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Monitoring Architecture for RTP
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Abstract

This memo proposes an architecture for extending RTP Control Protocol (RTCP) with a new RTCP Extended Reports (XR) (RFC3611) block type to report new metrics regarding media transmission or reception quality, following RTCP guidelines established in RFC5968. This memo suggests that a new block should contain a single metric or a small number of metrics relevant to a single parameter of interest or concern, rather than containing a number of metrics which attempt to provide full coverage of all those parameters of concern to a specific application. Applications may then "mix and match" to create a set of blocks which covers their set of concerns. Where possible, a specific block should be designed to be re-usable across more than one application, for example, for all of voice, streaming audio and video.

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1. Introduction

Multimedia services using the Real-Time Protocol (RTP) are seeing increased use. Standard methods for gathering RTP performance metrics from these applications are needed to manage uncertainties in the behavior and availability of their services. Standards , such as RTP Control Protocol Extended Reports (RTCP XR)[RFC3611] and other RTCP extension to Sender Reports (SR), Receiver Reports (RR) [RFC3550] are being developed for the purpose of collecting and reporting performance metrics from endpoint devices that can be used to correlate the metrics, provide end to end service visibility and measure and monitor Quality of Experience (QoE) [RFC6390].

However the proliferation of RTP/RTCP specific metrics for transport and application quality monitoring has been identified as a potential problem for interoperability when using RTP/RTCP to communicate all the parameters of concern to a specific application. Given that different applications layered on RTP may have some monitoring requirements in common, these metrics should be satisfied by a common design.

The objective of this document is to define an extensible RTP monitoring framework to provide a small number of re-usable Quality of Service (QoS)/QoE metrics which facilitate reduced implementation costs and help maximize inter-operability. The "Guidelines for Extending the RTP Control Protocol (RTCP)" [RFC5968] has stated that, where RTCP is to be extended with a new metric, the preferred mechanism is by the addition of a new RTCP XR [RFC3611] block. This memo assumes that any requirement for a new metric to be transported in RTCP will use a new RTCP XR block.

2. Terminology

This memo is informative and as such contains no normative requirements.

In addition, the following terms are defined:

Transport level metrics

A set of metrics which characterise the three transport impairments of packet loss, packet delay, and packet delay variation. These metrics should be usable by any application which uses RTP transport.

Application level metrics

Metrics relating to application specific parameters or QoE related parameters. Application specific parameters are measured at the application level and focus on quality of content rather than network performance. QoE related parameters reflect the end-to-end performance at the services level and are ususally measured at the user endpoint. One example of such metrics is the QoE Metric specified in QoE metric reporting Block [QOE].

End System metrics

Metrics relating to the way a terminal deals with transport impairments affecting the incident RTP stream. These may include de-jitter buffering, packet loss concealment, and the use of redundant streams (if any) for correction of error or loss.

Direct metrics

Metrics that can be directly measured or calculated and are not dependent on other metrics.

Composed metrics

Metrics that are not measured directly but rather are derived by algorithmically combining one or more measured metrics. An example is a metric derived based on direct metrics that have been measured.

Interval metrics

Metrics measured over the course of a single reporting interval between two successive report blocks. This may be the most recent RTCP reporting interval ([RFC3550], section 6.2) or some other interval signalled using an RTCP Measurement Information XR Block [MEASI]. An example interval metric is the count of the number of RTP packets lost over the course of the last RTCP reporting interval.

Cumulative metrics

Metrics measured over several reporting intervals for accumulating statistics. The time period over which measurements are accumulated can be the complete RTP session, or some other interval signalled using an RTCP Measurement Information XR Block [MEASI]. An example cumulative metric is the total number of RTP packets lost since the start of the RTP session.

Sampled metrics

Metrics measured at a particular time instant and sampled from the values of a continuously measured or calculated metric within a reporting interval (generally the value of some measurement as taken at the end of the reporting interval). An example is the inter-arrival jitter reported in RTCP SR and RR packets, which is continually updated as each RTP data packet arrives, but only reported based on a snapshot of the value which is sampled at the instant the reporting interval ends.

3. RTP monitoring architecture

There are many ways in which the performance of an RTP session can be monitored. These include RTP-based mechanisms such as the RTP SNMP MIB [RFC2959], or the SIP event package for RTCP summary reports [RFC6035], or non-RTP mechanisms such as generic MIBs, NetFlow, IPFix, and so on. Together, these provide useful mechanisms for exporting data on the performance of an RTP session to non-RTP network management systems. It is desirable to also perform in-session monitoring of RTP performance. RTCP provides the means to do this. In the following, we specify an architecture for using and extending RTCP for monitoring RTP sessions. One major benefit of such architecture is ease of integration with other RTP/RTCP mechanisms.

3.1. Overview

The RTP monitoring architecture comprises the following two key functional components shown below:

o RTP Monitor

o RTP Metric Block Structure

RTP Monitor is the functional component defined in the Real-time Transport Protocol [RFC3550] . It acts as a repository of information gathered for monitoring purposes and exchanges such information with the other RTP monitors using RTP Metric Blocks. According to the definition of monitor in the RTP Protocol [RFC3550], the end system that runs an application program that sends or receives RTP data packets, an intermediate-system that forwards RTP packets to End-devices or a third party that observes the RTP and RTCP traffic but does not make itself visible to the RTP Session participants can play the role of the RTP monitor within the RTP monitoring architecture. The third party RTP monitor should be placed on the RTP/RTCP path between the sender, intermediate and the receiver.

The RTP monitor also exposes real time Application QoS/QoE metric information in the appropriate report block format (e.g.,RTCP XR or other non-RTP means) to the management system. Such information can be formulated as various types of metrics, e.g., direct metrics/ composed metrics or interval metrics/ cumulative metrics/sampled metrics,etc. Both the RTCP or RTCP XR can be extended to convey these metrics,e.g., the basic RTCP Reception Report (RR) [RFC3550] that conveys reception statistics (i.e., transport level statistics) for multiple RTP media streams,the RTCP XRs [RFC3611] that supplement the existing RTCP packets and provide more detailed feedback on

reception quality and RTCP NACK [RFC4585] that provides feedback on the RTP sequence numbers for a subset of the lost packets or all the currently lost packets.

RTP may be used to multicast groups, both Any Source Multicast (ASM) and Source Specific Multicast (SSM). These groups can be monitored using RTCP. In the ASM case, the monitor is a member of the multicast group and listens to RTCP XR reports from all members of the ASM group. In the SSM case, there is a unicast feedback target that receives RTCP feedback from receivers and distributes it to other members of the SSM group (see figure 1 of [RFC5760]). The monitor will need to be co-located with the feedback target to receive all feedback from the receivers (this may also be an intermediate system). In both ASM and SSM scenarios, receivers can send RTCP XR reports to enhance the reception quality reporting.

3.2. Location of RTP Monitors

There are several possible locations from where RTP sessions can be monitored. These include end-systems that terminate RTP sessions, middleboxes that are an active part of an RTP session, and third-party devices that passively monitor an RTP session. Not every RTP sessions will include monitoring, and those sessions that are monitored will not all include each type of monitor. The performance metrics collected by RTP monitors can be divided into end system metrics, application level metrics, and transport level metrics. Some of these metrics may be specific to the measurement point of the RTP monitor, or depend on where the RTP monitors are located in the network, while others are more general and can be collected in any monitoring location.

End-system monitoring is monitoring that is deployed on devices that terminate RTP flows. Flows can be terminated in user equipment, such as phones, video conferencing systems, or IPTV set-top boxes. Alternatively, they can be terminated in devices that gateway between RTP and other transport protocols. Transport and end system metrics, application level metrics that don't reflect end to end user experience may be collected at all types of end system, but some application level metrics (i.e.,quality of experience (QoE) metrics) may only be applicable for user-facing end systems.

RTP sessions can include middleboxes that are an active part of the system. These middleboxes include RTP mixers and translators, MCUs, retransmission servers, etc. If the middlebox establishes separate RTP sessions to the other participants, then it must act as an end system in each of those separate RTP sessions for the purposes of monitoring. If a single RTP session traverses the middlebox, then the middlebox can be assigned an SSRC in that session which it can

use for it's reports. Transport level metrics may be collected at such middlebox.

Third-party monitors may be deployed that passively monitor RTP sessions for network management purposes. Third-party monitors often do not send reports into the RTP session being monitored, but instead collect transport and end system metrics, application level metrics that are reported via some network management application. In some cases, however, third-party monitors can send reports to some or all participants in the session being monitored. For example, in a media streaming scenario, third-party monitors may be deployed that passively monitor the session and send reception quality reports to the media source, but not to the receivers.

4. Issues with reporting metric block using RTCP XR extension

The following sections discuss four issues that have come up in the past with reporting metric block using RTCP XR extensions.

4.1. Using compound metrics block

A compound metrics block is designed to contain a large number of parameters from different classes for a specific application in a single block. For example, the RTCP Extended Reports (XRs) [RFC3611] defines seven report block formats for network management and quality monitoring. Some of these block types defined in the RTCP XRs [RFC3611] are only specifically designed for conveying multicast inference of network characteristics (MINC) or voice over IP (VoIP) monitoring. However different applications layered on RTP may have different monitoring requirements. Designing compound metrics block only for specific applications may increase implementation cost and minimize interoperability.

4.2. Correlating RTCP XR with the non-RTP data

Canonical End-Point Identifier SDES Item (CNAME), defined in the RTP Protocol [RFC3550], is an example of an existing tool that allows binding a Synchronization source (SSRC) that may change to a name that is fixed within one RTP session. CNAME may be also fixed across multiple RTP sessions from the same source. However there may be situations where RTCP reports are sent to other participating endpoints using non-RTP protocol in a session. For example, as described in the SIP RTCP Summary Report Protocol [RFC6035], the data contained in RTCP XR VoIP metrics reports [RFC3611] are forwarded to a central collection server systems using SIP. In such case, there is a large portfolio of quality parameters that can be associated with real time application, e.g., VOIP application, but only a minimal number of parameters are included on the RTCP-XR reports. With these minimal number of RTCP statistics parameters mapped to non-RTCP measurements, it is hard to provide accurate measures of real time application quality,conduct detailed data analysis and creates alerts timly to the users. Therefore correlation between RTCP XR and non-RTP data should be provided.

4.3. Measurement Information duplication

We may set a measurement interval for the session and monitor RTP packets within one or several consecutive report intervals. In such case, the extra measurement information (e.g., extended sequence number of 1st packet, measurement period) may be expected. However if we put such extra measurement information into each metric block, there may be situations where an RTCP XR packet containing multiple

metric blocks, reports on the same streams from the same source. In other words, duplicated data for the measurement is provided multiple times, once in every metric block. Though this design ensures immunity to packet loss, it may bring more packetization complexity and the processing overhead is not completely trivial in some cases. Therefore compromise between processing overhead and reliability should be taken into account.

4.4. Consumption of XR block code points

The RTCP XR block namespace is limited by the 8-bit block type field in the RTCP XR header. Space exhaustion may be a concern in the future. Anticipating the potential need to extend the block type space, it is noted that Block Type 255 is reserved for future extensions in [RFC3611].

5. Guidelines for reporting metric block using RTCP XR

5.1. Contain the single metrics in the Metric Block

Different applications using RTP for media transport certainly have differing requirements for metrics transported in RTCP to support their operation. For many applications, the basic metrics for transport impairments provided in RTCP SR and RR packets [RFC3550] (together with source identification provided in RTCP SDES packets) are sufficient. For other applications additional metrics may be required or at least sufficiently useful to justify the overheads, both of processing in endpoints and of increased session bandwidth. For example an IPTV application using Forward Error Correction (FEC) might use either a metric of post-repair loss or a metric giving detailed information about pre-repair loss bursts to optimise payload bandwidth and the strength of FEC required for changing network conditions. However there are many metrics available. It is likely that different applications or classes of applications will wish to use different metrics. Any one application is likely to require metrics for more than one parameter but if this is the case, different applications will almost certainly require different combinations of metrics. If larger blocks are defined containing multiple metrics to address the needs of each application, it becomes likely that many different such larger blocks are defined, which becomes a danger to interoperability.

To avoid this pitfall, this memo recommends the definition of metrics blocks containing a very small number of individual metrics characterizing only one parameter of interest to an application running over RTP. For example, at the RTP transport layer, the parameter of interest might be packet delay variation, and specifically the metric "IP Packet Delay Variation (IPDV)" defined by [Y1540]. See Section 6 for architectural considerations for a metrics block, using as an example a metrics block to report packet delay variation. Further, it is appropriate to not only define report blocks separately, but also to do so in separate documents where possible. This makes it easier to evolve the reports (i.e., to update each type of report block separately), and also makes it easier to require compliance with a particular report block.

5.2. Include the payload type and format parameters in the Metric Block

There are some classes of metrics that can only be interpreted with knowledge of the media codec that is being used (audio mean opinion scores (MOS) were the triggering example, but there may be others). In such cases the correlation of RTCP XR with RTP data is needed. Report blocks that require such correlation need to include the payload type of the reported media. In addition, it is necessary to

signal the details and parameters of the payload format to which that payload type is bound using some out-of-band means (e.g., as part of an SDP offer/answer exchange).

5.3. Use RTCP SDES to correlate XR reports with non-RTP data

There may be situations where more than one media transport protocol is used by one application to interconnect to the same session in the gateway. For example, one RTCP XR Packet is sent to the participating endpoints using non-RTP-based media transport (e.g., using SIP) in a VOIP session. One crucial factor lies in how to handle their different identities that are corresponding to different media transport.

This memo recommends an approach to facilitate the correlation of the RTCP Session with other session-related non-RTP data. That is to say if there is a need to correlate RTP sessions with non-RTP sessions, then the correlation information needed should be conveyed in a new RTCP Source Description (SDES) item, since such correlation information describes the source, rather than providing a quality report. An example use case is for a participant endpoint may convey a call identifier or a global call identifier associated with the SSRC of measured RTP stream. In such case, the participant endpoint uses the SSRC of source to bind the call identifier using SDES item in the SDES RTCP packet and send such correlation to the network management system. A flow measurement tool that is configured with the 5-tuple and not call-aware then forward the RTCP XR reports along with the SSRC of the measured RTP stream which is included in the XR Block header and 5-tuple to the network management system. Network management system can then correlate this report using SSRC with other diagnostic information such as call detail records.

5.4. Reduce Measurement information repetition across metric blocks

When multiple metric blocks are carried in one RTCP XR packet, reporting on the same stream from the same source for the same time period, RTCP should use the SSRC to identify and correlate the multiple metric blocks between metric blocks. This memo proposes to define a new XR Block (i.e., the Measurement information block [MEASI]) that will be used to convey the common time period and the number of packets sent during this period. If the measurement interval for a metric is different from the RTCP reporting interval, then this measurement duration in the Measurement information block should be used to specify the interval. When there may be multiple measurements information blocks with the same SSRC in one RTCP XR compound packet, the measurement information block should be put in order and followed by all the metric blocks associated with this measurement information block. New RTCP XR metric blocks that rely

on the Measurement information block [MEASI] must specify the response in case the new RTCP XR metric block is received without an associated measurement information block. In most cases, it is expected that the correct response is to discard the received metric. In order to reduce measurement information repetition in one RTCP XR compound packet containing multiple metric blocks, the measurement information shall be sent before the related metric blocks that are from the same reporting interval. Note that for packet loss robustness if the report blocks for the same interval span over more than one RTCP packet, then each must have the measurement identity information even though they will be the same.

6. An example of a metric block

This section uses the example of an existing proposed metrics block to illustrate the application of the principles set out in Section 5.1.

The example [PDV] is a block to convey information about packet delay variation (PDV) only, consistent with the principle that a metrics block should address only one parameter of interest. One simple metric of PDV is available in the RTCP RR packet as the "interarrival jitter" field. There are other PDV metrics with a certain similarity in metric structure which may be more useful to certain applications. Two such metrics are the IPDV metric ([Y1540], [RFC3393]) and the mean absolute packet delay variation 2 (MAPDV2) metric [G1020]. Use of these metrics is consistent with the principle in Section 5 of RTCP guideline [RFC5968] that metrics should usually be defined elsewhere, so that RTCP standards define only the transport of the metric rather than its nature. The purpose of this section is to illustrate the architecture using the example of [PDV] rather than to document the design of the PDV metrics block or to provide a tutorial on PDV in general.

Given the availability of at least three metrics for PDV, there are design options for the allocation of metrics to RTCP XR blocks:

- provide an RTCP XR block per metric
- provide a single RTCP XR block which contains all three metrics
- provide a single RTCP block to convey any one of the three metrics, together with a identifier to inform the receiving RTP system of the specific metric being conveyed

In choosing between these options, extensibility is important, because additional metrics of PDV may well be standardized and require inclusion in this framework. The first option is extensible but only by use of additional RTCP XR blocks, which may consume the limited namespace for RTCP XR blocks at an unacceptable rate. The second option is not extensible, so could be rejected on that basis, but in any case a single application is quite unlikely to require transport of more than one metric for PDV. Hence the third option was chosen. This implies the creation of a subsidiary namespace to enumerate the PDV metrics which may be transported by this block, as discussed further in [PDV].

7. Application to RFC 5117 topologies

The topologies specified in [RFC5117] fall into two categories. The first category relates to the RTP system model utilizing multicast and/or unicast. The topologies in this category are specifically Topo-Point-to-Point, Topo- Multicast, Topo-Translator (both variants, Topo-Trn-Translator and Topo-Media-Translator, and combinations of the two), and Topo-Mixer. These topologies use RTP end systems, RTP mixers and RTP translators defined in the RTP protocol [RFC3550]. For purposes of reporting connection quality to other RTP systems, RTP mixers and RTP end systems are very similar. Mixers resynchronize packets and do not relay RTCP reports received from one cloud towards other cloud(s). Translators do not resynchronize packets and should forward certain RTCP reports between clouds. In this category, the RTP system (end system, mixer or translator) which originates, terminates or forwards RTCP XR blocks is expected to handle RTCP, including RTCP XR, according to the RTP protocol [RFC3550]. Provided this expectation is met, an RTP system using RTCP XR is architecturally no different from an RTP system of the same class (end system, mixer, or translator) which does not use RTCP XR. The second category relates to deployed system models used in many H.323 [H323] video conferences. The topologies in this category are Topo-Video-Switch-MCU and Topo-RTCP-terminating-MCU. Such topologies based on systems (e.g.,MCUs) do not behave according to the RTP protocol [RFC3550].

Considering the translator and MCU are two typical intermediate-systems in the two categories mentioned above, this document will take them as two typical examples to explain how RTCP XR report works in different RFC5117 topologies.

7.1. Applicability to Translators

Section 7.2 of the RTP protocol [RFC3550] describes processing of RTCP by translators. RTCP XR is within the scope of the recommendations of the RTP protocol [RFC3550]. Some RTCP XR metrics blocks may usefully be measured at, and reported by, translators. As described in the RTP protocol [RFC3550] this creates a requirement for the translator to allocate an SSRC for the monitor collocated with itself so that the monitor may populate the SSRC in the RTCP XR packet header as packet sender SSRC and send it out(although the translator is not a Synchronisation Source in the sense of originating RTP media packets). It must also supply this SSRC and the corresponding CNAME in RTCP SDES packets.

In RTP sessions where one or more translators generate any RTCP traffic towards their next-neighbour RTP system, other translators in the session have a choice as to whether they forward a translator's

RTCP packets. Forwarding may provide additional information to other RTP systems in the connection but increases RTCP bandwidth and may in some cases present a security risk. RTP translators may have forwarding behaviour based on local policy, which might differ between different interfaces of the same translator.

7.2. Applicability to MCU

Topo-Video-Switch-MCU and Topo-RTCP-terminating-MCU, suffer from the difficulties described in [RFC5117]. These difficulties apply to systems sending, and expecting to receive, RTCP XR blocks as much as to systems using other RTCP packet types. For example, a participant RTP end system may send media to a video switch MCU. If the media stream is not selected for forwarding by the switch, neither RTCP RR packets nor RTCP XR blocks referring to the end system's generated stream will be received at the RTP end system. Strictly the RTP end system can only conclude that its RTP has been lost in the network, though an RTP end system complying with the robustness principle of [RFC1122] should survive with essential functions (i.e.,media distribution) unimpaired.

8. IANA Considerations

There is no IANA action in this document.

9. Security Considerations

This document focuses on the RTCP reporting extension using RTCP XR and should not give rise to any new security vulnerabilities beyond those described in RTCP XRs [RFC3611]. However it also describes the architectural framework to be used for monitoring at RTP layer. The security issues with monitoring needs to be considered.

In RTP sessions, a RTP system may use its own SSRC to send its monitoring reports towards its next-neighbour RTP system. Other RTP system in the session may have a choice as to whether they forward this RTP system's RTCP packets. This present a security issue since the information in the report may be exposed by the other RTP system to any malicious node. Therefore if the information is considered as sensitive, the monitoring report should be encrypted.

10. Acknowledgement

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Appendix A. Change Log

Note to the RFC-Editor: please remove this section prior to publication as an RFC.

A.1. draft-ietf-avtcore-monarch-14

The following are the major changes compared to 13:

- o Incorporate the key points in the section 3.2 into overview section.
- o Remove the figure 1 and use the description instead.
- o Add description in the section 3.3 to discuss the possible location of the monitors and the types of metric at that location.
- o Add the description to make the definition of Interval metrics/ cumulative metrics/sampled metrics clear.
- o Editorial Changes.

A.2. draft-ietf-avtcore-monarch-13

The following are the major changes compared to 12:

- o Editorial Changes.

A.3. draft-ietf-avtcore-monarch-12

The following are the major changes compared to 11:

- o Editorial Changes based on Charles' Comments.
- o Reference update.
- o Add one new section 5.2 to discuss Correlating RTCP XR with RTP data.
- o Add text in section 5.1 to highlight it is more appropriate to define each block in a separate draft.

A.4. draft-ietf-avtcore-monarch-11

The following are the major changes compared to 10:

- o Editorial Changes.

A.5. draft-ietf-avtcore-monarch-10

The following are the major changes compared to 09:

- o Discuss what exist already for monitoring in section 3.1.
- o Provide benefit using RTCP XR based monitoring in section 3.1.
- o add one new paragraph in section 3.1 to describe how monitoring architecture is applied to ASM/SSM.
- o Other Editorial Changes.

A.6. draft-ietf-avtcore-monarch-09

The following are the major changes compared to 07:

- o Rephrase application level metric definition.
- o Add one new section to clarify where to measure QoE related parameters.
- o Add text in section 5.3 to clarify the failure case when measurement interval is not sent.
- o Add text in section 5.3 to clarify how to deal with multiple measurements information blocks carried in the same packet.

A.7. draft-ietf-avtcore-monarch-08

The following are the major changes compared to 07:

- o Editorial change to the reference.

A.8. draft-ietf-avtcore-monarch-07

The following are the major changes compared to 06:

- o Clarify the XR block code points consumption issue in the section 4 and new section 5.4.
- o Other editorial changes.

A.9. draft-ietf-avtcore-monarch-06

The following are the major changes compared to 05:

o Some editorial changes.

A.10. draft-ietf-avtcore-monarch-05

The following are the major changes compared to 04:

o Replace "chunk" with "new SDES item".

o Add texts in security section to discussion potential security issues.

o Add new sub-section 5.3 to discuss Reducing Measurement information repetition.

o Other editorial changes.

A.11. draft-ietf-avtcore-monarch-04

The following are the major changes compared to 03:

o Update section 5.2 to clarify using SDES packet to carry correlation information.

o Remove section 5.3 since additional identity information goes to SDES packet and using SSRC to identify each block is standard RTP feature.

o Swap the last two paragraphs in the section 4 since identity information duplication can not been 100% avoided.

o Other editorial changes.

A.12. draft-ietf-avtcore-monarch-03

The following are the major changes compared to 02:

o Update bullet 2 in section 4 to explain the ill-effect of Identity Information duplication.

o Update bullet 3 in section 4 to explain why Correlating RTCP XR with the non-RTP data is needed.

o Update section 5.2 to focus on how to reduce the identity information repetition

o Update section 5.3 to explain how to correlate identity information with the non-RTP data

A.13. draft-ietf-avtcore-monarch-02

The following are the major changes compared to 01:

- Deleting first paragraph of Section 1.

- Deleting Section 3.1, since the interaction with the management application is out of scope of this draft.

- Separate identity information correlation from section 5.2 as new section 5.3.

- Remove figure 2 and related text from section 5.2.

- Editorial changes in the section 4 and the first paragraph of section 7.

A.14. draft-ietf-avtcore-monarch-01

The following are the major changes compared to 00:

- Restructure the document by merging section 4 into section 3.

- Remove section 4.1,section 5 that is out of scope of this document.

- Remove the last bullet in section 6 and section 7.3 based on conclusion of last meeting.

- Update figure 1 and related text in section 3 according to the monitor definition in RFC3550.

- Revise section 9 to address monitor declaration issue.

- Merge the first two bullet in section 6.

- Add one new bullet to discuss metric block association in section 6.

A.15. draft-ietf-avtcore-monarch-00

The following are the major changes compared to draft-hunt-avtcore-monarch-02:

- Move Geoff Hunt and Philip Arden to acknowledgement section.

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