Using RPR to Converge Video, Voice, and Data onto a Single Packet Based Network

June 2004

INFONETICS RESEARCH

Table of Contents

List of Exhibits

I. Executive Summary

The telecommunications industry is on a course to converge voice, data, and video services onto a single packet based network. The migration to a packet network is on a long time scale for many reasons, including the embedded base of SONET/SDH technology, but there is a common goal.

Most network traffic today is data, and data is growing every day, having already eclipsed voice and other types of traditional network traffic. But SONET/SDH was designed to handle voice, not data, so providers are looking for alternatives that will provide the underpinnings of a converged packet network.

Some new technologies look particularly attractive for this converged packet purpose, and are rapidly being adopted by a surprisingly large and quickly growing number of providers: RPR.

II. Introduction

A. Common Goal: Converged Packet Network

The telecommunications industry is on a course to converge voice, data, and video services onto a single packet based network. On a global basis, nearly every service provider is taking steps, albeit on many paths, that lead to this destination. The migration to a packet network is on a long time scale for many reasons, including the embedded base of SONET/SDH technology. Yet, while carriers will not move in accord on timing or method, there is a common goal.

Most network traffic today is data, and data is growing every day, surpassing voice and other types of traditional network traffic. Most carriers maintain multiple networks: at least one for voice and another for data, and the larger the carrier, the more likely they will have a voice network and several types of data networks. The optical networks that both voice and data traffic traverse were built for voice and are not efficient for data. These realities, taken with financial and operational pressures, have led providers to the conclusion that they must

streamline their network operations, and find a way to reduce the number of networks to a single, common network. The answer is a packet based network.

Three main service types must be carried concurrently on the packet network. The main data service is Ethernet as the layer 2 transport carrying much of the world's IP traffic, but there are also the legacy data services of ATM, private lines, and frame relay. Second, any new packet network must support existing voice, other TDM services, and VoIP. Video—including broadcast video, video on demand, and videoconferencing—is the third significant set of applications that must be accommodated by the converged data network.

Some new technologies look particularly attractive for this converged packet purpose, and are rapidly being adopted by a surprisingly large and quickly growing number of providers: RPR. In this paper, we explore Resilient Packet Ring (RPR) as one of the most promising new technologies, and examine why neither today's data networks nor voice networks are workable in this role.

B. SONET/SDH

SONET/SDH was developed 20 years ago as a state of the art, resilient, reliable, predictable network designed to carry increasing loads of telephone traffic. There are an estimated 375,000 rings worldwide, comprising some 135,000 SONET rings and 240,000 SDH rings.

Telephone traffic is based on circuits, which are quite different from data traffic, in that each telephone connection is allocated bandwidth at the full 56K or 64K: even when no one is speaking, the full bandwidth is reserved for the conversation, from one end through the backbone to the other end. When telephone traffic is aggregated onto a SONET (or SDH) optical network, standard aggregation hierarchy levels are used. SONET carries traffic in fixed optical capacities, such as OC-3 (155M), and is able to carry payloads of 1.5M, 45M, 155M, 622M, 1.2G, 2.4G, and so on. When SONET is adapted for data use, these same fixed levels of bandwidth must be applied. Consequently, private lines, voice, and data services have historically been provisioned at these common rates, then aggregated onto the SONET network. For data applications, the entire bandwidth is allocated for all the time, whether traffic is flowing or not.

Carriers are comfortable deploying SONET/SDH for the assurance it provides: SONET/SDH networks are designed for reliability not to drop a telephone circuit, private line traffic, or any video that might be riding on it. This super resiliency is achieved by counter-rotating dual rings, which can self heal to form a single ring when a link becomes unavailable (due to a fiber cut, for example). In practice, service providers use one ring for traffic, and reserve the other for use only in a failure. This means that 50% of the SONET network capacity lies fallow most of the time. This is inefficient, as carriers must install twice as much bandwidth as needed for the services they sell.

Unlike voice traffic, data traffic is bursty in nature. Data networks, such as Ethernet, are designed with this in mind, and allow for the aggregation of the data traffic from a number of sources onto a shared trunk line. This is very efficient, since traffic bursts can be statistically averaged across large numbers of subscribers. However, there are occasions when many or all of the segments are sending traffic simultaneously; at these moments, the quality of service can become unpredictable.

C. RPR Designed for Converged Packet Network

Resilient Packet Ring (RPR) is one of the few technologies clearly and aptly named. The IEEE 802.17 standard defines a protocol designed to carry packet traffic efficiently over rings, which provide for resiliency.

The goals of RPR solve the principal problems and drawbacks associated with voice and data networks, attempting to fill the bill as the single common network to efficiently handle legacy voice, legacy data, Ethernet and IP, video, and voice over IP (VoIP). The key technical features of RPR are:

- **Resiliency:** automatic protection mechanism to recover full operation within 50 milliseconds of a span failure, matching the world standard SONET/SDH feature
- **Services:** supports committed information rate (CIR) and latency-sensitive, jitter-sensitive traffic including voice and video, as well as high and low priority traffic flows
- **Efficiency:** employing spatial reuse, bandwidth is used only between source and destination nodes, unlike with SONET and SDH, which reserves bandwidth around the entire ring (and the backup ring); packets traverse the ring to their destination, then exit the ring, leaving the "space" open for reuse
- **Scalability:** supports automatic topology discovery, and allows for more than 100 nodes in a ring, far more than the 16 nodes in a SONET/SDH ring; nodes can be automatically inserted or dropped from the ring.

The principles of RPR operation include a number of features giving it superior ability to handle voice, data, and video traffic:

- RPR uses a **dual, counter-rotating, fiber ring topology** (similar to SONET/SDH and FDDI), with an outer ring and inner ring, sometimes called ringlets; this is the principal mechanism to effect resiliency; rings are also the most efficient topology to connect any number of nodes in terms of ports required; RPR can support simple rings, collapsed rings, or star topologies
- RPR **uses both fiber rings** to traverse traffic, making use of 100% of the capacity rather than reserving 50% for protection of failures as with SONET/SDH
- RPR has **priority mechanisms** and uses control messages to dynamically negotiate for bandwidth between/among nodes, allowing high priority traffic to be sent ahead of low priority traffic; high priority packets are delivered with minimal latency and jitter
- RPR supports **multicast packets** that can be transmitted to any number of nodes during a single trip around the ring—providing efficient delivery of bandwidth hungry broadcast video traffic

- RPR can **operate over Ethernet or over SONET/SDH,** allowing providers to make more efficient use of their existing SONET/SDH networks, or to dispense with the costs of SONET/SDH equipment and deploy RPR Ethernet rings
- RPR has **lossless packet transport;** packets cannot get lost on the ring

RPR was designed with better functions than other technologies; the drawbacks and limitations of SONET/SDH, Ethernet rings, and meshed Ethernet are noted below.

- **SONET/SDH:** limited to 16 nodes, must use multiple layers for IP traffic, and circuits "nail up" bandwidth with no means to make changes dynamically or allow reuse of unused capacity
- **Ethernet rings:** no high priority traffic mechanism (usually ad hoc arrangements with some proprietary techniques), limited number of nodes, and packets are processed at each node
- **Meshed Ethernet:** QoS and CoS are applied at every node, limited number of nodes, and protection mechanism of spanning tree protocol (STP) typically takes minutes rather than 50 milliseconds

D. Status of RPR Development and Standards

The IEEE 802.17 working committee was formed in 2001. The IEEE 802.17 draft standard is currently undergoing the workgroup ballot phase, with a milestone to complete sponsor ballot and ratification of the standard in June 2004.

III. RPR Applications

A. Converged Voice

Voice traffic has its own QoS requirements, including strict low delay tolerances for end-to-end delivery of conversations in near real-time. This stricture is easily supported in TDM SONET/SDH networks, which were designed for this purpose. Data networks do not have such severe QoS requirements, but the converged packet based network must accommodate them. RPR is designed to support these requirements.

The reliability of today's voice services must be replicated for the voice traffic destined for the converged packet backbone. The ring structure of RPR over Ethernet allows the same sub-50 millisecond recovery time as do SONET/SDH networks. And, RPR over SONET/SDH uses the SONET/SDH mechanisms, so reliability and preserving of capital investment is not an issue.

B. Converged Video

Video applications such as broadcast video, video on demand, and videoconferencing have real-time, low delay, low jitter, high availability QoS characteristics similar to voice; however, the bandwidth required is orders of magnitude greater—typically from 2–4M per Standard Definition TV stream (and 6–8M for HD TV) as opposed to 56–64K. RPR is designed to scale up to several Gigabits/sec capacity, runs over cost effective GE, and supports multicast packets for broadcast video.

C. Converged Data

Converging data traffic on the network provides little or no challenge for the RPR technology. The most severe restraint for data traffic is congestion, and not timeliness or high availability. RPR is designed to handle data requirements, including the QoS required for services such as ATM and frame relay.

IV. Why RPR Now?

A. RPR in Next Gen Access Networks

A number of access network trends are driving increasing use of Ethernet—and RPR will increasingly be part of the picture:

- Growing Ethernet traffic and the roughly 375,000 SONET and SDH rings worldwide guarantee a growing market for Ethernet over SONET/SDH (EoS), both using RPR and not, for the next 10 years; providers use EoS to collect and move Ethernet traffic to/from customers and among POPs/COs

- Service providers want to deploy Ethernet to satisfy customer demand for Ethernet services and to simplify their networks so they can carry the fast growing data traffic while handling TDM traffic
- Service providers are lowering the price per bit for Ethernet bandwidth—as opposed to jumping from T1 (1.5M) to T3 (45M) or E1 (2.0M) to E3 (52M)—and are offering it at increments that make sense to customers

A number of new uses of Ethernet will increase the role of RPR:

- The growing use of collector rings to aggregate growing DSLAM and cable CMTS traffic will increase the use of RPR over Ethernet and SONET/SDH for packet traffic, while also carrying TDM traffic
- Ethernet is beginning to be the preferred technology for fiber extension from wired buildings to other nearby buildings; introduced mainly on a trial basis in 2003, it is used more widely beginning in 2004, and will be fairly prevalent by 2006
- Most providers are adding Ethernet services over existing SONET/SDH rings; most ILECs are evaluating metro Ethernet technologies and want to carry TDM traffic, especially voice, over their metro networks
- The lack of carrier grade Ethernet access products was an impediment to adoption of Ethernet in 2003, but RPR, and other technologies (such as GFP) have made Ethernet products resilient and adaptable to the rings that many large carriers strongly prefer (whether over SONET/SDH or not); these new products are being deployed by major carriers now

B. Carriers use RPR with SONET/SDH

RPR is flexible enough to run over Ethernet or SONET/SDH, and carriers, who have invested in SONET/SDH use RPR as a means to provision packet traffic over SONET/SDH TDM. This is a great marriage of RPR's efficient packet protocol with the installed base of SONET/SDH. For example, carriers can allocate two OC-3 channels (one channel for each ring) on a SONET ring to RPR, then use RPR inside the fixed 2x155M capacity to efficiently pack multiple point-to-point flows of packet traffic around the ring, with a flow ingressing onto the ring at one node, and egressing at another.

For providers with embedded SONET/SDH infrastructure, RPR over SONET/SDH provides a popular option. Infonetics found in the *Service Provider*

Plans for Metro Optical and Ethernet, North America and Europe 2004 study (January 2004—see more below in Section V) that 63% of the provider respondents in that study plan to implement RPR sometime after January 2005, and that 56% are looking for RPR over SONET/SDH in the optical equipment they buy in the next year.

V. RPR Equipment Market Now and Future

A. Metro RPR Ethernet Equipment

Ethernet and the converged packet network are slowly but surely making a major dent in access networks—between 2003 and 2007, packet networks make major inroads into telecom equipment spending. In the next 10 years, packet will inexorably take over access, though there will never be a wholesale change because of SONET/SDH installed base. Carrier access equipment capex will grow slowly over the next few years, but every year packet will account for a larger portion of capex, driving double-digit growth for RPR through 2007.

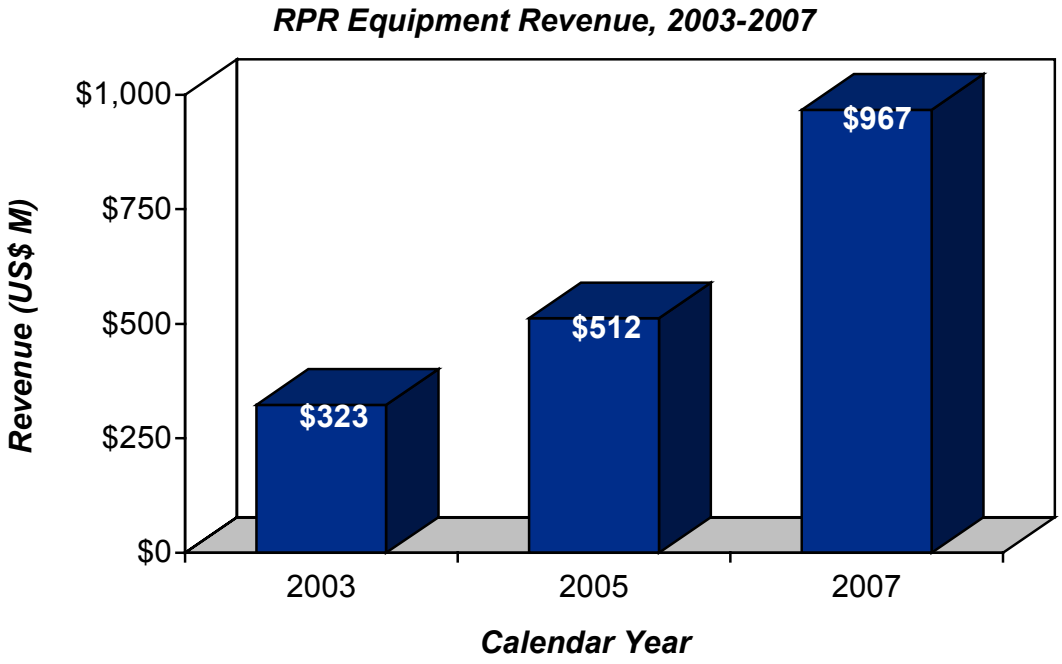
New technologies like RPR (and VCAT/GFP over SONET/SDH, etc.) are paving the way for Ethernet to take its place as a respected telecom grade option for access networks. These technologies, as part of Ethernet, naturally support data/packet traffic, and add support for existing customer TDM and data traffic types by delivering resiliency, fast recovery, options for new services, rings, and marriage into existing carrier networks.

The converged packet network currently makes up a small portion of the millions of network connections; business WAN connections are primarily T1/E1 and T3/E3 (including private lines, frame relay, and ATM), and SONET/SDH with some WDM. Residential subscribers today are served with ATM DSL; over the next 3–10 years, a growing portion will move to Ethernet-based services.

B. Forecast

The Infonetics Research biannual report *Metro Ethernet Equipment* measures the past shipments and forecasts various Ethernet technologies, including RPR (pre-standard RPR and 802.17). According to our January 2004 report, RPR is growing quickly with a CAGR of 36% between 2003 and 2007. Beginning with a base of $323M in 2003, service providers spend more on RPR equipment each year, reaching nearly $1B ($967M) worldwide in CY2007, for a cumulative 5-year total of $2.9B. The forecast below includes metro equipment for RPR over Ethernet as well as RPR over SONET/SDH.

Exhibit 1 **RPR Equipment Revenue Forecast**



VI. Service Provider Plans for RPR

A. Pre-standard RPR Already in Use

Carriers are beginning to deploy pre-standard RPR and VCAT/LCAS/GFP to efficiently pack packet traffic on their TDM rings.

The largest use of RPR over Ethernet is in interconnecting routers in POPs and COs worldwide; Asia Pacific, especially China, is the main market for RPR over Ethernet in access and IOF applications. Most major carriers offer their large customers Ethernet connections over SONET/SDH as a convenient high-end Ethernet service that transits their very safe SONET/SDH network.

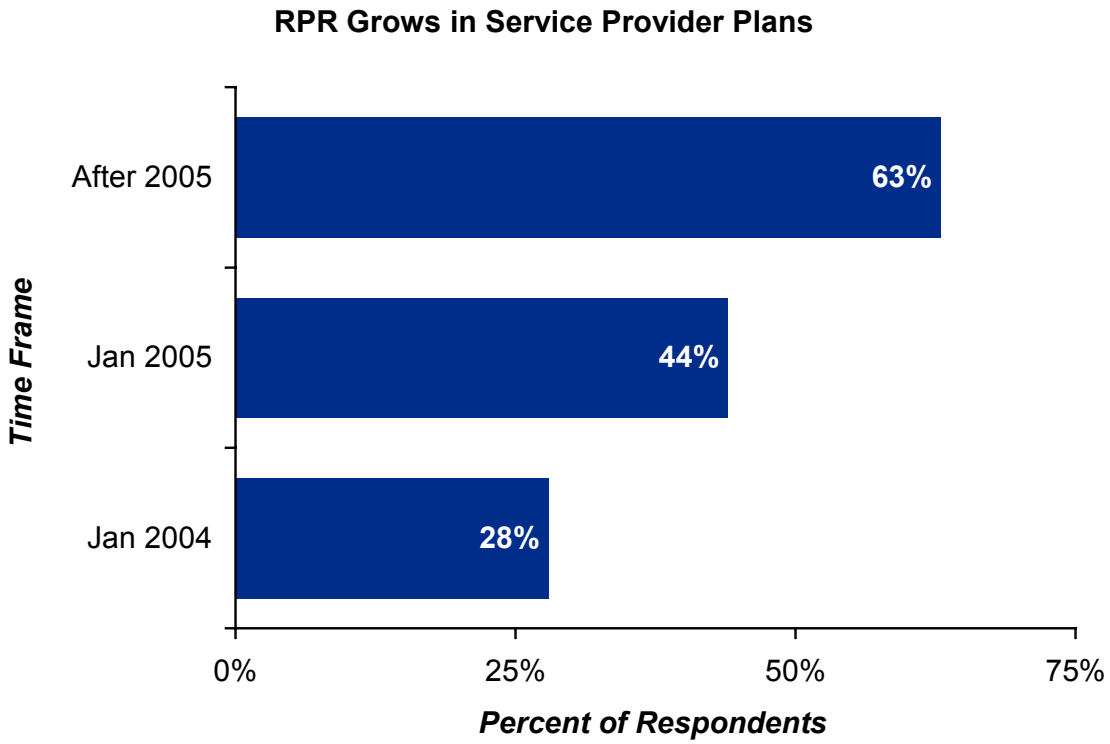
RPR over Ethernet is a less expensive choice of mostly alternative carriers and new builds in Asia Pacific, particularly China, serving the same purpose as SONET/SDH rings, namely to offer very reliable Ethernet services to buildings and businesses. Over time, carriers will slowly replace (or cap and grow) SONET/SDH rings with more of the simpler RPR over Ethernet collector rings with customer connections to transmit traffic to and from service provider locations, gaining the efficiencies of a packet based metro network.

B. RPR Is Growing in Service Provider Plans

Studies conducted by Infonetics Research measure the growing plans by service providers to use RPR to deliver Ethernet services. In the most recent study on this topic (*Service Provider Plans for Metro Optical and Ethernet, North America and Europe 2004,* published in January 2004), Infonetics conducted formal interviews with 27 providers in North America, Europe, and Asia Pacific. The 27 service providers interviewed are a mix of infrastructure-owning types, including RBOCs, ILECs, IXCs, PTTs, competitive operators, and ISPs, with average annual revenue of over $11B.

In January 2004, 28% of the respondent providers were already using (pre-standard) RPR as part of their networks, climbing to 44% by January, 2005, as shown in Exhibit 2.

Exhibit 2 **Service Provider Plans for RPR**



Sixty-three percent of respondents plan to use an RPR network sometime after 2005—double the percentage using one in 2004. In an Infonetics study published in 2002, RPR was in use by less than 20%, and about 25% planned use by the end of 2003; RPR awareness among carriers has increased quickly over the past two years, due to several factors:

- Service providers are more clear today that they must move toward a converged packet based network
- Providers know they must offer Ethernet services or lose customers to competitors
- Providers must protect their customers by not disturbing legacy services
- RPR offers a ring based architecture, which carriers know and love
- RPR can carry legacy services, including voice, ATM, frame relay, and private lines, while supporting Ethernet and emerging video applications

Respondents' carrier networks increasingly use converged packet. Over half of respondents now, and two-thirds in 2005, use Ethernet for their IOF (interoffice facilities) networks connecting their POPs and COs. Many of the carrier network connections use RPR.

Ethernet collector rings are increasingly popular as over 60% of the respondents reported current use or plans. Today the collector rings are deployed mostly with basic Ethernet rings, but also with RPR over SONET/SDH and RPR over Ethernet, growing quickly to 44% and 33%, respectively, by January 2005.

About 8% of respondents now, and 11% in 2005, use RPR or pre-RPR for intra-POP router connections, where customer aggregation routers connect to a backbone router, a system whose most efficient topology is a ring, which provides resiliency and saves money on core router ports.

VII. The Benefits of Integrated Access and Transport

Over the past few years, service providers have done a good job of getting their capital expenditures in a financially reasonable place. By 2003, North American

service providers had a very healthy average capex-to-revenue ratio of 15%. To drive profitability, providers are looking at the much larger area of increasing operational efficiency, or lowering operational expenditures. In the drive by service providers to lower opex, a number of approaches are common:

- Lay off employees, highly paid first—this has been largely achieved over the past two years
- Reduce the number of networks—this is a work in progress by nearly every major service provider, and usually involves taking steps toward convergence
- Reduce the number of layers in a network
- Reduce the number of elements in a network

When providers focus on reducing the number of layers in a network, they automatically reduce the number of elements in a network. Many carriers are adopting or planning a streamlined, integrated transport with equipment supporting both layer 1 (e.g., CWDM/DWDM) and layer 2 (e.g., SONET/SDH, Ethernet). Many are combining these layers in their access networks, creating an integrated access and transport network. The combination of RPR—with options of running over Ethernet or over SONET/SDH—and WDM gives a provider a great amount of flexibility in designing their way to the one common packet based network.

VIII. The Future of RPR

A. Access Rings

Today's access networks have historically been built on SONET/SDH. Carriers, in some parts of their networks, are already using Ethernet as the basic technology for access rings, whether cobbling together Ethernet switches in a ring, or moving to the much more substantial, reliable, and flexible RPR. With the option of RPR, carriers can choose to interoperate with existing SONET/SDH or Ethernet.

B. WDM Integration

In the access network, CWDM is quickly becoming the workhorse of wavelength technologies, and it can add another dimension of versatility to an RPR access network.

IX. Conclusions

RPR—in the pre-standard forms—already has a solid base. It is no unproven technology, and it is growing in terms of equipment revenue and numbers of adopting providers. It is used based on its distinct advantages of combining the best of resilient ring technology, borrowed from its TDM predecessors, and the best of packet technologies, supporting the triple play services, or any combination of legacy voice, VoIP, ATM, frame relay, private lines, IP, video, or Ethernet.

RPR has small beginnings to date—it is largely used and planned as a means to bring efficiencies to packet transport over SONET/SDH, thereby extending the life of the huge worldwide installed base of some 375,000 SONET/SDH rings. But RPR is also beginning to be used on its own over Ethernet. RPR will begin displacing SONET/SDH purchases, first in the access network during the next 3–4 years, then also in the metro IOF and metro core facilities in the 5–10 year timeframe. Investigate it—you may like it. It could be that single, common, packet based network you've been looking for to deliver data, voice, and video to your customers in the future.

About Infonetics Research

Infonetics Research (www.infonetics.com) is an international market research and consulting firm covering the data networking and telecommunications industries in North America, Europe, and Asia. We help companies develop, market, and sell smarter by providing objective analysis of **end-users, service providers, and product manufacturers** through in-depth research studies, quarterly market share and forecast services, and consulting and custom research services.

We've been a leader in the industry since 1990, and the first to peg many new markets, including VPNs, remote access, and ISP networks. We are informed from all sides of the market, and are recognized experts on emerging technologies and markets. We have proven market research methodology and statistical expertise and unrivaled forecast accuracy. Our coverage of buying patterns and user trends is the most in-depth in the industry, and we have a long history of delivering on time, all the time.

Services

- Market share, market size, and forecasts for North America, EMEA, Asia/Pacific, CALA, and worldwide
- Demand-side research on North America and Europe
- Service provider capex for North America, Europe, and Asia/Pacific
- Consulting, retainers, and event speaking
- Custom market research: demand-side research, market size and forecasts, white papers, and competitive analysis

Coverage Areas

- Broadband Networks
- Enterprise Routers and Switches
- Network Downtime
- Next Gen Voice
- Optical and Metro Ethernet
- Service Provider Capex
- Service Provider Routers and Switches
- VPNs and Security
- Wireless LANs

Contact Information

US Headquarters
255 West Julian Street #402
San Jose, CA 95110
United States
t 408.298.7999
f 408.298.2073

Boston Metro Office
3 Baldwin Green Common #307
Woburn, MA 01801
United States
t 781.933.9649
f 781.933.9659

London Office
P.O. Box 629
Bromley, Kent BR1 4WB
United Kingdom
t +44 (0) 20.8290.1954
f +44 (0) 20.8290.1954

For more information or to purchase this study, please contact **Larry Howard, Vice President**, at larry@infonetics.com, 408.298.7999 x225.