    Switching from unicast to multicast for multicast short time-shift
         draft-yang-avt-switch-multicast-short-timeshift-00.txt

Abstract

   When a client requests a time-shift service for a multicast session
   using RTP for media transport, like pause, instant replay, slow-
   motion video, frame-by-frame viewing, rewind, fast-forward, etc., it
   needs to switch from multicast session to unicast session. This
   unicast session will always serve for the time-shift service unless
   the client manually switches back to the multicast session. Actually
   a time- shift request may happens for all clients. That is,
   multicast session stream will be replaced by many unicast time-shift
   streams having significant impact on network bandwidth usage.

   In this document, we describe a method using existing RTP and RTCP
   protocol infrastructure that switches back to multicast session from
   unicast session of time-shift. In this method, a burst RTP flow
   which is a little faster than the primary multicast rate may be
   transmitted so that unicast session may catch up and switch back to
   multicast session.

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Table of Contents

1. Introduction

   Interactive time-shift is an important service for media application.
   Through time-shift control operations (e.g. pause, instant replay,
   slow-motion video, frame-by-frame viewing, rewind and fast-forward),
   viewers can access recorded programming and live streams. The time-
   shift service is available for recorded media and real-time
   streaming. For the real-time streaming, time-shift service requires
   recording/caching of the information. The time-shifted information
   can be sent by the original media source or by a server in the
   network that caches the stream and provides the time-shift service.

   Note that time-shift service may run on the client side but this
   requires the client to be able to cache the stream and
   synchronization to the main multicast stream needs to be managed by
   the client and does not require any specific protocol.

   This document looks at time-shift services where the original content
   is delivered using multicast. In this use case the time-shift
   service is using a unicast stream from a Multicast Short Time-shift
   (MST) server to the client. The synchronization between the
   multicast and unicast stream can be achieved by the client if he is
   using control commands like fast forward or RTSP [ref] Scale request.
   The MST can notice that the client is receiving in the unicast stream
   the same information that is current in the multicast stream.

   Network traffic will rise with the increase in the number of clients
   using time-shift service, because the time-shift service traffic
   changes from a multicast stream (one multicast stream for all
   clients) to a large number of unicast streams (one unicast stream per
   client). Time- shift services like slow-motion view, instant replay,
   frame-by-frame viewing, pause and rewind may often occur for most of
   viewers in prime-time (e.g. when watching sports events).

   We can separate the time-shift services of primary live streams
   delivered over multicast/broadcast into multicast long time-shift and
   multicast short time-shift. Some of the manipulations requested by
   the viewers are multicast short time-shift (e.g. short pause, instant
   replay, slow-motion video and frame-by-frame viewing). For the
   multicast short time-shift, the time offset between the unicast time-
   shift playback, after the time-shift request, and the current time of
   the primary multicast stream is small enabling the unicast stream to
   catch up with primary multicast stream by speeding up the playback,
   and then switch back to the original multicast session.

   In this document, we propose a solution for enabling the time-shifted
   stream receivers to catch up with the original multicast stream using
   the tools offered by the existing RTP and RTCP protocols. The

document also describes how to switch back to the primary multicast
session from the unicast session initiated by either the client or
the server. Using this solution allows the network bandwidth to be
effectively saved for the time-shift service of multicast
application.

In the scenario that we consider in this draft, an intermediary
network element (that we refer to as Multicast Short Time-shift
server) joins the multicast session and continuously caches the
multicast stream. When an RTP receiver sends a time-shift request,
the MST server starts a new unicast RTP session and transmits the
unicast stream to the RTP receiver over that session. A simplified
network diagram showing this scenario employing an intermediary
network element is shown in Figure 1, where the hashed lines show the
unicast stream.

```
                     +--------------------------------+
                     |   Intermediary Network Element  |
                     |                                |
                     |           MST Server           |
                     +--------------------------------+
                                ^ :
                                | :
                                | :
                                | v
     +-----------+        +-------------+        +-------------+
     | Multicast |        |             |---------->|  Time-shift |
     |           |------->|   Router    |        |      RTP    |
     |  Source   |        |             |.........>|   Receiver  |
     +-----------+        +-------------+        +-------------+
                                |
                                |                 +-------------+
                                |                 |   Existing  |
                         +---------------->|      RTP    |
                                          |   Receiver  |
                                          +-------------+
```
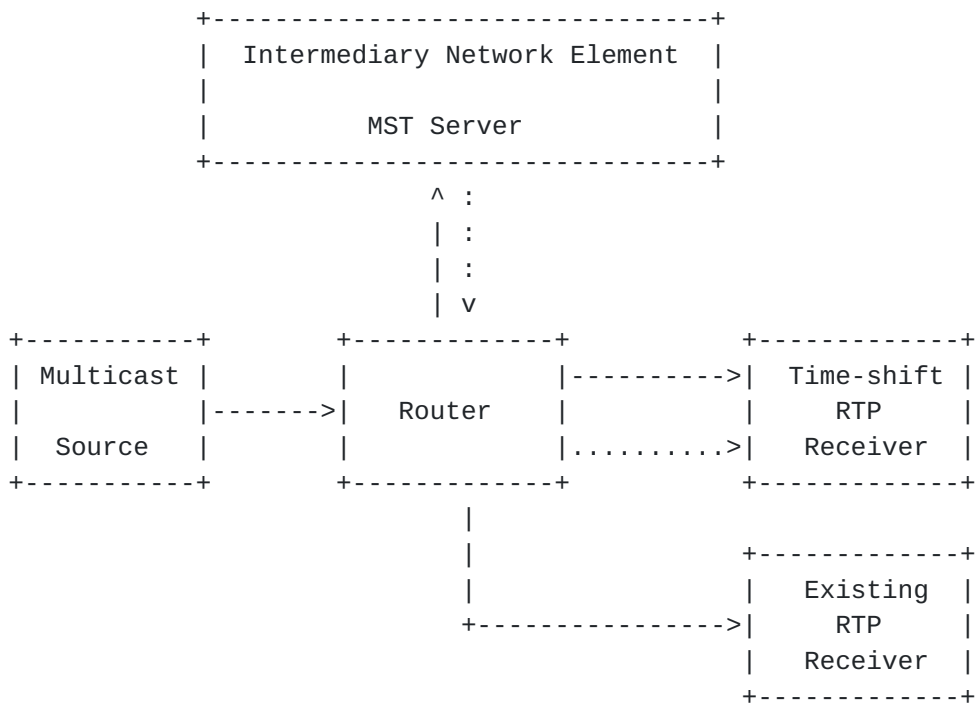
Figure 1: Reverse switch for multicast short time-shift
through an intermediary network element

The proposed solution is not dependent on a specific streaming
control protocol like RTSP [ref]. It addresses the synchronization
between a primary multicast RTP stream and a parallel time-shifted
unicast RTP stream. A principle design goal is to use an existing
protocol to define this solution. This improves the versatility of
the existing implementations, and promotes faster deployment and
better interoperability. To this effect, the proposal is to use the
switching of flows from unicast stream to multicast stream described
in RAMS [draft-ietf-avt-rapid-acquisition-for-rtp], and use the
capabilities of RTCP to handle the signaling needed to accomplish

   this automatic reverse switch for multicast short time-shift.

1.1. RTSP Time-shift and MST Reverse Switch

   RTSP 2.0[draft-ietf-mmusic-rfc2326bis] is an application-level
   protocol for setup and control of the media delivery with real-time
   properties, and provides an extensible framework to enable
   controlled, on-demand delivery of real-time data, typically streaming
   media.

   RTSP defines any necessary media transport signalling with regards to
   RTP. In appendix C.1 it defines the interaction of RTSP with respect
   to the RTP protocol [RFC3550]. Yet RTSP is not limited to RTP media
   delivery control but any delivery type of data. It provides a
   general media delivery control mechanism to play out the media, pause
   media, or stop media over different delivery channels, such as UDP,
   multicast UDP, TCP, RTP over UDP, etc.

   RTSP can also provide interactive time-shift function with different
   scale and speed. Section 13.4.8 in [draft-ietf-mmusic-rfc2326bis]
   has a scenario for Playing Live with time-shift where a certain media
   server may offer time-shift services to their clients. The usage of
   this play method can implement time- shift for Live Media or On-
   demand Media. Section 16.44 in [draft-ietf-mmusic-rfc2326bis]
   addresses the scaling for video and audio, it suggests sending only
   key frames for video but this may not achieve the right scale speed
   since it depends on the locality of such frames in the stream. It
   also requires analysis of the media payload for all supported codecs
   to find the key frames. In this document we call the interactive
   time-shift function in [draft-ietf-mmusic-rfc2326bis] as "RTSP Time-
   shift".

   For Live Media using RTP multicast over UDP, RTSP Time-shift can
   provide an initial switch from multicast session to unicast session
   when time-shift happens, but it cannot complete the reverse switch
   from unicast session of time-shift to the original multicast session.

   An MST server can for example transmit the unicast stream of the
   time-shift by a short burst stream and indicate to the receivers to
   speed up the playback through Non-perceptual Speedup Playback. After
   the burst of the unicast stream of time-shift catches up with the
   primary multicast stream, the client can switch back to the primary
   multicast stream so that the network bandwidth can be effectively
   saved. The synchronization due to catch up with the primary
   multicast session may also happen due to the client operation like
   the fast forward.

1.2. RAMS and MST Reverse Switch

   RAMS [draft-ietf-avt-rapid-acquisition-for-rtp] describes a method
   using the existing RTP and RTCP protocol for reducing the acquisition
   delay, allowing fast channel switch. RAMS defines the reverse switch
   from unicast burst session to the primary multicast session.

2. Conventions

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
   document are to be interpreted as described in [RFC2119].

3. Definitions

   This document uses the following acronyms and definitions frequently:

   Time-shift Control: Refers to the manipulation control of time-shift
   service (e.g. pause, slow-motion video, frame-by-frame viewing,
   rewind, fast- forward, etc.), not include the play method.

   Time-shift Playback: Refers to the normal playback with a natural
   playback rate after the time-shift control.

   Multicast Time-shift Interval: Refers to the time interval or the
   number of packets between the primary multicast stream and the normal
   playback during the unicast session after the time-shift control. In
   other words, it presents the time interval between the start point
   frame of the unicast session and the frame of the current location of
   the primary multicast session.

   Multicast Short Time-shift: The case when the multicast Time-shift
   Interval is short, such as 30 seconds. The normal playback during
   the unicast session after the time-shift control means that viewers
   finish the time-shift control (e.g. pause, rewind and fast-
   forward)and start to receive the unicast stream and play back again
   at the speed of the Primary multicast stream.

   Primary multicast stream: The multicast stream before time-shift
   request.

   Instant Replay: It is the case of the replaying of video footage of
   an event or incident directly after its occurrence. In television
   broadcasting of sports events, instant replay is often used during
   live broadcast, to show a passage of play which was important or
   remarkable, or which was unclear on the first sight.

Slow-motion Video: The case when the playback of a video clip appears to be slower than the natural speed of the events.

Non-perceptual Speedup Playback: During the speedup playback, after each interval of some frames, one frame is skipped as if it was not present, the next frame is directly rendered to take the place of the skipped frame, while keeping a fixed Frame Per Second (FPS)during the playback speedup.

4. Reverse switch for multicast short time-shift

This section gives an overview on the proposed method for reverse multicast time- shift switch from unicast time-shift RTP Sessions.

4.1. Overview

RTP Control Protocol (RTCP) Extensions for Single-Source Multicast Sessions with Unicast Feedback [RFC5760] specifies an extension to the RTCP to use unicast feedback to a multicast sender. The (Unicast RTCP) Feedback Target is a logical function to which RTCP unicast feedback traffic is addressed. The functions of the Feedback Target and the Distribution Source MAY be co-located or integrated in the same entity. In this case, The (Unicast RTCP) Feedback Target MAY be co-located or integrated in the Multicast Time-shift Server.

This section presents a proposed method to switch back to the multicast session from the unicast session of time-shift considering multicast short time-shift. The proposed method allows the network bandwidth to be effectively saved when an RTP receiver finishes its time-shift request and starts its time- shift playback by unicast stream. A Multicast Short Time-shift Server (MST) and new RTCP feedback messages are also introduced for the proposed method.

The MST server has a cache where the most recent packets from the primary multicast stream are continuously stored for some time. When a viewer wants to normally playback the unicast stream after time-shift request, the RTP receiver needs to send a playback request to the feedback target, and then receives the unicast stream from the MST server. In order to switch back to the original multicast stream, the MST server needs to transmit a burst unicast stream to RTP receivers. Using an accelerated bitrate (as compared to the bitrate of the original multicast stream). This means that at a certain point in time, the unicast burst will catch up with the original multicast stream. At this point, the RTP receiver no longer needs to receive the unicast burst and can switch back to the original multicast session.

The transmission of the unicast burst stream of time-shift playback
depends on the time-shift buffer size of RTP receivers and the
Multicast Short Time-shift Interval. In the case when the time-shift
buffer size of an RTP receiver can inadequately accommodate the
number of packets of the Multicast Short Time-shift Interval, the
receiver needs to playback for the duration of the speeding-up until
the remaining number of packets does not overflow at the time-shift
buffer. During the playback of the speeding-up, the receiver may
speed up video playback by the non-perceptual speedup playback so
that viewers could never perceived the existence of the speeding-up.
Refer to [I-D.yang-avt-rtp-synced-playback]

4.2. Message Flows

This section introduces the different messages for the proposed
method and the related messages flows.

- MST(Multicast Short Time-shift) synchronization
transmission(MSTST): This is the generic form of the different
messages that will be transmitted during the proposed method in this
draft for reverse switch multicast short time-shift.

-Time-Shift-Control-Commands: This message presents the request for
the Time-Shift service (e.g. fast forward, pause, reverse, ..etc.).
This message may be addressed by the MST server or other time-shift
server.

- MSTST Playback Request(MSTST-PReq): It's the message sent from the
RTP receiver to the MST to request the playback after the time-shift
request.

- MSTST Playback Response(MSTST-PRes): It's the response message sent
from the MST to the RTP receiver to confirm the playback process
initiation. Following this message, the RTP receiver will receive
the unicast burst RTP stream from the MST.

- MSTST Synchronization Indication(MSTST-SInd): When the unicast
burst catch up with the original multicast stream, this message is
sent from the MST to the RTP receiver to indicate this fact.

- MSTST Synchronization Response(MSTST-SRes): This message is sent by
the RTP receiver as a response to the MST confirming the need to
switch back to the original multicast session. Following this
message the RTP receiver is able to receive the multicast stream.

- MSTST Termination Request(MSTST-TReq): This message is sent by the
RTP receiver to the MST to terminate the process of the time-shift.

- MSTST Termination Response(MSTST-TRes): This message is a reply
sent by the MST to the RTP to confirm to the MSTST-TReq.

```
                    --------------------------
                    |         MST  Server     |
  -----------       |  ------   -----------   |   --------    ------------
 | Multicast |      | |  FT  | | Burst/Ret. | |  |        |  |    RTP     |
 |  Source   |      | |      | |   Source   | |  | Router |  |  Receiver  |
 |           |      | | ------   -----------   |  |        |  |  (RTP_Rx)  |
  -----------       |                          |   --------    ------------
        |           |     ------------------------      |           |
        |           |            |                      |           |
        |--- RTP Multicast->--------------------->|           |
        |                        |                      |           |
        |                  .......................................
        |                  .                                    .
        |                  .      <::Time-shift control commands ::>   .
        |                  .       ..Time-shift media stream     ..>    .
        |                  .......................................
        |                        |                      |           |
        |                        |<'''''''' RTCP MSTST-PReq''''''''|
        |                        |'''''''''' RTCP MSTST-PRes''''''>|
        |                        |                      |           |
        |                        |                      |           |
        |                        |....... Unicast RTP Burst .......>|
        |                        |                      |           |
        |                        |                      |           |
        |                        |'''''''''' RTCP MSTST-SInd'''''''>|
        |                        |<'''''''' RTCP MSTST-SRes''''''''|
        |                        |                      |           |
        |                        |                      |           |
        |                        |                      |<~SFGMP Join~|
        |                        |                      |           |
        |                        |                      |           |
        |----------------- RTP Multicast -------------------->|
        |                        |                      |           |
        |                        |                      |           |
        |                        |<'''''''' RTCP MSTST-TReq''''''''|
        |                        |'''''''''' RTCP MSTST-TRes '''''>|
        |                        |                      |           |
        |                        |                      |           |
        |                        |<'''''''' (RTCP BYE) ''''''''''''|
        |                        |                      |           |
```
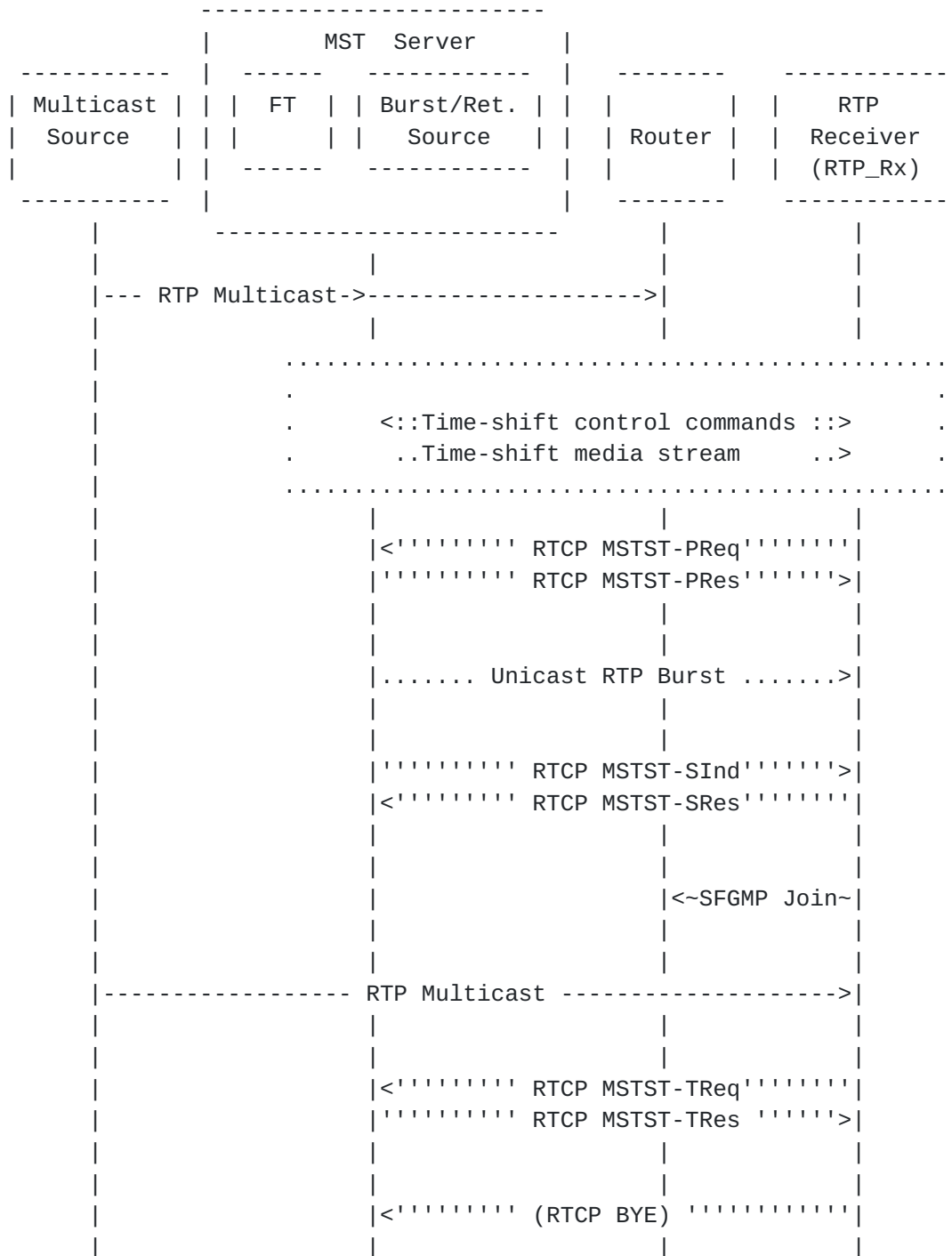
5. Security Considerations

   TBD.

6. IANA Considerations

   TBD.

7. Acknowledgements

   TBD.

8. Normative References

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