Media gateway for mobile networks

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The telecommunications community is migrating toward a new network architecture based on horizontal layers. Call control and connectivity, which have traditionally been bundled in telecommunication networks, are being separated into different layers. The connectivity layer is based primarily on asynchronous transfer mode (ATM) and Internet protocol (IP) transmission. Access networks and the core network are parts of the connectivity layer. The connectivity layer provides interfaces to legacy networks, such as the public switched telephone network (PSTN). The layered architecture is being deployed in third-generation mobile networks—that is, the universal mobile telecommunication system (UMTS). Ericsson has taken an active role in promoting this new architecture in relevant standardization bodies.

Media gateways (MGW) have been introduced to bridge between different transmission technologies and to add service to end-user connections. Smooth step-by-step migration toward the new network architecture is achieved by splitting the mobile services switching center (MSC) and the serving GPRS support node (SGSN) into a media gateway and servers.

The authors describe the role of the media gateway in third-generation mobile networks, and present Ericsson's new media gateway product, which is based on the Cello packet platform.

Introduction

As mobile communications evolve, mobile end-users will be offered wideband multimedia capabilities. The associated multimedia streams require that the networks should be more flexible than present-day networks—which are based on time-division multiplexing (TDM)—at providing bandwidth on demand. The networks must thus evolve toward cell- and packet-based technologies. As the transport technology evolves, the network paradigm also changes. The vertical networks—with a separate network dedicated to each individual application—will be replaced by a horizontally layered network architecture. Media gateways will play a fundamental role in the evolution toward the new network architecture, mediating at the crossing point between existing and new transmission technologies and network types.

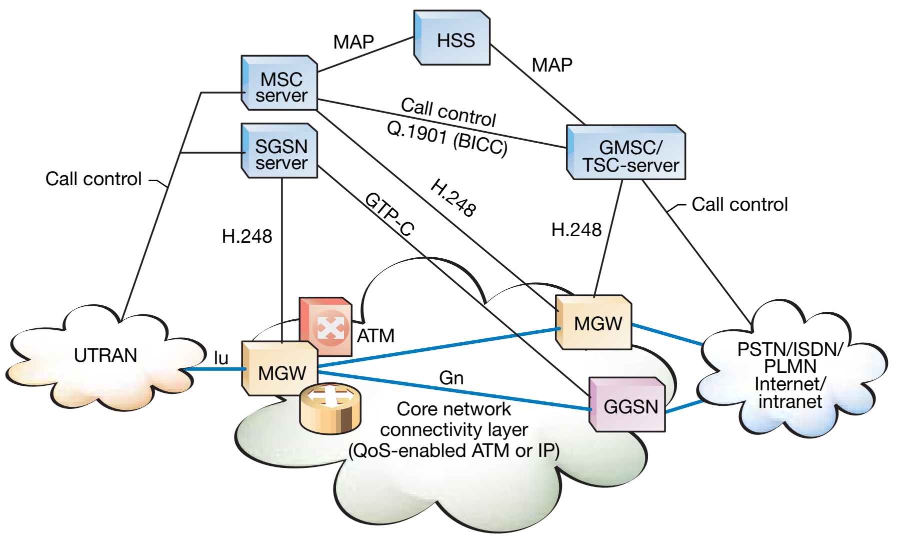
Ericsson is working actively with relevant standardization bodies and other fora (such as the ITU, ETSI, MSF, 3GPP and IETF) to bring about this network architecture and to ensure open and standardized interfaces. In the universal mobile telecommunications system (UMTS), the horizontally layered architecture[1] divides the network into an

- application layer;
- network control layer; and
- common connectivity layer.

In the network control layer (Figure 1), the MSC server controls circuit-mode services and the serving GPRS support node (SGSN) server controls packet-mode services. In the connectivity layer, the media gateway uses open interfaces to connect to different types of node in the core network and external networks. The media gateway control interface (H.248) facilitates a separation of network control and connectivity layers. The interface to the UMTS terrestrial radio access network (UTRAN) is called *Iu*. In Figure 1, a voice call between the UTRAN and PSTN is interconnected by two media gateways. *Media gateway A* switches ATM or routes IP traffic. It also provides interworking functions between ATM and IP. The MSC server and gateway MSC/transit switching center (TSC) server control *media gateway B*, by means of H.248 control paths. *Media gateway B* processes the media stream and provides interfaces to the PSTN. In this approach, the voice coder is only inserted when needed at the edge of the core network. This gives improved voice quality and facilitates more efficient use of bandwidth in the core network.

In the connectivity layer, the *Gn* interface handles packet-mode traffic between the media gateway and the gateway GPRS support node (GGSN).[2] The SGSN server controls the media gateway by means of H.248.

Figure 1
Layered network architecture, open interfaces.



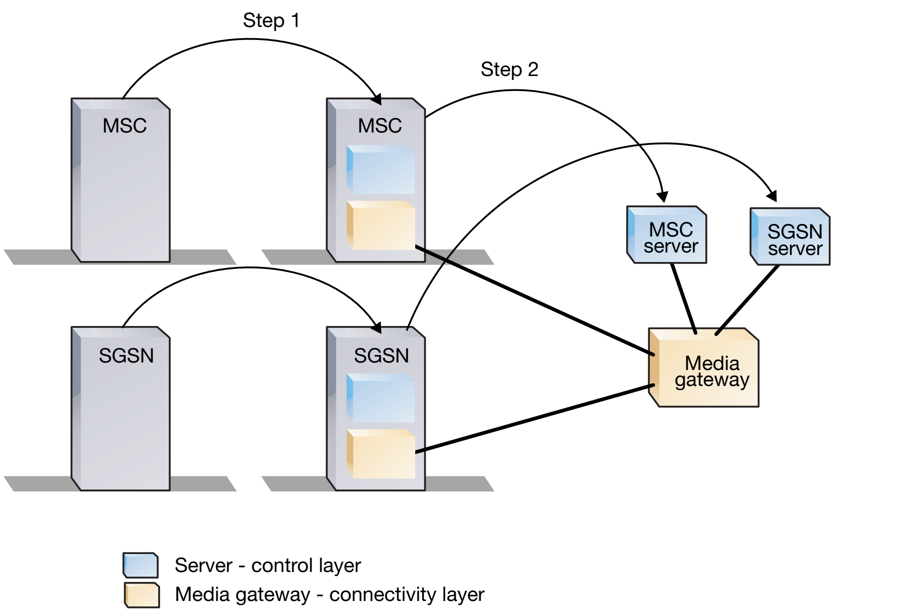


Figure 2
Ericsson server-gateway split migration path.

Quality of service (QoS) plays a central role in the new networks: it is a means of providing end-users with agreeable service and is essential for network management. The media gateway facilitates quality of service by supporting ATM and IP traffic engineering through a combination of

- ATM traffic management—for ATM; and
- multiprotocol label switching (MPLS) and differentiated services (DiffServ)—for IP.

Migration toward the new network

When described in terms of the new network architecture, Ericsson's AXE systems have traditionally comprised both the network control and connectivity layers in the same node. To migrate toward the new architecture, the AXE MSC is first divided internally, creating an MSC server and a media gateway. The node can then be physically split (Figure 2): the MSC server is based on

BOX A, TERMS AND ABBREVIATIONS

3GPP	Third-generation Partnership Project
AMR	Adaptive multirate
API	Application program interface
ATM	Asynchronous transfer mode
BICC	Bearer-independent call control
CDMA	Code-division multiple access
CORBA	Common object request broker architecture
DSP	Digital signal processor
DTMF	Dual-tone multifrequency
ET	Exchange terminal
ETSI	European Telecommunication Standards Institute
FTP	File transfer protocol
GGSN	Gateway GPRS support node
GPB	General-purpose board
GPRS	General packet radio service
GSM	Global system for mobile communication
GTP	Gateway tunneling protocol
GTP-C	GTP control
GTP-U	GTP user plane
GUI	Graphical user interface
HSS	Home subscriber server
HTML	Hypertext markup language
HTTP	Hypertext transfer protocol
IETF	Internet Engineering Task Force
IIOP	Internet inter-object request broker protocol
IP	Internet protocol
IPv4	IP version 4
IPv6	IP version 6
IRP	Integrated reference point
ISDN	Integrated services digital network
ITU	International Telecommunication Union
L2TP	Layer 2 tunneling protocol
LER	Label edge router
MGW	Media gateway
MIB	Management information base
MPC	Multiparty call
MPLS	Multiprotocol label switching
MSB	Media stream board
MSC	Mobile services switching center
MSF	Multiservice Switching Forum
MTP	Message transfer part
PDP	Packet data protocol
QoS	Quality of service
RNC	Radio network controller
RTP	Real-time transport protocol
SCCP	Signaling connection control part
SCTP	Stream control transport protocol
SDH	Synchronous digital hierarchy
SGSN	Serving GPRS support node
SNMP	Simple network management protocol
SPB	Special-purpose board
SS7	Signaling system no. 7
STP	Signal transfer point
TDM	Time-division multiplexing
TSC	Transit switching center
TTC	Telecommunication Technology Committee
UDP	User datagram protocol
UMTS	Universal mobile telecommunications system

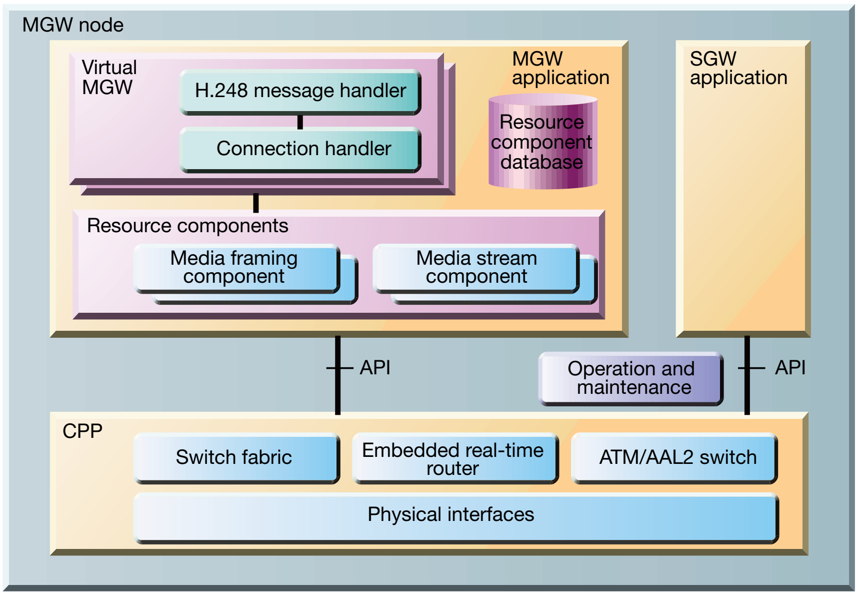
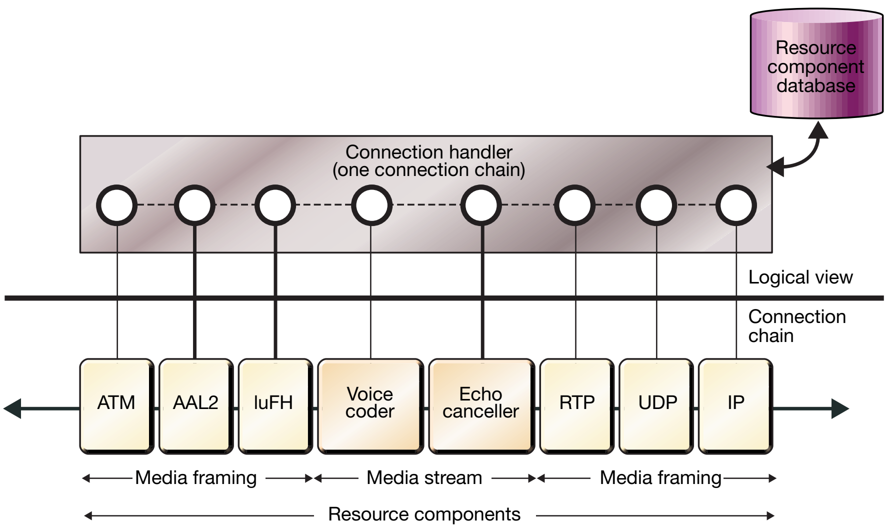


Figure 3
Functional architecture of the media gateway.

Figure 4
Connection model.



AXE and the media gateway is based on the Cello packet platform (CPP).[3]

A similar migration takes place in the GPRS network. The current SGSN is split into an internal server and a media gateway. These can then be physically split—all connectivity network functionality is ported to the media gateway. The media gateway is thus common to circuit-mode and packet-mode core networks. The media gateway will also be introduced into GSM core networks.

Media gateway

The media gateway comprises several functional entities. The physical node is divided into several virtual media gateways. A specific server controls each virtual media gateway, which shares resource components that are visible from the resource component database. However, resource components can also be preconfigured, by identity and type, for any virtual media gateway. Special care has been taken to provide clean and robust interfaces between the virtual media gateway, resource component database, and resource components. This modular approach facilitates smooth upgrades on different sides (Figure 3).

When an H.248 message arrives from the server, it is broken down and delivered to the virtual media gateway to which it belongs. The connection handler sets up the state logic for the connection and allocates available resource components according to the resource component database. These components are interconnected to process a stream and carry it through the media gateway from one network to another.

Resource components are composed of media framing components and media stream components. Media framing components terminate different protocol layers—for example, IP, user datagram protocol (UDP) and real-time transport protocol (RTP). The media stream components process voice and data calls. Resource components can be seen as versatile building blocks in the functional architecture. They also extract relevant data on performance and fault management according to the requirements in H.248 and according to the corresponding managed objects in the managed object model. The resource components interconnect to the Cello packet platform by means of application program interfaces (API).

The media gateway is designed as an application on the Cello packet platform,

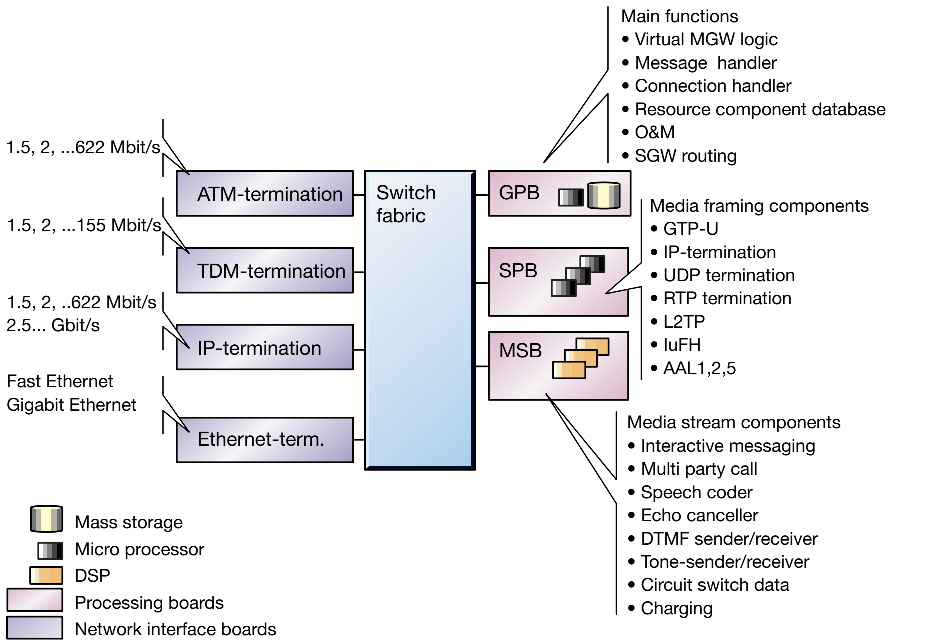


Figure 5
Hardware view and functional example of distribution.

which is a fully redundant telecom platform that can be used for several different products. Its robust, real-time control system and efficient cell transport system guarantee cost-effective applications that support time-division multiplexing, ATM and IP transmission. The execution platform of the Cello packet platform offers a scalable cluster of intercommunicating processors, a distributed, real-time operating system, a distributed real-time database, and O&M support. Internally, the Cello packet platform embraces ATM (including ATM adaptation layer 2, AAL2) switching capabilities. A cell-switching fabric allows functionality to be distributed across boards and subracks.

A real-time router[4], which is embedded in the media gateway, provides distributed forwarding at wireline speeds to all interfaces. The real-time router

- handles IPv4, IPv6, header compression, IP security protocol (IPsec), and differentiated services (DiffServ);
- provides MPLS edge functionality, including traffic engineering and protection;
- provides advanced firewall filtering and classification; and
- supports virtual private networks (VPN).

Figure 4 shows a simplified view of the connection model. The connection handler, which keeps a logical view of the connection chains, interconnects resource components by means of the switch fabric. The resource components can thus have any physical location in the node. Figure 4 shows a connection chain with compressed voice over ATM/AAL2 that is converted to uncompressed voice over IP (VoIP). In this example, voice coding and echo-cancellation services are performed on the voice stream.

By inserting different kinds of media framing and media stream components, it is possible to set up processing of virtually any media stream on demand. Only a small set of component types is needed, and it is not necessary to prepare in advance for all forthcoming combinations of functionality in a connection chain.

The media gateway comprises several physical interfaces ranging from 1.5 to 155 Mbit/s. Future releases will include 622 Mbit/s and 2.5 Gbit/s interfaces and Gigabit Ethernet. The interface to the switch fabric is not dependent on rate or technology. Operators can upgrade the switch fabric, interfaces, or processor boards without disturbing traffic. Three kinds of processor board are available (Figure 5):

- The general-purpose board (GPB) targets processes that execute on the distributed processor cluster.
- The special-purpose board (SPB) is a workhorse for protocol termination. The

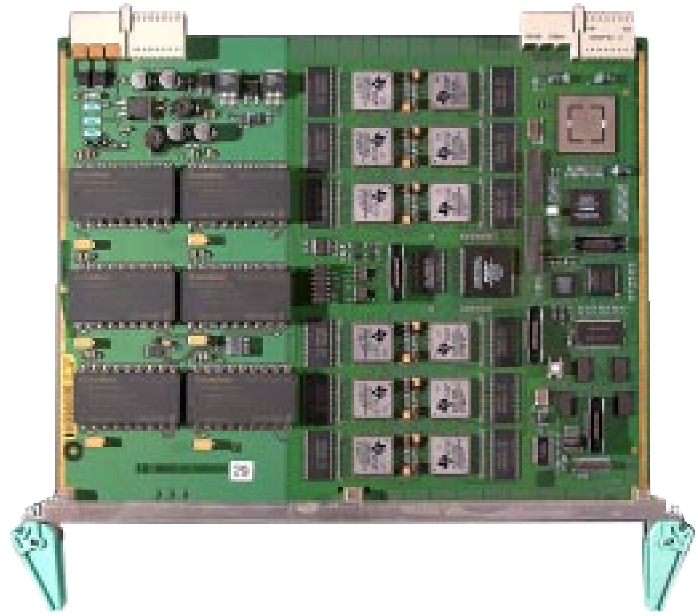


Figure 6
Photograph of the media stream board.

board, which comprises several standard microprocessors, is meant to handle most of the media framing components.
- The media stream board (MSB) is a workhorse for processing media streams (Figure 6). It is composed of several standard digital signal processors (DSP). Nearly all media stream components are processed on this board. To allow efficient and flexible resource handling, all media stream components in the media gateway are thought of as belonging to a common pool.

Resource components

The resource components can be allocated to any of the processor boards. However, for optimum performance, some board types have been developed for use with specific components (Figure 5). The resource components can be allocated in needed numbers and type relative to the board's total processing capacity. The concept also allows for future hardware acceleration—that is, some resource components can be implemented in dedicated hardware to further increase capacity and reduce footprint. Hardware support for the resource components that terminate ATM, AAL2, IP and TDM is provided on associated network interface boards.

Media framing components

The main task of the media framing components (Box B) is to convert protocols between different transmission networks and to adapt them to the media stream components (Box C).

The media framing components also support SGSN functionality, handling user data traffic between the radio network controller (RNC) and the GGSN in the GPRS network by interconnecting two gateway tunneling protocol (GTP) media framing components. The GTP tunnels are thus adapted in the media gateway between the *Iu* and *Gn* interfaces (Figure 1). Using this same mechanism, it is easy to process the streams by inserting a media stream component. For example, with the outlined architecture, the GPRS network can easily be enhanced with real-time media streams.

BOX B, MEDIA FRAMING COMPONENTS

Examples of media framing components
- Asynchronous transfer mode (ATM).
- ATM adaptation layer 1 (AAL1).
- ATM adaptation layer 2 (AAL2).
- ATM adaptation layer 5 (AAL5).
- Internet protocol (IP).
- User datagram protocol (UDP).
- Real-time transport protocol (RTP).
- Layer 2 tunneling protocol (L2TP).
- Multiprotocol label switching-label edge router (MPLS-LER).
- Gateway tunneling protocol (GTP).
- Time-division multiplexing (TDM).

Signaling gateway

In many network configurations, media streams and signaling share the same physical lines to the media gateway. A signaling gateway function is needed to convey the signaling messages across different transport domains. For example, call control messages must be exchanged for a call that spans an IP-based core network and the PSTN. These messages are set up between the servers but the call is transmitted through the media gateway node. To reduce the footprint, the signaling gateway application—which provides signaling interworking between IP, ATM, and TDM networks—has been co-located in the media gateway node. The signaling gateway application also contains signal transfer point (STP) functionality, in order to relay signaling system no. 7 (SS7) messages over the message transfer part (MTP3 and MTP3b) in TDM and ATM networks as well as over the stream control transport protocol (SCTP) in IP networks.

Operation and maintenance

The media gateway is managed by a Web-based thin-client application that can be run from a standard Web browser and Java virtual machine on any computer, locally or remotely. The thin-client application displays a graphical presentation of the management application but does not store data on the node. The client communicates with the media gateway using the hypertext transfer protocol (HTTP), Internet inter-ORB protocol (IIOP), file transfer protocol (FTP), Telnet, and the simple network management protocol (SNMP). The connection between the media gateway and the thin-client can be

- local—over an Ethernet cable; or
- remote—using a secure intranet.

Dedicated management applications are embedded in the media gateway—that is, it contains all the software it needs to manage the node. These applications (written in Java) typically use a common object request broker architecture (CORBA) or IIOP interface to manipulate the management data of the node.

The graphical user interface (GUI) has the same look and feel as all other network element interfaces in Ericsson's third-generation core network and radio access network. Online multilanguage HTML documentation—which provides Help,

BOX C, MEDIA STREAM COMPONENTS

Examples of media stream components

- Voice coder—the adaptive multirate (AMR) voice codec is the default voice coding/decoding algorithm for UMTS. All modes of the AMR voice codec are supported. This allows operators to choose the subset of voice codecs they want to use in their networks.
- Echo canceller—echo cancellers
  - attenuate echo generated from the conversion between four-wire and two-wire transmission in the PSTN; and
  - reduce mobile crosstalk.
- Circuit-switched data—the circuit-switched data application provides modem functionality to the PSTN and ISDN.
- Multiparty call—support for conversations between more than two parties.
- Tone sender/receiver—the tone sender/receiver provides tones to be sent to and received from end-users.
- DTMF sender/receiver—the DTMF sender/receiver sends DTMF tones to the far end of the connection as requested by a mobile station. It also receives DTMF tones—for example, tones that are to be used with the interactive messaging application.
- Interactive messaging—the interactive messaging application provides subscribers with informative messages on special conditions in the network or conditions that pertain to the service in use.
- Charging—the charging function supports the generation of volume-based charging information for GPRS services.

BOX D, APPLICATIONS ON THE CPP

The Cello packet platform (CPP) is a new platform from Ericsson that primarily targets node applications in the second- and third-generation access and core networks. It features a modular design that allows applications to scale from small base stations up to very large network nodes, such as a radio network controller or media gateway. The CPP allows different applications to be co-located in the same network node. Current applications on the CPP include

- UTRAN radio network controller;
- UTRAN radio base stations;
- GERAN (GSM EDGE radio access network) real-time routers;
- cdma2000 base station controllers;
- cdma2000 radio base stations; and
- media gateways.

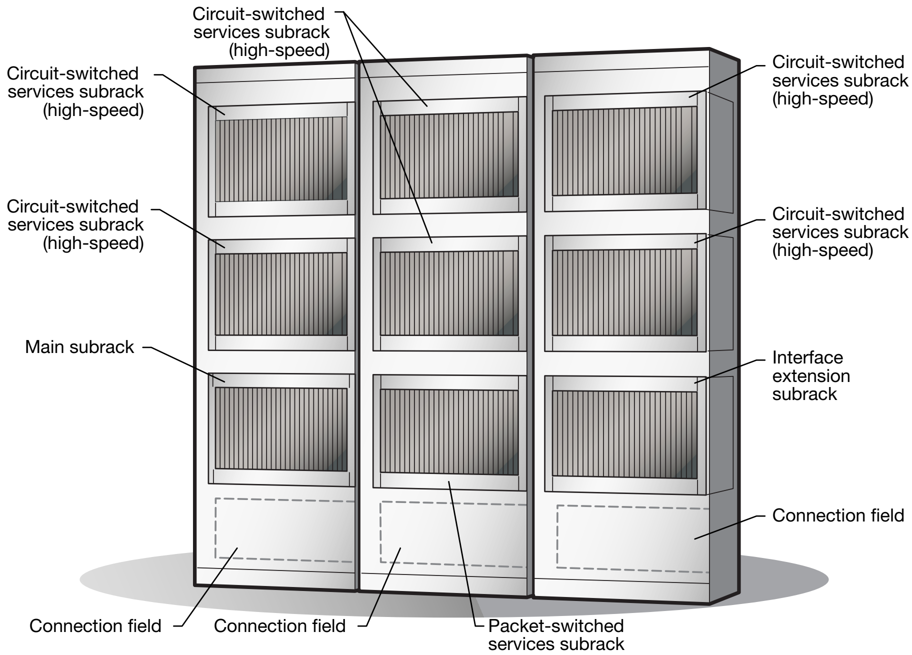


Figure 7
Example of media gateway configuration.

search functions, and interactive support for task-oriented operations—is integrated into the media gateway. This guarantees that the information is always consistent with the software release.

The media gateway supports integrated reference points (IRP). These recommendations from the 3GPP provide interoperability between managed network elements, such as the media gateway, and multiple-technology or multivendor management systems. An IRP is an information model that defines the interface between a network element and the network management systems.

BOX E, H.248

H.248 is a new protocol whose role is to control media gateways from servers. The protocol has been developed by the International Telecommunication Union (ITU) and Internet Engineering Task Force (IETF).[7, 8] H.248 defines a connection model, which is a central concept for describing the logical entities within the media gateway that can be controlled by the server. Thanks to this model, different transmission media can coexist, and media streams can be processed, in the connection. H.248 allows an authenticated server to establish, move, modify, remove, and obtain events that have been reported on a connection or group of connections. A server can audit the media gateway to determine the extent of its capabilities. H.248 is a framework protocol—that is, new capabilities can be added by means of packages and profiles.

Products

The media gateway can be configured to meet the needs of different operators. To facilitate installation, it comes in a limited number of preconfigured subracks. Resource components can be active by default or they can be activated gradually by means of software keys. "Hot-swapping" applies to all boards, and new types of resource component can be downloaded and put into service without disturbing traffic. Additional subracks can be introduced to upgrade capacity as traffic increases. Before delivery, the subracks are fully tested and configured at the factory.

Main subrack

The main subrack has internal links to the other subracks. It also terminates high-speed physical interfaces and contains central processing functions.

Interface extension subrack

The interface extension subrack contains high-speed interfaces to handle traffic in large media gateway nodes.

Circuit subrack with high-speed interfaces

The circuit subrack contains high-speed interfaces and a corresponding number of media stream boards to handle the traffic on the interface boards.

Circuit subrack with low-speed interfaces

The circuit subrack contains low-speed interfaces and a corresponding number of media stream boards to handle the traffic on the interface boards.

Packet subrack with forwarding engine interfaces

The packet subrack contains wireline-speed forwarding engines and special-purpose boards for terminating GPRS IP traffic.

Conclusion

Media gateways play an important role in the evolution toward the new, horizontally layered network architecture. The media gateways are positioned in the connectivity layer at the crossing point between different networks. They are fully controlled from servers via the H.248 protocol. In the connectivity layer, operators can select the transmission technology that best suits their needs—ATM, IP or TDM. By introducing MSC and SGSN servers that work together with the media gateways, operators can migrate their networks toward the new architecture.

The media gateway is built on the Cello packet platform. This platform is also used in several other network nodes, such as base stations, the radio network controller, and real-time routers. The media gateway has also been designed for use in all-IP networks that support real-time voice over IP (VoIP). It contains an embedded real-time router and an ATM/AAL2 switch with extensive support for quality of service and traffic engineering. The core of the media gateway architecture is flexible. This means that only the network interface boards are specific to a given transmission technology—current and emerging.

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