Riverbed Optimization System (RiOS) 9.1

A Technical Overview

NOTICE:
New Product Names

The contents of this asset do not reflect our recent product name changes. Here are the new Riverbed® names:

Old Names	New Names
Steelhead	SteelHead™
RPM, OPNET, Cascade	SteelCentral™
Stingray	SteelApp™
Granite	SteelFusion™
Flyscript	SteelScript™
Whitewater	SteelStore™

Table of Contents

SteelHead 9.1 New Features (formerly RiOS 9.1)

The following table highlights some of the new features discussed in this document.

Feature	Description
Internet Accelerator / Web Proxy	Caches large video objects including static videos and YouTube on-demand streaming video via HTTP(S) on the local (branch) SteelHead.
Link Aggregation / Etherchannel	Allow customers to connect ports bundled using Etherchannel to a single SteelHead using multiple inpaths.
Path Selection on Interceptor	Path Selection is now fully integrated with Interceptor.
Hardware Security Module (HSM)	Ability to use external Hardware Security Modules for certificates management in SteelHead.
Application Stats	Provides layer 7 visibility of application usage on the network.
Feature Enhancements	**Description**
Live Video Stream Splitting	Improved Stream Splitting performance for Microsoft Smooth Streaming, Adobe HTTP Dynamic Streaming and Apple HTTP Live Streaming video formats with a 5 times larger cache.
MAPI over HTTP	Provides bandwidth reduction for the new MAPI over HTTP protocol.
Citrix Auto-Negotiate Multi-Stream ICA	Enables the use of multiple TCP connections to carry traffic for a Citrix session on either port 1494 or 2598.
QoS Improvements	Significant performance boost and limit CPU utilization for QoS optimized traffic.
DSCP Marking for SteelHead Control Plane	Provide OOB DSCP marking and QoS for SteelHead Control Packets.
Updated AFE Classification	135 new applications related to web services, streaming media, games, network management, networking, file transfers, VPN and tunneling have been added.
SaaS Extension	Extends SaaS support for new applications: Box, SuccessFactors, Microsoft Dynamics and ServiceNow.

RiOS 9.0 Features

Feature	Description
SMB v3.02 Qualification	SMB v3.02 (Windows 8.1 and Windows Server 2012 R2) is now fully qualified.
QoS enhancements	Enhancements to simplify Basic QoS with the flexibility of Advanced QoS, along with inbound and outbound QoS feature alignment.
Path Selection enhancements	Enhancements to increase deployment flexibility, tune default behavior, simplify configuration and administration.
Secure Transport	Secure all IPv4 traffic between Path Selection sites (optimized and pass-through).
Integration with SteelCentral AppResponse	Monitor End User Experience for optimized web applications.
SteelHead SaaS GeoDNS	SteelHead's GeoDNS feature for Office 365 to improve optimization for Office 365 users.

The Riverbed Optimization System (RiOS)

Introduction

The Riverbed Optimization System (RiOS™) is the software that powers Riverbed's unique award-winning line of SteelHead™ application optimization, control and visibility appliances and SteelHead Mobile package.

Riverbed SteelHead is the industry's #1 optimization solution for accelerated delivery of all applications across the hybrid enterprise. SteelHead also provides better visibility into application and network performance and the end user experience plus control through an application-aware approach to hybrid networking, including path selection and QoS, and based on centralized, business intent-based policies for what you want to achieve – as a business.

A leader in the "Gartner Magic Quadrant for WAN Optimization Controllers" for seven years in a row, SteelHead pioneered WAN optimization in 2004. Today, Riverbed is leading the evolution from the traditional WAN model to providing optimization, visibility and control for the hybrid enterprise.

With RiOS, enterprises can implement solutions that help them to empower their distributed workforce while eliminating IT capital expenditures and simplifying IT management. Organizations often can achieve the following results with RiOS:

- **More productive users.** Applications can be accelerated by up to 100x, providing LAN-like application performance regardless of a user's location. Real-time and business critical applications flows can be protected using application-aware QoS.
- **Consolidated IT Infrastructure.** LAN-like application performance means that IT can be virtualized and centralized with no degradation in the end-user experience.
- **Hybrid network management.** Networks combining Internet and MPLS links can benefit from automated path selection, encryption of backhaul traffic, integration with cloud based security services and inbound QoS for local Internet-breakouts.
- **Reduced bandwidth utilization.** Organizations can cut bandwidth expenses and defer WAN upgrades to control costs.
- **Enhanced backup, recovery, and replication.** Backup, restoration, and data replication operations are accelerated helping minimize data loss and achieve shorter recovery point and time objectives (RPO/RTO). File servers, application servers and even virtual machine images can be backed up in minutes instead of hours or days.
- **Improved data security.** Data in remote offices can be centralized to remediate exposure points and risk to the organization, and backup tapes can be eliminated in branch offices.
- **Secure application acceleration.** Optimize SSL traffic without compromising the end-to-end trust model. Companies subject to compliance regulations such as SOX, HIPAA or PCI can deliver both performance and security for applications regardless of location
- **Enable the mobile workforce.** Overcome sub-optimal application performance for remote workers to bring productivity and performance expectations on par with in-office workers.
- **More cost-effective use of WAN resources**. RiOS provides inbound and outbound QoS capabilities for controlling recreational traffic and prioritizing business traffic on the WAN. The QoS engine can

identify up to 1300 applications for straightforward management of multiple traffic types.

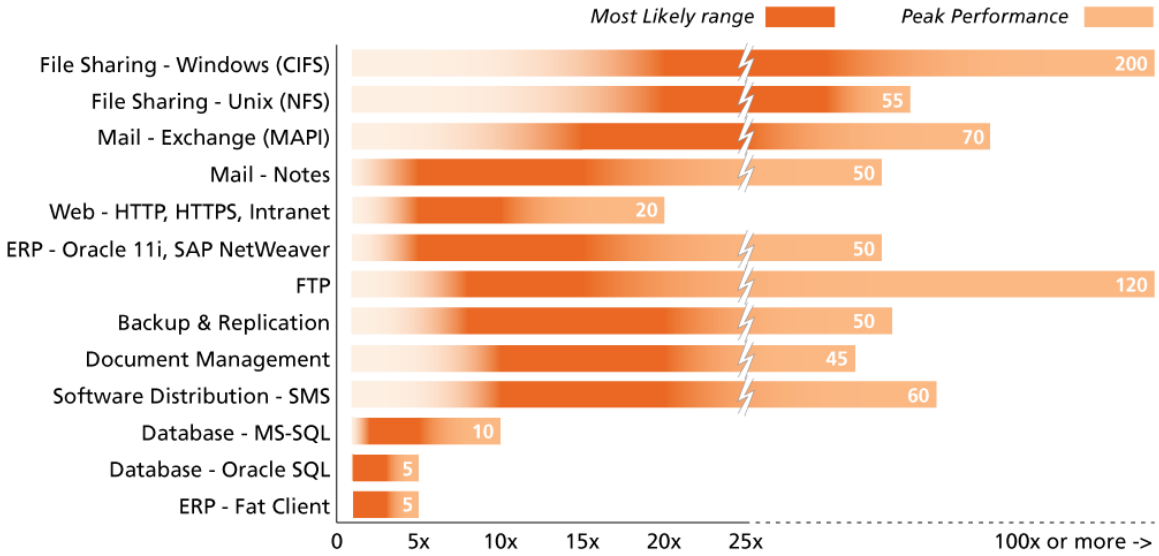
RiOS is designed to provide the highest performance across the applications that enterprises care about the most, while at the same time making it easy to deploy, manage, and monitor WAN optimization. RiOS provides an integrated framework for data reduction, TCP optimization, application-level optimization, QoS, path-selection, encryption of traffic, visibility and management services to provide a comprehensive solution for enterprise WAN optimization. RiOS scales across a range of applications and network topologies.

This paper is intended to introduce the major components of RiOS, and explain how they benefit the user. The RiOS technology is implemented in software that can be delivered in a way that meets the requirements of different environments and form factors. RiOS software can be deployed as a physical or virtual appliance, the end-user mobile Microsoft Windows laptop or desktop, or instantiated in the cloud on demand. The technology supports multiple types of cloud-based installations.

Why Customers Choose SteelHead products

Customers choose Riverbed SteelHead products for five main reasons: (1) best performance across a range of key enterprise applications, (2) a complete and integrated feature set that goes beyond traditional WAN optimization to include control and visibility, (3) the largest set of deployment options from cloud to end-user devices, (4) greatest scalability, and (5) easiest to deploy, manage, and monitor.

Riverbed SteelHead products accelerate the broadest scope of key enterprise applications using a multi-tiered optimization approach that yields significant performance gains for customers. SteelHead optimization technology leverages a superior data reduction algorithm and transport layer optimization to provide a foundation for acceleration of all TCP-based traffic. Above this foundation, RiOS further optimizes several application protocols via application-specific modules. The combination of this multi-tiered approach yields the best performance for key enterprise applications.



Riverbed SteelHead feature set has evolved to encompass not only WAN optimization but also control and visibility. When deploying SteelHead, beyond the ability to accelerate applications and reduce WAN traffic, customers can also apply QoS to protect business critical applications and real-time traffic, manage hybrid networks using a complete range of techniques and get visibility on network and application performance of their branch traffic. All optimization, control and visibility features work at unison ensuring consistency of application policies across all mechanisms.

Riverbed SteelHead products are now available in many different form factors including a range of appliances but also virtual appliances for virtualized datacenter and branch deployments. Riverbed SteelHead products offer multiple cloud deployment options including solutions for IaaS and SaaS. Finally SteelHead can be deployed on end-user devices running under Windows or Mac OSX.

The Riverbed WAN optimization solution was built from the ground up with an architecture that offers the greatest scalability on a number of dimensions. SteelHead products' universal data store combined with a patented hierarchical encoding provides unparalleled storage scalability and data reduction efficiency. Auto-discovery enables support for full mesh MPLS and complex network environments, giving organizations a faster ramp-up capability as well. The resulting customer adoption has led to large-scale SteelHead deployments in hundreds of sites around the world. Our common architecture platform also allows us to offer a unified solution between datacenters, branch offices, and mobile workers wherever they may be.

Many customers can deploy SteelHead products in a matter of minutes and with minimal ongoing administrative overhead. This virtually plug-and-play deployment capability helps customers achieve their optimization goals faster. In addition, SteelHead support for a bevy of network environments and topologies provides flexible and seamless network integration into existing infrastructure. SteelHead products give customers even greater flexibility by providing three WAN visibility modes for deployment (more information on WAN visibility modes is available in the "Transparency" section below). While other solutions force customers to make changes to their network in order to "fit" the solution in, Riverbed provides customers with optional modes of operation so they can decide which mode is most appropriate for their network infrastructure.

From a product architecture perspective, Riverbed has been at the forefront of WAN optimization technology. Riverbed's award-winning products have consistently proven themselves as the highest performing accelerators across the broad spectrum of applications that enterprises depend on. Exhibiting technological leadership, Riverbed has been selected as the "Technology of the Year - WAN Accelerators" by InfoWorld eight times (2005, 2006, 2007, 2008, 2009 and 2011, 2013 and 2014).

RiOS provides a complete approach to WAN optimization and acceleration that addresses the problems of bandwidth, latency and application protocol chattiness through a unified solution. RiOS also includes control capabilities including QoS, path selection, traffic encryption and other features to manage applications over a hybrid Internet and MPLS network according to their performance needs and criticality to the business. Finally, RiOS enables visibility on network traffic by reporting on application usage and by feeding Riverbed Performance Management products by capturing key performance metrics for further analytics by tools like SteelCentral NetProfiler. With enterprise management capabilities and numerous deployment options, RiOS gives customers flexibility with minimal configuration requirements.

RiOS - WAN optimization

This section covers WAN optimization and acceleration to address the problems of bandwidth, latency and application protocol chattiness.

RiOS optimization principles

RiOS optimization is designed with an application-independent foundation that enables Riverbed to build additional, application-specific optimizations on top of it. The components of RiOS optimization can be broken into four major groups, each with a different, but complementary goal:

Technology	Description	Result
Data Streamlining	Data deduplication to optimize WAN bandwidth utilization	WAN bandwidth utilization reduced by up to 60% to 95% Prioritize applications by bandwidth and latency
Transport Streamlining	Eliminate transport protocol inefficiencies	Applications accelerated by up to 100x
Application Streamlining	Optimize application protocol performance on WANs	Up to 98% reduction in packet round trips
Management Streamlining	Enable transparent deployment, centralized management, and virtualized branch office services	Fewer IT resources required for deployment and management. Simplify branch office infrastructure by virtualizing core services.

The RiOS TCP-Proxy Architecture

RiOS operates as a transparent TCP proxy. During TCP connection setup with Riverbed SteelHead Appliances, RiOS implements the logical single end-to-end TCP connection with three back-to-back TCP connections. The TCP proxy connections are established in a one-to-one ratio with no encapsulation, traffic mixing, or tunnel configuration. The two "outer" connections seen by the client or server look the same as an unoptimized single connection, while the "inner" connection is invisible to client and server, and allows RiOS to perform a variety of performance improvements for transmissions across the WAN. This design allows RiOS-powered products to optimize transfers across the WAN with no disruption or reconfiguration of clients, servers, or routers.

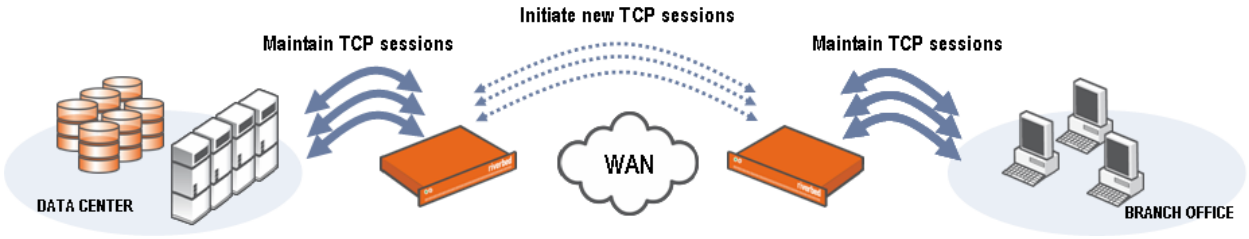


Figure 2, RiOS creates new TCP sessions across the WAN, which allows it to optimize WAN transfers with no changes in existing infrastructure.

With the SteelHead Mobile, RiOS acts as the WAN optimization endpoint while running on the remote computing device. In this scenario, RiOS replaces the original single end-to-end TCP connection with two back-to-back TCP connections. The server-side connection appears the same as its original connections, while the RiOS optimized connection accelerates traffic over the WAN directly from the remote computing device.

Figure 3, RiOS optimizes TCP connections over the WAN directly from the remote user's device (notebook computer, tablet, etc.).

Transparency

With regard to WAN optimization, "transparency" is often used to refer to the use of endpoint source and destination IP header information as optimized traffic flows through an appliance. The claimed advantage is that this practice provides an easier route to implementation and greater traffic visibility. While there are some corner cases where fully transparent solutions may be applicable, the reality for customers is that transparency can often create significant problems working with firewalls and mis-routing traffic. For more information on transparency and its challenges, please refer to the white paper, "Understanding the Hidden Caveats of Network Transparency."

Riverbed recognizes that organizations have varying network designs and visibility needs for their traffic. Consequently, RiOS provides three WAN visibility modes to give customers flexibility when deploying SteelHead products in their network. The three visibility modes are Correct Addressing, Correct Addressing plus Port Transparency, and Full IP Address and Port Transparency. The paragraphs below offer a high-level description of each mode and a brief overview of the scenarios where one would utilize one mode over another. It is worth noting that Riverbed is the only WAN optimization vendor that gives customers this level of flexibility rather than forcing a specific transparency mode onto the customer's network.

Correct Addressing

Correct Addressing refers to a mode in which RiOS addresses optimized traffic across the WAN so as to accurately reflect the source, destination, and nature of each packet. The endpoint source and destination IP addresses are used on the LAN portion of the network for the unoptimized traffic seen by the endpoints. However, optimized traffic over the WAN flows from a SteelHead appliance to a SteelHead appliance and is meaningful only to those appliances, so Correct Addressing sends that traffic using the appliance addresses. When performing Correct Addressing, RiOS also utilizes port 7800 for optimized traffic flows by default. Using this dedicated port in Correct Addressing mode does not tunnel traffic over the WAN. Instead, the traffic remains unencapsulated and TCP flows are proxied on a one-to-one basis for each connection.

Correct Addressing is the most commonly implemented visibility mode for Riverbed customers, because it is the easiest and most reliable mode to deploy. Many organizations also use Correct Addressing in

conjunction with real-time traffic such as VoIP, videoconferencing, and other QoS traffic, and RiOS functions seamlessly in this mode. In addition, SteelHead appliances using Correct Addressing can perform NetFlow exports for customers who desire greater visibility as well. The diagram below shows how traffic is essentially NATed as it traverses the infrastructure.

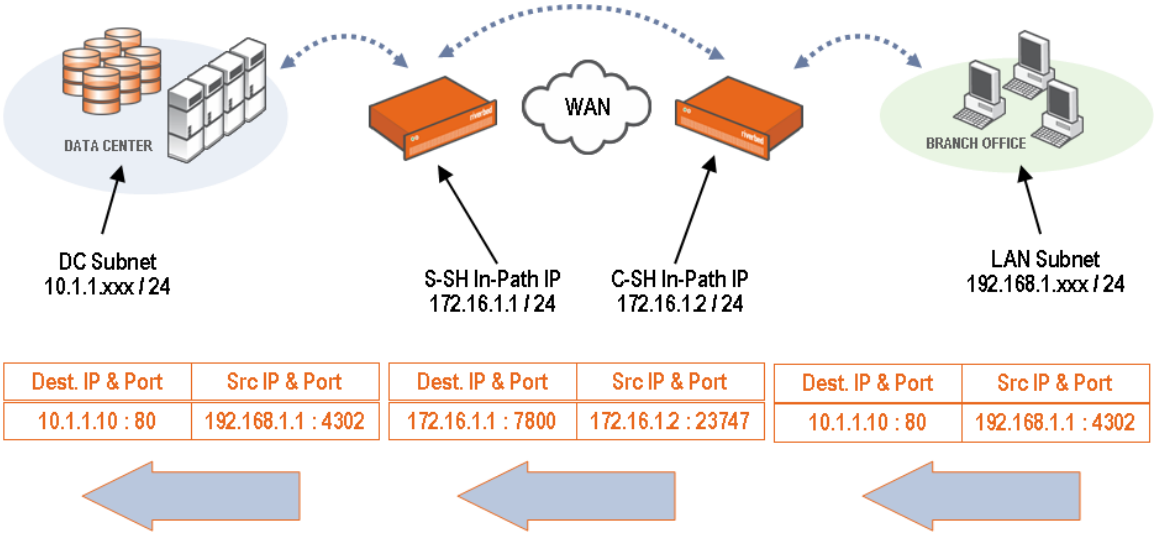


Figure 4, Correct Addressing mode uses SteelHead appliance addresses and ports over the WAN. This is the default mode of operation and the vast majority of implementations are deployed in this fashion.

Correct Addressing plus Port Transparency

Correct Addressing plus Port Transparency introduces a mild form of "spoofing" for the traffic sent over the WAN. Although the appliances are actually sending optimized traffic that looks different to network inspection devices from the "original" unoptimized traffic, Port Transparency uses those same original source and destination ports for optimized traffic sent across the WAN. However, in this mode the WAN traffic is still addressed to and from the appliances' IP addresses – only the port information is spoofed. Customers using this mode keep the benefits of Correct Addressing in terms of reliability and ease of deployment, and gain the ability to solve some problems that are more easily addressed by spoofing ports. For example, integrating into some port-based traffic classification or reporting systems on the WAN side of SteelHead appliances can be easier by using Port Transparency. Port Transparency still needs to be used with some caution since it can lead to unexpected results, especially with any technologies that inspect traffic and check for anomalies; but it also has the significant benefit of avoiding the more dangerous risks associated with spoofing source or destination IP addresses.

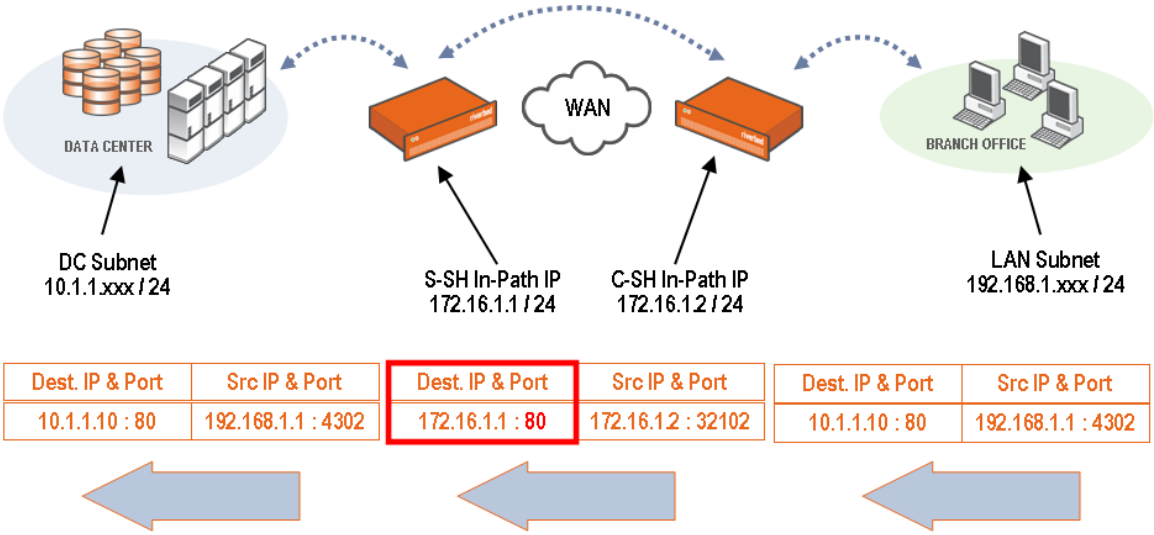


Figure 5, Correct Addressing plus Port Transparency mode utilizes SteelHead appliance addresses with endpoint ports over the WAN.

Full IP Address and Port Transparency

With Full IP Address and Port Transparency, RiOS offers a complete address-spoofing option. With Full IP Address and Port Transparency, optimized traffic across the WAN is addressed identically to unoptimized traffic on the LAN. Spoofing IP addresses in complex networks may introduce substantial risks of routing loops or misdirected traffic, but it can also solve unusual network integration issues that are hard to solve in any other way. This is particularly true when there is IP-address-based classification or reporting on the WAN side of the SteelHead appliances. Specifically this occurs often with service provider reporting that is based on endpoint IP addresses. Although Full IP Address and Port Transparency might appear to be the "easiest" approach for network integration, deployment experience to date has proven the superiority of Correct Addressing in most networks. In general, customers are likely to have the best results by avoiding the use of spoofing. However, RiOS provides spoofing options to handle even the most complex integration problems. RiOS also supports the use of different addressing modes simultaneously for different traffic, so the need to use Full IP Address and Port Transparency in one part of the network or for one traffic type does not require its use everywhere.

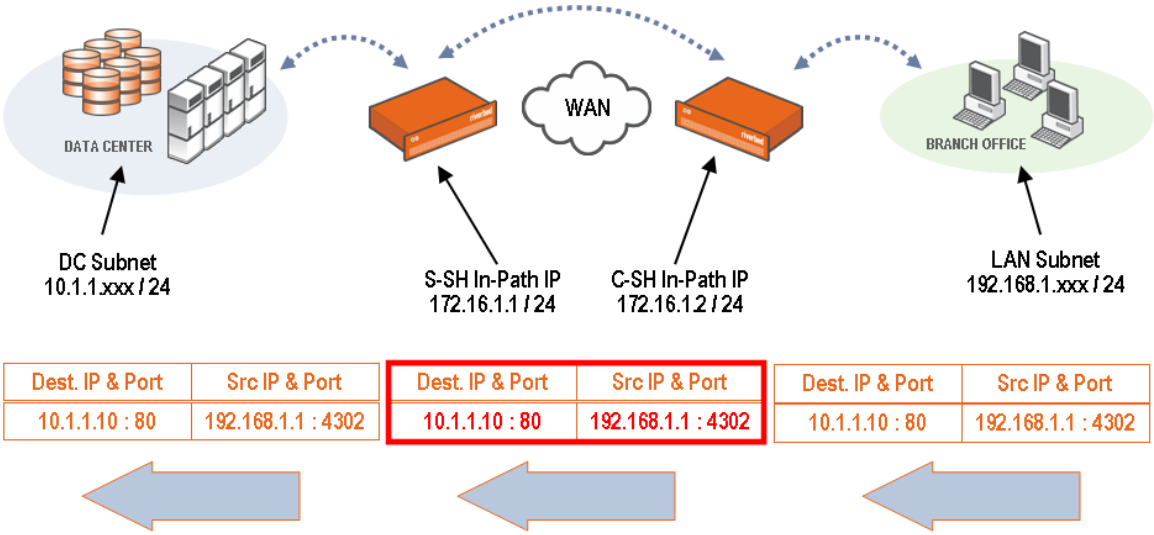


Figure 6, Full Transparency mode utilizes endpoint addresses and ports over the WAN

Transparency functionality has also been further enhanced to allow smoother interoperability with stateful packet inspection (SPI) firewalls. This includes support for NAT, PBR, lossy networks, asymmetric routing, NetFlow, etc. and works with such firewalls as ATT Netgate, Cisco PIX/ASA, Juniper/Netscreen, and Checkpoint.

Application-independent Foundation

With RiOS, all TCP traffic, regardless of the application that generated it, can be intercepted and accelerated. Riverbed's data streamlining algorithms remove redundancy from that traffic to reduce bandwidth utilization. Data streamlining is not limited to a "silo" of a particular application, but can apply optimizations *across* all application traffic. In addition, transport streamlining optimizes the behavior of TCP on the WAN. Moreover, with RiOS, both data streamlining and transport streamlining can be applied to SSL-encrypted data as well as data in the clear.

Contrast this to other approaches, such as caching, that *require* knowledge of the application protocol in order to perform data reduction optimizations. These approaches are limited in what applications they can support and generally cannot optimize transfers based on previous data from other applications.

Additional Application-specific Optimizations

For many widely used applications like Windows file sharing or Exchange email, the application protocols are often the limiting factors to performance across the WAN. In order to have an even greater impact on these applications' performance over the WAN, optimizations must be made to the application protocol itself. Riverbed delivers this capability by including additional application streamlining modules in the architecture. Application Streamlining enables RiOS to address application-specific bottlenecks in addition to the underlying data streamlining and transport streamlining optimizations. Application streamlining allows Riverbed to deliver and improve those optimizations incrementally, without any architectural changes. In the past, industry TCP optimizers or data compression devices have tried to include such application-specific optimizations, but have shown limited performance gains because the system was not designed to support application-independent as well as application-specific optimizations. With RiOS, all applications benefit

from the application-agnostic foundation, and the applications that enterprises care about the most gain more benefits from application-specific optimizations.

Universal Data Store

Building on top of its disk-based architecture, RiOS' universal data store allows the data reduction process to efficiently scale across multiple peers. By avoiding the inherent scalability and performance limitations of per-peer data stores, organizations can save costs on appliance storage and leverage the data reduction benefits of multiple peers feeding a universal store.

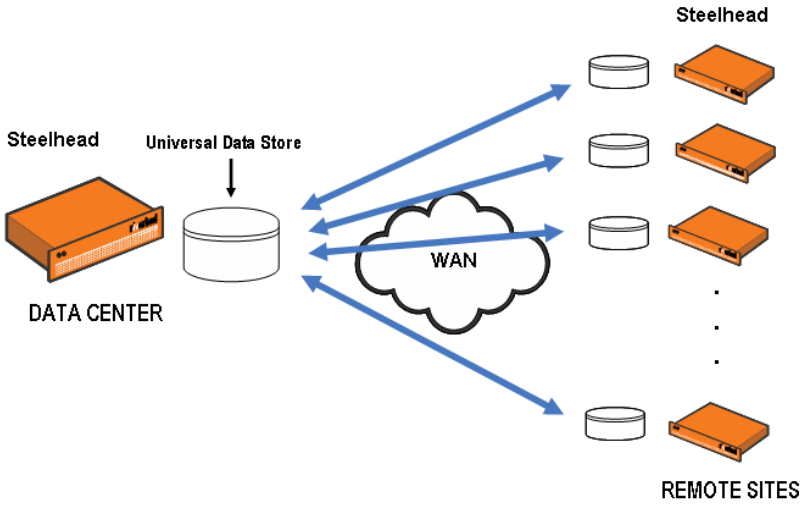


Figure 7, The Universal Data Store maximizes peering efficiency for higher scalability.

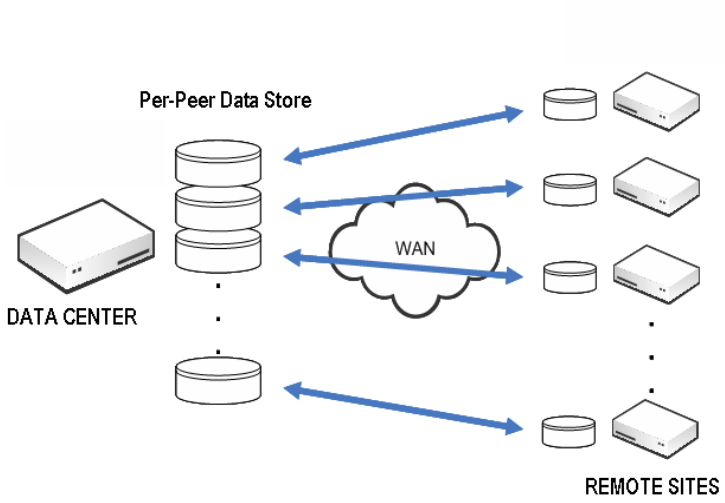


Figure 8, Per-Peer Data Store requires more storage and offers limited scaling benefits with multiple peers.

As detailed in the two figures above, even with identical data used at each remote site, per-peer data store requirements increase incrementally with each additional optimization peer. For example, with per-peer data stores in full mesh environments, the WAN optimization storage requirements can increase significantly, as each data store establishes a peer relationship with all the connected sites. Consequently, the per-peer

architecture can create a severe scalability limitation as companies seek to grow their WAN optimization implementation. In a deployment with multiple sites, per-peer segmentation could reduce usable disk space to only a few gigabytes of disk for each branch resulting in frequent data store "misses" or "cold hits." In contrast, the RiOS architecture supports efficient sharing in a large-scale enterprise environment – a difference that shows up as higher performance, day in and day out, for the Riverbed system.

Smart Communication Architecture

With the RiOS single-copy optimization architecture, all client requests are passed through to the server, just as if the SteelHead appliances were not present. The origin server handles permissions and file locking, as it was designed to do. The client is always assured that the data being sent is the correct data, and not an out-of-date copy. This approach ensures that a client is always working on the original data. Contrast this to approaches that try to short-circuit the application server's permission system by creating multiple local copies of data in branch offices. These approaches introduce the possibility of data integrity issues, data security challenges, and versioning and data coherency problems that can complicate auditing for compliance.

Microsoft Office OpLock Optimization

An additional RiOS feature for Microsoft Office mean latency optimizations over CIFS now remain enabled for all users even in times of contention for the same file, sometimes referred to as "overlapping opens". This optimization improves access times specifically for Microsoft Word and Microsoft Excel files.

Flexible Network Integration

RiOS technology supports virtually any network topology and/or technology capable of handling TCP traffic. RiOS uses a TCP proxy approach to network deployment that does not require the use of tunnels. This methodology allows customers to easily deploy SteelHead appliances and mobile software without modifications to the infrastructure. Organizations can also use Web Cache Communications Protocol (WCCP), Policy-Based Routing (PBR), or other out-of-path deployment options if these methods are desired as well. The absence of tunnels enables RiOS to auto-discover peers and support full mesh environments such as MPLS with minimal configuration, as well as scale efficiently in the largest enterprise environments. RiOS utilizes a TCP-based transport that adheres to standards for traffic management on shared network infrastructure. Using a standards-based transport helps avoid pitfalls associated with proprietary network transport implementations. RiOS also works easily with existing QoS, VoIP, and video conferencing, and provides the ability to mark and enforce QoS traffic on SteelHead appliances based on both latency and bandwidth. In addition to Correct Addressing, RiOS offers two other WAN visibility modes to provide additional flexibility for customers and their WAN optimization implementation.

Designed to Evolve

RiOS combines the benefits of an application-independent foundation and layer 7 protocol optimizations to enable the system to evolve quickly over time. As enterprises implement new applications, use new protocols, and face new demands, RiOS can quickly adapt to meet that need, while still applying data streamlining and transport streamlining optimization to all TCP-based WAN traffic. Other architectures are stuck with a "big bang" approach that requires a complete software redesign in order to provide new functionality, or even worse, a "bolt and glue" mentality whereby vendors acquire various products and try to combine them into one device.

Proven Approach

With tens of thousands of SteelHeads deployed in production environments around the world, RiOS has proven its optimization capabilities with thousands of enterprises and varied network topologies. Riverbed has taken the lead in innovating in the WAN optimization space with multiple vendors now trying to emulate the RiOS architecture and approach. Riverbed continues to build its technological lead through an ongoing process of learning and communication with customers as design partners.

Data Streamlining

RiOS data streamlining works across *all* TCP-based applications including Microsoft Office, Lotus Notes, CAD, Oracle, ERP, databases, and data backup and replication systems; and across *all* TCP-based protocols including, but not limited to, CIFS, MAPI (2000, 2003, 2007, 2010 and 2013) both encrypted and unencrypted, TDS (MS-SQL), NFS, FTP, HTTP, HTTPS, SharePoint and Oracle Forms. Data streamlining ensures the same data is never sent more than once over the WAN. Data streamlining reduces bandwidth consumption for many applications dramatically, typically by 60% to 95%.

Data Deduplication

RiOS intercepts and analyzes TCP traffic, segmenting the data and indexing it. Once the data has been indexed, it is compared to data on the disk or in memory. A segment of data that has been seen before is not transferred across the WAN; instead, a reference is sent in its place. This process enables duplicate data that has been previously sent across the WAN to be replaced by a small reference instead. By using a patented hierarchical structure, a single reference can represent many segments, and thus multiple megabytes of data.

RiOS data references can represent a very large amount of data. Thus, a single reference can represent megabytes of data previously sent over the WAN. The left side of Figure 9 on page 17 shows how this concept works visually.

If the data has never been seen by RiOS before, the segments are compressed using a Lempel-Ziv (LZ) based algorithm and sent to the counterpart RiOS-powered device on the far side of the WAN. There, segments of data are also stored on the counterpart appliance or endpoint. Finally, the original traffic is reconstructed using new data and references to existing data and passed through to the client. The level of LZ compression can be tuned to find the right balance of higher compression or faster throughput for a given environment and requirements.

RiOS data streamlining is highly scalable, with peak compression ratios that can be 100:1 or higher. These compression ratios (a result of eliminating the transfer of redundant data) are far higher than what typical TCP compression devices could provide. At the same time, data streamlining can find fine-grained changes because the average size of a segment stored on disk is approximately 100 bytes, or about the same as a sentence of text. Through its support of SSL encryption, RiOS can apply this data reduction to encrypted traffic as well (see the section on “Transport Streamlining for more information on SSL).

The scalable data reduction (SDR) operation can be performed interchangeably on the SteelHead appliance, either on disk (as SDR—for more matches and greater data reduction) or in memory (as SDR-

M—for faster throughput), or adaptively in either location or both (as SDR-A) for the best fit of each particular connections data and overall workload. This functionality dynamically and granularly maximizes the efficient utilization of available resources such as CPU, disk, and memory. Some SteelHead appliances also have solid-state disks (SSDs) for even faster performance seek, read, and write operations.

It is important to note that this segmentation process occurs at the byte-sequence level. If, for example, a user is emailing an edited file to a colleague, only the changes need to be sent across the WAN. As long as similar byte sequences are crossing the network, data streamlining will be effective even if the user changes the file name or uses a different mechanism to send the data over the WAN. For example, if the second colleague sends the file back using a document management system or file server instead of email, data streamlining will still recognize redundant data segments and only send the changes across the WAN. This segmentation process differs radically from other cache-based solutions by eliminating redundancies across all TCP traffic. A simple file cache, however, would not recognize that the data being transferred is the same.

Transport Streamlining

RiOS overcomes the chattiness of transport protocols through transport streamlining. Transport streamlining is a set of features that reduce the number of round trips necessary to transport information across the WAN while maintaining the reliability and resiliency of the transport. This is accomplished through a combination of window scaling, intelligent repacking of payloads, connection management, and other protocol optimization techniques.

RiOS accomplishes these improvements while still maintaining TCP as the transport protocol. As a result, RiOS transport streamlining adapts to network conditions on the fly, responding appropriately to events such as congestion or packet loss while still providing a reliable transport protocol that is a “good neighbor” to other traffic. In contrast, other approaches choose unsafe methodologies such as tunnels or proprietary protocols that achieve their optimization by stealing bandwidth from other traffic.

It is useful to underscore that the Riverbed “inner” connection between appliances is not a tunnel, but a proxied TCP connection that directly corresponds to each “outer” TCP connection between client and server. Although competitors may bring up confusing and vexing problems such as traffic mixing, MTU sizes, or TCP-over-TCP performance issues, these problems do not arise in the RiOS architecture.

Window Scaling and Virtual Window Expansion

A well-known method for improving TCP throughput is the use of larger windows to increase the number of bytes that can be “in flight” without being acknowledged. By increasing the window size, the maximum amount of data per round trip goes up, increasing the net throughput when the TCP window is the bottleneck. Although window scaling is available in most client and server TCP implementations, it is often challenging to configure correctly. In many Windows versions, correctly configuring window scaling requires esoteric knowledge of relevant settings and a willingness to edit the Windows registry—requirements that place window scaling out of reach for many organizations. Even with the appropriate knowledge and skill set, making these changes on every server in a large enterprise may require large amounts of administrative overhead and may not be a very scalable approach.

RiOS enables automatic window scaling across the WAN without requiring the user to make any changes to

clients, servers, or the routing infrastructure. Beyond simple window scaling, however, is the software's ability to *virtually* expand TCP windows and enable capacity that is hundreds of times greater than basic TCP payloads. As a TCP proxy, RiOS effectively repacks TCP payloads with a mixture of data and references to data. As noted in the data streamlining section, recognized data that would have been transported is instead replaced by a reference, which can represent a very large amount of data. In this manner, RiOS *virtually* expands the TCP frame, often by a factor of several hundred or more. This Virtual Window Expansion (VWE) dramatically reduces the number of round trips that need to be taken to deliver a given amount of data.

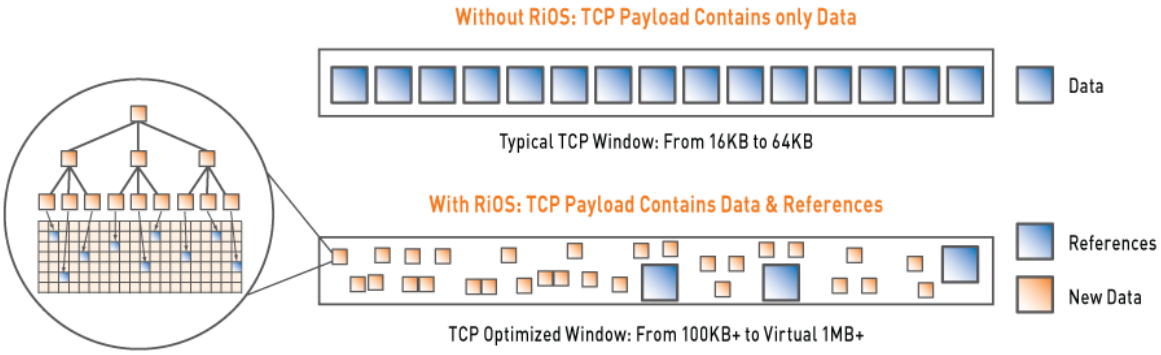


Figure 9, Virtual Window Expansion massively increases TCP payload by intelligently repacking the TCP Payload.

High Speed TCP and Max Speed TCP

A less-well-known problem is that it is often hard for a TCP connection to take advantage of available bandwidth on high-bandwidth, high-latency links, or in situations where packet loss is high. The RiOS implementations of High Speed TCP (HS-TCP) and Max Speed TCP (MX-TCP) can accelerate TCP-based applications so that a single connection runs at hundreds of Mbps (up to OC-12, 622 Mb/s) even when round-trip latencies are high. The potential benefits include:

- Higher throughput over long distance high bandwidth links
- Faster replication, backup and mirroring over very long distances
- Better utilization of high bandwidth links

HS-TCP achieves full utilization of investments in network bandwidth without losing or compromising any of the essential characteristics and benefits of TCP. These benefits include safe congestion control, even when HS-TCP connections share WAN links with "normal" TCP connections. Familiar TCP performance characteristics have been preserved. For example, there is no need to pre-determine available WAN bandwidth—HS-TCP self-adjusts transmission throughput appropriately.

In contrast, MX-TCP allows administrators to take advantage of 100% of a prescribed amount of bandwidth connectivity between any two locations. Whereas HS-TCP will back down in speed because of significant packet loss or congestion, MX-TCP is designed to use a set amount of bandwidth regardless of congestion or packet loss. Administrators can easily set the bandwidth limit for MX-TCP, enabling this functionality without requiring use of the total bandwidth available on a given connection.

Connection Pooling

Some applications are designed to open many TCP connections to accomplish required data transfers. Many of these connections are short-lived, yet each requires significant overhead to initiate communications.

Such short-lived connections can result in significant reductions in application speeds. For example, loading a single ordinary Web page can require a client to open 10 or more TCP connections.

Connection pooling enables RiOS to maintain a pool of open connections at all times for short-lived TCP connections. When a client makes a request that requires new TCP connections, the appliance can use an already-opened connection instead of incurring the overhead associated with opening a new connection. Note that such an already-opened connection is not recycled from a previous use: it is simple "pre-opened" before it is required for data transfer. With connection pooling, overhead associated with short-lived TCP connections can be reduced by 50% or more.

SSL Acceleration

Use of SSL as an encryption mechanism is a widely used security approach within many organizations. On SteelHead appliances and the SteelHead Mobile, RiOS provides a patent-pending approach to accelerating SSL-encrypted traffic that maintains the organizational preferred trust model. Using RiOS, SSL acceleration can be achieved while keeping all private keys within the data center and without requiring fake certificates in branch offices. Both SteelHead appliances and the SteelHead Mobile can auto-discover their SSL peers and begin optimizing SSL traffic, and RiOS provides centralized management of SSL acceleration capabilities for the enterprise via the SteelCentral Controller for SteelHead Management Console (SCC). SteelHead Mobile provides the enhanced security of an integrated Certificate Authority as a part of the SteelCentral Controller for SteelHead Mobile; this allows organizations the flexibility of using their own security certificates or generating a new certificate for distribution as a part of the licensing process.

Other approaches to SSL require fake certificates or server private keys on branch office appliances. These approaches compromise the security of an organization's infrastructure because keys must be distributed across the enterprise, making SSL sessions more vulnerable to attack. RiOS only distributes temporary session keys to branch office appliances.

Using this approach, RiOS can apply its best-of-breed data streamlining, transport streamlining, and application streamlining mechanisms to SSL encrypted traffic without compromising the preferred security model.

In SteelHead 9.1, support was added for "Hardware Security Module" or HSM devices to store cryptographic certificates and keys. SteelHead products are able to use private keys and/or certificates stored on HSM devices for SSL acceleration.

HSM devices ensure strong security, tamper-detection and protection of the sensitive cryptographic material. Customers are using HSM to ensure compliance and provide a higher level of security assurance. Riverbed is the first WAN optimization vendor to support HSM integration with SSL/TLS.

UDP Optimization

Many applications use UDP as a transport protocol instead of TCP. Data replication and IP Tunnels are two

common applications that make use of UDP as a transport protocol. Using a packet-by-packet approach, RiOS is able to provide the same data deduplication capabilities to UDP based applications as it does to TCP based applications.

SCPS Protocol Suite

The Space Communications Protocol Standards (SCPS) specification is a protocol suite that is designed to allow communication over challenging environments. The development of SCPS was funded jointly by NASA, NSA, and the United States Strategic Command and developed by a consortium led by the Mitre Corporation. Through a collaborative, multiyear R&D effort, the partnership created the Space Communications Protocol Standards-Transport Protocol (SCPS-TP). Since RiOS 7.0, the SCPS protocol suite is fully integrated, allowing you to fully optimize your applications even when they are being sent out into space.

Application Streamlining

RiOS was designed as an application-independent foundation that would provide optimization to all enterprise applications, but also support additional acceleration and ease-of-use functionality as needed. Application streamlining is the realization of that flexibility and power.

Application streamlining allows RiOS to provide additional layer 7 acceleration to important (but poorly behaved) protocols through transaction prediction and pre-population features. Additionally, application streamlining allows for key office-in-a-box functionality by precluding the need to deploy additional application and database servers in remote offices. Enterprise application services can now be simply deployed and managed via a consolidated IT model and accelerated with RiOS.

Application Streamlining Modules

Application streamlining modules provide additional performance improvement for applications built on particular facilities such as Microsoft Windows file systems (the CIFS protocol), Microsoft Office, Microsoft Exchange messaging (the MAPI protocol) including encrypted email, Microsoft SQL Server databases (the TDS protocol), Lotus Notes, HTTP and HTTPS, SharePoint, NFS, or Oracle 11i and Oracle 12. These modules are application protocol-specific and dramatically reduce application protocol round trips.

Application streamlining modules eliminate upcoming round trips that would have been generated by the application protocol. Reducing round trips can be necessary even with a very efficient implementation of TCP, because otherwise the inefficiency of the application-level protocol can overwhelm any improvements made at the transport layer. Application streamlining modules can eliminate up to 98% of the round trips taken by specific applications, delivering a significant improvement in throughput, in addition to what data streamlining and transport streamlining already provide.

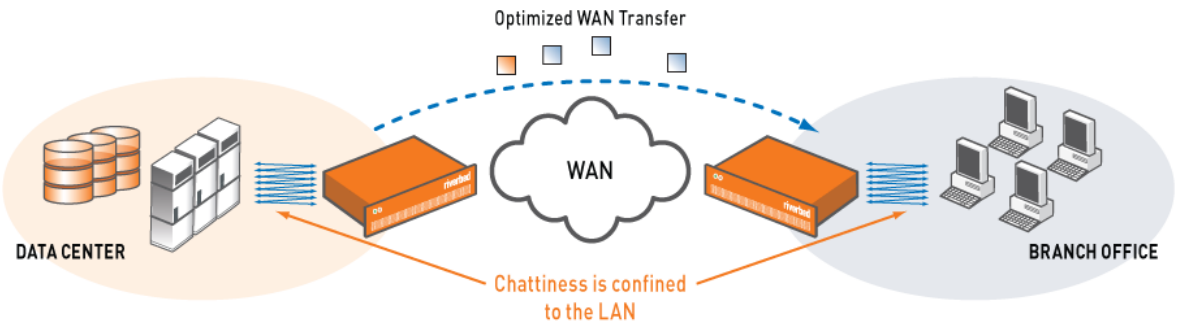


Figure 10, Application streamlining can eliminate up to 98% of round trips generated by application protocols.

It is easy to talk about "application streamlining" as a concept, but harder to deliver real performance improvement. Riverbed was the first vendor to deliver this method of layer 7 application protocol optimization, and no other vendor has as complete a range of application-level optimizations. Even vendors who offer some application-level optimizations for CIFS or MAPI often do not deliver the quality or depth of optimizations that RiOS does. With application streamlining, the evaluator of various technologies must dig beneath a standard checklist to see *how deep* and *in what ways* a vendor can streamline the application.

It should be noted that SteelHead Mobile provides acceleration of all applications running over TCP, but certain application streamlining modules are not currently available for the software client. More details on product specific features can be found in the feature table at the end of this document.

Windows File Sharing (CIFS) Optimization

Many vendors claim to have application-level support for CIFS. Yet, if a user makes changes early on in a file (for example, changing the title of a Word document), some vendors treat the rest of the file as though it were completely new data. Additionally, there are many ways to use CIFS. When some competitors claim they 'do' CIFS optimization, often they only optimize drag-and-drop file copies.

RiOS contains about a dozen CIFS optimizations for various operations such as file sharing, folder browsing, accessing files from within other applications, and more. Furthermore, some applications make use of CIFS with complex file-locking arrangements. Other application acceleration approaches can break these locks, or they simply not are able to optimize performance in these cases. RiOS has built-in technology, which allows application acceleration to be optimized, with appropriate file locking maintained.

RiOS supports SMB v1, SMB v2 and SMB v3 natively on all Windows platforms.

Apple Mac clients for CIFS can benefit from these same application specific optimizations to overcome latency. This optimization works for Mac OS 10.5.x (Leopard) to 10.8.x (Mountain Lion) when they connect via SteelHead appliances to typical CIFS file servers such as Windows Server and NetApp.

SMB Signing Support

This feature allows customers who serve files from domain controllers where Microsoft's SMB signing is set to '**required**' by default to protect themselves from "man in the middle" attacks. RiOS gives support for CIFS latency optimizations in the presence of signed packets. SMB signing support has been further enhanced for easier configuration and to work across multiple network domains. RiOS supports SMB v1, SMB v2 and

SMB v3 signing natively.

SMB Encryption Support

Windows 8 clients and Windows 2012 servers feature SMB v3 (originally called SMB v2.2), an upgrade to the CIFS communication protocol. SMB v3 includes the possibility to encrypt sessions. RiOS gives support for CIFS latency optimizations in the presence of encrypted sessions. Session security is preserved end to end as SteelHead appliances transparently decrypt and encrypt packets.

In RiOS 9.0, SMB v3.02 (Windows 8.1 and Windows Server 2012 R2) is now fully qualified for the following traffic:

- Unsigned
- Signed
- Encrypted
- IPv4
- IPv6
- NTLM Transparent and Delegation Mode
- End to end Kerberos

Lotus Notes Optimization

Developed with IBM, this application specific optimization improves the sending of large email attachments with a performance gain of up to 8x to 25x. In RiOS versions since the release of RiOS 8.0, optimizations also include server-to-server replication, calendaring, and more**.** RiOS transparently switches off transport compression so the SteelHead appliance can more effectively optimize Notes/Domino traffic for all applications. In RiOS versions since the release of RiOS 7.0, optimization for encrypted Lotus Notes is also supported.

Exchange (MAPI) Optimization

RiOS also delivers significant performance gains for the Microsoft Exchange MAPI protocol and is the only WAN optimization solution to provide support for the Exchange 2000, 2003, 2007, 2010 and 2013 MAPI protocol. Competitive solutions in the market will downplay the lack of MAPI 2003, 2007, 2010 or 2013 support and encourage customers to use Cache Mode. The downside of Cache Mode is that no data reduction techniques are applied to traffic so there are no benefits from a network utilization perspective. This means that Cache Mode does nothing to accelerate email retrieval for users receiving large attachments or resyncing their Inbox after traveling resulting in further delays for end-users. RiOS gives customers flexibility by supporting both Cache and non-Cache Mode for Exchange 2003, 2007, 2010 and 2013, again exhibiting broader and deeper support at the application tier.

RiOS MAPI acceleration also provides the ability to pre-populate MAPI traffic, further alleviating the morning rush when users login and pull down email. In many environments, this daily practice can cripple a branch office WAN link. Additionally, because RiOS operates transparently with unchanged clients and servers, no plug-ins are required with the SteelHead solution—whereas some competitive products require plug-in installs on every email client. RiOS delivers full spectrum optimization for Outlook Anywhere delivering the same level of optimizations as for the MAPI client. This delivers bandwidth and latency optimization for MAPI RPC over HTTP (encrypted and unencrypted), the transport for Outlook Anywhere.

With the release of Exchange 2010, Encrypted Mode is enabled by default, and Riverbed encrypted MAPI support extends RiOS MAPI acceleration benefits to secure SteelHead appliance customer environments where email encryption is used (often by default) between the client and host servers. Active Directory authentication can take place through either NTLM or Kerberos authentication. RiOS 8.5.1 added support for CAC secure card access to Exchange 2010 from Outlook 2007 over Outlook Anywhere (RPC-over-HTTP). When using encrypted MAPI, Outlook Anywhere, and Smartcards to provide client authentication, Outlook can now use the SCHANNEL authentication protocol.

In SteelHead 9.1, support was added for the new MAPI over HTTP protocol (without the RPC layer of the Outlook Anywhere protocol). MAPI over HTTP is supported with Exchange 2013 SP1 and either Outlook 2013 SP1 or Outlook 2010 SP2. Only bandwidth optimization is provided at this time, with latency optimization expected in a future release. Customers have an option to down-negotiate from MAPI over HTTP to the Outlook Anywhere protocol to get benefit from latency mitigation.

HTTP and HTTPS Acceleration

Riverbed provides additional layer 7 optimizations for HTTP and HTTPS that go beyond its traditional methodologies of WAN optimization. With these additional tools, organizations can make their key web-based applications faster than ever before. Applications such as SharePoint, intranet portals, web-based document management systems, as well as web-enabled ERP and CRM applications like SAP NetWeaver, JD Edwards, and Siebel, all receive significant application acceleration with RiOS's HTTP(S) capabilities.

In addition to standard data streamlining and transport streamlining functionality, RiOS enables several mechanisms to further optimize HTTP(S) traffic. For static web content, a "learning mechanism", that allows a client-side SteelHead appliance to track the objects that are requested for a particular web page, accelerates future requests by using the learned information and pre-fetching associated content. In addition, HTTP(S) leverages the learned information to send normally sequential data requests in parallel creating additional optimization benefits.

For dynamic web content, RiOS performs a parse-and-pre-fetch of embedded objects on dynamic web pages. When requests for dynamic content occur, RiOS parses the retrieved dynamic HTML page and immediately pre-fetches embedded objects to accelerate webpage load times. The net result is a significant reduction in round trips across the WAN for dynamic content that is often leveraged by web-based enterprise applications.

Another performance-enhancing feature for HTTP(S) is the object prefetch table. This enables the SteelHead appliance datastore to cache complete web page objects, allowing these to be served up immediately as a whole locally rather than reassembled from data references or transferred across the WAN. Unlike other cache approaches, consistency and "freshness" is maintained, as RiOS will always still deliver the latest version of the object being requested.

RiOS accelerates HTTP(S) traffic further by also optimizing metadata through its 304 Fast Response capability. If the local SteelHead appliance receives an "If-Modified" request within a specified expiration parameter, it will respond with a "Not Modified" response, and the client will retrieve the web content from its own local web browser cache. This eliminates round trips across the WAN and minimizes delay for end-users. This combined multilayer approach to HTTP(S) optimization delivers acceleration benefits to a range of web content and application scenarios.

SharePoint Acceleration

In RiOS versions since the release of RiOS 8.5, application-level latency optimization for Microsoft SharePoint is included. Prior to RiOS 8.5, SharePoint applications benefited only from the HTTP optimization feature. SharePoint adds several different protocols like Front Page Server Extension (FPSE) and WebDAV that run on top of HTTP and SteelHead appliances can greatly enhance SharePoint usage experience by optimizing and accelerating these application protocols.

Oracle 11i and Oracle 12 Optimization

Expanding its support for enterprise applications, RiOS also enables the optimization of Oracle Forms traffic found throughout the Oracle 11i and Oracle 12 E-Business application suites. This optimization applies specifically to the Oracle 11i and Oracle 12 Forms Web browser plug-in running in HTTP or socket/native mode. In order to optimize Oracle traffic, RiOS recognizes a client session has been initiated and intercepts the Oracle Forms request. This traffic is essentially unscrambled from its native format to apply data streamlining, transport streamlining, and optimize the client-server traffic bi-directionally. This is true for both the older Oracle JInitiator and now standard Sun JRE types of Java Virtual Machines (JVMs.) Data streamlining also significantly accelerates the initial download of bulky java applets at startup time, allowing user login and startup to complete in seconds rather than minutes. The net effect creates significant data reduction for Oracle Forms traffic and additional bandwidth savings, as well as improved application performance up to 50x.

Disaster Recovery Acceleration

RiOS's out-of-the-box acceleration of backup and replication operations already generated significant performance gains for data transfer jobs. Since RiOS 4.1, Riverbed has had a Behavioral Traffic Recognition algorithm for large-scale data transfers to accelerate backup and replication jobs even further. The traffic recognition capability identifies a large-scale data transfer flowing through a SteelHead appliance and applies some specific system optimizations to enhance the throughput and handling of high-rate, high-volume backup data sets.

Other Business Continuity improvements enable SteelHead appliances to scale for high-throughput disaster recovery environments, with up to four Gigabit LAN-side throughput and often up to 3:1 to 8:1 data reduction. These enhancements enable acceleration of asynchronous replication solutions such as EMC SRDF/A, CA XOsoft, IBM Tivoli Storage Manager, and more. SteelHead appliances are qualified by EMC for SRDF/A, and HDS for Hitachi True Copy, Universal Replicator, and H-NAS, along with other leading storage vendors' products.

These additional optimizations improve disk utilization, while also dynamically applying data reduction and compression algorithms. The resulting throughput enhancement further reduces the time required to complete a backup or replication operation beyond previous acceleration norms. A variety of options including tunable LZ compression, choices like SDR-M or Adaptive SDR, and granularity to have the data-streamlining mode dynamically toggled per flow all enable RiOS to deliver the best balance of high throughput versus maximum bandwidth reduction. Some environments might be highly bandwidth constrained, others may need the fastest possible throughput, and yet others may need to share the WAN connections between DR operations and other business applications, and Riverbed is extremely high performance and as flexible as required.

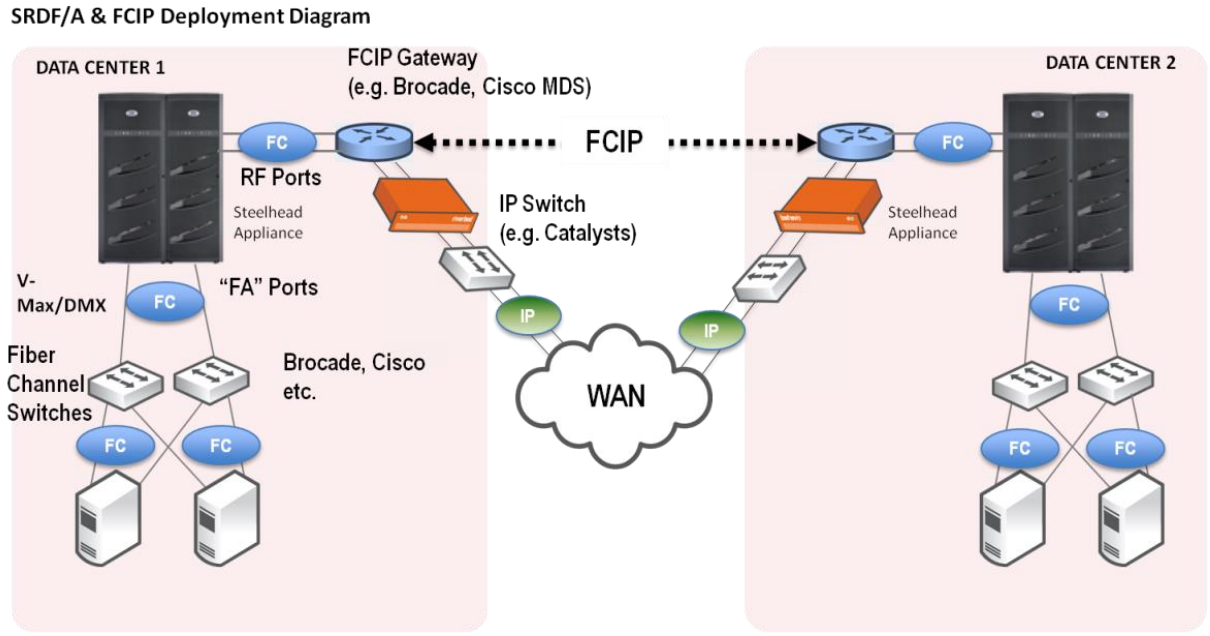


Figure 11, SRDF/A and FCIP illustrated.

Selective Optimization and Reporting for SRDF

Competitors are trying to change the playing field by claiming that playing dumb at the IP layer is all you would have to do. Riverbed has shown significant benefits from some of its prior DR-focused app-level optimizations (DIF/FCIP header isolation for improved data reduction, SRDF compression auto-negotiation).

With SAN replication, it is common to have multiple types of data interleaved within a single replication connection. By using Riverbed app-level knowledge of how the transactions are "bucketed" on the wire, different optimization policies can be applied for each type of data. This allows for overall higher throughput by not wasting resources on reducing uncompressible data. Also, with Riverbed knowledge of these "buckets" granular visibility can be provided to how much traffic is being transferred for each storage group, which is something that even cheap bandwidth can never allow you to do. Moreover, while EMC SRDF is the first protocol that is being targeted for this approach, the same value can be provided to similar technologies like SnapMirror or IBM XIV replication as storage partners choose to open up their protocol specifications to us.

Since RiOS 8.0, it is also possible to view per-group reporting for SRDF traffic. For a given stream of replication traffic, identification of individual groups like databases, home directories, files etc. are now available to get more visibility in reporting.

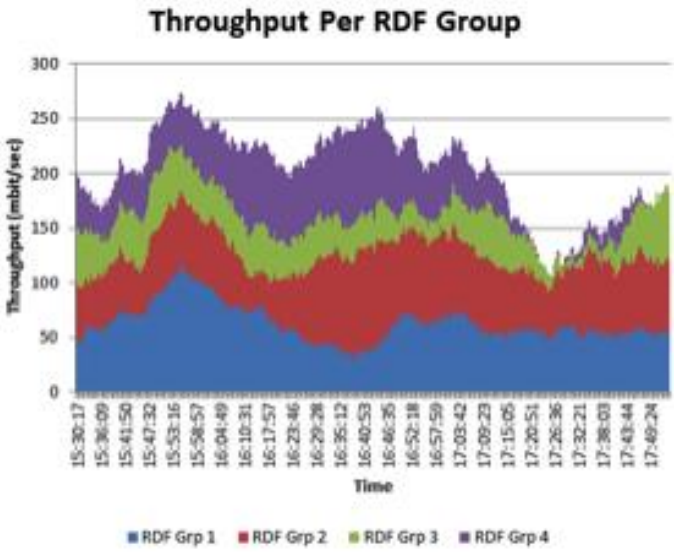


Figure 12, Per-group reporting for SRDF traffic.

Centralized Print Optimization

Some customers want to consolidate as much of the IT footprint as possible to the data center for higher utilization, lower hardware costs, and easier maintenance, and may choose to do this with print servers specifically. If printing operations are delivered across the WAN with a centralized print server, this could create a lot of extra WAN traffic and greatly hurt the performance of printing (and other applications.) RiOS can address this problem by optimizing the data transfers associated with printing across the WAN, using similar features as those for CIFS, and reducing bandwidth requirements by up to 75% and improving performance as much as 4X.

Transparent Prepopulation

To minimize the frequency of requests that must wait for new data to be sent across the WAN, RiOS can transfer the segments of a file or email to the remote RiOS-powered device before any client requests it. This transparent prepopulation process allows the initial end-user access of any new file or email to be accelerated.

Sometimes the first client to request particular content suffers a “miss penalty” as the new content is transferred across the WAN for the first time. Transparent prepopulation improves the user experience by carrying out the necessary data transfer in advance of the first request, so that all clients experience similar accelerated performance. Transparent prepopulation works with file servers, Exchange emails, or any other type of data that must be replicated across the WAN. The method that RiOS uses to prepopulate file servers requires no agent, thus simplifying infrastructure management while eliminating the miss penalty for predictable new content. Prepopulation can also be done on a granular level by specifying the individual file types instead of the entire share. This helps improve the efficiency of prepopulation.

SteelHead appliances also support a prepopulation mechanism for MAPI (Microsoft Exchange email). When users in a branch office close their email clients, the client-side SteelHead appliance optionally keeps the

Exchange TCP connection alive. Thus, as emails arrive their component segments are pulled across the WAN using all of the RiOS acceleration techniques. When users log in again to request their email, all the data is then available to the SteelHead appliances to optimize the transfers at maximum speed. This technique avoids big surges in email requests, such as the spikes that occur at the start of a workday that can bring the rest of a branch office's applications to a halt.

Native Stream Splitting for Live Video over HTTP

RiOS supports stream splitting natively on the SteelHead appliance for video formats such as Adobe Flash HTTP Dynamic Streaming, Microsoft Silverlight, and Apple HLS. Stream splitting ensures that a single stream is pulled across the WAN regardless of the number of users at the branch location requesting this stream. This single stream is then "split" at the edge, meaning local users connections are served from the SteelHead appliance itself without requiring these requests to go back to the origin of the live stream. This conserves WAN bandwidth, which is particularly important when considering video streams tend to consume a lot of bandwidth.

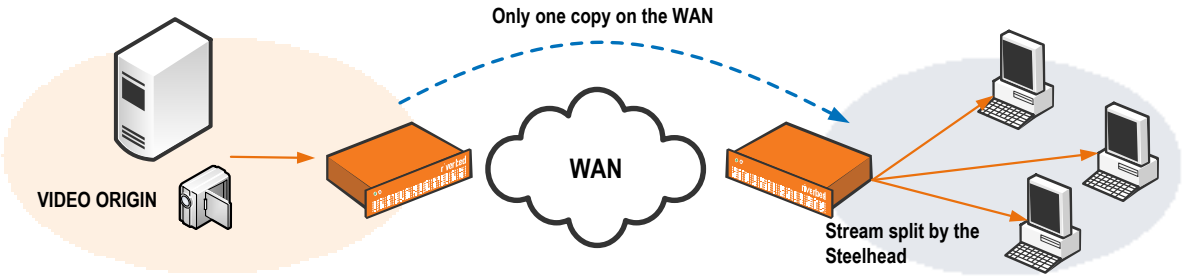


Figure 13, Only one copy of the live stream is sent over the WAN. The SteelHead appliance then "splits" this stream and serves it up to the interested users.

In SteelHead 9.1, stream splitting performance was improved by increasing the cache 5 times larger and holding onto video fragments 3 times longer. The time video fragments are kept in the cache is increased from 10 seconds to 30 seconds to support viewing clients that are out of sync. SteelHead 9.1 support the following video formats:

- Microsoft Smooth Streaming
- Adobe HTTP Dynamic Streaming
- Apple HTTP Live Streaming

Internet Accelerator / Web Proxy

SteelHead also includes a solution for applications that cannot be accelerated using SteelHead end to end. SteelHead includes a single-ended Web proxy that transparently intercepts all traffic bound to the Internet, and performs optimization without the need for a server-side SteelHead.

SteelHead Web proxy improves performance by providing Web object caching on both HTTP and HTTPS traffic. The efficient caching algorithm dramatically reduces the use of Internet traffic when multiple users are accessing the same content and provides significant bandwidth savings. The proxy includes a unique feature to cache videos including YouTube videos, thus enabling the use of HD content for business use, like training videos, without the need to overprovision the Internet links.

SteelHead Web proxy also provides visibility and logging for all Internet activity at any given branch as long

as that destined traffic passes through the Web proxy.

HTTPS Web proxy integrates with the certificate authority (CA) service on the SCC to generate server certificates and decrypt traffic for a predefined whitelist.

Web object caching includes all objects delivered through HTTP(S) that can be cached, including large video objects like static VoDs and YouTube video. The size of objects that can be cached is limited by the total available cache space, determined by the SteelHead appliance model. The proxy cache is separate from the RiOS data store. When objects for a given Web site are already present in the cache, the system terminates the connection locally and serves the content from the cache.

The target deployment models represent two different use cases:

- Internet connections backhauled through corporate data center
- Direct to Internet connections

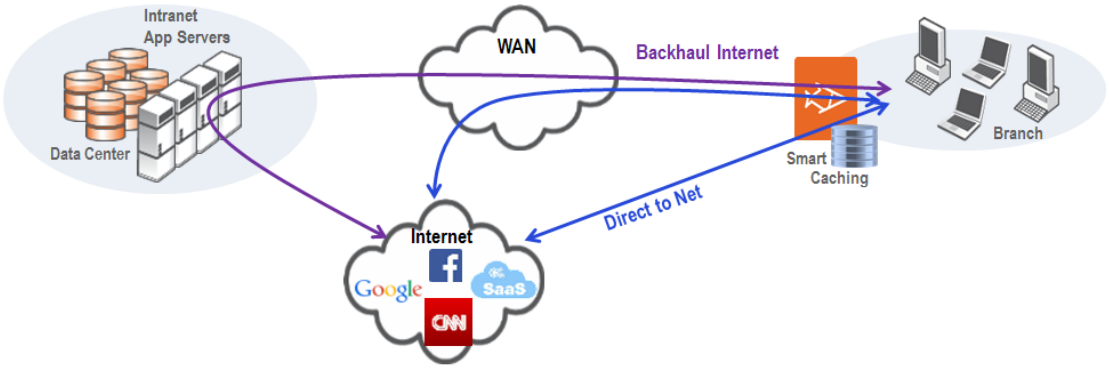


Figure 14, Target deployment models.

Native Kerberos

Kerberos allows clients and servers to mutually authenticate each other. Microsoft Windows Server uses Kerberos as its default authentication mechanism for Microsoft Exchange, Microsoft SharePoint, and Windows File Sharing amongst other applications. Since RiOS 8.0 traffic running over a Kerberos authenticated network is natively optimized, meaning those same optimizations described above for Microsoft Exchange, Microsoft SharePoint, etc. are now applied when Kerberos is used for authentication. In addition, all this is done without compromising the trust and security provided by Kerberos.

IPv6 optimization

Some customers are moving to IPv6, on their own accord, due to external mandates or due to internal mandates. For all of these customers, RiOS supports TCP level optimization through SDR, but also latency optimization for three protocols using IPv6: FTP, HTTP, and SSL. Riverbed also provides a large set of network integration and management features that are IPv6 compatible.

RiOS - Control

This section covers control capabilities including QoS, path selection, traffic encryption and other features to manage applications over a hybrid Internet and MPLS network according to their performance needs and criticality to the business.

Application awareness using Deep Packet inspection (DPI)

SteelHead control capabilities rely on the ability to precisely identify applications flows in order to apply the proper policies to them. Legacy solutions classify traffic using port numbers and IP addresses. Business applications based on HTTP are by default classified in the same bucket as non-critical YouTube traffic. This can only be resolved using classification based on IP addresses, leading to configuration complexity and increased operational risks. The application flow engine provides classification based on the content of the packet stream and allows more precise identification of flows and much simpler configuration of policies at the same time. Traffic can also be classified using the full assortment of packet rules, including IP addresses, 5-tuple, DCSP, TCP and UDP port numbers, and so on.

The Riverbed application flow engine utilizes a variety of techniques, often in combination, to maximize the accuracy and efficiency of its ability to provide application visibility into network traffic in real-time with the most flexibility. The engine uses multiple techniques like port-based classification, application signature matching, protocol dissection, behavioral classification and others. Here are the benefits of each of these techniques in detail:

- **Port Based Classification -** Port based classification is based on knowledge that certain applications utilize certain ports.
- **Pattern Matching / Application Signatures -** This typically translates to searching the initial traffic for well-known patterns, possibly at well-known offsets, or when combined with *protocol dissection* within specific protocol elements. This could be via regular expression matching and/or byte or string matching. Starting in SteelHead 9.1, over 1300 common enterprise applications are known by the flow engine. This ensures that critical applications like web, voice and video are protected, while recreational applications are contained. , it even offers the ability to clearly distinguish between SSL-encrypted applications. Or instead of looking at Facebook as a consumer app, it can allow Facebook news feeds and updates but block non-business applications such as Farmville.
- **Protocol Dissection -** This involves having a detailed understanding of the application protocol and the ability to parse the protocol messages and follow the conversation in order to identify and extract interesting information. This not only ensures accurate classification, but also enables deep contextual sub-classification and protocol attribute extraction.
- **Future Flow Registration -** Not really an inspection technique per se; however, the ability to identify and associate a flow that will take place in the future based on a flow that has been identified in the past is a powerful facilitating tool that ensures accuracy and performance.
- **Behavioral -** Behavioral classification relies on detection of behavioral attributes of the network traffic. The Riverbed engine can utilize packet size, packet inter-arrival time, packet rate, data rate, and entropy calculations in its detection of a behavioral signature for an application. Another behavioral technique involves the contextual understanding host behaviors and traffic patterns.
- **Decryption / Decoding -** Some applications utilize some sort of encoding, obfuscation, or simple encryption technique

Quality of Service (QoS)

RiOS allows customers to use Quality-of-Service (QoS) management in the way that best fits their network.

QoS marking

For customers already using QoS to support VoIP and other bandwidth sensitive traffic, RiOS can easily pass QoS DSCP markings to an enforcing device in a completely transparent hand-off. RiOS also allows the marking of DSCP bits for QoS, Class of Service (CoS), MPLS tagging, or any other classification mechanisms using the DSCP field. With RiOS, such DSCP marking can be applied to both optimized and pass-through traffic. RiOS also supports optional rules to categorize "outer connection" traffic and map those categories to specified "inner connection" ports. With these tools, RiOS easily integrates into existing QoS environments without disrupting traffic flows and enables a variety of approaches to traffic monitoring and shaping.

Advanced QoS using HFSC

Moreover, because of the significant data reduction achieved with RiOS technology, most QoS environments perform even better with Riverbed deployed. This enables customers, in many cases, to reclaim bandwidth and eliminate unnecessary QoS implementations further reducing network management overhead and complexity. For cases where the environment remains bandwidth constrained, RiOS provides customers with the ability to leverage extensive QoS capabilities with SteelHead appliances themselves. Users can employ Hierarchical Fair Service Curve (HFSC) class-of-service marking and enforcement at the "edge" of their network on SteelHead appliances, for both optimized and pass-through traffic. HFSC supports prioritization based on both bandwidth and latency, meaning that real-time traffic such as VoIP and video is protected against congestion and latency.

Riverbed QoS delivers a unique combination of best-of-breed classification and an advanced, unique scheduling technique, based on Hierarchical Fair Service Curves (HSFC). This technology addresses the need for accurate classification of applications, the allocation of minimum and maximum bandwidths (as other tools do), and the ability to prioritize applications based on their latency sensitivity (which is not possible with most other approaches).

Inbound QoS can also be applied to WAN traffic, which is increasingly important in cloud environments and where inter-office traffic (such as VoIP) must be subject to prioritization for the best performance.

Riverbed QoS uses a unique scheduler called the Hierarchical Fair Service Curve (HSFC) that addresses not just the allocation of minimum and maximum bandwidths (as many tools do), but also prioritizes and schedules applications based on their latency sensitivity (which is not possible with most other approaches). Imagine, for example, that two different real-time, critical applications such as VoIP and video conferencing were configured with bandwidth guarantees, but without the ability to set priority for each based on sensitivity. During heavy use periods, even when the bandwidth guarantees were honored, queues would become filled with video traffic causing the rate at which VoIP packets are scheduled to vary, introducing jitter and as a result, noticeably lower quality calls. Some QoS tools try to work around this by dedicating excess bandwidth, perhaps over-provisioning by 20% or more, to certain applications. This is wasteful, sometimes crude, sometimes complex, and in fact unnecessary. These tools also often encounter problems when trying to prioritize multiple types of traffic at the same time. Riverbed QoS can address these issues smoothly and simply, with distinct controls for both bandwidth and sensitivity. This delivers predictable

performance for critical applications.

The Riverbed QoS engine delivers streamlined application-level control and optimization by delivering the following features:

- **Content-aware Application Control –** With the content-aware application control the Riverbed engine can identify and classify hundreds of most common enterprise applications and is configurable to classify thousands of custom applications as well. This ensures that critical applications like web, voice, and video are protected while recreational applications are contained.
- **Intent-driven UI –** The solution offers the simplicity and the quickest ramp time with respect to QoS policies by offering high level configuration abstraction and comprehensive default policies delivering plug-n-play deployment.
- **Latency-aware Traffic Scheduling –** With this feature traffic can be scheduled for applications based on their sensitivity thus eliminating jitter and starvation.

QoS can also be used in a variety of specific needs environments. One example is the operation of QoS with Riverbed Interceptor appliances as the workload is distributed across a group of clustered SteelHead appliances in a large data center environment. In this case, QoS markings are preserved for prioritization even as traffic is redirected for optimization.

Another example is working with QoS for Citrix virtual desktops. In this case, the Citrix markings can be utilized to reserve bandwidth for time sensitive activities, such as desktop display, over less critical operations, like printing.

RiOS 9.0 provides a way to define a static network topology to a configuration that is shareable between SteelHeads. The network topology definition becomes a building block that simplifies SteelHead feature configure for Path Selection and QoS. You define a topology once and then reuse it as needed. The topology provides the network point-of-view to all other possible sites, including each remote site's networks and a remotely ping-able IP address.

In SteelHead 9.1, a significant performance boost and CPU utilization limits were added for QoS/Path Selected optimized traffic.

Networking / Link Aggregation / Etherchannel

In SteelHead 9.1, support was added to interoperate with network devices that use the EtherChannel protocol. SteelHead does not terminate EtherChannel and is transparent to the link aggregation devices. Load balancing is done by the upstream router or switch.

Hybrid Networking

The Rise of hybrid enterprise

Today, businesses are rapidly adopting cloud infrastructure and SaaS applications broadly across the enterprise. Enterprise workforces are using applications, managing data, and conducting research along with other activities on the Internet and in the Cloud. In fact, more than half of all enterprises are using the cloud for storage, ERP, email, collaboration, and more.

Yet data, including large files, unified communications, recreational traffic, and more that are destined for the public Internet still travel through the costly MPLS network. That's an inefficient way to access services and applications, such as cloud collaboration or cloud CRM, which can be accessed directly on the Internet without ever touching the corporate MPLS network. And the cost is high, especially when compared to broadband Internet. Typical studies tell us that a MPLS megabyte can cost up to 200 times more than a broadband megabyte, per month.

Until recently, enterprises followed a model where the vast majority of applications where hosted within private datacenters, with standardized WAN on MPLS network services. In an IT environment with public and private resources, a hybrid network that combines the strengths of highly reliable MPLS networks with the ubiquity and lower cost of Internet infrastructure can both deliver higher performance and be more economical.

Hybrid Networks represent the new optimal network architecture offering cost effectiveness and performance for organizations combining on-premise to off-premise IT assets (through SaaS or IaaS) or more generally increasingly seeing a growth of Internet based traffic. Hybrid Networks offer two complementary capabilities:

- Internet Backhaul to offload traffic from MPLS and triple the bandwidth available to users
- Local-Internet breakouts to offload Internet traffic and optimize performance for SaaS traffic - Hybrid networks can be used to easily direct a selected part or the totality of the Internet-bound traffic to local Internet gateways.

Riverbed makes hybrid networks easy

Until now, creating a seamless hybrid networking architecture has been obstructed by the complexity of defining which traffic goes on which network or by the complexity of setting up appropriate secured tunnels. Hard-coded router configurations and legacy technologies like policy-based routing are an intrusive burden on network administration, and ultimately neither are reliable nor granular enough to provide value. Without a simple way to define rules and configure the hybrid network, implementation of hybrid networking has remained difficult.

With Riverbed, organizations can embrace hybrid networks to maximize the performance of business-critical applications, boost network availability, and reduce costs while retaining IT control and minimizing complexity.

With SteelHead hybrid networking technology, IT organizations can deploy and manage hybrid networks to deliver greater application reliability and performance for less cost. SteelHead is including all the major building blocks to build a high performance, yet simple to manage hybrid network. SteelHead includes:

- A network and application aware path selection capability to direct traffic on the appropriate network (MPLS, Internet…)
- A dynamic tunneling capability with central control plane enabling secure backhauling of branch traffic to the corporate datacenter across the Internet
- A simple interface to zScaler or other cloud-based security services enabling local Internet breakouts without requiring further investment in on-premise Internet security appliances
- Inbound QoS to manage local Internet breakouts and protect business Internet against surges in

recreational Internet
- A new management plane to drive global hybrid networks using simple abstractions

Those hybrid networking functions also come with crucial capabilities supporting the whole network and the new mix of on-premise and off-premise applications, including:
- Existing SteelHead optimization capabilities for on-premise and Cloud based applications like Office 365 or Salesforce.com.
- SteelCentral Controller for SteelHead offering global and simplified configuration of SteelHead capabilities
- Integration between SteelHead and SteelCentral NetProfiler offering holistic visibility on network usage and performance and
- Integration between SteelHead and SteelCentral AppResponse for End-User Experience monitoring of on premise and SaaS applications

Riverbed is delivering, by far, the most comprehensive solution enabling a smooth transition of organizations to an hybrid enterprise.

A network and application aware path selection capability

Path selection is required to efficiently use the multiple available paths in the branch and datacenter. A typical branch configuration has 3 paths, one based on MPLS, one based on an Internet link combined with a secured overlay connecting back the branch to the datacenter using IPSec and a third path exiting directly to the Internet. Unlike legacy policy-based routing technologies, Riverbed path selection technology:

- Is application-aware and able to precisely distinguish business-critical applications from less important applications
- Constantly senses path availability in real time using active probes for dynamic path failover
- Is simple to manage through SteelCentral Controller (SCC) and its global management plane
- Works with application visibility and WAN optimization for complete management of business critical applications over the WAN

RiOS path selection technology provides the ability to deterministically re-direct traffic and application flows through alternate WAN paths based on service metrics, such as path availability and priority. This path selection technology empowers IT organizations with greater controls to maximize multiple WAN services based on business needs, service quality, and costs. It also utilizes the ability to redirect specific traffic or applications through one of three alternate gateway paths determined by destination availability in cascading order. Traffic flows can be classified by IP header information or through the deep packet inspection engine. Each traffic rule can have up to three gateway paths in priority order based on availability.

Unlike other approaches, RiOS path selection technology is transparent to the existing network, easy to configure through an intuitive graphical interface, and tightly integrated with RiOS rich DPI-engine for flexible and granular policy definition.

To influence the return path of traffic and override the original traffic path, our path selection technology must be configured at the other end. Path selection configuration is independent of any QoS settings, thus

allowing you to apply path selection rules whether QoS is enabled or not. Network paths may be defined as separate interfaces, separate gateways, or a combination of the two.

Path Selection relies on the following elements:

- **Classification –** The critical step for path selection is to identify traffic flow and to associate these traffic flow candidates with a different, configured path. In this step, the QoS functionality interacts with the path selection feature. Path selection uses Application Flow Engine (AFE) or IP header information for identifying traffic.
- **Forwarding -** WAN egress control is a transparent operation to the client, server, and any networking devices such as routers or switches. When path selection is configured, SteelHead appliances change the outbound physical interface transparently to the client, the server, and the intended default routing. Forwarding can either be performed directly using distinct SteelHead physical interfaces or indirectly using MAC address rewriting or DSCP marking to control PBR on an upstream router.
- **Monitoring -** Availability is determined by whether the host at the remote end of a path can be reached via end-to-end Internet Control Messaging Protocol (ICMP). The user can select the endpoint to monitor and any DSCP bits that should be set on the monitoring packets.
- **Path failover –** Application are configured with a prioritized list of paths. In case of the primary path being unavailable, traffic is redirected to the next path in the list. When no primary paths are available, traffic can be either blocked or redirected to the default path.

A dynamic tunneling capability with central control plane enabling secure backhauling

Path selection is the pivotal point for Hybrid networking strategy. Building Secure Transport around it is in the best interests of both customers and Riverbed. Traffic flowing between two SteelHeads can be secured by encryption and authentication; IT can cut cost by using Secured Internet links over expensive MPLS links. IPSEC based tunnels both VPN and SSL does not create tunnel instantaneously. Both solutions require prior handshake which interim results in poor performance. Pre-created tunnel solutions are difficult to manage and lead to scalability problems.

Secure Transport which is fully integrated into Path Selection addresses performance issues and scalability challenges. A concept called Secure Transport group in which a set of SteelHeads share the same cryptographic key and any SteelHead in the group can instantaneously create a tunnel which resolves performance and latency problems.

Secure Transport can only be configured using the SteelCentral Controller for SteelHead (SCC). All the SteelHeads in SCC can be placed in a secure group and associate networks to each uplink. SCC address scalability nightmare by automatically detecting remote sites for every branch office and grouping them accordingly.

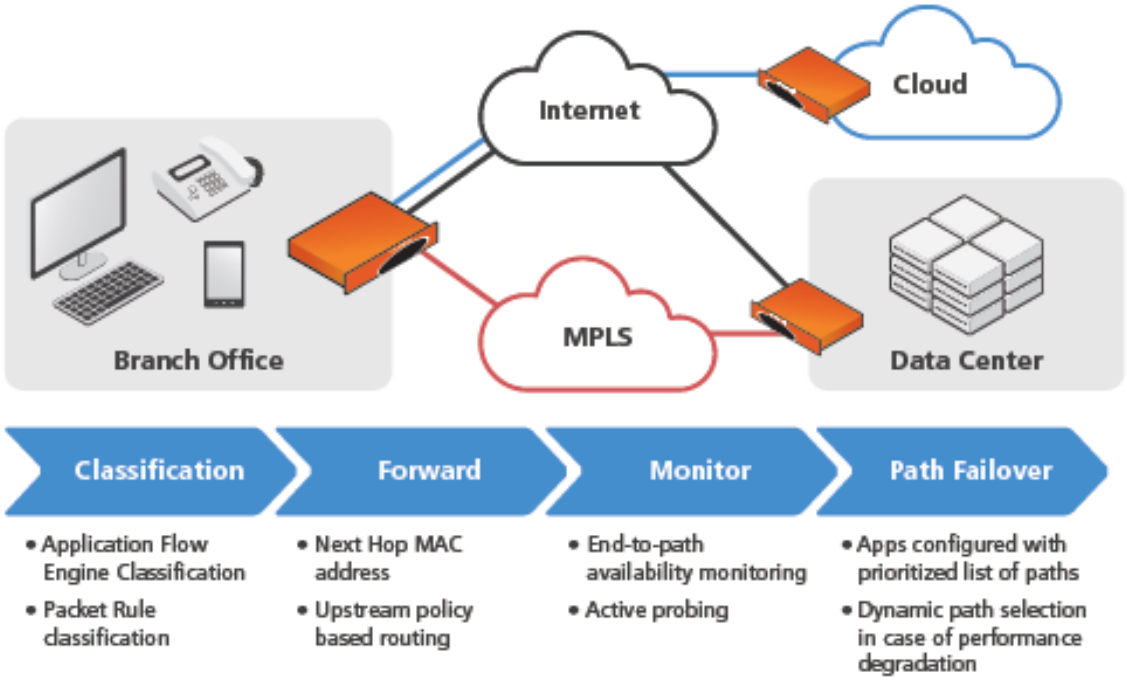


Figure 15, The 4 key elements of RiOS path selection

In RiOS 9.0, use Path Selection to maximize the benefits of multiple WANs by directing specific network traffic to a specific WAN gateway. For example, direct latency sensitive voice traffic to the MPLS WAN, while sending other application flows, such as bulk file transfers, to an Internet-based VPN.

A simple interface to zScaler or other in the cloud security services

As they embrace local Internet breakouts enterprises require strengthening their security environment within the branch themselves. To do so, enterprises typically implement Secure Web Gateways (SWG) that analyze specific ports like HTTP/HTTPS ports and often are using it in combination with Advanced Threat Detection (ATD) to detect the more advanced attacks.

For a few years those capabilities are being available as a cloud service. Companies like zScaler have deployed hundreds of point of presence across the globe where SWG and ATD capabilities are hosted and managed and sold as a cloud service. Such a distributed infrastructure effectively allows flexible implementation of the required branch security for Internet bound traffic without a significant impact on performance.

As they embrace those cloud based security services, enterprises must seamlessly integrate them into their hybrid networking architecture.

SteelHead hybrid networking includes a simple “cloud tethering” interface to zScaler or other in cloud-based security services in the form of easy to configure GRE tunneling. In combination with other SteelHead hybrid networking technology, this cloud tethering capability allows enterprises to enable local Internet breakouts without requiring further investment in on-premise Internet security appliances.

Inbound QoS to manage local Internet breakouts

SteelHead appliances are including advanced QoS capabilities to protect business critical applications against less important ones. This capability is typically used in an outbound fashion as traffic leaves its source.

When enterprises are using local Internet breakouts in the branch, the incoming (a.k.a. inbound) traffic coming from the Internet is originating from multiple disparate sources that are not equipped with SteelHead. As a result the finite bandwidth of the local Internet pipe can be filled as branch users are consuming a variety of business critical SaaS applications combined with less critical and sometimes bandwidth heavy applications like YouTube. In order to expand their protection of business critical applications to Internet bound applications, SteelHead appliances are including a unique inbound QoS capability that manages traffic from the destination instead of from the source like with traditional QoS.

This technology, which cannot be found in typical routers, utilizes dynamic configuration of SteelHead QoS queues to achieve a feedback loop with any remote sources utilizing TCP as a transport protocol.
When required to prevent congestion, SteelHead inbound QoS effectively slows down less critical inbound traffic in order to make room for more business critical flows, thus protecting experience and productivity for users of those applications.

Interceptor Path Selection

SteelHead 9.1 has extended the Path Selection feature to work with an Interceptor cluster setup. There are situations where the SteelHead products are not in layer 2-adjacency situation with WAN routers and therefore cannot direct packets onto a specific router according to Path Selection decisions. In such a setup, one or more Interceptors can be deployed at the right locations to forward packets according to Path Selection decisions. Interceptors follow Path Selection decisions done by SteelHead products based on the policies and network conditions.

RiOS - Visibility

This section covers RiOS ability to deliver visibility on network traffic by reporting on application usage and by feeding Riverbed Performance Management products by capturing key performance metrics for further analytics by tools like SteelCentral NetProfiler. With enterprise management capabilities and numerous deployment options, RiOS gives customers flexibility with minimal configuration requirements.

Comprehensive Network Visibility

By providing outstanding network visibility, RiOS ensures that its application acceleration capabilities do not cloud enterprises' reporting capabilities. RiOS technology can automatically classify traffic, allowing users to quickly see what applications are driving traffic across the WAN.

The Application Flow Engine simplifies shaping by allowing the network engineer to simplify application identification across over 1300 popular network applications. The Application Flow Engine simplifies shaping rules by simplifying the app identification process.

WAN Bandwidth Variations

Total WAN bytes measures the total bytes directed outward from the SteelHead appliance to the WAN over

time. This report provides a bandwidth-over-time view of all data flowing to the WAN through a SteelHead appliance. Previously, bandwidth over time was available only for optimized traffic, while the Traffic Summary would show byte summaries for all traffic (optimized and pass-through) but not the actual bandwidth consumption variation over time. This capability helps a SteelHead user visualize WAN-directed traffic from a SteelHead appliance and see if traffic is actually hitting the limit of the WAN link

The total WAN bytes report provides network engineers with views into WAN bandwidth consumption. This report helps the network engineer understand whether the WAN link is, or will be, undersized for the traffic flowing through the SteelHead appliance.

Application Discovery

Application Discovery shows the bandwidth consumption over time for up to seven applications in a single report, which previously could only be viewed one-at-a-time and only for optimizable applications. Application Discovery lets a network engineer visualize bandwidth consumption over time by application and compare bandwidth consumption across applications.

Application Discovery provides the network engineer with a visual record of LAN-to-WAN or WAN-to-LAN directed traffic, broken out by application. This information can be used to identify peak demand for network resources and help the network engineer set shaping rules effectively to maintain data flow.

Application Statistics

In SteelHead 9.1, a new report "Top Applications" provides a summary of bandwidth usage for the top 10 applications (both optimized and pass through) over the network. Applications are reported according to layer 7 classification. Application statistics help you make optimization, QoS and path selection policy decisions and allocate resources appropriately. Top Applications provide historical data for up to one week for the entire network.

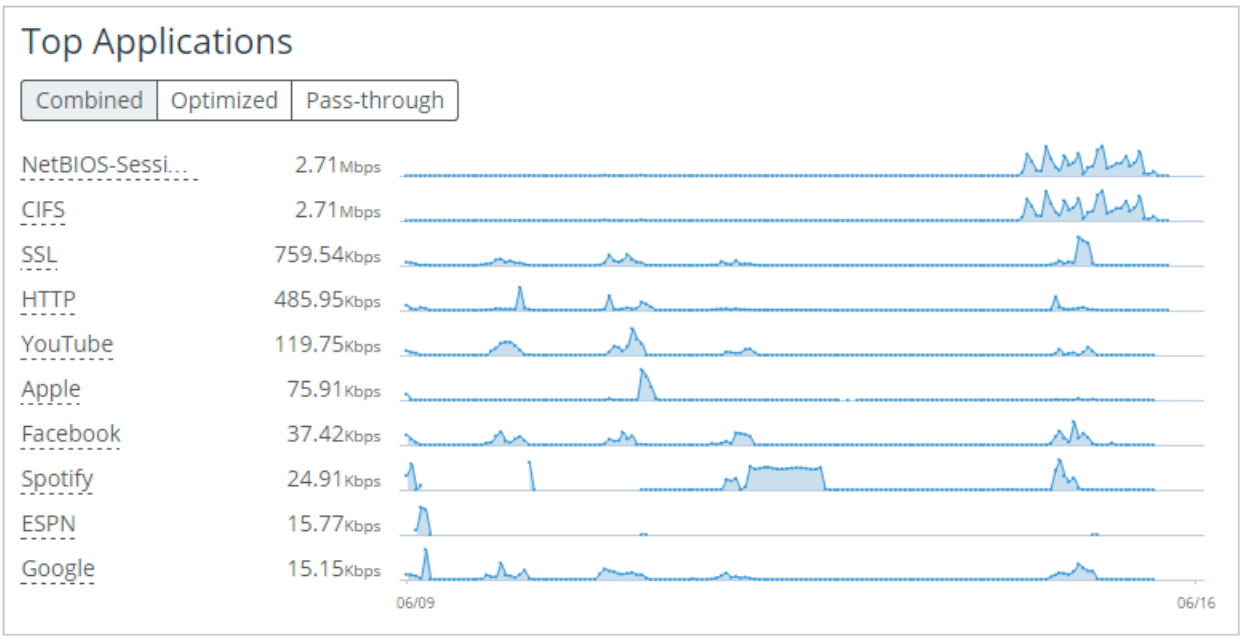
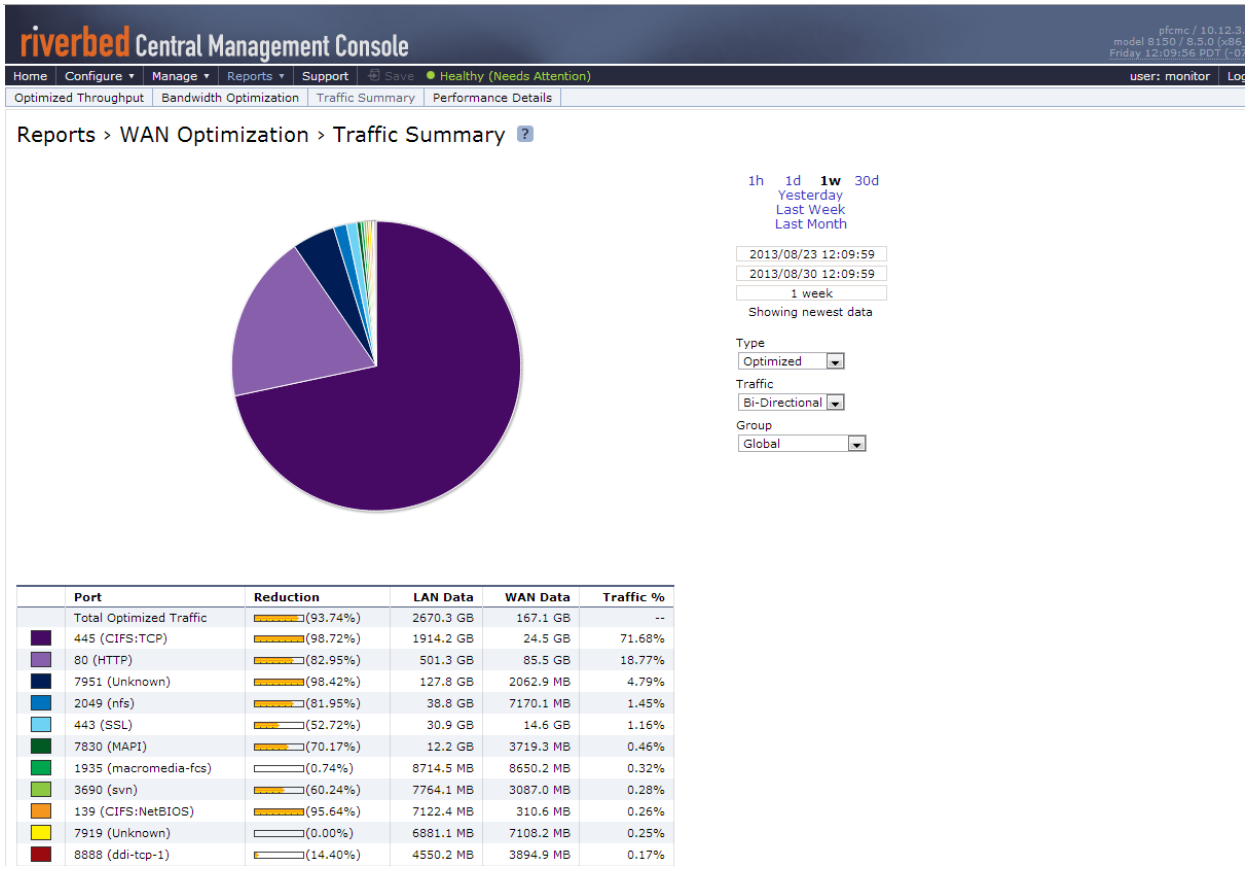


Figure 16, Top Applications Statistics

Benefit Reporting

Optimization benefit reporting helps quantify the improvements on the WAN made by RiOS features such as application specific and TCP latency features. This detailed report can show the number of round trips saved as well as the reduction in data.



	Port	Reduction	LAN Data	WAN Data	Traffic %
	Total Optimized Traffic	(93.74%)	2670.3 GB	167.1 GB	--
	445 (CIFS:TCP)	(98.72%)	1914.2 GB	24.5 GB	71.68%
	80 (HTTP)	(82.95%)	501.3 GB	85.5 GB	18.77%
	7951 (Unknown)	(98.42%)	127.8 GB	2062.9 MB	4.79%
	2049 (nfs)	(81.95%)	38.8 GB	7170.1 MB	1.45%
	443 (SSL)	(52.72%)	30.9 GB	14.6 GB	1.16%
	7830 (MAPI)	(70.17%)	12.2 GB	3719.3 MB	0.46%
	1935 (macromedia-fcs)	(0.74%)	8714.5 MB	8650.2 MB	0.32%
	3690 (svn)	(60.24%)	7764.1 MB	3087.0 MB	0.28%
	139 (CIFS:NetBIOS)	(95.64%)	7122.4 MB	310.6 MB	0.26%
	7919 (Unknown)	(0.00%)	6881.1 MB	7108.2 MB	0.25%
	8888 (ddi-tcp-1)	(14.40%)	4550.2 MB	3894.9 MB	0.17%

Figure 17, Traffic visibility and optimization from the SteelCentral Controller.

Pass through traffic reporting gives visibility into which connections are being optimized and which are not. It further qualifies the reason for pass through, whether this is due to the protocol (UDP, VoIP, etc.) or because the maximum capacity or number of connections for the SteelHead appliance model was exceeded.

Export to Third-Party Tools

RiOS also provides the ability to export detailed real-time flows from a SteelHead appliance or SteelHead Mobile to Cascade or a third party NetFlow v.5 or v.9 collector for greater visibility, analysis and diagnosis of issues. From the NetFlow collector, enterprises can view byte counts per port, per source/destination IP address, and from a specific interface. IT administrators can obtain traffic views for optimized vs. pass-through traffic separately or in aggregate and obtain top talker/listener tallies from a NetFlow compatible collector. In addition, the support of NetFlow v. 9 and its newer flexible formats allow us to export all the data a customer needs to build a site report (inbound and outbound LAN and WAN traffic) from a single

SteelHead appliance. This will provide the information that SteelCentral NetProfiler and other external reporting solutions need to generate reports without needing to correlate data from multiple flow sources.

The Application Flow Engine deep packet inspection-based application recognition technology also improves the power of the Riverbed Cascade flow integration by adding detailed application and shaping information into the flow data passed from SteelHead to Cascade appliances, making the Cascade reports much more powerful.

Embedded Shark Packet Capture

Riverbed offers integration of Cascade Shark™ functionality in Riverbed SteelHead appliances to provide onboard packet capture and integrated analysis of application problems with an intuitive, visual interface. This feature offers on-demand packet capture anywhere SteelHead appliances have been deployed within an enterprise network. Packet capture is fully integrated with Wireshark, enabling customers to isolate application-specific issues and even replay application transactions with packet-level visibility.

Integration with SteelCentral NetProfiler

SteelHead can be seamlessly integrated with SteelCentral NetProfiler to deliver visibility beyond traditional NetFlow reporting. SteelHead and SteelCentral NetProfiler share the same application definitions. It means that application labels used in the SteelHead UI are the same as in SteelCentral NetProfiler reports, thus making combined visibility and control workflows easier to handle. With WAN optimization and mechanisms like TCP proxies, the accuracy of application performance metrics like RTT is severely degraded. SteelHead products are computing individual RTT on each sections of an optimized TCP session enabling to rebuild a consistent view of end-to-end RTT inside SteelCentral NetProfiler reports.

Integration with SteelCentral AppResponse 9.5

RiOS 9.0 now empowers IT with greater visibility across the hybrid enterprise with end-user experience monitoring for web (on prem or cloud) and SaaS applications. With the integration of SteelHead 9.0 and SteelCentral AppResponse 9.5, leveraging SteelFlow WTA, we are now adding end-user experience monitoring. So now, in addition to traditional on-prem application visibility, you can get visibility into SteelHead-optimized web application and SaaS (Salesforce.com) traffic.

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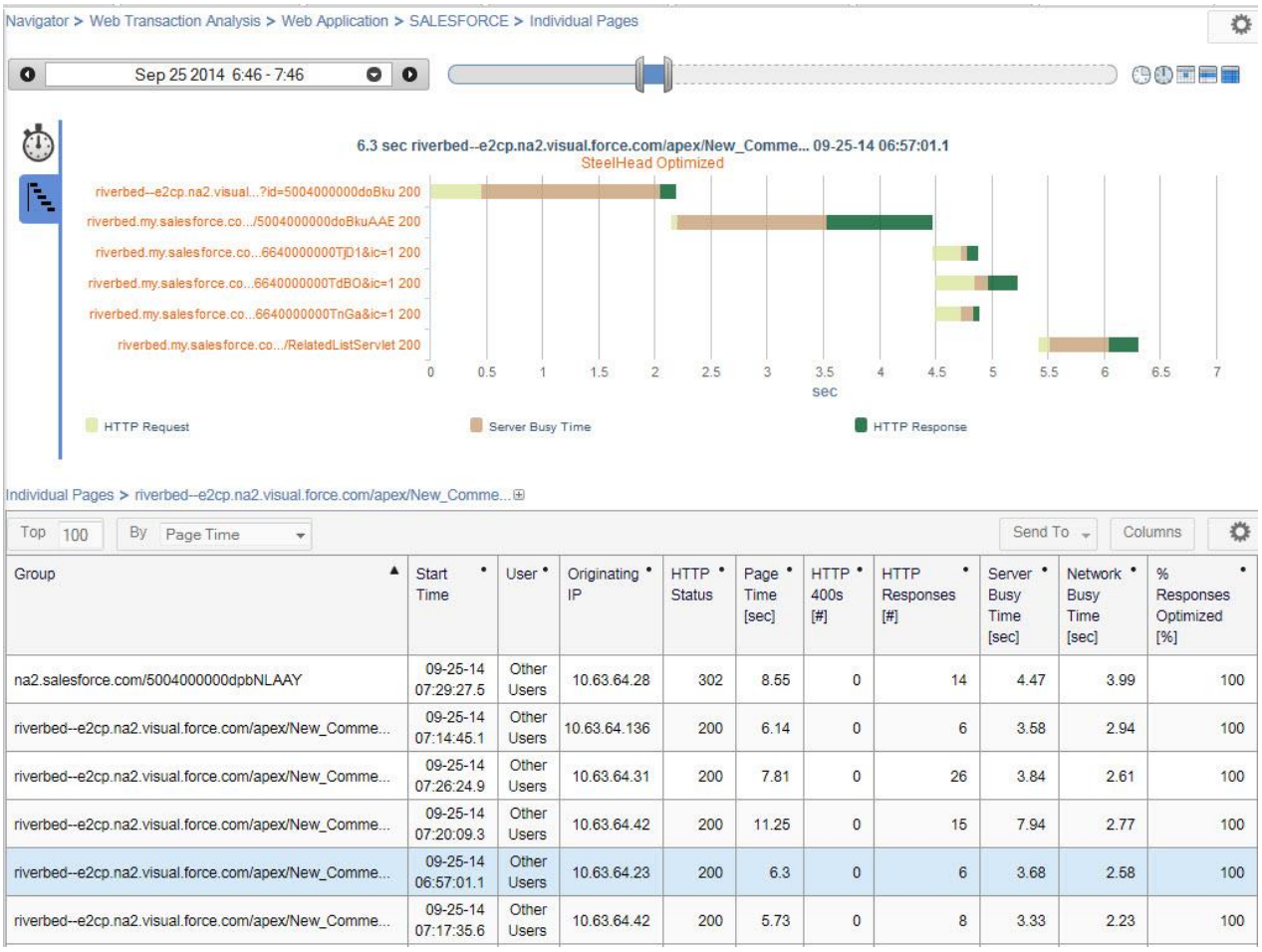

Group	Start Time	User	Originating IP	HTTP Status	Page Time [sec]	HTTP 400s [#]	HTTP Responses [#]	Server Busy Time [sec]	Network Busy Time [sec]	% Responses Optimized [%]
na2.salesforce.com/5004000000dpbNLAAY	09-25-14 07:29:27.5	Other Users	10.63.64.28	302	8.55	0	14	4.47	3.99	100
riverbed--e2cp.na2.visual.force.com/apex/New_Comme...	09-25-14 07:14:45.1	Other Users	10.63.64.136	200	6.14	0	6	3.58	2.94	100
riverbed--e2cp.na2.visual.force.com/apex/New_Comme...	09-25-14 07:26:24.9	Other Users	10.63.64.31	200	7.81	0	26	3.84	2.61	100
riverbed--e2cp.na2.visual.force.com/apex/New_Comme...	09-25-14 07:20:09.3	Other Users	10.63.64.42	200	11.25	0	15	7.94	2.77	100
riverbed--e2cp.na2.visual.force.com/apex/New_Comme...	09-25-14 06:57:01.1	Other Users	10.63.64.23	200	6.3	0	6	3.68	2.58	100
riverbed--e2cp.na2.visual.force.com/apex/New_Comme...	09-25-14 07:17:35.6	Other Users	10.63.64.42	200	5.73	0	8	3.33	2.23	100

Figure 18, SteelHead Optimized Salesforce Traffic from SteelCentral AppResponse 9.5

RiOS – Combining Optimization, Control and Visibility

SteelHead products are tightly integrating the 3 core mechanisms to improve performance of applications over the WAN: optimization, control and visibility. Below are a few use cases on which this ability is yielding to superior results.

NetApp SnapMirror Optimization, Control and Visibility

Today, when storage replication apps such as NetApp SnapMirror send their data to a network, the network sees and treats all packets as essentially the same. Yet, in reality, different packets originate from different storage volumes, which manage data for different applications (for example, ERP, Home Directories, Virtual Servers, etc.) that may have different SLAs defined by the business, such as Recovery Point and Recovery Time Objectives (RPO/RTO).

RiOS provides users with complete visibility and total control over the performance of SnapMirror across the WAN and allows to:

- Track throughput and data reduction for individual filers and volumes, as well as for SnapMirror as a whole

- Tune optimization settings for any volume to yield maximum performance
- Control WAN bandwidth allocation and network QoS for individual volumes to reflect business priority

Virtual Desktop Infrastructure (Citrix and VMware) Optimization and Control

Riverbed can optimize the traffic associated with delivery of virtual desktops for leading solutions like Citrix ICA and VMware View. This is simply enabled by automatically switching to RiOS compression and encryption in place of the less effective native compression and encryption options in the VDI products. In addition, Riverbed SDR-M can efficiently reduce the bandwidth requirements in memory for high throughput results. Typical results show that up to twice as many desktops can be supported on the same WAN (by halving the bandwidth requirements of each), and end user response times can improve by up to 80% (over uncompressed traffic) making for more satisfactory performance. Further, Citrix desktops can be optimized utilizing QoS markings, to prioritize interactive activities like desktop input and display over less time sensitive operations such as printing.

In SteelHead 9.1, the Auto-Negotiate Multi-Stream ICA feature was added to use multiple TCP connections to carry traffic for a Citrix session on either port 1494 or 2598. Multi-Port ICA is not necessary and no changes are required on the Citrix XenApp or XenDesktop Citrix computer policies. The Citrix optimization module will provide application class information to the QoS engine to allow configuration of independent QoS rules for the four priority connections. Additionally, Auto-Negotiate Multi-Stream ICA will provide the ability to apply Path Selection for Citrix traffic.

VMware PCoIP (View) optimization can be enabled with fine-grained bandwidth control and prioritization. This enables improved performance for VMware View over the WAN. PCoIP is a display compression technology used for Virtual Desktop Infrastructure (VDI) solutions. Riverbed QoS for PCoIP delivers bandwidth control and latency prioritization for virtual channels within a PCoIP stream, enabling fine-tuning of traffic including voice, video and display rendering, and can greatly improve the user experience when desktops are provided over the network.

Figure 19 is an example configuration where QoS is configured for this protocol.

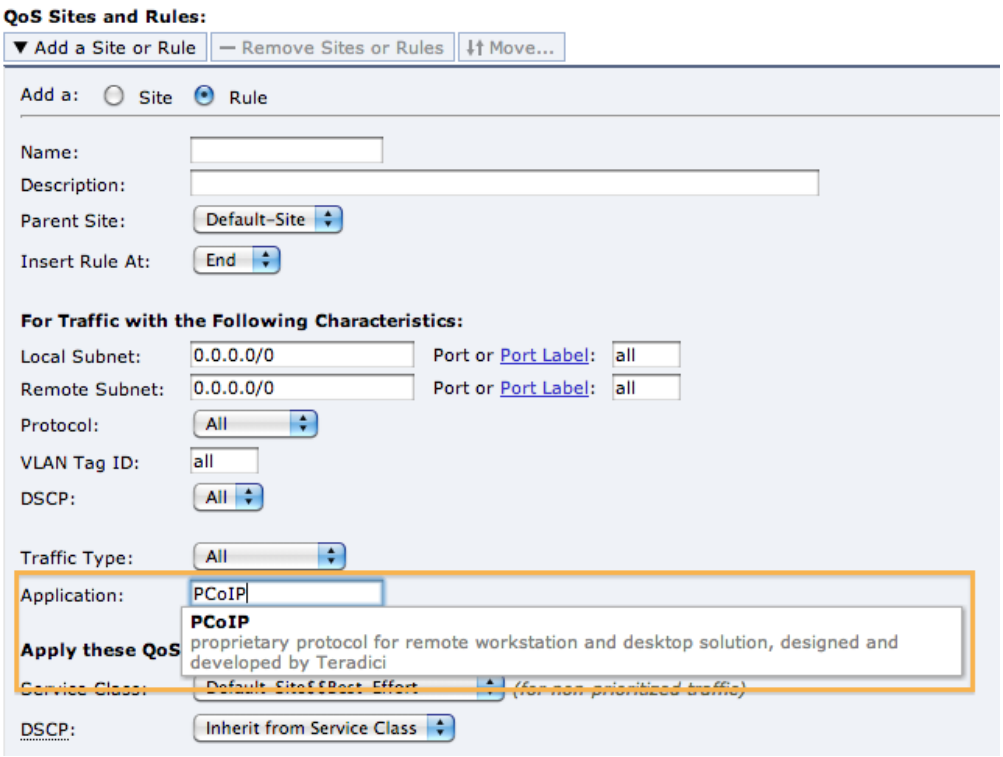

Figure19, Example PCoIP/VMware View Optimization Configuration.

Lync Control and Visibility

Microsoft Lync uses a variety of protocols for audio/video communications, file sharing and overall signaling. Without proper deep packet inspection, layer 3 or 4 rules must be used to classify Lync traffic. Worse, with audio and video flows, layer 4 classification requires forcing the use of specific ports in the Lync configuration. Since RiOS 8.5.1, SteelHead appliances are able to recognize Lync flows at the layer 7, without requiring cumbersome layer 3 or 4 rules or Lync configuration changes.

RiOS – Cloud and Internet optimization

As organizations migrate their initial data and later broaden their application footprint into the cloud, ensuring that applications perform as needed and as guaranteed becomes critical. Reduced control and manageability of infrastructure performance, as well as difficult migrations and complex deployments, can challenge IT.

Public, private and hybrid cloud environments all face the same performance limitations inherent in today's networks and applications – bandwidth constraints, latency and competition among applications.

SteelHead benefits are available for many cloud applications deployed in SaaS or IaaS formats.

SteelHead SaaS

Microsoft Office 365, Salesforce.com, Box.net are among the most used SaaS applications accessed daily by users worldwide. Organizations using those SaaS services must select an instance, and therefore a location, where their data will be hosted. By doing so, just like when they pick a location for any on-premise workload, organizations are consciously choosing those users that will be far away from the data from those that will be close. Yet, the same level of service is required to make those users productive, independently of the location of the SaaS instance.

Riverbed SteelHead SaaS accelerates Microsoft® Office 365, Salesforce.com, Box.Net, SuccessFactors, ServiceNow and Microsoft Dynamics from the cloud in the same way that traditional SteelHead products accelerate enterprise applications running on corporate networks. SteelHead SaaS mitigates the impact of latency and align performance to the maximum for all users whether they are close or far from the SaaS application.

SteelHead SaaS dynamically instantiates virtual SteelHead appliances as close as possible from the SaaS instance leveraging the formidable Akamai footprint, thus enabling an end-to-end management of the application without any intrusion in the SaaS provider datacenters. SteelHead SaaS also leverage Akamai's SureRoute Internet overlay for optimized latency and bandwidth for the Internet portion of the SaaS application delivery chain.

Delivered as a service, SteelHead SaaS is easy to deploy and requires no changes to the user side or in the SaaS provider cloud. IT can increase the service availability based on user demand, while meeting and exceeding IT service agreements.

In RiOS 9.0, SteelHead's GeoDNS feature for Office 365 helps to ensure users always have optimal optimization for their Office 365 mailbox no matter where the Office 365 mailbox or the user are located.

SteelHead CX for IaaS

Built for public cloud environments such as Microsoft Azure, Amazon Web Services (AWS) and VMware ESX-hosted clouds and vCloud Air, SteelHead CX for IaaS clouds extends the #1 optimization solution for the hybrid enterprise to Infrastructure as a Service (IaaS) public clouds. By overcoming application and network performance problems with data, application and transport streamlining, SteelHead CX speeds migration to the public cloud and accelerates access for users from virtually any location.

SteelHead CX's compatibility with a wide variety of cloud services gives organizations the freedom to move between cloud providers with ease. IT can easily deploy and manage SteelHead CX in just a few clicks and quickly integrate with other SteelHead solutions.

SteelHead CX also improves IT visibility by seamlessly integrating with SteelCentral NetProfiler for end-to-end network monitoring and reporting and SteelCentral AppResponse for end-user experience monitoring for web and SaaS applications. It also improves problem resolution with on demand gathering of packet and flow data from the branch through activation of SteelCentral NetShark.

RiOS - Virtualized Branch Services on the SteelHead EX Series Appliances

The Riverbed Virtual Services Platform (VSP) enables branch office services to be deployed in an easy-to-

manage, virtualized solution alongside RiOS in the same appliance. With VSP, Riverbed provides customers with the capability to run additional services and applications in a protected zone on SteelHead appliances. This revolutionary approach uses VMware® to provide dedicated resource instances for enterprise software. VSP runs in a protected partition on the SteelHead appliance to run best-of-breed services and applications while minimizing the branch office hardware.

Virtual infrastructure can be optimized in multiple ways, depending on your solution. Virtual Machine (VM) datastores can even be remotely hosted in a central data center and VMs can run at the branch. This is enabled with the Riverbed Granite solution. For more information on Granite, consult riverbed.com/products and view the Edge Virtual Server Infrastructure section.

VSP can **be managed with standard VMware tools**, such as vCenter®, and can be easily integrated into an existing virtualized enterprise.

VSP also creates an extensible platform for multiple technology partners to deploy their services without the need for an additional dedicated server or appliance in remote offices. VSP helps customers by enabling branch services such as IP address management (IPAM), video streaming, and local print server capabilities. The net effect is a platform that delivers flexibility, best-of-breed functionality, and simplified management for virtualized services on the edge.

Figure 20, VSP runs on all SteelHead EX series appliances.

VSP is a standard feature on all SteelHead EX series appliances, combining WAN optimization and branch office services onto a single appliance. This enables reduced costs by consolidating services that may otherwise run at the branch on dedicated server hardware.

RiOS - Management Streamlining

Unlike other approaches to application acceleration, RiOS was designed specifically to simplify deployment and management of WAN optimization devices. In fact, many customers can deploy devices running RiOS, such as the Riverbed SteelHead appliance, in just 15 minutes. SteelHead Mobile clients can also be easily deployed to remote workers using Riverbed MSI package creator to build installation and update packages. The net effect is an application acceleration solution with minimal administrative overhead.

Deployment is further simplified, because RiOS's requires no changes to servers, clients, or routers, and offers highly flexible network design options. In addition, the SteelCentral Controller (SCC) and SteelHead

Mobile Controller (SMC) provide management capabilities for enterprise-wide reporting, configuration, and deployment options.

The way data is displayed is flexible: time series data can be viewed as line charts or columns, data can be displayed, hidden or filtered, and individual data points can be inspected. Examples of individual data points include bandwidth optimization, data reduction percentages or QoS enforcement.

Device Configuration and Management

Every RiOS-powered SteelHead appliance supports individual device management via SSH command line and an HTTP or HTTPS graphical user interface. Deploying SteelHead appliances follows a very simple configuration process that essentially involves configuring interface IP and duplex information, subnet and management information, and then plugging the appliance into the network. Every device also supports SNMP traps and email alerts for conditions that require attention or intervention. This has been enhanced to include support for both SNMP v.2 and v.3 (for more security), for more detailed MIB information, to allow thresholds and alerts on MIBS, and for integration of a configurable XML/SOAP API. SNMP traps include accounting and audit alerts such as user login/logout, configuration changes, TCPDump started, etc. The API allows a broad set of reporting and management actions to be taken from external Network Management Systems (e.g. HP Openview). Most statistics are exposed and a number of configuration actions can be taken remotely. Collectively, these tools allow for easy management of the appliances and straightforward integration into existing network management systems such as HP OpenView.

Simplifying configuration even further, the patent-pending RiOS auto-discovery capability automates the establishment of optimization peering relationships throughout the enterprise. This gives large firms a method to efficiently scale WAN optimization deployments globally without creating additional complexity and overhead. Auto-discovery also enables easy integration with “any-to-any” networks, which is common to many of today’s WAN architectures, thereby circumventing problems specific to tunnel-based optimization technologies.

SteelHead Mobile installations overcome many of the challenges with deploying client software. The solution comes with an MSI package builder to construct installations and upgrades, which can be installed using deployment software such as SMS, Altiris, LANDesk, or other solutions. In addition, installs can be performed using a silent installation mode so users do not have to engage with the installation process.

SteelCentral Controller for SteelHead (SCC)

RiOS also allows centralized monitoring and management of a complete network of appliances via the Riverbed SteelCentral Controller (SCC). The SCC provides complete enterprise management, configuration and reporting capabilities from a single console.

A new management plane to drive global hybrid networks using simple abstractions

Riverbed SCC central management console marks the start of an era of dramatic improvement of manageability and usability of control capabilities. While SteelHead optimization has always been praised for its ease of use, for years, control capabilities like QoS, path selection or VPN that the industry has delivered have been a nightmare to manage. With the new SCC, Riverbed exposes to users an intuitive interface and management plane based on high level abstractions like applications, sites, uplinks or networks that matches the way they see their IT environment. SCC relies on a control plane designed to support intent

based configuration that provides a translation of global parameters into local SteelHead policies. Thanks to SCC, customers can implement new, more efficient, configuration and change management workflows that make hybrid-networking capabilities really usable at scale.

Automated appliance discovery and configuration

Deployment of SteelHead appliances is simplified even further through the SCC. Unconfigured SteelHead appliances can auto-discover the SCC via a DNS lookup and register with the SCC to receive a pre-arranged configuration. This powerful feature, called touchless configuration for SteelHead appliances, helps deploy devices quickly while achieving unparalleled management scale. Whether using touchless configuration or not, administrators can use the SCC to deploy configurations and optimization policies to appliances individually, in groups, or en masse across the enterprise.

The SCC can also provide aggregated or individual device reporting, group-based configurations and policies, and scheduled operations. It gives users global trending of performance statistics using up to one year of historical data, and the ability to zoom in on any period to retrieve more granular data. Additional management functionality includes automated over-the-wire software upgrades, global SSL certificate management, and an easy-to-use QoS rules configuration interface, all through an intuitive Web interface.

Some SCC enhancements give IT staff the ability to backup and restore SCC configurations, view improved reporting, make policy comparisons to improve consistency, and set up new SteelHead appliance configuration services.
Top Talkers Reporting allows network administrators to report on the top users of bandwidth, for either security monitoring or accounting purposes. The flows that are generating the heaviest use of WAN bandwidth are known as the *Top Talkers.* This feature gives them back more LAN and WAN visibility without having to use the WAN transparency feature or NetFlow.

There is now support for up to 2,000 SteelHead appliances per SCC.

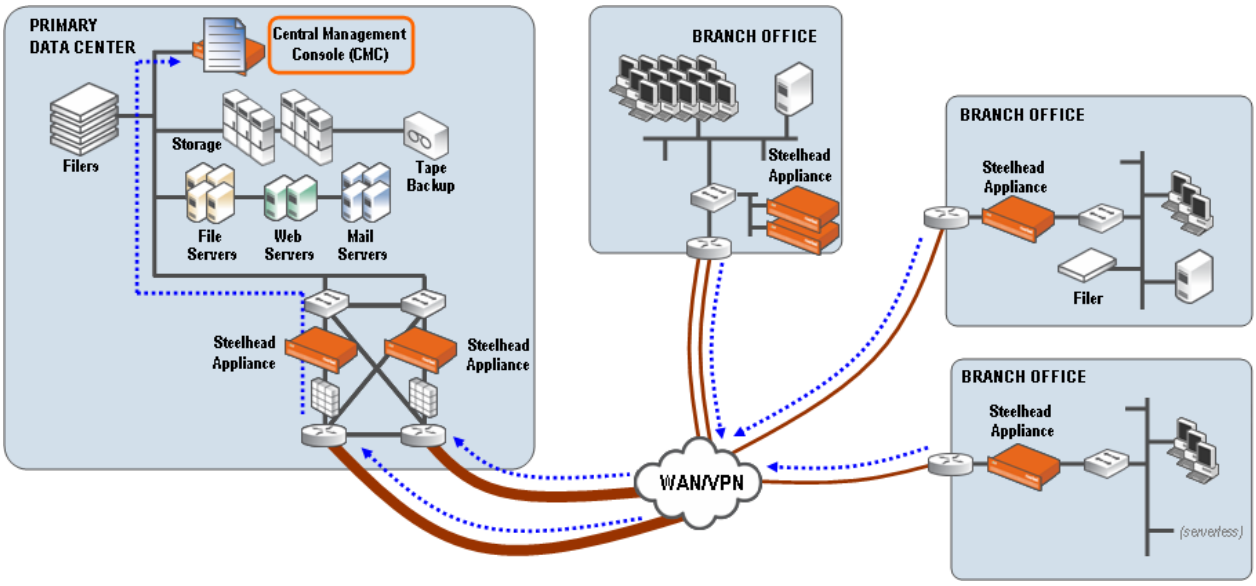

Figure 21, SteelHead appliances auto-discover the SCC and can be configured and monitored from a central console.

SteelCentral Controller for SteelHead Mobile (SMC)

Much like the SCC, the SteelCentral Controller for SteelHead Mobile provides central management capabilities for the SteelHead Mobile. The SMC enables easy deployment of mobile client software to remote users via an MSI package creator for install and upgrade builds. Additionally, the SMC integrates with Microsoft Active Directory and LDAP to enable configuration and policy optimization on a user or group basis.

Enterprise reporting is also available on an aggregated or per user basis to give a comprehensive view of traffic optimization for the entire mobile workforce. The SMC also provides license management, job scheduling, and notifications to extend its administrative capabilities.

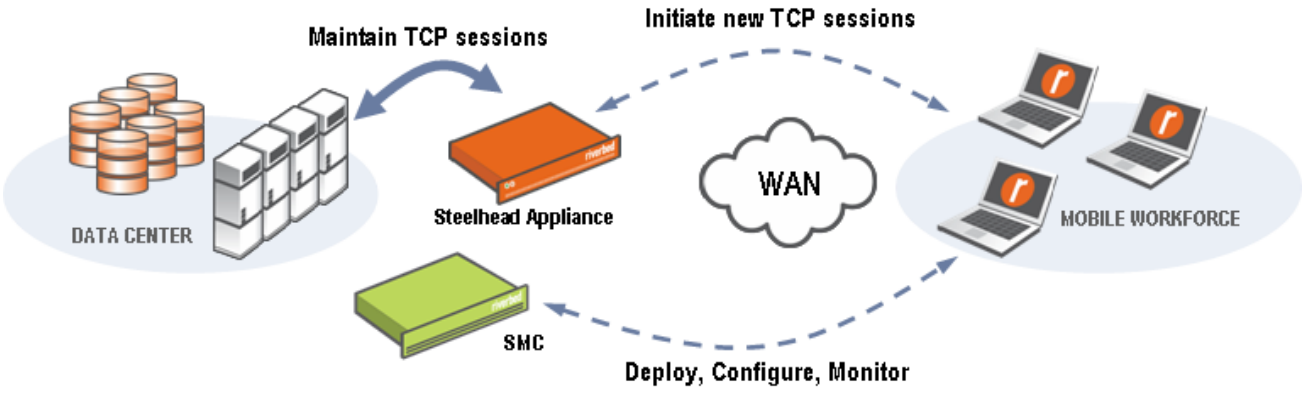

Figure 22, SMC enables easy deployment and control of mobile clients.

RiOS Deployment Options

By design, RiOS provides flexible integration with various network architectures, best-in-class scalability, and redundant configuration options for high availability environments. Riverbed has designed RiOS to interoperate with existing network deployments rather than force specific architecture and configuration requirements on customers that can affect availability and design alternatives in the longer term. Because of these design considerations, RiOS can easily be deployed in extremely complex hybrid network environments with minimal ongoing management.

The underlying RiOS technology enables a robust and scalable WAN optimization solution that can support both legacy infrastructure as well as the latest WAN technologies in use today. Devices running RiOS can be deployed with no changes to clients, servers, or to other critical infrastructure, and automatically detect each other across the WAN; there is no need for any tunnel configuration, DFS changes, client drive mapping changes, plug-ins, router configuration, route injection, or any of the other overhead required for competitive solutions. RiOS allows for normal client-server interaction, and focuses on accelerating the resulting data transfer. RiOS has been deployed in hybrid ATM / frame relay environments, over satellite infrastructure, and in full mesh Multi-Protocol Label Switching (MPLS) environments with no special requirements or caveats.

Enterprise-Class Scalability

With its auto-discovery capability to establish peering and support of any-to-any networks in the WAN cloud, RiOS can easily scale to support the world's largest enterprise networks. Because RiOS does not use tunnels, SteelHead appliances and mobile software can function easily in full mesh environments, such as MPLS, with no manual configuration requirement. This also translates into broader scalability for large-scale enterprises where the full mesh increases peering requirements exponentially. Tunnel-based approaches simply will not scale in an enterprise full mesh, because smaller branch offices will not have appliances that can accommodate thousands of peers. Many of these devices have a 10 - 20 peer limitation, meaning that optimization will be only sporadically applied. RiOS's superior design maintains a peering limit of 4,096 peers, so application acceleration benefits can be extended to all offices across the board.

In terms of throughput and connection optimization, Riverbed has appliances for all branch office sizes and data centers and the software mobile client extends application acceleration to the mobile workforce as well. At the enterprise level, an individual SteelHead appliance can support up to 150,000 connections, optimizing traffic for up to 10,000 users or more. Clusters of devices can support up to 1,000,000 concurrent connections and up to 4 gigabits per second of throughput, meeting the needs of the largest most complex networks anywhere. Enterprises using 10 GigE can easily attach to SteelHead appliances for additional throughput.

RiOS also scales application prioritization for over 1300 apps, including the majority of enterprise applications. For a complete listing of applications, consult the "*Riverbed QoS Application Classification Feature Brief*," available on the riverbed.com web site.

High Availability Clustering

RiOS simplifies redundant deployment with both in-path and out-of-path clustering. A series of RiOS-powered devices on a network path takes advantage of the way that RiOS passes through unoptimized

traffic when it reaches its performance limits. The next member of the cluster that has capacity handles such passed-through traffic by one member of the serial cluster. No other product available supports such a straightforward approach to increasing capacity and redundancy.

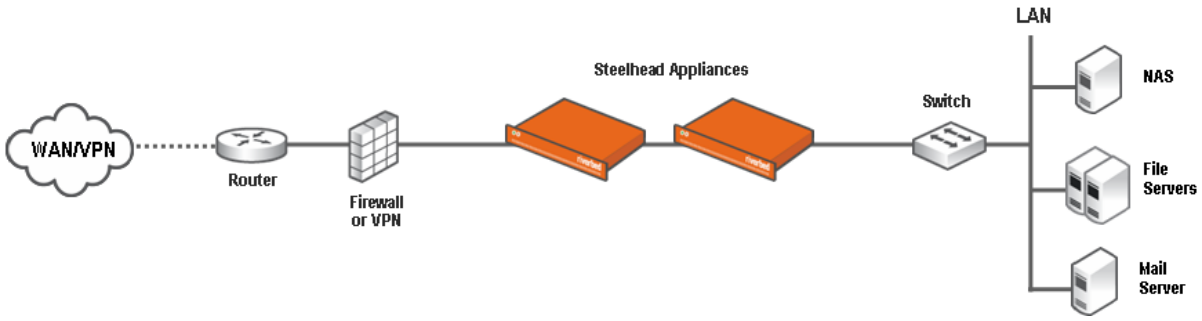

Figure 23, Serial clustering allows for simple in-path deployment while still providing redundancy.

RiOS also simplifies redundant deployment with support for in-path deployment on multiple network links. Only RiOS allows a single device to support simultaneous in-path deployment on 6 copper links or 6 fiber links, or even a mixture. In addition, Riverbed exclusive server-side and client-side connection forwarding means that multiple RiOS devices can cooperate to support optimization across multiple redundant links when there are too many links for a single device or the multiple links are physically too far apart for a single device.

RiOS also enables out-of-path clustering for redundancy and scale. This deployment mechanism allows for a pool of optimization devices to work together and handle incoming requests efficiently. In the event of a device failure, other devices can handle its requests. Users can cluster devices in an out-of-path deployment using a Layer 4 switch, WCCP or PBR.

Riverbed Interceptor Appliance

Alternatively, users can deploy the Riverbed Interceptor® appliance. The Interceptor appliance is an optional component meant for very large data center deployments. It functions as a specialized connection distribution device for a bank of SteelHead appliances, while eliminating the need to rely on WCCP or PBR. (WCCP and PBR can be difficult to configure and manage, and are not always reliable.) While a bank of SteelHead appliances will function properly with an L4 switch in place as a standard load balancing mechanism, the Interceptor appliance also supports more RiOS-specific functionality, such as asymmetric routing.

The Interceptor appliance uses the RiOS philosophy of simple, transparent deployment to ease integration into complex data centers and does not require any static route configuration. For large enterprise deployments, customers can leverage the Interceptor appliance to scale to up to 40 Gbps of throughput and 1,000,000 concurrent connections. The Interceptor appliance can also ensure warm performance by tracking SteelHead appliance peer relationships to avoid the inconsistent performance gains sometimes found in WCCP and PBR deployments.

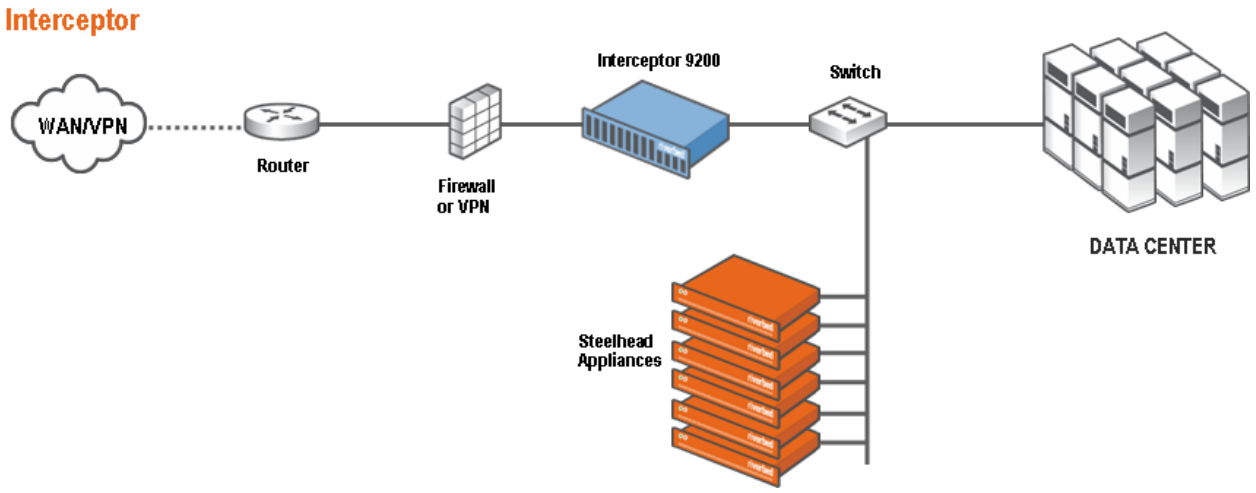

Figure 24, RiOS also allows for out-of-path deployment with optional clustering of devices.

For deployments requiring the highest levels of redundancy and performance, RiOS also supports warm standby between designated primary and backup devices. Using automated datastore synchronization, the data segments and the references created via Data Streamlining are automatically copied from the primary to the backup appliance. In the event of a failure in the primary appliance, the backup appliance will take its place with a hot datastore, and can begin delivering fully optimized performance immediately. RiOS even supports active/active configurations, in which each appliance is serving both as a primary for some traffic and as a backup for the other appliance, with full datastore synchronization. No other vendor can match these capabilities.

RiOS also permits a variety of other in-path, virtual in-path, or out-of-path configurations both parallel and clustered. RiOS has capabilities for integration into even the largest-scale, most-complex networks. Unlike other vendors' systems, RiOS achieves those capabilities without using dangerous, shortsighted approaches like route injection, fake addressing on the WAN, or non-scalable approaches like explicitly configured tunnels.

End-to-End Data Security

Historically, customers looking at WAN optimization solutions were often faced with a compromise between security and performance. They needed either to accept subpar performance while maintaining stringent security measures, or lower the security bar in order to improve application performance with WAN optimization. With RiOS, Riverbed eliminates this trade-off by offering security capabilities to protect data in both motion and at rest.

RiOS's patent-pending SSL acceleration module allows customers to securely accelerate SSL encrypted traffic without scattering digital certifications and private keys around the enterprise. Recent SSL sessions can be automatically re-used, further increasing the performance of SSL traffic while keeping it secure. In addition, RiOS's SSL capability works alongside existing SSL offload or load-balancing devices. Server IP auto discovery simplifies the setup of this features, as does support for wildcard to quick add a range of servers (for example *.riverbed.com). RiOS also provides an optional SSL capability to encrypt the inner-channel communications between SteelHead appliances to secure other data traversing the WAN that is not otherwise protected.

To protect data at-rest, RiOS supports AES encryption of the datastore inside SteelHead appliances to meet security or compliance regulations. AES-128 has been selected as the U.S. government encryption standard and RiOS can encrypt datastores using AES-128, AES-192, and AES-256 bit encryption schemes. It is worth noting that the SteelHead datastore contains short, unique segments rather than entire files or application objects. This makes it hard for an attacker to recover files from the "shredded" segments in the datastore, even without encryption. The optional encryption of the datastore provides an additional level of protection for the most security-conscious organizations.

SteelHead appliances have a unified trust model offering strong authentication to determine which should be allowed peer connectivity. This can be based on both self-signed certificates and well-known Certificate Authorities.

To date, Riverbed is the only WAN optimization vendor to provide this end-to-end security in their solution. RiOS also provides centralized management of security functions on remote SteelHead appliances through the SCC for enterprise-wide manageability. As evidence of Riverbed commitment to delivering secure WAN optimization, Common Criteria, FIPS, and DISA JITC compliance certifications are being sought.

Summary

RiOS provides a complete approach to WAN optimization and acceleration that addresses the problems of bandwidth, latency and application protocol chattiness through a unified solution. RiOS also includes control capabilities including QoS, path selection, traffic encryption and other features to manage applications over a hybrid Internet and MPLS network according to their performance needs and criticality to the business. Finally, RiOS enables visibility on network traffic by reporting on application usage and by feeding Riverbed Performance Management products by capturing key performance metrics for further analytics by tools like SteelCentral Profiler. With enterprise management capabilities and numerous deployment options, RiOS gives customers flexibility with minimal configuration requirements.

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Appendix 1: Features & Functionality Quick Reference

Type	Feature	SteelHead Appliance RiOS 9.0	SteelHead Appliance RiOS 8.5	SteelHead Appliance RiOS 8.0	SteelHead Appliance RiOS 7.0	SteelHead Mobile 4.0	Key Benefits
Data Streamlining	Memory only basic compression	●	●	●	●		Reduce bandwidth consumed by new traffic
	Disk based Data Reduction	●	●	●	●	●	Store all TCP traffic on disk; suppress retransmission of repeated traffic
	QoS Marking	●	●	●	●		Set QoS flags or honor existing settings
	QoS Enforcement	●	●	●	●		Optimize bandwidth usage by application; packet prioritization by application
	Hierarchical QoS	●	●	●	●		Multiple QoS classes to prioritize traffic by site, type and support diverse link speeds
	AppFlow Engine	●	●	●	●		Identify different applications based on Layer 7 information

Type	Feature	SteelHead Appliance RiOS 9.0	SteelHead Appliance RiOS 8.5	SteelHead Appliance RiOS 8.0	SteelHead Appliance RiOS 7.0	SteelHead Mobile 4.0	Key Benefits
Transport Streamlining	Basic TCP optimization	●	●	●	●	●	Use larger TCP frames to send more data per round trip
	Advanced TCP optimization	●	●	●	●	●	Set up new TCP session +repack TCP frames – vastly more data per R/T
	HS-TCP, MX-TCP	●	●	●	●		Reduce effects of congestion control-Fill up "Long Fat Networks" 800 Mbps+
	3 WAN visibility modes	●	●	●	●	●	Provide more visibility across the WAN for reporting
	Packet Mode optimization	●	●	●	●		Optimization of UDP based traffic

Type	Feature	SteelHead Appliance RiOS 9.1	SteelHead Appliance RiOS 9.0	SteelHead Appliance RiOS 8.5	SteelHead Appliance RiOS 8.0	SteelHead Appliance RiOS 7.0	SteelHead Mobile 4.0	Key Benefits
Application Optimization	CIFS Protocol (Windows) and NFS Acceleration	●	●	●	●	●	●	Reduce round trips generated by file sharing
	Local File Storage	●	●	●	●	●		Store copies of files on disk (Optional, separate from SDR) for off-line access
	MAPI	●	●	●	●	●	●	Reduce Microsoft Exchange round trips with 2000-2013 inc. encrypted MAPI
	HTTP Enhancements and SSL Optimization	●	●	●	●	●	●	Improve efficiency of HTTP requests and accelerate SSL traffic
	MS-SQL	●	●	●	●	●	●	Reduce round trips generated by applications running MS-SQL databases
	Oracle 11i	●	●	●	●	●	●	Reduce round trips and data generated by Oracle 11i JInitiator
	DR Acceleration	●	●	●	●	●	●	Optimize traffic based on DR behavioral traffic recognition
	Stream Splitting for HTTP Video	●	●	●	●	●		Native stream splitting for Flash and Silverlight video over HTTP
	Encrypted Lotus Notes	●	●	●	●	●		Optimization for Lotus Notes encryption v2
	NetApp SnapMirror specific optimizations	●	●	●				Improved performance in data replication environments
	Microsoft SharePoint specific optimizations	●	●	●				Greatly enhance the SharePoint via optimization of FPSE and WebDAV
	Web Proxy	●						Internet Optimization

Type	Feature	SteelHead Appliance RiOS 9.1	SteelHead Appliance RiOS 9.0	SteelHead Appliance RiOS 8.5	SteelHead Appliance RiOS 8.0	SteelHead Appliance RiOS 7.0	SteelHead Mobile 4.0	Key Benefits
Other Features	VSP Platform on SteelHead EX Series	●	●	●	●			VMware ESXi-based virtualized services on the SteelHead EX appliance
	Native Kerberos	●	●	●	●	●	●	Optimization for traffic authenticated using Kerberos
	PCoIP QoS Control	●	●	●	●			Fine-grained control for VDI environments
	SCSP protocol suite	●	●	●	●	●	●	Full integration of the SCPS protocol suite
	Application Flow Engine with 1000 Applications	●	●	●	●			Automatic application signature matching for top enterprise applications
	Enhanced 10GigE Performance	●	●	●	●			Additional throughput performance (up to 50%) for 10 GigE-based deployments
	Path Selection	●	●	●				Cost-effectively leverages and enhances hybrid networks
	SteelCentral NetProfiler Support in SteelHead	●	●	●				Delivers support for application-level visibility and reporting
	Secure Transport	●	●					Secure all IPv4 traffic between Path Selection sites
	SteelCentral AppResponse Support in SteelHead	●	●					Monitor EUE for optimized web applications
	Interceptor Path Selection Support	●						SteelHead Path Selection Support in Interceptor
	Link Aggregation	●						Etherchannel
	Hardware Security Module	●						SSL Offloading
	Application Stats	●						Application Visibility