PC-over-IP® Protocol Virtual Desktop Network Design Checklist

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PCoIP CONNECTED

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Revision History

Version	Date	Description
1	Jun 02, 2011	Initial release
2	Jun 20, 2011	Added requirement for PortFast, updated bandwidth guideline tables

PCoIP Protocol Virtual Desktop Network Design Checklist

The PCoIP protocol provides a real-time delivery of a rich user desktop experience in virtual desktop and remote workstation environments. To ensure a responsive desktop, the PCoIP protocol must be deployed across a properly architected virtual desktop network infrastructure that meets bandwidth, QoS, latency, jitter, and packet loss requirements.

For more detailed information see techsupport.teradici.com.

PCoIP Protocol Overview

- PCoIP Protocol uses UDP packets similar to other real-time protocols (VOIP, video conferencing)
- PCoIP protocol implements packet reliability and flow control similar to TCP, however this is done in an intelligent manner consistent with real-time requirements (ie USB always resent, imaging may be resent, but stale imaging/audio not resent).
- PCoIP protocol performs traffic shaping on the PCoIP packet traffic and will dynamically adapt image/audio quality depending on the available network resources
- PCoIP protocol will fairly share the available network resources with other PCoIP sessions on the network.
- WAN optimizations already built into the PCoIP protocol

Network Requirements			Notes
	Consider QoS options such as Class-based Weighted Fair Queuing (CBWFQ) or Low Latency Queuing (LLQ) on switch uplinks and on Layer 3 WAN/LAN links.		
		Mark and classify PCoIP traffic the same as real time interactive traffic according to your QoS marking scheme. (i.e. below VoIP RTP but above all other traffic).	This is necessary for the real time responsiveness of the protocol.
		If using DSCP markings, PCoIP traffic should be marked to DSCP AF41 or AF31 to ensure low drop probability inside each queue if WRED must be configured per the queue servicing the PCoIP protocol.	Choice of which DSCP value to use is influenced by the presence of possible video and/or VoIP control packets. Not all switches support the same number of priority queues; work with Service Providers to ensure proper end-to-end priority mapping.
		Avoid using low-latency queueing (LLQ) for PCoIP packets on links that carry VoIP traffic and are have less than 1.544Mbps of bandwidth.	The PCoIP packets can adversely delay the VoIP packets in the priority queue on low bandwidth links.
		Consider using low-latency queueing (LLQ) for PCoIP packets on links that do not carry VoIP and have greater than 1.544Mbps available. Consider the 33% LLQ rule.	The strict priority queue should only be considered if there are many different types of traffic competing with PCoIP and performance is suffering.
		Avoid adjusting the MTU on low bandwidth links to decrease serialization time for VoIP packets as the PCoIP protocol	It may be difficult to guarantee high quality conversations with both VoIP and PCoIP on

		packets should not be fragmented.	links with less than 1.544Mbps of bandwidth.
		Consider tuning the hardware transmit ring to 1 to ensure that software queuing takes place if LLQ is not possible and PCoIP or VoIP are experiencing high jitter.	Large packet serialization can sometimes cause high amounts of jitter. This should not be done in most cases as proper CBWFQ usage will allow for acceptable guaranteed session quality.
		Increase the queue-depth settings in the PCoIP queue if tail drops are experienced. If near maximum recommended queue depths, consider optimizing PCoIP for lower bandwidth or increasing the link bandwidth.	On a Cisco device look for the drop rate on the 'show policy-map interface' command.
		Ensure that your classification and QoS schemes work with your WAN Carrier's QoS schemes. This is especially applicable to MPLS networks.	Most WAN Carriers only offer 3 or 4 different classes of traffic on MPLS networks.
	Configure Weighted Random Early Drop (WRED) in the path of all PCoIP conversations. On Cisco Routers this is the 'random-detect' command.		PCoIP protocol incorporates rate limiting and flow control mechanisms optimized for virtual desktops. Unlike traditional UDP applications, WRED will work with PCoIP protocol and gradual packet loss allows time for PCoIP protocol to adapt. Tail drop does not allow time for PCoIP protocol to adapt and alleviate the congestion before user experience is impacted
		Confirm that the network interface is not configured for WRED if you have selected WRED for the service policy on that interface.	Note that configuring WRED on the physical interface overrides all other QoS queuing configurations.
	Consider segmenting PCoIP traffic via Layer 2 VLAN and/or COS types at the access layer of your network.		
		Only use Layer 2 QoS COS prioritization if there is noted congestion at the access layer or between the access and aggregation (distribution) layer.	Consider adding Layer 2 uplink bandwidth before applying Layer 2 QoS if possible.
		Carefully consider the use of auto-qos features at the layer 2 layer as this may result in WRED being applied at the switchport layer through the use of Shared/Shaped Round Robin (SRR) Queues.	SRR Queues are automatically configured on many Cisco access layer platforms when using the auto-qos feature. By default these enforce WRED for all but trunked packets marked with COS 5 (generally VoIP packets from a hardphone).
	Avoid Traffic Shaping unless absolutely necessary. Shaping works to smooth traffic bursts and achieve a defined CAR by buffering packets – increasing the latency.		Traffic shaping will increase PCoIP packet latency and can impact user experience. If necessary, consider Traffic policing as an alternative.
	Ensure 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, explicitly set the switch link to full duplex
	Ensure network ports are open for PCoIP protocol and VMware View		See VMware View Architecture Planning document (EN-000524-00) See knowledge base techsupport.teradici.com
	Ensure that PortFast is enabled on all network ports that PCoIP Zero Clients or VMware View Clients are connected to.		This ensures that the port is immediately configured to forward traffic in the event of a

			Spanning-tree recalculation.
	Ensure Intrusion Protection Services have been disabled or configured to allow PCoIP protocol and VMware View network ports		IPS can block some/all network ports and/or throttle bandwidth for PCoIP protocol
	Ensure that the round trip network latency is within specification		Excessive latency will impact desktop performance
		Less than 250ms round trip for VMware View 4.x hosts	
		Less than 150ms round trip for PCoIP Host Cards	
	Ensure the latency variation is less than 30ms		About 1 frame for 30 fps (HD video and default for PCoIP Software in VMware View.
	Minimize link packet loss		
		Packet loss should be zero for a properly configured LAN/WAN deployments. Packet loss within a single PCoIP session should target less than 0.1%	Users will typically notice performance degradation if the session packet loss is greater than 1%.
		PCoIP packets which arrive sufficiently out of order may be considered as lost packets by the PCoIP protocol. Avoid packet re-ordering in the network	This will show as packet loss in the PCoIP session logs, but not in network device logs
		Avoid gaps in PCoIP protocol traffic, PCoIP sessions will disconnect after 30 seconds of loss in traffic in either network direction or PCoIP port (4172 UDP/TCP)	Intrusion protection services (IPS) or intrusion detection services (IDS) should be disabled, or configured to allow (4172 UDP/TCP).
	Ensure that PCoIP packets are not fragmented at any point in the network path		
		Ensure MTU in network devices is not below the PCoIP packet MTU size - defaults - 1300 bytes VMware View Host, and 1400 bytes when connecting PCoIP Zero Clients to PCoIP Host Cards	Increase router MTU before reducing PCoIP packet MTU as lower PCoIP protocol MTU can impact desktop performance. Keep in mind that network devices may add additional encapsulation and increase PCoIP packet size
	Ensure that packet order is maintained		
		Do not use per-packet load balancing for any load balancing decisions along the path of traffic, including but not limited to: EIGRP load balancing, Static Route load balancing, or MPLS load balancing.	Out of order packets adversely affect the quality of the PCoIP protocol.
		For load balancers – ensure affinity (or related) is set to 1	Ensure same SA/DA sent on the same path.
		Configure WAN optimization devices to bypass PCoIP packets	Current WAN Optimization products can impact PCoIP packets causing increased latency and packet loss and packet re-ordering.
		Ensure that small packets are not prioritized over larger packets.	This can cause PCoIP packet reordering as small PCoIP packets to jump ahead of larger ones.
	VPN considerations		

		If a VPN is used, confirm that UDP traffic is supported (IPSEC, or DTLS-enabled SSL solutions)	**Do not route PCoIP traffic through TCP-based SSL tunnels**
		Avoid VPN overhead if possible, consider a VPN-less secure remote access solution such as VMware View Security Server 4.6 (or newer) which supports PCoIP protocol	
		Use QoS Pre-Classify if CBWFQ or LLQ is necessary on the outgoing interface of the VPN device.	This may not be available on many platforms or in many designs.
	Confirm the VMware ESX virtual switch traffic shaper is turned off.		

Network Bandwidth			Notes
	Perform detailed network health check		
		Determine other protocol traffic that exists on the network – especially other high priority traffic that could impede PCoIP packet forwarding	
		Determine network characteristics key for a successful real-time protocol deployment including latency, jitter (latency variation) and packet loss.	
	Ensure there is sufficient bandwidth allocated to PCoIP traffic		
		Plan for 200-250 kbps average for standard office applications with Windows experience settings optimized, or Plan for 80-150 kbps when optimizing the Windows experience settings and also optimizing PCoIP session variables.	See Table 1 and Table 2 for more details
		Consider bandwidth required for audio input/output	See Table 1 and Table 2
		Consider bandwidth required for USB traffic	PCoIP Zero Client bandwidth limit will limit USB traffic (not the case with a VMware View Client).
		Plan a minimum of 1Mbps per simultaneous user watching 480p video window	More bandwidth may be required depending on video resolution/user quality requirements
		Ensure network bandwidth analysis includes following network loading guidelines (ie 60%-80%)	Hardware interfaces running at over 80% utilization tend to have problems queuing packets due to network burstiness resulting in packet drops.
	Ensure there is sufficient bandwidth headroom for bursts of PCoIP protocol traffic		
		Plan for a minimum bandwidth headroom of 500kbps to 1Mbps per session for VMware View hosts	The actual burst bandwidth required will depend on the user and applications (considering the number of pixels changing, the level

			and complexity of compression, and the display frame rate).
		Plan for a minimum of 1 Mbps per session burst bandwidth for PCoIP Host Cards in remote workstations	Many workstation applications will require a higher burst bandwidth that varies per user and imaging workload.
		Oversubscription analysis (optional) can enable efficient link sizing while maintaining a reasonable expectation that burst bandwidth is available per session	Use of enterprise network loading guidelines is a reasonable basic planning alternative
	Consider bandwidth reduction options when operating in a known constrained network environment		
		Optimize desktop Windows experience settings (implement this first)	
		Optimize PCoIP Session variables	See PCoIP Session Variables
		Optimize display resolution/number of displays	

PCoIP Session Variables	
	PCoIP Maximum Bandwidth Limit – sets a limit on the bandwidth a PCoIP session can use. Be careful not to set a maximum bandwidth limit too low since the PCoIP protocol needs to burst. Consider setting when operating in a network with known link congestion. The limit set can vary across useage scenarios such as: • Single user on a link (i.e. home user on an internet connection) – set bandwidth limit to 90% of the link rate • Consider setting the maximum bandwidth to [(Available bandwidth for PCoIP packets)/(n users)] + 500kbps • The minimum bandwidth limit should be set between 500kbps and 1Mbps, however, this may need to be increased depending on the user requirements (see examples in Table 1 and Table 2)
	PCoIP Bandwidth Floor – the minimum bandwidth that will be transmitted when the session is attempting to transmit at a rate above the minimum. Consider only if operating on a network with known packet loss (ie Wireless) **Ensure sufficient bandwidth is available: (n users) * (minimum bandwidth) <= available link bandwidth**
	PCoIP Audio Playback Bandwidth Limit – configures audio compression. Resulting audio bandwidth will be near or below the limit set
	PCoIP Imaging: Minimum Image Quality – trades off display image quality vs. display frame update rate (lower image quality for a higher frame rate etc)
	PCoIP Imaging: Maximum Initial Image Quality – a lower maximum initial image quality will reduce the peak bandwidth during large screen changes and reduce the initial display quality
	PCoIP Imaging: Frame Rate Limit – sets a limit on the display update rate. Reduces average and peak bandwidth for high frame rate display content. Only useful when the native frame rate is above the limit.
	PCoIP Session MTU – option to adjust the PCoIP packet MTU to ensure is lower than the network MTU
	PCoIP Client PCoIP UDP port – option to adjust the PCoIP UDP port used at the client.

Configuration Example:

Marking and CBWFQ with LLQ for VoIP, SIP traffic not treated. Assuming a LAN Ethernet interface and a WAN Serial T1 interface. QoS is configured to guarantee the following:

- Strict Priority for four G.729 VoIP calls marked as EF
- Reserved bandwidth for 2 Task Worker PCoIP sessions marked as AF41 (500kbps minimum peak bandwidth, limited ability for oversubscription)
- The default class gets all the remaining bandwidth and is fair queued

```
!match PCoIP packets
access-list 100 permit tcp any any eq 4172
access-list 100 permit udp any any eq 4172

class-map match-all VOIP-IN
 match ip rtp 16384 16383
class-map match-all PCOIP-IN
 match access-group 100

class-map match-all VOIP-OUT
 match ip dscp EF
class-map match-all PCOIP-OUT
 match ip dscp AF41

policy-map ETH-IN
 class VOIP-IN
  set ip dscp EF
 class PCOIP-IN
  set ip dscp AF41
policy-map SERIAL-OUT
 class VOIP-OUT
  priority 128
 class PCOIP-OUT
  bandwidth 1000
 class class-default
  fair-queue

interface Serial 0/1
 bandwidth 1544
 no fair-queue
 service-policy output SERIAL-OUT

 !trust dscp markings coming into this router from across the WAN
 !do this if you need Layer 2 COS QoS and have a DSCP-COS map defined or set COS on e0/1
 mls qos trust dscp

interface Ethernet 0/1
 service-policy input ETH-IN
```

Configuration Example Continued:

Due to variance in user perception, bandwidth guidelines are intended to provide a starting point – more or less bandwidth may be needed to satisfy user performance requirements.

Table 1 Mainstream Office Desktop Scenarios

Example Virtual Desktop User Categories	General Office				Video Resolution					Video Usage		Audio Quality				
	Simple Screen Data/Text Entry	Basic Office and Web	Fast window switching	Win7 Aero Glass	Embedded Web Flash	360p	480p	720p	1080p	Occasional	Frequent	No Audio	Compressed Mono	Mono	Compressed Stereo	CD Quality Stereo
Task Worker	✓											✓				
	✓											✓				
Basic Office	✓	✓			✓								✓			
Office Productivity	✓	✓			✓									✓		
	✓	✓			✓	✓	✓			✓					✓	
Advanced Office	✓	✓	✓		✓	✓	✓			✓					✓	
	✓	✓	✓	✓	✓	✓	✓	✓		✓						✓

Example Virtual Desktop User Categories	Suggested Bandwidth Targets		Bandwidth Settings		Imaging Settings			Windows Experience Optimization
	Average Bandwidth	Minimum Peak Bandwidth (for bursts)	PCoIP Bandwidth Limit (kbps)	Audio Bandwidth Limit (kbps)	Minimum Image Quality	Maximum Initial Image Quality	Maximum Frame Rate	
Task Worker	<70 kbps	500 kbps	500 kbps	disable audio *	40	70	8	Yes
	<100 kbps	1 Mbps	1 Mbps	disable audio *	50	70	15	Yes
Basic Office	<150 kbps	750 kbps	750 kbps+	50 kbps	40	70	15	Yes
Office Productivity	<250kbps	1 to 3 Mbps	3 Mbps+	90 kbps	50	90	20	Limited
	<600 kbps	5 Mbps	5 Mbps+	200 kbps	50	90	24	Limited
Advanced Office	<1.25 Mbps	7 Mbps	7 Mbps+	450 kbps	50	90	30	No
	<2.5 Mbps	10 Mbps+	10 Mbps+	1.6 Mbps	50	90	30	No

Note:

Bandwidth – actual average and peak bandwidth required can vary greatly across user and enterprise environments and may be more or less than the values shown

PCoIP Bandwidth Limit – recommend that this is not set unless operating in a known constrained network

PCoIP Bandwidth Floor – recommend not setting this in View 4.5 or newer, unless operating on a network with known packet loss (ie wireless networks)

Windows Experience optimization – limited refers to basic optimization of desktop background, removing menu fading etc. Full optimization includes additional steps such setting visual affects to best performance etc.

Table 2 Power users and Designer (ie CAD) Desktop Scenarios

Example Virtual Desktop User Categories	General Office				Video Resolution					Video Usage		Audio Quality					3D Graphics (CAD, Digital Content Creation, or equivalent tool)		
	Simple Screen Data/Text Entry	Basic Office and Web	Fast window switching	Win7 Aero Glass	Embedded Web Flash	360p	480p	720p	1080p	Occasional	Frequent	No Audio	Compressed Mono	Mono	Compressed Stereo	CD Quality Stereo	Occasional image review	Static image analysis	Dynamic (active) Image Analysis
Basic CAD - WAN	✓	✓			✓	✓	✓			✓				✓			✓		
Basic CAD - LAN	✓	✓			✓	✓	✓			✓				✓			✓		
Video User	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						✓			
Power User - Video	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓			
Power User - CAD	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓		✓	✓	
Extreme User	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓

Example Virtual Desktop User Categories	Suggested Bandwidth Targets		Bandwidth Settings		Imaging Settings			Windows Experience Optimization
	Average Bandwidth	Minimum Peak Bandwidth (for bursts)	PCoIP Bandwidth Limit (kbps)	Audio Bandwidth Limit (kbps)	Minimum Image Quality	Maximum Initial Image Quality	Maximum Frame Rate	
Basic CAD - WAN	1 Mbps+	2 Mbps+	2 Mbps+	90 kbps	40	70	N/A	Yes
Basic CAD - LAN	3 Mbps+	10 Mbps+	10 Mbps+	90 kbps	40	70	N/A	No
Video User	7 Mbps+	30 Mbps+	30 Mbps+	1.6 Mbps	40	90	N/A	No
Power User - Video	30 Mbps+	50 Mbps+	90 Mbps+	1.6 Mbps	40	90	N/A	No
Power User - CAD	30 Mbps+	70 Mbps+	120 Mbps+	450 kbps	40	90	N/A	No
Extreme User	80 Mbps+	120 Mbps+	220 Mbps+	1.6 Mbps	40	90	N/A	No

Note:

Power User and Extreme User categories assume the use of a PCoIP Host Card in a remote workstation

Image Quality – adjustments may be needed for operation at lower bandwidths and/or constrained networks