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October 22, 2012

Multiple Media Types in an RTP Session
draft-ietf-avtcore-multi-media-rtp-session-01

Abstract

This document specifies how an RTP session can contain media streams with media from multiple media types such as audio, video, and text. This has been restricted by the RTP Specification, and thus this document updates RFC 3550 and RFC 3551 to enable this behavior for applications that satisfy the applicability for using multiple media types in a single RTP session.

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1. Introduction

When the Real-time Transport Protocol (RTP) [RFC3550] was designed, close to 20 years ago, IP networks were very different compared to the ones in 2012 when this is written. The almost ubiquitous deployment of Network Address Translators (NAT) and Firewalls has increased the cost and likely-hood of communication failure when using many different transport flows. Thus there exists a pressure to reduce the number of concurrent transport flows.

RTP [RFC3550] recommends against sending several different types of media, for example audio and video, in a single RTP session. The RTP profile for Audio and Video Conferences with Minimal Control (RTP/AVP) [RFC3551] mandates a similar restriction. The motivation for these limitations is partly to allow lower layer Quality of Service (QoS) mechanisms to be used, and partly due to limitations of the RTCP timing rules that require all media in a session to have similar bandwidth. The Session Description Protocol (SDP) [RFC4566], as one of the dominant signalling method for establishing RTP session, has enforced this rule, simply by not allowing multiple media types for a given receiver destination or set of ICE candidates, which is the most common method to determine which RTP session the packets are intended for.

The fact that these limitations have been in place for so long a time, in addition to RFC 3550 being written without fully considering multiple media types in an RTP session, does result in a number of considerations being needed when allowing this behavior. This document provides such considerations regarding applicability as well as functionality, including normative specification of behavior.

First, some basic definitions are provided. This is followed by a background that discusses the motivation in more detail. A overview of the solution of how to provide multiple media types in one RTP session is then presented. Next is the formal applicability this specification have followed by the normative specification. This is followed by a discussion how some RTP/RTCP Extensions should function in the case of multiple media types in one RTP session. A specification of the requirements on signalling from this specification and a look how this is realized in SDP using Bundle [I-D.ietf-mmusic-sdp-bundle-negotiation]. The document ends with the security considerations.

2. Definitions

2.1. Requirements Language

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].

2.2. Terminology

The following terms are used with supplied definitions:

Endpoint: A single entity sending or receiving RTP packets. It may be decomposed into several functional blocks, but as long as it behaves as a single RTP stack entity it is classified as a single endpoint.

Media Stream: A sequence of RTP packets using a single SSRC that together carries part or all of the content of a specific Media Type from a specific sender source within a given RTP session.

Media Type: Audio, video, text or application whose form and meaning are defined by a specific real-time application.

RTP Session: As defined by [RFC3550], the endpoints belonging to the same RTP Session are those that share a single SSRC space. That is, those endpoints can see an SSRC identifier transmitted by any one of the other endpoints. An endpoint can receive an SSRC either as SSRC or as CSRC in RTP and RTCP packets. Thus, the RTP Session scope is decided by the endpoints' network interconnection topology, in combination with RTP and RTCP forwarding strategies deployed by endpoints and any interconnecting middle nodes.

3. Motivation

This section discusses in more detail the main motivations why allowing multiple media types in the same RTP session is suitable.

3.1. NAT and Firewalls

The existence of NATs and Firewalls at almost all Internet access has had implications on protocols like RTP that were designed to use multiple transport flows. First of all, the NAT/FW traversal solution one uses needs to ensure that all these transport flows are established. This has three different impacts:

1. Increased delay to perform the transport flow establishment

2. The more transport flows, the more state and the more resource consumption in the NAT and Firewalls. When the resource consumption in NAT/FWs reaches their limits, unexpected behaviors usually occur.

3. More transport flows means a higher risk that some transport flow fails to be established, thus preventing the application to communicate.

Using fewer transport flows reduces the risk of communication failure, improved establishment behavior and less load on NAT and Firewalls.

3.2. No Transport Level QoS

Many RTP-using applications don't utilize any network level Quality of Service functions. Nor do they expect or desire any separation in network treatment of its media packets, independent of whether they are audio, video or text. When an application has no such desire, it doesn't need to provide a transport flow structure that simplifies flow based QoS.

3.3. Architectural Equality

For applications that don't require different lower-layer QoS for different media types, and that have no special requirements for RTP extensions or RTCP reporting, the requirement to separate different media into different RTP sessions may seem unnecessary. Provided the media flows have similar bandwidth requirements, so that the RTCP timing rules work, using the same RTP session for several types of media at once appears a reasonable choice. The architecture should be agnostic about the type of media being carried in an RTP session to the extent possible given the constraints of the protocol.

4. Overview of Solution

The goal of the solution is to enable having one or more RTP sessions, where each RTP session may contain two or more media types. This includes having multiple RTP sessions containing a given media type, for example having three sessions containing video and audio.

The solution is quite straightforward. The first step is to override the SHOULD and SHOULD NOT language of the RTP specification [RFC3550]. Similar change is needed to a sentence in Section 6 of [RFC3551] that states that "different media types SHALL NOT be

interleaved or multiplexed within a single RTP Session". This is resolved by appropriate exception clauses given that this specification and its applicability is followed.

Within an RTP session where multiple media types have been configured for use, an SSRC may send only one type of media during its lifetime (i.e., it can switch between different audio codecs, since those are both the same type of media, but cannot switch between audio and video). Different SSRCs must be used for the different media sources, the same way multiple media sources of the same media type already have to do. The payload type will inform a receiver which media type the SSRC is being used for. Thus the payload type must be unique across all of the payload configurations independent of media type that may be used in the RTP session.

Some few extra considerations within the RTP sessions also needs to be considered. RTCP bandwidth and regular reporting suppression (AVPF and SAVPF) should be considered to be configured. Certain payload types like FEC also need additional rules.

The final important part of the solution to this is to use signalling and ensure that agreement on using multiple media types in an RTP session exists, and how that then is configured. Thus document documents some existing requirements, while an external reference defines how this is accomplished in SDP.

5. Applicability

This specification has limited applicability and any one intending to use it must ensure that their application and usage meets the below criteria.

5.1. Usage of the RTP session

Before choosing to use this specification, an application implementer needs to ensure that they don't have a need for different RTP sessions between the media types for some reason. The main rule is that if one expects to have equal treatment of all media packets, then this specification might be suitable. The equal treatment include anything from network level up to RTCP reporting and feedback. The document Guidelines for using the Multiplexing Features of RTP [I-D.westerlund-avtcore-multiplex-architecture] gives more detailed guidance on aspects to consider when choosing how to use RTP and specifically sessions. RTP-using applications that need or would prefer multiple RTP sessions, but do not require the functionalities or behaviors that multiple transport flows give, can consider using Multiple RTP Sessions on a Single Lower-Layer

Transport [I-D.westerlund-avtcore-transport-multiplexing].

The second important consideration is that all media flows to be sent within a single RTP session need to have similar bandwidth. This is due to limitations of the RTCP timing rules, and the need for a common RTCP reporting interval across all participants in a session to avoid problems with premature SSRC timeouts. If an RTP session contains flows with very different bandwidths, for example low-rate audio coupled with high-quality video, this will result in either excessive or insufficient RTCP for some flows, depending how the RTCP session bandwidth, and hence reporting interval, is configured. This is discussed further in Section 6.4.

5.2. Signalled Support

Usage of this specification is not compatible with anyone following RFC 3550 and intending to have different RTP sessions for each media type. Therefore there must be mutual agreement to use multiple media types in one RTP session by all participants within an RTP session. This agreement must in most cases be determined using signalling.

This requirement can be a problem for signalling solutions that can't negotiate with all participants. For declarative signalling solutions, mandating that the session is using multiple media types in one RTP session can be a way of attempting to ensure that all participants in the RTP session follow the requirement. However, for signalling solutions that lack methods for enforcing that a receiver supports a specific feature, this can still cause issues.

5.3. Homogeneous Multi-party

In multiparty communication scenarios it is important to separate two different cases. One case is where the RTP session contains multiple participants in a common RTP session. This occurs for example in Any Source Multicast (ASM) and Transport Translator topologies as defined in RTP Topologies [RFC5117]. It may also occur in some implementations of RTP mixers that share the same SSRC/CSRC space across all participants. The second case is when the RTP session is terminated in a middlebox and the other participants sources are projected or switched into each RTP session and rewritten on RTP header level including SSRC mappings.

For the first case, with a common RTP session or at least shared SSRC/CSRC values, all participants in multiparty communication are required to support multiple media types in an RTP session. An participant using two or more RTP sessions towards a multiparty session can't be collapsed into a single session with multiple media types. The reason is that in case of multiple RTP sessions, the same

SSRC value can be use in both RTP sessions without any issues, but when collapsed to a single session there is an SSRC collision. In addition some collisions can't be represented in the multiple separate RTP sessions. For example, in a session with audio and video, an SSRC value used for video will not show up in the Audio RTP session at the participant using multiple RTP sessions, and thus not trigger any collision handling. Thus any application using this type of RTP session structure must have a homogeneous support for multiple media types in one RTP session, or be forced to insert a translator node between that participant and the rest of the RTP session.

For the second case of separate RTP sessions for each multiparty participant and a central node it is possible to have a mix of single RTP session users and multiple RTP session users as long as one is willing to remap the SSRCs used by a participant with multiple RTP sessions into non-used values in the single RTP session SSRC space for each of the participants using a single RTP session with multiple media types. It can be noted that this type of implementation is required to understand any type of RTP/RTCP extension being used in the RTP sessions to correctly be able to translate them between the RTP sessions.

5.4. Reduced number of Payload Types

An RTP session with multiple media types in it have only a single 7-bit Payload Type range for all its payload types. Within the 128 available values, only 96 or less if "Multiplexing RTP Data and Control Packets on a Single Port" [RFC5761] is used, all the different RTP payload configurations for all the media types must fit. For most applications this will not be a real problem, but the limitation exists and could be encountered.

5.5. Stream Differentiation

If network level differentiation of the media streams of different media types are desired using this specification can cause severe limitations. All media streams in an RTP session, independent of the media type, will be sent over the same underlying transport flow. Any flow-based Quality of Service (QoS) mechanism will be unable to provide differentiated treatment between different media types, e.g. to prioritize audio over video. If that is desired, separate RTP sessions over different underlying transport flows needs to be used. Any marking-based QoS scheme like DiffServ is not affected unless a network ingress marks based on flows.

5.6. Non-compatible Extensions

There exist some RTP and RTCP extensions that rely on the existence of multiple RTP sessions. If the goal of using an RTP session with multiple media types is to have only a single RTP session, then these extensions can't be used. If one has no need to have different RTP sessions for the media types but is willing to have multiple RTP sessions, one for the main media transmission and one for the extension, they can be used. It should be noted that this assumes that it is possible to get the extension working when the related RTP session contains multiple media types.

Identified RTP/RTCP extensions that require multiple RTP Sessions are:

RTP Retransmission: RTP Retransmission [RFC4588] has a session multiplexed mode. It also has a SSRC multiplexed mode that can be used instead. So use the mode that is suitable for the RTP application.

XOR-Based FEC: The RTP Payload Format for Generic Forward Error Correction [RFC5109] and its predecessor [RFC2733] requires a separate RTP session unless the FEC data is carried in RTP Payload for Redundant Audio Data [RFC2198] which has another set of restrictions.

Note that the Source-Specific Media Attributes [RFC5576] specification defines an SDP syntax (the "FEC" semantic of the "ssrc-group" attribute) to signal FEC relationships between multiple media streams within a single RTP session. However, this can't be used as the FEC repair packets are required to have the same SSRC value as the source packets being protected. [RFC5576] does not normatively update and resolve that restriction.

6. RTP Session Specification

This section defines what needs to be done or avoided to make an RTP session with multiple media types function without issues.

6.1. RTP Session

Section 5.2 of "RTP: A Transport Protocol for Real-Time Applications" [RFC3550] states:

> For example, in a teleconference composed of audio and video media encoded separately, each medium SHOULD be carried in a separate RTP session with its own destination transport address.

> Separate audio and video streams SHOULD NOT be carried in a single RTP session and demultiplexed based on the payload type or SSRC fields.

This specification changes both of these sentences. The first sentence is changed to:

> For example, in a teleconference composed of audio and video media encoded separately, each medium SHOULD be carried in a separate RTP session with its own destination transport address, unless specification [RFCXXXX] is followed and the application meets the applicability constraints.

The second sentence is changed to:

> Separate audio and video streams SHOULD NOT be carried in a single RTP session and demultiplexed based on the payload type or SSRC fields, unless multiplexed based on both SSRC and payload type and usage meets what Multiple Media Types in an RTP Session [RFCXXXX] specifies.

Second paragraph of Section 6 in RTP Profile for Audio and Video Conferences with Minimal Control [RFC3551] says:

> The payload types currently defined in this profile are assigned to exactly one of three categories or media types: audio only, video only and those combining audio and video. The media types are marked in Tables 4 and 5 as "A", "V" and "AV", respectively. Payload types of different media types SHALL NOT be interleaved or multiplexed within a single RTP session, but multiple RTP sessions MAY be used in parallel to send multiple media types. An RTP source MAY change payload types within the same media type during a session. See the section "Multiplexing RTP Sessions" of RFC 3550 for additional explanation.

This specifications purpose is to violate that existing SHALL NOT under certain conditions. Thus also this sentence must be changed to allow for multiple media type's payload types in the same session. The above sentence is changed to:

> Payload types of different media types SHALL NOT be interleaved or multiplexed within a single RTP session unless as specified and under the restriction in Multiple Media Types in an RTP Session [RFCXXXX]. Multiple RTP sessions MAY be used in parallel to send multiple media types.

RFC-Editor Note: Please replace RFCXXXX with the RFC number of this specification when assigned.

We can now go on and discuss the five bullets that are motivating the previous in Section 5.2 of the RTP Specification [RFC3550]. They are repeated here for the reader's convenience:

1. If, say, two audio streams shared the same RTP session and the same SSRC value, and one were to change encodings and thus acquire a different RTP payload type, there would be no general way of identifying which stream had changed encodings.

2. An SSRC is defined to identify a single timing and sequence number space. Interleaving multiple payload types would require different timing spaces if the media clock rates differ and would require different sequence number spaces to tell which payload type suffered packet loss.

3. The RTCP sender and receiver reports (see Section 6.4 of RFC 3550) can only describe one timing and sequence number space per SSRC and do not carry a payload type field.

4. An RTP mixer would not be able to combine interleaved streams of incompatible media into one stream.

5. Carrying multiple media in one RTP session precludes: the use of different network paths or network resource allocations if appropriate; reception of a subset of the media if desired, for example just audio if video would exceed the available bandwidth; and receiver implementations that use separate processes for the different media, whereas using separate RTP sessions permits either single- or multiple-process implementations.

Bullets 1 to 3 are all related to that each media source must use one or more unique SSRCs to avoid these issues as mandated below (Section 6.2). Bullet 4 can be served by two arguments, first of all each SSRC will commonly a native media type, communicated through the RTP payload type, allowing a middlebox to do media type specific operations. The second argument is that in many contexts blind combining without additional contexts are anyway not suitable. Regarding bullet 5 this is a understood and explicitly stated applicability limitations for the method described in this document.

6.2. Sender Source Restrictions

A SSRC in the RTP session MUST only send one media type (audio, video, text etc.) during the SSRC's lifetime. The main motivation is that a given SSRC has its own RTP timestamp and sequence number spaces. The same way that you can't send two streams of encoded audio on the same SSRC, you can't send one audio and one video encoding on the same SSRC. Each media encoding when made into an RTP

stream needs to have the sole control over the sequence number and timestamp space. If not, one would not be able to detect packet loss for that particular stream. Nor can one easily determine which clock rate a particular SSRCs timestamp shall increase with.

6.3. Payload Type Applicability

Most Payload Types have a native media type, like an audio codec is natural belonging to the audio media type. However, there exist a number of RTP payload types that don't have a native media type. For example, transport robustification mechanisms like RTP Retransmission [RFC4588] and Generic FEC [RFC5109] inherit their media type from what they protect. RTP Retransmission is explicitly bound to the payload type it is protecting, and thus will inherit it. However Generic FEC is a excellent example of an RTP payload type that has no natural media type. The media type for what it protects is not relevant as it is the recovered RTP packets that have a particular media type, and thus Generic FEC is best categorized as an application media type.

The above discussion is relevant to what limitations exist for RTP payload type usage within an RTP session that has multiple media types. In fact this document (Section 7.2) suggest that for usage of Generic FEC (XOR-based) as defined in RFC 5109 can actually use a single media type when used with independent RTP sessions for source and repair data.

> Note a particular SSRC carrying Generic FEC will clearly only protect a specific SSRC and thus that instance is bound to the SSRC's media type. For this specific case, it is possible to have one be applicable to both. However, in cases when the signalling is setup to enable fallback to using separate RTP sessions, then using a different media type, e.g. application, than the media being protected can create issues.

6.4. RTCP

An RTP session has a single set of parameters that configure the session bandwidth, the RTCP sender and receiver fractions (e.g., via the SDP "b=RR:" and "b=RS: lines), and the parameters of the RTP/AVPF profile [RFC4585] (e.g., trr-int) if that profile (or its secure extension, RTP/SAVPF [RFC5124]) is used. As a consequence, the RTCP reporting interval will be the same for every SSRC in an RTP session. This uniform RTCP reporting interval can result in RTCP reports being sent more often than is considered desirable for a particular media type. For example, if an audio flow is multiplexed with a high quality video flow where the session bandwidth is configured to match the video bandwidth, this can result in the RTCP packets having a

greater bandwidth allocation than the audio data rate. If the reduced minimum RTCP interval described in Section 6.2 of [RFC3550] is used in the session, which might be appropriate for video where rapid feedback is wanted, the audio sources could be required to send RTCP packets more often than they send audio data packets. This is clearly undesirable, and while the mismatch can be reduced through careful tuning of the RTCP parameters, particularly trr_int in RTP/AVPF sessions, it is inherent in the design of the RTCP timing rules, and affects all RTP sessions containing flows with mismatched bandwidth.

(tbd: A future version of this draft needs to provide details of the extent of this problem, recommendations for how to tune the RTCP bandwidth fraction and trr_int, and when the mismatch is so great that it's better to use separate RTP sessions. The recommendations will likely be different for RTP/AVP and RTP/AVPF sessions, since trr_int offers a potential solution that is not suitable in legacy session.)

Having multiple media types in one RTP session also results in more SSRCs being present in this RTP session. This increasing the amount of cross reporting between the SSRCs. From an RTCP perspective, two RTP sessions with half the number of SSRCs in each will be slightly more efficient. If someone needs either the higher efficiency due to the lesser number of SSRCs or the fact that one can't tailor RTCP usage per media type, they need to use independent RTP sessions.

When it comes to handling multiple SSRCs in an RTP session there is a clarification under discussion in Real-Time Transport Protocol (RTP) Considerations for Multi-Stream Endpoints [I-D.lennox-avtcore-rtp-multi-stream]. When it comes to configuring RTCP the need for regular periodic reporting needs to be weighted against any feedback or control messages being sent. The applications using AVPF or SAVPF are RECOMMENDED to consider setting trr-int parameter to a value suitable for the applications needs, thus potentially reducing the need for regular reporting and thus releasing more bandwidth for use for feedback or control.

Another aspect of an RTP session with multiple media types is that the used RTCP packets, RTCP Feedback Messages, or RTCP XR metrics used may not be applicable to all media types. Instead all RTP/RTCP endpoints need to correlate the media type of the SSRC being referenced in an messages/packet and only use those that apply to that particular SSRC and its media type. Signalling solutions may have shortcomings when it comes to indicate that a particular set of RTCP reports or feedback messages only apply to a particular media type within an RTP session.

7. Extension Considerations

This section discusses the impact on some RTP/RTCP extensions due to usage of multiple media types in on RTP session. Only extensions where something worth noting has been included.

7.1. RTP Retransmission

SSRC-multiplexed RTP retransmission [RFC4588] is actually very straightforward. Each retransmission RTP payload type is explicitly connected to an associated payload type. If retransmission is only to be used with a subset of all payload types, this is not a problem, as it will be evident from the retransmission payload types which payload types that have retransmission enabled for them.

Session-multiplexed RTP retransmission is also possible to use where an retransmission session contains the retransmissions of the associated payload types in the source RTP session. The only difference to previously is that the source RTP session is one which contains multiple media types. Thus it is even more likely that only a subset of the source RTP session's payload types and SSRCs are actually retransmitted.

Open Issue: When using SDP to signal retransmission for one RTP session with multiple media types and one RTP session for the retransmission data will cause a situation where one will have multiple m= lines grouped using FID and the ones belonging to respective RTP session being grouped using BUNDLE. This usage may contradict both the FID semantics [RFC5888] and an assumption in the RTP retransmission specification [RFC4588].

7.2. Generic FEC

The RTP Payload Format for Generic Forward Error Correction [RFC5109], and also its predecessor [RFC2733], requires some considerations, and they are different depending on what type of configuration of usage one has.

Independent RTP Sessions, i.e. where source and repair data are sent in different RTP sessions. As this mode of configuration requires different RTP session, there must be at least one RTP session for source data, this session can be one using multiple media types. The repair session only needs one RTP Payload type indicating repair data, i.e. x/ulpfec or x/parityfec depending if RFC 5109 or RFC 2733 is used. The media type in this session is not relevant and can in theory be any of the defined ones. It is recommended that one uses "Application".

In stream, using RTP Payload for Redundant Audio Data [RFC2198] combining repair and source data in the same packets. This is possible to use within a single RTP session. However, the usage and configuration of the payload types can create an issue. First of all it might be required to have one payload type per media type for the FEC repair data payload format, i.e. one for audio/ulpfec and one for text/ulpfec if audio and text are combined in an RTP session. Secondly each combination of source payload and its FEC repair data must be an explicit configured payload type. This has potential for making the limitation of RTP payload types available into a real issue.

8. Signalling

The Signalling requirements

Establishing an RTP session with multiple media types requires signalling. This signalling needs to fulfill the following requirements:

1. Ensure that any participant in the RTP session is aware that this is an RTP session with multiple media types.

2. Ensure that the payload types in use in the RTP session are using unique values, with no overlap between the media types.

3. Configure the RTP session level parameters, such as RTCP RR and RS bandwidth, AVPF trr-int, underlying transport, the RTCP extensions in use, and security parameters, commonly for the RTP session.

4. RTP and RTCP functions that can be bound to a particular media type should be reused when possible also for other media types, instead of having to be configured for multiple code-points. Note: In some cases one will not have a choice but to use multiple configurations.

8.1. SDP-Based Signalling

The signalling of multiple media types in one RTP session in SDP is specified in "Multiplexing Negotiation Using Session Description Protocol (SDP) Port Numbers" [I-D.ietf-mmusic-sdp-bundle-negotiation].

9. IANA Considerations

This document makes no request of IANA.

Note to RFC Editor: this section may be removed on publication as an RFC.

10. Security Considerations

Having an RTP session with multiple media types doesn't change the methods for securing a particular RTP session. One possible difference is that the different media have often had different security requirements. When combining multiple media types in one session, their security requirements must also be combined by selecting the most demanding for each property. Thus having multiple media types may result in increased overhead for security for some media types to ensure that all requirements are meet.

Otherwise, the recommendations for how to configure and RTP session do not add any additional requirements compared to normal RTP, except for the need to be able to ensure that the participants are aware that it is a multiple media type session. If not that is ensured it can cause issues in the RTP session for both the unaware and the aware one. Similar issues can also be produced in an normal RTP session by creating configurations for different end-points that doesn't match each other.

11. Acknowledgements

The authors would like to thank Christer Holmberg for the feedback on the document.

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