



Using Protocol Acceleration to Increase WAN Application Performance

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Enhance Performance with the Acceleration Module

Excruciating slow file transfers. Nightly server backups that are still running in the morning when you arrive at the office. Customer database queries with such poor response time that even the most patient of people give up on them. These are just a few examples of application performance problems that you might initially try to solve with a bandwidth upgrade. But you would probably find that adding bandwidth isn't the solution. This may be because bandwidth-greedy applications – not necessarily your customer-critical applications – gobble up all the new bandwidth. In other cases, applications may be unable to utilize the available bandwidth due to inherent protocol limitations.

If adding bandwidth won't solve these types of problems, what will?

The Acceleration Module is an optional component of PacketShaper, Packeteer's WAN Application Optimization product. This module improves application performance in environments with big links, large file transfers, high latency, and/or sizeable transactions. Before we get into the details of the technologies behind the Acceleration Module, let's examine the causes of performance problems.

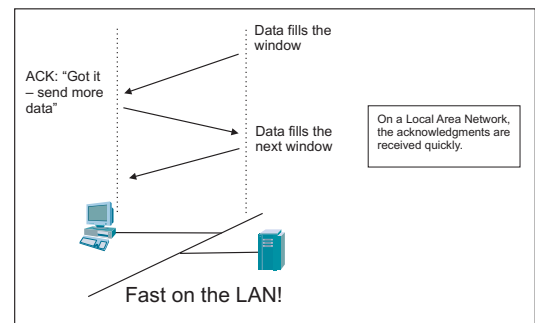
TCP: A Problematic Protocol

TCP is a reliable protocol used for transmission of data over IP networks. However, there are inherent TCP behaviors that work against higher latency connections. TCP utilizes a sliding window mechanism to limit the amount of data in flight at any time. When the window becomes full, the sender stops transmitting until it receives new acknowledgments (ACKs). Over long distance networks, where ac-

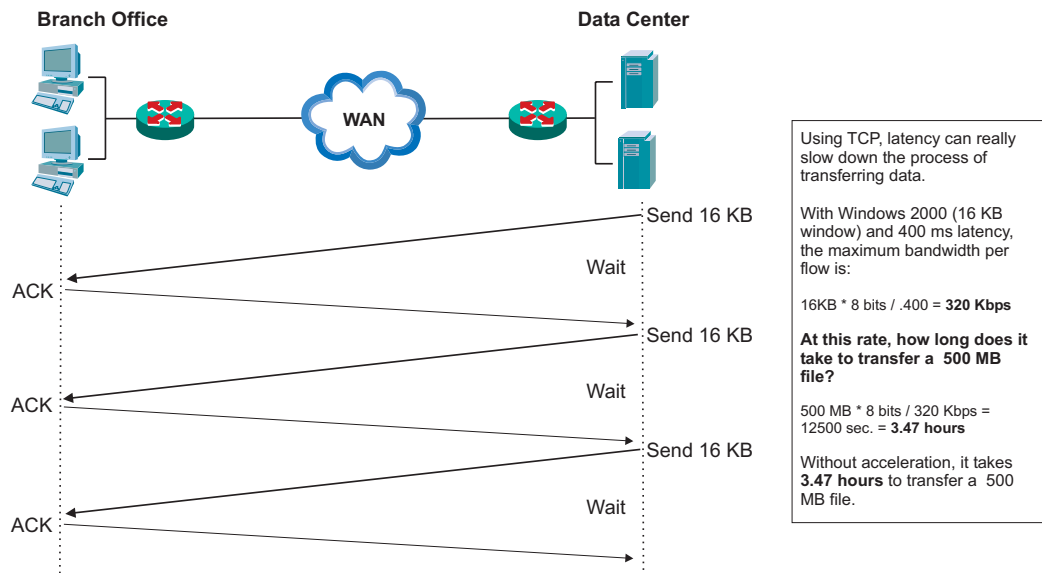
knowledgments are slow to return, the TCP window size often sets a hard limit on the maximum throughput rate. Each operating system has a predefined window size. For example, Windows 2000 uses a 16 KB window and Windows XP has a variable window size up to 64 KB.

Depending on the distance of the link, it can take anywhere from 15 to 600 ms to get the ACK. The following chart shows the typical delay due to distance.

WAN Link	Typical Delay
Same City	15 ms
Regional	30 ms
Across a Continent	100 ms
Between Continents	200 ms
Satellite	600 ms



As distance increases, so does the wait time for the ACK. Suppose Windows 2000 (with a 16 KB window size) is the operating system being used. Once the ACK is received, the next 16 KB of data is sent. This same process happens for every window (16 KB of data). As delay increases, the result is that large links become less and less utilized because valuable time is spent simply waiting for acknowledgements. Consequently, the data cannot be sent fast enough in order to use the available bandwidth. Much of the link gets wasted. From the user's perspective, everything is slow on the Internet: file transfers, web browsing, mail synchronization, and using web-based applications.



A typical example is in large data center-to-data center WAN links. Large WAN connections (DS3, 45 Mbps, OC-3/STM-1/155 Mbps) between data centers have become more affordable and, therefore, more commonplace. Having a large connection to speed the rate of disaster recovery backup, server synchronization, and distributed storage is now a sound concept. But most server mirroring and disaster recovery solutions use TCP protocols for their file transfers.

100 ms average delay (across-continent connection)

Link Size	Windows XP Potential Wasted Bandwidth	Windows 2000 Potential Wasted Bandwidth
512 Kbps	0	0
2 Mbps	0	720 Kbps (36%)
10 Mbps	4.8 Mbps (48%)	8.7 Mbps (87%)
45 Mbps	39.8 Mbps (88%)	43.7 Mbps (97%)
155 Mbps	149.8 Mbps (96%)	153.7 Mbps (99%)

Assume a business is running Windows XP and has a cross-continent link with 100 ms of latency. The maximum a single flow will be able to grow to is 5.1 Mbps. With a link size of 45 Mbps, approximately 88 percent of the bandwidth is being wasted due to TCP and window size limitations. Once again, user expectations are that the larger link size will allow for more efficient backups and synchronization. When this expectation is not met, the assumption is that more bandwidth will solve the problem, so the business upgrades to a 155 Mbps link. This only creates more waste since approximately 96 percent of the bandwidth is not utilized.

When available bandwidth is not fully utilized due to TCP and latency limitations, the result is wasted bandwidth and missed performance targets. Business productivity is negatively impacted when large file transfers and interactive transactions are slow. The ability to accelerate sizeable file transfers and interactive web-based applications is the key to resolving these issues.

The Packeteer Solution

While it is almost impossible to eliminate latency over networks, it doesn't mean the situation simply has to be tolerated or that something can't be done to lessen the impact. Packeteer's Acceleration Module minimizes the effects of high latency due to distance delay and can alleviate the following problems:

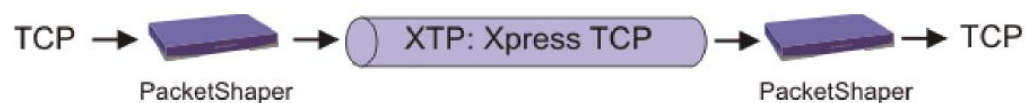
- Poor performance of large flows: large file transfers, disaster recovery backups, database synchronizations, and so forth
- The effects of packet loss and retransmissions
- Wasted WAN capacity and link under-utilization
- Customer-critical transaction applications with large transactions
- Unresponsive HTTP sessions

Packeteer provides acceleration for both transactions and file transfers to enhance network performance. Under the right conditions, acceleration yields significant performance improvements — up to 8x for web traffic and 50x for file downloads, especially over high-latency links.

Xpress TCP

Because TCP isn't a suitable transport protocol for high-latency networks, PacketShaper provides an alternative that is specifically designed to address the inherent problems with using TCP in a high-latency environment. This technology is called *Xpress TCP*.

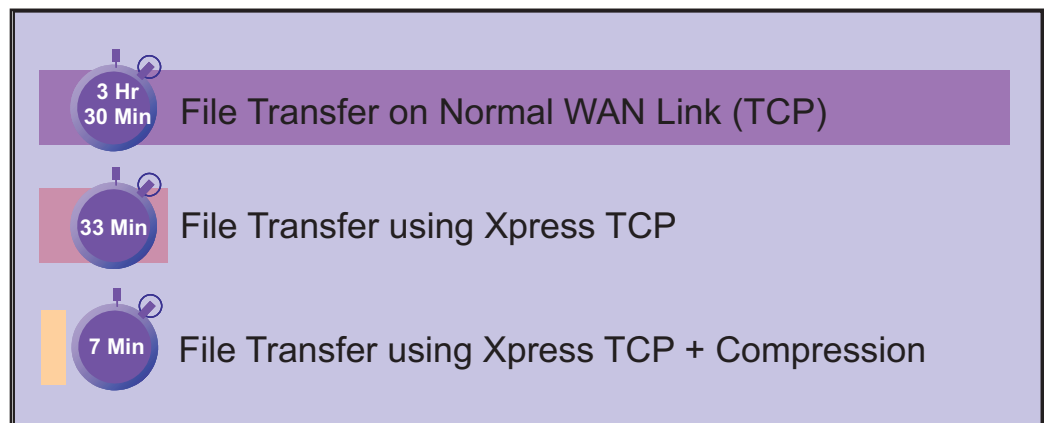
With Xpress TCP as the transport protocol for accelerated traffic, PacketShaper intercepts the TCP connection from the client and converts the data to XTP for transmission through the *Xpress tunnel*, a communication link between two PacketShapers. The PacketShaper on the other side of the tunnel translates the XTP data back to TCP. This process is illustrated in the following diagram.



Xpress TCP offers several advantages over standard TCP. First of all, Xpress TCP is a high performance protocol that's unconstrained by windowing limitations of normal TCP operations, thereby allowing the WAN link bandwidth to be fully utilized. It uses rate-based congestion control which allows a connection to quickly attain full-speed operation when significant bandwidth is available. With Xpress TCP, the ACKs are moved back to the local site, creating LAN-speed responses to client-server exchanges.

When packets are lost, selective ACKs resend the data before clients have a chance to react. This technique avoids the bandwidth tax required by aggressive forward error correction (FEC) technologies typically used in TCP.

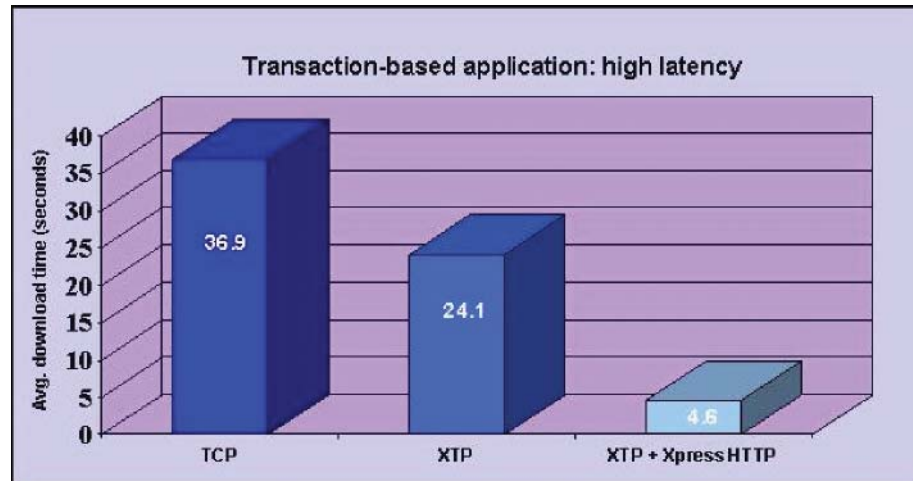
Let's return to the earlier example of the 500 MB file that took approximately 3.5 hours to transfer. By using Xpress TCP instead of standard TCP, the entire 2 MB link could be utilized: this same file would transfer in 33 minutes (7x acceleration). If you use the Compression Module in conjunction with the Acceleration Module, the 500 MB file could transfer in less than 7 minutes (30x acceleration).



Xpress HTTP

The Acceleration Module is able to significantly improve performance of web-based applications and XML-based web services on high-latency links. This technology is called *Xpress HTTP*. When acceleration is enabled, web pages display up to eight times as fast. Two features allow you to accelerate HTTP traffic: FastStart and Prefetch.

The *FastStart* feature accelerates web downloads by reducing the time needed to establish each new HTTP connection. Using FastStart, the PacketShaper acknowledges TCP connections immediately without waiting for a connection to be established to the web server. This immediate acknowledgement allows the browser to send its HTTP GET request right away. PacketShaper then combines the HTTP GET request with the XTP connection request. This process delivers the HTTP request to the web server one round-trip faster. For web pages that consist of large numbers of objects, FastStart greatly improves the responsiveness of the web page display.



The *Prefetch* feature reduces the time required to download and display web pages. The server-side PacketShaper unit intercepts the HTML pages returned by the web server and begins retrieving the various embedded graphics and objects on that page. The server-side PacketShaper then pushes the objects to the remote side of the link where they are served by the client-side PacketShaper unit when requested by the browser, thereby avoiding the network delay. In many cases, the objects can be local to the client before they are even requested.

Integration of Acceleration with Other Optimization Tools

Integration of optimization technologies becomes key when trying to maximize the improvement of application performance. Packeteer's technologies – Monitoring, Shaping, Compression, and Acceleration – work together to improve the performance of applications running on the network. For the most benefit, technologies should be implemented concurrently.

When users are experiencing application performance problems on your network, Packeteer's software modules work in concert to solve these issues.

- **Monitoring** is the first step. This module identifies and categorizes the applications on your network, necessary for the other optimization tools to do their jobs.
- **Shaping** contains recreational traffic and provisions bandwidth to your mission-critical applications in order to provide the quality of service your users deserve.
- **Compression** effectively increases the size of your link, making additional bandwidth available to your applications.
- **Acceleration** allows the entire link to be filled so that bandwidth doesn't get wasted. As a result, application performance improves and response times become acceptable.

By providing application-intelligent visibility, control, and compression, PacketShapers allow customers to be selective about which applications (and how much of each) get on to the WAN. With this infrastructure in place, acceleration can do its job of overcoming latency and TCP protocol design limitations for file transfers, data backups, and synchronizations between geographically remote sites.

Can You Benefit From Acceleration?

As explained earlier, having a large link doesn't guarantee that the link's bandwidth can be fully utilized. Your operating system's window size and latency are both factors on whether the link can be filled to its capacity. Estimating your link's percent utilization can help you determine whether your network can benefit from the Acceleration Module.

The tables below indicate the maximum bandwidth rate and percentage of potentially wasted bandwidth for a single flow when using Windows 2000 (16 KB window size). To determine the maximum bandwidth rate per flow in the first table, locate your round-trip latency and your WAN link size; the intersection of the row and column will give you the maximum bandwidth rate that can be achieved by a single flow given TCP constraints. The second table divides the maximum bandwidth rate by the WAN link size to determine the percentage of wasted bandwidth. The red cells will get the most benefit from Xpress TCP acceleration.


Window size: 16 KB Windows 2000

		MAX Bandwidth Rates for Single Flow (Mbps)										
		Table gives max bandwidth that can be achieved by single flow given TCP Constraints										
Round Trip Latency		1.5	2	4	10	25	45	100	155	200	500	1000
600		0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
300		0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
150		0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
100		1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
50		1.50	2.00	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56	2.56
25		1.50	2.00	4.00	5.12	5.12	5.12	5.12	5.12	5.12	5.12	5.12
10		1.50	2.00	4.00	10.00	12.80	12.80	12.80	12.80	12.80	12.80	12.80

		Potentially Wasted Bandwidth from Single Flow										
		Table provides link size LESS the max bandwidth by single flow given TCP Constraints										
Round Trip Latency		1.5	2	4	10	25	45	100	155	200	500	1000
600		86%	89%	95%	98%	99%	100%	100%	100%	100%	100%	100%
300		72%	79%	89%	96%	98%	99%	100%	100%	100%	100%	100%
150		45%	57%	79%	91%	97%	98%	99%	99%	100%	100%	100%
100		17%	36%	68%	87%	95%	97%	99%	99%	99%	100%	100%
50		0%	0%	36%	74%	90%	94%	97%	98%	99%	99%	100%
25		0%	0%	0%	49%	80%	89%	95%	97%	97%	99%	99%
10		0%	0%	0%	0%	49%	72%	87%	92%	94%	97%	99%

- Xpress TCP Strong Benefit - single flow can fill less than 50% of the pipe (two flows can't fill the pipe)
- Xpress TCP Medium Benefit - Single flow fills between 50% and 100% of the pipe
- Xpress TCP Minimal Benefit - A single flow can fill the whole pipe

Because the calculations are a bit involved, Packeteer has developed an online *Link Utilization Calculator*. All you need to do is select your operating system, input the latency in milliseconds, specify your link size, and estimate compression savings (if you are using or planning to use the Compression Module). The Calculator will then tell you how much of the link can be filled with a single flow and whether acceleration would be beneficial in your network environment.



The screenshot shows the Packeteer Link Utilization Calculator interface. At the top, it features the Packeteer logo and tagline. Below is a heading "Link Utilization Calculator" followed by a paragraph explaining the tool's purpose. A section titled "Fill in the fields below:" contains four input fields: "Operating System" (a dropdown menu), "Latency (in milliseconds)" (a text input with "ms" unit), "Link size (in Mbps)" (a text input with "Mbps" unit), and "Expected Compression Savings" (a text input with "%" unit). A "Calculate Utilization" button is positioned below the fields. A note at the bottom left states "* indicates a required field".

If the Link Utilization Calculator indicates that acceleration would be beneficial, the next step is to look at the types of applications on your network. Acceleration is most helpful with the following types of traffic:

- Large file transfers (CAD, X-rays, legal documents, multimedia files, print production files)
- Database synchronizations
- Server backups
- Storage mirrors
- Intranet portals
- Web-based applications
- XML-based web services

Larger transactions, such as customer queries from ERP or CRM packages, will benefit significantly from acceleration. For transaction-based applications with small transactions, Xpress TCP may not be as helpful; a more appropriate solution for these types of applications is Packeteer's congestion management technology included in the Shaping and Compression Modules.

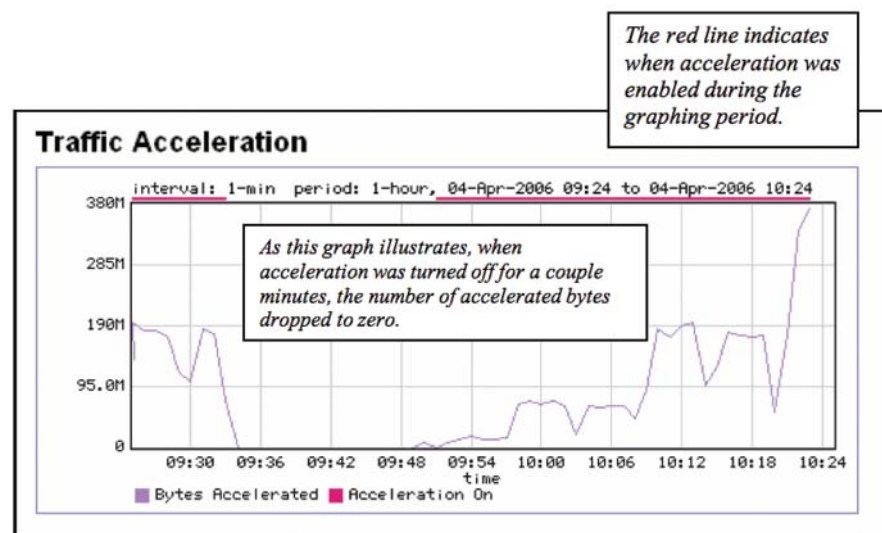
To determine if the applications used on your network are conducive to acceleration, refer to the separate document, "How Much do Applications Benefit from PacketShaper Acceleration?" This useful tool lists a variety of popular applications and uses a star rating system to indicate whether each application is likely to benefit from Packeteer's Acceleration Module.

Acceleration benefit tools are located on the Packeteer website at:

http://www.packeteer.com/products/packetshaper/accel_calculator/

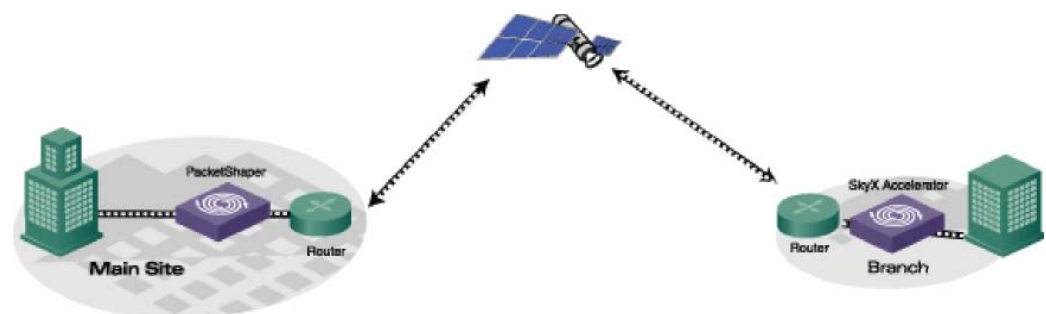
How Much Traffic is Getting Accelerated?

For an overview of how acceleration is working on your link, a Traffic Acceleration Summary report is available. There is one graph for the Inbound direction and another for Outbound. Each graph displays bandwidth utilization of accelerated bytes that went through acceleration tunnels. If acceleration is enabled at any point during the time period on the graph, a red horizontal line will appear above the graph.



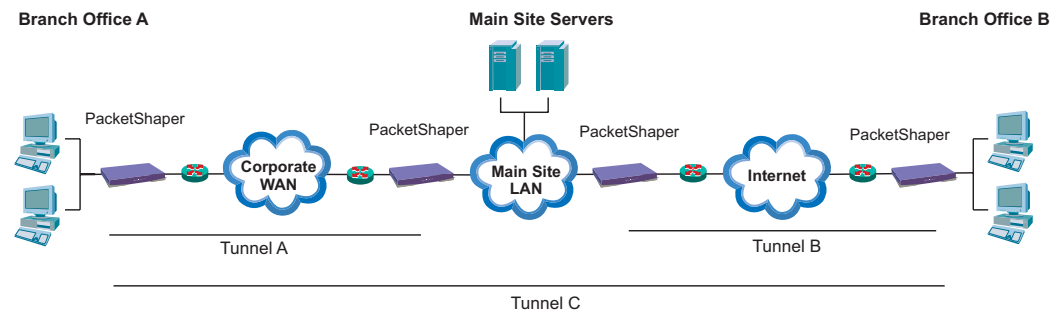
SkyX and PacketShaper Compatibility

In addition to tunneling with other PacketShapers, the Acceleration Module can create tunnels with SkyX Accelerator, Packeteer’s dedicated acceleration hardware device. SkyX provides functionality similar to the Acceleration Module: it accelerates TCP over high-latency links. Using a SkyX tunnel, you can accelerate traffic between hosts on one side of a PacketShaper and hosts on the other side of a SkyX Accelerator.



Xpress Tunnels

An Xpress tunnel is a communication link between two PacketShaper units. Its function is to transport data that has been accelerated, compressed, and/or packed. (Compression and packing features are included with the Compression Module.) The illustration below shows three Xpress tunnels. Tunnel A is set up between a branch office (A) and the main site. Tunnel B transfers data between another branch office (B) and the main site. Tunnel C transports traffic between the two branch offices.



ActiveTunnel™

Packeteer's *ActiveTunnel* feature automatically detects PacketShapers on the network and builds Xpress tunnels between them. These tunnels are considered to be *dynamic*. Alternatively, you have the option of manually defining the tunnel end-points. This type of tunnel is called *static*.

PacketShaper continually monitors the traffic traversing the tunnels. When resources are constrained and tunnel demand exceeds resources, the PacketShaper automatically determines which tunnels yield the best results and ensures they remain active. It deactivates less utilized, effective tunnels to support the more active, valuable tunnels. Although the PacketShaper caps out at 300 active tunnels (depending on model and memory), it can juggle many more potential tunnels and maintain the most beneficial as active, temporarily deactivating those that are least effective.

ActiveTunnel's ability to juggle a large number of tunnels, keeping the most effective ones active, enables PacketShapers that sit at the network edge to connect seamlessly to a large, fully meshed environment. Each of the connections in a meshed environment can have a tunnel, as long as there are PacketShapers deployed at the end points. With PacketShapers, scaling issues for tunnels are no longer an issue.

Each PacketShaper model has a limit to the number of Xpress tunnels that can be automatically or manually created. Specifications for each model are listed online in the Configuration Limits table in PacketGuide.



Tunnel Monitoring and Configuration

Although the ActiveTunnel feature automatically manages your tunnels behind the scenes, it's still useful to see how many tunnels are active, who their partners are, how well acceleration and compression are doing on each tunnel, and which tunnels, if any, are experiencing problems. The Xpress Tunnels Overview, shown below, provides a real-time snapshot of this type of information. It lists the tunnels that have formed with your PacketShaper as well as statistics for each tunnel.

XPRESS TUNNELS OVERVIEW													
global tunnel settings		Acceleration: on Compression: on Packing: on Firewall: off DiffServ: off Discovery: on MTU: (auto) Tunnel Mode: Enhanced											
xpress-ip settings		Main: 172.17.60.101 / 255.255.255.0				Lower: 172.17.62.101 / 255.255.255.0				Upper: 172.17.61.101 / 255.255.255.0			
add tunnel...		remove all...		remove checked...		update							
Tunnel Name <small>(285 Tunnels)</small>	Features	Device	Partner IP	Type	Outbound				Inbound				Del
					Pre-Comp. <small>(bps)</small>	Post-Comp. <small>(bps)</small>	% Saved	Acc. <small>(bps)</small>	Decomp. <small>(bps)</small>	Comp. <small>(bps)</small>	% Saved	Acc. <small>(bps)</small>	
172.17.59.208:Main	ACP	Main	172.17.59.209	dynamic	230k	124k	46%	0k	41.5k	9112	78%	0k	<input type="checkbox"/>
172.17.59.207:Main	ACP	Main	172.17.59.207	dynamic	190k	72.4k	62%	0k	28.7k	6664	77%	0k	<input type="checkbox"/>
172.17.56.210:Main	ACP	Main	172.17.56.210	dynamic	280k	54.5k	81%	0k	22.4k	5976	73%	0k	<input type="checkbox"/>
172.17.56.208:Main	ACP	Main	172.17.56.208	dynamic	164k	73.2k	55%	0k	15.6k	4360	72%	0k	<input type="checkbox"/>
172.17.57.208:Main	ACP	Main	172.17.57.208	dynamic	159k	48.6k	69%	0k	28.2k	6288	78%	0k	<input type="checkbox"/>
172.17.57.210:Main	ACP	Main	172.17.57.210	dynamic	246k	128k	48%	0k	37.0k	8560	77%	0k	<input type="checkbox"/>
172.17.59.207:Upper	ACP	Upper	172.17.59.207	dynamic	536k	239k	55%	0k	67.6k	17.9k	74%	0k	<input type="checkbox"/>
172.17.58.210:Main	ACP	Main	172.17.58.210	dynamic	331k	70.3k	79%	0k	20.5k	5976	71%	0k	<input type="checkbox"/>
172.17.56.208:Upper	ACP	Upper	172.17.56.208	dynamic	894k	341k	62%	0k	109k	28.3k	74%	0k	<input type="checkbox"/>
172.17.59.208:Upper	ACP	Upper	172.17.59.208	dynamic	978k	395k	60%	0k	75.3k	21.5k	71%	0k	<input type="checkbox"/>
172.17.57.208:Upper	ACP	Upper	172.17.57.208	dynamic	573k	209k	64%	0k	86.4k	22.6k	74%	0k	<input type="checkbox"/>
172.17.56.210:Upper	ACP	Upper	172.17.56.210	dynamic	868k	277k	68%	0k	67.8k	20.8k	69%	0k	<input type="checkbox"/>
172.17.57.210:Upper	ACP	Upper	172.17.57.210	dynamic	1.1M	296k	72%	0k	88.1k	24.8k	72%	0k	<input type="checkbox"/>
172.17.58.210:Upper	ACP	Upper	172.17.58.210	dynamic	69.7k	42.4k	39%	82k	14.1k	2168	85%	14k	<input type="checkbox"/>
172.17.58.208:Upper	ACP	Upper	172.17.58.208	dynamic	852k	296k	65%	0k	65.3k	19.2k	71%	0k	<input type="checkbox"/>
172.17.59.207:Lower	ACP	Lower	172.17.59.207	dynamic	75.8k	32.2k	58%	94k	0k	0k	0%	10k	<input type="checkbox"/>
172.17.56.208:Lower	ACP	Lower	172.17.56.208	dynamic	69.6k	25.5k	63%	91k	13.5k	2258	83%	13k	<input type="checkbox"/>

The overview indicates configuration information for each tunnel: name, functionality (Acceleration, Compression, Packing), the IP address of the tunnel partner, and whether it's static or dynamic. In addition, this screen displays the following statistics for each tunnel: utilization before and after compression/decompression, percentage of bytes saved due to compression, and rate of accelerated traffic.. If there is a problem with the tunnel, a warning icon will appear next to the tunnel name.

In addition to monitoring tunnels, this screen allows you to:

- Configure your global tunnel settings (such as enabling acceleration and setting the MTU)
- Define the Xpress-IP addresses (each built-in or LEM device that you want to use for Xpress tunneling must be assigned a unique IP address)
- Delete tunnels
- Create static tunnels and customize their settings

In Summary

Packeteer acceleration is summarized in the table below.

• Packeteer Acceleration	
What are the benefits of Packeteer acceleration?	<ul style="list-style-type: none"> • Optimizes application performance over high-latency links • Accelerates file transfers • Speeds database sync and backups, disaster recovery, XML and HTTP sessions • Increases link utilization on fat WAN links • Maximizes bandwidth utilization and ROI • Minimizes retransmission and recovers more quickly from errors
Which traffic gets accelerated?	<p>Only TCP applications get accelerated. The types of traffic that benefit most from acceleration are:</p> <ul style="list-style-type: none"> • CAD drawing transfers • Data replication • PC or server backups • Distributed storage • Disaster recovery • Web-based applications • Customer queries from ERP or CRM packages • Intranet portals • XML-based web services
How many PacketShaper units are needed?	<p>PacketShaper uses two-sided acceleration, meaning you must have a PacketShaper appliance at the initial and terminating end of any connection that transfers or receives accelerated traffic. Alternatively, you can have a SkyX Accelerator device as a tunnel partner for a PacketShaper.</p>
What are some key attributes?	<ul style="list-style-type: none"> • Xpress TCP, the transport protocol for accelerated traffic, overcomes latency and TCP protocol design limitations for file transfers and data backups between geographically remote sites. • Xpress HTTP technology significantly improves the performance of web-based applications and XML-based web services on high-latency links. • The Acceleration Module works in concert with Packeteer's other software modules: Monitoring, Shaping, and Compression. • Xpress tunnel technology reduces the need to configure/administer acceleration tunnels manually (although the capability to manually configure tunnels is there, if desired).



Fast WAN. Fast Apps. Fast Business.

For More Information

If you'd like more information about Packeteer products, consult Packeteer's website (www.packeteer.com) or call 408-873-4400 or 800-697-2253.

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