Digital Subscriber Line (DSL) and the Evolution of Asynchronous Transfer Mode (ATM) Networks

Definition

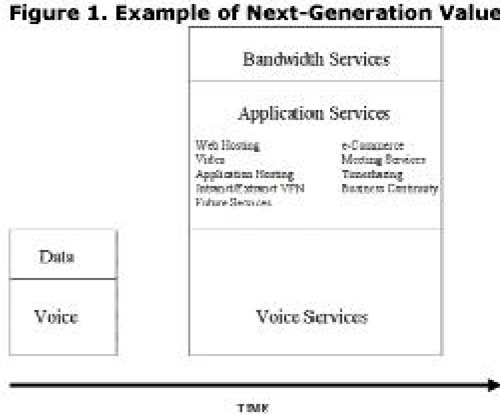
Digital subscriber line (DSL) is a generic name for a family of lines that propose to give the subscriber high-speed Internet access. DSLs typically operate on one pair of wires like a normal analog phone line.

Overview

Deregulation, together with increasing consumer and business demand for high bandwidth services, has led to increased competition among service providers. This increase in competition has, in turn, presented providers with an important set of business challenges.

With increased competition, it becomes critical for providers to market and press for innovative services. Providers must move up the value chain in service delivery, not only to differentiate themselves against their competition but also to protect against the commoditization of the traditional narrowband voice and data services. See *Figure 1*.

Figure 1. Example of Next-Generation Value-Added Services



Topics

1. Network Challenges

One of the greatest challenges service providers face today is the buildout of a network that delivers broadband and value-added services yet remains capable of economically supporting today's revenue-generating narrowband services—voice, integrated services digital network (ISDN), legacy data, and leased lines. Ironically, part of the answer to this challenge of designing the next-generation broadband network solution lies in adopting and adapting many of the attributes of today's narrowband networks: ubiquity, predictability, reliability, scalability, and manageability.

The explosion in demand for bandwidth presents another challenge for broadband services in both the core and the access edge of the network. In the core, carriers are deploying increasing amounts of fiber, utilizing dense wavelength division multiplexing (DWDM) technology, and applying bandwidth to the service quality problem that traditional router-based solutions cannot deal with. Because of this provisioning for peak loads, providers are witnessing tremendous underutilization of their network and are now realizing the potential business opportunities lost by not deploying quality of service (QoS)–capable equipment.

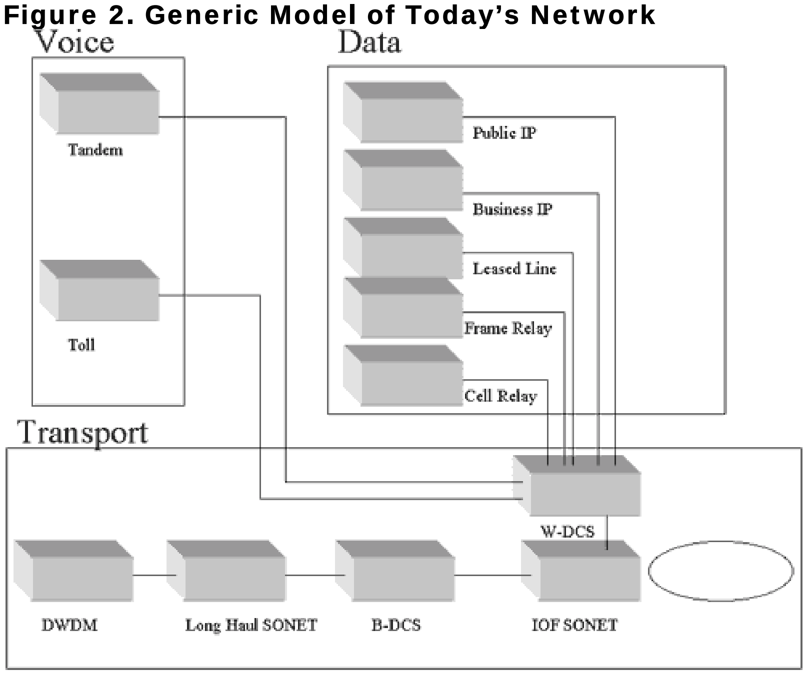
With the growing demand for higher-speed services, the access portion of the network is increasingly becoming the primary bottleneck. To alleviate this, new digital subscriber line (DSL) technologies are becoming available to extend the capacity of legacy copper-based facilities. However, access technologies are also about reach: having the ability to reach your customer base effectively whether "in region" or "out of region." This means multiple access technologies will be necessary for service providers to achieve the widest subscriber footprint possible. A versatile access network architecture must be capable of supporting multiple services over DSL, local multipoint distribution system (LMDS), microwave multipoint distribution system (MMDS), hybrid fiber/coax (HFC), and fiber.

2. Network Evolution

Today's Network of Networks

Today, service providers will find many organizations managing many networks in the delivery of their voice and data services. *Figure 2* depicts a generic model of such a network. Typically, the infrastructure is partitioned into three main segments: switched voice, data overlays, and transport.

Figure 2. Generic Model of Today's Network



Switched voice deals with traditional plain old telephone service (POTS), as well as with enterprise services. Toll, tandem, and local voice switches make up the infrastructure for this network segment.

Data services have evolved with the networks delivering these services. These services provide individual solutions for the delivery of leased line, frame relay, cell relay, and public, private, or business-class IP services. Equipment includes TDM bandwidth managers, cell and frame relay switches, and, of course, routers.

The transport segment deals with managing the plant (i.e., the fiber or copper) within the network. The main functions of this segment are to groom traffic, provide restoration in case of equipment or facilities failures, and provide the physical-layer transmission capabilities. For many networks, the transport segment remains the convergence point where multiple service types are aggregated and managed. Convergence only happens at Layer 1, or the physical layer—not the ideal point for maximum resource utilization and network and service performance.

Because these networks evolved over several years, there exists a tremendous amount of duplication. Each network has its own set of operational costs associated with operations, administration, maintenance, and provisioning. From a capital expenditure perspective, common equipment costs are replicated for each networking element. One must also consider the operational and capital expense associated with nonoptimized trunking. Convergence at Layer 1 is simply not efficient; nor is the cost of replicated trunks from the multitude of service elements in the network.

One can quickly realize why the terms convergence and consolidation have become so prevalent in our industry. The opportunities to reduce drastically the costs of implementing and operating today's (and future) services are tremendous.

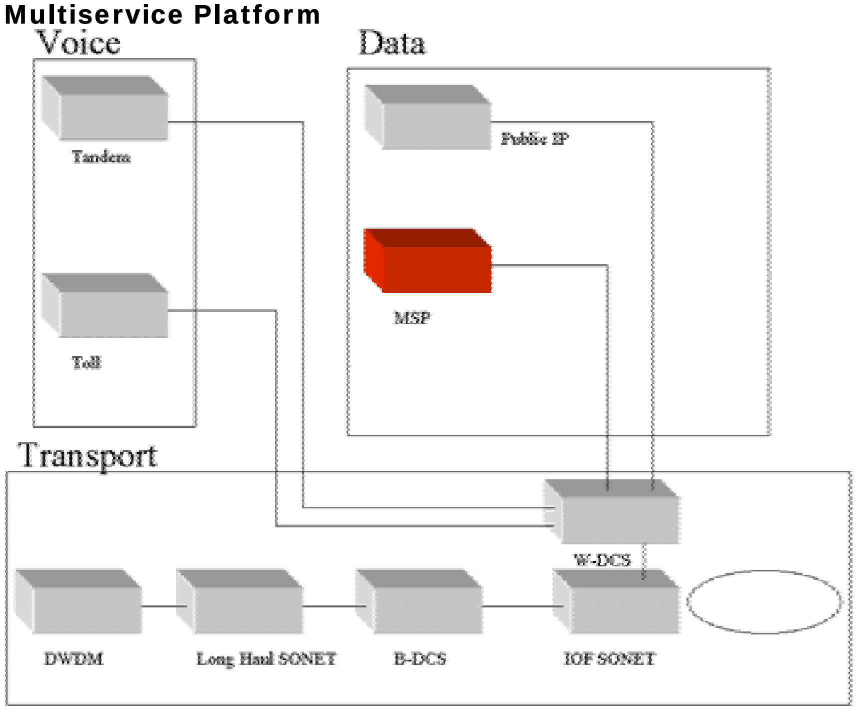
Hence, the real market threat to the incumbent or traditional carriers is coming from new-entrant local, regional, national, and global service providers. With little or no legacy investment, they have the greatest opportunity to implement the next-generation network today, complete with all of the financial advantages. This gives these new entrants a significant cost-base advantage as they begin to compete head-on with the traditional service providers.

The road to a consolidated network infrastructure may have many phases to its implementation. The phases vary depending on a service provider's legacy investments, current and planned services, plus any regulatory restrictions that may apply. The next section outlines an example scenario for implementing such a consolidated next-generation network.

The Multiservice Concept

Several years ago the concept of the multiservice platform (MSP) was introduced—a single platform capable of delivering multiple services while fully leveraging a broadband network infrastructure. The initial focus was on the data overlay services, such as frame relay, cell relay, leased line, and business-class IP virtual private networks (VPNs). *Figure 3* illustrates the effect of data overlay convergence.

Figure 3. Consolidation of Overlay Data Networks into the Multiservice Platform

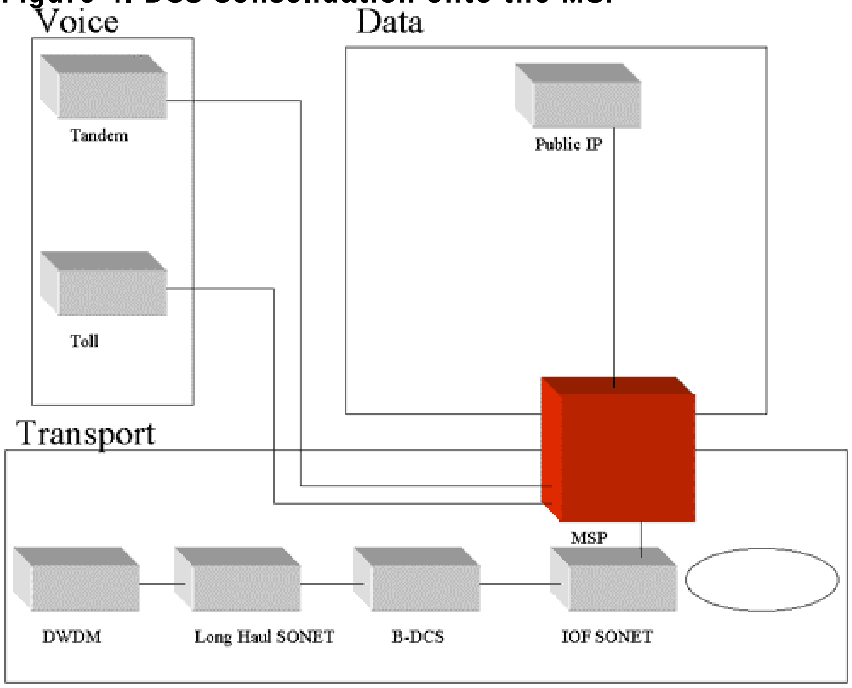


The business-case justification for convergence over a multiservice platform was overwhelming, and the result has been significant savings in capital and operations expenditure.

Integration of Digital Cross-Connect Functionality into the MSP

While the MSP is a service delivery vehicle for data services, it also performs a grooming and restoration function within the network. Traditionally, this has been the roll of time division multiplex (TDM)–based digital cross-connect systems (DCS). Therefore, circuit emulation techniques must be used to consolidate this function across a packet-based broadband infrastructure. However, there is more to DCS consolidation than simply circuit emulation. Fast restoration must be provided to meet various network-level service level agreements. Integration of synchronous optical network (SONET)/synchronous digital hierarchy (SDH) protection plus connection level protection is a must. In addition, today's DCS provides a mechanism for performing various node and network level maintenance and diagnostics. Designing in test access ports and connections, support for the full suite of F4/F5 OAM functions, and providing performance monitoring at the TDM layer are all prerequisites. *Figure 4* illustrates the effect of DCS consolidation within an MSP–based network.

Figure 4. DCS Consolidation onto the MSP



While grooming typically focuses on separate physical interfaces for each service type, the ultimate grooming and service delivery consolidation offering is based on an any service, any circuit (ASAC) concept.

Figure 5. ASAC–Enabled Multiservice Platform

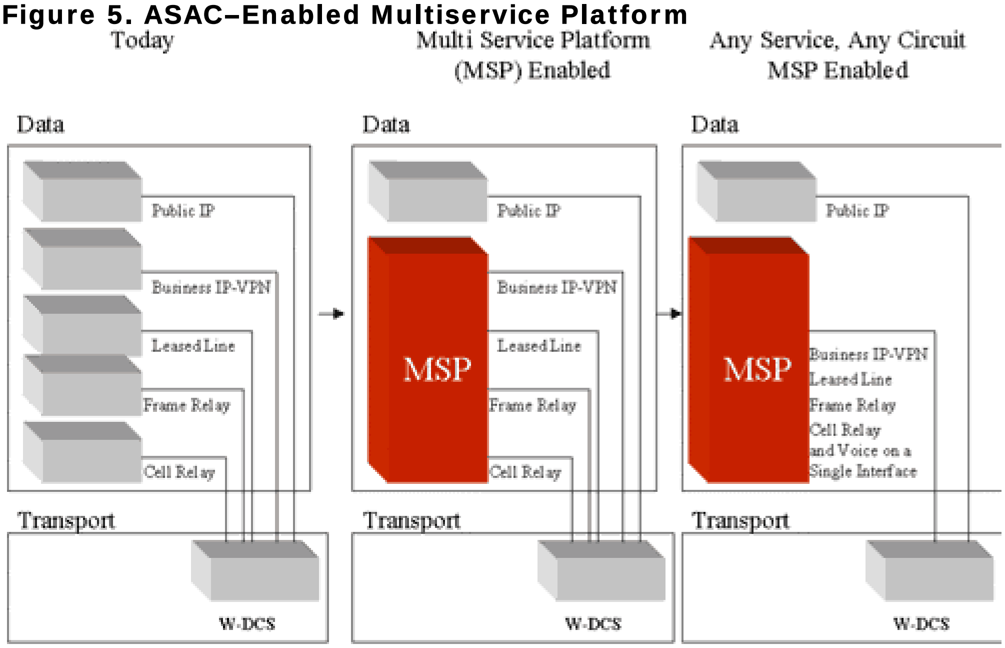


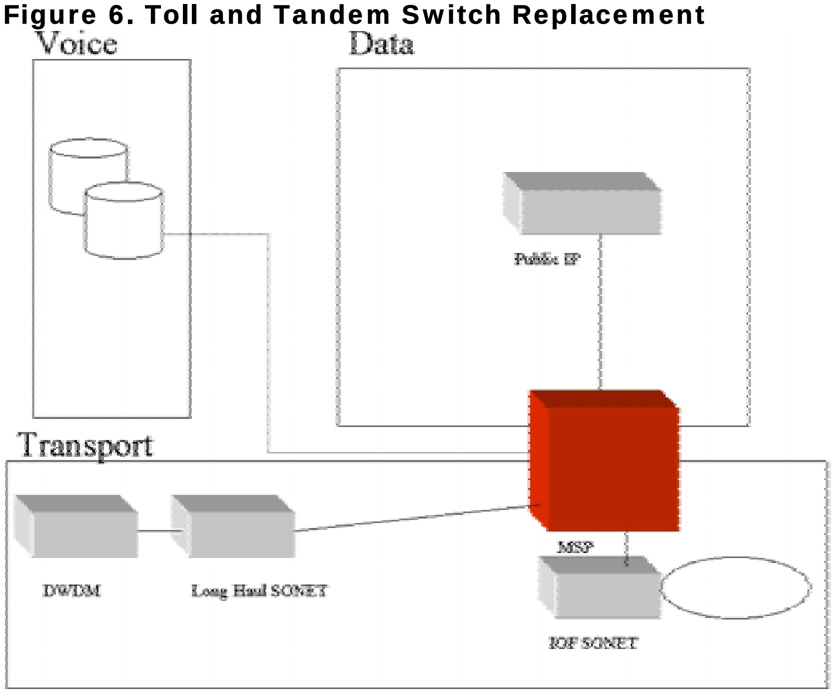
Figure 5 illustrates the effect of ASAC on an MSP. The principle is to eliminate the grooming function that typically aggregates similar service traffic onto

separate interfaces before being terminated by the MSP. An ASAC interface is capable of terminating any service that may be presented from the transport network. For example, a DS–3/E-3 ASAC interface will be capable of terminating frame-relay services, cell-relay services, and leased-line services—all on a single interface. With this functionality, the role of the DCS diminishes even further in the next-generation network.

Integration of Toll/Tandem Functionality into the MSP

Consolidation in the next-generation network is really about voice and data convergence. Switched voice services still represent the bulk of most service providers' revenue. Carriers must continue their investment in a narrowband infrastructure to satisfy their growth requirements for these services and to fund their expansion into new services. However, they realize that the impact of the data explosion, mainly generated by the Internet and networked computing, must be addressed through an investment in a broadband infrastructure. In order to maximize their investment, service providers are looking to converge their voice infrastructure within this broadband network.

Figure 6. Toll and Tandem Switch Replacement



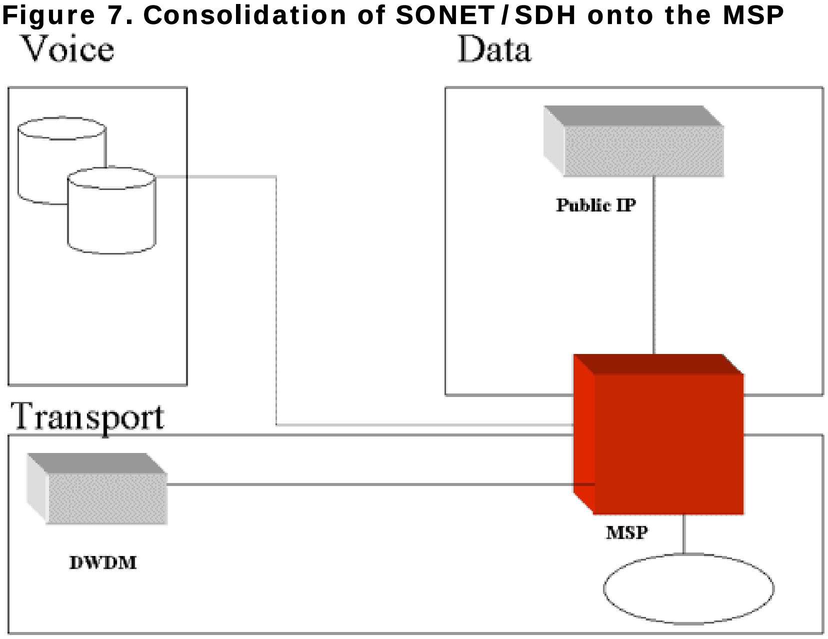
Most equipment vendors agree on the high-level architecture to achieve this goal. As shown in *Figure 6*, off-board call servers have replaced the toll and tandem switches. Many years of development have gone into the creation of various call-processing stacks to implement the level of sophistication and robustness consumers have come to expect of the switched voice network. To replicate an integrated solution on a broadband platform would simply be too daunting from the perspective of investment and time to implementation. Many established and new-entrant vendors are supplying their call-processing technology on off-board platforms that control various network elements by an open application programming interface (API). This separation of the networking fabric (or infrastructure) also allows the network elements and call-processing engines to scale independently. These off-board platforms are typically off-the-shelf UNIX–based workstations that follow a much more aggressive price/performance growth rate when compared to the price/performance ratio of the call-processing solution for integrated narrowband offerings.

In conjunction with a call server, a gateway function is required to perform the interworking function of the data and control planes, from narrowband to broadband. While some vendors believe this interworking function is yet another separate networking element, this can be cost-effectively addressed as an integrated function of the MSP.

Integration of Transmission Functionality into the MSP

Transmission consolidation involves integrating functionality into the MSP to enable interconnection directly over dark fiber. *Figure 7* illustrates the network view of consolidating traditional SONET/SDH add/drop multiplexing functionality into the MSP. The restoration capabilities outlined under DCS consolidation are the initial enablers to transmission consolidation.

Figure 7. Consolidation of SONET/SDH onto the MSP



The next step to broadening the scope of transmission consolidation is to provide a per-connection, low-latency (e.g., 50 ms) restoration scheme. Recent advances in the standards bodies in the areas of virtual path (VP) protection and VP ring architectures hold the most promise on the road to further consolidation.

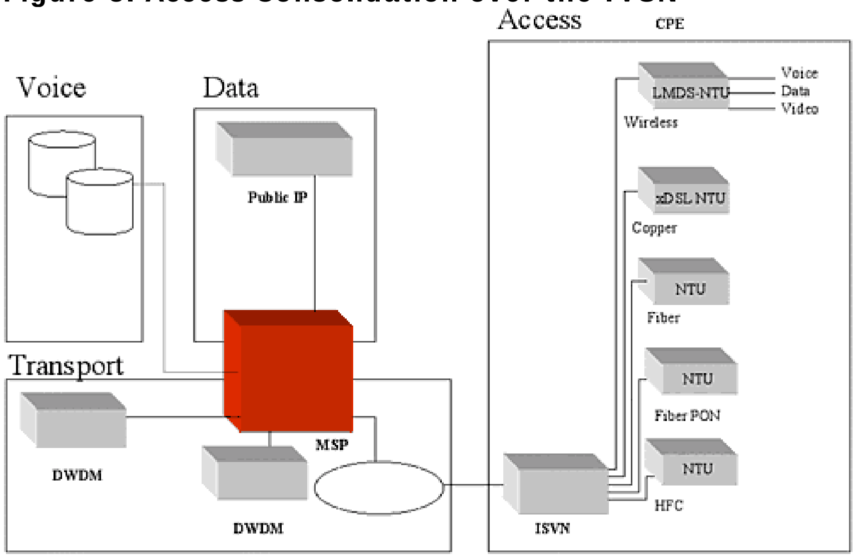
Integration of Multiaccess Functionality into the MSP

With the advent of broadband access technologies, many equipment vendors began to offer focused solutions for individual access media. For example, DSLAMs were developed for the delivery of various DSL technologies. A single-access technology solution does not offer an optimum solution for a service provider. Most carriers need to use multiple-access technologies within their service reach. Rather than standardizing, and thus supporting, multiple-access platforms, one for each technology, a provider would like to have a single platform capable of delivering all their access needs. A multiaccess platform, which provides a single versatile platform capable of supporting xDSL, wireless, passive optical, and hybrid fiber/coax transmission technologies, is preferred.

The access delivery point in the network also requires the functionality and flexibility of the multiservice platform, which would enable multiple services to be deployed at a much lower cost, while ensuring ease of future technology deployment. Integrating both concepts into a single platform would further improve the business case behind consolidation. This is the concept of the integrated versatile services node (IVSN).

Figure 8 illustrates the converged network including the access portion.

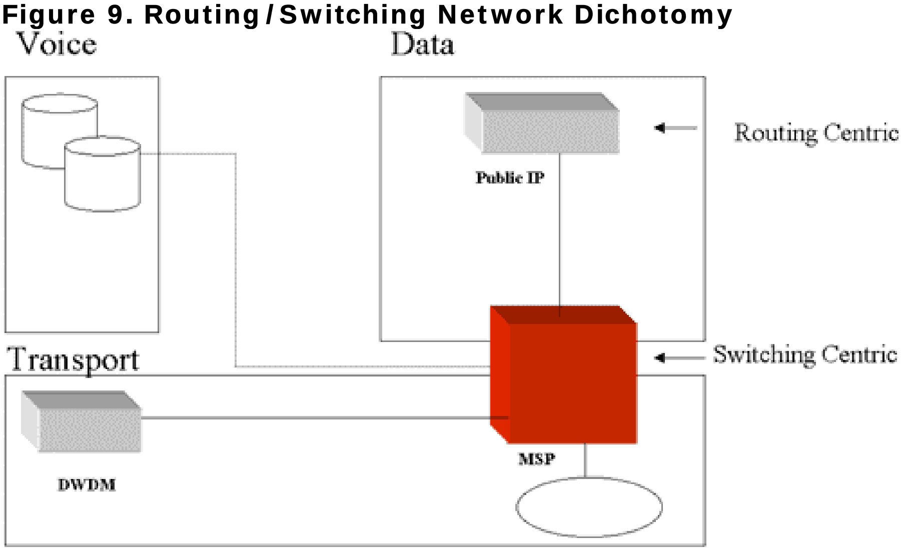
Figure 8. Access Consolidation over the IVSN



3. Vision of Two Worlds Converging

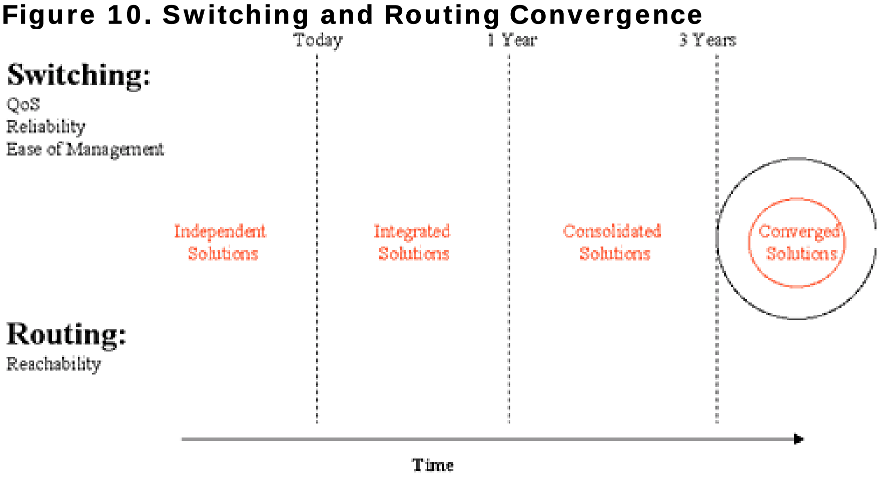
Figure 9 summarizes the consolidation as described earlier.

Figure 9. Routing/Switching Network Dichotomy



It becomes clear that two worlds emerge in the next-generation network architecture. One, switching-centric, is based upon the principles and attributes of the MSP. The other, routing-centric, is aimed at the public Internet service offering and is very much based on the principles and attributes of traditional, best-effort routers. These two worlds are converging, over time, into the next-generation network.

Figure 10. Switching and Routing Convergence



As shown in *Figure 10*, the competencies most attributed to switching solutions are end-to-end qualities of service, reliability, and ease of path management. The competency most attributed to routing solutions is reachability. The routing world has provided a network architecture whereby intelligence is distributed among many entities. Any-to-any connectivity is accomplished using a sophisticated control plane. The routing-centric world faces the challenge of delivering improved QoS and reliability to the internetworking domain—attributes fundamentally delivered via switching solutions. However, from a control-plane perspective, switching solutions very much have been transparent to routing solutions. This transparency must change in the near future to truly integrate the positive attributes of the switching world within a routing-centric network architecture.

The convergence of switching and routing will first take place in the network's core and the enabler for this true convergence is MSP.

Self-Test

1. Which portion of the network is becoming the bottleneck as the demand for higher-speed services grows?

    a. the switching area

    b. the delivery portion

    c. the access portion

    d. the convergence area

2. Which of the following is not typically one of the partitions of a network infrastructure?

    a. switched voice

    b. data overlays

    c. transport

    d. converged fiber

3. A provider would like to have how many platforms for delivering all their access needs?

    a. multiple

    b. double

    c. single

    d. plethora

4. The initial focus of MSPs was on ________________________.

   a. data overlay services

   b. transport services

   c. switched services

   d. voice convergence services

5. The competency most attributed to routing solutions is ______________________.

   a. reliability

   b. end-to-end qualities of service

   c. reachability

   d. ease of path management

6. Increasing demand is the sole reason for increased competition among service providers.

   a. true

   b. false

7. The challenge of designing the next-generation broadband network solution will in no way call upon the attributes of today's narrowband networks.

   a. true

   b. false

8. The role DCS is playing in the next-generation network is diminishing.

   a. true

   b. false

9. Consolidation in the next-generation network is really about voice and data convergence.

   a. true

   b. false

10. Switching-centric architecture is aimed at the public Internet service offering, while routing-centric architecture is based on MSP principles and attributes.

a. true

b. false

Correct Answer

1. Which portion of the network is becoming the bottleneck as the demand for higher-speed services grows?

a. the switching area

b. the delivery portion

c. the access portion

d. the convergence area

See Topic 1.

2. Which of the following is not typically one of the partitions of a network infrastructure?

a. switched voice

b. data overlays

c. transport

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See Topic 2.

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d. ease of path management

See Topic 3.

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See Topic 1.

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10. Switching-centric architecture is aimed at the public Internet service offering, while routing-centric architecture is based on MSP principles and attributes.

   a. true

   b. false

   See Topic 3.

Glossary

API
application programming interface

ASAC
any service, any credit

ATM
asynchronous transfer mode

DCS
digital cross-connect system

DSL
digital subscriber line

DSLAM
digital subscriber line access multiplexer

DWDM
dense wave division multiplexing

HFC
hybrid fiber/coax

IP
Internet protocol

ISDN
integrated services digital network

IVSN
integrated virtual services mode

LMDS
local multipoint distribution system

MMDS
microwave multipoint distribution system

MSP
multiservice platform

POTS
plain old telephony service

QoS
quality of service

SDH
synchronous digital hierarchy

SONET
synchronous optical network

TDM
time division multiplex

VP
virtual path

VPN
virtual private network

xDSL
digital subscriber line