Simplifying Global Internetworking: The Economics of a Phased Approach toward True Voice and Data Convergence

Definition

Simplifying global internetworking means the following:

- Converging voice and data access and switching over a common core network
- Enabling the communication between a variety of interfaces and networks
- Combining multiple elements in carrier networks, including DCS, multiservice switches, and packet voice switches

Overview

After the recent downturn in the telecom market, the industry has realized that the entrenched nature of service provider voice and data organizations, coupled with the large investments in legacy equipment, circuit and packet switching will coexist for a while with ATM, IP and TDM playing complementary roles.

The migration to a converged voice and data network will be through a phased approach and with products that can be installed in both data and voice organizations. These products will have the ability to support asynchronous transfer mode (ATM), time division multiplexing (TDM), and Internet protocol (IP) interfaces and combine multiservice and packet voice switching in one system, and thus function as a single point of convergence.

This paper describes what is believed to be the most efficient phased approach to a converged network and provides an economic analysis to assist service providers in their decision-making process.

Topics

1. 2G Billing Challenges

Today many service providers indicate that operating multiple networks based on circuit and packet switching is part of their corporate strategy. This is due to a variety of historical, technological, regulatory, and even internal political reasons. The tremendous growth in IP traffic, coupled with double- and triple-digit growth in frame and ATM services, pushed service providers to build a variety of packet-switched data networks in addition to their circuit-switched voice networks in the 1980s and the 1990s. Due to the different types of required expertise, the data organization grew separately from the voice organization, creating either two politically distinct groups within large service providers or separate subsidiaries altogether. The transmission organization, although a common entity as the infrastructure provider, has at times been the third leg of this stool.

For the past few years, the success of IP in handling Internet traffic led many to believe that the technology would be ideal to end the turf wars between these two organizations and converge service-provider networks in a cost-effective way. IP, however, as is widely known, does not currently have the necessary quality of service (QoS) capabilities to meet the voice quality that customers have come to take for granted from current voice networks. In addition, IP services do not generate the same level of revenues as fast packet and are therefore currently not a driver for convergence between the two data protocols. The rallying cry around IP created a degree of confusion in the market and led many to believe that ATM, the only technology that supports convergence with the proper standardized QoS capabilities, was becoming obsolete.

This confusion impacted both vendors and service providers. Due to the hype surrounding IP, vendors did not or could not develop viable and *real* products that could address both networks efficiently in service-provider organizations. Service providers saw that vendors were barely investing in the one technology, ATM, which could address their QoS concerns for both voice and data and as a result opted to run their companies with at least two and at times three different networks.

Service providers are, of course, fully cognizant of the operational inefficiencies in running multiple networks, not to mention the inability to offer enhanced services on their current circuit-switched networks. Service providers have to run several network operations center (NOC) facilities, and each network requires its own core expertise. Multiple networks also makes for difficult fault isolation, and ,with multiple networks, service providers have to spend twice the money to go the same distance.

Carriers also realize that as important as it is to protect legacy investments, it is equally important to be able to control costs and offer competitive services, which is possible mainly through the product innovations of start-up companies. However, up until just recently, the technical issues of convergence were not resolved and there were no products that could address the requirements of both voice and data networks adequately and act as the bridge between current ATM and future IP-based networks.

The recent downturn in the telecom market, however, has lifted the cloud of hype and has led the industry to realize that, due to the entrenched nature of the dual organizations and coupled with the large investments in legacy equipment, circuit and packet switching will coexist for a while, with ATM, IP, and TDM playing complementary roles.

As a result, only those products that can address and properly deal with this reality will be deemed viable and workable. The answer to the dilemma of convergence can be found in a new product, an "*omniservice switch*", a product with the ability to support all these interfaces and combine multiservice & packet voice switching in one system and thus function as a single point of convergence.

Omniservice switches have an ATM switching fabric that allows them to offer packet switching as well as take advantage of ATM networks for voice and in effect act as a bridge between current ATM and future quality-based IP networks. An omniservice switch does more than just separate and pass different types of traffic on to the appropriate network (ATM, public switched telephone network [PSTN], or IP); it also has the ability to participate in the signaling in those networks.

An omniservice switching solution is able to understand and participate in ATM PNNI as well as Signaling System Seven (SS7). In addition, when multiprotocol label switching (MPLS) is standardized, it will also be able to participate in the MPLS signaling and routing within the IP network, particularly initially the "ships-in-the-night" concept, which allows for support of ATM and MPLS on the same common platform and ultimately supports robust MPLS routing capabilities as the standards and carrier implementations become mature.

Incumbent vendors that have their own legacy issues to deal with are still offering re-engineered old products or stop-gap measures that do not resolve service providers' cost and services issues but do offer the longevity of a tried-and-true vendor. Start-up vendors are the ones who are offering new and state-of-the-art omniservice switches, which will help to control costs and enhance features. These conflicting realities have driven service providers to adopt a phased approach to the migration toward a converged packet-switched network.

2. The Phased Approach to Convergence

Although large service providers may have separate voice and data organizations or subsidiaries today, they do realize the importance and commercial benefits of a single network organization, and if they have not already done so, it is only a matter of time before they embark on a phased approach to a converged packet switching network to combat the skyrocketing operational expenditure (OPEX) and diminishing capital expenditure (CAPEX) budgets. The voice network has its own physical circuits, provisioning systems, and voice switches. Data traffic can be supported on as many as two parallel networks of ATM and IP with its own physical circuits, provisioning systems, data switches, and routers.

To play a significant role in service providers' phased migration plans, network equipment should have three major characteristics:

1. The ability to handle *both* voice and data services efficiently as well as grow with the requirements of service providers
2. The ability to be deployed by both voice and data organizations and provide a similar experience to both groups
3. Part of a *phased and realistic vendor product-development plan* that ultimately leads to true voice and data convergence while interoperating with embedded networks

An omniservice switch is the only product on the market today that can address all three requirements. For one, the product can be used in a phased fashion since it provides carrier-class multiservice edge switching, packet voice gateway capabilities (i.e., CES), as well as packet tandem switching (i.e. softswitch), and will eventually offer Class-5 packet access switching when all of the features and robust capabilities are fully developed.

In addition, the fact that the technology of omniservice switches straddles the transmission, voice, and data organizations gives carriers the opportunity and ultimately the experience to work with a product with the potential of converging these organizations.

In line with their own phased migration plans, service providers are best served to look for start-up vendors that also have a practical and phased product-development plan. Start-up omniservice switch vendors, or even incumbents that have announced their intention to develop omniservice switches, are required to have a short-term/long-term strategy to product development that is realistic and achievable.

For example, omniservice switches will only have true Class-5 functionality when the top 250 features have been developed and the switches themselves have been proven reliable and robust. At least for the next few years, carriers have no economic or operational reasons to migrate off their traditional Class-5 switches because of the following:

1. The established reliability of these switches directly impacts customer satisfaction.

2. Popular features such as three-way calling, call waiting, and others are a large source of revenue, and the switches are still in the process of being depreciated.

3. Most of the switches currently have excess capacity.

As a result, it is best for vendors not to rush to market with deficient and experimental products.

Technologically, an enlightened product plan toward an omniservice switch involves the development of a multiservice switch, which is then supplemented by a packet tandem switch. The packet tandem switch then acts as the foundation for building a full-featured Class-5 switch, both of which will reside on softswitches that utilize a general purpose server platform that is anticipated to continue significant price-performance improvements during the next few years. In fact at that time, the telecom arena will become an Omniclass market, where distinctions between Class 4 and 5 switches will disappear and omniservice switches will perform the combined functionality of both.

3. Phase I: Multiservice Edge Switching Deployment

Many vendors today have successfully handled the packetization of voice (TDM to ATM or TDM to IP), which is only one of the elements toward the migration to an all-packet network. What is usually not addressed, however, is the data piece, which once again leaves the service provider with multiple networks. On the other hand, since state-of-the-art omniservice switches sport an ATM core switching fabric allowing for interworking between any type of interface, including TDM, frame, ATM, or IP, they are deployable separately in new packet voice as well as upgraded carrier-class data networks that will ultimately converge. ATM, in effect, is currently the only technology that can carry both voice and data on a single network with quality of service.

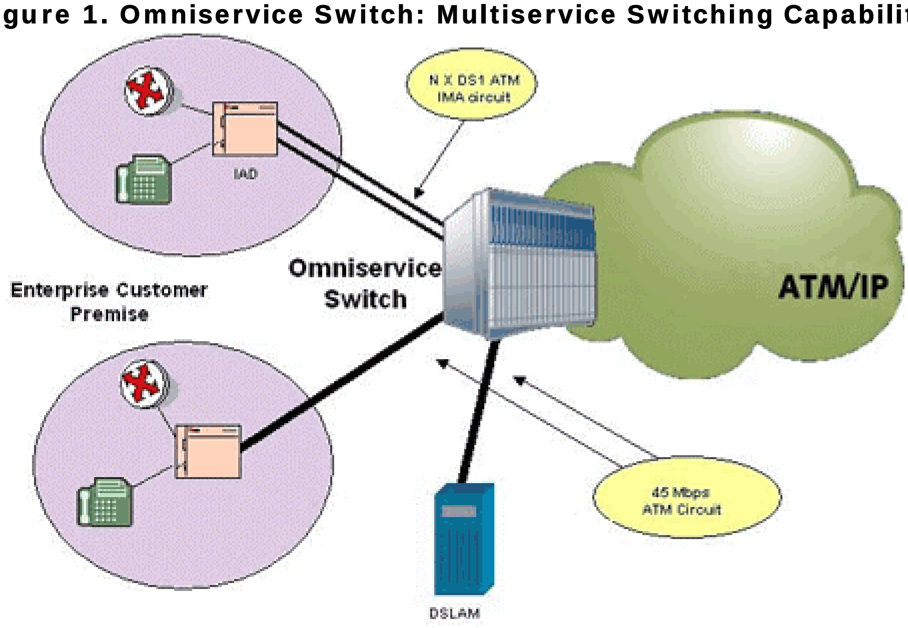
The phased approach involves the following steps:

1. Testing the omniservice switch for traditional and proven multiservice switch functionalities, such as integrated packet DCS, digital subscriber line access multiplexer (DSLAM) aggregation, ATM/IP switching, and frame-relay and inverse multiplexing over ATM [IMA] aggregation (see *Figure 1*)

2. Moving to packet voice switching applications

Carriers are usually more at ease with this approach, because the product can be adequately tested before the quality-sensitive voice service comes into the equation.

Figure 1. Omniservice Switch: Multiservice Switching Capability



Multiservice Switching Capabilities

Large service providers are very interested in multiservice switching for three main reasons:

- ATM will remain as the transport network of choice for the local loop for digital subscriber line (DSL), especially for the incumbent local-exchange carriers (ILECs).
- Multiservice switches are necessary for out-of-region expansion.
- The phenomenal growth of 200 percent to 400 percent in ATM and frame services are generating significant revenue derived from both plain vanilla and advanced services.

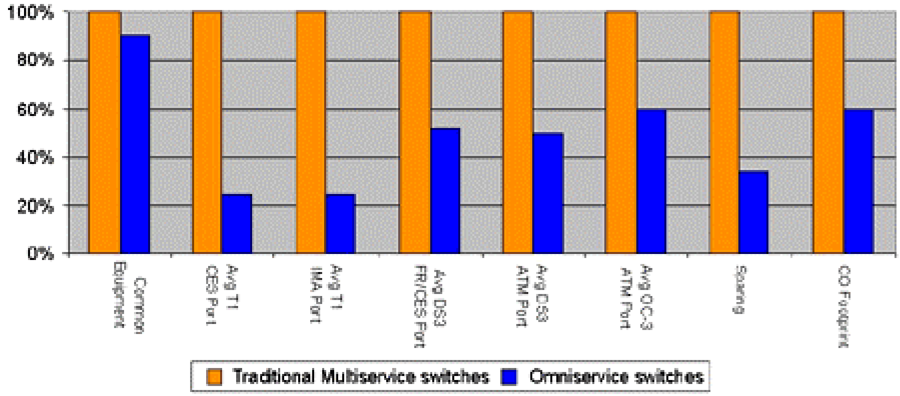
Carriers are especially interested in controlling a converged access pipe to the enterprise customer and offering new enhanced services such as virtual private networks (VPNs). The ability of omniservice switches to handle both voice and data gives carriers this capability. By placing an integrated access device (IAD) on the customer's premises to aggregate frame relay, ATM, Ethernet, and T1 voice connections, the aggregated data can be passed to an omniservice switch at the edge. The switch at this point could perform two different functions. For one, it would further aggregate the data traffic and pass a bigger pipe to a core switching architecture. Secondly, the voice traffic can be either aggregated and cross-connected at the omniservice switch (or a DCS) as well as be separated and handed off to a standard TDM–type application to the Class-5 switch.

Other than ATM and Frame Relay switching, traditional and proven multiservice switch functionalities include integrated packet DCS, DSLAM and IMA aggregation. There is a very real perception in the market today that service providers no longer want to continue to invest in legacy single-function DCS products and, if anything, would prefer to remove the DCS from their networks altogether. These boxes consume a great deal of space, a tremendous amount of power, and, worst of all, are single-function boxes that in two or three years will turn into boat anchors unable to offer any state-of-the-art capabilities, packet technology, or a migration path to the next-generation networks. An omniservice switch has integrated DCS capabilities and is able to perform 3/1/0 cross-connecting functions, transporting over an ATM core and outputting to another device in the original format.

With ATM switching capabilities, omniservice switch can also be used as a DSLAM aggregation switch. For example, multiple lightly loaded digital signal (DS)–3s coming in from DSLAMs located in a number of different offices in the metro area can be aggregated at the omniservice switch, which then sends out a fully-loaded DS–3 or an optical carrier (OC)–3 connection onto a core ATM switch or an IP router.

The multiservice switching capabilities of omniservice switches offer the best of both worlds: a switch that accommodates high-density multiservice access services such as frame relay, circuit emulation service (CES), IMA, and ATM user network interfaces (UNIs) at the edge and simultaneously aggregates a large capacity of DS–3, OC–3, and OC–12 ATM traffic. The advantage of combining these two functionalities translates into more than 30 percent total capital cost savings and more than 60 percent operational cost savings, as seen in *Figure 2*.

Figure 2. Cost Comparisons between Traditional Multiservice Switches and Omniservice Switches



In addition, the multiservice switching capabilities of omniservice switches are by far more advanced than current multiservice switches and fill a hole in the industry's current product lineup. These switches are technologically superior in four major ways:

1. Offering lower cost and higher port density and switching capacity. An omniservice switch needs to have at least 20 gigabits of core capacity to handle both voice and data, and many legacy multiservice edge switches do not go beyond 10 gigabits (see *Table 1*).

2. The any-service-to-any-port universal service module delivers interworking on a single blade and provides carriers with unprecedented provisioning flexibility and reduced sparing and inventory requirements. With traditional multiservice edge switches, service providers are forced to purchase individual modules for ATM, frame relay, circuit emulation, and IP functionality.

3. The utilization of ATM switched virtual circuits (SVCs) provides much higher bandwidth utilization efficiency in the core network, while PNNI provides network resiliency and availability through rerouting around failed links.

4. Omniservice switches provide a viable migration path to hybrid MPLS/IP networks when carriers are ready and the technology is standardized and available.

Table 1

Vendor	Multiservice Edge Switch (1 to 5 Gbps)	10–20 Gbps	ATM Core Switch (40+ Gbps)	Anticipated New ATM/MPLS Core Switch (80+ Gbps, OC-192 interface)
Cisco	MGX 8850 (PXM1)	N/A	MGX 8850 (PXM45)	MGX 8950
Lucent	PSAX 2300/CBX-500	GX-550 (20Gbps)	N/A	TMX 880
Marconi	ASX-1000	N/A	ASX-4000	BXR-48000
Alcatel	7470(36170)	N/A	7670	7670 RSP
Nortel	Passport 7480	N/A	Passport 15000	Passport 20000

4. Phase II: Evolution of Voice To An All Packet Network

The evolution of voice to an all packet network will take place in two logical steps. First a phased migration to packet tandem followed by the second step of adding class 5 features, thus ultimately migrating to a packet network and an omniclass packet voice switch. An Omniclass switch has the ability to provide tandem and end-office voice switching in a single, open and scalable softswitching system that supports TDM, ATM or IP networks.

The move from circuit-switched to packet-switched networks for voice revolves around augmenting the TDM tandem network with a packet backbone, and the packet tandem capabilities of an omniservice switch is a logical place to continue the growth after multiservice edge capabilities have been installed. There are several major reasons why the voice circuit-to-packet migration will begin at the Class-4 tandem. Domestic carriers have a $2 billion investment in Class-4 tandem switches and a more than $40 billion investment in Class-5 switches. Tandems represent a smaller and more manageable number of switches, offer less disruption to subscriber services, reside within close proximity to the packet core, have a smaller voice services feature set, and provide the highest bandwidth efficiency gain.

In addition, large carriers have a problem with exhaust on Class-4 ports and are hesitant to invest in legacy tandem switches due to total cost of ownership (TCO) and dead-end technology. An omniservice switch is a viable replacement and can interact with a traditional tandem switch in a variety of ways, including acting as a simple trunking gateway or peering with a Class-4 switch.

In addition to multiservice switching capabilities, the packet voice switching capabilities of an omniservice switch include the functionality of media gateways, softswitches and open interfaces to third-party application servers to give carriers a complete packet voice (VToA/VoIP) migration strategy. This avoids the introduction of yet another unfamiliar box—the narrowly focused media gateway—into the carrier's network. Economical carrier investments today will be in products that have numerous uses across multiple networks.

Packet Tandem Capabilities

It is important to realize that a media gateway and a softswitch from different sources do not easily integrate into a packet tandem switch. The interworking between the two components is a difficult and time-consuming task, and today only omniservice switches can tout this capability. In fact, many vendors have a media gateway but not a workable and robust softswitch. Some incumbent vendors have media gateways that are not open and only interoperate with their own switches and most importantly merely convert between TDM and ATM interfaces. This requires an external core ATM switching network. An omniservice switch, on the other hand, provides its own ATM switching capability directly over the existing transmission infrastructure, in addition to the media gateway functionality, thus saving the carrier from having to install an ATM network or expand the network that they have.

Many vendors that have tackled the issue of packet voice switching have approached the problem in the manner just described, i.e., providing a simple media gateway that can only convert TDM to ATM or IP without providing any switching capability. An omniservice switch, however, can provide not only the switching, but also the interworking functionality (via interworking through the core ATM switch fabric), thus providing much higher value through merging multiple network elements.

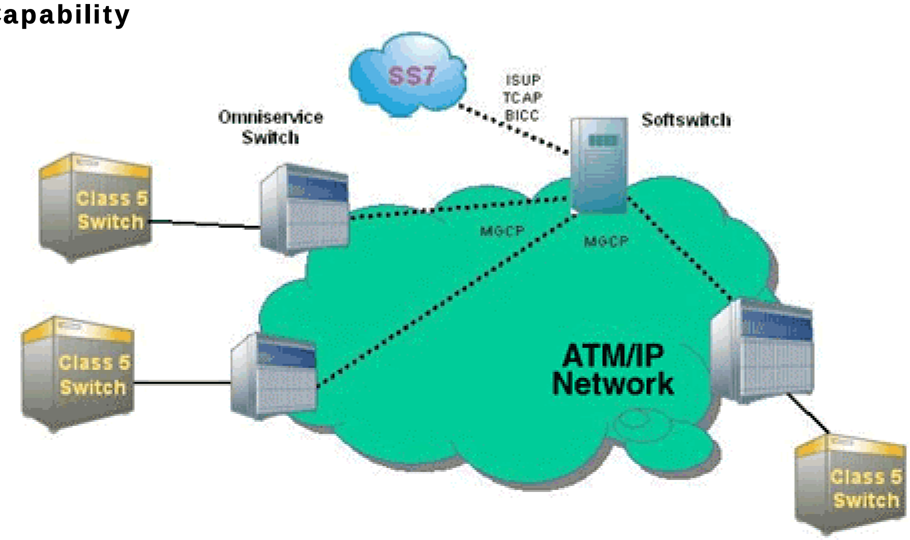
Some vendors provide only TDM–based media gateways, which have not been designed with a phased product roadmap and the realistic migration plans of service providers in mind. Such media gateways were meant to resolve a temporary problem (Internet off-load) in order to have a chance at replacing the service providers' tandem switches in the future. Although this was a panacea for service providers in the not so distant past, broadband services such as DSL are now effectively becoming the Internet off-load mechanism and service providers are more interested in investing in equipment which reduces costs and generates new revenue rather than one that solves a transient problem. Many service providers (especially in Europe) are seeing that the total traffic in their circuit-switched network has actually been decreasing thanks to the rollout of broadband services.

Migration to Packet Tandem

Migration to a packet tandem switch is made simple by the omniservice switch (see *Figure 3*). As stated, the media gateway element supports the interworking between the multiple interfaces, just as its softswitch element must support multiple signaling protocols as well as the interworking. The migration to a packet tandem itself may be divided into two steps. The first is to utilize TDM IMTs as the ingress/egress ports of the switch to existing circuit switches while utilizing packet trunking between the omniservice switch media gateway elements. In this step, only integrated services digital network (ISDN user part (ISUP) signaling would be needed in the softswitch element.

The second step is to actually interconnect multiple omniservice switches to each other via packet trunking. In this step, the bearer-independent call control (BICC) signaling protocol is used for the packet trunking part of the network. BICC is a modified ISUP that runs over the existing SS7 network and smoothly interworks with ISUP. This step can be easily extended to interconnect the Class-5 switches with the tandems via the packet trunking. This will require either native ATM/IP interfaces on the Class-5 switch or going through a media gateway that does the conversion from TDM to packet. The omniservice switch itself can be utilized for that purpose.

Figure 3. Omniservice Switch: Packet Voice Switching Capability



5. Economical Advantages of Packet Tandems

There are economical benefits to be gained in the various phases of migration to packet tandem, even starting with TDM trunks between the switches. The first step described leaves the Class-5 and the existing network intact, enabling a cap-and-grow approach and providing an opportunity to become familiar with the new network element. The biggest advantage is that packet trunking between the omniservice switch elements provides a much more efficient bandwidth utilization in the transmission infrastructure because of the use of ATM switched connections. A savings of as much as 30 precent of bandwidth utilization is achievable with voice traffic alone. When voice and data are switched using the omniservice switch, a higher efficiency yet, of as much as an additional 30 percent, is achievable.

At this point in the migration process, both voice and data are being handled by the omniservice switch as a single point of convergence (see *Figure 4*). Service providers will see amplified benefits from major OPEX and CAPEX savings, as seen in *Figures 5* and *6*.

Figure 4. Omniservice Switch as a Single Point of Convergence

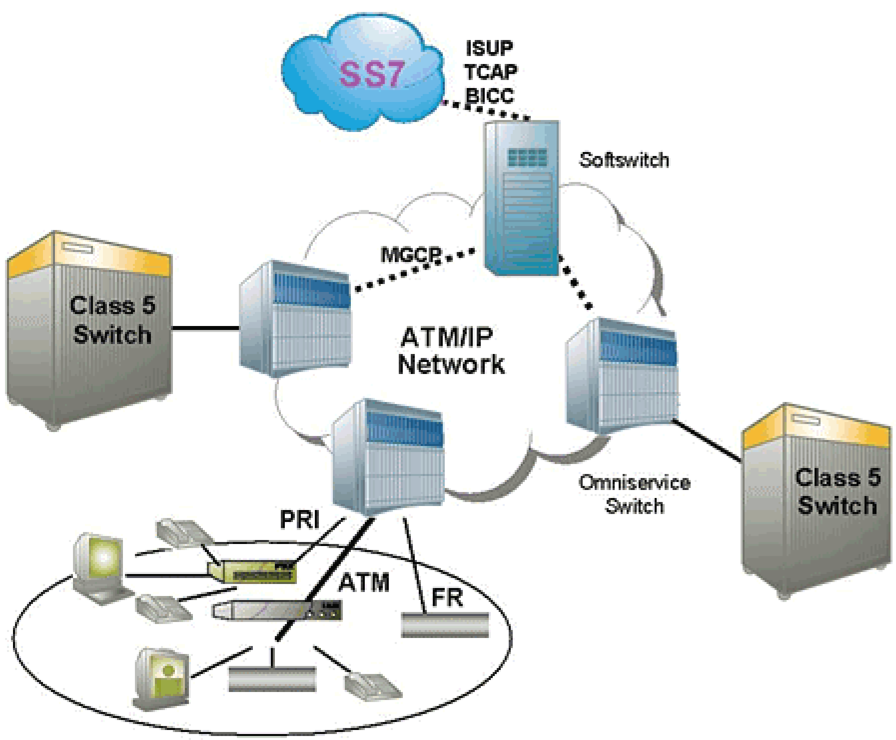
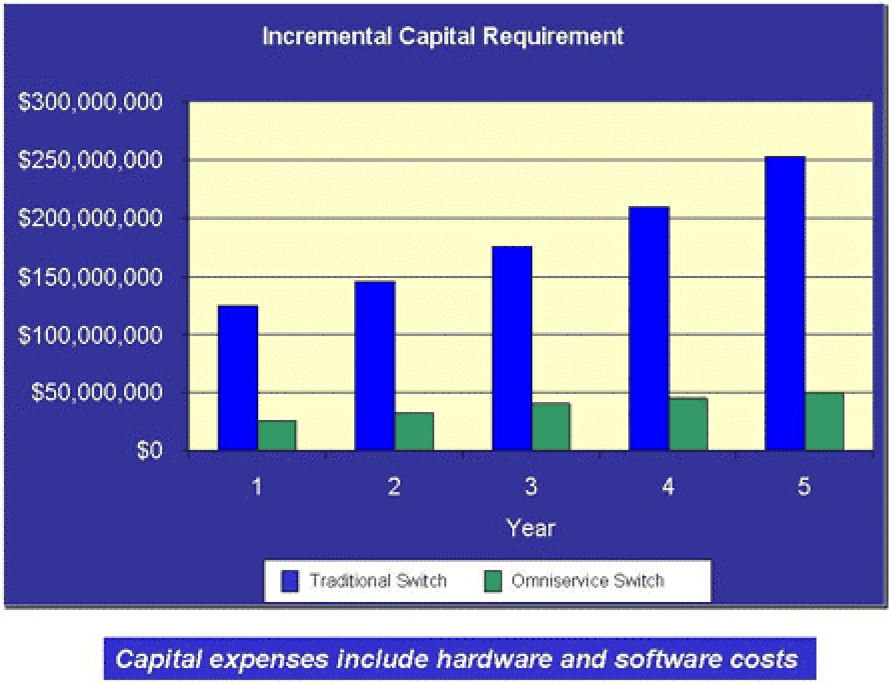


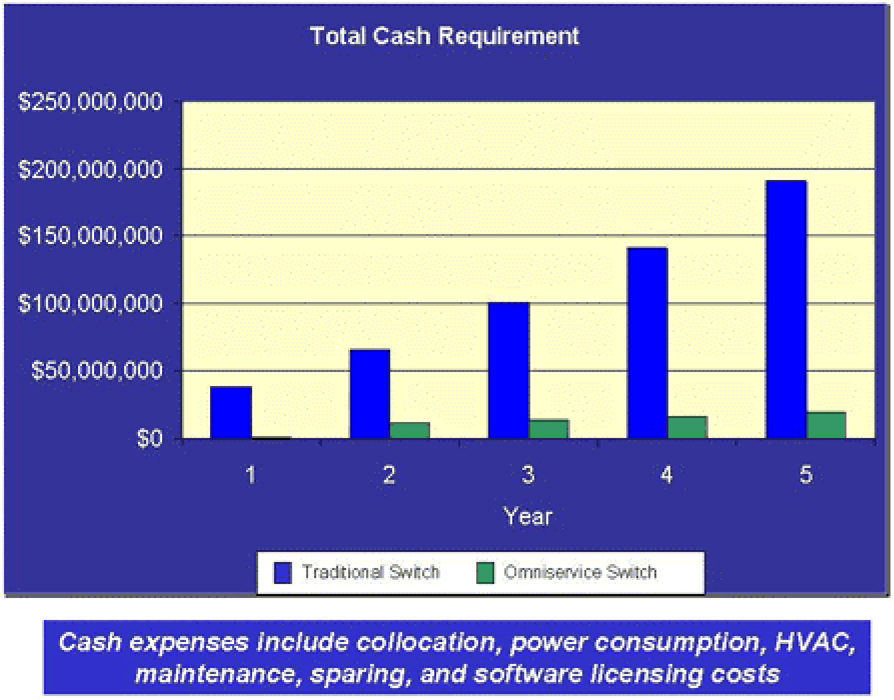
Figure 5. Incremental CAPEX Requirement—Traditional versus Omniservice Switch



Typically, a traditional tandem switch (1000 DS1 ports) consumes around 14 bays of central office (CO) space, which costs the service provider approximately $120,000 in annual occupancy costs. Contrast that with the space consumption of an omniservice switch, which would take up one-third of a bay of CO space and cost the service provider approximately $5,000 in annual occupancy costs.

The electricity consumed by the network elements, as well as the air conditioning required to maintain their operating environment, are major costs in operating a CO. Omniservice switches consume a fraction of the electrical current required by traditional voice switches, thus providing additional cost savings. Omniservice switches can also provide savings of 25-40% over class 4 ports.

Figure 6. Total Cash Requirement—Traditional versus Omniservice Switch



6. Phase III: Adding Class-5 Features for an Omniclass Switch

When the omniservice switch is ready to augment and replace Class 5 switches with adequate features and robustness, carriers need to embark on smaller and more isolated deployments over time to ensure successful implementation. At this point, service providers can migrate the IMTs between the Class 5 and the tandem switches from circuit-switched (TDM) to packet-switched (ATM/IP) technology, especially as existing Class-5 switches reach adequate capital depreciation levels, while still using the packet tandem functionality.

7. Conclusion

There is no doubt that converged networks lead to substantial savings in terms of both equipment and human costs. Converged networks lead to the following:

- Improved and integrated network management and operations, which leads to decreased service delivery costs and improved profitability

- Reduced CAPEX
- Increased bandwidth efficiency supporting more customers
- Accelerated circuit as well as service provisioning
- Reduced sparing costs
- New innovative services

With the era of hype being over, service providers can finally partner with vendors that have a deliberate and pragmatic product roadmap based on viable and innovative products today while supporting their future network vision with the latest technology. Service providers should be vigilant in partnering with vendors that pledge to deliver on their promises and believe in discussing only real products that can be delivered within realistic timeframes.

Self-Test

1. What are the reasons for multiple networks in service-provider organizations?
   a. Growth of data networks after the inception of voice networks and during different decades
   b. Regulatory Requirements
   c. Type of required expertise
   d. Multiple divisions in service-provider organizations
   e. All of the above
2. Which data services generate the largest amount of revenue?
   a. ATM and frame
   b. IP
3. What are some of the issues associated with running multiple networks?
   a. Inability to offer enhanced services
   b. Operating several NOC facilities

c. Each network requires its own core expertise

d. Difficult fault isolation

e. All of the above

4. Circuit and packet switching will coexist for a while, with ATM, IP, and TDM playing complementary roles.

   a. true

   b. false

5. An omniservice switch combines multiservice and packet voice switching in one system and thus functions as a single point of convergence.

   a. true

   b. false

6. Omniservice switches have a/an _______ switching fabric.

   a. IP

   b. ATM

   c. TDM

7. To play a significant role in service providers' phased migration plans, network equipment should have which of the following characteristics:

   a. The ability to handle *both* voice and data services efficiently as well as grow with the requirements of service providers.

   b. The ability to be deployed in both voice and data organizations and provide a similar experience to both groups.

   c. Part of a *phased and realistic product-development plan*.

   d. All of the above

8. A phased approach to a unified packet switched network involves which one of the following steps:

a. Testing the omniservice switch for traditional and proven multiservice switch functionalities, such as integrated packet DCS, DSLAM aggregation, as well as frame relay and IMA aggregation.

b. Moving to more complex packet voice switching applications.

c. All of the above

9. The first in the migration to packet tandem is to utilize _______ as the ingress/egress ports of the switch to existing circuit switches while utilizing packet trunking between the omniservice switch media gateway elements.

   a. TDM IMTs

   b. ISUP

   c. BICC

10. Service providers can experience bandwidth efficiencies of having their voice and data traffic traversing a common, efficient network core, which can produce up to a _______ reduction in the aggregate bandwidth requirements of separate voice and data.

   a. 5%

   b. 10%

   c. 30%

Correct Answers

1. What are the reasons for multiple networks in service-provider organizations?

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Glossary

Acronyms Guide

BICC
Bearer Independent Call Control

DSLAM
Digital Subscriber Line Access Multiplexer

IMT
Inter-Machine Trunk

ISUP
Integrated services digital network (ISDN) User Part

MPLS
Multiprotocol Label Switching (allowing QoS and traffic engineering on IP networks)

PNNI
Private Network-to-Network Interface; a routing protocol that advertises bandwidth resources as well as reachability

QoS
Quality of Service; the ability to guarantee transmission characteristics end-to-end

SS7
Signaling System 7

SVC
Switched Virtual Circuit; a communications circuit that is established for the duration of a session and then disconnected, much like a normal voice telephone call.

TDM
Time Division Multiplexing

UNI
User-to-Network Interface

Definitions

Circuit Emulation
Making an ATM virtual connection like a circuit to be able to faithfully transport voice over ATM

Internetworking
Communication between any two types of networks (here circuit- and packet-switched) or end equipment

Interworking
Communication Between a variety of interfaces and networks

Media Gateway
A network element that performs the physical conversion from circuit to packet

Omniclass
Omniclass is the ability to provide tandem and end-office voice switching in a single, open and scalable softswitching system that supports TDM, ATM or IP networks.

Omniservice Switch
A switch that combines multiservice and packet voice switching in one system functioning as a single point of convergence

Packet Voice Switch
Packet voice switching includes the functionality of media gateways and softswitches

Ships-in-the-Night
A protocol that allows MPLS and ATM on a common platform

Softswitch
Provides end-to-end call control and SS7 capability