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Supporting Quality of Service in IP multicast networks

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Abstract

Developers and providers of data, voice and video applications have to satisfy numerous Quality of Service (QoS) requirements and cope with different architectures emerging to provide these QoS in the Internet. IntServ, DiffServ or MPLS are technologies currently used in different administrative domains in the Internet to provide QoS. With multicast applications emerging, such as video conferencing, distance learning and tele surgery, it has become almost impossible to provide end-to-end QoS over multiple administrative business domains without interworking these technologies. This paper analyses general issues on supporting QoS for multicast applications and reviews different ways to implement IP multicasting in IntServ, DiffServ or MPLS based networks. Subsequently, network configurations based on these different architectures and their interworking to provide end-to-end QoS are also discussed.

Keywords: IntServ; DiffServ; MPLS; Quality of Service; Multicast

1. Introduction

Quality of Service (QoS) has become quite important in the Internet in recent years. In the beginning, the Internet was used to transmit only data and all the data were treated with the same service level, the Best Effort (BE), although IP protocol was designed to support different classes of service. Today data, video, audio and mission critical applications are merged together and send over the same network. Networks are now required to treat these applications different because users may like to pay more to an Internet Service Provider (ISP) for a better service or as another example a minimal level of performance must be guaranteed to mission critical applications. These are achieved by different QoS requirements that provide the necessary bandwidth resources, controlled latency and jitter required by interactive traffic and improve data loss characteristics of the network [1]. Some new applications, video conferencing, distance learning, network gaming, not only require QoS but also use multicasting technology.

Multicasting [2,3] provides a way to save bandwidth compared to the use of several unicast channels in some applications by duplicating multicast flows only to the multicast tree branches. Multicasting technology sends traffic to one or group of receivers on the network at the same time and also lessens the server load. Unlike unicast routing protocol, which maintains a same shortest path for a certain $<$source, destination$>$ pair, multicast routing protocol has to find one or more network topologies for a given group. The topology can be either shared-based tree where the source does not matter, e.g. Protocol Independent Multicast, Sparse Mode (PIM-SM, where the tree is referred as Rendezvous Point Tree RPT) and CBT (Core-Based Tree); or source specified tree, e.g. DVMRP (Distance Vector Multicast Routing Protocol), PIM-DM (Protocol Independent Multicast, Dense Mode) and PIM-SM. Source tree is usually referred as Shortest Path Tree (SPT). DVMRP and PIM-DM use flood-and-prune to establish multicast tree, whereas PIM-SM and CBT join/leave group explicitly. It should be noted that multicast also makes the network complicated because of the dynamic group joining / leaving and uncertain destination address.

Multiple Protocol Label Switching (MPLS), Integrated Services (IntServ) and Differentiated Services (DiffServ or DS) are widely used to provide QoS in IP networks. MPLS [4–6], developed by the Internet Engineering Task Force (IETF) working group, provides fast Internet traffic delivery by using label switching. It integrates label

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swapping with network layer routing and provides an approach to let network administrators implement Traffic Engineering and other features. MPLS supports multiple protocols in both data link layer (L2) and network layer (L3). Generic MPLS adds a shim header between the headers of L2 and L3. In an MPLS-capable network, ingress routers label the traffic based on Forwarding Equivalence Class (FEC), and core routers check the label to forward the traffic to next node. At egress node the label is removed and the traffic is restored to original. This pushes the complexity to edge routers, leaving the core routers simple to implement fast forwarding.

IntServ [7] was introduced to obtain QoS based on per-flow. Different applications can choose different controlled services to deliver their packets. Although IntServ gets more granularity, the routers have to maintain per-flow state and are generally not considered to be scalable. RSVP (Resource ReSerVation Protocol) [8,9] is a signaling protocol used by IntServ to set up resources in the sender to receiver direction.

DiffServ [10] is more scalable than IntServ because the implementation of DiffServ is based on per-class. In DiffServ domain, edge routers classify the packets based on DiffServ Code Point (DSCP) and meter, mark, delay or drop traffic according to Traffic Conditions Specification (TCS). However, core routers need to only check the DSCP to obtain QoS parameters. DiffServ needs support of IP protocol because DSCP field substitutes the ToS (Type of Services) field in IPv4 or the CoS (Class of Services) field in IPv6.

This paper considers issues of supporting QoS for multicast applications. Sections 2, 3 and 4 respectively focus on IntServ, DiffServ, and MPLS technologies to support multicast. Section 5 presents an end-to-end multicast support across DiffServ and IntServ networks. Interworking between IntServ and MPLS to support multicast is given in Section 6. Interworking between MPLS and DiffServ is explained in Section 7. The problems related to interworking between DiffServ and MPLS to support multicast are also presented here. In Section 8 the conclusive remarks and directions of future work in this area are given in brief.

2. IntServ and multicast support

IntServ was developed with the need of real time applications, such as teleconferencing and remote seminars. It provides an Internet service model that includes BE, real time and controlled link sharing and is inherently capable of supporting multicast. IntServ architecture [8] separates two function units, one for implementing or controlling QoS and another for signaling requests. There are two main QoS in IntServ, Guaranteed Service (GS) and Controlled-Load Service (CLS). Signaling is implemented by RSVP, however QoS control service is opaque to RSVP.

IntServ is application-based and provides per flow QoS. RSVP [9] cooperates with both unicast and multicast routing protocols. Resource reservation is implemented by RSVP Path and Resv messages. Since RSVP is receiver-oriented, receivers of the same multicast group in the SPT or RPT make resource reservation requests upstream towards the sender. These requests must be merged in the replication routers for scalability. RSVP provides three reservation styles, Fixed Filter (FF), Shared Explicit (SE) and Wildcard Filter (WF). Because RSVP routers have to maintain per flow soft state along the path, reservation overhead is logarithmic and RSVP is less scalable.

3. DiffServ and multicast support

Expedited Forwarding (EF) and Assured Forwarding (AF) are two main classes of QoS defined in DiffServ networks. Supporting multicast in DiffServ introduces some issues [10] that are not presented in unicast applications. Fig. 1 shows multicast application in the DiffServ network. The number of receivers in multicast group may change frequently because users join/leave group dynamically. It cannot be predicted in advance how much resources is

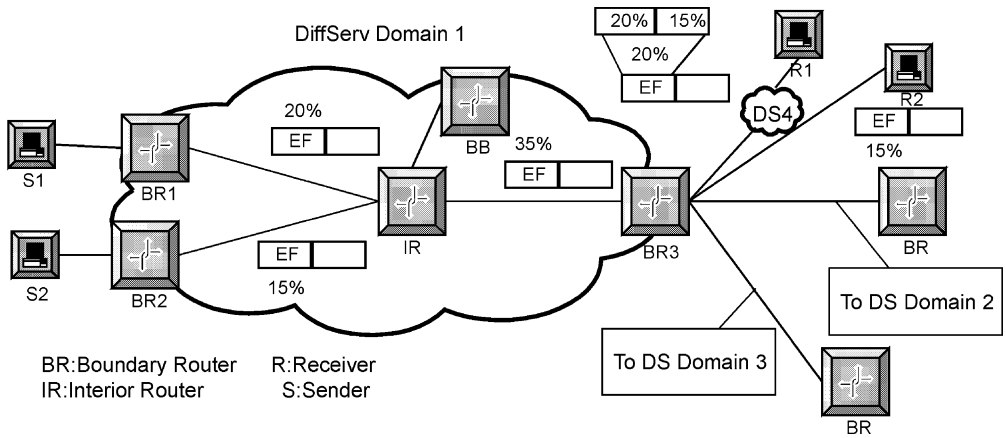

Fig. 1. DiffServ and Multicast.

needed for a specific group. DiffServ network may connect to other peering DiffServ networks to provide end-to-end QoS. These different DiffServ networks may have different Service Level Agreement (SLA). DSCP value of DiffServ traffic is assigned in ingress router and a mapping between different SLAs may be needed. In order to reduce classification and traffic conditioning burden at the egress router, enforcement can be made at the ingress router of the first DiffServ domain. This can be achieved for unicast traffic because traffic is predicable. In case of multicast, traffic may be replicated at any place of DiffServ domain and go into different downstream peering DiffServ domains. It's difficult to get an agreement among all receivers. The possible solution given by Blake, et al. [10] is to isolate the unicast traffic from multicast traffic.

Dynamic multicast group membership may cause other problems apart from resource reservation uncertainty. For example, consider two receivers and two groups in DiffServ Domain 1 of Fig. 1 where S1 is the sender of group 1 and S2 is for group 2. R1 and R2 join group 1 and group 2 respectively. Group 1 reserves 20% of the bandwidth to provide EF, and group 2 gets 15% bandwidth for EF. In this case there are no problems and bandwidth is allocated satisfactorily. If R1 wants to join group 2, R1 should get default QoS, which is 15% bandwidth for EF. A 35% bandwidth is therefore needed for EF starting from the branch point BR3 toward R1. The boundary router BR3 has the traffic conditioning function, and the new branch toward R1 will implicitly use additional 15% BW without permission from BR3. Therefore, BR3 will drop some packets to force the traffic to use admitted 20% BW. Without per-flow state in BR3, it will drop packets belonging to group 1 or group 2 randomly. Hence traffic of group 1 is adversely affected. This is a Neglected Reservation Subtree (NRS) problem given in [11,12] and a solution is also provided there. Receivers can use BE or Limited Effort (LE), where LE is lower than BE and gets part of bandwidth from BE to join groups. When required resources are confirmed, Bandwidth Broker (BB) assigns a new DSCP, such that receivers can get better service than BE or LE.

There are different ways to support multicast in DiffServ network. Core routers can be multicast-capable, multicast-incapable or multicast traffic is encapsulated to transfer to core routers. If core routers support multicast they have to maintain a multicast tree state per group. This makes core routers complex and not scalable as they have to check the state for every multicast tree. If core routers are unaware of multicast traffic, traffic is replicated at boundary routers. Striegel and Manimaran [13] have given a new architecture for multicast support in DiffServ domain. In this DiffServ Multicast (DSMCast) approach, core routers do not need to maintain multicast tree. The tree information is encapsulated in packet's header, and leaves core routers a little simpler and more scalable. However, encapsulation incurs additional costs. 'Fat' header consumes additional bandwidth for each packet, and additional CPU cost is also incurred due to header processing. Under basic DSMCast model, the tree is built based solely on the network topology. Multicast traffic is transmitted like unicast apart from that core routers have to inspect the header to make replication when needed. The extension headers include identification field for DS core nodes, appropriate branching information, tunneling bit to bypass DS-non-capable nodes, and adaptive DS field to adapt to the heterogeneous DSCP requirements by the different receivers.

The request that receivers join/leave the group is forwarded by the egress router to the ingress router to be processed. The multicast tree is then constructed by the ingress router. Member's join /leave structure is discussed in [14].

Bless and Wehrle [15] add an extension of DS entry to multicast routing table to support heterogeneous DSMCast group. This makes different branches in the same multicast tree get different QoS possible, but routers have to maintain a relative big routing table.

4. MPLS and multicast support

Unlike DiffServ and multicast, where the two are in the same network layer, MPLS and multicast are in the different layers. Ooms and Livens [16], and Ooms, et al. [17] have presented general issues in supporting IP multicast in MPLS networks.

MPLS routers include two separate components: control and forwarding. Control component uses standard router protocols in L3 to exchange information with other routers to build and maintain a forwarding table. When packets arrive, the forwarding component (based on a label swapping forwarding algorithm) searches the forwarding table maintained by the control component to make a routing decision for each packet. Multicast traffic is delivered to all receivers of the same group along multicast distribution tree. Multicast routing protocols usually use Reverse Path Forwarding (RPF) or other incoming interface check to determine if the packet received belongs to a particular multicast group. Therefore in MPLS, multicast tree should be built on a per-interface basis by combining label value and incoming interface.

There are three ways to initiate label assignment: topology-driven, request-driven and traffic-driven. When MPLS is used to transmit unicast traffic, Label Switching Path (LSP) is usually triggered by the network topology. In this case LSP already exists before traffic is transmitted. If topology-driven is applied to multicast, L3 tree needs to be mapped to L2 tree. MPLS-capable routers also have to maintain multicast tree. If multicast network topology changes frequently because of members dynamically joining/leaving, MPLS-capable routers spend a lot of resources to cope with these changes. Traffic-driven approach only

sets up LSP to branches with traffic. It consumes fewer labels than topology-driven approach. This may take a longer setup time of LSP, but is better for the longer life span multicast group members. LSPs can also be set up by request-driven approach. For explicit multicast members joining/leaving protocols, such as PIM-SM and CBT, join/prune messages can be used to trigger LSP. The drawback is that multicast routing tree has to be constructed twice in L3 and in L2. RSVP Path and Resv messages can also be used to trigger LSP.

Label distribution can be achieved by dedicated protocols (extension may be needed to support multicast), e.g. Label Distribution Protocol (LDP), or by piggybacking on routing protocols. For DVMRP and PIM-DM there are no routing protocols that can be used for piggybacking. Join/prune messages of both PIM-SM and CBT, and RSVP are two good candidates for piggybacking.

Fig. 2 presents some problems in an MPLS multicast network. Suppose R3 and R4 register to the same multicast group. R3 connects to MPLS network directly whereas R4 connects to an MPLS-incapable network. Label Edge Router4 (LER4) has to maintain two forwarding tables, one in L2 to LSR4 to reach R3 and another in L3 to non-MPLS network to reach R4. This is a mixed L2 and L3 forwarding [17] in a single router. Multicast traffic will go through different outgoing interfaces due to replication.

Consider the situation configured in Fig. 2 where S1 and S2 are senders and R1 and R2 are receivers of the same group and Label Switching Router3 (LSR3) is the Rendezvous Point (RP). Assume initially multicast traffic is delivered along RPT. Multicast traffic coming from iif2 (Incoming Interface) is duplicated and forwarded to oif1 (Outgoing Interface) and oif2. Later suppose R1 joins SPT from S1. The multicast traffic from S1 is transferred to R2 by RPT and to R1 by SPT. Traffic coming in iif1 from S1 goes to oif1. Traffic from iif2 belonging to S1 only goes to oif2 and traffic belonging to S2 is forwarded to both oif1 and oif2. This is co-existence of source and shared trees in PIM-SM [17] and LER3 may have to maintain (*, G) and (S, G) tree state for the same group. This may cause transmitting duplicate packets to the same receiver during switchover from RPT to SPT. Ooms, et al. [17] propose different solutions to solve this problem, either resort to L3 routing or use source specific label switching.

Setting up a source specific LSP is a solution to co-existence problem of SPT and RPT in PIM-SM. An example is given in [18]. Although Asynchronous Transfer Mode (ATM) is used in L2 in [18], the same methodology can be applied to general MPLS-capable L2 switches. Multiple labels are assigned in shared tree according to one Virtual Channel (VC) per source. Therefore, Multicast Routing Table (MRT) is needed to map shared tree to source-specific tree, and construct FEC-to-Next Hop Label Forwarding Entry (NHLFE). Label assignment is data-driven. Both Upstream Implicit and Downstream on Demand can be used. LDP is modified to support source-group tree structure. Labels reclamation is initiated from downstream LSR.

It is also possible to make core routers simple by pushing packets replication to LER [19]. Core routers do not have to maintain multicast routing state per group. Member's join/prune messages are forwarded to ingress router like unicast messages. Multicast traffic is duplicated there and transmitted to receivers transparent to core routers. PIM-SM multicast protocol has been discussed in [19]. In order to

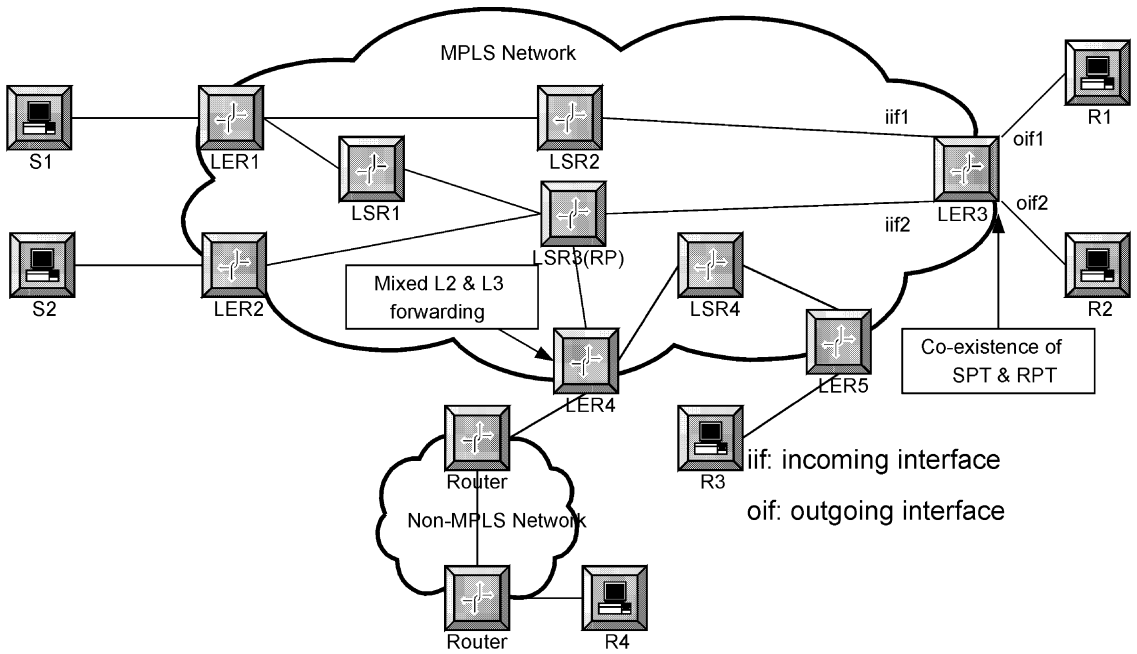

Fig. 2. Supporting multicast in MPLS.

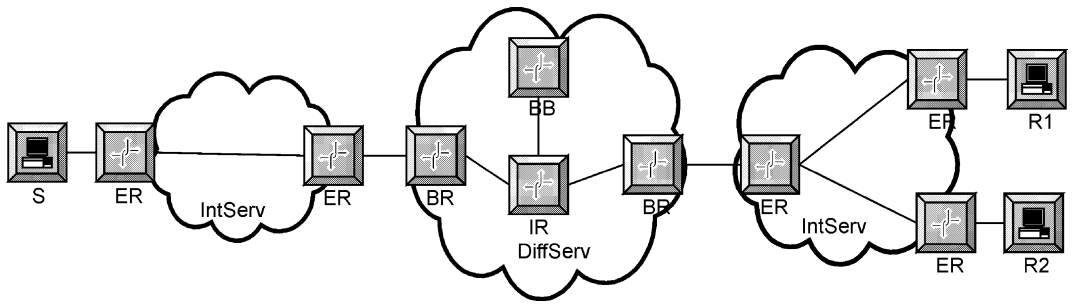

Fig. 3. Interworking between DiffServ and IntServ to support multicast.

make the problem simpler, LER is assumed to be the candidate of RP. All LSPs are pre-established by using LDP or Constrain-based Routed LDP (CR-LDP) to communicate PIM messages between LERs as well as to transmit multicast data. The trade-off is between bandwidth inefficiency and multicast non-capable core routers.

Traffic triggered label distribution is also discussed in [20]. Data packet is first used to trigger label distribution. Graft and Prune messages of Dense Mode multicast routing protocols are then used to add new branches or remove branches from the tree.

Some networks may not support BGP (Border Gateway Protocol) when multicast traffic spans multiple MPLS networks belonging to different ASs (Autonomous System); PIM-SM join message cannot reach the source in other AS. Ooms, et al. [21] have provided a solution to create a pre-calculated multicast tree extending MPLS signaling protocol other than multicast routing protocols. The tree is calculated based either on QoS requirement by the Network Management System (NMS) or by the initiator root or leaf of the tree in MPLS. Both root-initiated traffic engineered tree and leaf-initiated traffic engineered tree are mentioned in [21]. All tree information is embedded in signaling protocol, therefore, interior routers in MPLS do not need to support multicast. Ooms, et al. [21] have deployed CR-LDP as signaling protocol and extensions for CR-LDP are discussed in details. It should be noted that the tree constructed by this approach is immediately on L2 and applicable to applications of multicast that do not require dynamic tree.

5. Interworking between DiffServ and IntServ to support multicast

IntServ and DiffServ are complementary tools to provide end-to-end QoS. Su and Hwang [22] have discussed the multicast support to achieve end-to-end QoS with IntServ and DiffServ based networks. In Fig. 3, the core network is DiffServ-capable whereas the two stub networks are IntServ-capable. Senders and receivers connect to stub networks. RSVP is used as signaling protocol in IntServ, and Common Open Policy Service (COPS) is employed in DiffServ by the BB. When multicast group is formed, sender of the group broadcasts RSVP Path message to all receivers by tunneling through the DiffServ domain. Receivers who want to get better service than BE reply back with RSVP Resv message to sender. When Resv arrives, DiffServ issues COPS request to BB that then interacts with all routers inside the domain to reserve resources for receivers. In order to support different reservation styles (SE, FF and WF) of RSVP in DiffServ domain, some modifications to COPS objects are needed. Su and Hwang [22] have shown the end-to-end signaling procedures for DVMRP and PIM-SM in both FF and SE.

IntServ supports GS and CLS whereas EF and AF are supported in DiffServ. Fig. 4 shows the mapping of service level needed between IntServ and DiffServ.

In DiffServ core routers are able to change DSCP in order to support different reservation styles. Boundary routers and PIM-SM RP have the same functionality, such as classification, metering.

6. Interworking between MPLS and IntServ to support multicast

RSVP-TE (Traffic Engineering) is a specification of extensions to RSVP for establishing explicit LSPs in MPLS networks. RSVP-TE for LSP tunnels in RFC3209 [23] is restricted to unicast LSPs. Researchers [24,25] have specified extensions to RFC3209 to support multicast. These proposals do not require or rely on traditional multicast routing protocol to set up the multicast tree. They assume that the tree calculation is done by other means, be it online or offline. The tree pre-calculated in this way must satisfy the TE parameters used in MPLS. Two kinds of tree are proposed, root (sender)-initiated tree originated from ingress LER (root) and leaf (receiver)-initiated tree originated from egress LER (leaf).

Cheng [24] has discussed root-initiated tree. Tree explicit route object (TERO), tree record route object

CoS in IntServ	CoS in DiffServ	MPLS Service Class
GS	EF	Gold
CLS	AF	Silver/Bronze
BE		

Fig. 4. A way of mapping of CoS among IntServ, DiffServ and MPLS.

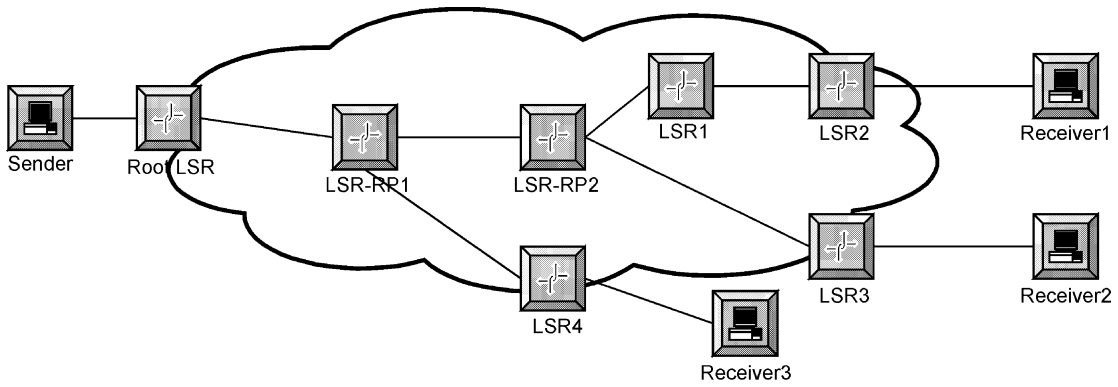

Fig. 5. Using RSVP-TE in MPLS to support multicast.

(TRRO) and their respective sub-objects extending from RFC3209 are used to calculate multicast tree. RSVP Path message containing pre-calculated tree is forwarded to all leaf LERs. Resv message is transmitted back to root LER and merged from downstream LSRs to upstream LSR.

Chung [25] has supported both sender-initiated tree and receiver-initiated tree. Sender-initiated tree is used for new source of multicast group; receiver-initiated tree is used for dynamically joining/leaving receivers. The tree information is pre-gathered in Multicasting Information Database (MIDB) by using Internet Group Management Protocol (IGMP). For a new sender (Fig. 5), root LSR uses this tree information to forward Path message to LSR-RP1, LSR-RP2, LSR1, LSR2 and LSR4, and confirmed by Resv message. After that, data traffic from sender is transmitted to receiver1 and receiver3. New receiver2 uses Join message to join the group, and Join message is forwarded to root LSR. This initiates the recalculation of the tree. After that, Root LSR sends Join message back to LSR-RP2 with a TREE object. Then LSR-RP2 sends Path message to LSR3 and gets back Resv message from LSR3. Receiver2 can now receive multicast data. LSR-RP is a LSR that has more than one branches participating in multicast group.

RSVP-TE provides a way to support multicast in MPLS. This approach is scalable because LSRs other than root LSR do not need to maintain MIDB. But periodical Path and Resv message contribute more traffic to network. Multicast supporting by RSVP-TE is restricted to source specific multicast group.

7. Interworking between MPLS and DiffServ

The basic difference between MPLS and DiffServ is that MPLS is in L2 and DiffServ is in IP Header. Clearly a mapping is needed between the two approaches. DSCP has 6 bits whereas MPLS has a 3-bit EXP field. If DSCP maps to EXP, some information will be lost. A mapping has been proposed by Rouhana and Horlait in [26] and is duplicated in Fig. 4. They also propose DRUM (DiffServ and RSVP/IntServ Use of MPLS), an architecture that delivers end-to-end QoS for both DiffServ and IntServ networks, and the mapping is based on DSCP, CoS in IntServ and EXP. Andrikopoulos and Pavlou [27] have used ATM in L2. Part of VCI is used to map DSCP. Interior DS-compliant ATM-LSRs perform the appropriate traffic management function on ATM cells to interpret DSCP correctly. Some extensions are needed in MPLS and LDP to make them DiffServ-capable.

Faucheur, et al. [28] have given detailed information about MPLS support of DiffServ. EXP-Inferred-PSC (PHB Scheduling Class) LSPs (E-LSP) and Label-Only-Inferred-PSC LSPs (L-LSP) are discussed specifically. If multiple BA (Behavior Aggregates) are mapped to a single LSP, the EXP field of MPLS shim header is used to determine the Per-Hop-Behavior (PHB). Up to eight BAs can be supported by one LSP for a given FEC. This is referred to as E-LSP. In L-LSP, separate LSPs are established to map different BAs. LSRs infer exclusively PSC from label value and EXP field conveys the Drop precedence. Label forwarding models for DiffServ LSRs, detailed operation of E-LSP and L-LSP are discussed in more details in [28].

Label Distribution in DiffServ-MPLS may be piggybacked or may use specific protocol. RSVP with extension is piggybacked to establish LSPs supporting DiffServ in MPLS networks. CR-LDP extended from LDP, describes LSPs with QoS requirements with some parameters.

Moh, et al. [29] have proposed an enhancement to E-LSP. It distributes traffic with the same class type to the same LSP. This is referred to as per-class TE or DS-TE. Labels are encoded to both FEC and service class (or class type) information. Three class types are defined: type 0 (BE), type 1 (EF) and type 2 (AF1 and AF2). Load is balanced by class type.

Jing, et al. [30] have presented an implementation algorithm to support DiffServ in MPLS-based ATM switches.

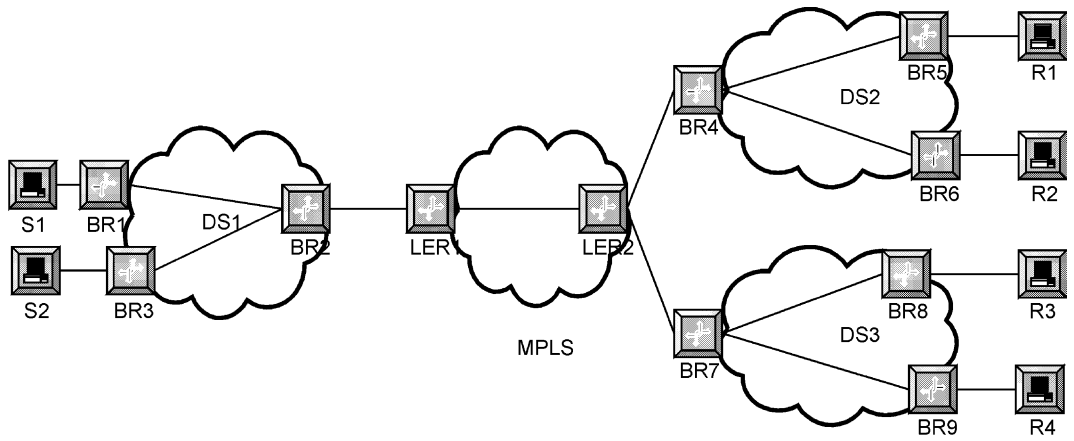

Fig. 6. Interworking between DiffServ and MPLS to support multicast.

The published literature in interworking MPLS and DiffServ networks relate to unicast applications. Problems arise when multicast traffic spans multiple Internet clouds. In Fig. 6, DS1, DS2, DS3 and MPLS network support multicasting. DS1, DS2 and DS3 may use different SLAs in each domain. The same issues related to supporting multicast in DiffServ and MPLS need to be considered here. The questions related to when the label is to be created and destroyed, how to distribute the label, and how to provide end-to-end QoS spanning multiple different networks need to be addressed. Multicast routing state may need to be maintained by all routers from end to end, or this function may be pushed to edge routers of each network and leave the core routers simple. For PIM-SM, it has to be decided where to locate the RP and how to cope with co-existence of SPT and RPT and problems mentioned in [21]. Extensions in LDP or CR-LDP are needed to support multicast and DiffServ in MPLS.

8. Conclusion

IntServ, DiffServ and MPLS are technologies currently used in Internet to provide QoS. Multicast applications, such as videoconferencing and distance learning, are emerging in a fast step. In this paper, general issues on supporting QoS to multicast are discussed and different ways to implement IP multicast in IntServ, DiffServ or MPLS based networks are analyzed in detail.

IntServ is inherently capable of supporting multicast and provides per-flow QoS. Scalability is critical and must be considered when QoS is required for multicast applications. Per-class based DiffServ is more scalable than per-flow based IntServ. MPLS and DiffServ have similarities in some aspects. They both have ‘fat’ edge routers and ‘slim’ core routers. They are however basically different in architecture. MPLS runs over L2, whereas DiffServ needs support of IP protocol because DSCP field substitutes the ToS in IPv4 or the CoS in IPv6. When considering multicast support, the network architecture plays an important role and must be determined at first. DiffServ, MPLS or both can be employed in core network, and multicast can be supported in entire network or only in edge routers. Each router needs to maintain a multicast tree if the entire network supports multicast. If multicast is supported only in edge routers of core network, multicast tree must be pre-calculated and multicast traffic is tunneled across core routers. In this case, core routers are more scalable. Some issues must be considered before supporting multicast in MPLS network. Multicast LSP setup trigger strategy and label distribution Scheme should be addressed. Mixed L2 and L3 forwarding in multicast routing protocols, co-existence of source and shared trees in PIM-SM, handling LSP setup in PIM-SM-enabled MPLS network where one is source tree between ingress LER and RP and the other is shared tree between RP and egress LERs, dynamic receivers joining/leaving, as well as flooding and pruning are main issues when supporting multicast in MPLS network.

Subsequently, network configurations based on these different architectures and their interworking to provide end-to-end QoS are also discussed. The interworking among IntServ, DiffServ and MPLS is more complicated in multicast network than that in unicast network. Cooperation of different technologies in one network, end-to-end QoS provision, and service type mappings are important points. IntServ and DiffServ are complementary tools to provide end-to-end QoS to multicast traffic. IntServ and DiffServ deal with the issues relevant to resource reservation and traffic policing. Here RSVP and COPS are used as signaling protocols to support QoS and multicast. RSVP-TE is used by MPLS to interwork with IntServ and is currently restricted to source specific multicast group. However, supporting DiffServ in MPLS is a scalable solution. E-LSP and L-LSP are used to support DiffServ in MPLS for unicast applications. Extensions to MPLS and LDPs should be considered if MPLS is to support multicast and DiffServ. Implementation of end-to-end QoS spanning multiple different networks is still in research if interworking

MPLS, DiffServ and multicast. When interworking the current different technologies such as IntServ, DiffServ, MPLS and multicast, mapping of service types is needed to deliver end-to-end QoS.

Based on this survey, it is observed that extensive research work needs to be done when interworking IntServ, DiffServ, MPLS and multicast, and it is hoped that there is a reasonable potential research and development activity in this area. This survey provides information to researchers and service providers to get a general view of supporting QoS to IP multicast. What have been done, what technologies are available, and what needs to be researched and developed are clearly presented here.

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