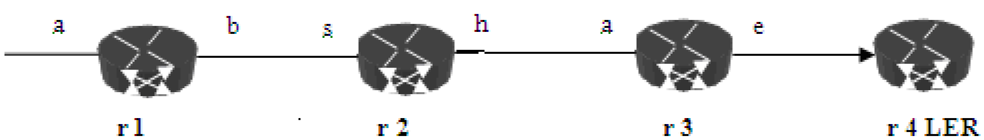


Figure 6: Basic MPLS Network with 4 Routers

2.2.1 Control of Label Distribution

There are two modes used to load these tables. Each router could listen to routing tables, make its own cross-connect tables, and inform others of its information. These routers would be operating independently. *Independent control* occurs when there is no designated label manager, and when every router has the ability to listen to routing protocols, generate cross-connect tables, and distribute them.

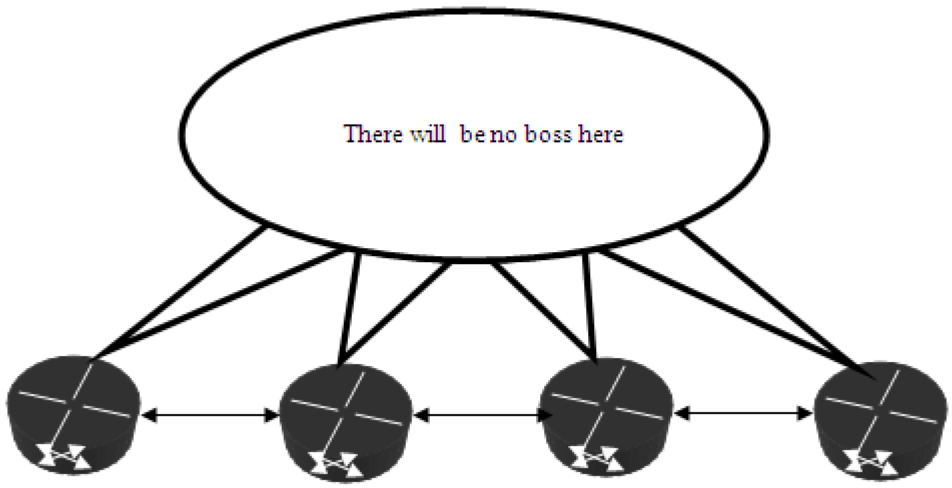


Figure 7: Independent Control

The other model is *ordered control*. In the *ordered control* mode, one router – typically the egress LER – is responsible for distributing labels. Each of the two models has its tradeoffs. Independent control provides for faster network convergence. Any router that hears of a routing change can relay that information to all other routers. The disadvantage is that there is not one point of control making traffic, which makes engineering, more difficult.

Ordered control has the advantages of better traffic engineering and tighter network control however, its disadvantages are that convergence time is slower and the label controller is the single point of failure.

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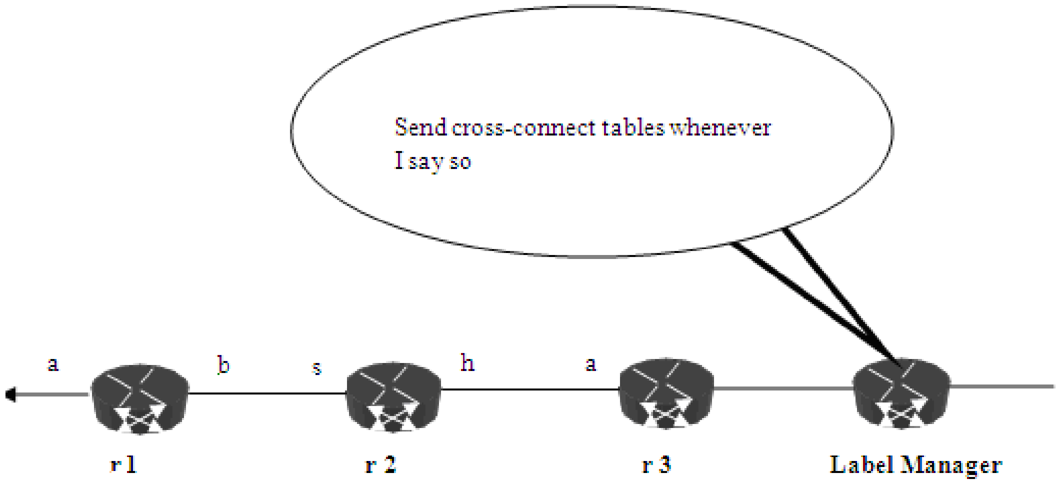

Figure 8: Ordered Control (pushed)

2.2.2 The Triggering of Label Distribution

Within ordered control, there are two major methods to trigger the distribution of labels. These are called down-stream unsolicited and down-stream on demand.

DOU

We saw the labels "pushed" to the down-stream routers. This push is based upon the decisions of the label manager router. When labels are sent out unsolicited by the label manager, it is known as *down-stream unsolicited* (DOU). For example: The label manager may use a trigger point (such as a time interval) to send out labels or label refresh messages every 45 seconds. Or, a label manager may use the change of standard routing tables as a trigger – when a router changes, the label manager may send out label updates to all affected routers.

DOD

When labels are requested, they are "pulled" down or demanded, so this method has been called *pulled or down-stream on demand* (DOD). Note that in the first step the labels are requested and in the second step the labels are sent.

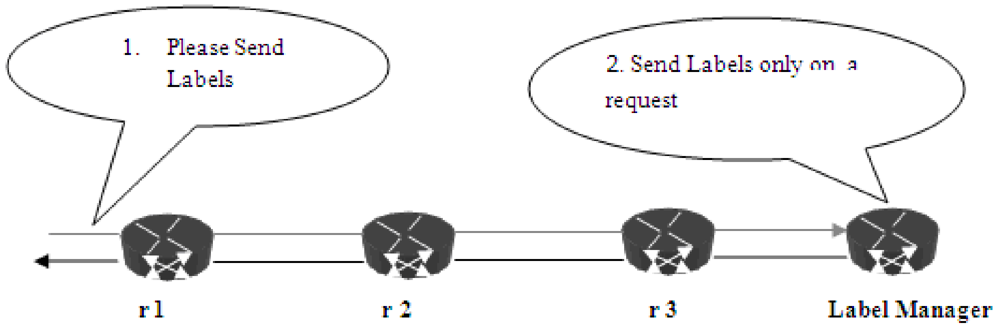

Figure 9: Down-stream on Demand (DOD)

Whether the labels arrive via independent or ordered control via DOD or DOU, the *label switch router* (LSR) creates a cross-connect table similar to the one shown in Figure 11. The connect tables are sent to router r3 to r1. The tables heading read: label-in, port-in, label-out, port-out, and instruction (I). In this case, the instruction is to swap (s). It is important to note that the labels and cross-connect tables are router specific.

After the cross-connect tables are loaded, the data can flow from router 1 to router 4 with each router following its instructions to swap the labels.

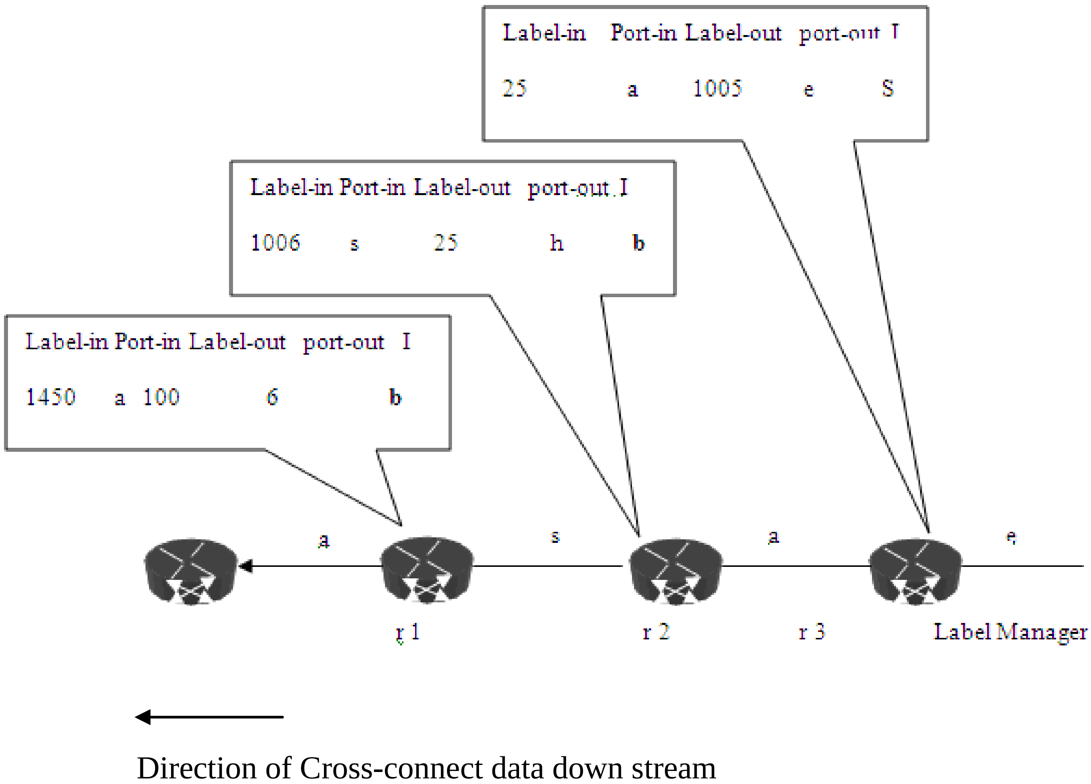

Figure 10: LSR with Cross-connect Tables Populated

The *label switch router* (LSR) creates a cross-connect table similar to the one shown in Figure 11. Here the connect tables are sent from router r3 to r1. The tables heading read: label-in, port-in, label-out, port-out, and instruction (I). In this case, the instruction is to swap (s). It is important to note that the labels and cross-connect tables are router specific. In a traditional ip network routing tables plays vital role but here cross-connect tables do play a vital role.

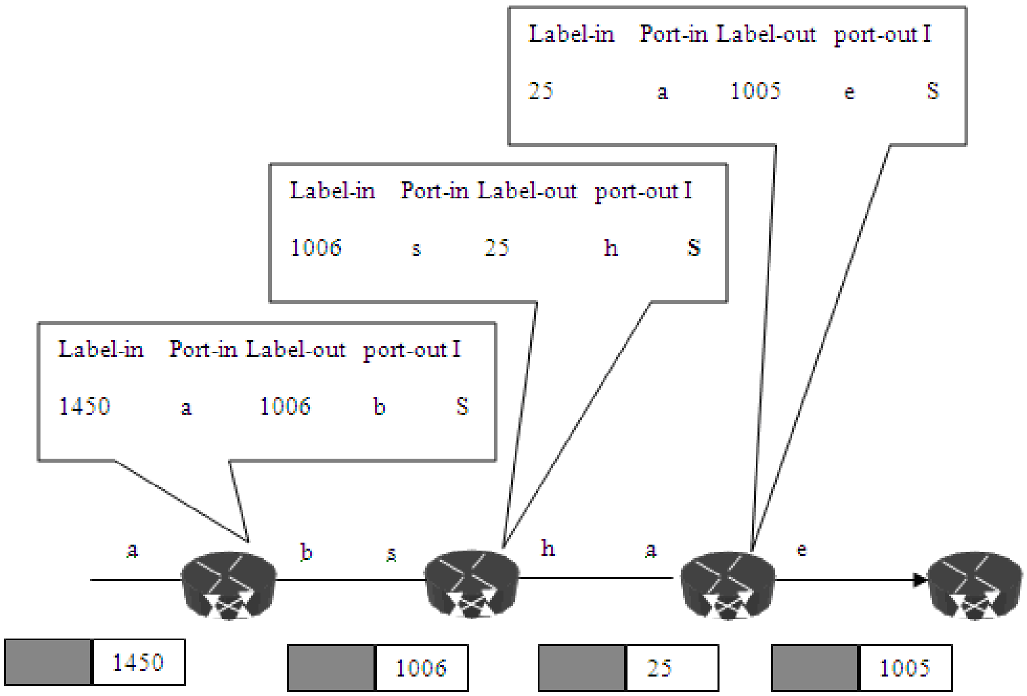

Figure 11: Data Flow on LSP

After the cross-connect tables are loaded, the data can now follow a designated LSP (label switch path) and flow from router 4 to router 1. Here the cross-connect tables do play a vital role during the time of routing as these tables are to be verified by each and every router upon the delivery of an ip/mpls packet to successfully deliver the packet to the desired destination. The table consisting of Label-in is the label that is before switching/swapping and Label-out is the label that is after switching/swapping.