

The Case for Broadband Services Concentrators in the Central Office

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Introduction

Digital subscriber line (DSL) service providers are in a bind. High-speed Internet access, the foundation of DSL broadband service, has become a commodity, leading to high user price sensitivity and sapping the profitability of basic, “best-effort” Internet service. Just as the commoditization of basic phone service has compelled traditional telephony providers to offer higher-margin services such as call-waiting, caller ID, and call-forwarding, DSL providers must expand their portfolios to include value-added services such as multiline voice over digital subscriber line (VoDSL), streaming audio and video, frame relay, and unified messaging.

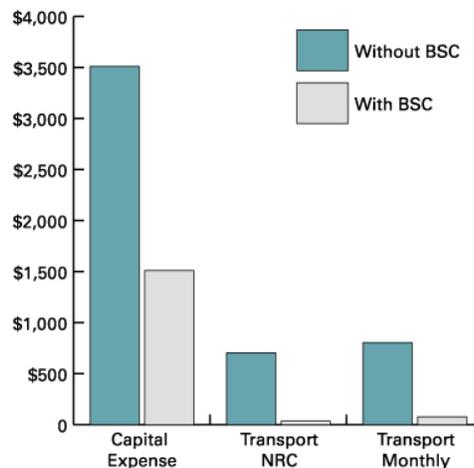


Figure 1: Backbone Capital and Operating Costs

To offer any of these value-added services, providers must be able to enforce quality of service (QoS) and meet service-level agreements (SLA) on a per-service, per-subscriber basis in a scalable and cost-effective fashion. The addition of value-added services, coupled with the requirement of scaling infrastructure to deliver more services to more subscribers, adds significant complexity to networks—all in the face of intense pressure to reduce their capital and operating expenditures. Going forward, they must maximize the value of their existing equipment and realize rapid returns on any additional capital investment (see *Figure 1*).

Today carriers are working to determine what devices are required to enable scalable value-added services and where these devices should be deployed. Some of the networking requirements can be addressed by products deployed in the metro office, such as subscriber management system (SMS) platforms and IP service switches (IPSS). However, the very nature of these requirements makes it clear that a critical set of capabilities must be addressed in the central office (CO). Existing solutions, coupled with the cost constraints carriers face, make it clear a new class of CO-based product is required.

This paper proposes a new class of cost-effective, scalable products, purpose-built for the CO, called broadband services concentrators (BSC). BSC enable service providers to deliver a wide range of value-added services by providing critical networking functionality in the CO. They can help providers manage the transition from asynchronous transfer mode (ATM)-based to Internet protocol (IP)-based services while offering a rapid return on investment. BSCs can also serve as a flexible, high-performance, high-density platform for emerging broadband technologies,

including synchronous high bit rate digital subscriber line (G.SHDSL), single-platform delivery of DSL service, and plain old telephone service (POTS).

The Changing DSL Market

Internet traffic is growing steadily and the number of Internet users with DSL broadband access is growing with it. RHK projects that the volume of Internet traffic will double between 2001 and 2005. Cahners In-Stat Group forecasts that the number of DSL broadband subscribers will increase from about 8 million worldwide in 2001 to nearly 25 million by 2004 (see *Figure 2*). Clearly, there are abundant opportunities for DSL broadband providers.

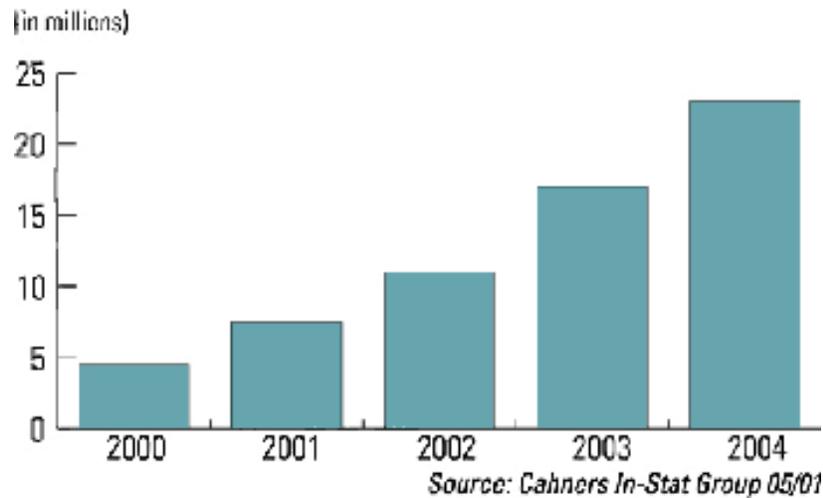


Figure 2: Worldwide New DSL Subscribers Forecast

But even as the DSL broadband market grows, high-speed Internet access is becoming commoditized, depressing profit margins for basic Internet service. To grow revenues and earnings as they go forward, DSL broadband providers must expand their product portfolios beyond price-sensitive Internet access to value-added services such as multiline VoDSL, streaming video and audio, frame relay, and unified messaging.

Providers must surmount a number of challenges as they roll out these new services, stemming in large measure from the initial architecture of DSL broadband networks, which were originally built to provide simple, best-effort Internet access.

With demand strong, competition fierce, and capital/operating expense budgets under pressure, service providers have begun the process of working out the required infrastructure to enable value-added services. A brief review of network evolution illustrates how we got here.

Carriers Create Basic Connectivity

The initial rollout of DSL broadband service was aimed at delivering basic, “best-effort” Internet access. Building upon an existing ATM networking infrastructure, providers connected subscribers to Internet service providers (ISP) using end-to-end virtual circuits (VC). Carriers’ initial networks consisted of ATM switches, digital subscriber line access multiplexers (DSLAM), and ATM concentrators.

Carriers connected subscribers to ISPs via end-to-end VCs, reserving one VC for each subscriber. This provisioning scheme was essentially dictated by the ATM-based architecture of carriers’ original broadband networks.

As broadband subscriber bases grew, VCs proliferated, with the growing traffic load threatening to overburden carriers' networks. This strain was somewhat relieved by the fact that carriers could deliver best-effort Internet access using unspecified bit rate (UBR) VCs. This networking scheme eliminated the need for traffic-shaping and enabled statistical oversubscription of backbone bandwidth, somewhat improving the scalability of the ATM-based access network.

ISPs Address Router VC Scalability; Carriers Tune ISP Connections

As carriers' subscriber bases continued to expand, the growing number of sessions and the explosion of VCs overwhelmed the capacity of the general-purpose routers that had been deployed by ISPs, restricting service scalability. In response, ISPs deployed SMSs at their points of presence (PoP) to terminate the VCs of tens of thousands of subscribers.

While this solution addressed scalability issues at the ISPs' PoPs, it did not resolve the provisioning and scalability problems created by the exponential explosion of VCs in carriers' access networks. These problems were compounded as carriers sought to connect broadband subscribers to multiple ISPs. In response, carriers added SMS platforms in their metro offices to help manage the explosive growth of subscriber VCs and to cope with the emergence of multiple ISPs upstream (see *Figure 3*).

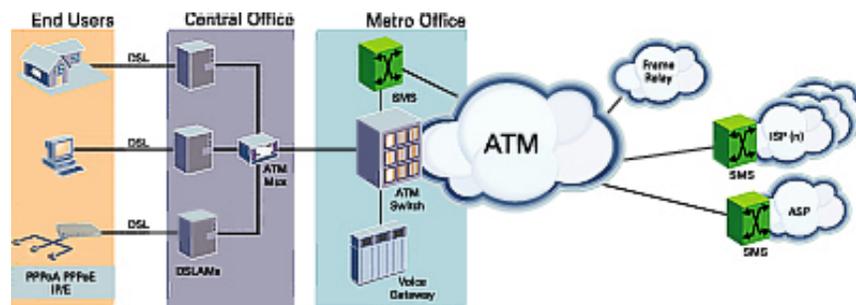


Figure 3: Adding SMS Platforms to Help Manage Growth

Even as carriers deployed SMSs in their metro offices, new services requiring QoS guarantees emerged, including Web-based services offered by application service providers (ASP) and packet-voice services.

Today: Carriers Must Offer Value-Added Services

Carriers recognize the need for more robust networking capabilities to enable revenue-enhancing value-added services (see *Figure 4*). Specific requirements may vary from carrier to carrier, but in general, these enhanced capabilities may include

- **subscriber provisioning and aggregation**—Classifying, aggregating, and auto-configuring of subscribers and services. Enables easy provisioning of new subscribers and services, and management of multiple concurrent services per subscriber.
- **access QoS and bandwidth management**—Controlling QoS per service per subscriber and performing access line shaping with efficient multicast optimizes equipment and bandwidth utilization.
- **network services**—Supporting tunnel switching, encryption, virtual routing, and related virtual private network (VPN) technologies. Ensures efficient networking with service providers and QoS for aggregated advanced service classes.
- **policy-based networking and administration**—Supporting profile creation, SLAs, and VPN membership enables flexible service creation based on a wide variety of criteria.
- **core/peer IP routing**—Supporting border gateway protocol (BGP), intermediate system to intermediate system (IS-IS), open shortest path first (OSPF) routing protocol, and

multiprotocol label switching (MPLS) allows complete interoperability with existing network architectures.

While there is broad agreement on the scope of the general networking requirements necessary for enabling value-added services, there is not yet a clear direction in terms of where each of these functions should be sited to maximize service-provisioning, cost-effectiveness, and network/service scalability.

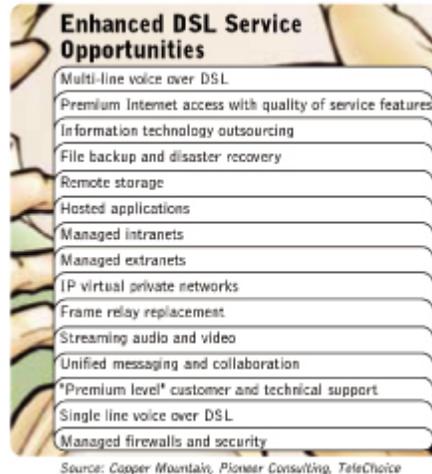


Figure 4: Enhanced DSL Service Opportunities

Metro-Only Solutions Are Not Enough

A number of carriers are exploring the deployment of new, more robust SMS platforms called IP service switches in their metro offices to handle all of these networking requirements (see Figure 5). IPSSs feature more sophisticated rate shaping and additional support for dynamic routing protocols and strive for carrier-class reliability, larger capacity, and improved QoS support.

While it's clear that metro solutions will play an important role in the provisioning of value-added services, there are some significant limitations to this "one-box, one location" approach.

Lack of Complete Service Visibility in the Metro Office

Value-added services require QoS per service, per subscriber. QoS is only possible if all subscriber services are being managed together on a per-user basis. Because many services, including frame-relay services, ATM adaptation layer 2 (AAL2) voice, and ATM-based services, are not managed by the metro-based IPSS device, no per-subscriber QoS or rate shaping is possible (e.g., traffic destined for the voice gateway is not seen by the IPSS [see Figure 6]).

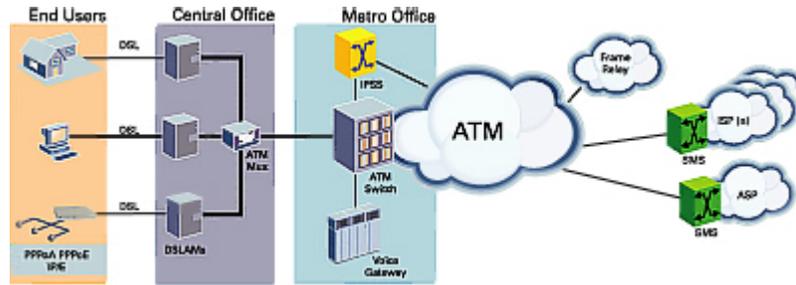


Figure 5: New, More Robust SMS Platforms

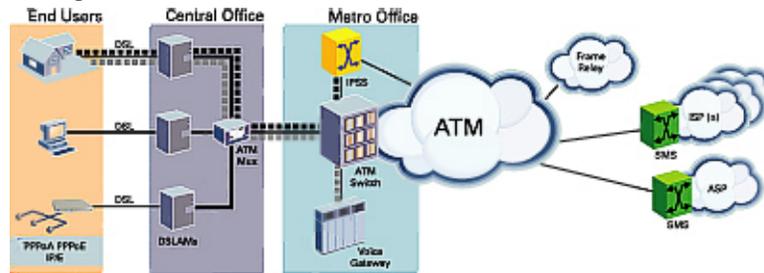


Figure 6: Limits of the IPSS

Inefficient Delivery of Advanced Services

As more advanced services begin to emerge over broadband networks, delivering those services with the least amount of network resources is critical to lower costs. Trying to provision these services solely from the metro office results in a significant increase in complexity and unacceptably high costs.

For example, carriers cannot complete local packet-voice calls without first sending them to the metro office Class 5 switch and back, resulting in unnecessary delay and transport costs. With multicast video applications (see Figure 7), carriers must deliver the service to subscribers over separate packet streams replicated in the metro office, resulting in excessive ATM switch loads and bandwidth requirements.

Scalable, Cost-Effective Network Provisioning Cannot be Accomplished from the Metro Alone

Most carriers have adopted one of three options for networking traffic at the customers' premises: Internet protocol over Ethernet (IPoE) for business customers; point-to-point protocol over asynchronous transfer mode (PPPoA) for single-premises hosts or customer-premises equipment (CPE) routers; and point-to-point protocol over Ethernet (PPPoE) for simple, flexible networking for consumers.

Metro-office provisioning of PPPoA traffic results in one VC per-service, per-subscriber, leading to an unmanageable number of VCs, resulting in high operational expenses. PPPoE and IPoE traffic loses per-service QoS as it hits the first ATM device. To maintain QoS for value-added services at the metro office, carriers must overprovision for this traffic, giving all services the same QoS as the highest-value service. This results in network overbuilding and higher-than-necessary capital expenses.

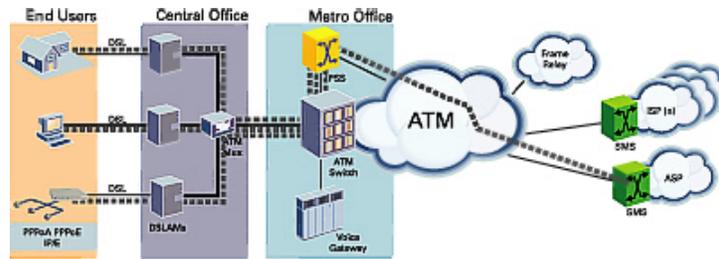


Figure 7: Multicast Video Applications

A New Class of Product Is Required in the CO: The Broadband Services Concentrator

To deliver scalable, profitable value-added services, carriers require a new class of product located in the CO: a broadband services concentrator (See *Figure 8*). The CO is the ideal location to address key networking limitations of metro-only solutions. In addition, the BSC must mesh seamlessly with carriers' existing network infrastructures, preserve the value of their earlier investments, and deliver a rapid payback.

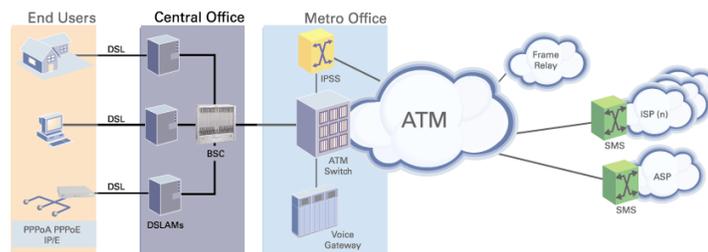


Figure 8: Broadband Service Concentrators

Delivering Key Networking Capabilities in the CO

With advanced QoS/class of service (CoS), subscriber provisioning and aggregation, and bandwidth-management capabilities, BSCs are intended to provide the correct combination of networking features necessary for enabling scalable value-added services.

BSCs should distinguish between AAL2 voice, frame relay, and IP traffic and further distinguish between each user's traffic within each traffic class. Because BSCs can see all subscribers' services and differentiate between types of service, it can manage these services on a per-user/per-service basis, assigning appropriate QoS for each service and for each user.

With complete service visibility, the BSC is able to aggregate subscribers' traffic onto shared tunnels per service, eliminating the need for carriers to provision per-subscriber/per-service VCs between the CO and the metro office. Advanced capabilities, such as local-call completion and CO-based packet replication, ensure efficient delivery of advanced services to subscribers. The BSC thus dramatically reduces bandwidth congestion on the backbone, enabling carriers to avoid over-provisioning, and minimizes additional investment in ATM-switching equipment as carriers add subscribers and expand services.

Because the BSC is able to see and differentiate between all types of services and aggregate traffic from multiple subscribers onto shared, per-service tunnels, it enables carriers to automate subscriber service provisioning. Once a carrier has established a tunnel between the CO and the metro office for a specific service, the BSC must automatically provision subscribers, identify the nature of each subscriber's traffic, and send it on the appropriate tunnel, regardless of whether the subscriber's traffic is transported via IPoE, PPPoA, or PPPoE. The BSC should include

advanced auto-provisioning capabilities to enable carriers to add new subscribers and new services for existing subscribers quickly.

Rapid Payback

BSCs will deliver a rapid payback on investment in several ways (see *Figure 9*):

- It enables carriers to realize substantial savings on capital expenses, reducing the need for additional ATM gear upstream.
- It reduces operational costs and accelerates revenue flows by automating and speeding up the provisioning of new subscribers and new subscriber services.
- It optimizes backbone bandwidth and thereby achieves significant savings on monthly backbone costs.
- It improves the scalability of metro-office SMS/IPSS platforms by relieving them of the multiple burdens of subscriber provisioning, QoS support, and bandwidth management.

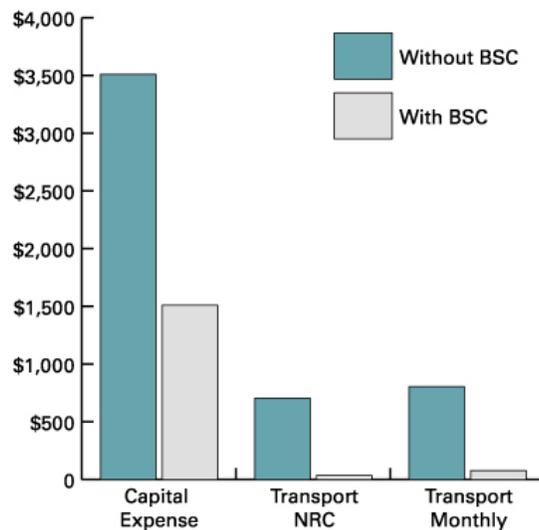


Figure 9: Backbone Capital and Operating Costs

Conclusion

Broadband carriers' success will depend on their ability to cost-effectively provision and easily scale new, profitable, value-added services for a rapidly growing subscriber base. Implementing the required networking functionality to support these advanced services in both the metro and CO is clearly required.

BSCs are architected specifically to cost-effectively provide the advanced features required in the CO. These features enable profitable value-added services by dramatically reducing the number of VCs required to support these services, automating subscriber/service provisioning in the access network, conserving backbone bandwidth, improving network/service scalability, minimizing one-time capital expenses, and reducing ongoing operating expenses.

About the VantEdge Broadband Services Concentrator

Copper Mountain Networks has developed the VantEdge, the industry's first BSC. The VantEdge is designed to provide wirespeed, "intelligent concentration" that optimizes subscriber provisioning, aggregation, access QoS, and bandwidth management in the CO. It extends service intelligence to the very edge of the carrier's network and provides a carrier-class service delivery platform while reducing capital and operational expenditures.

About Copper Mountain Networks

Copper Mountain Networks is a leading provider of intelligent broadband access solutions for carriers and service providers. The company offers a broad set of DSL and aggregation equipment for central office, digital loop, and multitenant unit (MTU) networks worldwide. These products enable efficient and scalable deployment of advanced voice and data services while leveraging existing network infrastructures, reducing both capital and operational costs. Copper Mountain's products have been proven in some of the world's largest broadband network deployments. This paper is courtesy of Copper Mountain Networks. For more information visit <http://www.coppermountain.com> or contact Keith Higgins at khiggins@coppermountain.com or +1-650-687-3312.