Framework of Control Protocol for Relayed Multicast

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Abstract. In this paper, we introduce Relayed Multicast Control Protocol (RMCP). The RMCP has been designed for realizing and managing the relayed multicast. Relayed multicast, as known as Overlay Multicasting or Application-level Multicasting, is a data delivery scheme for one-to-many multicast application, in which one or more intermediate Multicast Agents are employed for relaying application data from a sender to many receivers along a tree hierarchy. In RMCP, a special-purpose entity, named Session Manager, is used to manage the overall control operations. RMCP is designed to ensure that the multicast applications and services can be provided along with the associated relayed data transport schemes over current Internet environments in which IP multicast has not completely been deployed.

1 Introduction

IP multicasting has not been widely deployed in real Internet in spite of its substantial transport efficiency [1, 2]. In the meantime, the overlay multicasting schemes [3 – 5] as also known as Application-level Multicasting have recently been highlighted among many researchers as the alternative to the conventional IP multicasting.

The End System Multicast (ESM) was designed as an overlay multicasting scheme for conference applications in the Carnegie Melon University [3], in which 'Narada' is developed as a tree-building scheme for overlay tree. In ACIRI, the Your Own Internet Distribution (YOID) scheme has been designed and experimented for overlay multicasting [4]. In addition to these, a lot of studies on overlay multicasting have been made so far [5].

In this paper, we discuss the Relayed Multicast Control Protocol (RMCP), which is currently being developed and standardized in ITU-T SG17 and ISO/IEC JTC1/SC6 [6]. The RMCP has been designed for realizing and managing the relayed multicast data delivery, as known as Overlay Multicasting. The Relayed Multicast is a data delivery scheme for one-to-many multicast applications, in which one or more intermediate Multicast Agents (MAs) are employed for relaying application data from a sender to many receivers along a tree hierarchy. In RMCP, a special-purpose entity, named Session Manager, is used to manage the overall session status. RMCP is designed to ensure that the multicast applications and services can be provided over current Internet environments where IP multicast has not completely been deployed.

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This paper is organized as follows. Section 2 discusses a model of the relayed multicast data transport. In Section 3, we present a framework of Relayed Multicast Control Protocol (RMCP), together with the protocol operations. Section 4 discusses some guidelines for implementations of RMCP. Section 5 concludes this paper.

2 Data Transport Model for Relayed Multicast

In the conventional data transport approach, a sender communicates directly with receivers by using IP unicast or multicast. In the relayed multicast scheme, a new entity named Multicast Agent is employed for communication between a sender and receivers. Instead of the multicast-capable routers in the networks, Multicast Agents (hosts) are deployed for relaying (or routing) the multicast data from a sender to many receivers even over unicast network regions. With the help of Multicast Agents, the multicast data can traverse non-multicast network regions until they reach the end receivers.

Figure 1 describes relayed multicast transport model. In the figure, sender (media server) and receivers (media players) represent typical multicast applications such as real-time streaming media applications. For the relayed multicast, Multicast Agents are located along the path from the sender to receivers. The sender transmits multicast data, and each receiver gets the data by multicast.

The relayed multicast model is designed to realize multicast data communications without any modification of the existing network routers and applications such as streaming media. In the relayed multicast, each receiver may be equipped with a Multicast Agent in the same system or local network. The MA will deliver the multicast data received from its upstream Multicast Agent to the concerned media player. The media player has only to listen to its Multicast Agent so as to get the multicast data. The sender may also have its Multicast Agent in the same system or local network. Such a Multicast Agent is particularly called 'Sender Multicast Agent (SMA)'. If the sender is in the multicast environment such as an Ethernet LAN, several distinct SMAs may be deployed in the LAN.

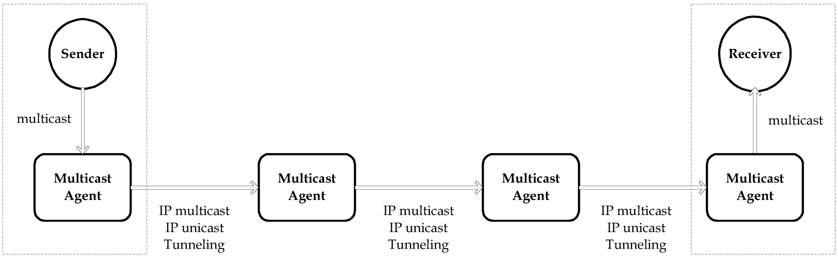

Fig. 1. Relayed multicast transport

3 Framework of Relayed Multicast Control Protocol

The Relayed Multicast Control Protocol (RMCP) is an application-level control protocol used for realizing and managing the relayed multicast data transport with support of Multicast Agents (MAs) and Session Manager.

3.1 RMCP Entities

An RMCP session consists of Multicast Agents, and Session Manager. The media server and media players are not involved into the RMCP control operations, although they are main entities in the relayed multicast data transport, as shown in the following figure. An MA may be established with media server or media player within the same host system. Communications between MA and media server/players are not the scope of RMCP.

An MA is an entity used to relay application data from the upstream entity (including media server) to its downstream entities (including media player). In particular, an MA attached to the media server is called Sender MA (SMA). Differently from the other MAs, the SMA directly receives the original multicast data from the media server. For the relayed multicast, all the media players are required to be equipped with an MA within the same system or connected to it in the same local network. Each media player may get multicast data from the corresponding MA, which is also outside the scope of RMCP.

Session Manager is a special-purpose entity used for managing the relayed multicast. It is responsible for the overall RMCP operations. Session Manager will communicate with the media server by an out-of-band channel so as to get generic session information. The main role of Session Manager is to configure a tree hierarchy for the RMCP session. In response to the join request of an MA, Session Manager informs the MA about the best suitable upstream MA. Session Manager is also used to monitor overall session status on membership dynamics and QoS.

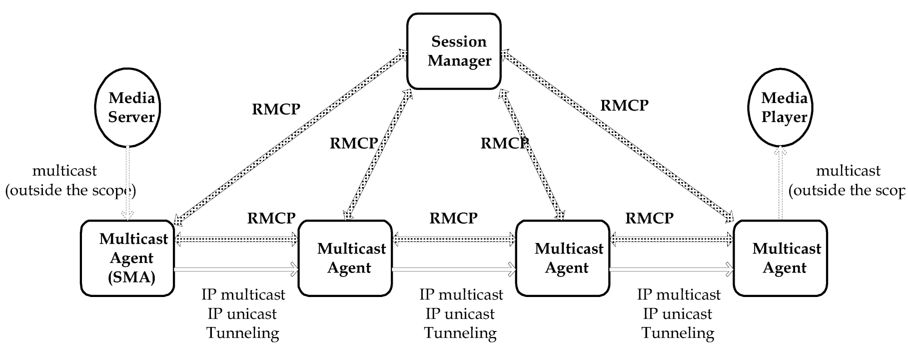

Fig. 2. RMCP entities

3.2 RMCP Messages

In RMCP, the six control messages are used: JR (Join Request) and JC (Join Confirm), RR (Relay Request) and RC (Relay Confirm), SR (Status Report) and SC (Status Confirm). The JR and JC messages are used just once for the session join, while the other four messages are periodically exchanged during the session. The periodic RR & RC messages are exchanged between two peers of the upstream and downstream MAs, while the SR and SC messages are exchanged between Session Manager and MAs. All the RMCP messages are encapsulated over TCP. This ensures that all the messages are reliably transferred between the corresponding two RMCP entities.

3.3 Protocol Operations

The RMCP is a control protocol used for realizing the relayed multicast data transport. RMCP is used to exchange information necessary for establishing and monitoring the data channels between the RMCP entities. The RMCP assumes that each MA has its own data transport module. The RMCP will operate based on the close interactions with the data transport module.

3.3.1 Session Join

To join an RMCP session, each MA sends a JR message to Session Manager, and waits for the responding JC message. On reception of a JR message, Session Manager performs a tree configuration algorithm to find the best suitable parent to the joiner among the active MAs.

In response to the Join Request, the Session Manager must send a JC message to the new joiner. If the new joiner will receive a successful JC message, it begins the data channel control operations with the designated upstream MA. The JC message may indicate a rejection of the join request for any abnormal reasons, which include the case that Session Manager identifies a suitable parent. If the JC message indicates a rejection, or if there is no response from Session Manager, then the new joiner cannot participate in the session.

3.3.2 Data Channel Control

After reception of a successful JC message from Session Manager, the new joiner begins the data channel control operations with the designated upstream MA. It sends the first Relay Request (RR) message to the parent and waits for the responding Relay Confirm (RC) message.

After reception of the first RR message, the upstream MA enrolls the new joiner into its children list. In response to the RR message, the upstream MA sends an RC message to the joiner. After that, the upstream MA establishes a data channel by invoking its data transport module. The specific type of data channel was indicated in the RR message.

3.3.3 Session Monitoring

Session monitoring is used for Session Manager to monitor session status such as membership dynamics and QoS perceived by users. For this purpose, Status Report and Confirm messages are exchanged between MAs and Session Manager.

As soon as each MA has joined the tree (established a data channel with its upstream MA), it begins the periodic SR messages to Session Manager. The SR messages include information on the tree membership and QoS measurements. Based on the received Status Report, the Session Manager maintains and updates the session membership lists. In response to the Status Report, Session Manager sends the SC message, which may contain a new SR_TIME timer value.

Each MA will generate the subsequent SR messages based on its SR_TIME timer or when it wants to leave the session (as done by the RR messages).

4 Implementation Guidelines

In RMCP, Session Manager is involved in Session Join and Session Monitoring. Each new joiner must contact with Session Manager by sending a Join Request message. Session Manager responds with a Join Confirm message that contains information on the location of the upstream MA and on whether the SR messages must be reported.

In Session Monitoring, each MA reports session status to Session Manager by sending the SR messages. Based on the information contained in the SR message, Session Manager collects and updates the session membership lists. Session Manager must respond with the SC message.

Each MA basically performs the RMCP operations with its upstream MA as well as its downstream MAs in the Data Channel Control phase. It also interacts with Session Manager in Session Join and Session Monitoring. Each MA must be equipped with both RMCP control and data transport modules in the system. From the initialization, an MA will be informed on MAID, Session ID and location of Session Manager via an out-of-band signaling mechanism

After initialization, an MA first performs the Session Join operations by contacting with Session Manager. After a successful Session Join, it will connect to its upstream MA that was informed by Session Manager, so as to establish a data channel such as unicast, multicast or multicast-in-unicast. After the successful establishment of a data channel, the MA sends periodic Relay Request messages based on RR_TIME timer, so as to indicate that it still keeps alive in the session.

During the session, the data transport module may continue to measure the perceived QoS in terms of data throughput (bytes per second) or the number of totally received data packets. In response to the request of the RMCP module, the measured QoS is transferred to the RMCP module via a suitable QoS MIB (e.g., in Session Monitoring). Each time a receiver generates the periodic Relay Request or Status Report messages, the RMCP module will contact with the data channel so as to check if the data channel is still valid.

5 Conclusions

In this paper, we have introduced the RMCP protocol designed for control of the Relayed Multicast, which is being developed and standardized in ITU-T SG17. For present, the RMCP implementation and validation works are still being progressed.

The existing overlay multicasting schemes are all characterized by the unified data and control modules for overlay multicasting. For improving the interoperability among the overlay multicasting schemes, in the proposed RMCP scheme, the control plane (for tree building/session monitoring) is separated from the data plane (for data forwarding over overlay tree).

Observing that the overlay multicast or application-level multicast delivery solutions are considered as alternative short-term solution for one-to-many multicast application services, the associated control scheme or protocol needs to be designed for interoperability, as described in this paper.

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