



Optimizing and Accelerating Satellite Communications- A New Perspective

A Technology White Paper

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23020 Eaglewood Court #100
Sterling, VA
800-677-5050 | www.ltidata.com

Introduction

When land-based wired or wireless communications are either insufficient or non-existent, satellite communications stand as the only viable option to maintain critical network connectivity. Within the Department of Defense (DoD), satellite often serves as the primary link between ground forces and their command. At the federal civilian level, reliable access to agency resources and information is not merely a factor in achieving the mission; it can mean the difference between success and failure – and often the difference between life and death. Beyond day-to-day operations, satellite communications also continue to be a core feature of agency Disaster Recovery/Continuity of Operations (DR/COOP) planning.

Yet, despite the clear and compelling need for satellite communications and its wide deployment across the federal civilian and DoD landscape, it remains an expensive and sometimes uneven technology, with bandwidth costs significantly greater than those of land-based communications networks and the technology beset by latency and other performance issues.¹ Latencies over standard geosynchronous satellite wide area networks (WANs) take 540 milliseconds (ms) or more, hundreds of times that of local area networks (LANs). Packet loss and high error rates further compound the problem, making Internet connections via satellite a very difficult experience for many government users. These issues with satellite have also contributed to underutilization, with many agencies only operating at 25 percent or less capacity when using standard TCP/IP over satellite channels.

With an annual budget deficit exceeding \$1 trillion a year and increasing pressures from a skeptical public, the federal government is tightening its belt, exploring all possible measures for reducing costs. Improving satellite utilization through better performance will not only increase mission readiness, it could significantly reduce the cost-burden on agencies.

Thankfully, there is now a solution that addresses the traditional low bandwidth, high latency obstacles that impede the speed and performance of applications and services transmitted over satellite links – WAN optimization from Riverbed Technology. With this solution, it is not uncommon for an agency to actually receive utilization rates that exceed their expensive satellite links; deferring bandwidth upgrade costs and reducing operating expenses through increased user productivity. Further, Riverbed's unique implementation of the SCPS protocol ensures high performance even in challenged networking environments, while complying with DoD interoperability standards.

¹ www.gao.gov/products/GAO-10-825

Challenges: Bandwidth, Latency, and Packet Loss

Agencies looking to better utilize satellite communications can face a variety of environmental and operational obstacles. The first is the availability of the bandwidth itself. Many satellite networks are constrained by either the unavailability of satellite bandwidth in their operating region or on their preferred satellite, or simply do not have the budget for needed bandwidth upgrades. The SATCOM operator is often faced with the challenge of doing more with less. As DoD users look to expand the role of satellites to support operations commonly performed over the LAN or terrestrial WAN, the fundamental differences in the nature of satellite bandwidth can make these goals an impossibility.

Another major challenge is latency, typically manifested in the form of propagation or processing delay. Round-trip latency is defined as the time it takes one device to send and receive a unit of information from another device. Latency is measured in milliseconds and is based on a number of factors, chief among them being the physical distance between the devices. In land-based communication networks, the distance between the user and the server varies considerably, with the average latency of client-server communications on a WAN being around 40 ms. In the case of a geosynchronous satellite at an altitude of 22,000 miles, round-trip latency is 540 ms, and often reaches 700 ms and beyond when other networking factors are introduced. For double-hop satellite connections the latency can reach a full second or more. This not only limits the ability of TCP to efficiently transport data packets, but also seriously impedes the performance of applications such as disaster recovery operations, Common Internet File System (CIFS), Microsoft SharePoint, SMTP (email), and a host of other common traffic types.

Performance loss in these connections, however, is the result of more than just the physical distance between device endpoints. Satellite is often beset with high packet-loss from a variety of intrusions, including weather events, power outages, blockage, and interference. This level of packet loss varies according to environmental and operational network conditions, but any packet loss or reorder can have a profound effect on throughput. High error rates can increase network transaction speeds to intolerable levels, frequently resulting in retransmissions, timeouts, and badly degraded user experiences.

At the heart of satellite performance problems are the protocols that drive the network, both at the transport layer as well as the applications themselves. Over a high-speed LAN where latency is minimal and bit errors approach zero percent, TCP functions almost flawlessly. But over links with a half-second delay and environmental bit errors, TCP is confounded. It inaccurately associates loss with congestion and unnecessarily reduces transmission windows. Because of this improper congestion response, TCP can never fully utilize the link.

Compounding the problem are the protocols at the application layer. Many are “chatty,” requiring a high volume of small packet back-and-forth transfers to complete the transaction. With each transfer requiring a half second round trip time, even a simple file transfer could take minutes to complete. If carried by a TCP implementation with a small transmission window, the result is an application that is essentially unusable over satellite. High latency, matched with protocols designed for land-based systems, means that agencies engaged in satellite communications suffer degraded mission readiness and capabilities. Some IT departments mistakenly assume the issue is the result of constrained bandwidth, and pour more resources into increasing the size of their satellite channels. However, more bandwidth does nothing to mitigate latency or modify the protocols that high-latency frustrates; even with the added cost of more bandwidth, the performance remains unchanged.

The Solution: Application Acceleration and WAN Optimization

Recognizing the issue of latency and its deleterious effects on the fighting force, the DoD initiated a joint industry partnership to develop a common standard protocol for Internet-over-satellite communications. Through a collaborative, multi-year R&D effort, the partnership created the Space Communications Protocol Standards-Transport Protocol (SCPS-TP, commonly referred to as ‘skips’). SCPS required a basic rethinking of the network and represented the first major development in satellite acceleration.

Unlike TCP, the SCPS protocol was designed to operate in an environment of high-latency and limited bandwidth. The first commercial implementation of the SCPS protocol was released under the brand name SkipWare, now an exclusive technology in the Riverbed product family. A pioneering product in the SCPS community, SkipWare is responsible for most of the industry firsts associated with SCPS, and is largely credited for the widespread adoption of the protocol today. Expanding on the early work done with SCPS, SkipWare goes far beyond the original capabilities of the protocol to become the robust, full-featured technology solution it is today.

SkipWare provides many tools and performance features that far exceed the original specification of the SCPS protocol. Perhaps its greatest differentiator is SkipWare's ability to operate seamlessly with modern modem technologies. The proliferation of dynamic bandwidth transmission systems, such as TDMA and DVB, presents a unique challenge to WAN optimization technologies. As bandwidth allocation changes over the network, WAN optimization technologies must be able to automatically detect these changes and respond accordingly. SkipWare is designed to sense increases and decreases to bandwidth allocation and automatically adjust its transmission window in response, without requiring user intervention. SkipWare is highly responsive to these fluctuations, providing adjustments on a per round-trip time basis. It can be deployed seamlessly with the industry's best known SATCOM modems, including iDirect, ViaSat, and Comtech EF Data, providing first-class interoperability for the federal customer.

SkipWare has also been designed to provide rapid recovery from packet loss, allowing users to operate at high levels of bandwidth efficiency even over very "dirty" links. Specialized recovery mechanisms such as Selective Acknowledgments (SACK) and Selective Negative Acknowledgments (SNACK) have been built into SkipWare to recognize packet loss on the network, but respond by simply marking lost packets for later retransmission. Only under extreme circumstances does SkipWare reduce its transmission window in response to loss; maintaining line rates even with high bit errors and packet reordering. These loss-resistant technologies, combined with SkipWare's other layer-4 optimization features, provide the perfect complement to the forward error correction technologies commonly used in satellite modems, and increase the overall performance of Riverbed optimization technologies over the satellite channel.

Even with the SCPS protocol deployed as a remedy to the deficiencies of TCP, satellite networks still face a number of performance challenges associated with the inherent limitations of common networking applications over high latency, constrained bandwidth channels. To solve these challenges, LTI DataComm offers the Riverbed Steelhead solution, a full-featured acceleration package for satellite networks that serves as the perfect complement to SkipWare. Where SCPS leaves off, the Riverbed Optimization System (RiOS) picks up. RiOS is the operating system that powers Steelhead appliances, providing multi-layer WAN optimization and dramatically higher bandwidth utilization rates. The industry-leading application and protocol optimization capabilities in RiOS provide agencies LAN-like performance over satellite connections, with out-of-the-box compatibility over any satellite network.

The Riverbed technology optimizes application performance using a combination of TCP optimization, application protocol streamlining and data deduplication. TCP optimization techniques such as connection pooling, local acknowledgements, and increasing the TCP payload size go a long way towards enhancing application behavior over WANs. Specifically of importance to satellite WANs, Riverbed natively supports Loss Tolerant Transport over Satellite (LTTS) and TCP Westwood – to estimate the available bandwidth on a link.

Application protocol streamlining works to reduce the “chattiness” of traditional client-server applications. Optimizing application behavior by read-aheads and write-backs for file sharing protocols such as CIFS or pre-populating users’ mailboxes for MAPI are just a couple of examples of how application protocols can be optimized over WANs.

In addition to features that strike at the heart of latency-bogged networks, at the protocol level, Riverbed Steelhead appliances provide data deduplication on the wire. This process uses intelligent algorithms to recognize data patterns that have previously been exchanged (across applications) so that only new or modified information is actually transmitted over the wire – or in this case, a satellite link. These data patterns are stored on the appliance data store from where the original data is re-assembled, and then sent on to the recipient’s computer. This minimizes the amount of bits and bytes transmitted between a client and server separated by an expensive satellite link. Through this revolutionary technology, a file that might take one minute on the first cold pass can be transmitted subsequently in a “warm pass” in only a fraction of a second (see figures A and B below).

Figure A: Common file transfer rates over satellite at 2 mbps

WAN RATE: 2 mbps			
	Not Optimized	Cold Pass & SkipWare	Warm Pass & SkipWare
12.2 MB File	55.67 sec	44.18 sec	.65 sec
162 MB File	11 min 40 sec	8 min 6 sec	13.2 sec
*580 m/s round trip delay, no errors			

Figure B: Common file transfer rates over satellite at 4 mbps

WAN RATE: 4 mbps			
	Not Optimized	Cold Pass & SkipWare	Warm Pass & SkipWare
12.2 MB File	30.47 sec	22.15 sec	.71 sec
162 MB File	5 min 52 sec	4 min 3 sec	14.8 sec
*580 m/s round trip delay, no errors			

For those agencies and warfighters who are deployed in the field, Riverbed also offers Steelhead Mobile client software, which provides WAN optimization on end user laptops.

Security is also a major feature of every communications deployment. Riverbed satellite acceleration is backed by AES 256-bit encryption, certified by the Defense Information Systems Agency (DISA) Joint Interoperability Test Command (JITC), and battle-tested on some of the most secure communications channels in the DoD. The Riverbed Steelhead appliances store transmitted information through encrypted byte caching, meaning that the data is saved as 1s and 0s, rather than as files and folders. Even if a physical terminal is breached or stolen, the files themselves cannot be compromised.

Practical Use Case

The DoD faces some of the most difficult communications environments in the world. Deep in the mountainous terrain at the edge of Afghanistan, sending and receiving critical intelligence can be more than a challenge. Without any infrastructure, the DoD has few options. Building a fixed-based communications channel often requires constructing – and defending – radio towers or fixed wireless infrastructures. Even satellite can be a challenge, with the mountains themselves sometimes standing in the way of a clear shot to the satellite. In these scenarios, the DoD often leverages unmanned aerial vehicles (UAVs), which serve as way-stations between satellites and warfighters on the ground. But this adds a new link in the chain and further slows down communications, increasing latency to as great as 2,000 ms. With two seconds per transaction, and one hundred transactions often needed to load a simple web-page, the standard TCP/IP protocol breaks down and application failure is common. LTI DataComm was able to deploy the Riverbed WAN optimization technology and deliver a 75 percent reduction in data latency on the battlefield – enabling deployed warfighters to receive and respond to actionable intelligence without delay.

The LTI DataComm Approach

With 30 years of experience in the federal IT market, LTI DataComm is a proven and trusted partner of leading government agencies and the DoD. LTI DataComm is committed to providing world class technologies that have been certified to operate on DoD networks and improve network visibility, performance, and security. Partnering with the pioneers in satellite acceleration, Global Protocols, and with Riverbed, the market leader in wide area data services, LTI DataComm is the leading WAN services specialty company.

LTI DataComm provides solutions and services through the following contract vehicles:

GSA – NETCENTS – ECS III – SEWP IV – ITES-2H – BLS BPA – Seaport-e

Deployment Process

LTI DataComm provides a simple and efficient deployment process for all federal government customer engagements.

1. The government customer engages the LTI team to define current performance issues
2. LTI addresses questions and concerns through open discussion and white-boarding of technologies
3. LTI provides comprehensive engineering support to test these technologies in the customer's environment and to understand success criteria for deployment
4. The customer evaluates the proposed ROI
5. The customer orders products through LTI's streamlined acquisition process
6. LTI deploys the equipment as architected for the customer's network
7. LTI addresses any proposed changes to customer requirements
8. LTI ensures success through follow up and additional services if necessary

ROI remains an important consideration of any WAN optimization implementation. LTI DataComm provides agencies with a detailed analysis of the capital expenditure (CAPEX) proposed versus the customer's current operational expenditure (OPEX) and helps to set expectations and future cost savings prior to a purchase commitment. While the time to recapture upfront costs for this technology varies, LTI DataComm often sees customers benefiting in as few as 8-9 months.

Government agencies are constantly seeking new ways to improve both their network performance and costs incurred when deploying satellite communications. In conjunction with Riverbed, LTI DataComm provides a proven, secure, and cost-effective solution that helps realize immediate network performance improvements. For more information, please visit www.ltidata.com or contact your local sales team at (800) 677-5050.

About LTI DataComm

LTI DataComm, a woman-owned/veteran founded small business established in 1981, is a supplier of superior network and security solutions to the federal government. They enable mission critical IT objectives to be met by providing engineering expertise and program support services through a comprehensive Managed Solutions offering. LTI DataComm engineer teams design, integrate, and support Network Performance Optimization, Cyber Security, and Enterprise IP Video solutions that deliver highly measurable results and maximize IT investments. LTI DataComm drives client success through the development and implementation of network solutions by leveraging strategic partnerships, an intimate understanding of end-user requirements, leading-edge technical knowledge, and customer-focused personnel. Additional information can be found at www.ltidata.com.

About Riverbed

Riverbed delivers performance for the globally connected enterprise. With Riverbed, enterprises can successfully and intelligently implement strategic initiatives such as virtualization, consolidation, cloud computing, and disaster recovery without fear of compromising performance. By giving enterprises the platform they need to understand, optimize and consolidate their IT, Riverbed helps enterprises to build a fast, fluid and dynamic IT architecture that aligns with the business needs of the organization. Additional information about Riverbed (NASDAQ: RVBD) is available at www.riverbed.com.