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| *Title:* | **HLS: On Redundant Pictures SEI message for HEVC** | | |
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# Abstract

This is an evolution of the preceding proposals P0062, Q0090 and R00159 presenting Redundant Pictures for HEVC. This proposals describes how Redundant Pictures provide the ability for significantly reduce traffic overhead (up to few times) while joining new participant to the multi-point video conference while keeping visual quality. This ability is an additional argument for introducing Redundant Pictures to HEVC.

At the previous JCT-VC meeting it was well-established that packet loss protection of video streams loss using existing HEVC and MMT tools is often not sufficient for current networks The current networks sometimes have packet loss probabilities up to 20% described in details in IP network model standards TIA-921 (ANSI) and in G.1050 (ITU-T) in 2011. As was agreed during MMT discussion the existing error protection tools are able to cover only up to 3% of packet loss. The Redundant Pictures provide source-level packet loss protection scheme required for fulfilling the gap between current HEVC abilities and real networks requirements.

# Introduction

This proposal describes the method of how the video traffic can be reduced for video sharing applications and for the period of joining new participants in video conferencing applications. The Redundant Pictures provides such functionality which increase the total quality of service (QoS). The connection period became smaller and quality is not degraded.

Currently, the tandem free solution is very useful for low cost video conference servers. The video scalability also became common solution for heterogeneous networks.

Usually, MP-video conference solutions suffer from joining of new participants because of significant pollution on whole traffic (in case of fixed quality) or decrease video quality during the connection period due to necessity of sending Intra-pictures. To decrease this pollution the Progressive Intra Refresh (PIR) or sequential connection are used, but it allows only to spread the traffic or quality degradation.

There are the same disadvantages in video sharing applications. Redundant Pictures allow to reduce the storage space and network traffic for a lot of use case of video shearing while keeping quality at the same level as uploaded stream – without including large amount of Intra Random Access Points IRAPs.

# Problem Statement

## Multi-point video conference Standard scenarios for joining new participant

***Approaches:***

1. All participants waiting to each other and started simultaneously by transmitting IRAP/PIR to each other
2. New participant waiting refreshing with periodic IRAP/PIR
3. New participant send request for all to start IRAP/PIR update
4. New participant join sequentially: each participant (starting from new one) sent IRAP/PIR to other participants

All approaches obtained after discussion with companies provided video conferencing solutions (such as Vidyo, Huawei, Google, Microsoft, Skype, SPIRIT DSP….)

All of those techniques suffer from degrading of the video quality for existing/old users. Some of them allow to hide the problem by spreading quality degradation in time (like PIR and sequential connection). This is one the reasons of such small amount of applications with multipoint video conferences. It is not easy to allow participation in multi-point video conference for users who lost connection often. It restrict the usage of video conferencing for social networks with large amount of participants. Some of them attending to the conference some leave at the nearest time – all other suffer from deterioration of the video quality and from increased traffic.

## Video sharing applications

1. MPEG DASH technology have a lot of redundancy which possible to reduce, but enough simple and known solution
2. Proprietary solutions such as Apple’s HTTP Live Streaming, Microsoft’s Smooth Streaming, and Adobe’s HTTP Dynamic Streaming are not compatible with each other and possibly have the same redundancy in storage and streaming.

# 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 and questions were discussed during the presentation of JCTVC-R0159:

1. *In the envisioned usage, the redundant picture would be marked as a non-reference picture that is indicated not to be output, while a decoder that understands it could use it as a basis for decoding an approximation (perhaps with some drift) of a missing picture.****Answer****:* RP was proposed for increasing error robustness for packet loss, especially for high packet loss- in this case the small drift is negligible in respect of loosing part of the stream.
2. *The redundant picture is sent at a different POC, in a different access unit, substantially after the… The relationship with vps\_poc\_proportional\_to\_timing\_flag equal to 1 was discussed. There was some confusion over this aspect.****Answer****:* The same aspect was already discussed at the previous meeting. After the offline discussion with chair of that BoG it was agreed that restriction related to POC and picture timing was reasonable.
3. *There are actually two SEI messages proposed in the contribution.*
4. *Progressive intra refresh was mentioned as an alternative to this.****Remark:***PIR allows to spread in time and reduce the quality degradation – they doesn’t allow to keep the quality at the same level and reduce the traffic for the joining period.
5. *A usage in which only some parts of a picture are refreshed, somewhat similar to what was discussed for R0059, was illustrated.*
6. *Some* ***interest was expressed in further study of the idea****, although it is not clear there is a desire to move toward adoption at this time.* ***Further study would be needed*** *to determine whether there is adequate need for this.*

Some other aspects already discussed during several previous JCT-VC meeting:

* *It was asked whether the design is backward compatible to HEVC version 1, and it seems yes.****Answer****:* The backward compatibility is allowed by setting value deltaPOCminus1 to 0.
* *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.****Answer****:* 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.
* *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.****Remark****:* 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.
* *It was asked whether the AVC redundant pictures feature has been used. It seemed no.  
  Answer:* As was mentioned above the redundant pictures in the same AU (as in AVC) are not so efficient as in suggested approach.

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****.*

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

# Redundant Pictures for traffic reduction

## Multi-point video conference Standard scenarios for joining new participant

When the new participant joining to the video conference the traffic bandwidth increasing significantly, and strongly depend on the number of participants. That is the result of exchanging IRAP pictures (or PIRs) between participants. But existing participant do not need to send big IRAP pictures (or PIRs) to each other. Redundant pictures can reduce the number of IRAP pictures in the video conference traffic. Redundant IRAP pictures (RIRAP) from existing participants are used to start decoding existing streams by new participant. Server extracts redundant pictures and primary Inter pictures and send RIRAP pictures only for new user, while the old users exchange regular Inter pictures.

The figure 1 shows the case when we trying to keep quality of the picture (keeping in mind that Intra/Inter ratio is much bigger then depicted on the figure).

Within limited incoming bandwidth we can use the following approach (depicted below).

* Each old participant sent to the server regular Inter picture and redundant picture with the same quality (or lossless respectively to reconstructed). (Usually outcoming channel have more free bandwidth then incoming)
* New participant also sent his IRAP picture to other participants with good quality at once and receive redundant IRAP pictures from others with some delay (because of income channel bandwidth)
* While new participant have not yet receive redundant IRAP picture from others, old participants sent regular Inter pictures only to each other, but not for new one.
* After the transmitting period of redundant IRAP pictures for new participants, the others start to sent him regular Inter pictures with long term prediction as showed at the picture

It allows us to do not have delay for getting picture from new participant, allows to keep quality for old participants.

Only new participant (“D”) have little delay (equal to Intra/Inter ratio) for the connection period without big pollution on the picture quality of existing participants.

There are only two negligible degradation of quality: first when IRAP from new participant reduce the incoming bandwidth for old participants and second time for 4th Inter picture after joining to the conference because of long term prediction.



Fig.1. Joining of new participant using Redundant Pictures

As was mention during previous meetings redundant pictures have some drift in case if redundant picture is lossy or without quantization of predicted picture as in SP/SI slices in h.263+ (for primary and for redundant) before adding a residual).

First of all it is possible to use a lossless redundant IRAP picture without any drift respective to the primary Inter picture (the reconstructed primary picture will be used as source for encoding redundant picture instead of original picture). In that case the size of lossless IRAP based on reconstructed primary picture will be less than usual lossless intra picture based on original picture, because reconstructed picture have much less noise after quantization.

It is possible to control the quality of Redundant pictures and use QP values less then QP of primary pictures. In that case the drift will be less then quantization noise.

From the quality degradation point of view the drift can be compared with quality of standard approach. When new participant joining to the conference we have to send IRAP pictures to each other. In this case we have much more degradation of image quality as shown on the chart below (**Violet** curve for regular Inter pictures before joining and **Blue** one for IRAP pictures for joining). Additionally, it is need to note that quality after IRAP picture will not be restored quickly. Using redundant pictures we can significantly reduce the quality degradation for joining period. The **red** curve is the regular Inter pictures quality for old participants (only for joining period) and the green curve can reach the same quality as red (**green** curve obtained by multiplying Inter frame bit-budget by 10 times and using BD-rate curves for the sequence “FourPeople”). But the quality of Redundant IRAP pictures can be easily adjusted by increasing bit-budget for Redundant IRAP pictures up to lossless (as explained below).



Fig.2. Quality for the period of joining of new participant

As was already mentioned before – the lossless pictures can be used as redundant pictures without any drift. The reasonable question in this case is the size of such lossless redundant pictures. This information provided on the Fig 3 as ratio between lossless redundant pictures (LLRP) and primary pictures (PrmP) in terms of time which is needed to transmit LLRP with the bit-rate of PrmP ( =(1000/fps)\*sizeof(LLRP)/bit-rate ). It will be the waiting period (delay) for the new participant only (if he want to connect to the conference without any drift). Just for notes: the lossless encoded reconstructed picture (used for RPs) is almost twice less than lossless encoded original picture.

The chart below present the comparison of two approaches – redundant pictures (RP) with drift and without drift (**green bar** and curve) (based on HEVC HM13). Bars on the charts shows the delay of receiving redundant IRAP for new participant (**red bar** shows the standard **Intra/Inter ratio** in terms of ms) (less value is better). The curves shows the drift between PrmP and RP in terms of PSNR. Inter pictures quality (**light blue** curve) and Intra pictures quality (**red** curve) showed just for reference quality.

As can be noted, the drift is much less (PSNR quality bigger) then the quality of Primary Pictures and our experiments (based on H.264) shows that such drift is subjectively negligible and reducing from picture to picture. There are no needs to use LLRP to exclude drift for most of application, but it still possible.

As can be noted, the delay of receiving RP is almost the same as for standard Intra pictures, but only new participant need to wait redundant IRAP instead of all participants in standard approach.



Fig.3. Delay and drift for new participant starting video conferencing

## Video sharing applications

The most known issue which tried to solve different video sharing servers is ability to share different resolution and quality of the same content for large amount of users. The most usable solution is MPEG DASH technology which split the stream on large amount of segments with different characteristics (resolution, Bit-Rate, GOP structure …).

All DASH video segments are started from IRAP pictures, that is why the user playing video from the beginning need to receive and decode large amount of IRAP pictures and server need to store the large amount of segments started from IRAP pictures with different quality and bit-rate of the same content. In case of using redundant pictures large amount of segments of the same resolution and quality can be replaced with one segment containing only Inter pictures and several Redundant Inter pictures connected with previous segments for seamless playing video content without Intra coded pictures, and several Redundant IRAP pictures for starting playing from different time location and switching between the different resolutions.

# Comparison

Figure 1 present the comparison between existing solution and proposed approach with using Redundant Pictures.





Fig. 1 The whole traffic for the new MPVC participant joining period.

As can be noted that the dependency between network traffic and amount of participant is quadratic. Redundant pictures allows to get the liner dependency between part of the network traffic needed for IRAP pictures and only regular Inter pictures traffic remain with quadratic dependency from the number of participants. The table 1 provides the theoretical comparison for different approaches (described in section 2) for joining of new participant to Multi-Point Video Conference.

Table 1. Theoretical comparison of different approaches



# Conclusion

For traffic reduction for video sharing and in multi-point video conference (for joining of new participant)

* Redundant pictures allows significantly reduce the traffic for considered use cases
* Allows significantly increase the period of IRAP pictures in streams (or remove it at all)
* With limited channel bandwidth the quality can be significantly improved by using redundant pictures
* In worst case, when some of the participants lose the connection often (mobile or wireless), the redundant pictures can help to save quality of other participants.
* The drift between Redundant Pictures and Primary Pictures can be negligible or absent (when lossless coding is used for RP)
* The storage space for video sharing can be significantly reduced.

For robustness from packet loss

* Redundant pictures are very useful in different error protection scenarios such as the interactive scenario using the feedback channel to signal lost data and non-interactive scenarios based on forward error correction approach.
* The proposed technique allows to separate the protected primary coded picture and the associated redundant picture for better error resilience in case of bursts.
* The proposed solution allows to protect the large sized IRAP frames which are more sensitive to transmission errors.

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.

The new redundant pictures are constructed in a manner which allows to add such functionality to HEVC version 1 because the redundant pictures are regular pictures and not marked for output and will be discarded by already implemented decoders and can be used in future versions with small modifications. The source code will be provided.

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.

# References

1. M. Sychev, V. Stepin, V. Anisimovsky, S. Ikonin, “Redundant frames for SHVC/MV-HEVC/HEVC”, JCTVC-P0062/ JCT3V-G0043 document, Jan. 2014.
2. ANSI, “Network model for evaluating multimedia transmission performance over internet protocol”, ANSI/TIA-921, June 2006.
3. ITU\_T, “Network model for evaluating multimedia transmission performance over Internet Protocol”, ITU-T Recommendation ITU G.1050, March 2011.
4. P. Frossard, “FEC Performance in multimedia streaming,” IEEE Communications Letters, vol. 5, no. 3, pp. 122-124, Mar. 2001.
5. T. Stockhammer, D. Kontopodis, and T. Wiegand, “Rate-distortion optimization for JVT/H.26L coding in packet loss environment”, Packet Video Workshop 2002, Pittsburgh, PY, USA, Apr. 2002.
6. I. Radulovic, P. Frossard, Y. Wang, M.M. Hannuksela, A. Hallapuro “Multiple Description Video Coding with H.264/AVC Redundant Pictures”, IEEE transactions on circuits and systems for video technology, vol. 20, no. 1, January 2010.
7. ITU-T, “Advanced video coding for generic audiovisual services”, ITU-T Recommendation H.264, May 2003.
8. Y.-K. Wang, S. Wenger and M.M. Hannuksela, “Common conditions for SVC error resilience testing,” JVT document P206, Aug. 2005.
9. P.Baccichet, S.Raneand B.Girod, ”Systematic Lossy Error Protection based on H.264/AVC Redundant Slices and Flexible Macroblock Ordering”, PV2006, Hangzhou, PRC.
10. M. Sychev, V. Stepin, S. Ikonin, “Redundant picture SEI message”, JCTVC-Q0090/JCT3V-H0029 document, Mar. 2014.
11. M. Sychev, S. Ikonin, “HEVC/MV-HEVC/SHVC HLS: SEI message recommended by MMT for improvement of HEVC packet loss resilience”, JCTVC-R0159/ JCT3V-I0040 document, Jul. 2014.

# Patent rights declaration(s)

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