



Accelerating Application Delivery

For Satellite Networks

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ACCELERATING APPLICATION DELIVERY IN SATELLITE NETWORKS

Satellites are an attractive option for carrying Internet and other IP traffic to the many locations across the globe where terrestrial options are limited or price prohibitive. Unfortunately, Internet protocols are not optimized for satellite conditions, and consequently, throughput over satellite networks is restricted to only a fraction of the available bandwidth. What is needed to ensure that important data arrives at its destination efficiently and reliably is protocol acceleration that has a combination of *transaction acceleration* and *file transfer acceleration*.

Transaction acceleration overcomes the delay associated with the ongoing “chatter” in client /server and Internet environments. Unnecessary ‘chatter’ round- trips cause poor transaction response times especially in high latency and BER-susceptible satellite environments. Packeteer provides transaction acceleration that reduces round trips and application wait times, making web and business applications perform dramatically faster.

File transfer acceleration is needed to make maximum use of available bandwidth and speed delivery of large files. Packeteer’s file transfer acceleration overcomes inherent TCP protocol limitations by expanding window size and managing the effects of packet loss to increase the speed of transfers. As a result, satellite links experience dramatic transfer speed improvements.

This paper will provide a basic understanding of the technical problems associated with delivering important application data via satellite transmission, the impact on the network, and a basic overview of how Packeteer’s SkyX overcomes these challenges.

THE LATENCY PROBLEM

Latency is inherent to moving packets around a network; put simply, it is the time it takes for a packet to travel from source to destination. Therefore, flows cannot ramp up to take advantage of the available bandwidth resulting in longer connection setup times and underutilized links.

The Problem

Data networks running over satellites are faced with overcoming several unique network limitations, including the challenges presented by the distance that data needs to travel. Orbiting at an altitude of 22,300 miles, the round-trip time over a geosynchronous satellite is more than half a second. This is an order of magnitude larger than typical terrestrial WAN connections. Also, the wireless signal is subject to bit errors caused by atmospheric conditions. Yet another unique challenge for satellite networks is that they are frequently designed to take advantage of a return channel that is much smaller than the forward channel.

TCP, the protocol used for reliable transmission of data over IP networks, is optimized for short hops over low-loss cable or fiber. Its algorithms are designed to avoid congesting shared networks, and do not respond well to the large latency, high bit error rates, and asymmetric bandwidth of satellite networks.

These satellite conditions adversely interact with a number of elements of the TCP architecture its window sizing, congestion avoidance algorithms, and data acknowledgment mechanisms. This combination severely constricts the data throughput rate that could otherwise be achieved over satellite links.

1. Window Size: 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.

Impact: Over satellite networks, where acknowledgments are slow to return, the TCP window size often sets a hard limit on the maximum throughput rate. The minimum window size needed to fully utilize an error-free link (known as the "bandwidth-delay product") is 100 KB for a T1 satellite link and 675 KB for a 10 Mbps link. However, TCP without extensions is limited to a maximum window size of 64 KB. More critically, most operating systems set a default window size considerably smaller than this maximum, often as little as 8 KB, which imposes a maximum throughput rate over satellite of only 128 Kbps regardless of the bandwidth available.

2. Congestion Control: In order to avoid the possibility of congestive network meltdown, TCP assumes that all data loss is caused by congestion and responds by reducing the transmission rate.

Impact: Over satellite links, TCP misinterprets the long round-trip time and bit errors as congestion and responds inappropriately. Similarly, the TCP "Slow Start" algorithm, which over the terrestrial infrastructure prevents new connections from flooding an already congested network, forces an excessively long ramp-up period for each new connection over satellite. While these congestion avoidance mechanisms are vital in routed environments, they are ill suited to single-path satellite links.

3. Data Acknowledgements: The simple, heuristic data acknowledgment scheme used by TCP does not adapt well to long latency or highly asymmetric bandwidth conditions. To provide reliable data transmission, the TCP receiver constantly sends acknowledgments back to the sender. The sender does not assume any data is lost or corrupted until a multiple of the round-trip time has passed without receiving an acknowledgment.

Impact: This algorithm does not respond well over satellite networks where the round-trip time is long and error rates can be high. Further, this constant stream of acknowledgments wastes precious return channel bandwidth and if the return channel is small, the return of the acknowledgments to the sender can become the system bottleneck.

How much bandwidth is being wasted?

Windows 2000 has a window size that can transport up to approximately 16k of data. Depending on the distance of the link, it can take anywhere from 15 to 600ms to get the acknowledgment (ACK). As distance increases, so does the wait time for the ACK. Once the ACK is received, the next 16k of data is sent. This same process happens for every window (16k of data). The result is that satellite links become less and less utilized as delay increases because valuable time is spent simply waiting for acknowledgements. Consequently, the data cannot be sent fast enough in order to use the available bandwidth.

WAN Link	Typical Delay due to Distance	Windows XP maximum throughput	Windows 2000 maximum throughput
Same City	15 ms	32 Mbps	8 Mbps
Regional	30 ms	16 Mbps	4 Mbps
Across a Continent	100ms	5.2 Mbps	1.3 Mbps
Between Continents	200ms	2.6 Mbps	640 Kbps
Satellite	600ms	850 Kbps	213 Kbps

The above chart shows the typical delay due to distance and the typical maximum throughput for Windows XP and Windows 2000. To determine the maximum throughput, 64k default window size for Windows XP and 16k (average) window size for Windows 2000 was used.

For example, assume a business is using a 2 MB satellite link. They can expect to waste around 57 percent of its bandwidth since maximum throughput is only around 850 Kbps for Windows XP. Most businesses use Windows 2000, so it is more common to be wasting around 89 percent. Another way to look at this is that 89 percent of your monthly bandwidth charge is for bandwidth that is not being used.

600 ms average delay for satellite links

Link Size	Windows XP max throughput	Potential Wasted Bandwidth	Windows 2000 max throughput	Potential Wasted Bandwidth
512K	850 Kbps	0	213 Kbps	299 Kbps/58%
2 MB	850 Kbps	1.15 Mbps/57%	213 Kbps	1.78 Mbps/89%
10MB	850 Kbps	9.15 Mbps/91%	213 Kbps	9.78 Mbps/97%
45 MB	850 Kbps	44.15 Mbps/98%	213 Kbps	44.79 Mbps/99%
155 MB	850 Kbps	154.15 Mbps/99%	213 Kbps	154.78 Mbps/99%

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 transactions and large file transfers are slow. The ability to accelerate transactions and large file transfers is the key to resolving these issues.

THE SOLUTION

While it is almost impossible to eliminate latency over networks, steps can be taken to minimize the impact and significantly improve data transmission quality. SkyX addresses these challenges.

What's Needed to Accelerate Application Traffic?

Considering the variety of network limitations and their associated impact on costs, a comprehensive solution is needed to address the problem and accelerate traffic. In order to accelerate application traffic, the solution must be able to *eliminate*:

- The impact of high latency due to distance delay
- Poor performance of large flows such as large file transfers, disaster recovery backups, database synchronizations
- The effects of high packet loss and retransmissions
- Wasted WAN capacity and link under-utilization
- Slow and problematic connections

SkyX Solves these Problems

A wide array of technologies is available to increase the window size or compress traffic. However, they fail to meet users expectations or maximize bandwidth utilization. The exception is Packeteer's SkyX. With SkyX, it is now possible to eliminate the impact associated with distance latency and bandwidth utilization. SkyX provides acceleration for both transactions and file transfers to enhance network performance.

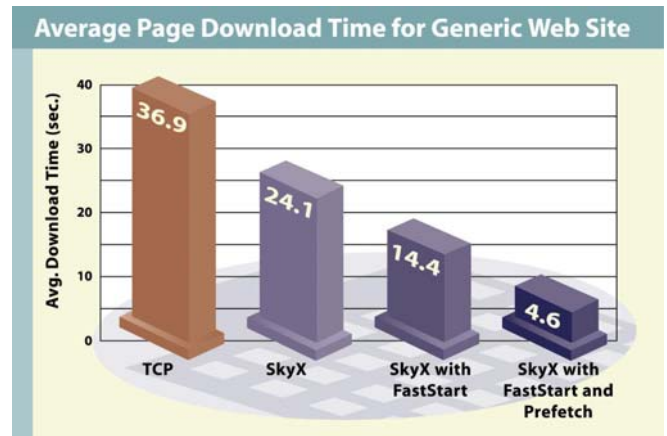
Transaction Acceleration:

With enhanced HTTP performance, response times improve dramatically. SkyX FastWeb technology, which includes Web Prefetch and FastStart, speeds delivery of embedded objects and Web-based applications. It also further accelerates web downloads by reducing the time needed to establish each new HTTP connection.

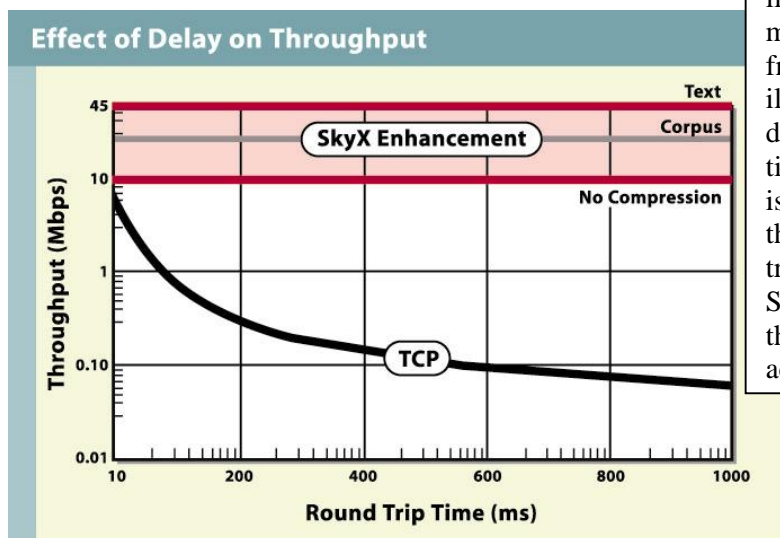
Unlike file transfers that typically consist of a single, large download, web traffic is characterized by large numbers of short connections. FastStart and Web Prefetch are specifically designed to optimize the download and display of Web pages.

FastStart saves one round-trip time for each Web object by reducing the handshaking required to establish each new HTTP connection. Using FastStart, SkyX 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. SkyX 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.

Web Prefetch reduces the time required to download and display each web page by proactively retrieving the embedded graphics and other objects on each page along with the requested HTML file. The server-side SkyX intercepts the HTML files returned by the web server and begins retrieving the various embedded objects on that page on behalf of the browser. The server-side SkyX then pushes the objects to the remote side of the link where they are served by the browser-side SkyX when requested by the browser, thereby avoiding the network delay.



Round Trip Delay vs. Throughput



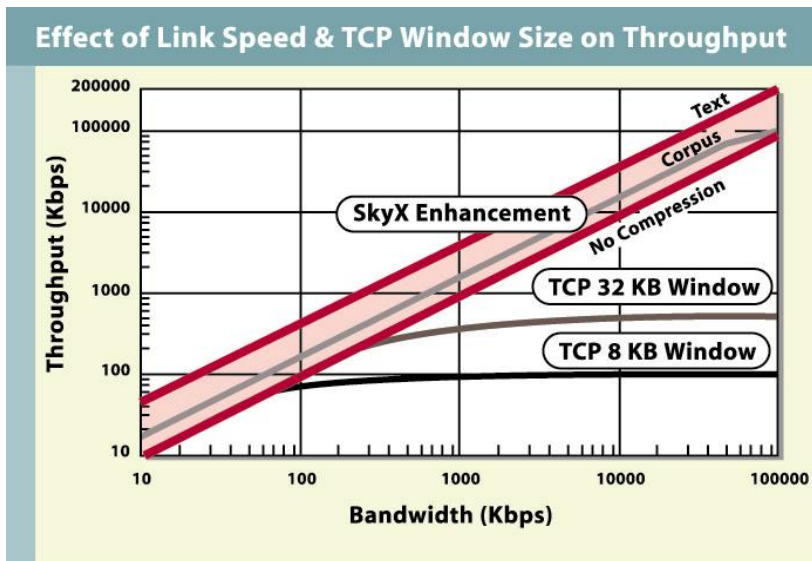
SkyX removes the dependency of TCP on the round-trip time of the link. This figure shows the measured throughput on an error-free, 10 Mbps link. These results illustrate that TCP throughput drops rapidly as the round-trip time increases. In contrast, SkyX is able to maintain full usage of the link regardless of the round-trip time. For compressible text, SkyX consistently delivers throughput rates greater than the actual bandwidth.

- SkyX Transaction Acceleration**
- Reduce round trips using FastStart
 - Reduce round trips by eliminating TCP slow start
 - Reduce round trip waits using Web Prefetch
 - Reduce application wait times due to more efficient retransmission behavior

File Transfer Acceleration:

SkyX accelerates all TCP-based applications -- including Web access, FTP file transfers, ERP, and email -- by replacing TCP with a protocol specifically optimized for long delay, high bit error, and asymmetric bandwidth conditions. The result is faster performance for database connectivity, Web applications, and remote access applications while maintaining full TCP reliability and end-to-end flow control.

SkyX transparently intercepts TCP connections from the client and converts the data to the Xpress Transport Protocol (XTP) for transmission over the network. SkyX on the opposite side of the link then translates the data back to TCP for communication with the server.



Without performance enhancement, a default window size of 8 KB limits TCP throughput to less than 100 Kbps over satellite. Even on operating systems using a 32 KB window, TCP is only able to reach a throughput of 440 Kbps. SkyX protocol translation overcomes this limitation, taking full advantage of the available bandwidth regardless of the window size of the end nodes. For compressible data, SkyX can provide throughput rates far greater than the link bandwidth.

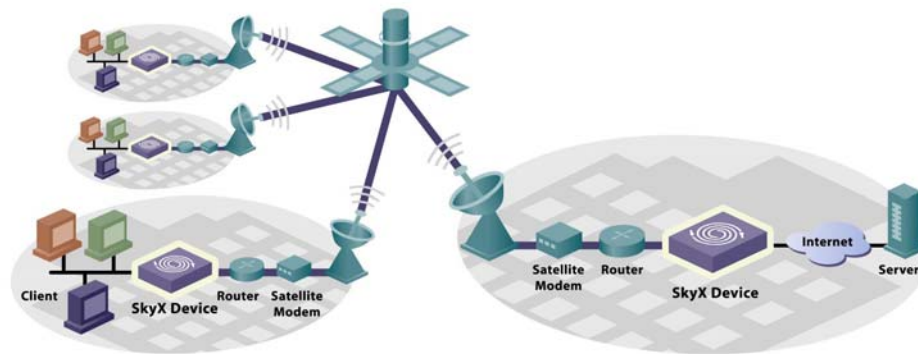
The large XTP window removes network dependency on the bandwidth-delay product, allowing high throughput independent of the TCP window size of the end nodes. To optimize bandwidth utilization, SkyX dynamically adjusts the XTP window size based on the link bandwidth, delay, and number of simultaneous connections.

In addition, the data compression functionality offers compression ratios of up to 10:1, with typical traffic mixes realizing 2:1 to 4:1 – increasing the amount of data carried over the link.

- SkyX File Transfer Acceleration**
- Increase speed of transfers with window size expansion
 - Increase speed of transfers by eliminating TCP slow start
 - Increase speed of transfers by eliminating loss backoff effect
 - Reduce application wait times due to more efficient retransmission behavior.

How to Deploy SkyX

SkyX is fully transparent – no changes, modifications, proxies, or settings required. SkyX's efficient protocol-layer architecture delivers higher performance and scalability. And because SkyX can be managed by a browser or CLI, it can be up and running without extensive installation and troubleshooting.



SkyX Product Line

SkyX Gateway - Ready-to-install, rack-mounted hardware device provides SkyX performance to all network devices. The SkyX XR10 is ideal for branch offices or for use as a remote unit on hub spoke networks. SkyX XH45 and XH155 are perfect for hub sites with XR10 or with the SkyX Server complementing them at remote sites.

SkyX Client/Server - For mobile users on a VPN and remote branch offices, the SkyX Client/Server SS10, SS45, and SS155 combine a client software solution installed on end-user PCs working in conjunction with server hardware located at the network hub.

Summary

SkyX's combination of transaction and file transfer acceleration provides significant benefits to drive optimal business productivity:

- ☑ Accelerated TCP over high latency links, such as satellite
- ☑ Optimized WAN application performance, link utilization and efficiency
- ☑ Enhanced web-based performance and improved response times
- ☑ Maximized bandwidth utilization and ROI
- ☑ Expedited delivery of large flows and file transfers

SkyX is part of a complete solution from Packeteer that also includes network visibility, control, and management. Packeteer's solution provides insight into performance issues with application intelligence and real-time monitoring, ensures application availability and performance with QoS control, and increases WAN capacity with advanced compression capabilities. For large-deployments, centralized management increases efficiency and productivity for low total cost of ownership.