SLIPSTREAM

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Web Accelerators: Image Comparison – Quality and Compression

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1 Introduction

Images constitute a significant portion of traffic on the Internet today as images are frequently used in graphic rich web content. Users frequently upload/download image files and exchange pictures with other users via email. Images entail large amounts of information when articulated digitally, which requires compressed file formats, such as JPEG, GIF and PNG, for efficient storage and handling. Image files are bandwidth intensive and tend to slow down even the best managed networks. Low bandwidth dial-up and wireless users are often faced with slower response times when downloading image rich web pages. Likewise, transfer of image files on low bandwidth connections often involves longer waiting periods.

2 Image Compression/Acceleration Challenge

Vendors of web accelerator software products are hard-pressed to improve compression of image files in order to accelerate transmission. It is really difficult to compress standard image files any further without altering the image quality or file formats. Therefore, image quality is compromised in order to gain further reductions in file sizes. Likewise, file formats are also changed to some intermediate compression format to reduce bandwidth requirements for transmission and then restored back to the original image formats at the other end.

Recent versions of most acceleration solutions change the image format to their own non-standard proprietary compression formats during the transmission, in addition to reducing the image quality. The solution developer can use any possible algorithms or techniques to reduce the image size. The client software then restores the image file back to its original format before forwarding it to the web browser. One cannot, therefore, really compare different acceleration products based on the file sizes of the restored images on the client side since they are no longer the bit lengths transferred from the web server to the end user.

3 Image Quality vs. Compression

The compression gain achieved by converting an image file format to proprietary formats is limited, since the original image file formats already employ some form of data compression. That is why almost every acceleration solution reduces the image file size by reducing the image quality to a certain degree. Generally, the lower the quality of the reconstructed image, the smaller is the size of the transferred image. Therefore, in order to let end-users choose a compromise between transmission speed and image quality as a matter of preference, almost every acceleration solution provides the image quality level setting meter to allow the end-users to select image quality levels for browsing web sites.

4 Comparison of Image Acceleration Solutions – Key Issues

The question is how to compare different acceleration solutions based on image compression and quality settings. It is hard for end-users to make a fair comparison, since:

- Each acceleration solution provider defines their own image quality levels/settings, which are usually different from that of their competitors', see Figure 1. As a result, end-users can not do any side by side comparison of images downloaded with competitive products, since they do not have the same image quality settings to start with. Visual comparisons are very subjective and differences in quality settings could affect user perceptions. For example, an image with a slightly higher quality setting and lower acceleration will tend to sway the user perception in its favour and bias the results of comparison.
- End users may not know the actual transferred image sizes and it is not something that is easily available without a certain level of technical expertise. A higher quality image means a larger bit-length is required to transfer the image and consequently longer time for download as compared to a lower quality image. This makes the task of comparing competitive products even harder.
- Finally, with the two dimensions (image quality and file size) put together, it gets even more difficult to tell what is better, a higher quality image with a larger file size, or a lower quality image with a smaller file size. In a visual comparison, it generally boils down to user predisposition towards one or the other and lose objectivity of comparing solutions based on performance and efficiency.

Visual comparison, which tends to be very subjective in the first place, is rendered less reliable by the issues discussed above. A great degree of caution must be exercised with the visual method, as it can easily lead the user to erroneous conclusions about the performance of an acceleration product, since visual comparison does not objectively compare the image quality levels and compressed file sizes.

5 Rate-Distortion (R-D) curves

The key question is: what is an objective metric for comparing the quality of images produced by different products? Rate-Distortion (R-D) curves are commonly employed to compare different image compression algorithms or products. An R-D curve is a two-dimensional plot, with Rate measured as the transferred bit length or bpp (bits per pixel) and Distortion measured as the Mean Squared Error (MSE) of the quality of the transferred image. MSE is calculated as the average squared error between the compressed image and the original image per pixel. The lower the MSE, the closer the compressed image is to the original image.

6 Image Quality Settings of SlipStream and Competitive Products

Average MSE values in Discrete Cosine Transfer (DCT) Domain of 15 random JPEG images downloaded from the Web, were calculated for each image quality setting of SlipStream and a competitive Web Accelerator and the resulting average MSE values are plotted in Figure 1. The chart is easy to use. The MSE values represent the level of

distortion or deterioration in the quality of the downloaded image - larger the MSE value, poorer the image quality. The original image quality has an associated MSE value of zero.

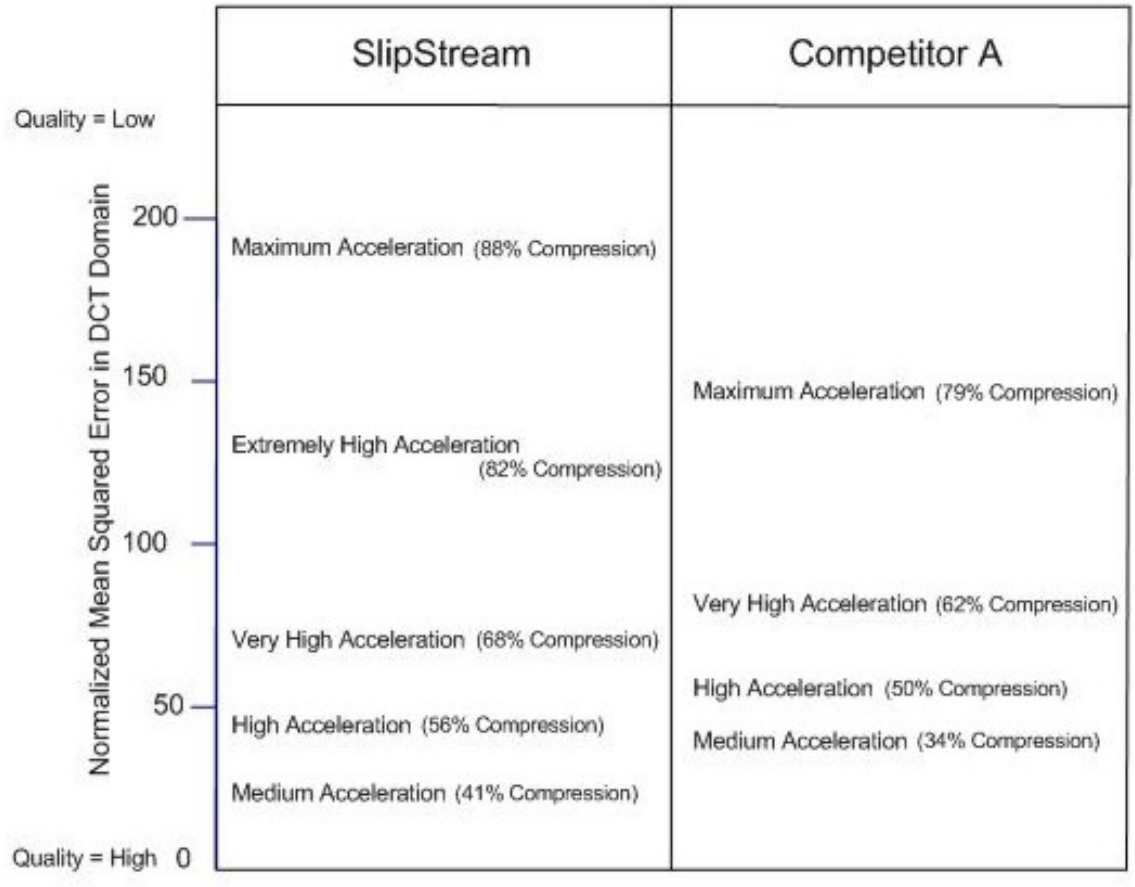

Figure 1: Image Quality Setting Equivalencies of Different Web Accelerators (average of 15 randomly selected web images)

The lower and upper end values correspond to the two ends of the image quality slider of the accelerators. One common mistake that most testers make is that they automatically assume that the end points on the image quality sliders (the extreme end setting labels) represent the same quality levels in each product. In fact they are quite different as seen from the chart in Figure 1. The competitive product in this case offers a narrow range of image quality settings and their high end setting corresponds to one of the intermediate settings of SlipStream. This also means that this Competitor A does not offer as high image acceleration as SlipStream. When comparing competing accelerator products, visually or otherwise, one should make sure the products are configured for image quality settings with the closest MSE values, for example, 'Maximum Acceleration' setting of Competitor A has an MSE value closer to 'Extremely High Acceleration' setting of SlipStream, one notch below the extreme/end value.

7 Comparison of SlipStream and Competitive Products

Figure 2 shows the R-D curves of the two acceleration products, SlipStream and Competitor A. The points on the curves are averages of 15 randomly chosen web JPEG images at each image quality setting of the competing products.

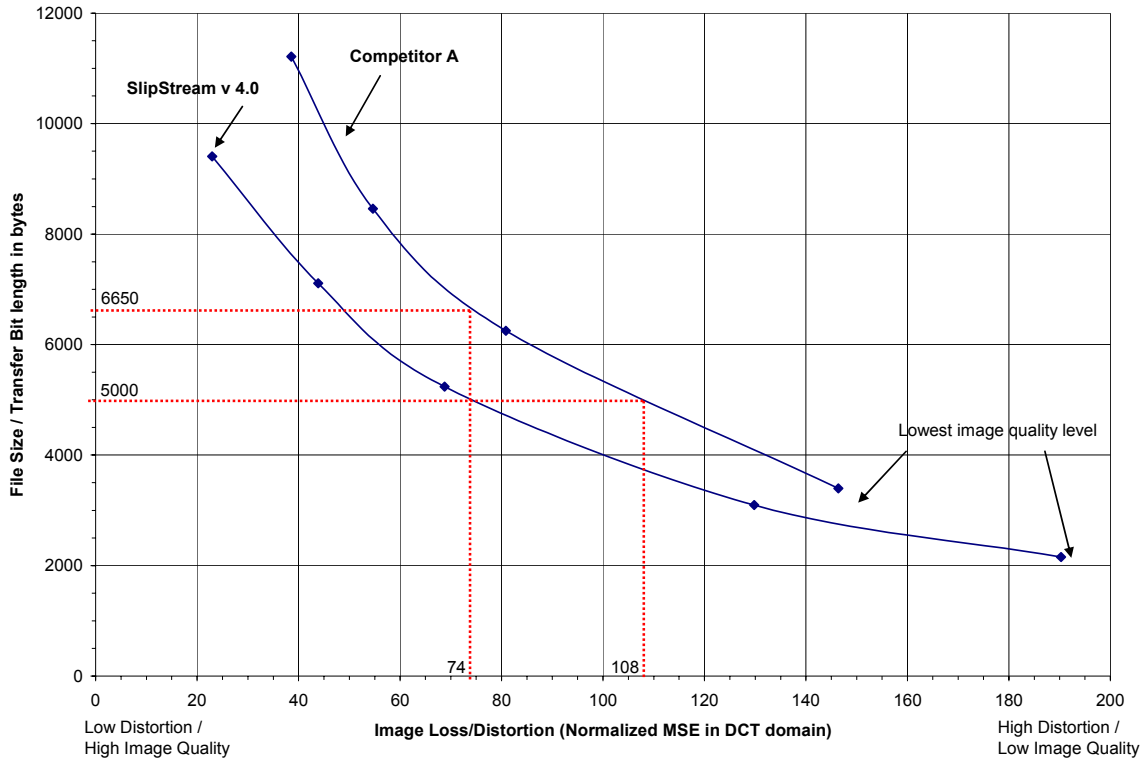

Figure 2: R-D curves for SlipStream and Competitor A's Acceleration Product (average of 15 randomly selected web images)

The R-D curves can be read in two different directions. Following a straight line vertically, one can tell how many bytes of data (file size) will need to be transferred by each product to fetch an image with the same level of image distortion (equivalently, image quality). For example, to download an image with an MSE loss value of 74 (distortion level), Competitor A's solution needs to transfer a larger file with 6,650 bytes, while SlipStream's solution needs to transmit a smaller file with 5,000 bytes only, proving that for a given level of degradation (distortion/error) of image quality, SlipStream's solution offers a higher image compression for data transfer. Likewise, following a straight line horizontally, one can read distortion levels that different products will introduce in the images for the same transferred bit length (file size). For example, to compress an image file down to 5,000 bytes of transferred bit length, SlipStream's product will produce an image distortion/loss of 74 MSE compared to 108 for Competitor A, again proving that for the same level of image file

compression, SlipStream's solution offers a lower image distortion/loss (higher image quality). With R-D curves, one can easily compare different image compression products fairly.

8 Conclusion

As no two vendors have identical file compression and image quality trade-off settings, it is hard to visually compare the downloaded images and draw objective conclusions about product performance. Visual comparison would invariably lead to erroneous conclusions. R-D image quality and compression curves provide an objective way of comparing acceleration products from different vendors. Based on a comparison of the R-D curves, the SlipStream solution offers the highest image quality for given file compression levels as compared to competitors.