Creating Next-Generation Signaling Gateways Using AdvancedTCA* and AdvancedMC* Technology

Interoperable and Industry Standards-Based Modular Building Blocks Enable Price and Performance Benefits

Executive Summary

Advanced Telecom Computing Architecture (AdvancedTCA*) has already been adopted by major telecom equipment manufacturers (TEMs) as an open, standards-based modular communications platform (MCP) of choice for next-generation telecom infrastructures (see Appendix A). A modular and standards-based approach leads to interoperable and readily available commercial-off-the-shelf (COTS) solutions from multiple vendors, and allows the telecom industry to realize dramatic price and performance benefits as well as the ability to deploy innovative applications faster.

As AdvancedTCA-based MCP adoption grows, standards compliance and interoperability among numerous modular building blocks are becoming focal points for network equipment providers. This white paper presents examples of AdvancedTCA-based building blocks for SS7 infrastructure solutions such as signaling gateways. Examples are based on COTS PMC and AdvancedMC* modules from Interphase Corporation, and AdvancedTCA blades from Intel.

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Introduction to SS7 Infrastructure and Signaling

Because the primary application of signaling gateways is to allow TDM networks to interconnect with emerging IP-based IMS networks, the demand for signaling gateways will grow until IMS networks achieve the same subscriber capacity as TDM networks. At this inflection point, demand for signaling gateways will be driven by the need to provide carrier-to-carrier signaling demarcation (or firewall). A number of factors have energized SS7 signaling growth beyond simple "call control" to provision enhanced services for TDM and IP domains. These factors include new subscriber growth rates in emerging markets, steady growth in SMS messaging, VoIP-enhanced services, and interoperability between the legacy public switched telephone network (PSTN) and next-generation networks. The market for network elements using SS7-based signaling (MSCs, SSPs, STPs, HLRs, SMSSs, and SS7 gateways) remains strong and is expected to grow to $8 billion by 2008.[1]

A signaling gateway transports application signaling between the SS7 network and the IP network, serving to bridge legacy PSTN with the packet-switched, next-generation network. When used in conjunction with softswitches, media gateways, application servers, and media servers, a signaling gateway provides the call control functionality and service processing capabilities of traditional PSTN switches. Signaling gateways implement SS7 protocol stack and related SS7-over-IP SIGTRAN subcomponents.

Signaling Transport (SIGTRAN) addresses issues of transport, including signaling performance within IP networks, and interworking with the PSTN. It also addresses SIP/MEGACO/ISUP interworking such as translating the MTP-based SS7 message (such as IAM) to an IP-based message (such as IP IAM), and translation from point code to IP address.

Signaling Protocol Stacks

Figure 1 shows the signaling protocol layers for SIGTRAN and SS7 in the boxes on the left and right, respectively. The center box shows the protocol layers that are the focus of a signaling gateway.

There are many different SS7 application protocols specific to various SS7 network elements in both wireline and wireless networks. ISUP and TCAP, shown in Figure 1, are only two of these protocols. It is important to note that the signaling gateway does not need to be aware of the protocols used above the Layer 4 signaling connection control part (SCCP).

Figure 2 shows the relationship between the SS7 (blue) and SIGTRAN (gray) protocol layers. The signaling gateway maps the SS7 protocols to the equivalent SIGTRAN protocol (and vice versa) at the same layer when SS7 messages need to be sent between TDM networks and IMS networks. As the diagram shows, there are typically different options for protocols in each of the layers. The signaling gateway needs to support all these options.

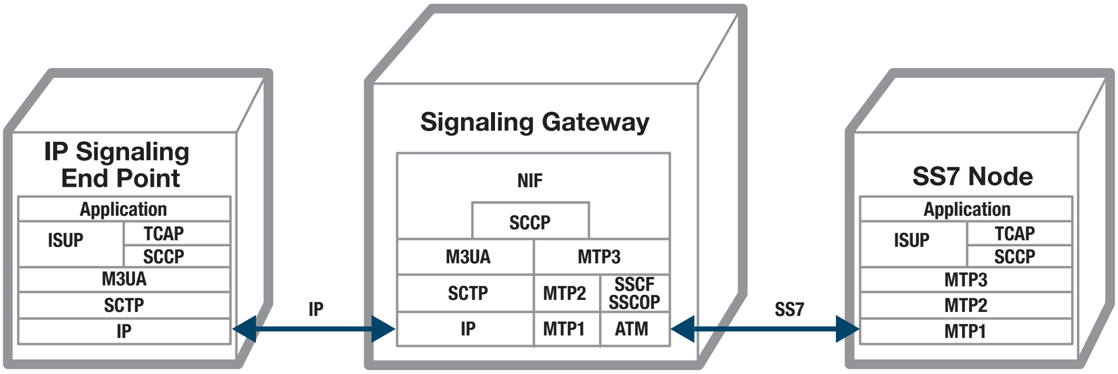


Figure 1: SIGTRAN and SS7 protocol stacks

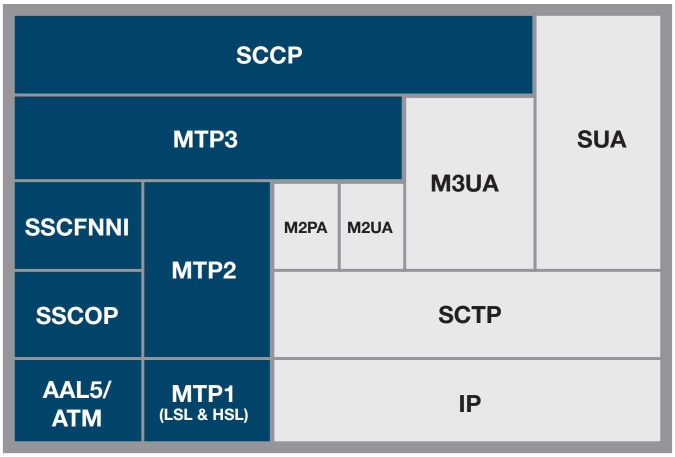


Figure 2: Signaling gateway SS7 (blue) and SIGTRAN (gray) protocol stacks

SS7 variants: Like many international standards, SS7 has been modified in various parts of the world. While all follow the layer model shown in Figure 2, the layers have differences. Variants in use today include ANSI, ITU-T, ETSI, TTC-Japan, and NTT-Japan.

Physical interfaces: There are a number of different physical interfaces for signaling, including T1, E1, J1, OC3 / STM-1, and Gigabit Ethernet.

Data link layer: Above the physical layer, there are several different data link layers used with signaling. These include:

- SS7-MTP
  - Low-speed links (LSL): 64 Kb/s channels
  - High-speed links (HSL): 1.544 DS-1 or 2.048 E1
  - ATM/SAAL HSL: ATM AAL5 over HSL links
- Ethernet: SIGTRAN links/associations

Signaling in the IMS Network

It is expected that, over time, many of the intelligent services provided in TDM networks will migrate from SS7 TDM platforms to the equivalent IMS platform. An example is the home location register (HLR) used in wireless networks. IMS has an equivalent platform known as the home subscriber services (HSS). Integrated HLR/HSS platforms are now emerging in the market, which will not only simplify the network but will also provide a common application behavior for users regardless of the type of phone being used (wireline, wireless, or VoIP).

However, as long as TDM networks continue to be in use (and we expect they will be with us for a long time), signaling applications can be seamlessly migrated from SS7-based network platforms to IMS-based network platforms by using the signaling gateway to mediate the two networks. When an SS7 platform is migrated to IMS, the SS7 point code, which was assigned to that platform, is assigned to the signaling gateway. The signaling gateway is then configured to forward messages to the IP address of the IMS platform. The reverse translation occurs when the IMS network platform responds. Neither network needs to be aware of the other network.

Because the signaling gateway must handle the destination point code of any SS7 platform migrated into the IMS network, support for multiple destination point codes in the signaling gateway is a critical feature.

Signaling Gateway Requirements

Signaling Gateway Implementations within the Network:

Integrated/distributed platform: Signaling gateway functions can be integrated into the network platform directly, and AdvancedTCA greatly simplifies efforts to accomplish this integration. The signaling gateway can be implemented on pairs of AdvancedTCA blades (according to the performance required). These pairs of blades can be installed in the same AdvancedTCA chassis used for the overall application platform (such as HLR/HSS) that needs to support users on both TDM and IMS networks.

Standalone platform: Where the volume of SS7 traffic at a particular network location is substantial, it is possible to deploy the signaling gateway AdvancedTCA blade pairs in a dedicated AdvancedTCA chassis. Regardless of the deployment model chosen, the signaling gateway blades are standard building blocks.

Roles of Signaling Gateways in the Network:

SS7 to IMS interconnection: As shown in Figure 3, one of the primary functions of a signaling gateway is to allow wireline, wireless, and IMS networks to integrate with each other.

Border gateway: This is used between different networks to provide a demarcation/"firewall" function.

Carrier-to-carrier: In this application, a signaling gateway allows signaling networks from two different carriers to communicate with each other. The signaling gateway can provide overload protection, preventing one of the networks from overloading the other net-work. It can also be used to manage services that one carrier is allowed to access in the other carrier's network.

User-to-network (session border controller): Session border controllers are used between VoIP phones and the IMS network. Because VoIP uses IP networks, many security issues need to be addressed. There have also been several different and incompatible VoIP technologies such as different versions of SIP and H.323 that a session border controller can support. While this is not a specific focus of this white paper, the application is very similar to a signaling gateway.

IP transport for existing SS7 networks: Existing SS7 networks are based on X.25 network technology. IP networks are now ubiquitous and have substantially lower operating costs than the SS7 X.25 network. Therefore carriers can achieve substantial operating cost improvements by installing signaling gateways between their SS7 network nodes and transporting the signaling traffic over IP networks. This function is transparent to the SS7 network nodes and therefore can be implemented on a link-by-link basis.

SS7 mediation: Like many standards, SS7 has a number of options and country variants (such as ANSI, ETSI, ITU, and China). SS7 also has a number of different physical interfaces, including:

- Channelized T1/E1/J1 (56 Kbps/64 Kbps low-speed links)
- Unchannelized T1/E1/J1 (1.5 Mbps/2.0 Mbps high-speed links)
- ATM T1/E1/J1 (ATM high-speed links)

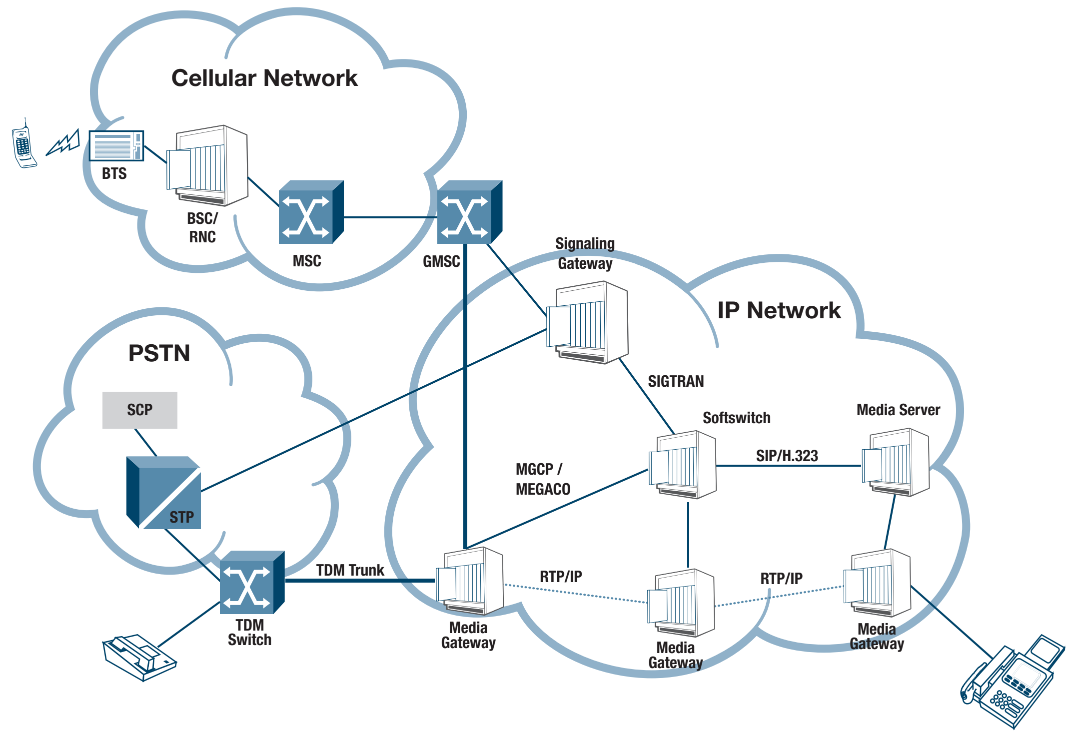


Figure 3: Signaling gateway in the network

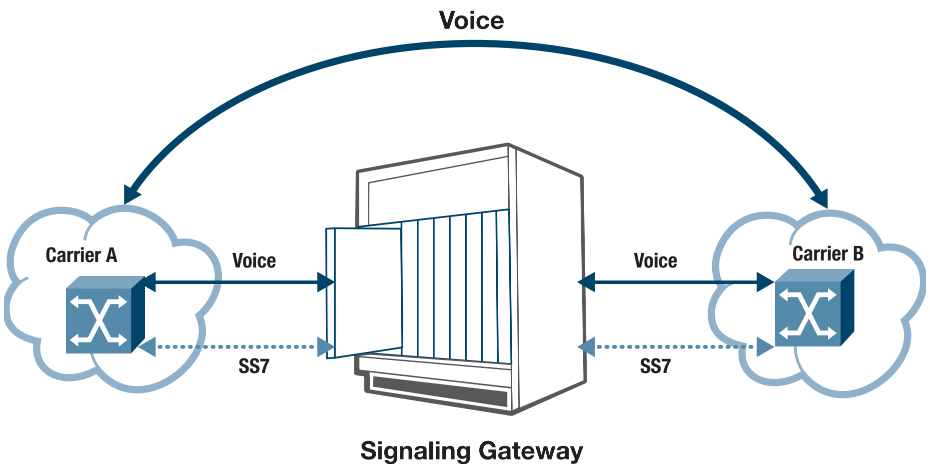


Figure 4: Signaling gateway as a border gateway

Previously, networks were connected at a small number of network gateways. However, as competition has grown, there has been an increasing need to interconnect multiple networks. In many cases these networks have been based on different variants and interfaces. For example, network platforms designed for one region (such as Europe ETSI SS7) are being deployed in another region (such as North America ANSI SS7). Therefore, signaling gateways are used to support and interconnect these different networks and platforms.

Critical Features of a Signaling Gateway:

Carrier-grade reliability: Carrier-proven, highly available architecture, eliminating message loss with no switch-over delay

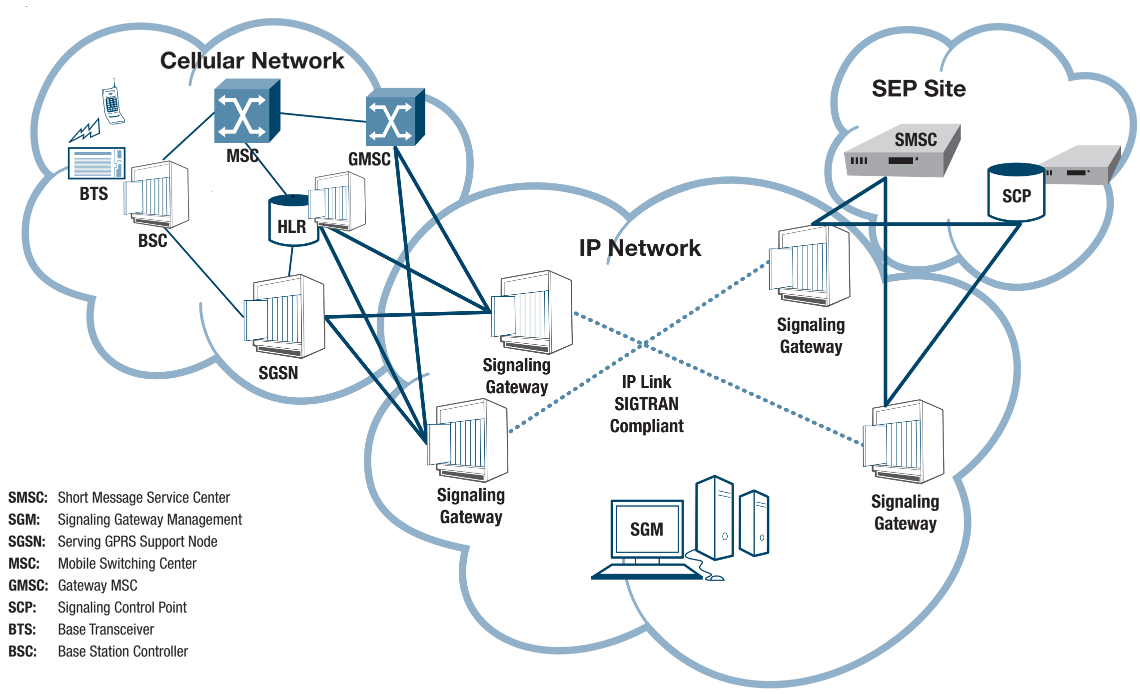


Figure 5: Signaling gateway in wireless networks

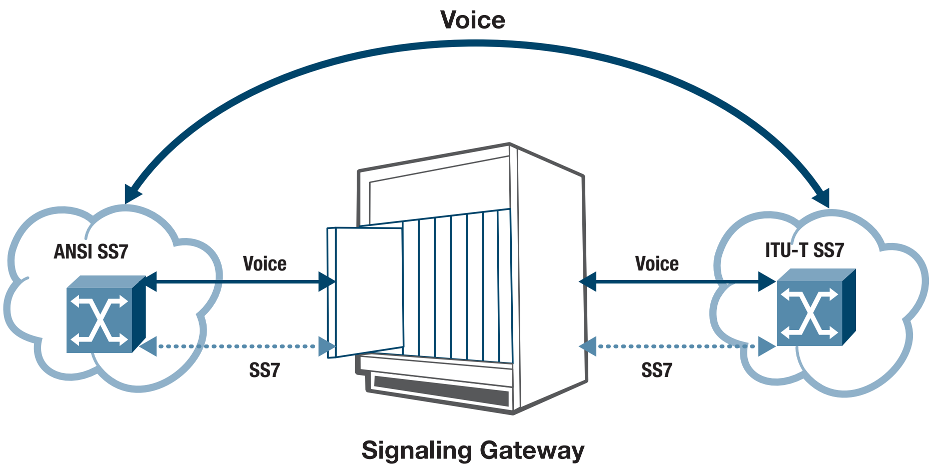


Figure 6: Example of typical signaling gateway deployments: SS7 mediation

High-availability architecture: Five nines-ready transport service, available to network elements with no single point of failure

Scalable solution: Scalable to multi-processor system for higher capacity need; also scalable from 2 to 256 SS7 low-speed links and 2 to 32 ATM-based high-speed links

Multiple routing criteria capability: Allows OPC, DPC, CIC, SSN, point code, and global title translation-based routing

Multiple SS7 interface support: Channelized T1, E1, J1 interfaces for low-speed links, unchannelized T1, E1 interfaces for high-speed links, and ATM-based high-speed links (Q.SAAL-based)

Support for multiple originating and destination point codes: At least 10 self-point codes; routes to at least 2048 DPCs

Multiple SS7 variant support: ANSI, ITU-T, ETSI, TTC-Japan, NTT-Japan, and China and other country variants

Supports SIGTRAN standards: M3UA IETF RFC 3332, SCTP IETF RFC 2960, M2UA IETF RFC 3331, and M2PA IETF RFC 4165

Building a Signaling Gateway Using AdvancedTCA* Modular Building Blocks

Key Engineering Parameters:

Message System Units (MSU)/second: In SS7, each message sent or received is called an MSU. SS7 transactions consist of the number of MSUs exchanged by the SS7 platforms. An average MSU/second can be calculated, based on the type of platform, the mix of transactions the platform must handle, and the number of transactions per second.

MSU size: This is the average number of bytes in the MSU. This is required to ensure that the targeted link load capacity of the SS7 link is not exceeded.

Redundancy: SS7 links/link sets are commonly configured for 1+1 redundancy with load sharing. In the event that an SS7 link or link set fails, the full SS7 message load will be switched to the remaining link set. To provide sufficient capacity to support this extra load in a failure condition, links are typically configured to use only 40 percent of their capacity under normal operating conditions.

Link loading: Since SS7 platforms vary in terms of capacity and performance, there are situations where the link loading capability may be significantly lower than 40 percent. This occurs when an SS7 platform is designed to handle a small number of users but still uses a full T1 to connect to the SS7 network.

In engineering a signaling gateway, the primary parameter is the number of MSU/sec that the signaling gateway must handle. This is calculated from parameters outlined above for a given network implementation. Typically, the calculated MSU/sec is the key parameter, as this drives the processing capacity of the signaling gateway. However, in an implementation where the link loading is low, the number of physical SS7 links that can be supported becomes a critical engineering factor.

Table 1: Modular building block products from Intel and Interphase

System Application	AdvancedTCA* Single Board Computer from Intel	Interphase PMC/AdvancedMC*
High Compute	Intel NetStructure® MPCBL0040 Single Board Computer; dual Dual-Core Intel® Xeon® processors LV 2.0 GHz, hard disk option, AdvancedMC* expansion site, rear transition module	*i*SPAN* 3639 AdvancedMC* 4/8 port T1/E1/J1 Communications Controller
High Compute	Intel NetStructure® MPCBL0030 Single Board Computer; dual Low Voltage Intel® Xeon® processors (2.8 GHz), hard disk option, PMC expansion site	*i*SPAN* 4539F PMC T1/E1/J1 Communications Controller
Balanced Compute	Intel NetStructure® MPCBL0010 Single Board Computer; Low Voltage Intel® Xeon® processor (2.8 GHz), two AdvancedMC* expansion sites	*i*SPAN* 3639 AdvancedMC* 4/8 port T1/E1/J1 Communications Controller
I/O Optimized	Intel NetStructure® MPCBL0020 Single Board Computer; Intel® Pentium® M processor 760Δ (2.0 GHz), hard disk option, three PMC expansion sites, rear transition module	*i*SPAN* 4539F PMC T1/E1/J1 Communications Controller

Configuration Options and Considerations

A signaling gateway consists of two key hardware components: the server implemented on an AdvancedTCA blade, and the intelligent SS7 interface controller implemented as an AdvancedMC or PMC I/O module.

Signaling gateway software is optimized to take advantage of the intelligent SS7 interface controller by implementing Layers 1 and 2 of the SS7 stack in the line card. Layers 3 and 4 are implemented in the server. This configuration allows significant offload and acceleration of the SS7 protocol processing into the intelligent SS7 interface controller. Typical I/O modules will support four or eight T1/E1 interfaces providing support for 120 to 240 SS7 links.

As outlined above, the key design challenge for a signaling gateway is to determine the MSU/sec required and number of physical SS7 links that must be supported. The appropriate SBC can be selected, based on its MSU/sec processing capacity, and integrated with I/O modules installed either on the SBC or in AdvancedMC carrier blades to support the number of links required.

Two options described in this white paper meet the integration and interoperability requirements to build a next-generation signaling gateway. Table 1, above, outlines the primary building blocks, based on PMC and AdvancedMC modules from Interphase, and AdvancedTCA blades from Intel.

Option 1: AdvancedTCA Blade with I/O AdvancedMC*

A typical AdvancedTCA blade can support between one and three I/O modules. The MSU/sec and number of SS7 links required will drive the number of server blades. In cases where the SS7 links are heavily loaded and the number of T1/E1s required is four or less, the Intel NetStructure® MPCBL0040 or Intel NetStructure® MPCBL0030 Single Board Computer (SBC), supporting one I/O module, would be well suited.

Figure 7 shows a configuration using the Intel NetStructure MPCLB0040 SBC and Interphase *i*SPAN* 3639 AdvancedMC T1/E1/J1 Communications Controller. However, if additional SS7 links must be supported, then the Intel NetStructure® MPCBL0010 SBC with two I/O modules or the Intel NetStructure® MPCBL0020 SBC with three I/O modules should be considered.

Option 2: SBC and Carrier with I/O AdvancedMC

When the number of SS7 links to be supported exceeds the I/O module capacity of the SBC, the number of I/O modules must be expanded. AdvancedTCA provides the flexibility to add an AdvancedMC carrier blade, which can support up to four AdvancedMCs. The SBC can be integrated with as many AdvancedMC carrier blades as needed to achieve the required SS7 link capacity.

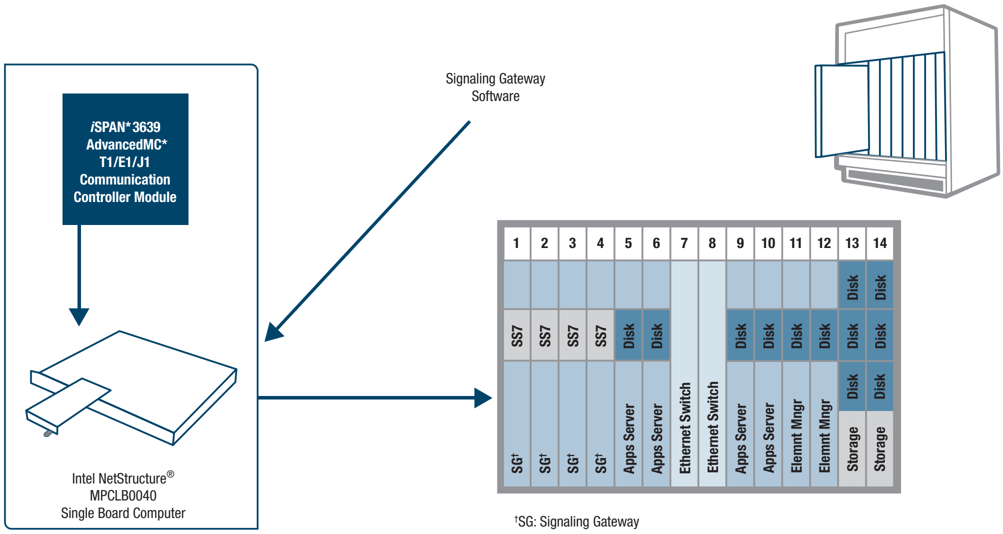


Figure 7: Signaling gateway implemented on AdvancedTCA* single board computer and AdvancedMC*

Figure 8 shows a configuration using two Interphase *i*NAV* 31K AdvancedTCA Carrier Cards and two Intel NetStructure MPCLB0040 SBCs along with the Interphase *i*SPAN 3639 module.

System Architecture Description and Software Offering Description

The Interphase *i*NAV* 9400 Signaling Gateway enables message distribution and routing services to switches and service node elements between PSTN and IP networks. This equips the service provider with better manageability by enabling a diverse and distributed signaling network, compared to the legacy network. As a standalone network element, the *i*NAV 9400 provides exceptional and reliable message throughput, capacity, and support services to the SS7-based intelligent networks.

The *i*NAV 9400 incorporates the MTP and SCCP layers of the SS7 protocol for PSTN interface. The MTP protocol provides basic message handling, distribution and network management procedures. The SCCP performs specialized routing and management functions necessary to provide end-to-end signaling between network nodes for intelligent services, such as toll-free service and local number portability.

The *i*NAV 9400 also incorporates IETF's MTP3 User Adaptation (M3UA), and MTP2 peer-to-peer adaptation (M2PA) over Stream Controlled Transmission Protocol (SCTP) to connect IP signaling nodes.

The *i*NAV 9400 offers a fault-tolerant, dual SBC-based high-availability architecture designed to fulfill the reliability and availability requirements of a typical real-time network. Fault tolerance is achieved by deploying redundant resources such as multiple Ethernet links and multiple SS7 links. Reliability is achieved by continuously exchanging heartbeats between the hosts and monitoring their statuses.

The *i*NAV 9400 platform is available on SBC blades where both the signaling link cards and signaling controller are hosted on the same platform. Both SBCs handle and process traffic in 1+1 active-active mode. Traffic is routed over all available network interfaces across both servers, conforming to load distribution procedures.

Providing High Availability via Geographic Redundancy

High availability is achieved by deploying two redundant signaling servers and link interfaces across the two servers. Reliability is achieved by continuously exchanging heartbeats between the hosts and monitoring their status via dual dedicated Ethernet connections, and through redundant processes and interprocess communications.

At any time, both signaling servers are active, having responsibility for processing traffic both to and from the application and the network. Incoming traffic is handled and routed through the available network interface based on load-distribution algorithm. The

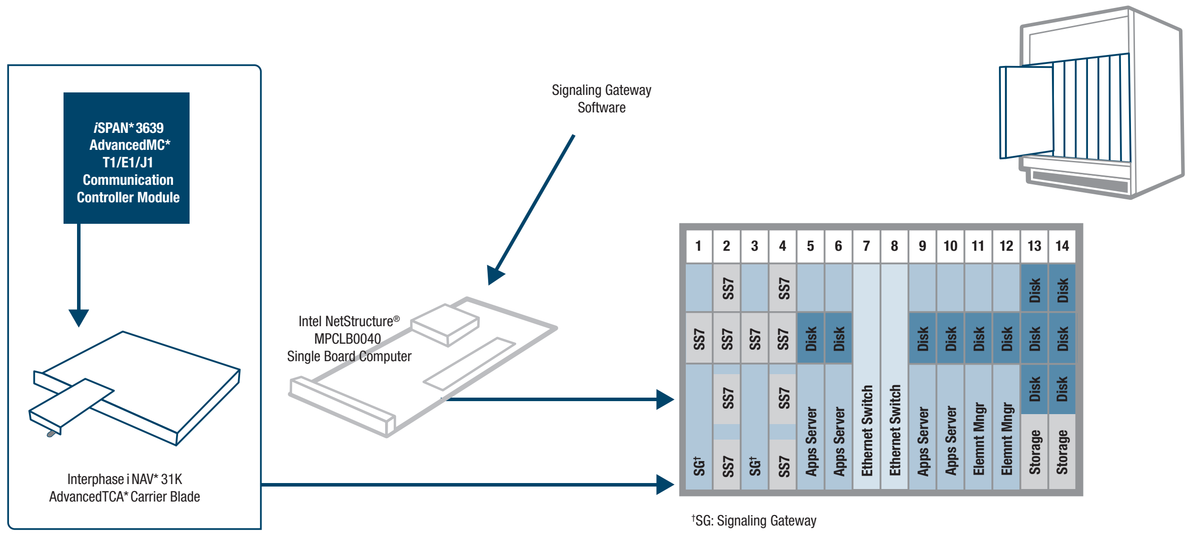


Figure 8: Signaling Gateway implemented on AdvancedMC* Carrier and AdvancedMC*

load-distribution algorithm takes care of traffic delivery through the same server or via peer box to the destination, based on the status of the network connections.

In the event of software failure, proper recovery steps have been built and, if required, the server restarts automatically without operator intervention. During this scenario, the other signaling server keeps functioning, thereby enabling the service and alleviating a single point of failure.

This dual-host architecture appears as two SGPs in the IP network working under the same signaling gateway. To achieve complete reliability, IP nodes (IPSEPs) for any defined routing key or application server will connect to both SGPs and exchange traffic with both at the same time. The signaling gateways can be physically deployed in separate locations to provide geographic redundancy as long as the Ethernet links connecting the redundant servers have a heartbeat message propagation delay less than 300 ms.

Conclusion: Benefits of a Modular Building-Block Approach

As shown in this white paper, a signaling gateway that transports application signaling between an SS7 network and an IP network can easily be implemented using AdvancedTCA building blocks from Intel—a market segment leader for AdvancedTCA single board computers—and Interphase Corporation, a leading supplier of next-generation networking technologies. In addition, this white paper demonstrates that AdvancedTCA architecture has the flexibility to support various configurations for implementing a signaling gateway.

This is just one example of an application that can be implemented using AdvancedTCA. Others include radio network controllers (RNCs), serving and gateway GPRS Support Nodes (xGSNs), and call session control functions (CSCFs). The important item to note is that modularization in the communications industry is happening now, and AdvancedTCA-based architecture is a leader in that trend.

Eighty percent of network equipment providers or TEMs surveyed in 2006 had AdvancedTCA-based product offerings in various stages (see Appendix A). AdvancedTCA architecture offers the following four key features that are critical to a solid and robust product offering:

1. 99.999% availability, enabling AdvancedTCA products to support critical network infrastructure deployments
2. NEBS Level 3 support, providing continued operation for 96 hours in -5˚ C to 55˚ C ambient temperatures
3. Support for single-core and multi-core single board computers such as the Intel NetStructure MPCBL0040, MPCBL0030, and MPCBL0020 SBCs that enable TEMs and service providers to support key network infrastructure functionality such as signaling gateways

4. Support for standards-based PCI mezzanine cards and Advanced mezzanine cards from Interphase, allowing TEMs and service providers to drive down cost by utilizing outstanding, commercial-off-the-shelf, standards-based building blocks.

As TEMs continue to look for ways to lower R&D costs, Intel and Interphase products, based on AdvancedTCA specifications, will continue to offer a strong alternative to proprietary architectures.

For more information on the performance of these signaling gateways, please contact:

Intel: **www.intel.com/design/network/products/cbp/atca/index.htm#sbc** or email: **ICA_leads@intel.com**

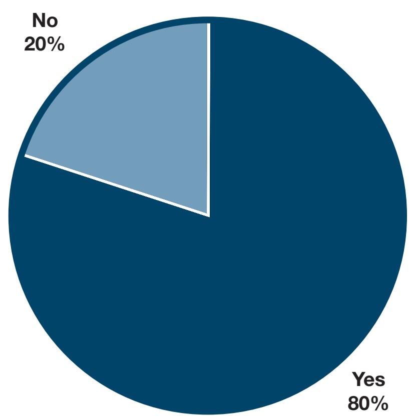
Interphase: **www.iphase.com** or email: **fastnet@iphase.com**
1-800-FASTNET or **+1-214-654-5000**

Appendix A: Key Findings from IDC 2006 Survey

- Eighty percent of the network equipment providers (NEPs) surveyed are either deploying or planning to deploy network equipment based on AdvancedTCA.
- Eighty percent of the NEPs surveyed are planning to implement Linux* on their AdvancedTCA platforms.
- Key buying criteria for selecting AdvancedTCA products are:
  - Leading-edge technology/performance
  - Adherence to standards and interoperability
  - Price and total cost of ownership

ATCA NEP Survey Results

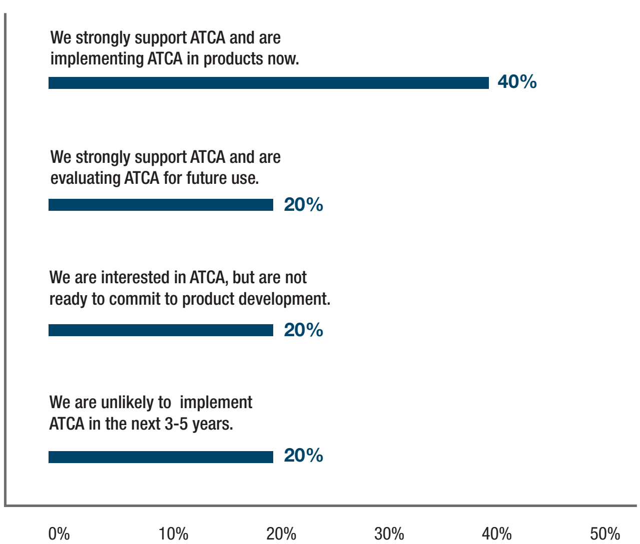
Q. Do you plan to implement Linux* on your ATCA platforms?



Source: IDC 2006

ATCA NEP Survey Results

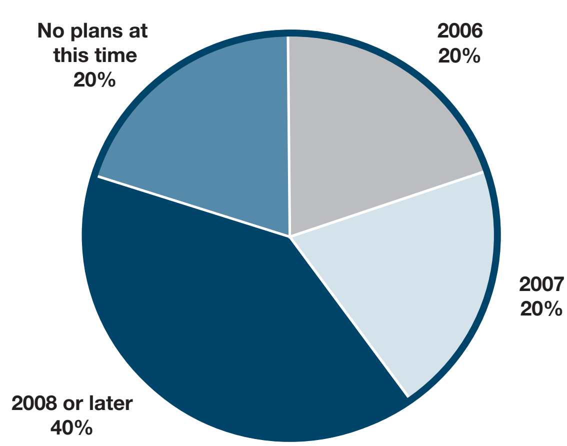
Which statement best characterizes your views on ATCA?



Source: IDC 2006

ATCA NEP Survey Results

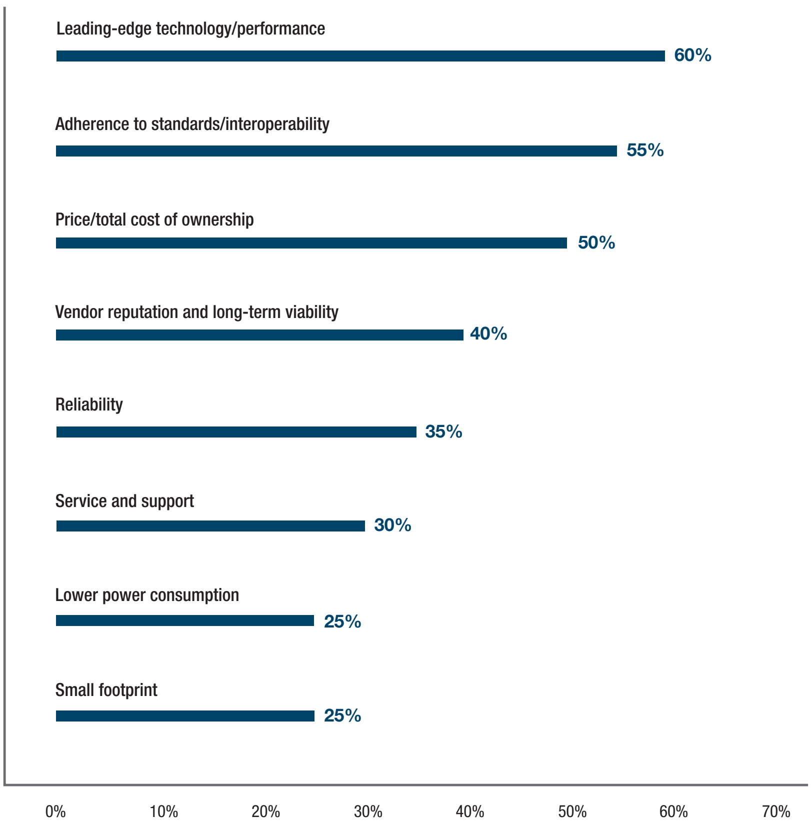
Q. What is your time frame for ATCA implementation?



Source: IDC 2006

ATCA NEP Survey Results

What are your key buying criteria when selecting ATCA products and vendors? (multiple responses allowed)



Source: IDC 2006

[1] 2005/2006 Telecom Core Infrastructure Market Intelligence Service, volume I: SS7 Network Elements, Venture Development Corporation, May 2006.

[Δ] Intel processor numbers are not a measure of performance. Processor numbers differentiate features within each processor family, not across different processor families. See http://www.intel.com/products/processor_number for details.

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