

Comparison of Image Distribution Schemes in a Wireless Presentation System

G. X. Kok¹, K. N. Choong²

^{1,2}Wireless Innovation, MIMOS Berhad, Malaysia

*Corresponding author E-mail: gx.kok@mimos.my, kn.choong@mimos.my

Abstract

We proposed and compared several image distribution schemes for the webviewer scenario in a wireless presentation session. Simulation study showed that by optimizing the image transmission rate, a good tradeoff solution that maximizes the combined weighted video and image quality could be achieved.

Keywords: wireless presentation system; image distribution; video quality; transfer rate throttling; optimization

1. Introduction

Presentations are typically conducted using laptops and are displayed on large screen displays (projectors, televisions, etc.). Traditionally, video data are transferred from a display source to a display sink directly using some display cable such as VGA, DVI, and HDMI. Due to the rapid advancements in wireless and video encoding technologies (such as H.264 [1][2] and H.265 [3]), it is now possible to stream video from one device to another through a wireless connection. The benefits of this include reduced clutter, higher mobility freedom, enhanced control, reduced downtime, and lower costs. Figure 1 shows an example wireless presentation system.

In Figure 1, the wireless presentation box is connected to the projector through a display cable. The wireless presentation box also acts as a Wi-Fi access point, and the laptops are connected to the wireless presentation box wirelessly. Using custom software downloaded from the wireless presentation box, a user will be able to mirror the contents of his/her laptop's desktop screen onto the large screen display.

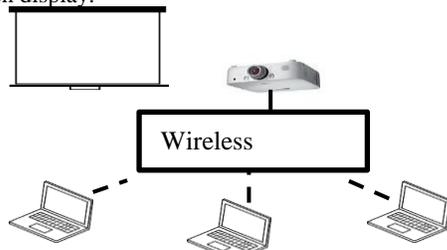


Figure 1: A wireless presentation system

A participant may be seated far away from the display and thus may not be able to see the presented video clearly. A distant participant

may also find his/her view obstructed by other participants and/or objects. To overcome this problem, some wireless presentation systems such as wePresent WiPG-2000 [4] and Extron ShareLink 250 W [5] contain a feature called “webviewer” or “web sharing”. With this feature, the wireless presentation box captures a snapshot of the presentation video periodically and hosts the snapshots on a web server within itself. A user far away from the display can view the snapshots of the presentation through a web browser from his/her device.

In this paper, we performed a simulation study on the performance of a wireless presentation system in the webviewer scenario. This paper is organized as follows. We provide the details of the proposed image data transfer throttling schemes in Section 2. Results and discussion is given in Section 3. Finally, we conclude in Section 4.

2. Image distribution schemes

In the webviewer scenario, the presenter streams the desktop screen of his/her computing device to the wireless presentation box. Simultaneously, the wireless presentation box performs a snapshot of the received video periodically and sends the captured image to a list of clients called webviewers. We denote the set of all webviewers as C . Images are encoded using the JPEG format, or any other lossy image compression format, and transported using the TCP. In this paper, we compare the following image distribution schemes.

2.1 Scheme 1: Sending available image immediately

In this scheme, when an image is available to be distributed to the webviewers, the wireless presentation box sends the image to all the webviewers, *immediately*.

2.2 Scheme 2: Throttling of image transfers

As the number of webviewers increases, the amount of data that must be transferred across the network increases. This is because at periodic intervals, the wireless presentation box has to send an image to each of the webviewers. Depending on the available bandwidth, the wireless presentation box may have to throttle the image data transfer rate to reduce the impact on the transmission of the video stream.

2.3 Proposed scheme 1: optimal throttling of image transfers

If we assume that the wireless presentation box distributes its available image data transfer rate allocation, img_rt evenly among all webviewers $c \in \mathbf{C}$, then the delay between the time the wireless presentation box sends an image and the time a webviewer completely receive an image, img_dl can be computed as follows, where img_sz is the typical size of a distributed image.

$$img_dl = \frac{img_sz}{img_rt/|\mathbf{C}|} \quad \text{Eq. 1}$$

To ensure that images are delivered in a timely manner to the webviewers, we define a metric called image quality, $img_quality$. This metric maps img_dl to a value in the interval [0 1], as shown in Figure 2.

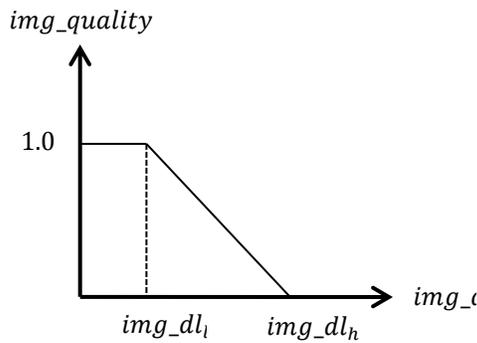


Figure 2: Image quality as a function of delay

In Figure 2, img_dl_{low} and img_dl_{high} are the low and high image delay thresholds, respectively. The equation for $img_quality$ is given as follows:

$$img_quality = \min\left(\max\left(\frac{img_dl}{img_dl_{low} - img_dl_{high}} + \frac{img_dl_{high}}{img_dl_{high} - img_dl_{low}}, 0\right), 1.0\right) \quad \text{Eq. 2}$$

In most wireless presentation systems, video data is delivered using TCP, which ensures reliable data transfer. What this means is unless the link between the presenter device and the wireless presentation box fails, there is no discrepancy between the video stream sent by the presenter device and the video stream received by the wireless presentation box. As such, standard objective video quality metric such as PSNR or SSIM, which compare the quality of a video with reference to a reference video, are not suitable for evaluating video quality in this study. Instead, in this study we defined and used a simple metric called video quality, $vid_quality$ for evaluating video quality. The equation for $vid_quality$ is given as follows, where vid_enc_rt is the data rate of the encoded video bit stream, vid_rt

is the actual or allocated data rate for the transfer of the video stream in a desktop mirroring session.

$$vid_quality = \frac{\min(vid_rt, vid_enc_rt)}{vid_enc_rt} \quad \text{Eq. 3}$$

Equation 3 can be explained as follows with the reasonable assumption that the video bitrate of the presented video is generally fixed and is not configurable. Indeed, to the best of our knowledge, none of the available wireless presentation systems in the market currently provides a mean to change the bitrate of the presented video. Equation 3 simply measures how many percentage of the video bitrate that we can allocate for video transfer. For e.g., if the video bitrate is 4 Mbps and we can allocate 4 Mbps for video data transfer, then we can expect the video to play smoothly. On the other hand, if we can only allocate 2 Mbps for video data transfer, we can expect the presented video to experience various ill effects such as stutters, delay, and drifting, which cause an unpleasant viewing experience to the participants. Also, in a desktop mirroring session, as the desktop screen of the presenter device is captured, encoded, and transferred live to the wireless presentation box, the entire video stream of a session is not available prior to the session. As a result, any allocated rate higher than vid_rt cannot be utilized to improve video quality and is 'wasted'. This explains why we used the $\min(\cdot)$ operator in Eq. 3.

With both image quality and video quality defined, the overall quality of a particular desktop mirroring session, $ovr_quality$ can be defined as follows, where α is the video quality weight.

$$ovr_quality = \alpha(vid_quality) + (1 - \alpha)(img_quality) \quad \text{Eq. 4}$$

Eq. 4 states that the overall quality of a desktop mirroring session is simply the weighted average of video quality and image quality.

We further define $max_nw_tcp_thrp$ as the maximum achievable TCP throughput in the network. In practice, this value can be measured empirically using a tool such as iperf [6], or deduced based on the wireless standard (e.g., IEEE 802.11 b/g/n/ac) used in the network. As this maximum throughput is used to send both image and video data, we have at the following constraint:

$$vid_rt + img_rt \leq max_nw_tcp_thrp \quad \text{Eq. 5}$$

Since there is limited available bandwidth, and the bandwidth is used to transfer both video and image data, the wireless presentation box may need to throttle the image data transfer rate as the number of webviewers increases so that user satisfaction levels of the presentation participants are kept at a high level.

We would like to determine the optimal image data transfer rate that provides the highest satisfaction level to the presentation participants. This problem can be formulated officially as follows:

$$img_rt^* = \arg \max_{img_rt} (ovr_quality) \quad \text{Eq. 6}$$

$$s.t.: vid_rt + img_rt \leq max_nw_tcp_thrp$$

2.4 Proposed scheme 2: optimal throttling of image transfers with maximum tolerable image receive delay

In this scheme, we modified the previous scheme slightly to include a constraint in the maximum tolerable image receive delay, max_img_dl .

$$img_rt^* = \arg \max_{img_rt} (ovr_quality) \quad \text{Eq. 7}$$

$$s.t.: vid_rt + img_rt \leq max_nw_tcp_thrp$$

and $img_dl \leq max_image_dl$

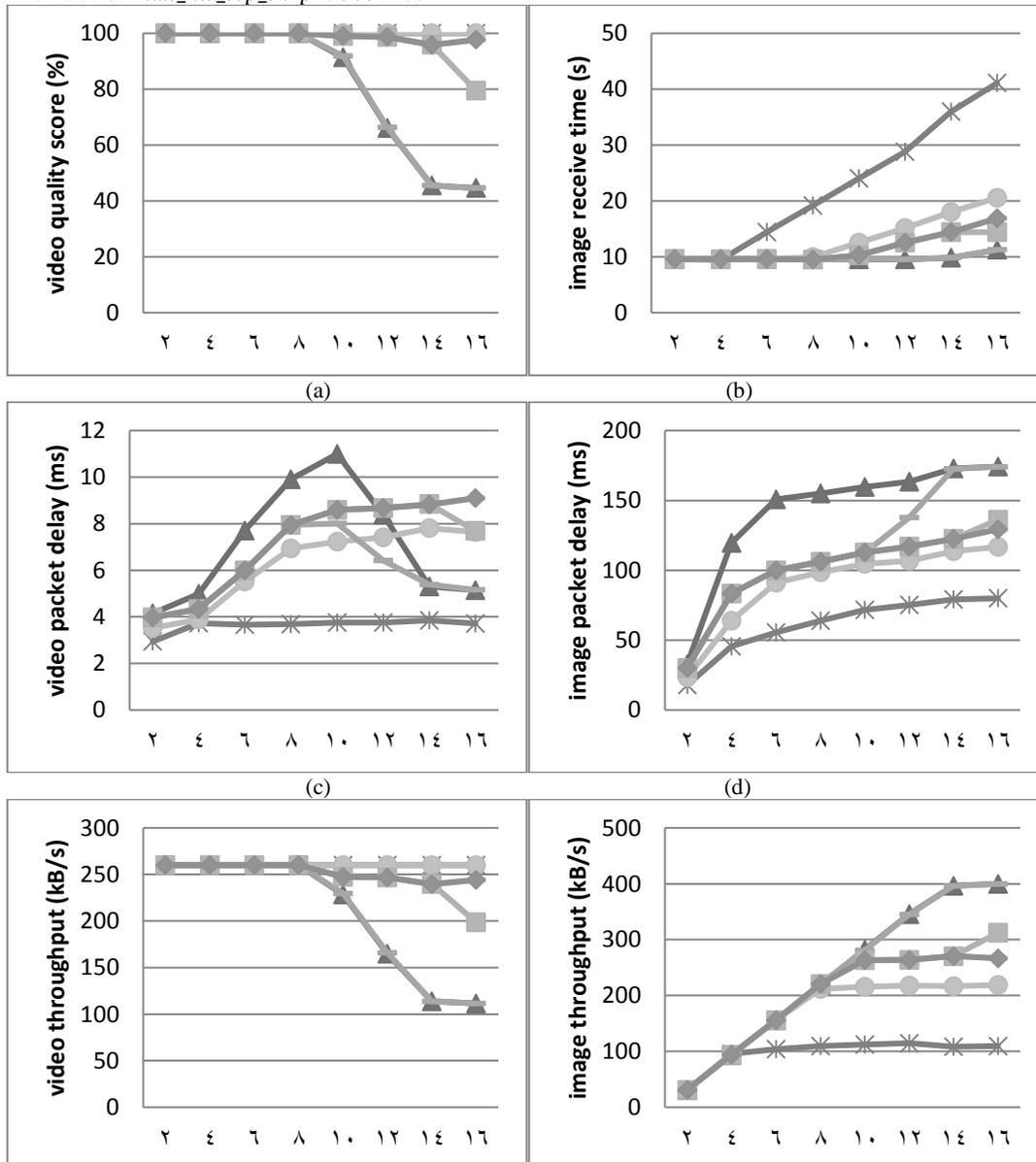
3. Results and discussion

We evaluated the image distribution schemes using network simulator 2 (ns-2) [7]. A number of nodes were placed in a square area of dimension 100 m by 100 m. Node 0, was designated as the wireless presentation box and was placed on the coordinate (50, 100) in the Cartesian coordinate system. Other nodes were randomly placed within the square area and were connected to node 0 wirelessly. Node 1 was designated to send a video stream to node 0 using TCP. Other settings for the simulation are as follows:

- Duration of the simulation: 300 s
- Bitrate of the video stream: 2 Mbps (or equivalently 250 kB/s)
- At periodic intervals of 10 s, node 0 sent an image 300 kB in size to all the webviewer clients using TCP.
- The MAC and physical layer used is IEEE 802.11 ERP-DSSS [8][9]. The MAC data rate is 11 Mbps.
- The value of $max_nw_tcp_thrp$ is 500 kB/s.

- The video quality weight parameter, α was set to 0.7.
- The low and high image delay thresholds, img_dl_{low} and img_dl_{high} , were set to 3 s and 10 s, respectively.
- Each scenario was repeated 10 times and the average of the result is used in our comparisons.

Figure 3 shows the results from the simulations. For all image distribution schemes, in general, as the number of webviewer clients increases, video quality (Figure 3a) and video throughput (Figure 3e) decrease while image receive delay (Figure 3b), image packet delay (Figure 3d), image throughput (Figure 3f), video packet inter-arrival time (Figure 3h), and video packet jitter (Figure 3i) increase. As the number of webviewers increases, there is more load within the network as the wireless presentation box has more data to send (recall that it has to send an image to each of the webviewers periodically). As the network has a limited amount of bandwidth, when the amount of image data increases, the rate of video data transfer was sacrificed. This explains why video quality and video throughput decrease as the number of web viewers increases.



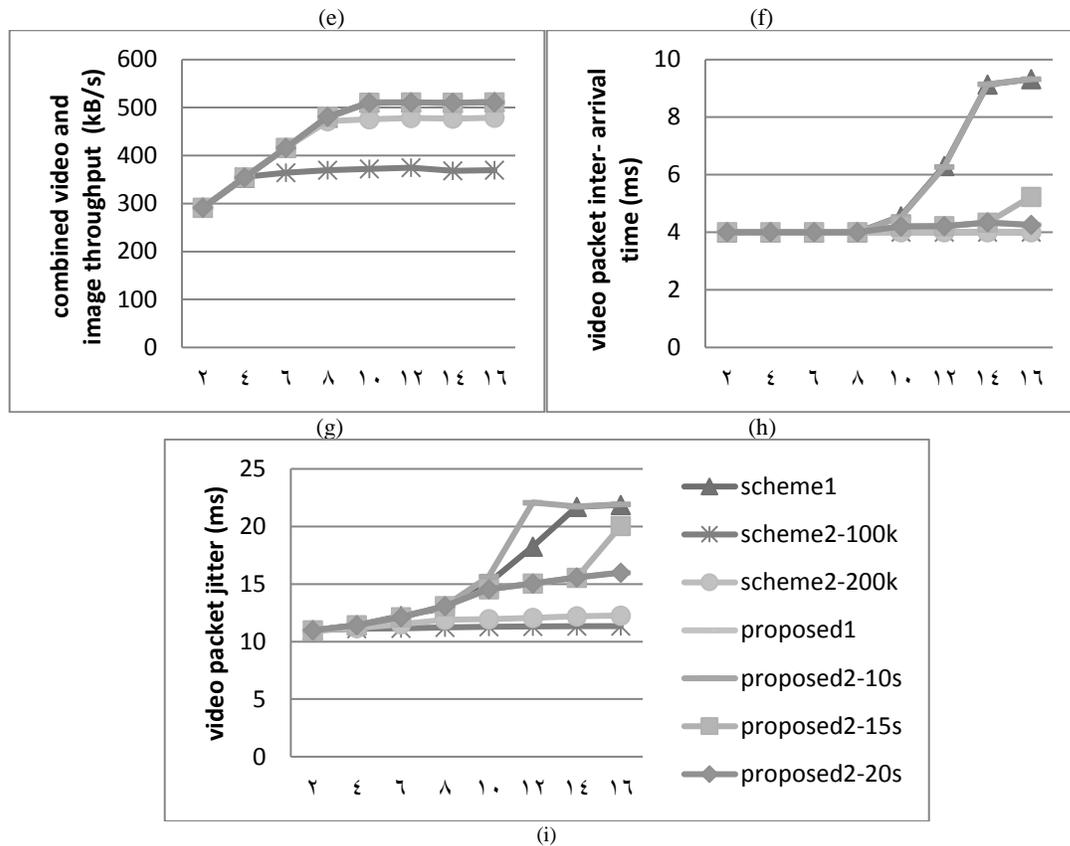


Figure 3: (a) video quality, (b) image receive delay, (c) video packet delay, (d) image packet delay, (e) video throughput, (f) image throughput, (g) combined video and image throughput (h) video packet inter-arrival time, (i) video packet jitter

The schemes *scheme2-100k* and *scheme2-200k* implemented a maximum image data transfer rate of 100 kB/s and 200 kB/s, respectively. By throttling image data transfers, we were able to prevent the decrease in video quality as the number of webviewers increases, as shown in Figure 3a (compare *scheme2-100k* and *scheme2-200k* with *scheme1*). Video packet inter-arrival time (Figure 3h) and jitter (Figure 3i) also became lower when there was more image data transfer throttling and more bandwidth was allocated for video. However, this comes at the expense of increased image receive delay, which is defined as the delay between the time the wireless presentation box sends an image and the time a receiver completely receives the image, as can be observed in Figure 3b. From Figure 3g, which shows the combined video and image throughput, it can be observed that both *scheme2-100k* and *scheme2-200k* were not fully utilizing the maximum achievable TCP rate, which is about 510 kB/s. With the maximum achievable TCP throughput, the number of webviewer clients, and the video rate as inputs, the *proposed1* scheme computes the optimal rate as the maximum image data transfer rate. It can be observed in Figure 3a that by comparing the *proposed1* scheme with *scheme1*, the *proposed1* scheme managed to maintain a high video quality level even as the number of webviewer clients is increased. By comparing the *proposed1*, *scheme2-100k*, and *scheme2-200k* schemes, it can be observed that the *proposed1* scheme was able to fully utilize the available network resource (Figure 3g) to reduce image receive delay (Figure 3b).

The schemes *proposed2-10s*, *proposed2-15s*, and *proposed2-20s* imposed a maximum image receive delay of 10 s, 15 s, and 20 s on top of the *proposed1* scheme, respectively. For the *proposed2-10s* scheme, the amount of bandwidth that must be allocated for the transfer of image data is high due to the strict

timing requirement; as a result, the scheme only performed similarly to *scheme1* in video quality (Figure 3a) and image receive delay (Figure 3b). When we compare *proposed2-15s* to *proposed2-20s*, at 16 users (one wireless presentation box + 15 webviewers), in order to maintain a maximum image delay of 15 s, the *proposed2-15s* scheme allocated more bandwidth for the transfer of image data (i.e., there was less throttling of the image data transfer rate) (Figure 3f) and obtained lower video quality (Figure 3a) than the *proposed2-20s* scheme. In general, as the image receive delay constraint becomes looser (the maximum image receive delay increases), more bandwidth can be allocated for the transfer of video data (Figure 3e) and video quality increases (Figure 3a) as a result.

4. Conclusion

In this paper, we proposed and compared various image distribution schemes for the webviewer scenario. As TCP is used for video transfer, video quality decreases as the number of webviewers increases because the rate that can be allocated for video data decreases. By throttling the transfer rate at which images can be downloaded by the webviewer clients, better video quality can be achieved. We proposed a scheme to determine the optimum maximum image data rate to use. Results showed that with the proposed scheme, better video quality and lower image receive time, both of which affects the overall satisfaction level of the users in a desktop mirroring session, could be achieved.

References

- [1] G. J. Sullivan and T. Wiegand, "Video Compression - From Concepts to the H.264/AVC Standard," *Proc. IEEE*, vol. 93, no. 1, pp. 18–31, Jan. 2005.
- [2] "VideoLAN - x264, the best H.264/AVC encoder." [Online]. Available: <http://www.videolan.org/developers/x264.html>.
- [3] "x265 HEVC Encoder / H.265 Video Codec." [Online]. Available: <http://x265.org/>.
- [4] "wePresent WiPG-2000 | wePresent 2000 Advanced Wireless Projection System." [Online]. Available: <http://www.wepresentwifi.com/wipg2000.html>.
- [5] "Extron Electronics - ShareLink 250 Series." [Online]. Available: <http://www.extron.com/company/article.aspx?id=sharelink200ad>.
- [6] "iPerf - The TCP, UDP and SCTP network bandwidth measurement tool." [Online]. Available: <https://iperf.fr/>.
- [7] "The Network Simulator - ns-2." [Online]. Available: <http://www.isi.edu/nsnam/ns/>. [Accessed: 14-Nov-2012].
- [8] D. Vassis, G. Kormentzas, A. Rouskas, and I. Maglogiannis, "The IEEE 802.11g standard for high data rate WLANs," *IEEE Netw.*, vol. 19, no. 3, pp. 21–26, May 2005.
- [9] L. Villaseñor-González, "A Performance Study of the IEEE 802.11g PHY and MAC Layers over Heterogeneous and Homogeneous WLANs," *Ing. Investig. y Tecnol.*, vol. 8, no. 1, pp. 45–57, 2007.