eMBMS

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The Broadcast Advantage
Optimized RAN and Transport Resources

The Unicast Approach

- Multiple streams of the same content delivered individually from the content source.

The Broadcast Approach

- Single stream of content delivered to multiple users.
Three Key Use Cases For Public Safety

1) Streaming video for real-time situational awareness

2) Push To Talk

3) File delivery for non-real-time services such as all points bulletin (e.g. amber alert), software updates/upgrades, ...
LTE Broadcast: evolved Multimedia Broadcast Multicast System (eMBMS)

- First introduced in 3GPP Rel-9
- eMBMS bearer provides efficient delivery over transport network and air interface
  - Downlink only transmission
  - IP multicast in transport network
  - Broadcast subframe in air interface --- all UEs in common broadcast group tune into the same subframes
- GBR bearers --- quality content delivery (e.g. video content)
- Transport and radio resources are set up dynamically when there is an active broadcast session
Multimedia Broadcast over a Single Frequency Network (MBSFN)

- MBSFN area: group of cells performing synchronized eMBMS transmission so signals from all cells in the area appear as multipaths to UEs (automatically combined for diversity gain)
  - Basic building block for providing eMBMS service
  - Same frequency; same subframe allocation and MCS selection per physical channel
- Similar to multipaths from a single cell, but with longer distance thus larger propagation delay → need for extended Cyclic Prefix (CP) and strict synchronization
- Important for eMBMS due to lack of MIMO, HARQ, and frequency selective scheduling
- Uses extended CP in eMBMS subframes and normal CP in unicast subframes

Synchronization requirements
- Frequency sync: 50 ppb
- Phase sync: 1.5 us
- Content sync: SYNC protocol between BMSC and eNB to map content to specific scheduling period
Multimedia Broadcast over a Single Frequency Network (MBSFN)

Identical signals transmitted

Base 1

Cyclic Prefix
Useful Symbol Time

Base 2

Cyclic Prefix
Useful Symbol Time

Unicast subframe
7% CP overhead

4.7us 66.6us

eMBMS subframe
25% CP overhead

16.6us 66.6us

Note: All signals & multipath over a useful symbol time are from the same symbol & add constructively

Note: dashed lines represent multipath
Flexible radio resource definition

- Up to 6 out of 10 MBSFN sub-frames per frame (i.e. max. 60% loading)

Resources allocated to eMBMS follows a cyclic pattern

- eMBMS transmission can occur only on predefined radio frames
- Configurable periodicity of 1, 2, 4, 8, 16 or 32 radio frames
  - Min Subframe rate = 1 SF / 320ms
  - Max Subframe rate = 6 SF / 10ms
- eMBMS subframe allocation is conveyed in SIB2

UEs can consume eMBMS services while connected or idle

Flexible bandwidth allocation to eMBMS services vs. unicast: 1/320th to 6/10th
MBSFN Area Planning

Service definitions

Where: distribution area
What: contents
When: schedule

Required eMBMS capacity = $f(MCS, \%BW)$
- MCS: # bits / subframe
- %BW: # subframes / sec

Unicast traffic demand
- Busy hour?
- %BW available for broadcast

Protection tier (yellow cells) may be added on top of intended broadcast area (blue cells) to meet capacity requirement based on service definition

Broadcast areas with strong signal and line of sight, as well as weak or no neighbor interference caused by either unicast or other broadcast (gray cells) may not require the use of protection tier
Service Area (1 of 2)

- **Service Area** is a group of cells distributing a broadcast service
  - Typically statically defined
  - Can be supported by multiple whole MBSFN areas
  - 3GPP allows a maximum of 65536 service areas in a PLMN
  - No limit on # cells in a service area
  - No limit on # cells in an MBSFN area, or MBSFN sync area
Service Area (2 of 2)

- One cell can belong to up to 8 MBSFN areas and it can serve multiple Service Areas (SA)
Service Area Example: Push To Talk

State Police PTT

Town A Police PTT

Town B Police

MBSFN AREA #1

MBSFN AREA #2

MBSFN AREA #3

MBSFN AREA #4

MBSFN AREA #5

Content N+A

Content N+B

Content N

Content N+C
E2E System Architecture and Environment

eMBMS elements

Bearer plane

BMSC – Broadcast Multicast Service Center
MBMS GW – MBMS Gateway
MCE – Multi-cell/multicast Coordination Entity

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C-plane functions

- Control eMBMS sessions: initiates session control messages (e.g. Session Start/Stop) towards MBMS-GWs
- Server for file repair and reception report services: direct HTTP interface to UEs
E2E System Architecture and Environment

- ** bearer plane**
- ** U-plane functions**
  - Content ingestion point
  - Bearer content processing: FEC, FLUTE, SYNC
  - Distributes content towards MBMS-GWs

**eMBMS elements**

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**eMBMS elements**

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E2E System Architecture and Environment

C-plane functions
- Relays session control messages towards MMEs involved in an eMBMS session
- Creates and maintains M1 GTP-U tunnel
E2E System Architecture and Environment

U-plane functions
- Distributes content towards eNBs participating in an eMBMS session
- Uses IP Source Specific Multicast (SSM): MBMS-GW is the source host of M1 traffic
E2E System Architecture and Environment

C-plane functions
- Relays session control messages towards MCEs
- Maintains M3 SCTP connection with every MCE
**MCE C-plane functions**

- Coordinate radio resource allocation among eNBs of the same MBSFN area to enable MBSFN operation
- Deterministic admission control of eMBMS sessions
E2E System Architecture and Environment

**eMBMS elements**
- Allocates radio resources per MCE instructions
- Joins/leaves IP SSM channels per active eMBMS sessions

**eNB C-plane functions**
- Allocates radio resources per MCE instructions
- Joins/leaves IP SSM channels per active eMBMS sessions

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**Diagram Notes:**
- SGW, PGW, SGi
- S1-U, S5/S8
- Area 1, Area 2
- Video Server
- Mobile Backhaul Network
- BMSC
- Encoder / Segmenter
- File server / CDN node
- Content Source

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**Figure Details:**
- eNB/MCE
- MME
- MBMS-GW
- S11, Sm, SGmb, SGI-mb
- Uu, S1-U, S1-MME
- Video Server
- Encoder / Segmenter
- File server / CDN node
- Content Source
- Mobile Backhaul Network
- SGW, PGW, SGi
- Video Server
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E2E System Architecture and Environment

- **eNB U-plane functions**
  - broadcasts content received over M1 GTP-U tunnels
Sample eMBMS Capacities (10MHz FDD)

- Single cell with no protection tier dense urban area
  - Spectral Efficiency = 0.2 bps/Hz
  - Assume 1 subframe per 32 radio frames assigned to eMBMS
    - Total eMBMS capacity = 6 Kbps (using 0.3% of carrier)

- Large MBSFN dense urban area
  - Spectral Efficiency = 2.5 bps/Hz
  - Assume 1 subframe per 32 radio frames assigned to eMBMS
    - Total eMBMS capacity = 78 Kbps (using 0.3% of carrier)
  - Assume 2 subframes per every radio frame assigned to eMBMS
    - Total eMBMS capacity = 5 Mbps (using 20% of carrier)
eMBMS Enhancements in 3GPP Release 10 and 11

Release 10:
- Subframe reuse
- Counting
- ARP

Release 11:
- Multi-carrier support
Conclusion

- eMBMS important capability for public safety
- Greatly improves efficiency when sending information to multiple users in the same cell
- Careful planning of MBSFN areas required based on the type of service
  - May need to do modeling for the specific type of service (e.g. PTT)
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