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Digital transmission of television signals

IP network architecture with network layer route diversity providing resilient IP multicast video distribution

ITU-T Recommendation J.283

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IP network architecture with network layer route diversity providing resilient IP multicast video distribution

Summary

This Recommendation proposes an IP network architecture supporting network layer route diversity to construct resilient video distribution infrastructure using IP multicast.

Source

ITU-T Recommendation J.283 was approved on 29 November 2006 by ITU-T Study Group 9 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

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CONTENTS

Introduction

IP multicast is a promising technology for providing IP-based video distribution because of its bandwidth efficiency that accommodates millions of clients. The construction of a stable IP multicast network is a very important issue to meet the service quality requirement of IP-based video distribution. This Recommendation describes a set of architectural concepts for constructing an IP multicast network with high availability.

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IP network architecture with network layer route diversity providing resilient IP multicast video distribution

1 Scope

Highly available IP multicast network architecture will be discussed in order to maintain sufficient service quality for IP-based video distribution. This Recommendation concerns network layer (Layer-3) route diversity between the server edge routers and the client edge routers. Note that Layer-3 route diversity is independent of Layer-2 resiliency, i.e., protection and/or restoration. As Layer-2 resiliency does not cover Layer-3 route diversity, e.g., Layer-2 resiliency cannot handle a router's failure. This Recommendation focuses on Layer-3 architectural issues. Coordination with Layer-2 resiliency would contribute to even higher reliability.

2 References

2.1 Normative references

None.

2.2 Informative references

[RFC 2328] IETF RFC 2328 (1998), *OSPF Version 2*.

[RFC 2362] IETF RFC 2362 (1998), *Protocol Independent Multicast-Sparse Mode (PIM-SM): Protocol Specification*.

3 Terms, definitions and acronyms

This Recommendation defines the following terms:

3.1 multicast: A packet delivery mechanism from one source to many clients supported by IP routers.

3.2 video distribution: Digital video services for an unspecified number of clients.

3.3 Protocol Independent Multicast-Sparse Mode (PIM-SM): A multicast routing protocol based on an explicit join model for multicast groups that may span a wide area.

3.4 RP: A Rendez-vous Point among multicast sources and group members. Packets transmitted from multicast sources are distributed via an RP router at the beginning of multicast transmission.

3.5 Open Shortest Path First (OSPF): A unicast routing protocol for large-scale intra-domain networks. OSPF is a link state based routing protocol specified according to the ISO IS-IS routing protocol.

3.6 cost: A cost is a parameter configured by an operator in order to make a network resource utilization effective. Example definition is described in [RFC 2328].

4 IP multicast network

Figure 1 shows an example of an IP multicast network. Each IP router replicates packets conveying video stream and forwards them to downstream routers or clients along multicast trees. A Multicast tree is established from client-edge routers to the multicast source[1] on a hop-by-hop basis by a multicast routing protocol such as PIM-SM (Protocol Independent Multicast – Sparse Mode) running on each router. In PIM-SM, each router decides an upstream router using unicast routing information destined for the multicast source.

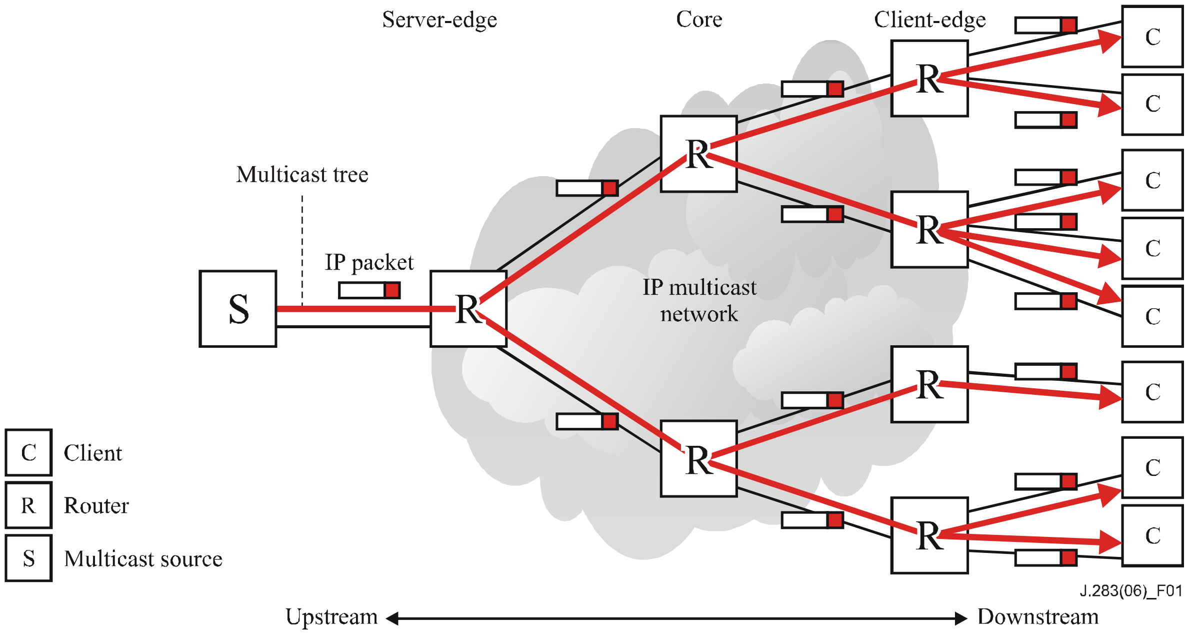

Figure 1/J.283 – Example of IP multicast network

5 Considerations of router/link failure

On the other hand, Figure 1 has only one unicast route between the client-edge routers and the multicast source. When an intermediate router or link between them fails as shown in Figure 2, multicast packets do not arrive at the client until recovery of the failure. In detail, from the viewpoint of the network layer, the following procedures occur in the routers below the failure point.

a) A unicast routing protocol such as OSPF (Open Shortest Path First) detects the failure and withdraws the unicast route for the multicast source.

b) PIM-SM recognizes that there is no unicast route for the multicast source. As a result, the corresponding multicast trees are broken.

c) OSPF detects the failure recovery and recalculates the unicast route for the multicast source.

d) PIM-SM knows the reappearance of this unicast route and reconstructs the multicast trees.

1 The multicast source can be an RP (Rendez-vous Point) router in PIM-SM.

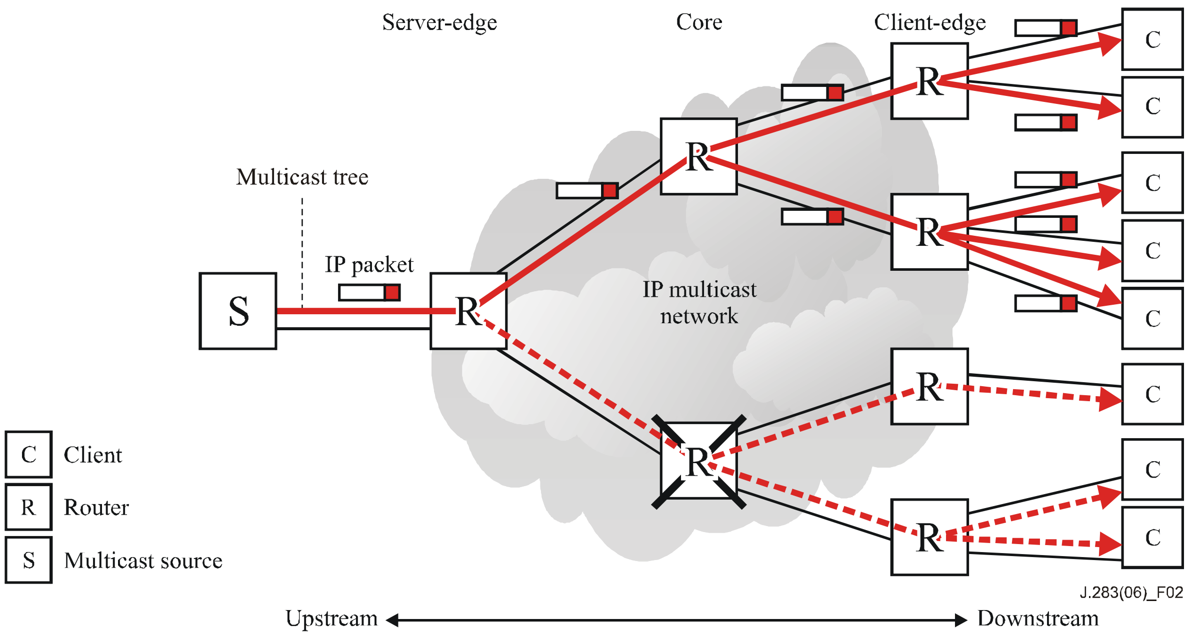

Figure 2/J.283 – Example of router failure scenario

6 Requirements

In order to prevent long-time service disruption due to single router or link failure on multicast trees as described in clause 7, this clause describes requirements and recommendations of IP network architecture for resilient IP multicast video distribution. The most important point is that the route diversity of multicast trees is provided dynamically.

a) In order to avoid long-time service disruption due to one router or link failure on multicast trees, an IP multicast network is required to be constructed with unicast route diversity from any client-edge router to the multicast source. That is, an alternative unicast route is required to appear automatically when the original route is withdrawn.

b) Multicast trees are required to be reconstructed dynamically along the alternative unicast route after failure.

c) For quick convergence of the reconstruction of multicast trees, it is recommended that at least two equal-cost unicast routes are arranged from any client-edge router to the multicast source so that one or other of the unicast routes can be always preserved.

7 IP network architecture with network layer route diversity

This clause categorizes the following three types of IP network architecture realizing network layer route diversity.

1) Category 1: A client-edge router has only one best route destined for the multicast source. Another route(s) is possible, but its cost is greater than the best route.

2) Category 2: A client-edge router has at least two best routes, i.e., equal-cost routes, destined for the multicast source. However, other routers such as core routers do not always have equal-cost routes for the multicast source.

3) Category 3: A router except for server-edge routers has at least two best routes, i.e., equal-cost routes, destined for the multicast source.

4) Category 2+1, 3+1: In addition to Category 2 or 3, another route(s) destined for the multicast source is possible in every router, but its cost is greater than the best routes.

Figures 3 through 7 depict examples of IP network architecture. All the categories satisfy Requirements a) and b) in clause 6. However, only Category 1 does not satisfy item c) in clause 6.

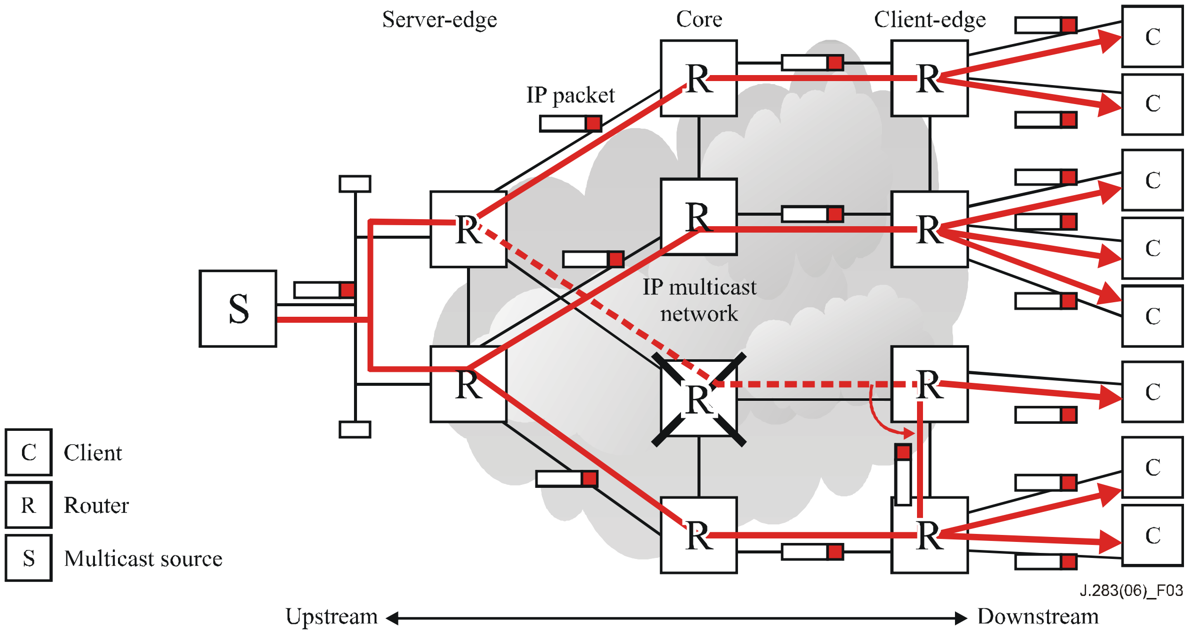

Figure 3/J.283 – Example of IP network architecture (Category 1)

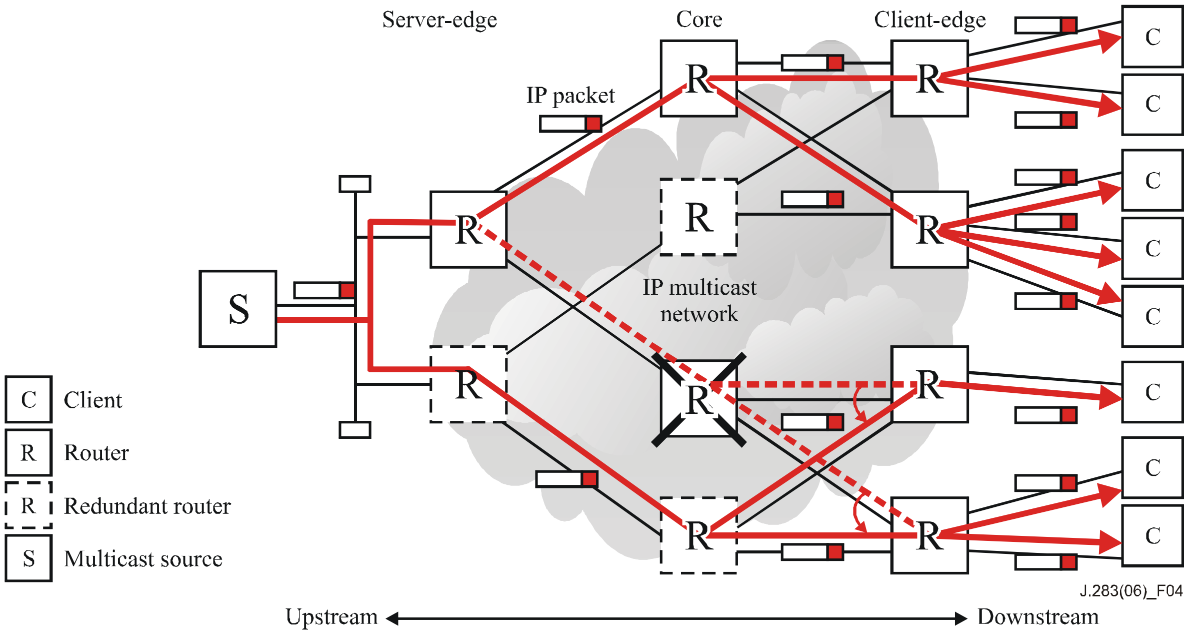

Figure 4/J.283 – Example of IP network architecture (Category 2)

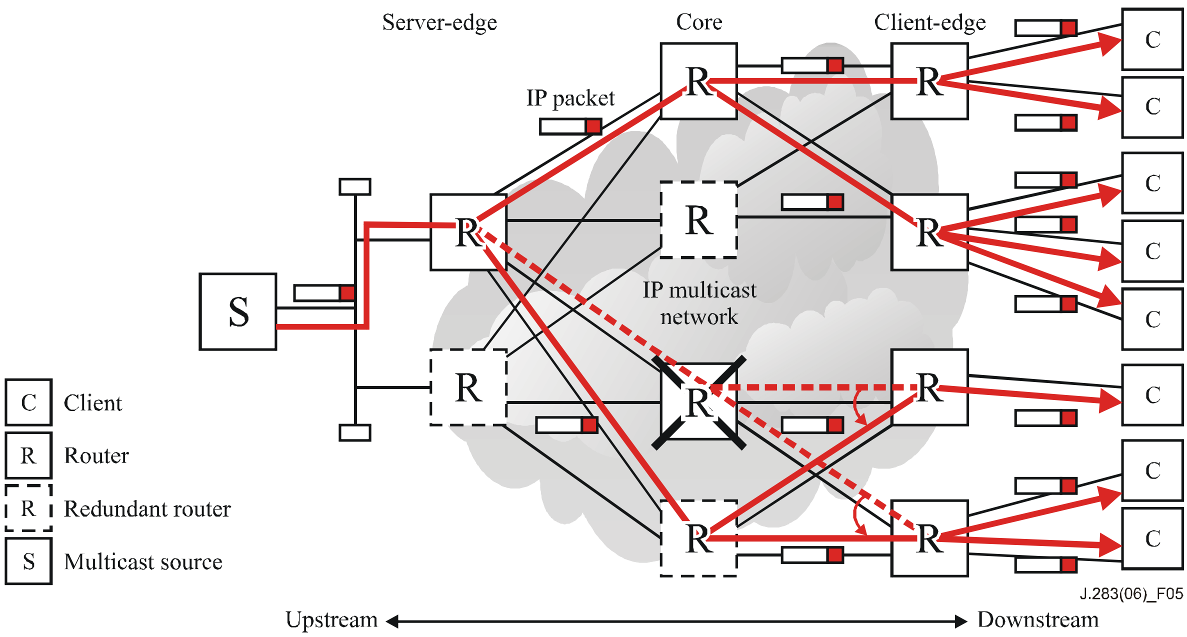

Figure 5/J.283 – Example of IP network architecture (Category 3)

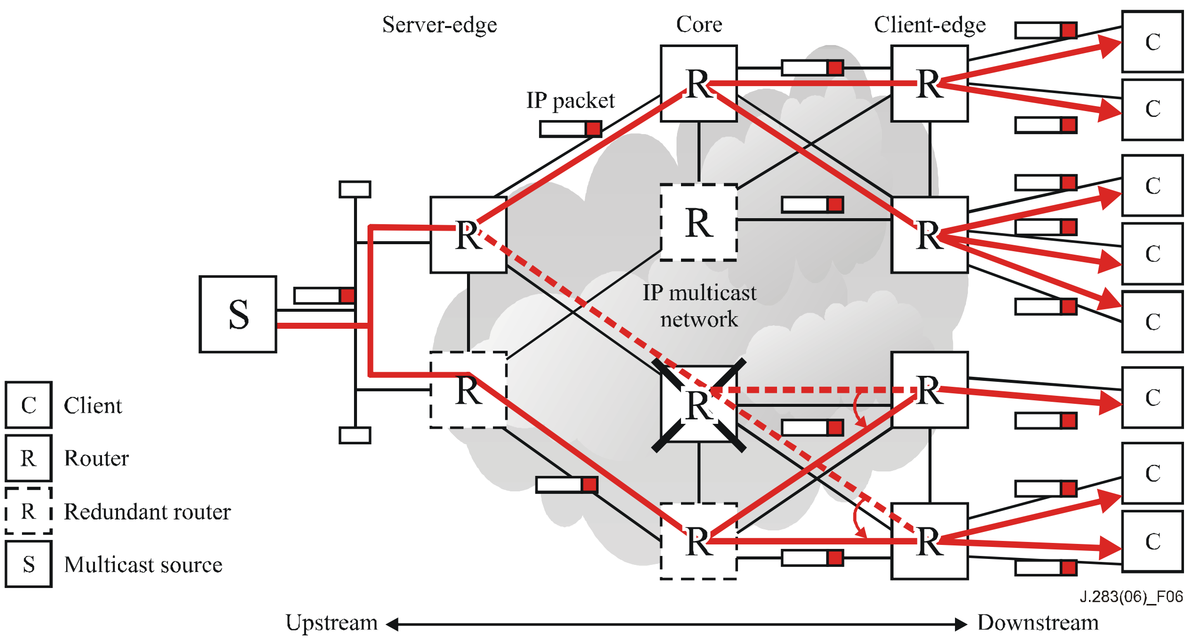

Figure 6/J.283 – Example of IP network architecture (Category 2+1)

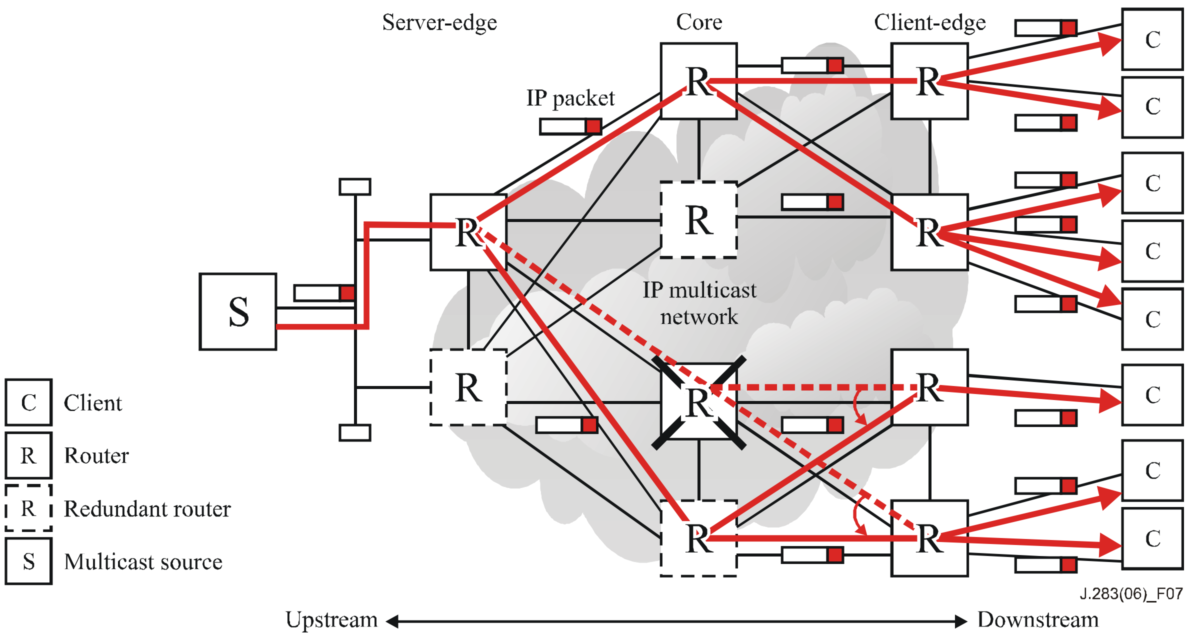

Figure 7/J.283 – Example of IP network architecture (Category 3+1)

In all the categories, the following procedures are performed to reconstruct multicast trees if a router/link failure occurs on them.

a) OSPF detects the failure and withdraws the corresponding unicast route for the multicast source. Unicast route recalculation occurs.

b) (Category 1) As a result, an alternative route is recalculated, and then appears on the unicast routing table for the first time.

b') (Categories 2, 3, 2+1, 3+1) Even during the route recalculation phase, the other equal-cost unicast route remains as an alternative route on the unicast routing table. Therefore, the router can rapidly proceed to Step c).

c) PIM-SM reconstructs the multicast trees according to the alternative unicast route if they have been established along the withdrawn route.

After recovery of the failure, similar procedures to Steps c) and d) in clause 5 are conducted.

Comparing Category 3 with Category 2, the network resiliency will increase because more network layer route diversity is provided in Category 3. For example, even if two routers fail simultaneously at different levels, e.g., the core and server-edge, Category 3 can continue multicast distribution, but Category 2 cannot. However, the network topology is more complicated and may be expensive in Category 3 considering the incidence of such a failure scenario.

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