On-demand mobile media—A rich service experience for mobile users

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Images, voice, audio and video content—indeed, all kinds of rich media—will soon reach mobile terminals as part of mobile multimedia services. The introduction of standardized mobile messaging services, such as EMS and MMS, will enrich person-to-person messaging and pave the way for content-push services. On-demand mobile media services will be delivered to users via media streaming and download techniques that enrich mobile browsing and general content access.

The authors describe the business opportunities, technology, and product strategies for the delivery of on-demand mobile media.

Introduction

Multimedia-enriched services are expected to drive usage, operator revenue and bandwidth consumption in mobile networks. At the center of these multimedia services are end-users with their wireless mobile devices. End-users are likely to have great expectations, since in the end, they are the ones who must pay for service. Therefore, the services must be compelling. Unlike the delivery of media on the fixed Internet, where service is free but is not backed by any guarantees, quality of service (QoS) is important in the wireless Internet.

On the Internet, news sites are being enriched with short audio and video clips, comic strips are being turned into animated graphics, and simple text pages are being enhanced with images and scrolling text. The technology with which to deliver on-demand media is currently in the process of being standardized and implemented in mobile devices. While the basic technology of the wireless Internet is similar to that of the fixed Internet, the fundamental challenges are not, and the associated services will probably also differ.

Mobile multimedia begins with messaging services. Enhancements to short message service (SMS) are already well on the way in the form of media-rich EMS and MMS.[1] In the case of WAP and access to Web content, two important enhancements brought by GPRS and WCDMA services are media download and media streaming.

Thanks to the increase in data-transmission rates in GPRS and WCDMA mobile networks—from 40 to 384 kbit/s for typical wide-area coverage—operators and content providers who are able to deliver attractive, high-quality media services have major business opportunities.

Mobile services and the merits of on-demand mobile media

Delivery of mobile media service

Over time, all existing services will probably be enhanced with rich media in order to meet growing user expectations. Rich media content also forms the basis of many new services. Figure 1 provides a selection of possible, near-term, on-demand services that are well suited to mobile use, including news and sports services, live cameras providing traffic information, and surveillance. Likewise, many entertainment services will be attractive and grow in popu-

BOX A, TERMS AND ABBREVIATIONS

3GPP	Third-generation Partnership Project
API	Application program interface
CDR	Call detail record
DRM	Digital rights management
EMS	Enhanced messaging service
GPRS	General packet radio service
HTML	Hypertext markup language
HTTP	Hypertext transport protocol
IETF	Internet Engineering Task Force
IP	Internet protocol
MIPS	Millions of instructions per second
MMS	Multimedia messaging service
O&M	Operation and maintenance
OEM	Original equipment manufacturer
PDA	Personal digital assistant
QCIF	Quarter-CIF (common interchange format)
QoS	Quality of service
RAM	Random access memory
ROM	Read-only memory
RTCP	Real-time transport control protocol
RTP	Real-time transport protocol
RTSP	Real-time session protocol
TCP	Transmission control protocol
SDP	Session description protocol
SMIL	Synchronized media integration language
SMS	Short message service
UDP	User datagram protocol
UMTS	Universal mobile telecommunications system
W3C	World Wide Web (WWW) Consortium
WAP	Wireless application protocol
WCDMA	Wideband code-division multiple access
WML	Wireless markup language
XHTML	Extensible HTML

Figure 1
Examples of on-demand media services.

larity—the cartoon of the day, quiz of the day, movie previews in ticketing applications, and so on.

For some applications, such as news summaries, a bit rate of less than 20 kbit/s will provide adequate quality for voice and images. But for others, such as live sporting events, the bit rate must be at least 256 kbit/s (Figure 2). Many interesting lower bit rate services can efficiently make use of slide shows in which the audio is combined with a set of images. The elements of a presentation can also be tied to active links, offering interactivity. Truly powerful mobile multimedia services are based on a strict set of standardized capabilities, to ensure interoperability, but permit enough flexibility to be composed differently for different purposes.

The delivery of on-demand mobile media will enable powerful services. But perhaps even more important are the combinations of services and increased traffic that will result thanks to the wealth of content transported over the mobile network—when users run across content that is interesting or humorous, they often want to share it with friends. Thus, a benefit of on-demand services is that they can give rise to an increase in messaging. Similarly, persons who receive interesting media clips might feel inspired to test new on-demand services.

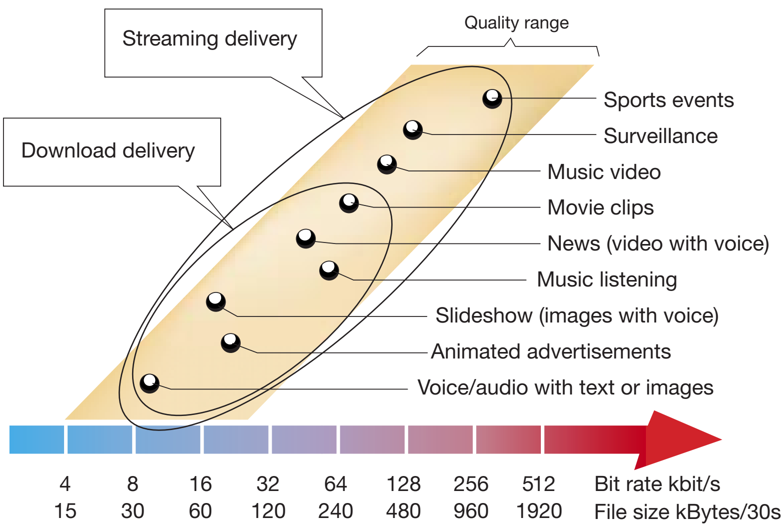


Figure 2
Bit rate demands and storage requirements for different on-demand mobile services. The storage requirements are expressed in kilobytes and computed for a clip duration of 30 seconds.

BOX B, A MOBILE TICKETING SERVICE

An operator might offer an advanced ticketing application through a WAP cinema portal. When a user visits the portal, a positioning service determines the user's geographical location. Based on this information, a list of nearby movie theaters and associated program schedules is obtained from a database on the Internet. The attributes of the films are matched against the user's preferences, which are stored on a profile server. In less than five seconds, the service generates a WAP page showing a selection of available movies and show times. If the user clicks on a preview button while browsing through the list of films, then a streaming service is invoked to play the corresponding movie trailer on the mobile device. If the user likes what he sees, he can purchase a ticket—the purchase amount is automatically charged to the user's phone bill.

User benefits of mobile media

In many respects, the delivery of on-demand mobile services differs from that of fixed Internet services. While the multimedia capabilities of mobile devices are more limited than PCs, the convenience of an always-on, always-with-me device for on-demand media delivery is distinguishing. Take ticketing services, for example (Box B)—clearly, mobile users enjoy significant benefits when components are properly integrated into advanced services:

- mobility (rich media anywhere, anytime);
- high quality of service;
- presentation that is suited to the mobile devices (voice/audio and images/video make a better interface than scrolling text)
- complete service packages; and
- location-based multimedia services.

A new channel of media consumption is opening up as the media, Internet and wireless industries converge to yield wireless multimedia. Given the forecasted number of subscribers of third-generation services, the media industry is anxious to provide content to users anywhere, any time.

Business opportunities and operator roles

Compelling multimedia services will certainly attract many users. This, in turn, will generate interest on the part of various companies in providing wireless multimedia-based services. Notwithstanding, it does not make sense to require every service provider to dimension its equipment to serve millions of users. At the same time, however, every potentially successful service must be dimensioned appropriately. A successful service is also dependent on adequate quality of delivery. Many services will cost (subscription fee or pay-per-view), which means that a transaction must be carried out for the service to take place. Some services might also benefit from knowing the identity of the user, so that individual preferences can be served, service access can be managed, and so on.

End-users expect service to be good and worthy of the price they pay. Media service providers expect a channel to consumers which provides adequate quality, enables them to get paid, and which protects against piracy. An operator that chooses to take on the role of media distributor can ensure that these expectations are fulfilled.

By functioning as distributor and enabling operator-powered services, operators have many opportunities to add value to Mobile Internet services—in particular, to mobile multimedia services.

The value chain in Figure 3 shows an overview of the different roles that are required to enable mobile multimedia services. The gray boxes represent roles that can solely be fulfilled by the operator. The green boxes represent roles that can be fulfilled by the operator or its partners. The blue boxes denote functions affected by new technologies. These are introduced as enablers of on-demand mobile media services.

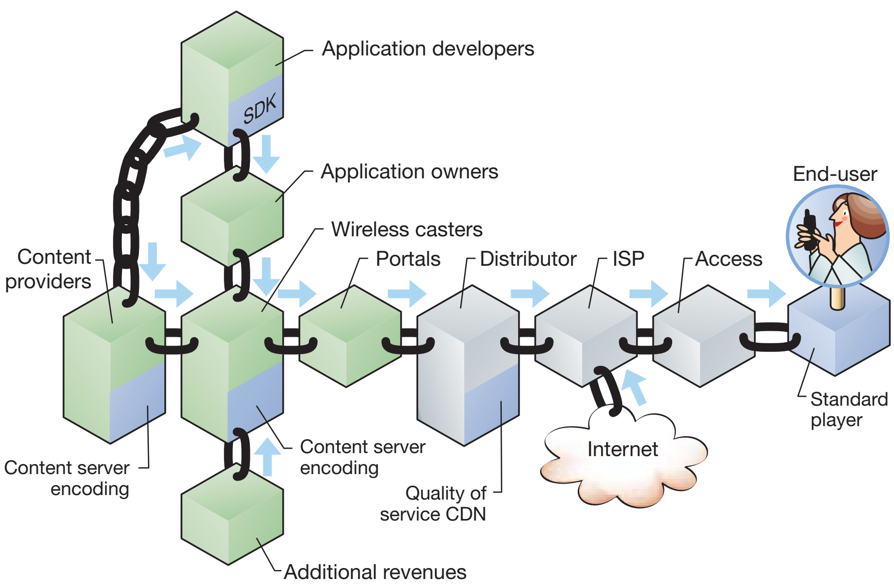
The content provider (Figure 3, left) owns the content. The wireless caster provides the actual service. The service is developed by the application developer. The owner of the application owns and probably also brands the service. Portal providers set up portals from which the end-user can find and access on-demand mobile media services.

On a service-by-service basis, the operator may decide which of these roles it wants to keep for itself. There is a trade-off between providing all the elements in a complete service (thus reaping all the revenues and carrying the entire risk) and offering a product that is a component in a service (reduced risk). I-mode has shown that only a fraction of services is successful.

Flexibility is crucial, and the operator has several options in deploying a content-delivery service:

- The operator can host a content-delivery

Figure 3
Roles in a simplified value chain of mobile media distribution.



service via servers inside the operator domain. The operator would thus function as a broker and content manager.
- The operator can provide operator power to enhance content from any service partner. The end-user will be able to browse any Internet site and access streaming content. Through agreements with service providers, the operator delivers operator-powered services to its subscriber base.
- The operator can combine these scenarios through its own portals.

Key factors of success for future operators and the Mobile Internet are quality multimedia content and portfolios of compelling applications (possibly provided by partners).

Content distribution chain

Figure 4 gives on overview of the media distribution chain, which describes the steps that an operator must take to deliver on-demand multimedia content to end-users. The five most important steps are:
- content creation;
- distribution of content to servers, from which it can be accessed on-demand;
- content management, which helps the end-user to find specific content of interest;
- delivery of content from servers to the end-user; and
- content presentation.

The process of creating content starts with raw content, which originates from cameras, VCRs, audio sources, CDs, and so on. If the raw content solely exists in analog format, it must first be digitized.

Most raw digital content needs editing, which typically produces a set of elementary video and audio clips and still images. Some text might also be generated at this stage to accompany or complement other content.

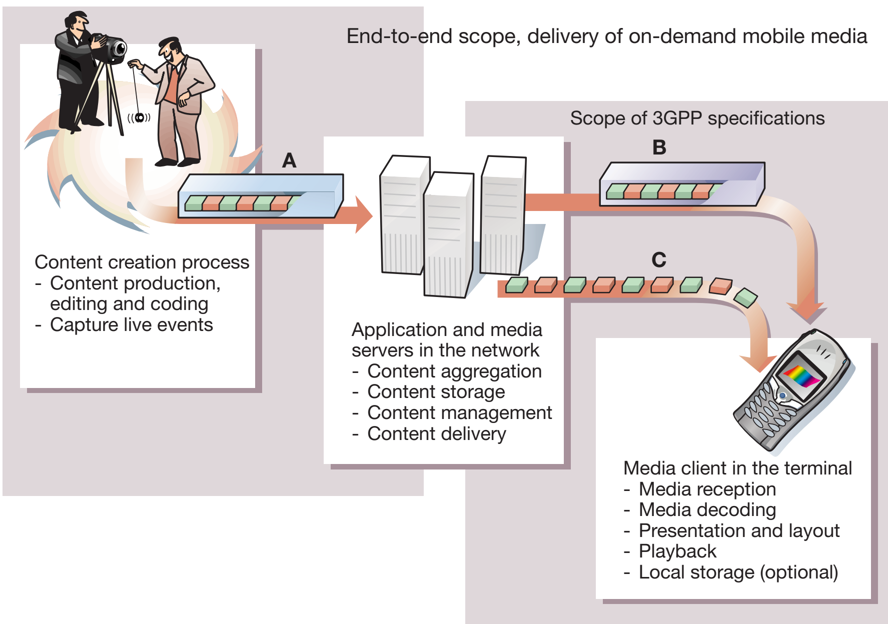
Before multimedia content can be delivered to end-users, it must be transformed into a format that is compatible with the end-user device (physical display size, processor power) and network (protocols and available bit rates).

For example, to transport video content over low bit rates (say, 64 kbit/s), the video resolution must first be decreased, typically using quarter-CIF (common interchange format) at 176 x 144 pixels and 10-to-15 frames per second. Moreover, the video must be compressed to further reduce bandwidth—quality decreases at lower bandwidths, but also depends on the complexity of the scenes. Greater motion and more complex textures require larger bandwidth. This is why sporting events are so demanding, whereas news services can get by with less bandwidth (Figure 2).

Different kinds of media require different codecs. The compression of a TV signal, for instance, results in two bit streams: one audio and one video. Since the two belong together, logically, they need to be processed and played back in sync. Therefore, they are usually stored together in the same media file according to a certain file format. Besides the actual bit stream, the media file contains
- information on the codecs—this allows synchronized playback of the bit streams; and
- information on the creator and owner of the content.

After the content has been edited and compressed it is put onto a media server. It is also usually put into the context of a specific application. In the simplest case, this context is provided by a Web or WAP page, which contains links to the media clips on the media server. However, HTML and WML are limited in their abilities to deal

Figure 4
Distribution of mobile media content. The content-creation process (left) results in distinct media files (A). The process of delivering content (right) contains two options: media file download (B), and media streaming (C).



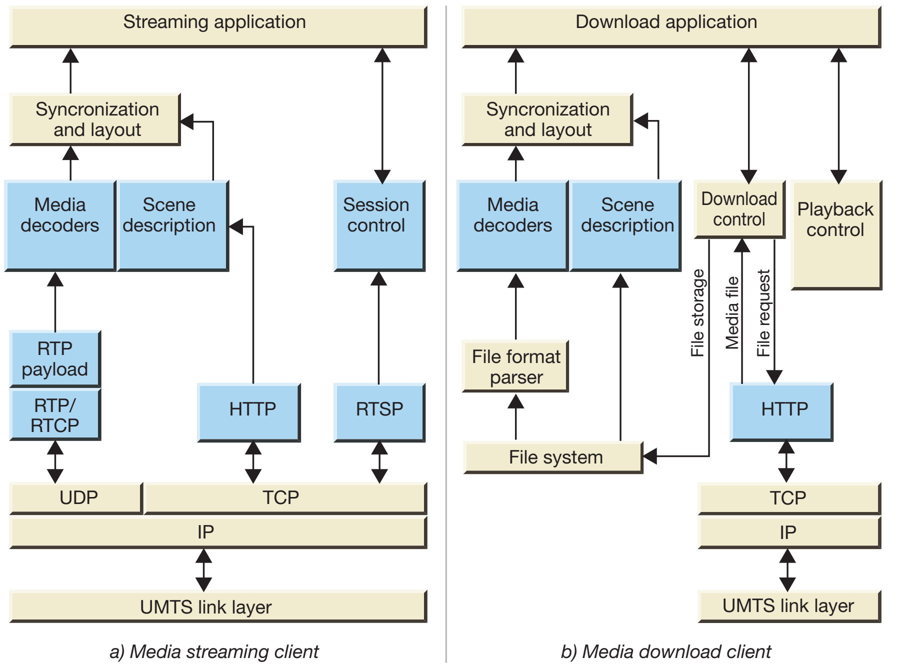


Figure 5
Mobile media player protocols and their applications. The protocols ensure simultaneous playback of voice, audio, images, video, and formatted text into mobile multimedia applications.

with continuous media types, such as audio and video. Therefore, specific scene-description languages (like SMIL) have been developed allowing application developers to express relationships, in space and time, between media elements, and to add interactive browsing facilities.

Numerous media clips are constantly flowing from professional media services. These need to be stored and tagged in such a way that they can later be found and retrieved. In essence, content management is about the reuse of content. In addition to providing links to content, more advanced content management can be used including integrated content search functions.

Once the content has been put onto a media server, it can be delivered on-demand via download or streaming. To download content, the user clicks on a link and waits for the content to be downloaded and playback to begin. Download capabilities are easy to integrate into Web browsers, since the hypertext transfer protocol (HTTP) can be used for downloading files.

To access streaming data, the user clicks on a link to start playback, which is almost immediate. Because streaming is a semi-real-time service that receives and plays back data at the same time, it puts greater demands on protocols and service implementation, especially when the service is to work over networks with little or no quality of service.

During playback of downloaded or streaming media, the compressed bit streams of the different media types are decoded and played back in sync according to the synchronization information in the downloaded file or in the streamed data.

Mobile media delivery

The greatest technical challenges associated with on-demand mobile media services have to do with wireless delivery and presentation. Because the last hop of the content distribution chain is over a wireless link to the mobile terminal, all content must be coded and compressed to make efficient use of spectrum. Thus, before the content can be played back, it must be uncompressed and decoded in the terminal. In general, however, most mobile terminals have limited memory, processing power, display size, and audio capabilities. The lack of memory limits storage capacity for multimedia clips; small displays limit the resolution of images and video. Finally, in contrast to PCs, mobile terminals usually cannot dynamically download and upgrade software components, such as new media codecs. Notwithstanding, service quality must be high to attract end-users, content owners and application developers. And spectrum must be used efficiently to keep pricing at a reasonable level.

The capabilities of mobile terminals and of the mobile network are limited compared to the fixed Internet, but the mobile application environment is much more heterogeneous. Today, a variety of mobile terminals (PDAs included) can play back multimedia content. In addition, mobile systems encompass a variety of different radio access networks, each of which has different physical characteristics that limit typical radio access link rates. Third-generation systems also contain a sophisticated UMTS bearer model that allows services to use bearers with different quality of service, ranging from best-effort bearers that demand fewer resources to more expensive bearers that demand considerable resources but offer excellent link quality at high bit rates.

A comparison of the two main delivery mechanisms, namely downloading and streaming, shows that it is much more chal-

BOX C, 3GPP ON-DEMAND MEDIA PROTOCOLS

The protocols used for on-demand mobile media consist of several layers and can be grouped into UMTS protocols and TCP/IP protocols. Access to Internet-based servers can be provided to third-generation terminals using TCP/IP over UMTS. The 3GPP has defined a UMTS bearer model that provides different traffic classes. The streaming traffic class in this model can guarantee a minimum bit rate over the UMTS network. The TCP/IP protocol stack consists of three layers (Figure 5):

1. In the network layer, the Internet protocol interconnects all networks between destination and source nodes;
2. Either UDP or TCP is used in the transport layer; and
3. Depending on the service, several protocols can be used in the session layer.

The hypertext transport protocol (HTTP), which is used for browsing applications on the Internet, provides the semantics of requesting and transferring information between servers and clients in a distributed and collaborative way. Most often, the information requested from the server consists of HTML objects. However, HTTP is not restricted to HTML—essentially any information can be requested and transferred between the client and the server, including media objects. HTTP is used on top of TCP.

The real-time transport protocol[2-3] (RTP) is a well-established transport protocol for real-time data. Designed to run on top of UDP, it is used by many applications including IP telephony. It is currently the preferred way of sending audio and video data over packet networks. Associated with RTP is the real-time transport control protocol (RTCP), which reports transmission quality to the server.

RTP adds a time stamp and a sequence number to each UDP packet in a special RTP header. The time stamp is related to the sampling or the presentation or composition time of the media carried in the payload of the RTP packet. It is used for playing back media at the correct speed, and together with RTCP, it is used for synchronizing the presentation of other streaming media. A payload specification defines the interpretation of the time stamp and other RTP fields. The recipient uses the sequence number to detect the loss of packets. Statistics on loss can be reported to the server by means of RTCP.

The real-time streaming protocol[4] (RTSP) is used as a session control protocol for media streaming applications. Several features and semantics in RTSP have been inherited from HTTP. Using RTSP, a client streaming application can establish a session with a media-streaming server. Using this session, the client can ask the server

- to start streaming media;
- to pause, back-up and replay, and fast-forward streaming media; or
- to stop streaming and disconnect the session.

RTSP is usually used on top of TCP but can also be used on top of UDP.

The W3C defined the synchronized media integration language (SMIL) for the synchronization and layout of media streams for on-demand media applications. Profiles can be created from this language. Moreover, several modules have been defined in the SMIL specification. A SMIL module is a collection of semantically related elements and attributes; a language profile is the collection of modules that pertain to a particular application domain. For streaming media, the 3GPP has defined a profile for SMIL using a subset of the SMIL 2.0 language profile.

lenging to integrate streaming services into mobile application environments than it is to download multimedia. To ensure interoperability between clients and servers from different vendors, streaming requires the standardization of media codecs and streaming protocols.

The IETF has worked quite some time on the standardization of streaming protocols, but as yet a common Internet streaming standard has not been established. Instead, all major vendors of streaming solutions have developed proprietary solutions. Furthermore, because the task of addressing the specific challenges of mobile streaming lies outside the scope of the IETF, Ericsson initiated a work item on packet-switched streaming in the 3GPP. The initiative, which is supported by all major telecom companies, was formally approved in June 2000. Figure 5 depicts the architectures of

- a client that is streaming media (shown left); and
- a client that is downloading media (shown right).

The grey boxes denote the components that are subject to the IETF and 3GPP standardization of on-demand mobile media. For details on the protocols used in 3GPP, see Box C; the media codecs are discussed in Box D. Note: the client on the right requires only standardized components for media decoders and the scene description. The transmission protocols associated with streaming components (RTP/RTCP, RTP payload, and RTSP) have been replaced by a download/playback control function that downloads a media file over HTTP and plays it back.

3GPP release 4 (March 2001) includes

two specifications that define the basic 3GPP mobile streaming standard.[5-6] The focus of further work in the 3GPP is on additional media types and further enhancements to transport over wireless links, capability exchange, and content protection.

Robust transport over wireless links

Users have little tolerance for "wireless" disturbances and the effects of outages. Hence, the quality of any pay service must live up to end-user expectations. In the context of an interactive streaming service, quality refers to the standard of received video or audio streams and to latency aspects, such as service response times. For instance, playback must start at most a few seconds after a stream has been requested. Furthermore, interruptions of any kind must be avoided during playback. This last requirement represents a major challenge, given that connections can break temporarily (100-1000 ms) during cell handover.

Capability exchange

As noted above, the capabilities of mobile terminals and of the radio access network vary. Notwithstanding, the task is to give the largest possible group of users access to content and to deliver it at a level of quality that matches the capabilities of the mobile terminal and radio access technology in use.

The 3GPP is addressing the issue of heterogeneity through appropriately designed capability exchange mechanisms which allow the terminal and media server to negotiate

- the capabilities of the mobile terminal;
- the capabilities of the mobile network; and
- user preferences.

This approach permits the server to send multimedia data that has been adapted to the capabilities of the user's mobile terminal and network. For example, a user who accesses a specific service via a WCDMA network can have content delivered at higher bit rates than someone who accesses the service via a GPRS network.

Content protection

Content must be protected to secure the value chain. That is, if the rights of the content owner cannot be protected, then valu-

BOX D, 3GPP MEDIA CODECS

Every media codec developed and standardized in, or adopted by, the 3GPP is suitable for use in wireless applications. Important factors affecting codecs are bit rates, complexity (in terms of millions of instructions per second, MIPS), memory (in terms of RAM and ROM), quality in error-free conditions and in typical wireless environments, and cost of implementation. The available, standardized media types for text, voice, audio, images and video are listed below:

- XHTML basic: XHTML Basic is designed for Web clients that do not support the full set of XHTML features; for example, Web clients such as mobile phones, PDAs, pagers, and set-top boxes. The document type is rich enough for content authoring.
- AMR: The AMR voice codec (3GPP TS 26.090) encodes narrow-band (4 kHz "telephony" bandwidth) voice using one out of 8 rates between 4.75 kbit/s and 12.2 kbit/s. The media type is well suited to all voice and news clips. AMR was standardized by ETSI in 1998.
- AMR wideband: The AMR wideband voice codec (3GPP TS 26.190) encodes wideband (8 kHz audio bandwidth) signals using one out of 9 rates between 6.60 kbit/s and 23.85 kbit/s. The media type is well suited to all kinds of voice and audio clips, and provides high-quality sound. AMR wideband was standardized by 3GPP in 2001.
- MPEG-4 AAC-LC: The low-complexity version of the Advanced Audio Codec of MPEG-4 provides a range of bit rates and quality levels. The media type is well suited to high quality audio at bit rates of 64 kbit/s and above. MPEG-4 AAC was standardized by ISO/IEC in 1999.
- JPEG: The JPEG compression provides lossy compression of typically photographic images with a compression ratio of 4:1 to 30:1 leading to typical mobile compressed file sizes of 5-20 kBytes. JPEG was standardized by ISO/IEC in 1992.
- GIF: A format for color raster images which is among the most widely used formats for graphics compression. While GIF87a supports still images only, GIF89a also supports simple animation sequences.
- H.263: The H.263 standard supports video compression for applications, such as video-conferencing, video-telephony, and video-streaming. H.263 aims particularly at video coding for low bit rates (typically 20-30 kbit/s and above). H.263 baseline was approved in 1995, while the latest version including the profile and level specifications is from 2000.
- MPEG-4 visual: The simple profile is suited for mobile application scenarios since it is optimized for low bit rate coding and includes coding tools for increased error-resilience. Level 0 of the simple profile supports video formats up to QCIF resolution at a maximum frame rate of 15 Hz.

able content will never find a legal way into on-demand mobile media applications. There are several levels of content protection ranging from simple solutions which simply disallow the storage of the consumed content up to complete digital rights management (DRM) solutions which use encryption and conditional access to protect and manage access to valuable multimedia content.

Ericsson strategy and products

Ericsson's stance on on-demand multimedia is to embrace and drive standards through the 3GPP. Ericsson is taking an end-to-end approach to the issue by collaborating with

- strategic partners who are addressing the needs of the media industry (including 3GPP multimedia-compatible authoring tools); and
- suppliers who will provide 3GPP multimedia-enabled handsets.

Terminals

By providing an integrated platform solution for OEM vendors, Ericsson ensures that the basic technologies required for on-demand mobile media are available in an efficient and optimized way.

Ericsson's mobile platform includes hardware and software components that have been optimized for small, built-in environments. Moreover, the platform contains the protocol and media decoder solutions for streaming and downloading media.

Vendors of terminals who develop products on Ericsson's mobile platform access the services through an open API. This solution, which permits vendors to develop applications and graphical user interfaces on top of the platform, enables vendors to differentiate their products from those of other vendors.

The platform uses open standards and is tested and verified through reference designs that prove the concept of interoperability. Specifically, the platform provides the following on-demand media components:

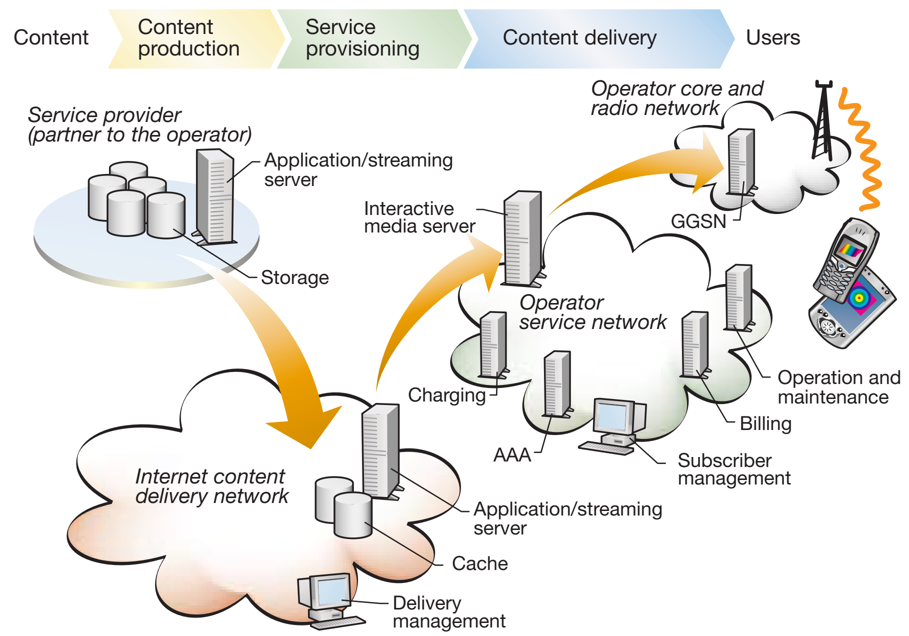
- a UMTS and GSM/GPRS protocol stack;
- a TCP/IP protocol stack and associated session protocols, such as RTP/RTCP, RTSP and HTTP;
- support for file formats of downloaded media files;
- media decoders for audio, video, still images, and voice; and
- an integrated environment that enables on-demand media applications to access the platform components through an open API.

The Interactive Media solution

The Ericsson Interactive Media suite consists of products that enable the operator to function as a distributor of on-demand multimedia services. The core product, the Interactive Media server, works with authoring tools from leading vendors and with 3GPP-compliant terminals from any vendor. The Interactive Media products are also compliant with the Ericsson service network framework.[7]

In a typical use case, the end-user finds a link to compelling streaming content while browsing. Since the service provider to this link has an agreement with the operator, the request is redirected to the Interactive Media server in the operator environment (Figure 6). If the content has not been stored there in advance, it is trans-

Figure 6
Typical use case of interactive media.



ferred (almost immediately) to the Interactive Media server.

The interfaces of the Interactive Media server (Figure 7) contain the following functions:

- network integration node (this contains Ericsson's value-adding functions);
- streaming server component (the component holds streaming data and functions as a "bit pump"); and
- optional Web server (the server holds static data, such as SMIL presentations and images).

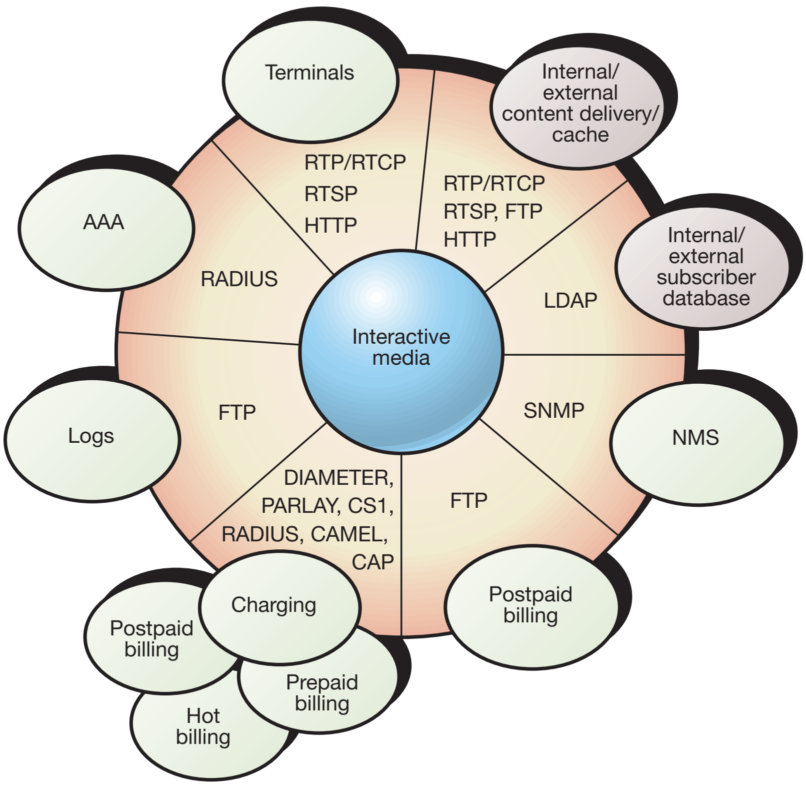
The network integration node, which is the heart of the Ericsson solution, enables the operator to take on the value-adding role of media distributor, thereby securing a sustainable future in providing services instead of merely serving as a transport provider.

The network integration node is designed to select media according to current network conditions. It does so by managing the complete set of ongoing sessions, instead of allowing sessions to be managed independently of one another as is the case in ordinary Internet solutions. Multiple sessions affect one another's performance, since all sessions must share the air interface. The network integration node makes optimized decisions in an aim to yield as many completed high-quality sessions as possible. Its decisions control each session in terms of the bit rate and codec that are enabled in the authoring process. The bit rate can be changed by changing the mode from, say, video streaming to audio with static elements, or by changing the actual bit rate of the stream.

The network integration node ensures that media delivery services are smoothly and seamlessly integrated into the operator network environment. The integration includes

- flexible service charging;
- authentication and the mapping of IP addresses to MSISDN;
- subscriber database connection—to manage user sessions; and
- operation and maintenance, including statistics.

Figure 7
External interfaces to the Interactive Media server.



Deployment scenarios

The Interactive Media solution has been designed to give flexible deployment. The product can first be deployed as a centralized solution—a high level of access security can be maintained when a centralized solution is employed as a gateway to external content or service providers located outside of the operator domain. Later, as the number of subscribers increases, the Interactive Media server can be deployed in a distributed configuration within the operator environment.

Conclusion

The building blocks for on-demand mobile services have been standardized in the 3GPP, providing a solid base for multimedia services. Key factors of the success of operators and the Mobile Internet are quality multimedia content and a portfolio of compelling applications that comply with these building blocks.

Operators have numerous opportunities to add value to Mobile Internet services. In particular, they can function as a distributor of multimedia services and assume multiple roles in the value chain. Indeed, operators will be able to add value to any multimedia service, regardless of who provides it.

With its Interactive Media suite, Ericsson is well-prepared to fulfill the needs of operators who want to be first in the market with new and compelling multimedia services. At the same time, Ericsson provides an integrated multimedia-enabled terminal platform for OEM vendors. This platform enables on-demand media applications to access platform components through an open API.

In the future, more services will be enhanced with rich media. The first steps in this direction have already been taken for messaging and on-demand services. More advanced and powerful media types, such as vector graphics and synthesized audio will also be supported. Improved transport mechanisms will further enhance the quality of on-demand mobile media services.

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