User interest in mobile TV services is growing thanks especially to the rapidly evolving multimedia capabilities of mobile terminals. Mobile operators are thus eyeing mobile TV services both as a new source of revenue and as a way of increasing customer loyalty.

This article looks at some key components of a mobile TV solution that capitalizes on the capabilities of third-generation (3G) networks – in particular, built-in support of unicast and broadcast transmission, which fosters and sustains a strong uptake of service.

Drivers and challenges of a mass-market mobile TV service

Surveys show that end-users consider mobile TV to be one of the most interesting mobile applications on offer. Mobile TV is often identified with “linear TV” and scheduled broadcast distribution, but the concept of TV and especially that of mobile TV is rapidly evolving to embrace on-demand TV as well as podcast TV.

Market surveys and feedback from numerous test and commercial installations around the world confirm that users expect to be able to access TV content when and where they want, for instance while they are commuting via bus or rail.

As mobile TV gains ground among operators and end-users, the need to deliver it in a cost-effective way with guaranteed quality of service (QoS) becomes paramount. These two aspects are equally important: cost-effective delivery is a must in order for operators to maximize their revenues, just as adequate quality of service is necessary to guarantee a satisfactory end-user experience.

At present, mobile TV services are delivered over unicast best-effort bearers. In most cases, this form of delivery is adequate provided there is sufficient capacity in the network. Nonetheless, a surge in the volume of packet data traffic is putting pressure on the ability of networks to deliver delay-sensitive streaming services. For mobile TV services to succeed, a number of enablers must be put into place that maintain and improve the quality of the end-user experience. These enablers are:

- network capacity through proper dimensioning and enhanced technology;
- improved QoS handling for streaming services (as compared with background interactive traffic); and
- efficient broadcast capabilities in 3G networks – for example, multimedia broadcast/multicast service (MBMS).

Ericsson, followed by other companies, is introducing these enablers into its networks and terminals, and commercial deployments are set to begin in 2008. High-speed downlink packet access (HSDPA), for instance, brings exceptional capacity to unicast. Similarly, streaming QoS with guaranteed bit rates is now being introduced into terminals (it is already widely supported in networks). And initial deployments of MBMS began in 2008, adding unique broadcast capabilities to 3G networks.

Broadcast versus unicast

There has been a lot of talk lately about broadcast technologies being adequate enablers of mobile TV services. While this might be partially valid for traditional TV, it is evident – with the evolution of mobile TV service through on-demand TV, podcast TV, and interactivity – that unicast bearers are the true essential enablers.

The preferred solution for efficiently delivering mobile TV services calls for a combination of unicast and broadcast bearers. With unicast, operators can offer a broad selection of TV channels or content, even though only a limited number of users will view most channels. By contrast, operators can boost system capacity by employing broadcast capabilities to deliver the most popular channels in densely populated areas. The combined use of 3G unicast and broadcast capabilities enables operators to offer a virtually unlimited number of channels, as opposed to pure broadcast solutions, which put a hard limit (dictated by the amount of available spectrum) on number of channels.

In a nutshell, unicast can be used efficiently:

- to deliver a large number of niche TV channels to individual end-users;
- to deliver on-demand TV;
- to time-shift the delivery of linear TV (pause/play, fast-forward, rewind);
- to deliver podcast TV to individual end-users; and,
- to provide interactivity for, and facilitate the personalization of, TV service.

Likewise, broadcast techniques are best used to efficiently deliver popular TV channels to a larger number of end-users in a given geographic area and podcast TV to a large group of end-users.

Therefore, although unicast remains a fundamental component for delivering evolved mobile TV services, the addition of broadcast gives operators the most flexible and cost-effective solution for providing these services over a 3G network. In this context, the OMA BCAST standard plays an important role by defining a framework for global interoperability of mobile broadcast services.1
MBMS – the 3G broadcast technology

As explained above, operators need broadcast technology to cope with a high penetration of mobile TV services; the technical solution over 3G networks is called MBMS (multimedia broadcast/multicast service). Other wireless broadcast technologies also exist (such as DVB-H) but are not covered in this article, whose focus is on the capabilities of a 3G network.

The article Multimedia Broadcast/Multicast in mobile networks presented MBMS in some detail. At the time of publication (January 2005), the 3GPP standard defined just two modes of transmission: broadcast and multicast. Toward the end of 2006, 3GPP introduced a new “counting” mode for broadcast, also commonly referred to as enhanced broadcast. 3GPP designed the enhanced broadcast mode to better suit the characteristics of mobile TV services (in particular, fast channel switching) while achieving high spectrum efficiency. Below we provide an overview of the enhanced broadcast mode. Readers who wish to learn more about the broadcast and multicast modes of MBMS should refer to the aforementioned article.

Figure 1 illustrates the principle of MBMS enhanced broadcast mode. A tree-like transport plane bearer is established for each TV channel from the broadcast/multicast service center (BM-SC), through the GGSN and SGSN, to each radio network controller (RNC) that serves the target area. The transport plane bearer carries the audio and video components of the TV channel to the RNC. The RNC signals the availability of the TV channel on a common MBMS control channel (MCCH), which is always present in MBMS-enabled cells. When an end-user selects a TV channel, the terminal reads the MCCH information to determine whether or not the TV channel is available via MBMS in the cell. If the terminal does not find the TV channel on MCCH or there is no MCCH (for example, when an end-user is roaming in another country), the terminal can ask the TV server to send the content via unicast. The availability of the unicast alternative is indicated in the electronic service guide (ESG).

The information provided over MCCH indicates whether the

- TV channel is delivered on a point-to-multipoint radio bearer, in which case the terminal needs only “tune” to that radio bearer; or
- terminal needs to request a dedicated point-to-point radio bearer. No radio bearer is established until a terminal has requested one (this way, unused radio resources are conserved for other purposes). When the number of point-to-point radio bearers for a given TV channel reaches a predefined threshold, the RNC switches to a point-to-multipoint radio bearer and releases the point-to-point bearers (the threshold represents the breakeven point in terms of total cell power consumed by either transmission mode). After having switched to point-to-multipoint mode, the RNC randomly triggers terminals, inducing them to report their interest in the TV channel. This “recounting” procedure allows the RNC to reassess the appropriate transmission mode as users move to other cells or stop watching the TV channel.

**BOX A, UNICAST, BROADCAST, POINT-TO-POINT, POINT-TO-MULTIPOINT**

Unicast refers to a particular case of end-to-end, point-to-point communication between a server and a client (or receiver). Broadcast communication is typically end-to-end, point-to-multipoint communication between a server and multiple receivers. MBMS-enhanced broadcast mode extends this concept. It offers an end-to-end, point-to-multipoint communication service, but may employ any combination of point-to-point or point-to-multipoint radio bearers to reach the actual receivers.
The RNC thus always employs the most favorable transmission mode, conserving unused radio resources for other services. Note, however, that MBMS-enhanced broadcast does not make "plain" broadcast mode obsolete. In some cases -- for instance, where a large number of end-users with a common interest are concentrated in a limited geographic area -- MBMS broadcast (without recounting) is the perfect solution. Typical examples are local broadcasts in sports arenas or at exhibitions where targeted content can be distributed exclusively to the local audience. The MBMS service area concept defines the distribution area of an MBMS service with the granularity of one cell, allowing operators to define precisely where content is to be broadcasted.

Electronic service guide

MBMS service providers employ service announcements to inform user equipment (UE) or terminals about available services and how they can access them. In the context of TV services (such as linear TV, VoD, and podcast TV) the service announcements take the form of an electronic service guide (ESG), which is an XML file with technical information that receiving devices use to request, receive, decrypt and render services. Ericsson promotes the OMA BCAST standard, which defines a service guide structure and describes ways of accessing it -- for instance, by using a push mechanism over a broadcast bearer or a unicast pull mechanism.

The OMA BCAST ESG structure is made up of numerous fragments. The core fragments contain the program guide -- that is, the information which is meaningful to end-users, such as a list of TV channels and programs (previous, current, next) on each TV channel. The ESG also contains information that is understood by the receiving application but is not rendered to end-users. This includes the access fragments, which tell UEs what alternative bearers exist for each TV channel. The UEs select the most appropriate bearer in their current location, prioritizing broadcast bearers over unicast bearers when both options are available. The ESG is a key feature for offering mobile TV services that seamlessly integrate unicast and broadcast delivery. Note that the ESG solely refers to the access technology; the type of radio bearer used in broadcast mode is dictated by the information provided over MCCH.

Service access and content protection

After the broadcast client has received access information via the service announcement, the system cannot restrict reception of the media stream. The media streams must thus be encrypted to limit reception to those people/devices who have subscribed to the service. In other words, all receivers can receive the media streams but only subscribing clients can decrypt and render them.

An organized, layered hierarchy protects access to the MBMS service as follows (Figure 2). Each broadcast media flow is encrypted using an MBMS traffic key (MTK). This key is changed frequently and distributed, interleaved, in the actual broadcast flow. The traffic key is protected with an MBMS session key (MSK), which is distributed via unicast. Only devices that have registered and

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**BOX B: PODCAST TV**

Podcast TV describes a service to which end-users subscribe to view some kind of video content on a regular basis or as it becomes available. The video clips are pushed to subscribers. They are downloaded in the background, without user intervention, and stored in the terminal for off-line viewing. Examples include the last episode of a TV series, weather forecasts, news updates, and so forth.
authenticated with the BM-SC may receive the MSK. The MSK, in turn, is protected against eavesdroppers by the MBMS user key (MUK), which is derived from a shared secret key (Ks'). This key is established during the authorization procedure, part of the generic bootstrapping architecture (GBA). The actual media-protection keys change frequently and may thus solely be decrypted by registered devices.

The MUK and MSK are stored on the SIM card (more secure) or in device memory. The OMA BCAST specification delineates the protection of service access and content. Service access protection (SAP) is about limiting access to the service. Content protection (also known as digital rights management, DRM) is about the management of received content. Usage rights objects might restrict how end-users use content. An end-user, for example, might be able to record a mobile TV session but will be prevented from forwarding it. The OMA BCAST SmartCard profile complies with and further extends the 3GPP MBMS access-protection scheme described above.

Interactivity and personalization

Several TV programs contain “interactivity features” that help integrate the audience with the show they are watching. Popular TV shows like “Big Brother” and “American Idol” let the audience vote on its favorite contestants. Viewers typically cast their votes via voice calls or premium SMS with a keyword. The advantage of this approach is that it reuses existing charging methods. The price of a vote depends on the number dialed, and the charge is collected via a phone bill.

OMA BCAST takes interactivity one step further by specifying an interactivity enabler. Interactivity with an end-user is triggered by the reception of an interactivity media document, which describes the interactivity sequence (Figure 3). Interactivity media documents may be sent via unicast or inter-leaved with broadcast flows and transmitted to all listening devices. User feedback is then sent to the feedback collection server over a standard 3G unicast bearer (for example, via HTTP or SMS).

The interactive service content is distributed as a separate logical flow to receiving devices that then merge it into the actual pre-

Figure 3
Example of voting interactivity sequence:
(1) The device displays two alternatives. (2) After making a selection, the end-user is asked to confirm the charge. (3) The vote is then sent.

BOX C, ARCHITECTURE FOR MOBILE TV OVER 3G

Figure 4 gives a simplified view of a typical architecture for mobile TV over a 3G network. The BM-SC is a logical entity defined by 3GPP. In practice, its functionality is split among several physical components. The gray box roughly illustrates the distribution of BM-SC functionality.

The TV server is the first contact point for the terminal and the central control unit of the mobile TV service. The ESG aggregator translates and combines program information from content providers and inserts it into the ESG.

The media controller distributes content streams to UEs via unicast or broadcast. The encryptor encrypts the broadcast streams under the supervision of the service access protection (SAP) function (Figure 2). Unicast streams do not require additional access protection because standard 3G unicast security mechanisms already apply.

The broadcast controller establishes and releases MBMS bearers through the core and radio network.

The live encoder, podcast TV, and on-demand TV servers encode TV content in a format that is suitable for mobile devices and encapsulate it in applicable protocols for distribution.

The interactivity server generates interactivity documents. The feedback collector processes feedback from end-users.

Protocol names are mentioned for completeness. For further details, the reader is kindly referred to the following documentation from 3GPP:
- Multimedia Broadcast/Multicast Service (MBMS); Architecture and Functional Description (3GPP TS 23.246).
- Multimedia Broadcast/Multicast Service; Protocols and Codecs (3GPP TS 26.346).
sentation of the TV service. Therefore, one may personalize the interactive service experience. Users may browse the ESG, choose from a variety of interactive services and, by means of personal settings, specify how they want the service to be displayed.

“Voting” is but one example of an interactive service, and the interactivity enabler can be used to realize other services, such as news tickers or chat applications, or to distribute personalized or location-dependent advertisements.

Conclusion

Mobile TV is often identified with the “linear TV” of legacy, fixed TV networks, but Ericsson’s vision of Mobile TV also embraces the distribution of on-demand TV and Podcast TV content. The client’s electronic service guide (ESG) is a complete “content browser” that presents live, recorded and locally stored multimedia content by combining linear TV, on-demand and Podcast TV into a unified service offering.

MBMS is a technical extension to 3G networks: it reuses deployed infrastructure and spectrum. Moreover, Ericsson’s implementation of MBMS can be deployed as a software upgrade.

MBMS is used to boost capacity for transmitting popular Mobile TV channels to large audiences. The radio network determines whether it should employ point-to-point or point-to-multipoint radio-transmission resources. Mobile TV channels are thus solely broadcasted as needed. Integration with unicast makes it possible to offer a virtually unlimited number of Mobile TV channels and on-demand content. Consumer studies of legacy TV systems and Mobile TV trials have shown that users expect a large variety of channels, but only a small set of channels are especially popular at any given time.

Thanks to its inherent flexibility and efficiency, MBMS is Ericsson’s preferred choice of broadcast technology for Mobile TV as well as any other service that must deliver the same content to a large group of users in a 3G network.

Interactivity and personalization are powerful means of captivating an audience and increasing TV viewing time. Mobile TV, with its natural integration of unicast and broadcast communication channels, introduces entirely new ways of interacting with an audience and of creating a personalized TV experience. This new approach will become a key differentiator of Mobile TV offerings.

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