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White Paper

Maintaining A High Quality Experience Over Unmanaged Networks

Quality of Service and Quality of Experience –
Scalable Video Coding (SVC) – Unequal Error Protection (UEP) -
RADVISION's Error Resiliency Solution

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This paper is intended to describe the error resiliency and packet loss robustness features available in RADVISION's products.

These features include:

- RADVISION's SVC-based solution
- Unequal Error Protection (UEP) tools
- Packet Retransmission and VFU

The above mentioned features are available on the following products:

SCOPIA Desktop V7.0

SCOPIA Elite

SCOPIA BEEHD

SCOPIA VC-240

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Quality of Service and Quality of Experience

It is well-known that video quality in a video call or video conference is tightly coupled with network conditions. However, as video conferencing infrastructure become massively deployed, it can no longer be assumed that network QoS is available, as use of non-dedicated lines and the public Internet becomes more prevalent.

In network topologies where QoS is not guaranteed, there are techniques that can be utilized to ensure a reliable channel regardless of network conditions. These techniques can help maintain a high Quality of Experience (QoE) even when network quality is low, by overcoming transient packet loss situations and reducing the effects of network losses on video quality.

These error resilience techniques, however, come at a cost - either in latency, as a result of increased buffering, or in bandwidth, which is directly proportional to the bandwidth of the protected stream and the excepted loss rate.

Scalable Video Coding (SVC)

As explained in details in the RADVISION whitepaper *"Delivering a Truly Scalable Visual Communications Solution"*, Scalable Video Coding (SVC) allows senders to transmit a single video stream, encoded once, supporting a range of resolutions, bitrates and quality levels, by discarding selected data (a process known as "layer thinning").

But SVC introduces another significant advantage over single-layer coding: temporal scalability. Temporal scalability introduces a layered structure of frame dependency, which allows any network element, including the receiving client, to decode the bit stream even when some of the data is missing.

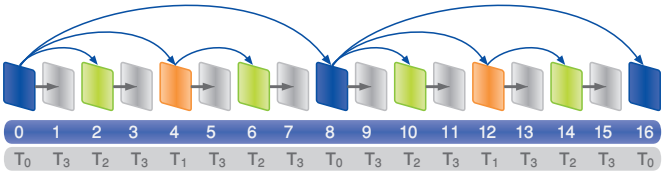

Fig 1: a Temporal Scalability multi-layered frame structure example

The layered frame structure in figure 1 is an excellent illustration of the strength of temporal scalability. Unlike single-layer coding, where each frame depends on the previous frame, and so a loss of any frame is significant, we can see in this example that the odd-numbered frames (1, 3, 5, etc.) can be discarded from the stream without any influence on the rest of the frames. Frames 2 or 6, for instance, have limited dependency, and if lost, they will affect only one other frame. Therefore, this layered stream in essence is much more resilient to errors than a similar single-layer stream.

The use of such a multi-layered SVC stream allows applying error resiliency techniques to parts of the stream (specific layers) only, a technique known as Unequal Error Protection (UEP). This saves considerable bandwidth, while maintain a high level of resiliency.

Therefore SVC and other error resiliency techniques (such as Forward Error Correction, or FEC) are not competing techniques but complementing ones.

Unequal Error Protection (UEP)

Existing error resilience techniques can be categorized into two general groups: protective coding and correction codes. Both are used to protect data against possible data loss.

Using **protective coding**, the encoder may select not to exploit all the redundancy in the stream for compression purposes. As a result, the stream has more redundancy, and is therefore much more resilient to packet loss. On the other hand, the compression is much less efficient, which adversely affects quality.

A typical way to implement protective coding is to increase the INTRA macro-block frequency in the video stream.

Using **correction codes**, such as Forward Error Correction (FEC), an encoder can protect streams without directly affecting coding efficiency. FEC involves sending additional packets to protect the data. In case data is missing, it can be fully restored using the FEC packets. This, however, dramatically increases the bandwidth required, due to the addition of FEC packets, and can introduce latency due to the extra processing needed. Also, as the overall bandwidth is limited, it may affect quality.

On top of these, **packet retransmission** can be used, to compensate for packets lost. Depending on the senders' and receivers' capabilities, a specific packet, or even a whole frame, can be resent. With single-layer coding this technique usually introduces substantial latency and is not suitable for interactive communication. With the use of multi-layer coding technique, such as SVC, re-transmission can be used without introducing latency.

The most common technique used for recalibrating sender and receiver involves generating a new key frame (INTRA frame) upon request from the receiver, using a **Video Fast Update** (VFU) command.

RADVSION employs Unequal Error Protection (UEP) methods, designed for data protection over erroneous networks. UEP allows the sender to protect different levels of data in different ways - therefore optimally protecting the SVC stream. Important data, located in the base layer of the multi-layered stream, is highly protected; less important data, located in higher layers, is less protected or not protected at all.

In case of re-transmission, only the important data will be retransmitted. Due to the specific layer structure of the RADVISION SVC stream, retransmission can be used without introducing additional delay.

Exploiting these techniques, RADVISION is able to protect the stream without adding a substantial amount of bandwidth, as in the protective coding approach, while maintaining a very high quality of experience, as in the correction code approach.

RADVISION's Error Resiliency Solution

RADVISION's error resiliency solution employs these technologies in a unique combination to create the highest quality of experience, even in error-prone network conditions.

These technologies include:

- Temporal Scalability, as part of the H.264/SVC implementation
- UEP using FEC
- Packet retransmission
- Video Fast Update (VFU)

Another important component, required for a high quality experience, especially over unmanaged networks, is bandwidth management. While the techniques described in this document are designed to recover from packet loss, effective bandwidth management can help users abstain from packet loss. A follow-up whitepaper will cover this important aspect of the RADVISION solution.

Combining these technologies, the RADVISION solution guarantees high quality, regardless of the level of packet loss, as shown in figure 2 below:

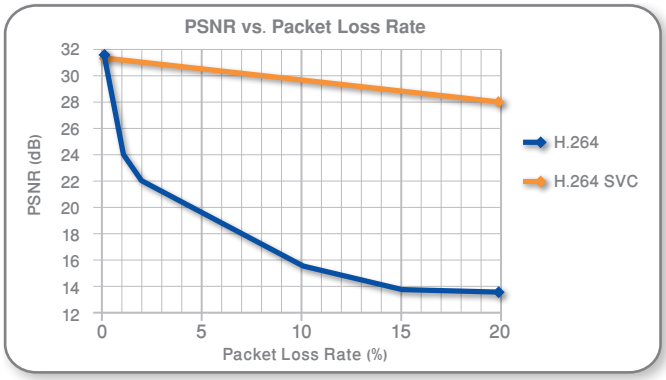

Fig 2: Quality in different Packet Loss rates conditions

Figure 2 illustrates how H.264 offers excellent quality (shown here in terms of Peak Signal-to-Noise Ratio, or PSNR), but declines significantly when packet loss rate increases. RADVISION's solution maintains the same excellent quality at a much higher packet loss rates.

As the RADVISION solution is embedded in all of the RADVISION product line, from desktop to infrastructure, users can benefit from these error-resiliency techniques in every aspect of their communication:

- Point-to-point calling between desktop client, even when one (or both) of the parties are not inside the corporate LAN.
- Making a conference call using the MCU via desktop client, even when the MCU or the desktop client is not located in the same campus.
- Making a video call using the VC-240, either point-to-point or through the MCU.
- In MCU to MCU cascading, which allow enterprises to deploy MCUs across their campuses (distributed model) and still maintain the highest quality of experience, using a "virtual" MCU.

All of these are practically impossible to achieve with traditional solutions, setting annoying and unnecessary boundaries for video conferencing deployment. RADVISION's solution allows all the video conferencing components to communicate with one other in great synergy, even over unmanaged lines and networks.

RADVISION's Solution vs. Existing Solutions

As seen in figure 2, video from a single layer coder, even H.264, typically cannot be used over networks with more than 1% packet loss. State-of-the-art error correction schemes, on top of single-layer coders, can help the video handle packet loss of up to 5%. But an H.264/SVC stream protected by UEP technologies can offer great unprecedented visual quality, with no artifacts, even at a packet loss rate of up to 40% packet loss.

Moreover, existing error resiliency schemes, which are applied on top of single-layer coders, yield a significant bitrate overhead. Some protect the entire Group of Pictures (GOP), resulting in up to 30% overhead and an increase in the number of packets, which increases the chance for packet loss. Others protect certain frames or certain areas within a frame, resulting in limited resiliency, especially over public Internet and networks with packet loss rates higher than 5%.

RADVISION's protection of the SVC stream adds only 10-15% overhead. The strength of the solution, however, is unrivaled. For instance, for a 512Kbps call, with 3% packet loss, the RADVISION output is flawless, without any visible artifacts apart from an occasional drop of frame rate to 28fps.

In addition, as mentioned above, the RADVISION solution is embedded in all of the RADVISION product line, from desktop to infrastructure. This allows users to benefit from these error-resiliency techniques, without a need for specific software or hardware, offering a real high quality experience to all users at any time or location. In addition to its infrastructure products powered by SVC, RADVISION will soon introduce the SVC SDK, for vendors who wish to deploy a ready-made Scalable Video Coding engine within their products.

Scalable Video Coding and Unequal Error Protection offer many benefits to video network infrastructure, improving error resiliency and overcoming the challenges of maintaining a high quality experience, even over unmanaged networks. The RADVISION solution enables an increased uptake of visual communication solutions in the enterprise arena.

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