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| *Title:* | **HEVC/MV-HEVC/SHVC HLS: SEI message recommended by MMT for improvement of HEVC packet loss resilience** | | |
| *Status:* | Input Document to JCT-VC and JCT-3V | | |
| *Purpose:* | Proposal | | |
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# Abstract

One of MPEG requirements is error resilience for packet loss. This contribution presents the coverage of these requirements using current HEVC and MMT coding tools. It was shown that the current standard did not fully protect video stream from packet loss. The IP network model standardized in TIA-921 (ANSI) and in G.1050 (ITU-T) in 2011 provides the numerical networks characteristics, which show that the current networks have packet loss probabilities up to 20%. It is proposed to use described in JCTVC-Q0090 redundant picture SEI messages which are recommended by MMT group of MPEG for high packet loss resilience.

# Introduction

The previous standards (H.263, H.264 [5, 6]) allow using redundant frames for error resilience in error prone channels [7]. The redundant picture is an additional representation of protected primary picture. In H.264/AVC each primary coded picture may have up to 127 redundant pictures. After decoding the reconstructed region represented by a redundant picture should be similar in quality to the same region in associated primary picture. The redundant frames specified in H.264/AVC are included in the same access unit (AU) as the primary coded picture. This is not a good solution when the bursts (grouped packet loss) appear in a stream. The redundant pictures were not inherited by HEVC video codec standard.

The part of MPEG requirements are related to error resiliency from packet loss, but are not fully covered by current video layer and transport layer tools. There are some network model standards (provided by ANSI and ITU-T) describe current situation with IP networks. According to these models the network channels are not fully protected by MPEG standards.

The new approach described in JCTVC-Q0090 “Redundant Picture SEI message” (RP SEI) was provided at the previous MPEG meeting. The main advantage of proposed approach was the distance in coding order between primary frames and redundant ones. It allows to reduce significantly the probability of simultaneous primary and redundant frames loss in the same group/sequence of lost packets. Hence, it allows to protect video stream from burst packet loss.

# Problem Statement

## MPEG Requirements

There are a lot of applications described in (**w11096**) related for network transmission:

*MPEG envisions HVC to be potentially used in the following applications*

*• Surveillance*

*• Broadcast*

*• Realtime communications, video chat, video conferencing*

*• Mobile streaming, broadcast and communications*

*• Video On Demand*

*• Internet streaming, download and play*

*• 3D video, telepresence*

The one of the requirements for HEVC (**w11096**) is the error resilience for packet loss:

*Video bit-stream segmentation and packetization methods for the target networks shall be developed.*

*The video layer and its interfaces to the network layer should be designed in a way such that relevant error resilience measures can effectively and flexibly be applied for networks needing error recovery, e.g. networks subject to burst errors. Proper balance of increase in complexity, loss in coding efficiency and benefits achieved by the error resilience measures at the coding layer should be achieved.*

There are several requirements for transmission we have in MMT (w11540):

*i. MMT shall support resiliency to packet loss (****including burst losses****).*

*j. MMT shall support resiliency to packet arrival jitter.*

*k. MMT shall support resiliency to packet re-ordering.*

*l. MMT shall support the control of end-to-end delay.*

There are no details of network characteristic in requirements for packet losses, but the standard TIA-921 and G.1050 describe the IP Network Model. The current standard of HEVC and MMT allows to protect streaming Video up to 1-2% of packet loss without degradation of QoS. But some current IP Networks have configurations with more than 3% of packet loss. It is really hard and impossible to protect video streaming from more than 3% of packet loss using current tools of HEVC and MMT. For that case we provide our solution that was implemented on video (source) level and can`t be implemented on transport level (for current standard). We`ve already tested this solution in our video conference software and now it is the best solution for networks with high packet loss.

## Network

For networks with different quality level described in Table 1 [2, 3] the sequential packet loss for well-managed network is just random loss, but for partially-managed network and for un-managed network the sequential packet loss achieves up to 200 and 10000 ms respectively as it`s shown in Table 2. The one way latency leads to the long delay especially for case of using negative acknowledgment channel (NAC) (backward channel to signal lost packets). The jitter also has a big influence to the latency.

Table 1. Different test profiles for network impairment [2, 3]

|  |  |  |  |
| --- | --- | --- | --- |
| **Service Test Profiles** | **Applications (Examples)** | **Node Mechanisms** | **Network Techniques** |
| Well-Managed IP Network | High quality video and VoIP, VTC (Real-time applications, loss sensitive, jitter sensitive, high interaction) | Strict QoS, guaranteed no over subscription on links | Constrained routing and distance |
| Partially-Managed IP Network | VoIP, VTC  (Real-time applications, jitter sensitive, interactive) | Separate queue with preferential servicing, traffic grooming | Less constrained routing and distances |
| Unmanaged IP Network, Internet | Lower quality video and VoIP, signaling, transaction data (highly interactive) | Separate queue, drop priority | Constrained routing and distance |
| Transaction data, interactive |  | Less constrained routing and distances |
| Short transactions, bulk data (low loss) | Long queue, drop priority | Any route/path |
| **Traditional Internet applications (default IP networks)** | Separate queue (lowest priority) | Any route/path |

Table 2. Network impairment ranges for different service level agreements [2, 3]

|  |  |  |  |
| --- | --- | --- | --- |
| Impairment Type | well-managed | partially-managed | un-managed |
| One Way Latency, ms | 20 to 100 (regional)  20 to 300 (intercontinental) | 50 to 200 (regional) 50 to 400 (intercontinental) | 50 to 800 |
| Jitter (peak to peak), ms | 0 to 50 | 0 to 150 | 0 to 500 |
| Sequential Packet Loss, ms | Random loss only (except when link failure occurs) | 40 to 200 | 40 to 10000 |
| Rate of Sequential Loss, sec-1 | Random loss only (except when link failure occurs) | ≤ 10-3 | ≤ 10-1 |
| Random Packet Loss, % | 0 to 0.05 | 0 to 2 | **0 to 20** |
| Reordered Packets, % | 0 to 0.001 | 0 to 0.01 | 0 to 0.1 |

# Relation to prior work

The previously standardized redundant frames in H.263, H.264 [5, 6] were not helpful for increasing robustness of video transmission through error prone channels. It was contained within the same access unit (AU) as a primary frame. During 16th JCT-VC meeting the redundant frames for HEVC were introduced first time in JCTVC-P0062 [1]. The main advantage of proposed approach was the distance in coding order between primary frames and redundant ones. It allows to reduce significantly the probability of simultaneous primary and redundant frames loss in the same group/sequence of lost packets. There are several aspects were discussed during the presentation of JCTVC-P0062:

1. *It was asked whether a decoder would be expected to wait several frame periods for a redundant picture to arrive and then decode that picture for use as a reference picture for the prediction of other dependent pictures that have arrived in the meantime.*
2. *It was noted that the proposal is entirely new as a concept for HEVC, and has arrived at a late stage of the development of the current phase of extensions development.*
3. *It was asked whether, assuming we like the proposed functionality, it could be added in a later extension rather than being done within the current phase of work. This seemed possible in principle…*
4. ***Further study was encouraged****…*

On 17th JCT-VC meeting the different approach based on SEI messages was presented for redundant pictures and discussed:

1. *It was remarked that those restrictions related to POC and picture timing etc. for redundant pictures would not be needed, as normative decoding process for redundant pictures should not be specified.*
2. *It was asked whether the design is backward compatible to HEVC version 1, and it seems yes.*
3. *It was asked why not using auxiliary picture types for redundant pictures? One possible reason is that it is desirable to use it with HEVC version 1 in backward compatible.*
4. *One participant, who claimed to be the one who originally introduced the redundant picture feature into the world, commented that the redundant pictures feature is not useful anymore nowadays. Another participant commented that the design seems to work for what is intended, but his company has no plan to use the feature.*
5. *It was asked whether the AVC redundant pictures feature has been used. It seemed no.*
6. *It was asked any other participants besides the proponent think that the group should standardize the support of redundant pictures? There was no in the BoG.*
7. *It was requested to ask the same question to a larger audience.*
8. *Revisit in track.*

In track:

***Further study was encouraged on this topic****, but no immediate action was planned. This would be for consideration beyond the scope of the current phase of work.*

This contribution also was presented in MMT session (MPEG Systems):

***Our disposition to this contribution is that it is interesting idea*** *so you can bring further contributions to MMT.* ***There are experts interested in this work as well****.*

According comments of 17th JCT-VC meeting, it should be noted that:

1. After the offline discussion with chair it was agreed that restriction related to POC and picture timing was reasonable.
2. The backward compatibility is allowed by setting value deltaPOCminus1 to 0.
3. The auxiliary pictures with different POC values in one AU do not seem good. On the other hand the redundant picture putted in the same AU with protected primary picture is not efficient.
4. Addressing to section 2.2 of this contribution. The physical layer of network is much better then early – as was mentioned by participant, but managing of network is not good enough for video transmission. And wireless network also have a lot of issues for real time video transmission systems.
5. As was mentioned above the redundant pictures in the same AU (as in AVC) are not so efficient as in suggested approach.

So, the experts who are involved in transmission systems research are really interested in such error resilience method. And experts from HLS did not find any major issues in suggested Redundant Pictures SEI messages.

# Recommended SEI message

During previous MPEG meeting the Redundant Picture SEI message was proposed in JCTVC-Q0090. It was introduced that redundant pictures splitted in time from protected primary pictures allow to increase packet loss immunity of video transmission systems, especially for high packet loss probabilities. Any major technical issues were not found during meeting discussions. The RP SEI messages [10] were introduced to both JCTVC and MMT groups without any objections in JCTVC group and with good evidence from MMT group. During presentation in MMT group it was noted that current transport level tools did not allow to protect video stream from packet loss in unmanaged networks (the default IP networks [2, 3]) and in other error prone networks with high packet loss probabilities (with more than 3%). So they are strongly required in such tools. MMT group also noticed that support from source coding level would be very helpful for packet loss protection task.

The source code supported RP SEI messages can be provided.

# Conclusion

The MPEG community have the requirements for packet loss resilience, which is not fully covered according to network model provided by TIA-921 [2] and G.1050 [3]. The current video coding tools and transmission tools allow to prevent packet loss in video stream only if packet loss probabilities is less than 2-3%. Some of them require delay, which is not desirable for real time applications. Another type of redundancy can prevent video packet loss for higher error probabilities (>3% - default IP network). In JCTVC-Q0090 “Redundant Pictures SEI message” the SEI approach was introduced to HEVC. There are no major issues found by JCTVC group and the good evidence was provided by MMT group of MPEG Systems after presentation at the previous meeting. The redundant SEI message has no mandatory influence on HEVC version 1 codec, but has a non normative influence which allows to protect the video stream from packet loss and in unmanaged networks with much more effectiveness than different protection mechanisms. Comparing to channel level protection schemes this method uses the existing memory which allows significantly reduce the memory used by channel level for saving packet for retransmission or for FEC based algorithms.

We suggest the committee adopts the redundant picture SEI message (JCTVC-Q0090) to the standard. The source code supported Redundant Picture SEI messages can be provided by Huawei in case of adoption.

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# Patent rights declaration(s)

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