A Riverbed Technology White Paper

The Riverbed Optimization System (RiOS)

A Technical Overview of Version 3.0

riverbed

TABLE OF CONTENTS

Introduction 2
Application-independent Foundation 3
Additional Application-specific Optimizations 3
Disk-based Architecture 3
Smart Communication Architecture 3
Designed to Evolve 4
Data Streamlining 4
Eliminating Redundant Traffic 4
Traffic Marking and Visibility 5
Transport Streamlining 5
High Speed TCP 6
Connection Pooling 6
Application Streamlining 6
Application Streamlining Modules 7
Transparent Pre-Population 7
Proxy File Service 7
Management Streamlining 8
Individual Device and Centralized Reporting, Configuration, and Management 8
RiOS Deployment Options Enable Massive Scale and Redundancy as Well 9
Riverbed Interceptor 9
Data Security 10
Summary 10
About Riverbed 10

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 acceleration appliances and associated management appliances. RiOS is based on patented technologies that solve a range of problems affecting wide area networks (WANs) and application performance, including:

- Insufficient WAN bandwidth
- Inefficient transport protocols in high-latency environments
- Inefficient application protocols in high-latency environments

Using Steelhead appliances running RiOS, enterprises are able to implement solutions that help them empower their distributed workforce while eliminating IT capital expenditures and simplifying IT management. Organizations often see the following results because of RiOS:

- More productive users. Applications can be accelerated by up to 100x, providing LAN-like application performance regardless of a user's location.
- Consolidated IT. Nearly LAN-like application performance means that IT can be consolidated and centralized with no reduction in end-user experience.
- Reduced bandwidth utilization. Organizations can reduce bandwidth expenses and defer upgrades that cut monthly bills.
- Enhanced backup, recovery, and replication. Data in remote offices can be secured more easily over the WAN than with local tape backup; recovery times are shortened dramatically; data centers can be replicated more frequently.

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 Wide-area Data Services (WDS) appliances. RiOS provides an integrated framework for data reduction, TCP optimization, application-level optimization, remote-office file services, and management services to provide a comprehensive solution for enterprise WDS. RiOS scales across a range of applications and network topologies.

This paper is designed to introduce the major components of RiOS, and explain how they benefit the user. RiOS is designed with an application-independent foundation that enables Riverbed to build additional, application-specific optimizations on top of it. The components of RiOS can be broken into four major groups, each with a different, but complementary goal:

Technology	Description	Result
Data Streamlining	Optimize WAN bandwidth utilization	WAN bandwidth utilization reduced by up to 60% to 95%
Transport Streamlining	Eliminate transport protocol inefficiencies	Applications accelerated by up to 100x Up to 98% reduction in packet roundtrips
Application Streamlining	Optimize application protocol performance on WANs	
Management Streamlining	Enable transparent deployment and centralized management	Fewer IT resources required for deployment and management

RiOS is software, but Riverbed delivers RiOS in the form of the Riverbed Steelhead, an easy-to-use hardware appliance. This paper describes RiOS, but may also refer to "RiOS-powered devices" or Riverbed Steelhead appliances.
The RiOS Architecture

RiOS was designed using an approach that combines the benefits of TCP optimization, application acceleration, and caching/data reduction techniques, but the RiOS approach does not contain the architectural limitations that these approaches possessed as stand-alone optimization methodologies. This architecture allows RiOS to provide highest performance increase possible to a broad range of applications without requiring changes to existing infrastructure.

In order to accomplish this, RiOS is built as a transparent TCP proxy. During TCP connection setup, RiOS replaces the original single end-to-end TCP connection with three back-to-back TCP connections. The two "outer" connections seen by the client or server look the same as the original connection, while the "inner" connection is invisible to client or server and allows RiOS to perform a variety of performance improvements for transmissions across the WAN. This design allows RiOS-powered devices to optimize transfers across the WAN with no disruption or reconfiguration of clients, servers, or routers.

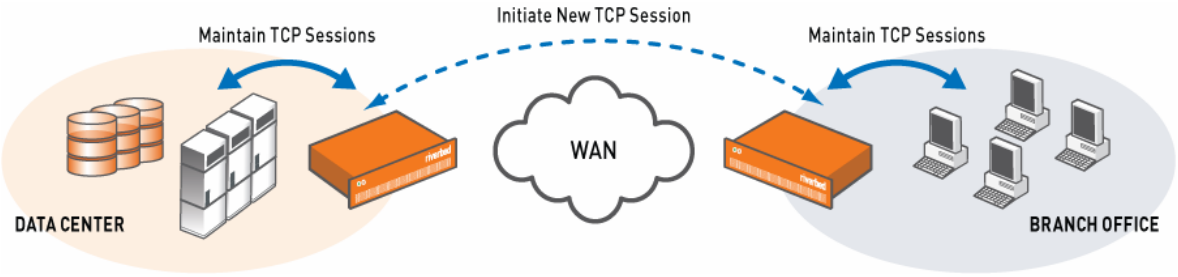

Figure-1: RiOS creates a new TCP session across the WAN, which allows it to optimize WAN transfers with no changes to existing infrastructure.

Application-independent Foundation

With RiOS, all TCP traffic, regardless of the application that generated it, can be intercepted and optimized. 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* applications. In addition, Transport Streamlining optimizes the behavior of TCP on the WAN.

These optimizations are applied to all traffic that uses TCP as the transport protocol, regardless of the particular application. Contrast this to other approaches, such as caching, that *require* knowledge of the application protocol in order to perform optimizations. These approaches are limited in what applications they can support and generally cannot optimize transfers based on data from other applications.

Additional Application-specific Optimizations

For many widely-used applications like Windows file servers 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 WANs, optimizations must be made to the application protocol itself. Riverbed delivers this comprehensive solution by including additional Application Streamlining modules into the architecture. Application Streamlining enables RiOS to address application-specific bottlenecks in addition to baseline Data Streamlining and Transport Streamlining optimizations. Application Streamlining allows Riverbed to deliver and improve those optimizations incrementally, without any architectural changes. Approaches such as 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.

Disk-based Architecture

Unlike other vendors' systems that were originally memory (RAM) based, RiOS was designed with a disk-based architecture from the beginning. Using disk instead of RAM in order to store data gives RiOS a data repository that is several orders of magnitude larger, which in turn, gives RiOS the ability to store and find repeated data much farther back in time (See the "Data Streamlining" section for more detail). Additionally, RAM-based architectures typically do not do well with large files, because the file size will often exceed the size of the data repository (ie, RAM available).

Smart Communication 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 natively designed to do. It is on the return trip, when the server has responded, that RiOS Data Streamlining takes effect. That way, the client is always assured that the data being sent is the correct data, and not a copy. This approach ensures that a client is always working on the original data. Contrast this to approaches which try to short-circuit the application server's permission system by creating local copies of data in branch offices. These approaches introduce data integrity issues, potential data security challenges, and possible versioning and data coherency issues.

Yet, the RiOS approach uses a single-copy architecture. Unlike products that store multiple copies of files throughout the network. The RiOS approach allows the origin server to store the primary file, and RiOS-powered devices to store only segments of data that are unrelated to any one particular file (again, see the "Data Streamlining" section for more detail). This design eliminates consistency and versioning errors found with many application acceleration approaches that use traditional caching, and makes compliance auditing easier as well.

Designed to Evolve

This approach of an application-independent foundation and application-specific optimizations permit RiOS to evolve quickly over time. As enterprises implement new applications, use new protocols, and face new demands, RiOS can quickly and effectively adapt to meet that need. 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.

Data Streamlining

- Reduce WAN Bandwidth Utilization by 60 – 95%
- Eliminate redundant data transfers at the byte level
- Perform cross-application optimization
- Provide Quality-of-Service marking and enforcement

RiOS Data Streamlining works across *all* TCP-based applications including Microsoft Office, Lotus Notes, CAD, ERP, databases, and data backup & replication systems; and across *all* TCP-based protocols including, but not limited to, CIFS, MAPI, TDS (SQL), NFS, FTP, and HTTP. 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 Streamlining also supports rules-based policy administration of optimization classes, packet marking, and enforcement for Quality of Service (QoS) and route control.

Eliminating Redundant Traffic

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. A segment of data that has been seen before is not transferred across the WAN; instead, a 16-byte reference is sent in its place. By using a hierarchical structure, a single reference can represent multiple segments, and thus multiple megabytes of data.

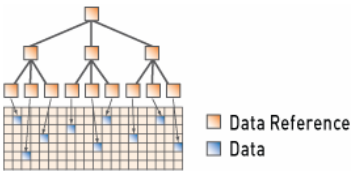

Figure-2: RiOS data references can represent a very large amount of data. Thus, a single 16-byte reference may represent megabytes of data previously sent over the WAN.

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. Finally the original traffic is reconstructed using new data and references to existing data and passed through to the client.

RiOS Data Streamlining is highly scalable, with peak compression ratios that can be 100:1 or higher. These compression ratios (as 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.

It is important to note that this segmentation process occurs on the byte 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, the second colleague sends the file back using a document management system or file server instead of email).

The other advantage of Data Streamlining is that unlike a cache-based approach, redundancies can be found across all TCP traffic, not just within one type of application like file systems or web traffic. For example, a file originally sent by email, and then later edited and transferred via a file server would be recognized as "redundant" by RiOS. A cache, however, would not recognize that the data being transferred is the same. (For more information on caching and how it differs from RiOS, please see "The Five Ugly Truths about WAFS and Caching" from Riverbed.)

Traffic Marking and Visibility

RiOS allows customers to use Quality-of-Service management in the best way they see fit on their network. Riverbed suggests that enterprises implement QoS within the routing core of their network in order for optimal bandwidth management, but understands that might not always be possible. With RiOS 3.0, users can employ 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.

RiOS also allows the use of DSCP marking for Quality of Service (QoS) , Class of Service (CoS), MPLS tagging, or any other classification mechanisms using the DSCP field. By default, RiOS can pass through DSCP markings to enable QoS enforcement via a router or a specialized QoS device. RiOS also supports optional rules to categorize "outer connection" traffic and map those categories to specified "inner connection" ports. With these tools, RiOS enables a variety of approaches to traffic monitoring and shaping.

Transport Streamlining

- Applications run up to 100 times faster
- Reduce transport protocol chattiness by 65% to 95%
- Automatically adjust transfer parameters based on network conditions
- Enable up to 95% utilization on high-bandwidth, high latency connections

RiOS overcomes the chattiness of transport protocols through Transport Streamlining. Transport Streamlining is a set of features that is designed to reduce the number of roundtrips 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 more.

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 or proprietary protocols that achieve their optimization by stealing bandwidth from other traffic.
Window Scaling and Virtual Window Expansion

A well-known method for improving TCP throughput is the use of larger windows in order 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.

RiOS enables automatic window scaling across the WAN among Steelhead appliances 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.

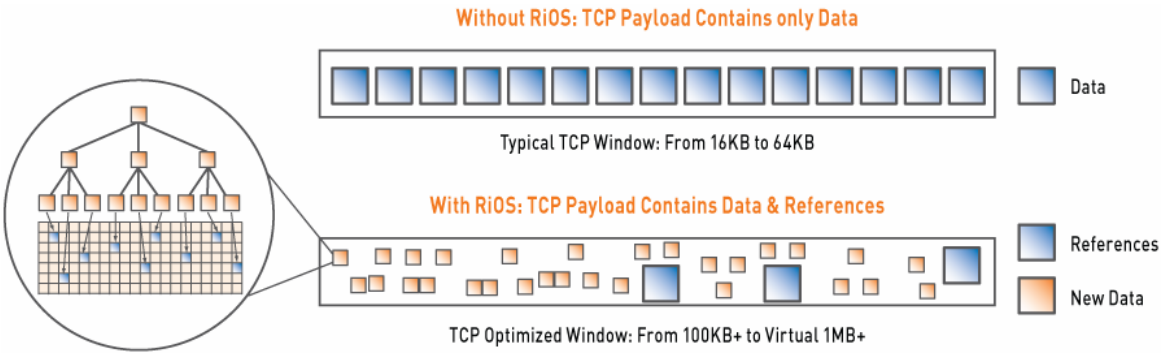

Figure-3: Virtual Window Expansion massively increases TCP payload by intelligently repacking the TCP Payload.

High 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. The RiOS implementation of High-Speed TCP (HSTCP) 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

RiOS achieves full utilization of investments in network bandwidth without losing or compromising any of the essential characteristics and benefits of TCP. This includes safe congestion control, even when HSTCP 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 – HSTCP self-adjusts transmission throughput appropriately

Connection Pooling

Some applications are designed to open many TCP connections in order 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.

RiOS performs connection pooling on short-lived TCP connections. Connection pooling enables a Steelhead appliance to maintain a pool of open connections at all times. 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. With Transport Streamlining, overhead associated with short-lived TCP connections can be reduced by 50% or more.

Application Streamlining

- Applications run up to 100 times faster
- Reduce application protocol chattiness by 65% to 95%
- Address the most important application protocols: CIFS, NFS, MAPI, HTTP, MS-SQL
- Provide disconnected operations

RiOS was designed as an application-independent foundation that would provide acceleration 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 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 for remote offices with the simple deployment and management of an appliance form-factor.

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 Exchange messaging (the MAPI protocol), Microsoft SQL Server databases (the TDS protocol), HTTP, or NFS. These modules are application protocol-specific and dramatically reduce application protocol roundtrips.

Application Streamlining Modules eliminates upcoming round trips that would have been generated by the application protocol. Reducing roundtrips 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, adding an order of magnitude improvement in throughput, in addition to what Data Streamlining and Transport Streamlining already provide.

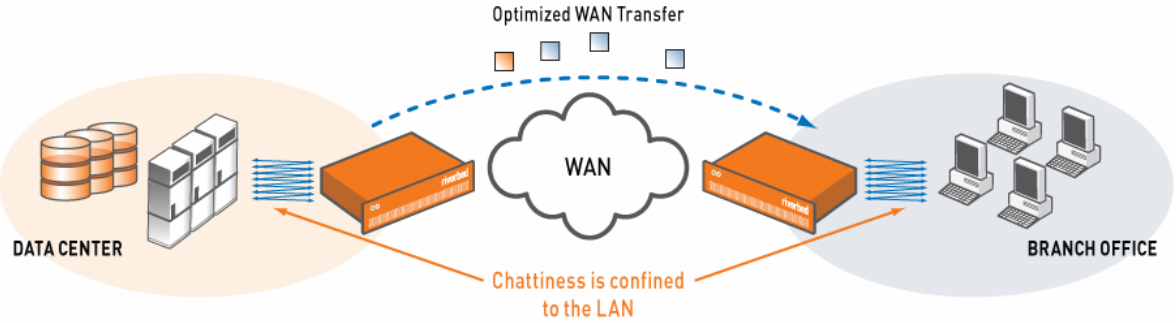

Figure-4: Application Streamlining can eliminate up to 98% of roundtrips generated by application protocols.

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 transaction prediction, and no other vendor has as complete a range of application-level latency optimizations. Even vendors who offer some application-level optimizations for CIFS or MAPI often don't deliver the quality or quantity of optimizations that RiOS does. With Application Streamlining, the evaluator of various technology must dig beneath a standard checklist to see *how deep* and *in what ways* a vendor can streamline the application.

For example, 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), other vendors' products treat the rest of the file as though it were completely new data. Additionally, there are many ways to use CIFS. When some vendors claim they 'do' CIFS optimization, often times they only optimize standard drag-and-drop file sharing.

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, many applications, such as some CAD applications and MS Office running on Windows Service Pack 1, make use of CIFS with very complicated file-locking systems. Other application acceleration approaches may break these locks, or simply not be able to optimize performance in these cases. RiOS has built-in technology which allows application acceleration to be optimized, with native file locking maintained.

Transparent Pre-Population

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 it is requested by any client. This transparent pre-population process allows the initial 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 pre-population 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 pre-population 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 new content.

Proxy File Service

Application Streamlining Modules and transparent pre-population can improve performance by anticipating future requests. The last part of RiOS Application Streamlining is the optional Proxy File Service (PFS), which can improve performance by deferring current requests or permitting certain operations even if WAN connectivity is disrupted. PFS is an integrated local file server with

support for disconnected operations and replication. With appropriate configuration, PFS ensures that files are still accessible in a remote office, even if the WAN goes down. PFS can also function as a local file server for use by branch offices, optionally with high-performance replication to/from the data center for backup or publication. PFS has a separate, dedicated portion of disk space, and will never interfere with Data Streamlining activities required for remote data and application access.

With reads and writes performed locally in the branch, and changes replicated efficiently to the branch, PFS offers benefits that are complementary to transaction prediction and transparent pre-population. Because the optional PFS service requires additional configuration and other considerations, PFS is disabled by default, but can be enabled with no disruption to existing infrastructure when its benefits are required. PFS is a highly scalable solution that has been designed to work with any type of origin server, Windows/CIFS based or not, and requires no server-side agents.

With the introduction of PFS, Riverbed is the only vendor in the application acceleration, WAN optimization or WAFS market to offer *both* a high-performance acceleration system without the data integrity and communications issues of caching *yet still provide facilities for disconnected operations*. With competing systems, the choice of vendor determines whether this behavior is required for deployment, or completely unavailable. Using RiOS, the end user decides whether PFS should be used in their deployment, or even for specific remote offices.

Finally, to ensure that PFS is simple to implement and manage on an ongoing basis, RiOS enables an intuitive management interface for PFS activities. This management interface allows the administrator to use a GUI for configuration of PFS on various appliances, and also schedules regular automatic updates of the PFS shares on appliances, requiring no ongoing administrative oversight.

Management Streamlining

- Transparent approach ensures minimum impact on the network
- Centralize reporting and management
- Enable redundancy
- Provide features for flexible network integration

Unlike other approaches to application acceleration, RiOS was designed specifically to ease deployment and management of application acceleration devices. In fact, many customers can deploy devices running RiOS, such as the Riverbed Steelhead appliance, in just 15 minutes.

This ease is enabled by RiOS's transparent approach. Yet this ease is combined with unparalleled flexibility: no other software offers the same high level of reporting, configuration, and deployment options.
Transparency

Devices running RiOS can be deployed with no changes to clients, servers, or to other critical infrastructure. Devices running RiOS automatically detect each other across the WAN; there is no need for any tunnel configuration, DFS changes, client drive mapping changes, router configuration, route injection, or any of the other overhead required for competitive systems. This transparent approach also ensures that standard client-server interactions are not disrupted. RiOS allows for normal client-server interaction, and focuses on accelerating the resulting data transfer.

Individual Device and Centralized Reporting, Configuration, and Management

Every RiOS-powered device supports individual management via SSH command line and HTTP or HTTPS graphical user interface. Every device also supports SNMP traps and email alerts for conditions that require attention or intervention. Collectively, these tools allow for easy management of individual devices and straightforward integration into existing network management systems such as OpenView.

Continuing with the issue of transparency, RiOS ensures that its application acceleration capabilities do not cloud enterprises' reporting capabilities. Steelhead appliances can automatically assign application names to port numbers, allowing enterprises to quickly see what applications are driving traffic across the WAN. Appliances will also show per application stats for traffic that is passed through unoptimized. Finally, appliances can show acceleration per RiOS QoS class (if QoS on the appliance is being used).

RiOS v3.0 also provides the ability to export real-time flows from a Steelhead appliance to a third- party Netflow collector. From the Netflow collector, enterprises can view byte counts per port, per src/dest IP address, and from a specific interface. IT

administrators can obtain traffic views for optimized vs. pass-thru traffic separately or in aggregate and obtain top talker/listener tallies from a Netflow v5 compatible collector.

RiOS also allows monitoring and management of a complete network of application acceleration devices via the Riverbed Central Management Console (CMC) appliance. The CMC permits aggregated or individual device reporting, group or individual configurations, scheduled operations, and more. It provides users with global trending of performance statistics using up to 1 year of historical data, and with the ability to zoom in on any time period that the administrator desires.

Management functionality includes automated over-the-wire software upgrades, an easy-to-use QoS rules configuration interface, and configuration for deployments, all through an easy-to-use Web interface. The CMC also enables a powerful feature called touchless configuration for new Steelhead appliances: simply plug in the remote Steelhead appliance, give it an IP address (or let it dynamically get one), and it will automatically communicate with the CMC in order to configure itself. A new Steelhead appliance can be deployed with unparalleled ease using the CMC.

RiOS Deployment Options Enable Massive Scale and Redundancy as Well

By design, RiOS provides best-in-class scalability both in individual devices and through the ability of multiple devices to work together. For example, an individual Steelhead appliance can support up to 40,000 connections, optimizing traffic for 10,000 users or more. Clusters of devices can easily support 1,000,000 connections and 4 gigabits per second of throughput, meeting the needs of the largest most complex networks anywhere.

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. Such passed-through traffic by one member of the serial cluster is handled by the next member of the cluster that has capacity. No other product available supports such a straightforward approach to increasing capacity and redundancy.

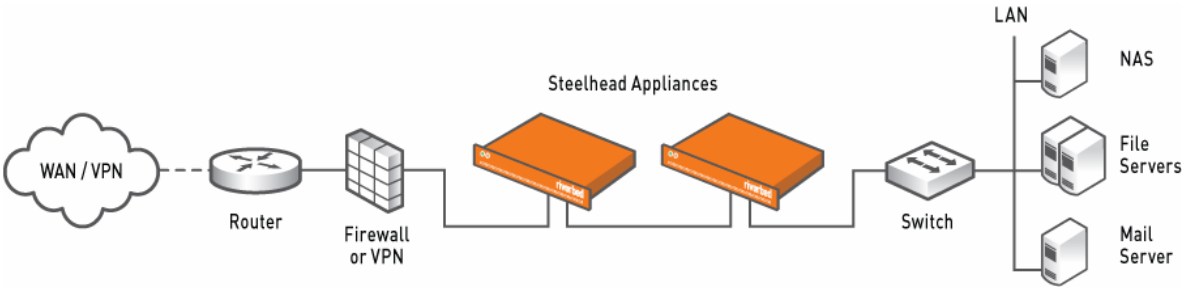

Figure-5: Serial clustering allows for simple in-path deployment while still providing redundancy

RiOS also simplifies redundant deployment with support for in-path deployment on multiple network links. Only RiOS allows a single device to support up simultaneous in-path deployment on 6 copper links or 3 fiber links. In addition, Riverbed's 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 an L4 switch and WCCP or PBR.

Riverbed Interceptor

Alternatively, users can deploy the Riverbed Interceptor®. The Interceptor is an optional component meant for very large datacenter 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 also supports more RiOS-specific functionality, such as asymmetric routing. The Interceptor uses the RiOS philosophy of simple, transparent deployment to ease integration into complex data centers.

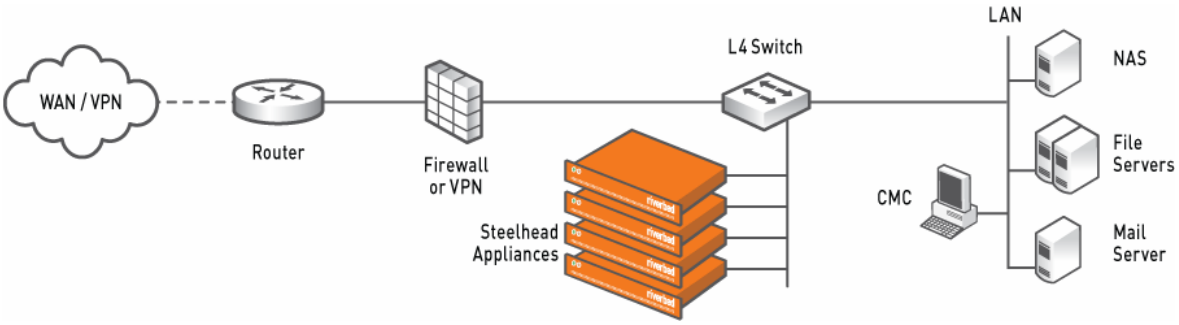

Figure-6: RiOS also allows for out-of-path deployment with optional clustering of devices.

For deployments requiring the highest levels of redundancy and performance, RiOS also supports warm standby between designated primary and backup devices. Using automated data-store 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 also permits a variety of other in-path, virtual in-path, or out-of-path configurations both parallel or 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, short-sighted approaches like route injection or unscalable approaches like explicitly-configured tunnels.

Data Security

While RiOS is not specifically designed as a data security platform, RiOS-powered devices possess security features necessary to help protect enterprise data. RiOS enables device-to-device IPSec encryption over the WAN, to ensure that any data traveling across the network is protected. Recall also that RiOS sends only small segments of files (the changes to data) as opposed to all the actual data. This means that, even if someone was attempting to steal data, they would have a very difficult time piecing any data together.

Summary

The Riverbed Operating System (RiOS) is the most effective, scalable approach to enterprise application acceleration. RiOS enables the highest performance increase across the applications which enterprises care the most about.

RiOS achieves this because it was designed from the ground up to deal with three distinct, but related problems that hinder application performance: WAN bandwidth limitations, transport protocol inefficiencies, and application protocol chattiness. RiOS simultaneously performs Data Streamlining, Transport Streamlining, and Application Streamlining in order to address these problems. At the same time, RiOS provides Management Streamlining in order to simplify the deployment and ongoing management of RiOS-powered devices.

About Riverbed

Riverbed Technology is the performance leader in wide-area data services (WDS) solutions for companies worldwide. By enabling application performance over the wide area network (WAN) that is orders of magnitude faster than what users experience today, Riverbed is changing the way people work, and enabling a distributed workforce that can collaborate as if they were local. Additional information about Riverbed (Nasdaq: RVBD) is available at www.riverbed.com.

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