Bandwidth-guaranteed Reliable Multicasting

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Abstract

In order to provide highly reliable IP (Internet protocol) broadcasting services, it is very important to guarantee the multicast bandwidth, and enhance multicast transmission reliability. This article describes Multicast MPLS (multiprotocol label switching) for these purposes and explains its applicability to IP broadcasting.

1. Advances in multicast network functions

Reliable IP (Internet protocol) broadcasting will require several enhancements to the multicast network functions (**Fig. 1**). For example, for smooth delivery of HDTV (high-definition television) video streams, which require a large amount of bandwidth, a multicast network requires a "multicast bandwidth guarantee" function (c) to statically reserve line bandwidth for data streaming. To minimize broadcasting downtime caused by network failures, a "multicast fast rerouting" function (b) is required to enable fast recover of the multicast delivery path when a path failure occurs. To deliver multiple broadcasting services separated into different broadcasting quality levels, a "multicast group assignment" function (a) is necessary at the server edge to filter traffic into multicast paths with different QoS (quality of service) levels (e.g., with different bandwidths, with/without protection, etc.). To support planned or emergency

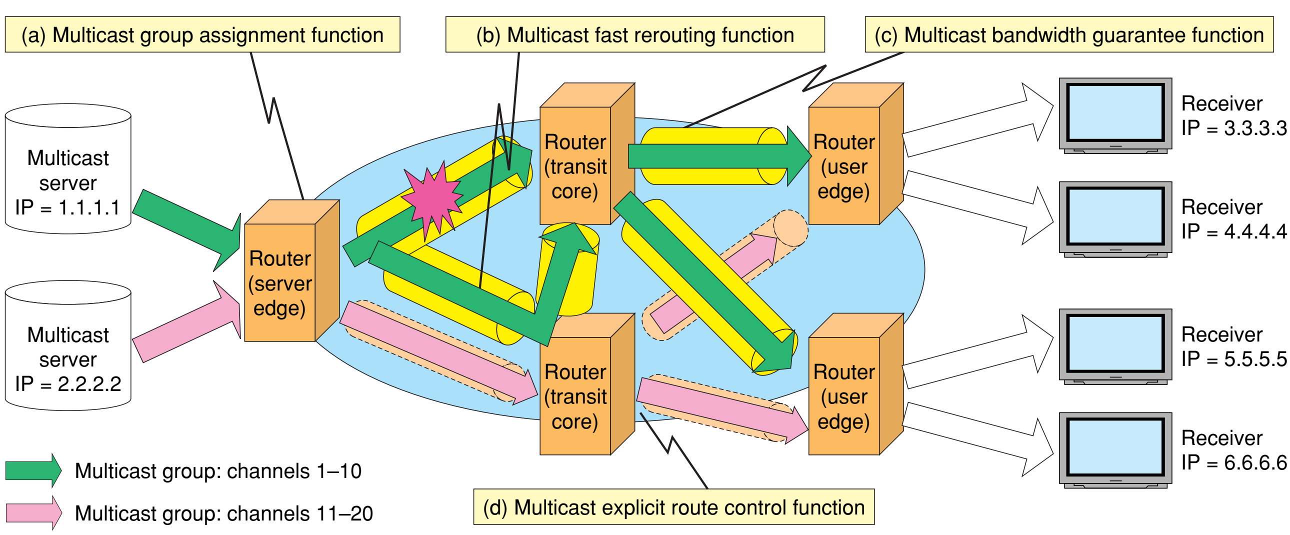

Fig. 1. Multicast functions for highly reliable transmission.

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maintenance, a "multicast explicit route control" function (d) is required for aggregated path switchover of all multicast routes and for explicit routing of delivery routes. However, because these four functions have not been implemented, it is difficult to achieve highly reliable IP broadcasting using existing IP multicast technologies such as PIM (protocol-independent multicast). This article describes Multicast MPLS, which enables all these operations [1], [2].

2. Multicast MPLS

Multiprotocol label switching (MPLS) transfers packets according to label information in fixed-length packet headers. It is a data transfer scheme that can carry many kinds of traffic including IP packets and enables traffic engineering for these packets. This section describes Multicast MPLS technology that enables MPLS transmission in a multicast environment. An overview of Multicast MPLS is presented in **Fig. 2**. First, the server edge router establishes a Multicast MPLS path from the server edge to the user edge using the RSVP-TE (resource reservation protocol traffic extension) signaling protocol [3] with multicast extensions.

In the example in Fig. 2, server edge router 1 exchanges RSVP-TE Path/Resv messages with user edge routers 4, 5, and 7. At such a time, it is possible to include routing information (1 → 2 → 3 → 4) in the Path message destined for user edge router 4 and to explicitly route to the user edge by sending this Path message according to the specified path. When the Path message arrives at the user edge router, the router sends a Resv Message, which retraces the route that the Path message followed. The Resv message includes an MPLS forwarding label and configures the label-switching table for Multicast MPLS forwarding at each node. In our example, the label switching relationship is configured as 100 → 55 → 300 from server edge router 1 to user edge router 4. This procedure is followed for all multicast-receiving user edge routers. At this point in the scenario, the table for router 3, which is a branch node for the multicast route, is configured to assign the output label of the branch route by copying the payload and swapping the label of the incoming MPLS packet. In other words, at transit core router 3 in Fig. 2, the table is configured to branch-copy the MPLS packet arriving from transit core router 2, which has input label 55 as label 300 for user edge router 4 and as label 10 for user edge router 5 based on the MPLS label switching table. This is how the multicast MPLS path is preconfigured in Multicast MPLS.

At the server edge, an MPLS header is attached to the input IP multicast data and the MPLS path-mapping table is set. This table makes it possible to filter the forwarding Multicast MPLS path by multicast group. Meanwhile, at each user edge router, the MPLS header is deleted from the input multicast

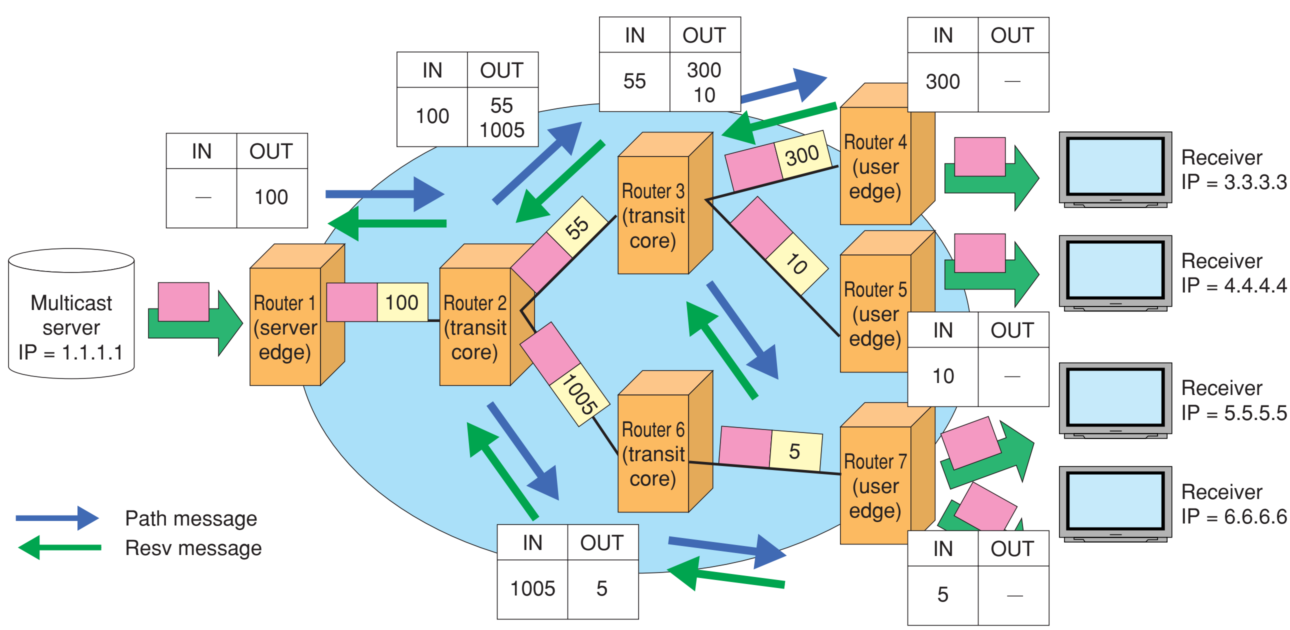

Fig. 2. Multicast MPLS.

MPLS packet, and the switching table is configured for IP packet forwarding.

Because the multicast route is preconfigured in this way, the IP multicast packets output by the streaming server are converted to MPLS packets and filtered to the appropriate MPLS path. These IP multicast packets are forwarded to the user edge according to the multicast MPLS route explicitly routed by the transit core node. Then, at the user edge these packets are reconverted to IP packets and delivered to the receiver. At this time, all of the links that make up the multicast route are reserved by FastReroute, which provides fast link protection. In the event of a link failure, fast rerouting is executed through the reserved links to avoid any disturbance, which makes fast recovery possible.

Thus, multicast MPLS enables us to provide advanced multicast transmission functions in order to achieve the various MPLS functions shown in **Table 1**.

3. Extension for uninterruptible multicast transmission

To increase the reliability of IP broadcasting even further, uninterruptible transmission in the multicast transmission network is also envisioned. A method for achieving uninterruptible multicast transmission is shown in **Fig. 3**. The streaming server is given two interfaces on the server edge. In this model the server edge has a redundant architecture. Two symmetric MPLS paths, which each have the same number of hops from sender to receiver and the same branched points but have disjoint routes, are configured on planes A and B. The explicit route control function of Multicast MPLS enables us to set up this kind of symmetric multicast MPLS path and this path enables equal multicast transmission delays over both planes. Furthermore, the receivers are also given dual interfaces at the user edge. The streaming server delivers the multicast data in parallel to the dually redundant

Table 1. IP multicast technology and multicast MPLS technology.

	IP Multicast	Multicast MPLS
Bandwidth guaranteed	Poor: No bandwidth guarantee	Good: RSVP-TE signaling sets up bandwidth-guaranteed path.
Fast rerouting	Poor: Several tens of seconds. Depends on IP unicast route convergence time and error detection time.	Good: A few tens of milliseconds. Independent of IP unicast route convergence time.
Independent path assignment per group	Poor: PIM-SSM establishes multicast path based on RPF. Multicast paths that have the same source address follow the same route.	Good: Enables independent path assignment.
Explicit route control	Poor: No control mechanism. Multicast route follows the RPF path for the source.	Good: Can control and set up any route based on path information carried on Path message.
Overall path switchover	Poor: Cannot perform overall path switchover.	Good: MakeBeforeBreak enables overall path switchover without interruption.

RPF: reverse path forwarding

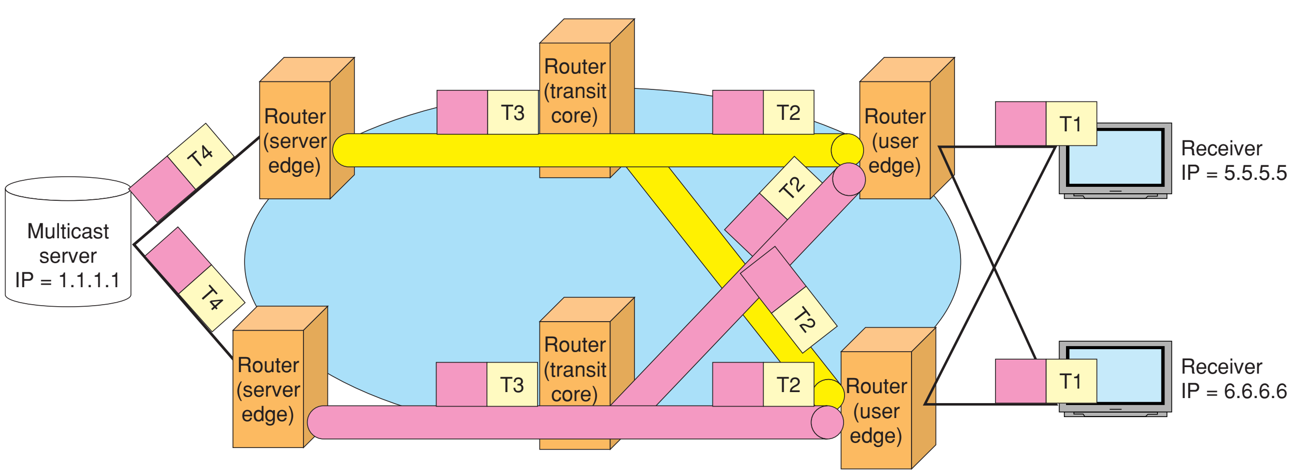

Fig. 3. Uninterrupted multicast transmission based on RTP.

multicast routes. An RTP (realtime protocol) header is attached to multicast data and the timestamp value is stored in the header. This data is transferred to the user edge along the symmetric multicast MPLS paths nearly synchronously. At the user edge, the RTP header's timestamps arriving through the redundant paths are processed, and the data is constantly selected from one path and transmitted downstream so that the succession of timestamps is maintained. With this mechanism, if one of the redundant paths fails, the data from the other path can be received without interruption and forwarded. Thus, uninterruptible transmission can be achieved.

Conclusion

Highly reliable IP broadcasting is possible through advances in the multicast transfer network achieved using multicast MPLS. We are considering applying it in the next-generation network as a method of achieving highly reliable multicast transmission.

References

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