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Delivering content with LTE Broadcast

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Delivering content with LTE Broadcast

Ericsson has demonstrated LTE Broadcast with evolved Multimedia Broadcast Multicast Services at a number of international trade shows. These demos have shown the solution's potential to create new business models for telcos and ensure consistent QoS, even in very densely populated places like sports venues.

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The solution is built on LTE technology, extending the LTE/EPC with an efficient point-to-multipoint distribution feature that can serve many eMBMS-capable LTE devices with the same content at the same time. It can be used to boost capacity for live and on-demand content so that well-liked websites, breaking news or popular on-demand video clips can be broadcast – off-loading the network and providing users with a superior experience.

Single-frequency network (SFN) technology is used to distribute broadcast streams into well-defined areas – where all contributing cells send the same data during exactly the same radio time slots. The size of the coverage area of an LTE SFN can vary greatly, from just a few cells serving a stadium, to many cells delivering content to an entire country. eMBMS-enabled devices can select the broadcast streams within the SFN that are of interest. In this way, devices download only relevant data – not everything within the area to then just throw unwanted data away. This ensures that devices work in a battery-efficient way.

Business incentives

The coextending evolution of mobile technologies and devices has made it possible for people to consume video using handheld equipment without compromising their experience. Based on an Ericsson ConsumerLab study[1], the most recent Ericsson Mobility Report[2], states that video is the biggest contributor to mobile-traffic volumes, accounting for more than 50 percent. And the growth of traffic is expected to continue, increasing 12-fold by 2018.

According to another study, carried out by Mobile Content Venture[3], more than half of US consumers would consider viewing programs on their smartphones and tablets – 68 percent of respondents stated they would watch more TV if the content was provided on their mobile device, and 61 percent said they would switch operator to gain access to mobile-TV services. The majority of respondents said content they would find interesting to watch while on the move includes local news and weather information, movies, national news, sitcoms and sports.

To meet this growing demand for mobile TV, operators are rapidly updating their offerings, continuously adding new services and content to live and on-demand streams – increasing the volume of information transported. Naturally, this causes network utilization to rise, requiring more efficient ways to deliver content, while network dimensioning becomes all the more crucial, and new business models are needed to maintain ARPU.

Given the direction in which the industry is clearly moving, Ericsson has developed an end-to-end LTE Broadcast

BOX A Terms and abbreviations

AL-FEC	Application Layer FEC
API	application program interface
ARPU	average revenue per user
BLER	Block Error Rate
BM-SC	Broadcast Multicast Service Center
CDN	content distribution network
eMBMS	evolved MBMS
eNB	eNodeB
EPC	Evolved Packet Core
EPS	Evolved Packet System
FDD	frequency division duplex
FEC	forward error correction
FIFA	Fédération Internationale de Football Association
FLUTE	file delivery over unidirectional transport
HEVC	High Efficiency Video Coding
IMB	integrated mobile broadcast
ISD	inter-site distance
ISI	inter-symbol interference
M2M	machine-to-machine
MBMS	Multimedia Broadcast Multicast Service
MBMS-GW	MBMS-gateway
MBSFN	Multimedia Broadcast over an SFN
MCE	Multicell Coordination Entity
MME	Mobility Management Entity
MPEG	Moving Picture Experts Group
MPEG-DASH	MPEG-Dynamic Adaptive Streaming over HTTP
NBC	National Broadcasting Company
OFDM	orthogonal frequency division multiplexing
PGW	packet data network gateway
SDK	software development kit
SFN	single-frequency network
SGW	service gateway
SNR	signal-to-noise ratio
TDD	time division duplex
UDP	User Datagram Protocol
UE	user equipment

FIGURE 1 **Broadcast versus unicast**

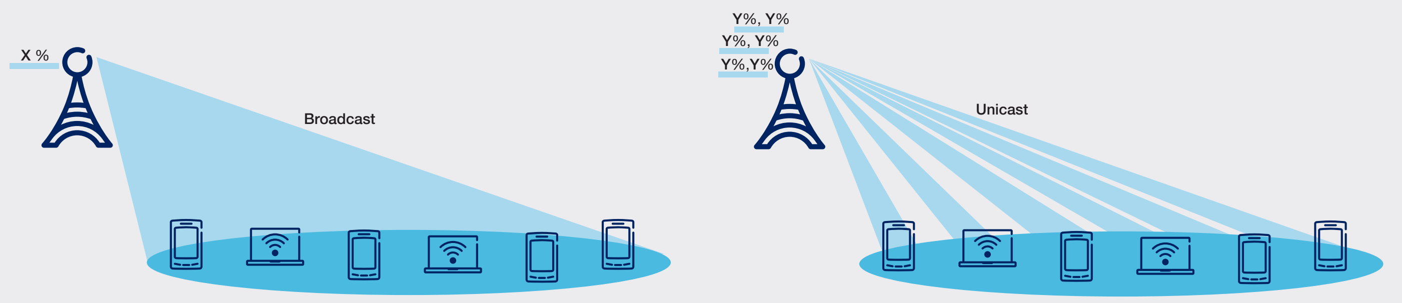


Table 1: Broadcast versus unicast

Broadcast	One data channel per content	Limited data channels, unlimited number of users	Resource allocation viewer independent
Unicast	One data channel per user	Unlimited channels, limited number of users	Resources allocated when needed

solution. The concept has been built on eMBMS technology and based on a set of use cases that can be divided into two main categories:

- delivery of live premium content; and
- unicast off-loading (for example, local device caching).

Premium content

Despite the diversity of available content and an obvious shift by subscribers towards on-demand viewing, watching certain events and programs live continues to appeal to large audiences.

London 2012 is a good example of an event that enjoyed widespread live-viewing appeal. Ratings place the NBC coverage of the games as some of the most watched TV in US history; almost half of the online video streams were delivered to tablets or smartphones, and revenue expectations were far surpassed. Some use cases for premium content are as follows:

Regional and local

This use case covers regional and local interest events, such as concerts, sports fixtures or breaking news. Such as the Super Bowl, FIFA World Cup matches, as well as elections and royal weddings. Given suitable content security and digital-rights handling, this use case can be enhanced to allow users to store and replay the event on-demand from their device for a certain period of time.

Venue casting

This use case covers specific locations such as shopping malls, museums, airports, university campuses and amusement parks. In this case, the operating enterprise may wish to broadcast content to users, which can vary from breaking news of national interest to very specific information such as special offers available at the mall, additional information about the main artist of an art exhibition, or departures and arrivals information at the airport.

For all of these premium-content use cases, operators can deliver services on a nationwide basis as well as locally. The duration of a broadcast and the size of the geographical area where it is available can be managed dynamically, depending on the nature and relevance of the content. By using unicast for blended services, broadcast services can be complemented with interactivity – opening up new ways to generate revenue from content.

At a soccer match, for example, these value-added services could include video streams carrying footage from additional camera angles, diverse audio coverage and live results of related matches taking place at the same time in other stadiums.

Unicast off-loading

MBMSs are traditionally associated with the delivery of live, linear TV, although this technology also supports file delivery. Exploiting this and the caching capability available in both mobile and fixed devices creates new possibilities for a range of use cases.

Popular content

Operators can choose to deliver popular TV and video clips to the local cache of a user's device at their convenience. Based on content popularity and busy-hour-traffic distribution, operators can deliver content when network load is low. Content shared on popular video streaming sites, as well as the content provided by national and cable TV channels can all be pre-loaded to mobile devices through broadcast – significantly reducing the overall network capacity required to deliver frequently-consumed video streams.

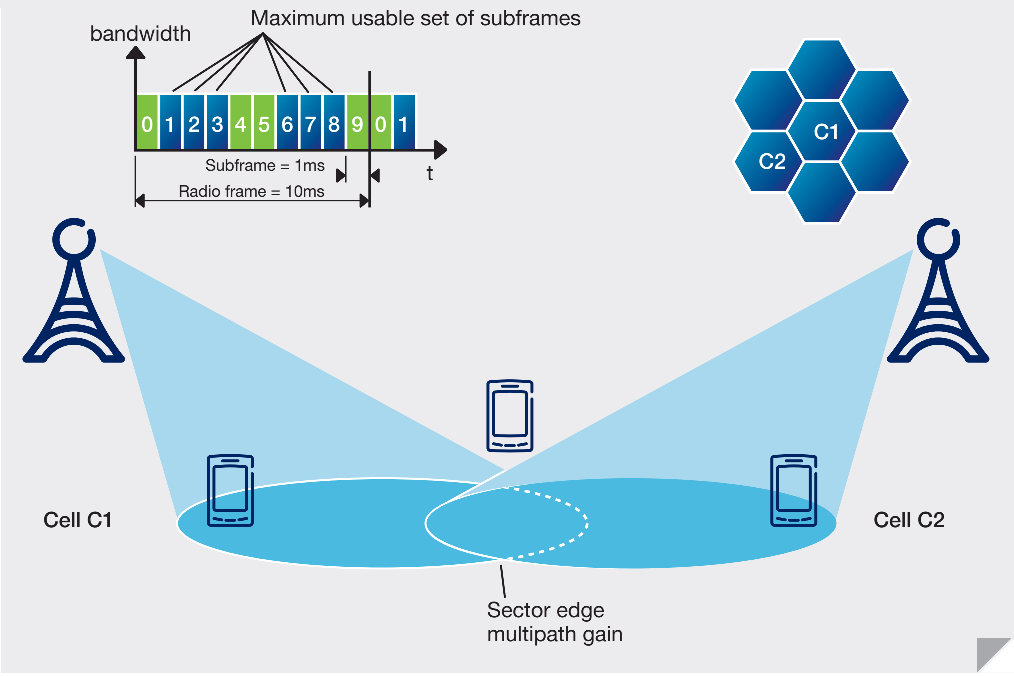
News

Daily clips and subscription content such as a magazine can be pre-delivered to the cache of a subscriber's preferred device for that content.

Software upgrades

Upgrades to application software and operating systems are usually released over the network to large numbers of subscribers at the same time. This traditional way of performing an upgrade can be a burden on the network. By using LTE Broadcast instead, upgrades can be distributed as packages to a multitude of devices at little expense in terms of required resources – an

FIGURE 2 SFN principles



approach that is particularly advantageous if the broadcast can be delivered during off-peak hours.

M2M and B2B

Over the coming decade, machine-to-machine (M2M) data traffic and the internet of things will create more connectivity demands on the network and create the need for diverse types of eMBMS LTE-enabled devices. LTE Broadcast technology supports efficient one-to-many transfer of machine data in any file format, which can be used for M2M use cases, off-loading the network and providing the essential machine connectivity and control.

Ericsson value proposition

The concept of Ericsson's LTE Broadcast solution enables unicast and broadcast service blending, aiming to help meet the challenges created by rising mobile usage and the growth of video traffic in LTE networks. The solution covers the entire chain from live encoder, through delivery via point-to-multipoint transport to devices.

Particular focus has been placed on the specification and implementation of the device, starting with the physical chipset as well as transport control middleware – essential enablers for the creation and deployment of eMBMSs.

Implementing live streaming with MPEG-DASH[4] is a technology choice that supports the common use of a player on devices and a live encoder head-end system for both unicast and broadcast – reducing operating costs and maximizing infrastructure usage. As outlined later in this article, extensive simulation, lab testing and field trials have been conducted with the aim of characterizing the spectral efficiency of eMBMSs in deployed networks with mixed traffic profiles.

The results show that live video broadcast with commercially acceptable levels of video and audio degradation is achievable. For video broadcasting to smartphones and tablets, compression using the H.264[5] standard is feasible, with HEVC[6] coming sometime in the near future.

System architecture

Broadcast and unicast radio channels coexist in the same cell and share the available capacity. The subset of available radio resources can temporarily be assigned to a broadcast radio channel.

Mobile-communication systems such as LTE are traditionally designed for unicast communication, with a separate radio channel serving each device. The resources allocated to the device depend on the data rate required by the service, the radio-channel quality and overall traffic volumes within the cell.

Broadcast is implemented as an extension to the existing EPS architecture (see **Figure 7** and **Box B**). Ericsson's LTE Broadcast system is mainly a software upgrade applied to existing nodes. The concept was designed according to 3GPP MBMS 23.246 for E-UTRAN and to coexist with unicast-data and voice services.

LTE Broadcast gives operators the flexibility to tailor the way content is delivered to suit their capabilities.

Service dynamics

This supports live streaming and file-delivery use cases. Different service combinations may be delivered simultaneously over the same bearer.

Time dynamics

LTE Broadcast activation triggers the allocation of radio resources on a needs basis. A session may be active for a short time say several minutes or for longer periods: several days in some cases. When the session is no longer active, the assigned radio and system resources can be reallocated for use by other services.

Location dynamics

LTE Broadcast can be activated for small geographical locations, such as stadiums and city centers, or for large areas, covering say an entire city or region. As long as there is sufficient capacity in the network, multiple broadcast sessions can be active simultaneously.

Resource allocation dynamics

This involves the free allocation of resources for LTE Broadcast. Up to 60 percent of the FDD radio resources and up to 50 percent for TDD can be assigned to a broadcast transmission.

Principles of the radio interface

The LTE radio interface is based on OFDM in the downlink, where the frequency selective wideband channel is subdivided into narrowband channels orthogonal to each other. In time domain, a 10ms radio frame consists of subframes of 1ms each; where a subframe is the smallest unit with full frequency domain that can be allocated to a broadcast transmission.

With eMBMS, all users within the broadcast area, provided they have the right subscription level and an MBMS-capable device, can receive broadcasted content. By setting up a single bearer over the radio interface, operators can distribute a data stream to an unlimited number of users.

Although it is possible to deliver broadcast within a single cell, the concept becomes truly interesting with SFN, the principles of which are illustrated in the lower part of **Figure 2**.

Broadcast data is sent over synchronized SFN – tightly synchronized, identical transmissions from multiple cells, using the same set of subframes and modulation and coding scheme, appear to the device as a transmission from a single large cell over a time-dispersive channel. This improves received signal quality and spectral efficiency (as shown in Figure 2). For a more detailed description, refer to LTE/LTE-Advanced for Mobile Broadband[7].

The maximal usable set of subframes is shown in the top left of the diagram, and the nodes are time-synchronized to a high precision.

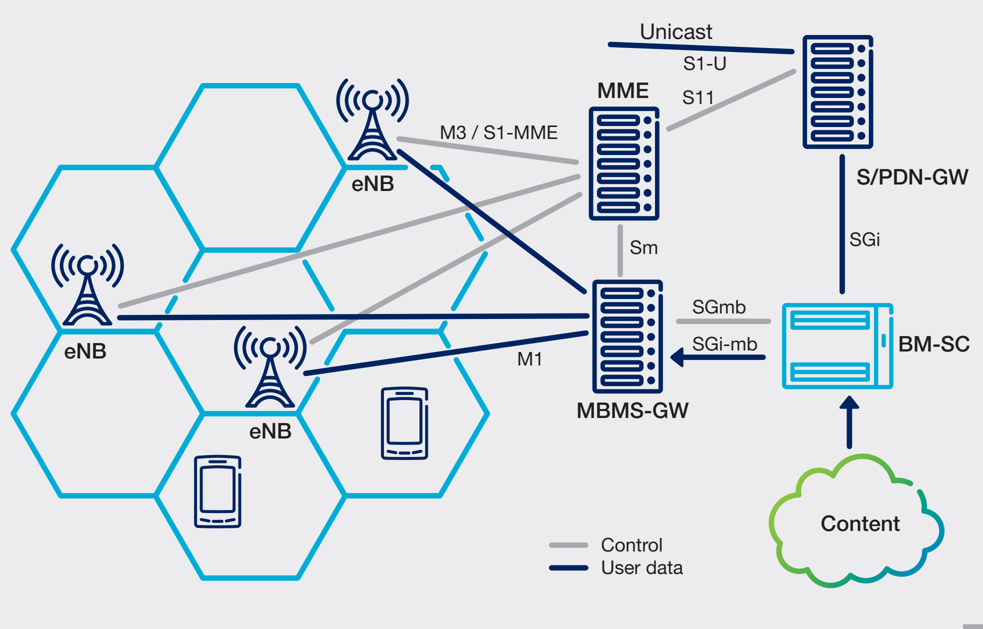
By using long data-symbol duration in OFDM, it is possible to mitigate the effect of inter-symbol interference (ISI) caused by delayed signals. For additional protection against propagation delays LTE/OFDM uses a guard interval – delayed signals arriving during the guard interval do not cause ISI and so the data rate can be maintained. For SFN, unlike unicast, signals arrive from many geographically separate sources and can incur large delay spread.

Consequently, one of the factors limiting MBMS capacity is self-interference from signals from transmitters with a delay that is greater than the guard interval (low transmitter density). To overcome this, a long cyclic prefix is added to MBSFN-reserved subframes to allow for the time difference in the receiver and corresponds to an ISD of approximately 5km.

Architecture

The eMBMS architecture, shown in **Figure 3**, is designed to handle transmission requirements efficiently.

FIGURE 3 **Architecture – with only eMBMS components shown**



The Broadcast Multicast Service Center (BM-SC) is a new network element at the heart of the LTE Broadcast-distribution tree. Generic files or MPEG-DASH live video streams are carried as content across the BM-SC and made available for broadcast. The BM-SC adds resilience to the broadcast by using AL-FEC – which adds redundancy to the stream so that receivers can recover packet losses – and supports the 3GPP-associated delivery procedures. These procedures include unicast base file repair – allowing receivers to fetch the remaining parts of a file through unicast from the BM-SC and reception reporting, so operators can collect QoE reports and make session-quality measurements.

Another new network element is the MBMS-GW, which provides the gateway function between the radio and service networks. It forwards streams from the BM-SC to all eNBs participating in the SFN transmission. IP multicast is used on the M1 interface between the gateway and the eNBs, so that the packet replication function of existing routers can be used efficiently. The gateway routes MBMS session control signaling to the MMEs serving the area. The MMEs in turn replicate, filter and forward session control messages to the eNBs participating in the specific broadcast session.

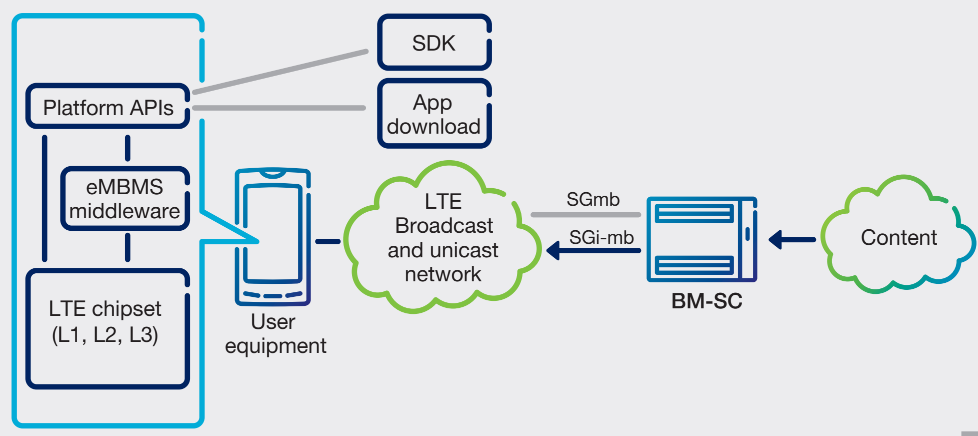
The eNBs provide functionality for configuration of SFN areas, as well as broadcasting MBMS user data and MBMS-related control signaling on the radio interface to all devices. Note, the eNB contains the 3GPP Multicell Coordination Entity (MCE) function.

eMBMS LTE-enabled devices are an essential part of the ecosystem. LTE capabilities are becoming integrated into more and more types of devices and may be implemented on devices other than phones and tablets such as embedded platforms for M2M communications.

The UE platform is divided into three main blocks (see **Figure 4**):

- the lower block incorporates the LTE radio layers, which are typically implemented in the LTE chipset, supporting unicast as well as broadcast;
- the middleware block handles the FLUTE protocol[8], AL-FEC decoding, unicast file repair and other functions. It includes transport control functions, such as service scheduling, as well as a cache for post-broadcast file processing; and
- the top platform block exposes APIs to the middleware and connectivity layer methods.

FIGURE 4 **UE and SDK in eMBMS ecosystem**



Application development is enabled through an SDK, which provides the platform APIs. The SDK enables developers to create and test eMBMS-enabled applications without requiring detailed knowledge of the underlying transport, control, or radio-bearer technology.

Spectral efficiency

According to 3GPP specifications, eMBMSs and unicast services should be provisioned on a shared frequency. Consequently, while a broadcast service is active, radio-interface resources can be borrowed from unicast capacity.

Spectral efficiency can be defined as the possible information rate transmitted over a given bandwidth with a defined loss rate. The information loss rate depends on the modulation and coding scheme used for physical transmissions and the protection offered by AL-FEC. This definition of spectral efficiency includes packet overheads, such as AL-FEC redundancy.

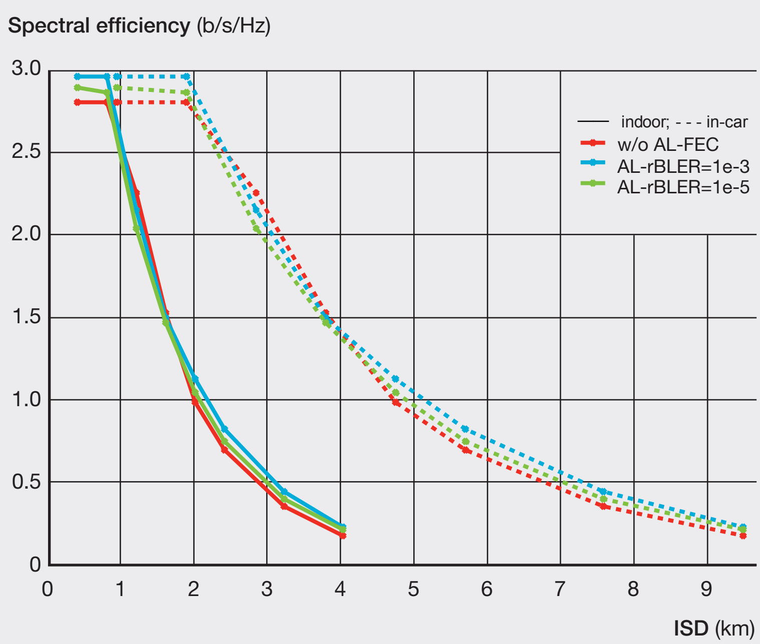
The simulation results from an evaluation of spectral efficiency are shown in Figure 5. The results associated with a broadcast transmission depend on the ISD in a link budget – signal-to-noise ratio (SNR) – limited deployment. Two urban environments were simulated: indoor scenarios with 20dB penetration loss and in-car scenarios with 6dB loss assuming 95 percent coverage probability in all cases.

The failure criterion used was 10^{-3} BLER (corresponding to a packet loss of four packets per hour) and simulations were run with and without AL-FEC. An ideal Raptor code with FEC covering 2s per source block was used in this evaluation. The payload for each source block consisted of 50 packets with each IP packet spanning two transport blocks.

The MBSFN simulation area included 19 sites, each with three sectors. The results show that MBMS spectral efficiency of about 1-3bps/Hz (indoor/in-car) could be achieved for a cellular ISD of up to 2km. The simulation results and additional testing show that FEC improves video quality and saves capacity.

From the graphs in Figure 5, it is possible to conclude that when ISD is less than 1km, spectral efficiency is greater than 2.5b/s/Hz. By allocating one subframe for MBMS transmission in 20MHz spectrum, corresponding to 10 percent of capacity, the achievable data rate is in the range of 5Mbps.

FIGURE 5 **Evaluating spectral efficiency**



BOX B
Standards

The standardization of MBMS started in 3GPP with Rel-6, which supported GERAN and UTRAN access networks. Over time, 3GPP has improved the access network support by, for example, defining the integrated mobile broadcast (IMB) solution, which uses UTRAN TDD bands to offer up to 512kbps per content channel. Support for E-UTRAN access (LTE) was added to 3GPP Rel-9 as part of the eMBMS standardization activity.

Live video and file delivery

The two main eMBMS use cases are live streaming and on-request file delivery. Live streaming supports services for real-time video and audio broadcasting, and on-request file delivery enables services such as unicast off-load (local device caching), software updates and M2M file loading. In fact, any arbitrary file or sequence of files can be distributed over eMBMSs.

The target broadcast area for these use cases may be any desired size – some scenarios require a small broadcast area, such as a venue or a shopping mall, and other cases require much larger areas, even up to nationwide coverage. Ericsson has selected MPEG-DASH for live streaming delivery over eMBMSs.

This solution slices the live stream into a sequence of media segments, which are then delivered through the system as independent files.

Typically, HTTP is used to fetch these files. In the eMBMS case, one quality representation is delivered as a sequence of files through eMBMSs using MBMS file delivery.

By using MPEG-DASH with eMBMSs, the same live encoder and common clients can be used for unicast and broadcast offerings. This solution also supports using the same system protocol stack for both live streaming and file-delivery implementation.

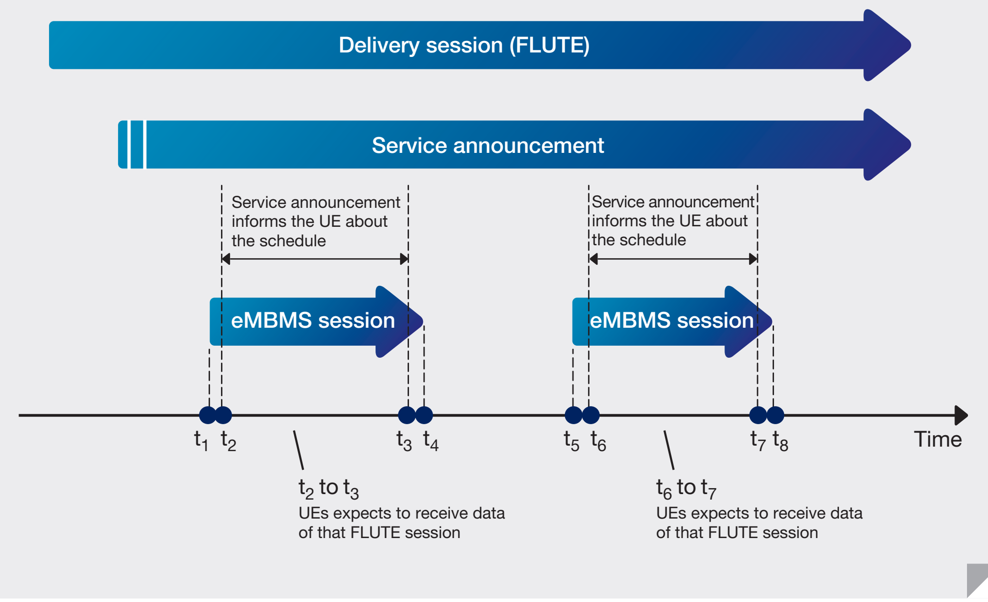
The IETF FLUTE protocol[8] allows distribution of files over unidirectional links using UDP. Most service-layer features can be used for both streaming and file delivery; transmission reliability can be increased using AL-FEC in both cases. File delivery can also make use of the unicast file-repair feature – allowing UEs to fetch any missing file segments. However, this feature is not intended for use with services that have real-time requirements, such as live streaming.

With FLUTE, delivery and eMBMS sessions are used, where the duration of a delivery session may span one or more eMBMS sessions. The broadcast is active for the entire eMBMS session, during which UEs can receive content. The relationship between delivery sessions and eMBMS sessions is shown in **Figure 6**. Service announcement is used to inform devices about delivery sessions and also about eMBMS sessions using a schedule description. UEs do not need to monitor the radio interface for eMBMS sessions continuously.

In Figure 6, the schedule description instructs the UE to expect an eMBMS session between t_2 and t_3 and between t_6 and t_7. Before the UE expects an eMBMS session, it is already active on the radio interface ($t_1 < t_2$). When it comes to file-delivery services, it is preferred that devices should search for sessions prior to expected transmission time on the radio, to ensure that they do not miss the start of a transmission.

The example in Figure 6 could represent a service, such as downloading an application that allows users to activate, receive and interact with the broadcast using unicast services from a phone, tablet or television.

FIGURE 6 **Example of two scheduled broadcasts**



From the point of view of the user and the UE middleware, the two broadcasts belong to the same MBMS user service, which presents a complete offering including activation and deactivation.

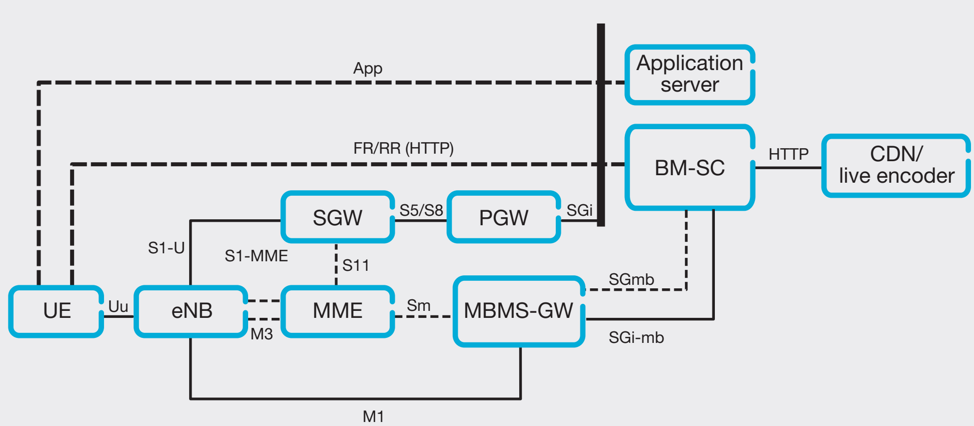
Conclusions

The data volume in mobile networks is booming mostly due to the success of smartphones and tablets.

LTE Broadcast is one way of providing new and existing services in areas that can at times be device dense, such as stadiums and crowded city centers. Single-frequency network technology is used to distribute the content over the air interface.

LTE Broadcast provides operators with techniques to deliver consistent service quality, even in highly crowded areas. Such techniques for delivering content efficiently are valuable as they free up capacity, which can be used for other services and voice traffic. ❖

FIGURE 7 **eMBMS architecture**



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Thorsten Lohmar

joined Ericsson in Germany in 1998 and worked in different Ericsson Research units for several years. He worked on a variety of topics related to mobile-communication systems and led research projects specifically in the area of multimedia technologies. On the development front, he is focusing on the technical coordination of eMBMSs with an end-to-end perspective. He is currently working as a senior specialist for end-to-end video delivery, principally in mobile networks. Lohmar holds a Ph.D. in electrical engineering from RWTH Aachen University, Germany.

Michael Slssingar

is an Ericsson senior specialist in service delivery architectures and holds a post-graduate diploma and master's in computing and software engineering. He has held many senior engineering roles at Ericsson, mainly in the media-delivery field, and has contributed to the Ericsson IPTV and Mobile TV delivery solutions. In the field of MBMS, Slssingar initially specialized in WCDMA MBMS, where he helped develop the Ericsson Content Delivery System. More recently, he has worked with LTE eMBMS broadcast, where he has a strong interest in the service layer BM-SC node, UE middleware and metadata provisioning areas.

Stig Puustinen

is a senior project manager at System Management within Business Unit Networks, where he is currently running an LTE/EPC systems project involving extensive eMBMSs work. He joined Ericsson in 1991, and has since held a variety of project- and program-management roles. He was involved in the early releases of GSM, the first introduction of WCDMA/HSPA and the first release of LTE/EPC.

Vera Kenehan

is a strategic product manager within LTE Radio and has worked with several generations of radio-access technologies, including LTE, WCDMA and PDC. She was largely involved in the initial standardization of LTE, including eMBMS. For the past two years, she has been working on the MBMS product as well as promoting and bringing eMBMS to the market. She holds a master's in telecom engineering from the University of Belgrade, Serbia.

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