

This document provides general guidelines for typical office users that are connecting PCoIP Zero Clients to VMware View 4 virtual desktops over remote access WAN networks. The PCoIP protocol enables the broadest range of network support to handle any enterprise user demands. Network requirements can vary greatly depending on the network parameters, application graphical requirements and user demands. As such, this document is not intended to replace more detailed documentation provided by VMware and Teradici.

There are a number of tuning options for optimizing performance on a WAN including;

- Adjust the Windows Experience (section 2)
- Ensure sufficient minimum bandwidth for PCoIP packets (section 3.2.1)
- Minimize packet buffering for PCoIP packets through the network (sections 3.2.2)
- Ensure an appropriate queuing/priority configuration in the switch/router (Section 3.2.2)
- Adjust the VMware View settings per user
 - Image quality (section 4.1)
 - Maximum display frame rate (section 4.1)
 - Maximum bandwidth (section 4.2)
- Follow key WAN testing guidelines (section 5)

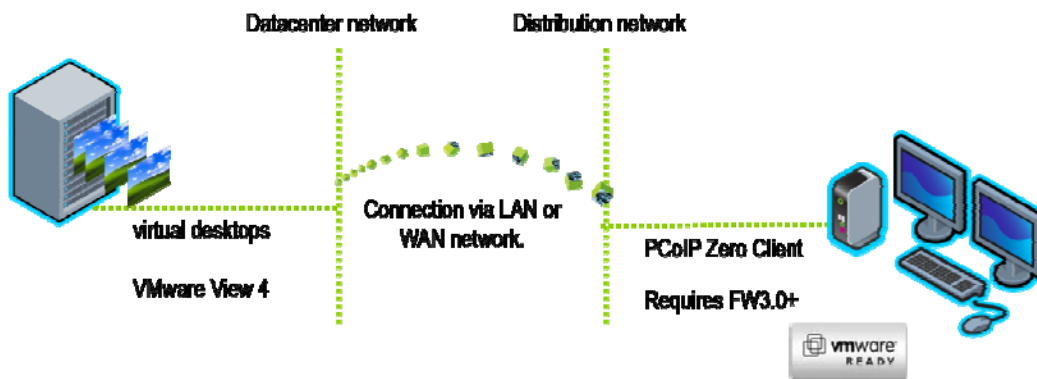
Detailed information on configuring VMware View or PCoIP Zero Clients can be found in the following documents:

- Using PCoIP Zero Clients with VMware View 4 (TERA0904005) – available from your Teradici Sales Director.
- Getting Started with VMware View (EN-000276-00) see http://www.vmware.com/pdf/view40_quickstart.pdf
- VMware View PCoIP Network Sizing Guide see <http://www.vmware.com/files/pdf/VMware-View-PCoIP-Network-Sizing-Guide-IG-EN.pdf>
- For additional VMware View documents see <http://www.vmware.com/support/pubs>

1 System Requirements

Prerequisites for connecting a PCoIP Zero Client to VMware View 4 include:

- A functional VMware View environment using the latest VMware View 4.x release and VMware View Manager.
- Virtual desktops with Microsoft Windows XP or Vista installed.
 - Windows 7 support is expected in an upcoming release of VMware View, please contact VMware.
- A PCoIP Zero Client with the latest 3.x firmware installed. For a list of VMware Ready PCoIP Zero Clients see <http://www.teradici.com/pcoip/pcoip-products/vmware-view-clients.php>
- A functional remote access network environment between the datacenter office and remote sites.



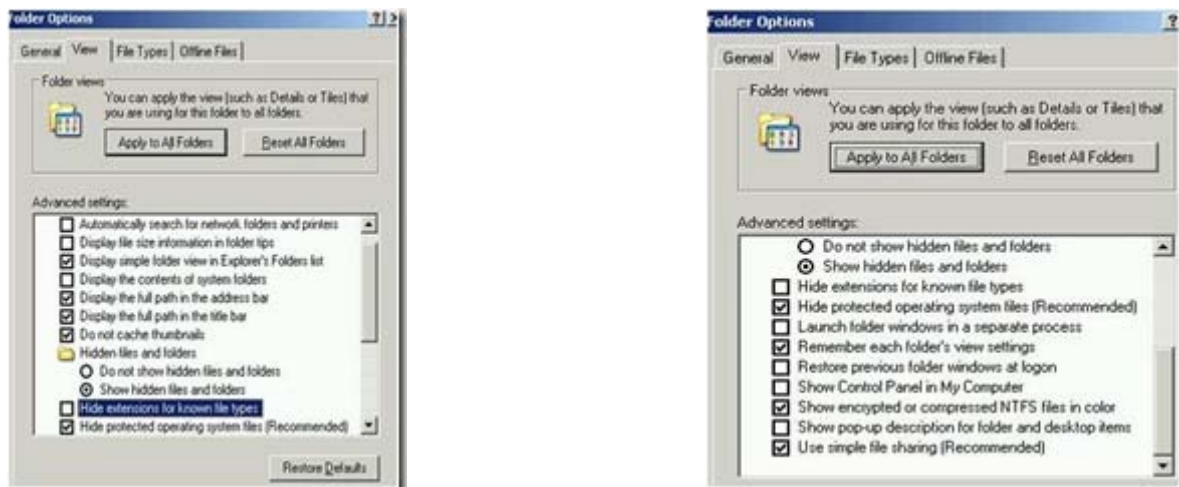
2 Optimizing Windows XP Virtual Machines for Low Bandwidth Access

There are a number of visual settings in Windows XP that require additional bandwidth to deliver. An initial set in optimizing for WAN networks is to consider turning these features off to significantly reduce in the average and peak network bandwidth required.

2.1 Visual Settings Optimization:

- Set Visual affects to best performance
 - Right click on 'My Computer' and select 'Properties' >> Click the 'Advanced' tab >> Click the 'Settings' button >> Select the 'Adjust for best performance' option
- Remove Desktop wall paper
 - Start >> run >> gpedit.msc >> Computer Configuration >> Administrative Templates >> Windows Components >> Terminal Services >> Enforce Removal of Remote Desktop Wallpaper >> Enabled
- Enable Blank Screensaver
 - Start >> run >> gpedit.msc >> User Configuration >> Administrative Templates >> Control Panel >> Display >> Screen Saver >> Enabled
 - Start >> run >> gpedit.msc >> User Configuration >> Administrative Templates >> Control Panel >> Display >> Screen Saver executable name >> scrnsave.scr
- Enable Classic Start Menu
 - Right-click on the taskbar and go to properties. Go to the Start Menu tab and choose Classic Start Menu, click apply, click Customize >> Scroll to the bottom of the Advanced Start menu options and check the box for "Show Small Icons in Start menu" and uncheck the "Use Personalized Menus" box. Click OK, and click OK.
- Disable additional fading
 - Right-click on the desktop and go to properties >> Go to the Appearance tab and click effects, uncheck all of the boxes and click OK. Click Apply
- System Icon and text changes
 - Open the Control Panel, go to the View menu, choose toolbars >> customize >> set the Text options to No text labels and set Icon options to Small icons. Go to Tools >> Folder Options >>View tab and check/uncheck the boxes below>>click apply

Figure 1 System Icon and Text Changes



3 Network Planning Considerations

The PCoIP protocol provides a real-time delivery of a rich user desktop experience using UDP. To ensure a responsive desktop, PCoIP protocol must be deployed across a properly architected network infrastructure that meets bandwidth, latency, jitter and packet loss requirements. Since every customer/end user perception is different the following factors must be taken into consideration for network planning such as:

- Graphically intensity of the typical user (e.g. forms pages or 3D viewer).
- Importance of image quality to user (e.g. administration or artist).
- Amount of interactivity vs. static viewing.
- Increased bandwidth may be required to satisfy more demanding users.

3.1 Network Bandwidth Planning – Basic Office Productivity Desktops

Determine minimum bandwidth required for simultaneous access for typical office productivity users.

- Key considerations include:
 - Plan for 200-250kbps average bandwidth for a basic office productivity desktop: typical office, applications with no video, no 3D graphics, and the default Windows and VMware View settings. Significantly lower average bandwidths can be achieved by optimizing Windows (Section 2) and VMware View (Section 4) for low bandwidths.
 - Plan for 500kbps - 1 Mbps minimum peak bandwidth to provide headroom for bursts of display changes. In general, networks should be sized using the average bandwidth, but with consideration for peak bandwidth to accommodate bursts of imaging traffic associated with large screen changes.
 - Plan for 1Mbps per simultaneous user running 480p video.
 - Plan for less than 70-80% network utilization.
 - *Note: 250kbps per user is based on the assumption that all users are operating continuously and performing similar tasks over a 8-10hr day. Situations may vary in that some users may be fairly inactive and consuming almost no bandwidth allowing more users per link - as such these guidelines are intended to provide a starting point for more detailed bandwidth planning and testing.*
 - *Note: Average bandwidths in the 100kbps range are common since users are typically not continuously active throughout the day.*

3.1.1 1.5Mbps T1 Example for a basic Microsoft Office desktop

- Basic office productivity applications, no video, no 3D graphics, and keyboard/mouse USB traffic.
- Bandwidth required – $(250\text{Kbps}/0.80) * 5 = 1.5\text{Mbps}$.
- **Result: Up to 3-5 concurrent users per T1 line.**
- *Note: may require VMware View and Windows optimization to achieve this user density.*

3.1.2 10Mbps Example for a Microsoft Office desktop with occasional multimedia

- Basic office productivity applications, up to a single user watching occasional 480p video, no 3D graphics and keyboard/mouse USB traffic.
- Bandwidth required – $(250\text{Kbps}/0.80) * 28 = 8.7\text{Mbps}$.
- Bandwidth required – $(1\text{Mbps}/0.80) * 1 = 1.3\text{Mbps}$ (for a single user watching video at any given time)
- **Result: Up to 28 concurrent users per 10Mbps line.**
- *Note: may require VMware View and Windows optimization to achieve this user density.*

3.2 Network Configuration Considerations

In order to ensure a successful VMware View deployment, perform a network assessment to determine proper configuration to support the necessary bandwidth while meeting latency, jitter and packet loss requirements.

3.2.1 Network bandwidth:

- Be sure a full-duplex end-to-end network link is used.

- Note: older switches may incorrectly default to half duplex when connected to a link with auto-negotiation, in this case, the switch link must be explicitly set to full duplex.
- Confirm network connectivity and that sufficient bandwidth is available between the VMware View server, VMware View manager and the PCoIP Zero Client.
- Consider segmenting PCoIP traffic via IP QoS DSCP or a layer 2 CoS or virtual LAN (VLAN).
- If a VPN is used, confirm that UDP traffic is supported.
 - Do not route PCoIP traffic through TCP-based SSL tunnels. Use IPSEC or DTLS-enabled SSL solutions.

3.2.2 Network Latency and Jitter:

- Be sure that the round trip network latency is less than 250ms for VMware View 4.x.
- Perform a thorough assessment of active application traffic across the end-to-end network to ensure that there is sufficient minimum bandwidth available for PCoIP traffic even with network congestion.
- Network congestion and traffic shaping with deep packet buffers can cause high packet latency, which can be considered as lost packets to PCoIP protocol.
- Be sure that the buffers in all routers/switches are set to minimize latency (e.g. to absorb 50ms to 100ms of PCoIP packet traffic).
 - If a service provider is not able to reduce the buffer depths in all routers in the network path, consider applying traffic shaping policies in the Customer Edge (CE) router, or Service provider Edge (PE) router.
- Allow PCoIP traffic to burst when network bandwidth is available (e.g. do not set a hard limit on PCoIP traffic as a % of the link rate).
- Ensure sufficient priority for PCoIP traffic while considering the real-time nature of the protocol. Consider options such as Class-based Weighted Fair Queuing. (CBWFQ)
 - Assign a priority to PCoIP traffic that is above standard TCP traffic, but below Voice-over-IP (VOIP) protocol.
 - Ensure guaranteed network bandwidth for PCoIP traffic during congestion. In general, set PCoIP traffic to have 80% of the remaining bandwidth after the higher priority traffic is allocated. E.g. consider a network that guarantees 20% of a link bandwidth for critical traffic such as VoIP, PCoIP should be set to receive 80% of the remaining bandwidth, or 64%. This allows other protocols such as file transfers or web traffic to always be able to transfer some traffic, without starving the PCoIP sessions.
 - If traffic shapers are being used, use them in conjunction with a scheduling queue, and assign high priority to this queue based on the CoS value set for PCoIP traffic. This is CBWFQ
- To reduce packet latency further, configure priority-queuing for low-latency traffic also called low-latency queuing. It can be configured in conjunction with class of service to match and mark the high-priority traffic and then send it to a low-latency queue, On Cisco devices, Network managers can trial different queue-limits to make sure that there are no tail-drops on PCoIP packets. This will give high priority to low-latency traffic. This is a version of policy-based routing available on most routers.
- Configure congestion avoidance policies to use weighted random early detection (WRED) for PCoIP traffic.
- Ensure that the ESX virtual switch traffic shaper is turned off.
- *Note: periodic excessive latency is an indication that traffic shaping with deep packet buffers is impacting PCoIP packet delivery during periods of congestion.*

3.2.3 Network Packet Loss:

- PCoIP protocol is tolerant to a reasonable amount of packet loss. Since PCoIP traffic is a real-time delivery of a rich user desktop experience packet loss should be minimized where possible.
- There are multiple potential sources of packet loss in a VMware View environment including:
 - Network congestion triggering congestion avoidance algorithms. While this is expected behavior when congestion avoidance policies are configured, excessive packet loss due to congestion is an

indication that additional optimization is required to increase bandwidth available or to reduce PCoIP traffic.

- PCoIP packets that arrive with a high latency due to network congestion may be considered as lost packets by VMware View.
- PCoIP packets that arrive sufficiently out of order may be considered as lost packets by VMware View. Be sure to minimize packet re-ordering in the network.
- *Note: if network logs show no packet loss, but VMware View and/or PCoIP Zero Client logs show packet loss – this is an indication of packet with high latency, or sufficiently out-of-order packets being considered as lost.*

Table 1 Resolution Options When Experiencing Significant Packet Loss for a VMware View Session

Description	Resolution Options to Consider						
	Optimize the Windows Experience Settings (section)	Optimize VMware View settings for bandwidth limits, image quality and frame rate	Minimize the packet buffer depth in all switches/routers	Increase priority of PCoIP traffic	Increase the amount of bandwidth assigned to PCoIP traffic	Increase the link bandwidth	Minimize packet re-ordering in the network
Significant packet loss due to congestion (e.g. WRED being triggered)	↙	↙		↙	↙	↙	
Packets considered lost by VMware View due to high latency packet delivery	↙	↙	↙	↙	↙	↙	
Packets considered lost by VMware View due to sufficiently out-of-order packets	↙	↙					↙

4 VMware View Manager Settings for the Desktop

4.1 Display / Imaging

- Optional optimization: Adjust the image quality settings.
 - **Warning:** Teradici has carefully selected the default values and recommends that you do not change these settings unless you have carefully determined the overall effect to be beneficial.
 - **PCoIPImagingMinimumImageQuality** GPO – set to a value between 30-100 (default is 50). In a limited bandwidth scenario this setting allows configuring the preference between:
 - A higher frame rate (lower value) for smooth motion, with lower image quality.
 - A higher image quality (higher value) for crisp imaging, with less smooth image motion.
 - **PCoIPImagingMaximumInitialImageQuality** GPO –set to a value between 30-100 (default is 90). In a limited bandwidth scenario, this setting allows configuring the preference between:
 - A higher initial image quality, with larger peaks in bandwidth during large screen changes.
 - A lower initial image quality, with smaller peaks in bandwidth during large screen changes.
 - Note: if used, consider adjusting the maximum imaging quality before applying a bandwidth limit or adjusting the minimum image quality.
 - Note: the “Minimum Image Quality” must be set to a value below the “Maximum Initial Quality”.
 - **PCoIP.maximum_frame_rate** – default is 30 frames per second (fps). In a limited bandwidth scenario, this setting allows configuring the preference between:
 - A higher frame rate for smooth display imaging motion, with possible increased average network bandwidth.
 - A lower frame rate for a lower average network bandwidth, with less smooth image motion
 - If used, create a registry key:
HKEY_LOCAL_MACHINE\SOFTWARE\Policies\Teradici\PCoIP\pcoip_admin_defaults\pcoip.maximum_frame_rate setting in Hz (e.g. 8, 12 or 15 fps).

4.1.1 Example: Network Congestion Causes Occasional Degraded User Experience

- **Scenario:**
 - Basic office productivity applications, no video, no 3D graphics.
 - T1 line with 4 active users.
 - An analysis of the link shows periodic spikes in bandwidth that consume all of the link bandwidth available, or the bandwidth assigned to PCoIP traffic. Further analysis shows that the network traffic during these spikes are roughly distributed across all active users.
 - Users notice a momentary degradation in their desktop experience.
- **Resolution:**
 - Set the Windows XP Visual settings for best performance as described in Section 2.
 - Reduce the maximum initial image quality PCoIPImagingMaximumInitialImageQuality = 70 .
- **Result:**
 - Users maintain an acceptable desktop experience even during spikes in bandwidth.

4.2 Network

- Optional optimization: Set the ceiling on the bandwidth an individual user can consume (in Kbps)
 - **Warning:** PCoIP protocol is architected to take advantage of available network bandwidth and fairly share bandwidth across active users on a link. As such, Teradici recommends that you do not change this setting unless you have carefully determined the overall effect to be beneficial.
 - Be careful not to set a maximum bandwidth limit too low such that individual sessions cannot take advantage of additional link bandwidth when available. In this case, consider increasing link bandwidth at network congestion point(s).
 - **PCoIPMaxLinkRate** GPO – set to the desired maximum PCoIP session bandwidth in kilobits per second (e.g. 1000 = 1000Kbps = 1Mbps). Default is 1Gbps, 0 = no bandwidth constraints.
 - Note: if used, this setting must be configured for all users that share a particular network link.

4.2.1 Example: Network Congestion from a Small Number of Users Cause Degraded User Experience

- **Scenario:**
 - Basic office productivity applications, no video, no 3D graphics.
 - 6 Mbps link with 20 active users.
 - An analysis of the link shows periodic spikes in bandwidth that consume all of the link bandwidth available or the bandwidth assigned to PCoIP traffic. Further analysis shows that one or two users are consuming 3-4Mbps during the degradation (possible the users are watching video even though that was not planned for).
 - The remaining users notice degradation in their desktop experience.
- **Resolution Options:**
 - Set the Windows XP Visual settings for best performance as described in Section 2.
 - Set the maximum PCoIP bandwidth per user using the PCOIPMaxLinkRate. Since only one or two users spike at a given time, the bandwidth is set at 1000kbps. This must be set for all users on the link.
 - If after making this setting the users still notice a momentary degradation in their desktop experience, consider adjusting the image quality settings – reduce the maximum initial image quality PCoIPImagingMaximumInitialImageQuality = 70 increasing the minimum image quality PCoIPImagingMinimumImageQuality = 60.
- **Result:**
 - Users maintain an acceptable desktop experience even when a few users spike in bandwidth.

4.2.2 Example: Optimizing for increased user density on WAN network links

- **Scenario:**
 - Basic task worker/call center applications, no video, no 3D graphics. Low average bandwidth is a higher priority than user experience.
 - 1.5 Mbps link with >5 active users.
- **Resolution Options:**
 - Set the Windows XP Visual settings for best performance as described in Section 2.
 - Set the maximum PCoIP bandwidth per user using the PCOIPMaxLinkRate. The actual setting will depend on the number of users targeted for the link. This must be set for all users on the link.
 - Reduce the maximum initial image quality PCoIPImagingMaximumInitialImageQuality = 70, and the minimum image quality PCoIPImagingMinimumImageQuality = 40.
 - Reduce the PCoIP.maximum_frame_rate = 8 fps.
 - If the average bandwidth is not sufficiently reduced, even lower settings can be used for the bandwidth limit and image quality.
- **Result:**
 - More than 5 users can be active simultaneously on a T1 WAN link.

5 WAN Connected Virtual Desktop Testing Guidelines

- Test real workloads with multiple users actively sharing the link. Key considerations include:
 - Single user bandwidth tests are invalid since PCoIP protocol will take as much bandwidth as possible unless constrained by the network, or by configuration. When constrained, the PCoIP protocol will fairly share bandwidth with other PCoIP protocol users.
 - Do not try to simulate desktop performance by limiting a single session. This is also an invalid test.
 - Do not rely on video playback to be representative of real-application user performance
 - Test real web sites that users will go to, not just sites that support windows media since MMR will improve video in just that case.
- **Note: do not use random packet loss to emulate network loss.** *Random packet loss is not representative of real network loss and will result in PCoIP protocol using the minimum quality and performance.*
 - *Free WAN emulation tools can randomly drop packets to emulate network packet loss. However, in real networks random packet loss is rare and due to poor network link quality which is typically repaired by Service Providers when it occurs. PCoIP protocol adapts to the packet loss to reduce the network load, however the random loss algorithm causes PCoIP protocol to continually lower the display quality and frame rates until the minimum quality floor is hit.*
 - *A common cause of packet loss is network congestion (or the result of congestion avoidance algorithms being triggered) which results in periodic and sequential packets lost. This loss goes away when the congestion is alleviated. More sophisticated WAN emulation tools incorporate more intelligent packet loss algorithms. PCoIP protocol adapts to the packet loss to reduce the network load to help alleviate the network congestion causing the loss.*
- X86 and/or Thin Client considerations:
 - Multi-media redirection can make certain video's look better on an appropriately powerful client, but the same performance improvement will not be realized when using Office applications or scrolling PDF's etc. Turn off MMR to see what the client will look like with new media that is not supported by redirection (e.g. HTML5, Google WebM).
 - Test with the client devices you plan to purchase.

For more detailed information on VMware View 4 to PCoIP Zero Client operation see the on-line knowledge base at <https://support.teradici.com> (access required, contact support@teradici.com or your Teradici Sales Director to obtain access).