Technical white paper

Optimizing performance with HP RGS 7.1

**Information and recommendations
for HP Remote Graphics Software 7.1**

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Purpose of this document

- Describes the various factors that affect the performance of HP RGS[1] and outlines how these factors interact with each other in remote workstation environments
- Describes the tools and settings in HP RGS available to help optimize performance

HP RGS performance overview

This section defines the concept of a "virtual workstation user" and provides an overview of the technologies behind HP's Virtual Workstation Solution. It also discusses the high-level differences between workstation virtualization technologies and illustrates how the major desktop virtualization providers implement these technologies in their products.

- System-level: the CPU and graphics performance of the host (the "Sender") and the remote system (the "Receiver"), as well as the performance improvements in HP RGS software releases over time, especially when using the latest release—HP RGS 7
- Application-level: the type of image/content (wireframe graphics, solid graphics, audio, video, etc.), and the rate at which the display content is changed or refreshed through user activity, video playback, etc.
- Display-level: the number of displays, the size of the display window(s), and the resolution of the displays on the RGS Sender
- Network-level: the quality of the network that connects the two devices, including variables such as latency, packet loss, and available bandwidth
- HP RGS Options and settings: the options and settings available within HP RGS to help control and optimize your user experience

Figure 1. Factors affecting HP RGS pipeline performance

Remote Operation Pipeline Stages
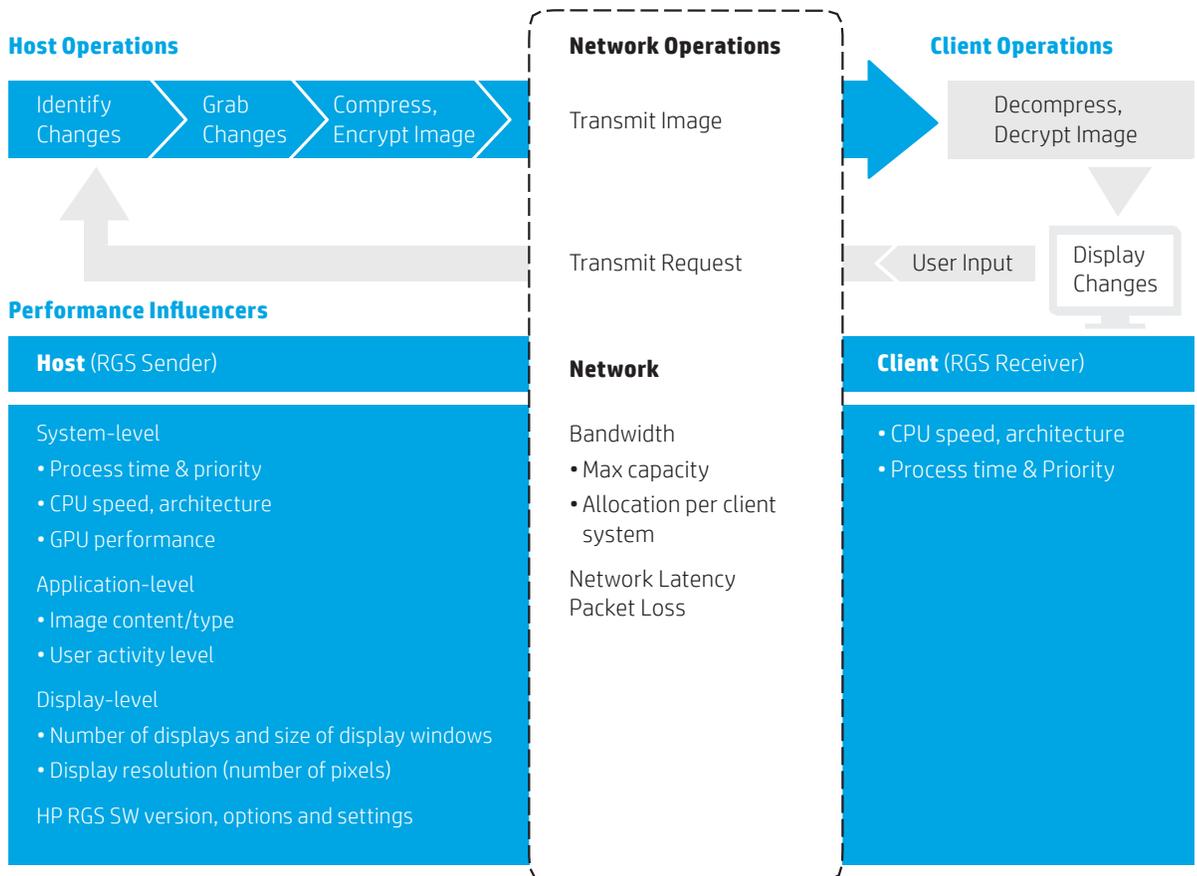
The following sections examine each of these factors in detail—particularly network quality—and provide test data to illustrate how these variables interact in a simulated network environment.

System hardware and software performance

System hardware, especially the available CPU and graphics resources, plays an important part in overall RGS performance by providing the power to capture, compress and encrypt each image update. In particular, the following system components have a direct impact on RGS:

• CPU clock speed and number of CPU cores

• Graphics cards (GPU) on Sender desktop

HP RGS software and performance

In addition to the impact of system hardware, HP has added important performance improvements to the RGS software over the last two major software releases. Specifically:

• HP RGS 7.1 added multi-threaded encode and decode to HP3. This enhancement can greatly increase the frame rate, screen resolution or both.

• HP RGS 7.1 added Hardware AVC encoding with NVIDIA® Quadro "K" series and newer graphics devices.

• HP RGS 6 added the AVC (Advanced Video Compression) option which can greatly reduce network bandwidth consumption. This setting is only recommended when the default HP codec (HP3) cannot provide an adequate experience due to limited network bandwidth.

• HP RGS 6 incorporated HP Velocity into the Sender and Receiver. HP Velocity is a Quality of Service (QoS) optimization solution, which improves frame rate performance on poor quality networks with high-latency and packet loss. HP RGS 7.0 incorporated HP Velocity 2.1 to further improve performance on high-latency networks. RGS 7.1 added the Velocity status indicator to the Receiver toolbar, as well as the ability to turn Velocity on and off and view live statistics of network improvement with HP Velocity.

AVC and HP Velocity are discussed in more detail later in this document.

HP3 codec and performance

The HP3 codec—the default compression method for HP RGS— works in conjunction with a display capture method that is responsible for determining changes that have occurred on the desktop. The HP RGS Sender automatically selects the highest performing capture method based on the operating system and available hardware. The capture methods are:

GPU
This method is only available on NVIDIA® graphics devices running Windows 7 or later. It utilizes the GPU to compute the differences from one captured frame to the next, and the GPU presents the resulting differences back to the RGS Sender.

Changelist
The Changelist is supported on Windows® 7 (with Aero disabled) and Linux® (RHEL 6/SLED 11). This capture method receives information from a mirror driver (Windows) or the X server (Linux) to determine what parts of the screen have changed.

Software Comparitron
The Software Comparitron uses an optimized SSE2 comparison engine to compute frame-to-frame differences. In this method, RGS captures and maintains 2 frames of data. The system CPU computes the differences between these two frames and then RGS uses this information to refresh the remote display.

Windows 7 and later systems with desktop composition enabled (Windows 7 with Aero and all Windows 8 and later) perform best with the GPU display model, which bypasses the re-composition Windows normally applies to screen captures. Support for the GPU display model can be verified in the Diagnostics tab of the senderConfigApp. In addition to NVIDIA graphics, the GPU display model relies on configuration information that can be removed by graphics driver installation or a "clean" update. For this reason it is best to install the graphics driver before installing the RGS sender. Displays in Portrait mode are not currently supported by the GPU display model.

HP3 codec Increase text rendering quality control

The RGS receiver has a checkbox on the Settings Performance tab labeled Increase text rendering quality. When enabled, the HP3 codec analyzes the captured image and will use a different encoding for data with few colors in a block as well as automatically increase the quality above the base quality setting for areas of high local contrast.

These steps visibly increase the image quality with minimal impact on the compression ratio. The analysis does consume more CPU resources and tends to make the image quality control less linear when the quality factor is lowered from the default setting of 65. Work streams that are video centric or bandwidth constrained may benefit from disabling this control.

AVC codec and performance

Like the default HP3 codec, the optional Advanced Video Compression (AVC) codec also relies heavily on the available system resources. HP has recommended minimum hardware configurations when using AVC, Refer to the HP Remote Graphics Software Version 7 User Guide for more information on these recommendations. A link to the User Guide is available at the end of this document.

Performance aspects of applications and image types

The type of application(s) running on the Sender, and therefore the remote image types you are sharing is second only to network quality in affecting HP RGS Performance—the greater the amount of change in the image data, the greater the demand for network bandwidth to maintain acceptable performance.

Mostly static screens consisting of spreadsheets and numbers change very few pixels, even in quad display setups. By comparison, full screen videos or 3D model animations can send a constant, heavy stream of pixel changes through the network. While HP RGS is designed specifically for high-resolution images, animation and video streaming, the combination of a high rate of change in the image, together with poor network performance (described in the next section), can limit the performance seen by the end user.

In addition, RGS settings such as the type of video compression and the RGS Image Quality—or "Q" level— can also have a significant impact based on different data types. Refer to the section titled "HP RGS performance features" for more information on these settings.

Display resolution impact on bandwidth

This section describes how display resolution and configuration, as well as several related factors, impact the remote workstation performance.

Most importantly, the number of screens and resolution of the screens configured in an RGS connection directly affects the total amount of display data that RGS must manage and update as the display changes. As resolution increases, the total volume of pixels grows, increasing the bandwidth required to maintain a high frame rate. Likewise, adding displays also directly increases the bandwidth requirements.

The percentage of the total pixels on the screen(s) that change with each display refresh also has a significant impact on bandwidth consumption. The HP codec and Quality setting (Q value) described later in this paper can reduce bandwidth consumption by increasing image compression before RGS transmits the image across the network.

The example in Table 1 (below) illustrates how various display resolutions impact network bandwidth requirements with the default HP3 or optional AVC compression technologies and various frame rates. The values shown in Table 1 are general estimates—the results may vary in your environment and with your content.

Table 1. Example calculations of **heavy use case** with the impact of display resolution, frame rate, compression method and quality slider on bandwidth consumption. Assumes an average of **25% of the screen is in constant change**.

Display resolution: 1920 x 1200 (WUXGA)	Desired frames per second (fps)			
	15 fps	24 fps	30 fps	60 fps
Encode path and quality setting	**Estimated bandwidth (Mbits/sec)**			
HP3 – Quality: 65	10 Mbps	16 Mbps	21 Mbps	42 Mbps
AVC – Quality: 65	3 Mbps	5 Mbps	7 Mbps*	13 Mbps*
AVC – Quality: 10	1 Mbps	2 Mbps	2 Mbps*	4 Mbps*

Table 1 Notes:

• When screen motion stops, bandwidth usage drops to near 0

• **HP3** required network bandwidth = (total pixels on screen) x (24 bits) x (average image change %) x (compression rate) x (frames per second)

• ***AVC** required network bandwidth = (total pixels on screen) x (24 bits) x (compression rate) x (frames per second). Note that **AVC is capped at 24 fps**

• Estimated compression ratio: HP3 Q=65: ~20:1, AVC Q=65: ~250:1, AVC Q=10: ~850:1

Actual compression ratios will vary depending on your content, HP RGS settings, and system configuration. Changing the quality slider from the default 65 impacts needed bandwidth. Unchecking the text quality button in HP3 mode will increase compression/decrease needed bandwidth.

Although AVC technology provides higher image compression compared to HP3, there are other tradeoffs. HP recommends using the default HP3 compression where acceptable. Refer to the section titled: "AVC (Advanced Video Compression)" for more information. AVC does not currently support 4k displays.

Network quality

Network quality is comprised of several key elements – latency, bandwidth, and "packet loss" (the frequency of data transmission errors). These three elements work together to control the actual network performance as seen by an HP RGS user. Let's begin by taking a closer look at these elements.

Latency

Latency, or network delay, is measured in milliseconds (ms) and is the amount of time it takes a packet of data to travel from the Receiver system to the Sender and return to the Receiver.

As measured by a "ping" test, latency is a function of geographical distance, Network Address Translation (NAT) filtering and hops. Since a data packet can only travel as fast as the speed of light, the further the packet must travel, the greater the delay. Hops, or the number of devices the data must pass through between the sender and receiver, can be especially significant in data transmission across large ocean or continental distances.

Network latency times are characterized for RGS as described in Table 2:

Table 2. Relative impact of network latency on RGS remote workstation performance

Network delay	Example geographies	Responsiveness/user experience	Subjective impact	Behaviors
<20 ms	Europe, Japan	Excellent	No visible difference from local system	Like local workstation
20 ms to 60 ms	North America	Good	End user not likely to notice affects	May be slight lag in window drags. Video may become "jumpy"
60 ms to 100 ms	Trans- Atlantic	Good	End user is aware that the system is remote	Streaming audio can lose sync. "Alert" audio messages OK. Window drags lag cursor.
100 ms to 200 ms	Trans-Pacific	Acceptable	May be objectionable for some use cases	HP recommends pilot testing for specific applications
>200 ms		May be unacceptable, depending on application	May be unacceptable, depending on application	HP recommends pilot testing for specific applications

As of 2014, typical network delay measurements published for public enterprise networks ranged from less than 20 ms for smaller geographies like Japan and Europe, to less than 40 ms for North America, 70-80 ms across the Atlantic Ocean, and 100-115 ms across the Pacific Ocean. Private corporate networks typically meet or exceed these numbers for similar geographies. Networks involving public infrastructure and routing may vary slightly.

You can test the network delay in your environment by using the simple "ping" function (inside a command prompt window) between the two endpoints of interest.

Note: As compared to standard network performance as characterized above, the **HP Velocity** feature of HP RGS 7 can significantly boost performance and frame rate by improving overall data throughput, especially on high-latency networks with packet loss. Refer to the following section on HP Velocity for more information.

Bandwidth

Bandwidth is the data-carrying capacity of the network connection; it is typically measured in bits-per-second, with the most common measurements for modern high-performance networks stated in Mbps (Millions of bits-per-second or "Mega- bits"). From the perspective of HP RGS, there are two aspects of bandwidth that affect performance:

• The actual maximum bandwidth achieved on a given network (which may be less than the theoretical maximum).

• The percentage of the maximum bandwidth that may be allocated to any single connection on the network.

In many cases, corporate IT departments control bandwidth availability, and it may be necessary to allocate additional bandwidth on connections regularly used for intensive HP RGS sessions.

The RGS quality slider, unchecking boost text quality and Advanced Video Compression settings can be used to reduce the bandwidth required for HP RGS sessions.

Packet loss

"Packet loss" occurs when data on the network (organized in "packets") fails to reach its destination. For enterprise networks, packet loss is most commonly due to network congestion, which causes the packets to "time-out" (expire) before they reach their intended destination. In this case, to ensure the integrity of the data transmission, the packet must be continuously retransmitted until it reaches its destination.

While packet loss rates for enterprise networks as of 2014 are very low, and rarely exceed 0.5% (99.5% or more of the packets go through without retransmission), the sheer volume of data on the network can still present problems especially for long-distance connections where latency is already a factor. Frequent packet loss can result in slow overall data transfer, effectively appearing as reduced network bandwidth.

The HP Velocity feature of HP RGS can greatly reduce the negative impacts of packet loss. Refer to the following section on HP Velocity for more information.

Configuring your network for optimum performance

There are several methods to test and measure the network bandwidth, latency, and the number of hops between the remote and local systems:

• Use the ping command to measure network latency.

• Use the Traceroute (Linux) or tracert (Windows) command, which reports the number of hops it takes to reach a computer in addition to the network latency.

• Use the Test TCP (TTCP) tool, a command-line sockets-based benchmarking tool for measuring TCP and UDP performance between two systems. The TTCP tool is available at pcausa.com/Utilities/pcattcp.htm

Once you've characterized your network performance, you can decide if improvement is required.

If you are not satisfied with your network performance, look at the log files on your network switch (if the local computer is connected to one). A significant number of errors on the switch port may indicate that the computer or network is not configured correctly. Work with your IT organization to optimize your computer and network configuration.

For more details on configuring a network connection for optimum performance, refer to the HP RGS 7 User Guide.

HP RGS performance features

HP RGS includes several performance-related features that allow you to fine-tune the interactive experience. These features are especially important when working with highly interactive applications in a low-bandwidth or high-latency network environment. This section introduces some of the most important of these features, and provides test results to illustrate their impact on performance. In addition, Table 4 at the end of the section summarizes many of the HP RGS performance settings. Refer to the HP RGS 7 User Guide for complete information and implementation details.

Image quality

The Image Quality setting ("Q value") controls how aggressively HP RGS compresses the image data, and therefore controls the amount of image data transmitted over the network during an RGS session. The available settings range from 0 – 100, with a default value of 65. An Adaptive Image quality setting is also available, which when enabled, automatically varies the Q value (up to the maximum you set), with a goal of achieving target frame rate.

As shown in the Figure 2, lowering the Q value typically results in lower bandwidth consumption. HP advises that you experiment with different settings for the Q value. Choose the one that balances the best image quality with good interactivity. Note that the data shown in Figure 2 is a worst-case scenario. A typical use case consumes significantly less bandwidth.

Increase text rendering quality is a setting that will keep text sharp and clear regardless of the image quality slider setting. Figure 2 below shows the impact to bandwidth of enabling this setting.

Figure 2. Effect of Quality Slider value, Increase Text Quality setting and compression methods (HP3 vs. AVC) on bandwidth utilization in worst-case scenario.

Max Bandwidth at different quality slider settings
(Worst-case scenario)
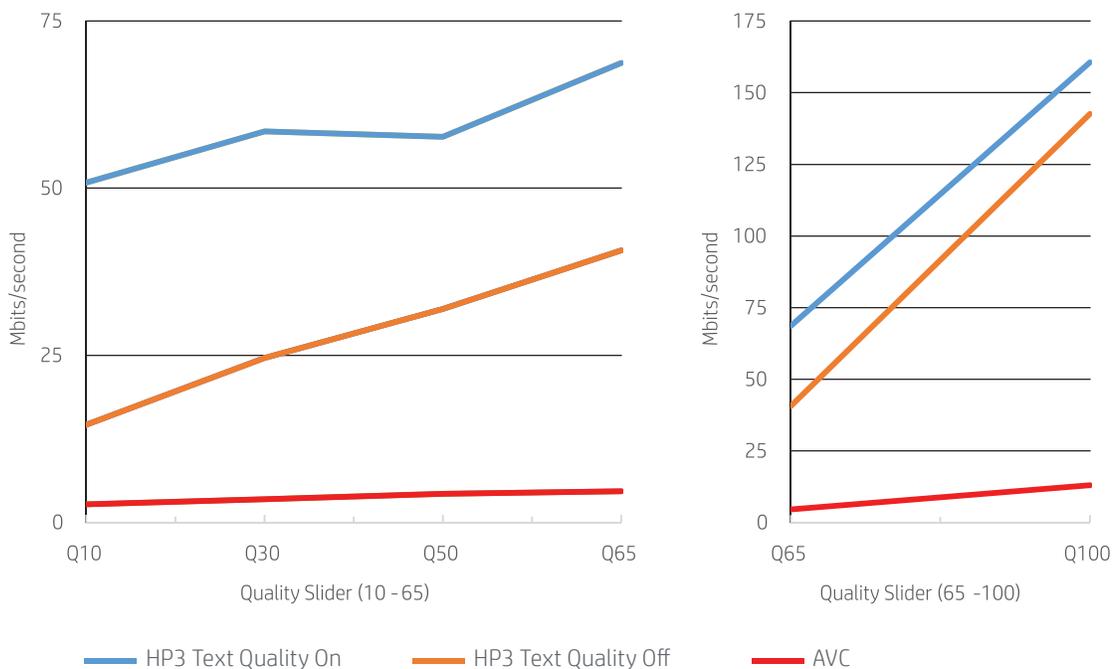
Advanced Video Compression (AVC)

This option enables a modern video codec to greatly reduce the network bandwidth needed for high-quality video streams. It is ideal for video or 3D applications in textured mode. A unique characteristic of AVC mode is performance with very low quality settings. When bandwidth is very constrained, enable AVC and reduce quality to 10 or lower. You will notice that 3D models in motion will appear pixilated and highly compressed, but when you stop moving them they snap back to a full resolution clear image. An additional aspect of AVC is that you can choose to have the compression done by either a graphics card (GPU mode) or the CPU (CPU mode) on the RGS Sender config UI. Note that only NVIDIA® Quadro® graphics cards are enabled for GPU-mode compression.

AVC requires a onetime activation via internet access at the client device. Activation takes place the first time the feature is selected and an RGS connection is made.

Important: CPU consumption might be higher on both the RGS Sender and Receiver when using Advanced Video Compression. The default RGS compression (HP3) is recommended unless reduced network bandwidth consumption is required. Refer to the HP RGS User Guide for complete details on using Advanced Video Compression.

Figure 3 shows a comparison of bandwidth consumption between the HP3 (default) and AVC (optional) compression techniques, illustrating how AVC can improve frame rate when the network bandwidth is constrained. Note that the data shown in Figure 3 is a worst-case scenario. A typical use case consumes significantly less bandwidth.

Figure 3. Comparison of frame rates achieved with HP3 and AVC compression in constrained networks with worst-case scenario.

HP RGS frame rate (fps) in a constrained network

HP3 (text quality disabled) and AVC* compression, Q = 65 and 10

(Worst-case scenario)
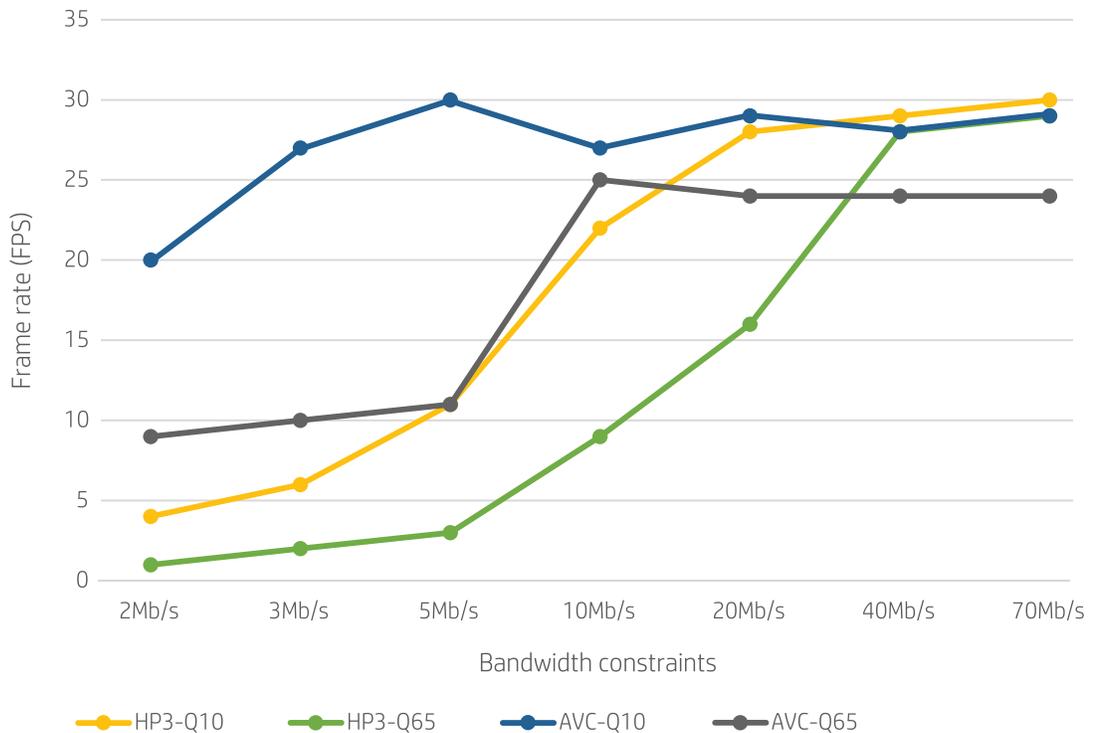
*HP3 and AVC frame rate capped at 30 frames per second for this comparison. AVC is capped to 24 frames per second in production version of HP RGS. HP3 is capped at 30 frames per second by default. HP3 frame rate can be changed in the sender config UI.

HP Velocity

HP Velocity is a Quality of Service (QoS) feature of HP RGS that improves the user experience by addressing common network bottlenecks, such as packet loss, network latency, and Wi-Fi congestion. HP Velocity automatically ensures the best end-user QoS by optimizing the underlying network conditions over wired, wireless, managed, and unmanaged networks.

Starting with HP RGS 6, HP Velocity is delivered as an install-time option (default is to install HP Velocity) together with HP RGS. There is no additional cost for installing and using HP Velocity. It requires a onetime activation via internet access at the client device. Activation takes place when the first RGS connection is made.

HP RGS with HP Velocity can improve performance on all but the best-performing networks (networks with very low latency and packet loss rates). Figure 4 shows an example comparing performance with and without HP Velocity.
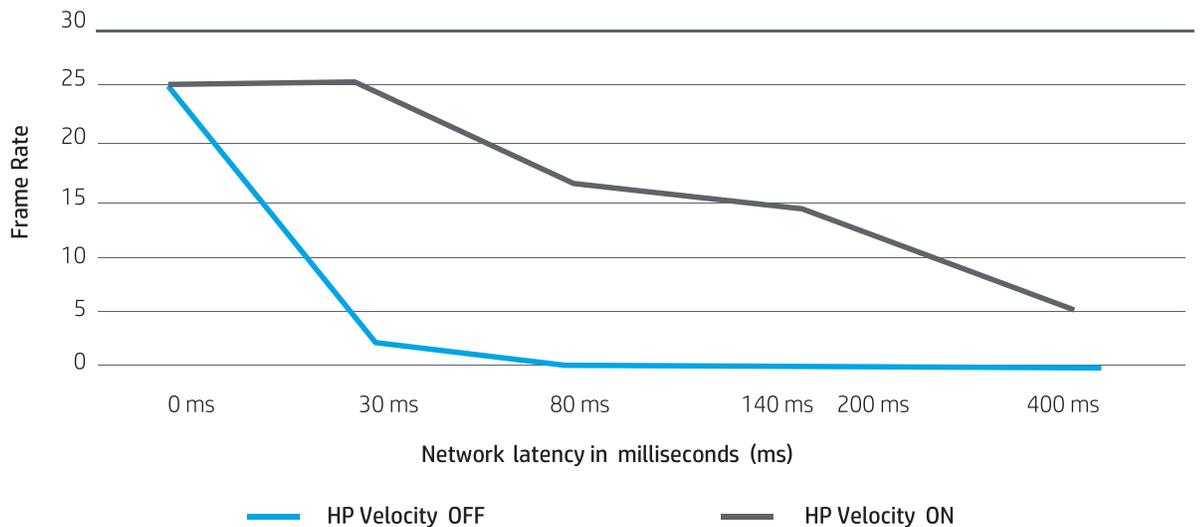
Note: The data shown in Figure 4 is a **worst-case scenario**. This example also includes 0.5% packet loss above 0ms latency introduced via a network simulator.

Figure 4. Comparison of frame rates with and without HP Velocity under various network conditions

Effect of HP Velocity on frame rates (fps)

RGS 7.0, Q=65, HP3 comp. 0.5% packet loss above 0 ms latency

(Worst-case scenario)

HP RGS version

Increasing performance is a constant focus for the HP RGS team so be sure you are always using the latest version of HP RGS when top performance is a goal. For example, see Figure 5 for a performance comparison of RGS 7.1 to RGS 7.0

Figure 5. Comparison of frame rates with RGS 7.1 vs 7.0 with various applications and resolutions

RGS 7.1 vs RGS 7.0
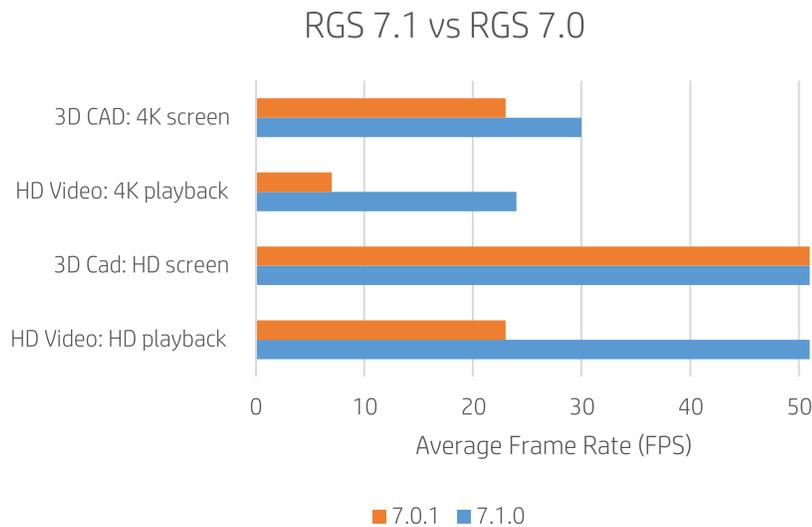
HP RGS performance features and settings summary

Table 4 summarizes the various settings and features that affect HP RGS performance.

Table 4. Settings and features affecting HP RGS performance (available on the RGS Control Panel unless otherwise noted).

Setting/feature	Description
Increase text rendering quality	This setting keeps text and lines crisp at all RGS quality settings, but can increase bandwidth and reduce frame rate. Un-check this to increase frame rate or reduce bandwidth usage.
Advanced Video Compression on Sender	Enables Advanced Video Compression. Use when limited available network bandwidth is negatively impacting performance
Image quality slider	Sets the maximum image quality.
	HP RGS maintains the image quality specified by this option. When Adaptive image quality is selected, RGS uses this option's setting as the Max image quality when the updates-per-second value allows.
Adaptive image quality Minimum image quality Target update rate	When Adaptive image quality is enabled, RGS gradually degrades the image quality down to the Minimum image quality setting (from 0–100) anytime the updates-per-second value falls below the Target update rate (from 0–30 updates per second).
	Note: These options are disabled when Advanced Video Compression is enabled.
HP Velocity	Improves the HP RGS user experience by addressing common network bottle-necks, such as packet loss, network latency and WiFi congestion.
	HP Velocity is included with HP RGS and requires a one-time activation via the internet at the client device. Activation takes place when first RGS connection is made.
Max Image Update Rate (RGS configuration file setting)	Sets the maximum number of image updates per second. The default is 30. Set-ting the value to 0 removes any specific limit on the frame rate, and may allow performance greater than 30 fps as system and network conditions permit.

Achieving the optimum performance in your environment

In summary, achieving the best overall HP RGS performance is a combination of several factors:

- Update your systems to the latest version of HP RGS (RGS 7.1, at the time of publication) to ensure you have the latest performance enhancements, features, and fixes.

- Uncheck "increase text rendering quality" to achieve maximum frame rate.

- HP3 is capped at 30 fps and AVC is capped at 24 fps. These limits can be changed in the config files.

- Ensure your Sender and Receiver hardware is adequate for the job, especially when using AVC.

- A good quality network, including acceptable latency, bandwidth, and packet loss is crucial to good performance. Calculate what you need, measure and monitor the performance of your network, and ensure bandwidth is adequate (maximum bandwidth as well as bandwidth per user).

- Don't use a "High Q" (above 65) if your image quality is acceptable at a lower Q value.

- Don't use more displays or a higher display resolution than you require for the data you are sharing.

- Consider using AVC compression if limited available network bandwidth prevents adequate performance with standard HP3 compression.

Appendix A—Benchmark information

We used the following test conditions in collecting the data for this whitepaper.

Systems:
- Sender: HP Z640 Workstation configured with a single display @1920 x 1200
- Receiver: HP Z640 Workstation configured with a single display @1920 x 1200
- Windows® 7 Professional 64-bit operating system used on Sender and Receiver

Application benchmarks:
- Worst-case scenario: Visually rich 60 fps 1080 p video clip with full screen play back
- 3D CAD: Seemage transmission

Network and performance:
- Network connect is 500 Mbps through a network simulator
- Latency (network delay) is based on the settings in the network simulator and noted in the figures as appropriate
- Bandwidth utilization is an average of 30 seconds of data as measured by HP Performance Advisor utility
- Frame Rate is the average of 30 readings taken at approximately the same point in time during each test
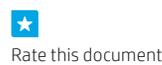
Appendix B—Abbreviations and naming conventions

Table 1. Abbreviations and terminology used in this document

Convention	Definition
CPU	Central Processing Unit
GPU	Graphical Processing Unit (Graphics Card). Note that some graphics cards have more than one GPU processor
OS	Operating System
QoS	Quality of Service
Q value	HP RGS Image Quality setting
Receiver	RGS remote client system
Sender	RGS host system
SW	Software

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