A Convedia White Paper

White Paper

IP Media Servers in Wireless Networks

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Contents

Introduction

IP media servers are well known in the wireline world, where they are recognized as critical components of modern service platforms. In the wireline world, IP media servers deliver service to both PSTN subscribers with "black phones" and "next-gen" subscribers with IP terminal devices. Wireline service platforms today make use of IP media servers for multimedia processing tasks such as playing announcements, audio/video recording and playback, interactive voice response (IVR), fax reception and transmission, automatic speech recognition (ASR), text-to-speech conversion (TTS), and multimedia conferencing.

In the wireless world, the demand for enhanced voice and video services is possibly even stronger than in the wireline world. Wireless subscribers seem to have an insatiable demand for innovative new services such as ringback tones, push-to-talk, or video messaging. However, today's enhanced services are typically supported with inflexible and expensive circuit-based service and media processing platforms. The migration of circuit-based service platforms to cost-efficient and flexible IP-based service platforms is just beginning. In many ways, it lags behind the deployments and economic benefits already experienced by many wireline carriers. As a result, the value of equipment such as IP media servers, and the additional multimedia features associated with IP-based services, is only now beginning to be appreciated in the wireless industry.

The objective of this white paper is to help wireless service providers and vendors of wireless solutions and applications understand the value and benefits offered by IP media servers

The objective of this white paper is to help wireless service providers and vendors of wireless solutions and applications understand the value and benefits offered by IP media servers. This document begins with an overview of wireless network technology, along with the role, function, applicable standards, and use of IP media servers in next-generation wireless networks. The paper then outlines how Convedia's IP Media Servers provide an optimized Multimedia Resource Function Processor (MRFP) in the IP Multimedia Subsystem (IMS) of a 3G wireless network.

Access Network

Wireless networks architectures can be divided into two big pieces: the access network and the core network. This section touches only briefly on the access network because it is the core network (presented in the subsequent section) which is of most interest for enhanced services and media servers. However, some discussion of access technologies is useful, in order to understand processing requirements for media servers in the core network.

Standards

The main function of the access network is to convey signaling and user data between the mobile handsets and the core network. Wireless access networks perform this function using radio frequency technology and equipment. As with all areas of telecommunications, cellular wireless technology is evolving rapidly and has progressed through several generations already. Greatly simplified, the generations are as follows:

- 1G: Analog
- 2G: Digital
- 2.5G: Digital with data capability
- 3G: Digital with faster data

Because of the rapid evolution of wireless network innovations, cellular standards are among the most fragmented standards in the telecommunications industry. Currently, the industry is faced with no fewer than five separate standards for 3G wireless: W-CDMA, CDMA2000, EDGE, UTRA TDD / TD-SCDMA, and DECT.

The two prominent 3G standards are W-CDMA and CDMA2000

The first two—W-CDMA and CDMA2000—and their evolution paths are the best-known. W-CDMA evolved from the 2G GSM standard, and CDMA2000 evolved from the 2G CDMA standard. Two large international organizations manage these two technologies for both access and core wireless networks: the Third Generation Partnership Project (3GPP) manages GSM/W-CDMA, and the Third Generation Partnership Project 2 (3GPP2) manages CDMA/CDMA2000.

2G and 2.5G networks are widely deployed today and 3G is being rolled out rapidly. Interest in enhanced services began with 2.5G, but it is with 3G that wireless enhanced services will achieve widespread deployment and use.

Handset Channels

Important aspects of the access network relevant to enhanced services are the contents of the audio channel and the data channel between each handset and the edge of the core. 2G networks have only audio channels, while 2.5G and 3G networks have both audio and data channels.

An audio channel carries audio that has been compressed to reduce bandwidth consumption over the radio link. A variety of codecs are available and used for the compression, including G.729, G.723.1, GSM-FR, GSM-EFR, AMR-NB, QCELP, EVCR, and SMV. Although audio is always highly compressed in the access portion, many wireless networks today use the common G.711 64 Kbps codec in the core portion for simplicity and cost reduction. Normalization to/from G.711 is done at the edge of the core. Transcoder Free Operation, which will result in the use of compressed codecs in the core, promises to reduce the additional latency and voice quality degradation that can result from multiple transcoding operations in an end-to-end voice path through the wireless network.

The audio channel carries compressed audio to reduce bandwidth consumption over the radio link

The data channel to and from 2.5G and 3G terminals can carry any kind of data stream, including both audio and video with any codecs. Commonly-used video codecs include H.261, H.263, and MPEG-4. Push-to-Talk is an example of a service that makes use of the data channel to carry both signaling and audio (and does not use the standard audio channel). Video conferencing is an example of a service that uses the data channel for video.

The data channel can carry any kind of data stream, including audio and video

Non-Cellular Technologies

Cellular is not the only wireless technology in wide deployment. The other standard in common use is 802.11 (Wi-Fi), which provides wireless IP connectivity. 802.11 can be used for any IP-based application that runs on regular IP networks, including audio- or video-based applications. 802.11 networks do not currently support most of the mobility features of cellular networks, and today are more like standard wireline IP networks from the point of view of services. However, eventually Wi-Fi networks will behave much like today's cellular networks, and dual-mode wireless devices will support seamless handoff and roaming between Wi-Fi and 3G service providers.

802.11 (Wi-Fi) provides high-speed wireless access, with 3G-like mobility and roaming features expected in the future

Core Network

This section provides a high-level overview of the core network architectures of the two main standards and their evolution paths, GSM/W-CDMA (3GPP) and CDMA/CDMA2000 (3GPP2). In each of the simplified core network architectures, the Multimedia Resource Function (MRF) has been identified, along with the connectivity with other key architecture components.

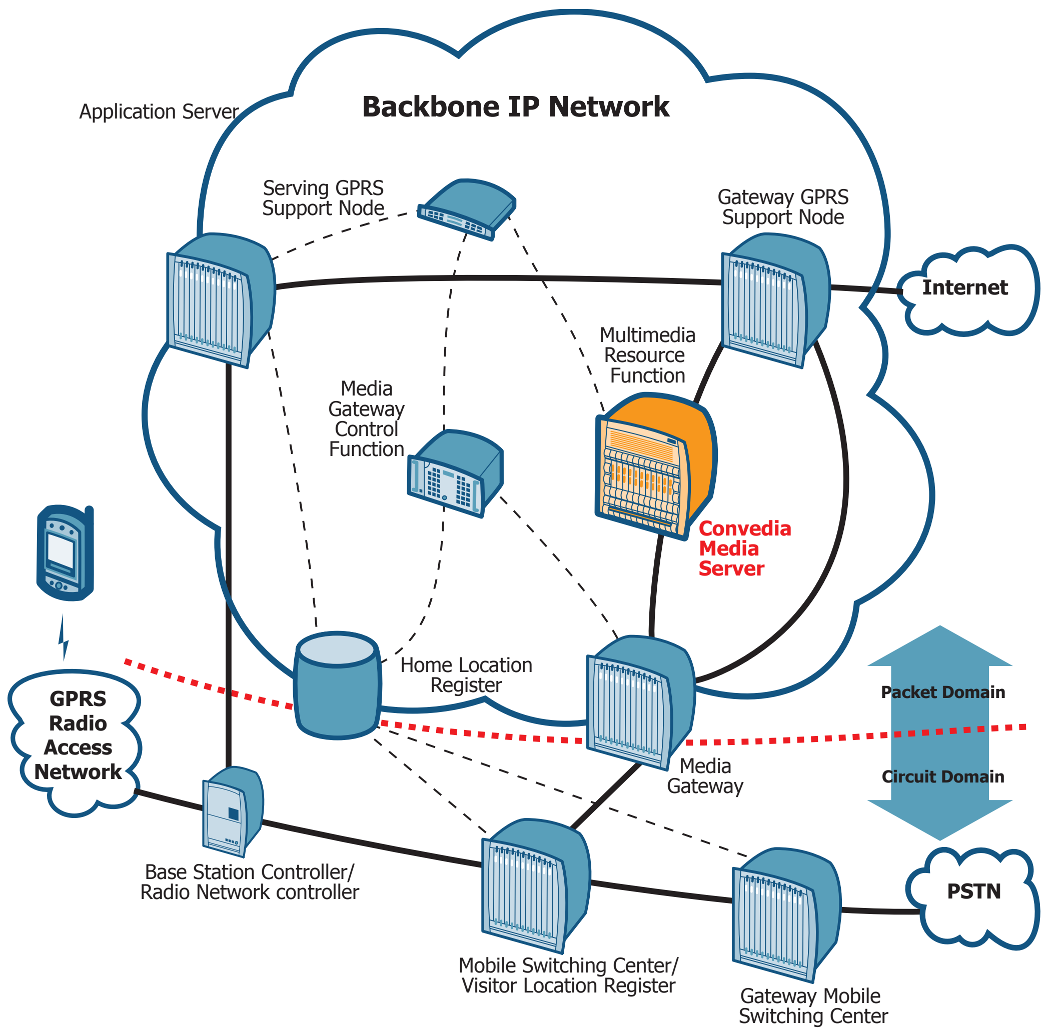
The section concludes with the converged IP Multimedia Subsystem (IMS)—the "Inner Services Core" for 3G wireless networks. The Multimedia Resource Function Processor (the MRFP is a sub-part of the MRF) is a recognized component of the IMS architecture, and is delivered in physical networks by an IP media server.

GSM to W-CDMA

GSM-based wireless networks, with initial deployments throughout Europe, are now in operation throughout the world. Existing GSM service providers are already migrating their circuit-switched wireless networks to 2.5G architectures, with a migration path to pure-IP 3G wireless networks defined by 3GPP.

GPRS Architecture (2.5G GSM)

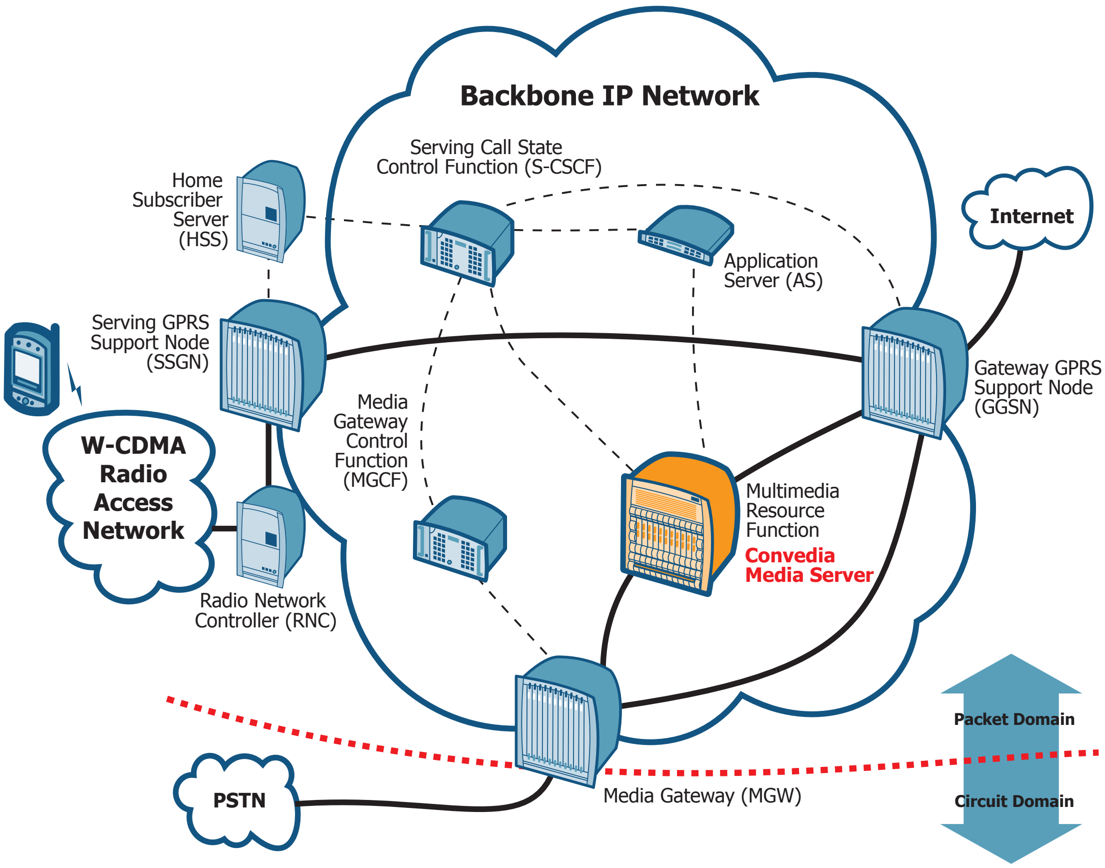
The diagram below depicts a generalized GSM-based 2.5G network, commonly referred to as a General Packet Radio Service (GPRS) network architecture. The radio access network is based on digital circuit-based GSM wireless technology, but the architecture introduces an IP packet-based service overlay network, the first steps in the migration to a pure 3G architecture. The MRF delivers media processing functions on behalf of the Application Server (AS), and performs the media functions on the Real Time Protocol (RTP) streams flowing to/from the Media Gateway (MGW) and the Gateway GPRS Serving Node (GGSN). This approach is analogous to the VoIP overlay strategy increasingly deployed by established wireline service providers.



GSM 2.5G (GPRS) Architecture

GPRS architectures are evolving to a 3G architecture, with an IP-based radio interface known as W-CDMA. The MRF now delivers media processing functions on behalf of both the AS and the Serving Call State Control Function (S-CSCF). With IP connectivity directly to the wireless device using W-CDMA, a broad range of enhanced services will be delivered economically to a growing subscriber base of wireless users with end-to-end IP connectivity.

W-CDMA Architecture (3G GSM)



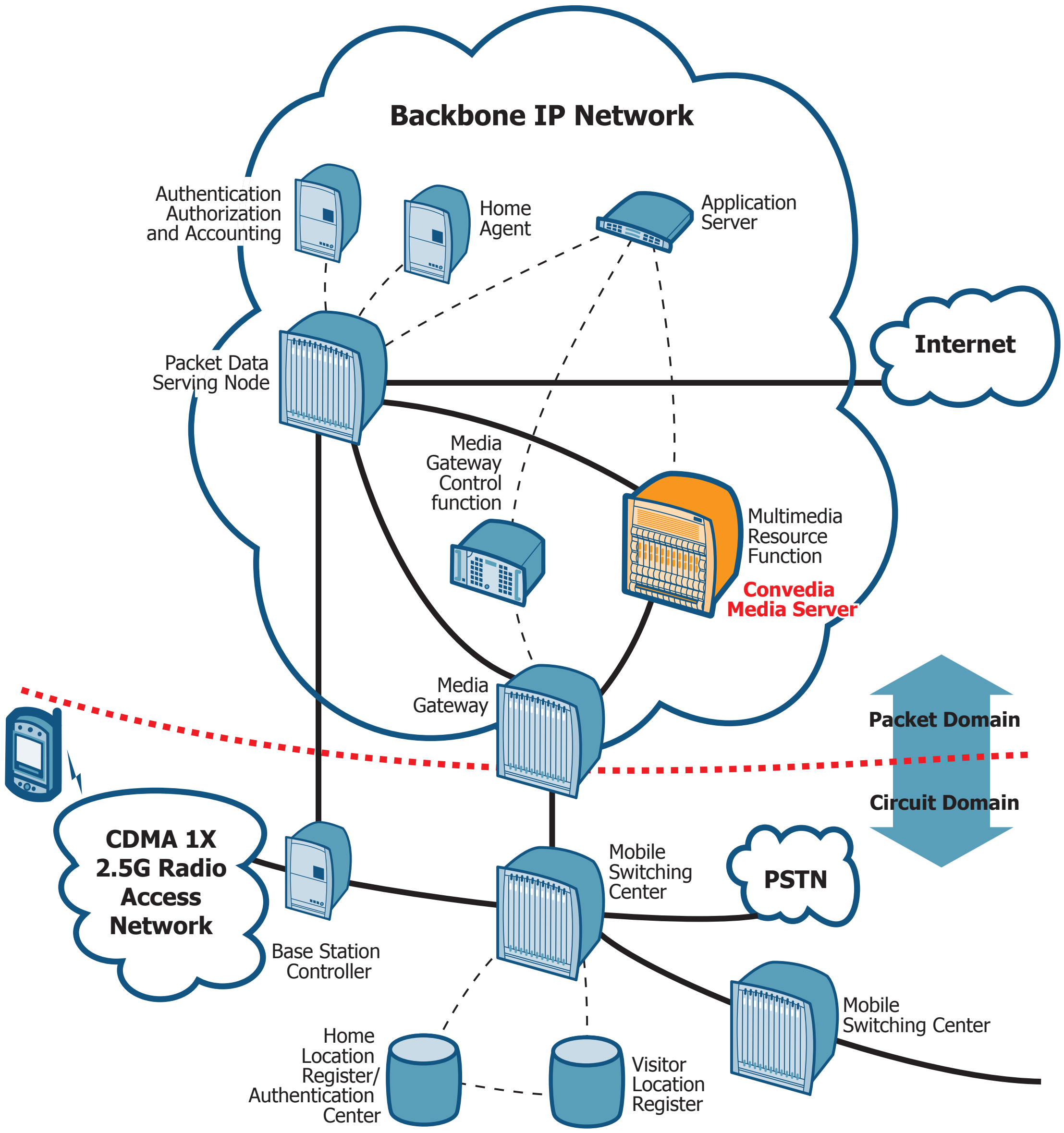
3G W-CDMA Architecture

CDMA to CDMA2000

CDMA2000 1X Architecture (2.5G CDMA2000)

CDMA-based wireless networks, which were originally deployed in North America, are now also a common standard in Asia and other parts of the world. Existing CDMA service providers are already migrating their wireless networks to 2.5G architectures, with a migration path to pure-IP 3G wireless networks defined by 3GPP2.

The diagram below depicts a generalized CDMA-based 2.5G network, called the CDMA2000 1X network architecture. The radio access network is based on digital circuit-based CDMA wireless technology, but (as with GPRS) the architecture has an IP packet-based service overlay network. The MRF delivers media processing functions on behalf of the AS, and performs the media functions on the RTP streams flowing to/from the MGW.

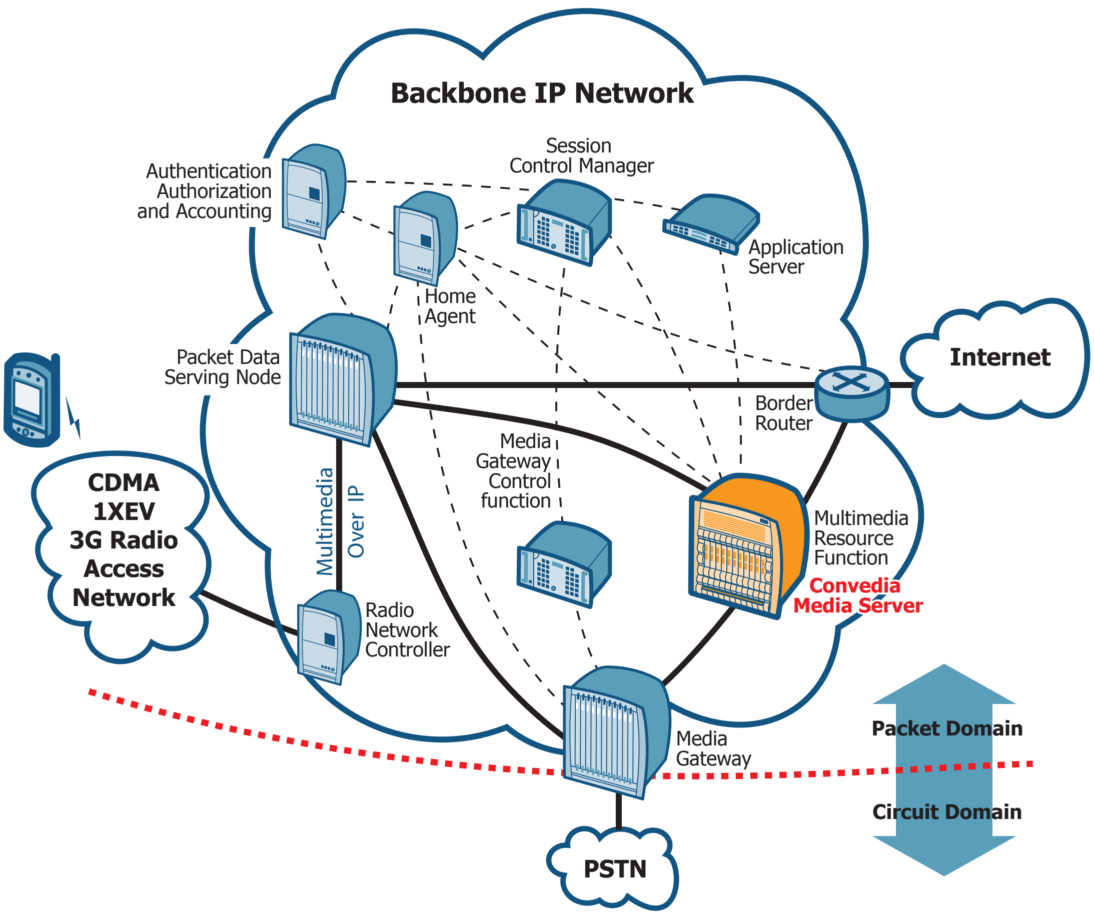


CDMA 2.5G (CDMA2000 1X) Architecture

In parallel with GSM evolution, CDMA architectures are evolving to the pure-IP 3G architecture (shown below) with an IP-based radio interface known as CDMA2000 1X-EV.

CDMA 2000 1X-EV Architecture (3G CDMA2000)

The MRF delivers media processing functions on behalf of both the AS and the Session Control Manager (SCM), and performs the media functions on the RTP streams flowing to/from the MGW and the Border Router. With IP connectivity directly to the wireless device using CDMA2000 1X-EV, a broad range of enhanced services will be delivered economically to a growing subscriber base of wireless users with end-to-end IP connectivity.



3G CDMA2000 Architecture

Convergence

3GPP IP Multimedia Subsystem (IMS) standards are enabling a convergence of IP-based service architectures

Although cellular access networks make use of a large number of incompatible standards and technologies, the core network architectures of the 3G standards all use IP (as do next-generation wireline architectures), and the applicable standards are rapidly converging. This is especially true in the IP multimedia service portion of the core architectures—the 3GPP IP Multimedia Subsystem (IMS) and the 3GPP2 IP Multimedia Domain (MMD)—where 3GPP2 has mostly adopted the 3GPP IMS. In addition, the IMS uses essentially the same Session Initiation Protocol (SIP) standard for call signaling that is used in next-generation IP-based wireline networks.

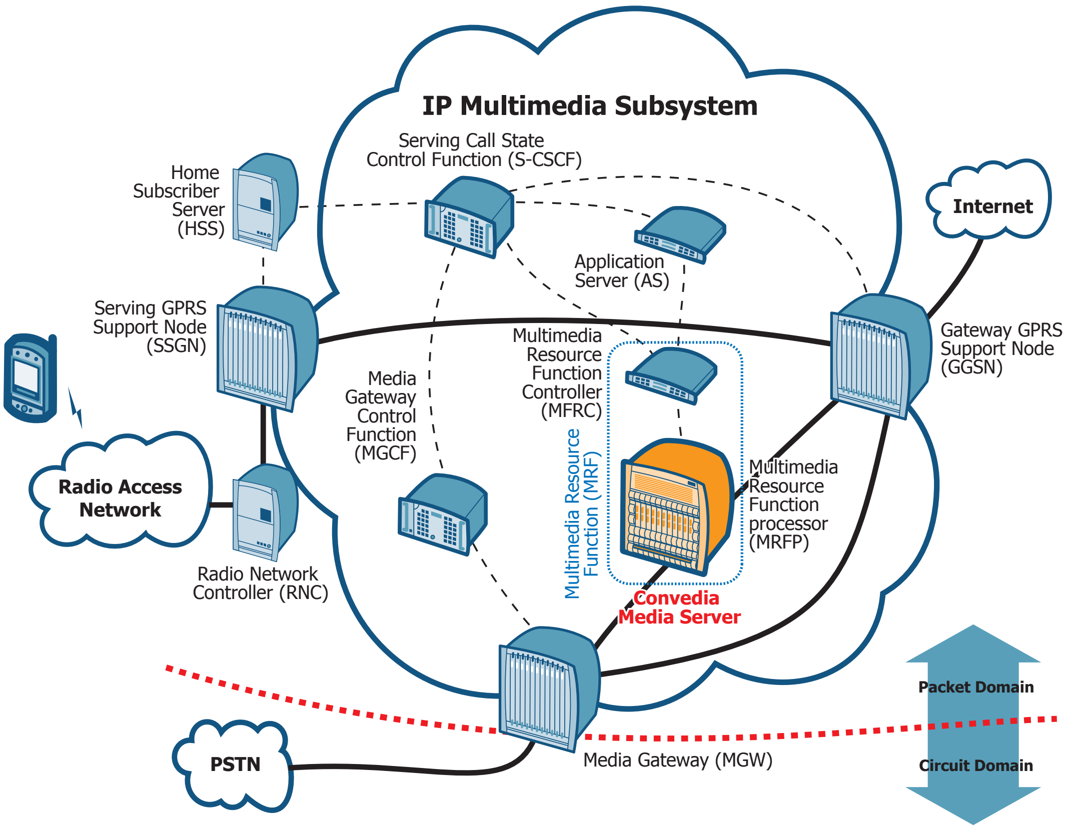
The IP nature of all the core wireless architectures, the convergence of the core multimedia architectures, and the ubiquitous use of SIP in wireless and wireline are all critical for the success of multimedia enhanced services, because they provide an essentially common foundation on which these services can run.

The convergence between wireless and wireline has been mostly the result of wireless architectures adopting proven wireline technologies, most notably IP and (in services) SIP, Session Description Protocol (SDP), and RTP. But recently, technology adoption has also occurred in the other direction, with some wireline service providers choosing the IMS architecture for their core networks to enable them to offer mobility for 802.11 and wireline IP terminals.

There are several organizations involved in wireless services and enhanced services, including 3GPP, 3GPP2, and the Open Mobile Alliance (OMA). The OMA in particular, is leading the global effort to create a single Push-to-Talk standard. Many IETF standards (including SIP, SDP, and RTP, mentioned above) are used in wireless networks, and many others will be adopted as enhanced services penetrate into wireless.

IP Multimedia Subsystem (IMS)

The diagram below shows the harmonized IP Multimedia Subsystem (IMS) architecture in a little more detail. The Multimedia Resource Function (MRF) has been further decomposed into its two components, the MRF Controller (MRFC) and MRF Processor (MRFP), which mirrors the division between the Media Gateway Control Function (MGCF) and Media Gateway (MGW). Both are controlled by or through the Serving Call State Control Function (S-CSCF) call agent. Applications in the Application Server (AS) in turn drive the S-CSCF to set up and tear down calls (which may involve the MGCF and MGW) and drive the MRFC and MRFP for enhanced multimedia processing.



IP Multimedia System (IMS) Architecture

The MGW is a slave entity controlled by the MGCF, which in turn is controlled by the S-CSCF. Its sole task is to convert between TDM multimedia streams and IP multimedia streams. In exactly parallel fashion, the MRFP is a slave entity controlled by the MRFC, which is controlled by the AS. Its role is enhanced processing on the contents (audio, video, and so on) of IP multimedia streams. The roles of the MRFC are mediating between the AS and MRFP—that is, conveying AS commands to the MRFP and MRFP responses and notifications to the AS, and generating charging records that identify usage of MRFP processing resources.

IP Media Servers deliver the Multimedia Resource Function Processor (MRFP) in the IP Multimedia Subsystem (IMS)

As was described earlier in the GPRS and CDMA2000 1x diagrams above, the MRF and its components MRFC and MRFP also appear in 2.5G networks. In physical realizations of a standards-based 2.5G and 3G architectures, an IP media server delivers the Multimedia Resource Function Processor (MRFP).

Network Evolution

The world of wireless networks is of course much more complex than the simplified view presented above. As wireless networks evolve toward "pure 3G" architectures, three of the key issues that will command increasing attention are: the transition from IPv4 to IPv6 for its greater addressing range and support for IP mobility; Quality of Service (QoS) differentiation, and charging for various types of traffic and their different demands for network performance; and security (for example, authentication and encryption) for all data in the network including signaling and multimedia streams.

Media Server

As noted above, IP media servers perform the role of the MRFP in both 2.5G and 3G networks. This section will examine in detail IP media servers and their function in wireless networks.

Role

A media server is **service-agnostic**—it has no knowledge about the services for which it is performing media processing

A media server is a generic multimedia processing component that appears, under various names, in all next generation network (NGN) architectures. A media server is a slave component of the network and therefore operates under the control of a master call agent component, which in wireless network is mainly an AS but can also be an S-CSCF. The call agent contains the service logic that directs the media server to provide the required multimedia processing upon the RTP media streams.

A media server is **plug-and-play**—it does not need to be modified for each new service.

A key quality of a media server is that it is inherently service-agnostic—a media server has no knowledge about the services requesting it to perform multimedia processing. An application requiring multimedia processing simply requests that one or more processing operations be carried out in sequence by the media server. Because it is service agnostic, a media server is a "plug-and-play" component; that is, it need not be modified for each new service. This also makes the media server inherently flexible for supporting a large variety of enhanced multimedia services, both existing and future.

Building Blocks

The operations that a media server is able to perform are often called "building blocks," because they are packaged together to create the user experience required for a particular application. Building blocks are invoked and controlled by the call agent using one or more of the media server's control interface protocols.

The following are typical examples of media server building blocks:

Building blocks are atomic media processing operations.

Audio

Building blocks are invoked by a call agent using a media server control protocol

- Playing audio files such as announcements, prompts, messages, and names
- Recording audio files such as messages and names
- DTMF detection
- Interactive voice response (IVR)
- Automatic speech recognition (ASR)
- Text-to-speech conversion (TTS)
- Simple, unfeatured conference mixing (for example, 3WC or 6WC)
- Featured conference mixing, including loudest speaker notification, gain control, and muting

- Fax detection, receiving, and sending

Video

- Playing video files such as announcements, prompts, and messages
- Recording video files such as messages
- Video interactive voice response (IVR)
- Video conference mixing, including voice activated switching and continuous presence (for example, quad split)

Audio or Video

- Transcoding between different codecs or rates (also applies to most of the above building blocks)
- Multi-unicasting (that is, replicating the audio and/or video payload of RTP)

Individually each of the building blocks is relatively simple, but when they are put together on a call, the combination can perform all the multimedia processing required by any conceivable service. For example, play, record, DTMF detection, featured conference mixing, and multi-unicasting are all building blocks used to create an event conferencing service. Additional enhanced services can be created by combining media server building blocks with other service building blocks, such as presence, location, instant messaging, web GUIs, and downloadable clients.

Wireless Services

The following are some examples of wireless services that can be created or optimized using an IP media server. Each of these, of course, relies on an application in the network to execute the service logic, perform network signaling, and control the media server. For each service, the key media server building blocks required to support the application are identified

Audio services

- Network announcements (play)
- Personalized (or color/customized) ring back tones (play)
- Call/conference recording (record)
- IVR-based information services (play, DTMF)
- ASR/TTS-based information services (play, DTMF, ASR, TTS)
- Automated attendant (play, DTMF, ASR, TTS)
- Three-way and six-way conferencing (simple mixing, transcoding)
- Presence-based conferencing (simple mixing, transcoding)
- Business conferencing (featured mixing, transcoding, play, DTMF)
- Chat rooms (featured mixing, transcoding, DTMF)
- Gaming conferencing (simple mixing, transcoding)
- Push-to-Talk (multi-unicast, transcoding)
- Voice messaging (play, DTMF, record)
- Unified messaging (play, DTMF, record, TTS, fax)

Numerous wireless services are enabled through various combinations of media processing building blocks

Video services

- Video conferencing (video featured mixing, transcoding, video play, DTMF)
- Video messaging (video play, DTMF, video record)

Audio or Video

- Transcoding at the network edge where the core uses a single codec
- Transcoding between networks
- Transcoding between different codecs and rates on a per-call basis

Interfaces

As with all IP network components, media servers have a number of interfaces for communication with other components in the network.

Control

The control interface allows the call agent to send commands to the media server and receive responses (synchronous messages) and notifications (asynchronous messages) from it.

SIP is the dominant control protocol for IP media servers

Control protocols for media servers that are currently in use in the industry are MGCP and SIP, with SIP rapidly emerging as the more important of the two. H.248, although popular for media gateway control, has never been used much for control of media servers. Given the strong and growing market interest in the SIP interface, it seems unlikely that H.248 will ever become widespread for media servers.

XML-based scripts can also be used with SIP

Within the SIP control protocol there are several options, including the addition of XML-based scripts, which can be used for additional application control over media processing. See references [NETANN], [MSML], [MOML], [VOICEXML], [WPSIP], and [WPMSML] for more details on media server control interfaces.

RTP transports encoded audio and video

Multimedia

RTP is the protocol that transports encoded audio and video into and out of the media server. RTP that reaches a media server in wireless networks is carried on either the voice channel or the data channel of a mobile handset. As far as multimedia processing is concerned, these are equivalent. For more information see references [RTP], [RTPAV], [RTPMIME], and [RTPDTMF].

NFS or HTTP can be used to access multimedia content on external file servers.

External File Server

Multimedia files for playout and recorded multimedia files can be stored inside the media server or on an external file server. When stored externally, the media server uses its external file server interface and protocols such as NFS and HTTP to perform streaming file read and write operations to retrieve or store files.

MRCP is used by the media server to control an adjunct speech server

External Speech Server

ASR and TTS, when executed by a media server, are actually performed either internally or on external speech servers. When external servers are used, the media server uses its external speech server interface and the Media Resource Control Protocol (MRCP), to control the external speech server. This makes it appear to the network that the speech servers are integrated in the media server. See reference [MRCP].

Management

Management of media servers is performed through OAMP interfaces such as SNMP, web GUIs, and command-line interfaces (CLIs). Media servers need very little service provisioning—only internal multimedia files for announcements if they are used.

SNMP, CLI, and Web GUIs provide management

Implementation in Wireless Networks

The IMS and 3G architectures allow ASs and MRFPs to be independently located. ASs and MRFPs can be physically located either inside the IMS or on an external network such as the Internet or a private IP network. When the AS is inside the IMS, it makes use of the MRFP inside the IMS. When the AS is on an external network, it can use the MRFP either inside the IMS or on an external network.

There are many ways to architect the IMS, but applications in any network will typically be a mix of applications provided by the cellular service provider and ones provided by third-party application service providers (ASPs). The MRFP in the IMS can serve applications provided by the cellular provider but also, with appropriate security, ASPs.

It is worth noting that the 3GPP IMS concept of the MRFP remains, for historical reasons, quite limited compared to the reality of IP media server capabilities. References [IMS] and [3GCONF] define only a few building blocks for the MRFP:

The 3GPP IMS concept of the MRFP remains, for historical reasons, limited compared to the reality of IP media server capabilities.

- Playing multimedia announcements
- Audio transcoding
- Media analysis (which might include DTMF detection)
- Featured conference mixing

The 3GPP's Speech Recognition Framework (SRF) adds ASR and TTS to the capabilities of the IMS, but has not yet been architected to use the MRF.

Benefits

Media servers, as powerful and efficient enablers for enhanced services in wireless networks, bring strong benefits to both mobile application developers and mobile service providers.

Solution Vendor Efficiency

Vendors of wireless solutions will find that using a media server (rather than integrating board-level components on their own) reduces their development cost and time-to-market. This is because media servers are fully integrated network components, and already meet or exceed the operational requirements of service providers. They also provide a choice of open, standardized control interfaces—from simple to powerful, scripted and unscripted—so that developers can match the interface to the requirements of the application. A family of compatible media servers, such as Convedia's CMS-6000 and CMS-1000 Media Servers, offer further development efficiency because they share the same control interfaces, multimedia processing features, and management capabilities. Convedia is committed to driving the full set of media server building blocks and processing capabilities into the 3GPP standards so that wireless service providers and application developers have access to the same set of rich capabilities already utilized in wireline next-generation networks.

Service Provider Cost Reductions

It used to be that each new enhanced service introduced into the network required its own separate multimedia processing hardware. The result of this "service node" approach to supporting enhanced services resulted in numerous incompatible devices requiring ongoing management, inflexibility in delivering new services, and inefficient use (or reuse) of available media processing resources.

Shared, generalized media processing for all enhanced services reduces CAPEX and OPEX

Media servers provide a shared multimedia processing layer for all enhanced services in the network, no matter what media type or control protocol, which reduces capital and operational expenditures. Convedia's high-density CMS-6000 Media Server offers additional cost savings including reduced space, power, and cooling requirements. And Convedia's family of compatible media servers gives service providers the flexibility to deploy small media servers near the network edge, large media servers in the core, or both.

Service Provider Revenue Improvements

IP media servers facilitate rapid introduction of new services for acceleration of new revenue streams

Possibly even more important to service providers than CAPEX and OPEX reduction are revenue improvement. IP media servers facilitate rapid introduction of new services for acceleration of new revenue streams. Convedia IP Media Servers are uniquely positioned to support a broad range of services, because Convedia's total focus on media servers has led to a strong ecosystem of solution vendor partners all using Convedia IP Media Servers to rapidly deliver a broad range of best-in-breed solutions.

Conclusions

Wireless service providers are already offering many enhanced voice and video services to their subscribers. However, the underlying infrastructure to support these services is still largely built around traditional circuit-based service and media processing platforms.

Convedia IP Media Servers provide an optimized Multimedia Resource Function Processor (MRFP) for 3G wireless networks.

3G standards organizations are now adopting technologies and applicable standards from next generation IP-based wireline networks in the definition of their own IP Multimedia Subsystem (IMS) standards. The IMS architecture defines a converged IP-based core infrastructure for supporting multimedia enhanced services in 3G wireless networks. As part of the IMS, Convedia's IP Media Servers provide a powerful, robust, and scalable standards-based Multimedia Resource Function Processor (MRFP) function to support application developers and wireless service providers in efficiently delivering a broad range of enhanced multimedia services.

Abbreviations

3G	3rd Generation
3GPP	3rd Generation Partnership Project (GSM 3G standards group)
3GPP2	3rd Generation Partnership Project (CDMA 3G standards group)
AMR-NB	Adaptive Multi Rate – Narrow Band (Codec)
ASR	Automatic Speech Recognition
CDMA	Code Division Multiple Access
CDMA 1XEV	CDMA 1 X(times) EVolution
CDMA 1XEV-DO	CDMA 1XEV - Data Only
CLI	Command Line Interface
DECT	Digital European Cordless Telephone
DTMF	Dual Tone Multi Frequency
EDGE	Enhanced Data rates for Global Evolution
EVRC	Enhanced Variable Rate Coder
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GSM	Global System for Mobiles
GSM-EFR	GSM-Enhanced Full Rate (Codec)
GSM-FR	GSM-Full Rate (Codec)
HLR	Home Location Register
HTTP	Hyper Text Transport Protocol
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IVR	Interactive Voice Response
Megaco	MEdia GAteway COntrol
MGCF	Media Gateway Control Function
MGCP	Media Gateway Control Protocol
MGW	Media GateWay
MOML	Media Object Markup Language
MPEG	Moving Pictures Experts Group
MRCP	Media Resource Control Protocol
MRF	Multimedia Resource Function
MRFC	Multimedia Resource Function Controller
MRFP	Multimedia Resource Function Processor (e.g. Convedia IP Media Server)
MSML	Media Session Markup Language
NFS	Network File System
NGN	Next Generation Network
PSTN	Public Switched Telephone Network
QCELP	Qualcomm Code Excited Linear Predictive (Codec)
QoS	Quality of Service
RNC	Radio Network Controller
RTP	Real Time Protocol
S-CSCF	Serving – Call State Control Function
SDP	Session Description Protocol
SGSN	Serving GPRS Support Node
SIP	Session Initiation Protocol
SMV	Selectable Mode Vocoder (Codec)
SNMP	Simple Network Management Protocol
TDM	Time Division Multiplexing
TD-SCDMA	Time Division – Synchronous Code Division Multiple Access
TTS	Text To Speech
UMTS	Universal Mobile Telecommunication System
UTRA TDD	UMTS Terrestrial Radio Access - Time Division Duplex
W-CDMA	Wideband CDMA
XML	eXtensible Markup Language

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