

Security Level:

RP-141920: Motivation of Rel-13 New Study Item proposal for Support of single-cell point-to-multipoint transmission in LTE

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Source: Huawei, HiSilicon
Document for: Information
Agenda Item: 14.1.2

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Critical communications

Critical communications can be used for public safety applications and also for general commercial applications (e.g., utility companies and railways).



Figure 1: Use cases

To enable LTE to support critical communications, 3GPP initiated the standardization work in Rel-12.

Rel-12 GCSE

In Rel-12 GCSE, group communication was specified based on the existing eMBMS. The system architecture is as below:

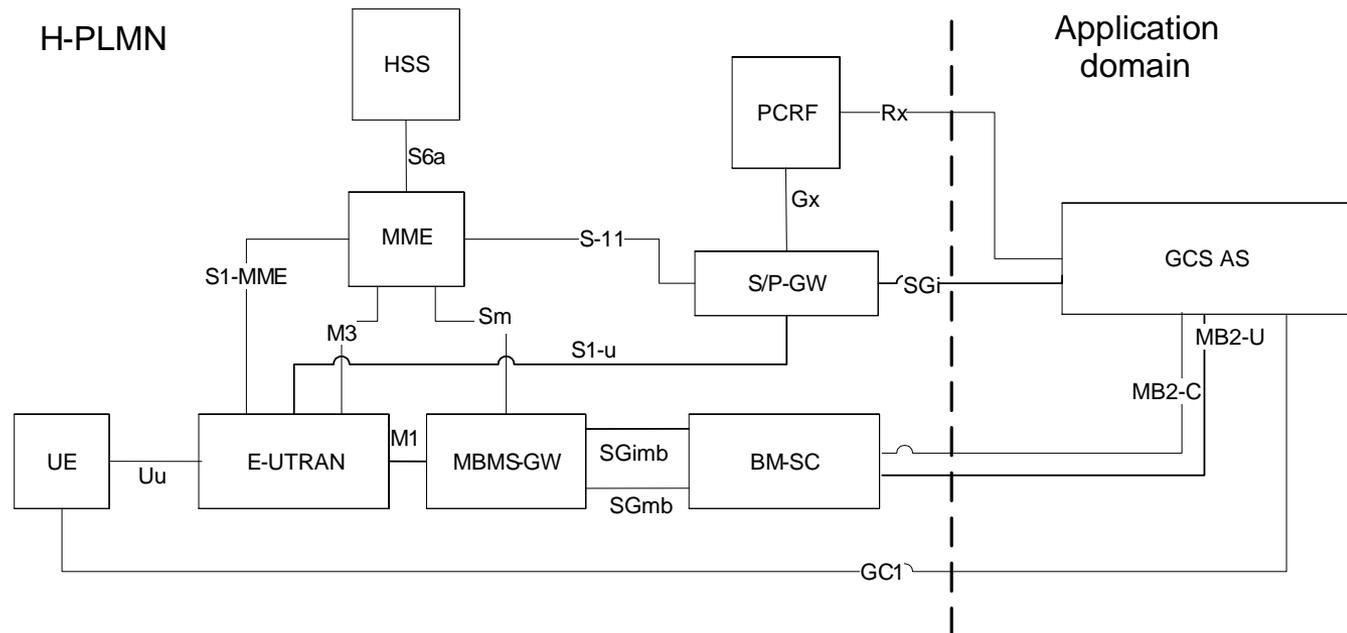


Figure 2: GCSE system architecture

However, the radio functions of current eMBMS is not efficient and flexible to support critical communications.

Problems of critical communications over eMBMS – static multicast area

eMBMS was originally designed for the provision of media content in a large pre-planned area (i.e. MBSFN area), e.g. for mobile TV. It is assumed that interested users are evenly distributed over the MBSFN area.

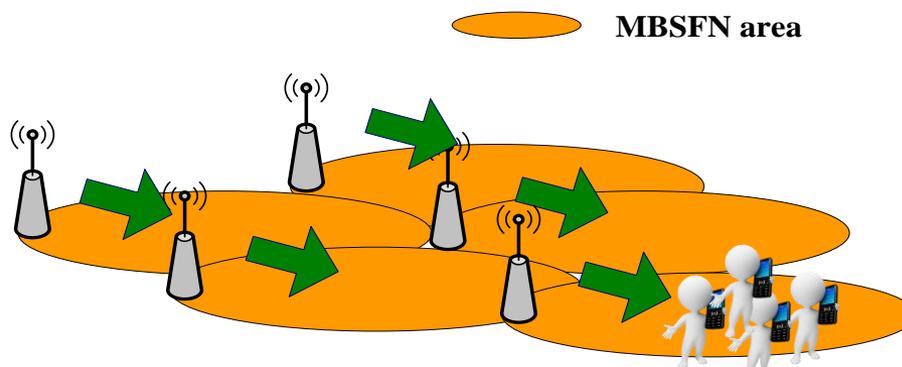


Figure 3: Uneven user distribution

For critical communications over eMBMS, eMBMS broadcasting may happen in cells where no interested users exist, as shown in Figure 3, because:

- MBSFN area configuration is rather static (e.g. configured by O&M). The multicast area can't be dynamically adjusted according to user distribution, e.g. cell by cell.
- Different groups have to share the same MBSFN area and PMCH.

Problems of critical communications over MBMS – static resource allocation

For critical communications over eMBMS, the following problems exist for resource allocation:

- It is not possible to assign the entire system resource for group communication (i.e. only up to 6 subframes per radio frame could be configured as MBSFN subframes).
- The MBSFN subframe configuration is rather static (e.g. configured by O&M) and can not be dynamically adjusted according to the number of active groups and the traffic load of different groups.
- MBMS transmission will occupy the entire system bandwidth, and multiplexing with unicast in the same subframe is not allowed, even though not all the radio resources in frequency domain are utilized (e.g. because the traffic under broadcasting is of low data rate).

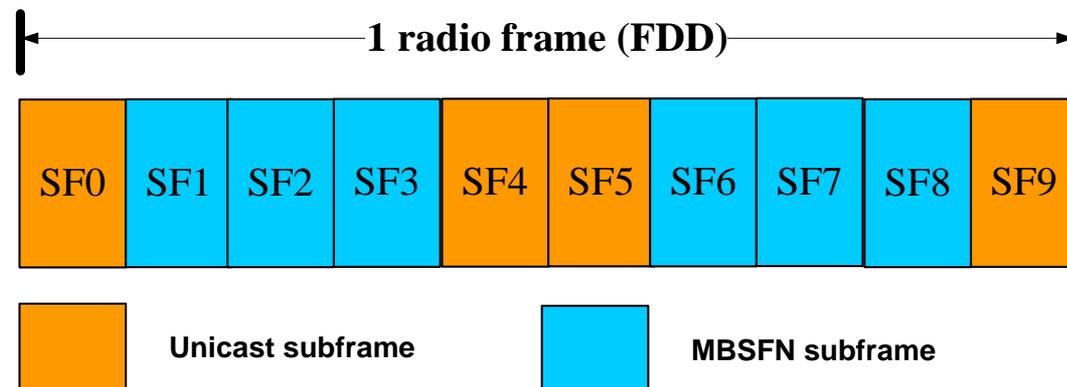


Figure 4: MBSFN subframes

Problems of critical communications over MBMS – resource waste

For critical communications over MBMS, it is very likely that:

- MBMS bearers are pre-established, to shorten the group call setup delay;
- Many more MBSFN subframes than those effectively used are booked, to satisfy potential concurrent group calls;

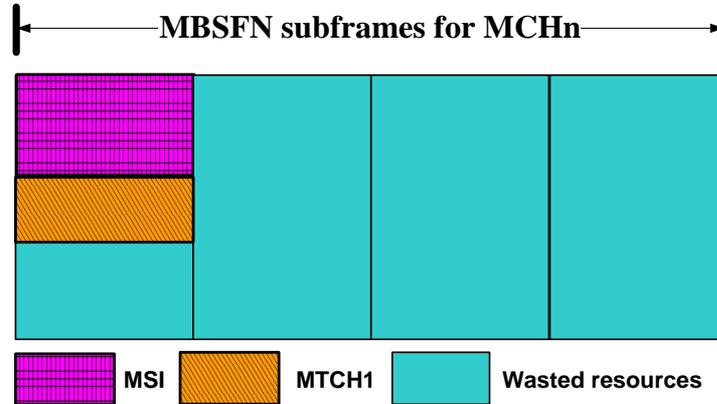


Figure 5: Waste of radio resources

Radio resource allocated for MBSFN might be wasted in case there are no available or no sufficient traffic data to broadcast, although technically the unused MBSFN subframes could be reused for DL unicast scheduling for TM9/10 UEs, because:

- We cannot rely on large-scale TM9/10 UE support. We cannot expect a large amount of ordinary UEs to support TM9/10, nor for public safety UEs.
- So far, no network supports TM9/10, because 1) only 2 TX are deployed and 4 TX are unlikely to be available soon, especially for FDD networks; 2) there is more reference signal overhead for DMRS comparing to CRS.

Note: When there is no available traffic data to schedule, radio resource still will be unnecessarily consumed by the periodically transmitted “empty” MSI.

Problems of single cell MBSFN

Even if 3GPP specifies MBSFN with single cell granularity in Rel-13, the following problems remain:

- The static radio resource allocation for MBSFN.
- The impossibility to multiplex unicast and MBMS in the same subframe.
- The waste of radio resource in case there is no available or no sufficient traffic data to broadcast.

Below are some other problems:

- MBSFN only supports extended cyclic prefix, which is actually not necessary for single cell MBSFN. This leads to 14.3% system capacity lost.
- Advanced technologies, e.g. MIMO, can't be adopted for single cell MBSFN.

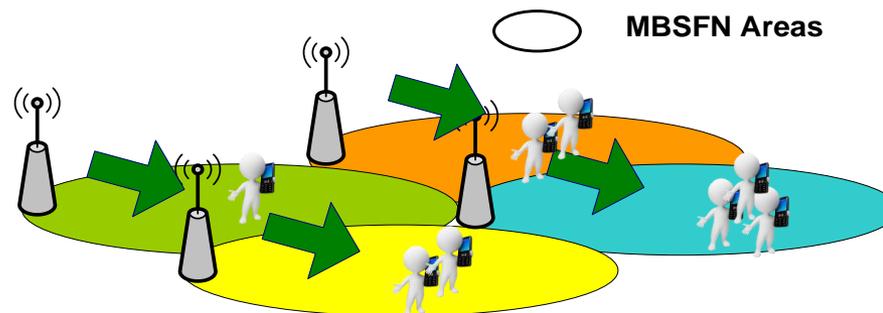


Figure 6: Single cell MBSFN

Single-cell PTM transmission

For critical communications, radio efficiency should be seriously considered, whether critical communications are deployed in dedicated network or in shared network (i.e. in carrier operator's network).

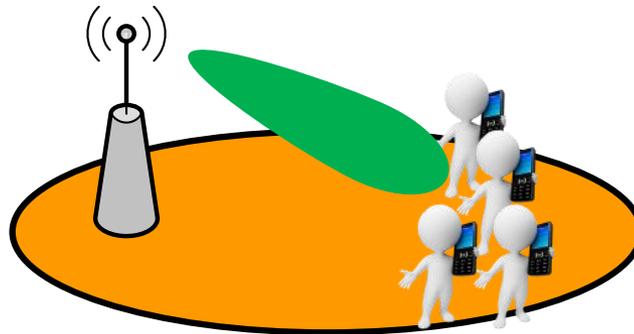


Figure 7: Single-cell PTM transmission

Problems for critical communications over eMBMS could be solved by the so called Single-cell Point To Multipoint transmission, where:

- Multicast is performed over PDSCH on a per cell basis.
- Common Group-RNTI is assigned to a group of users to schedule the traffic via shared radio resources.

Smooth evolution

- To enable the smooth evolution from Rel-12 GCSE (MBMS based) to Rel-13 Single-cell PTM transmission, the Rel-12 GCSE system architecture is kept.
- Enhancement will focus mainly on the radio efficiency improvement.

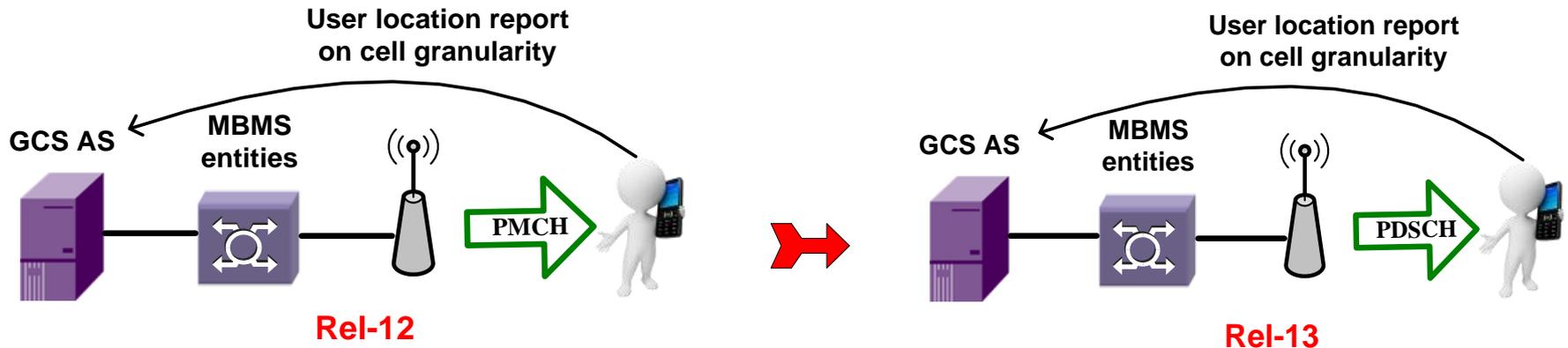


Figure 8: Path of smooth evolution

DL data routing

Below is the high level procedures for DL data routing:

- **Step 1:** The interested UE reports its location information (e.g. ECGI of the current cell and/or TAI) to the GCS AS.
- **Step 2:** GCS AS triggers the establishment of the MBMS bearer, in case e.g. the number of UEs in Cell A for Group A is more than 4 (see page14).
- **Step 3:** Appropriate MME/MCE/eNB nodes are selected according to the UE location information.
- **Step 4:** MCE sends the MBMS session start message towards the concerned eNB(s), i.e. the eNB where user locates.
- **Step 5:** The concerned eNB(s) join the transport network IP multicast.

For UE location reporting:

- We assume that the report of the UE location and interest is done in the application layer, according to the Rel-12 GCSE work (as well as the Rel-13 enhancement, i.e. SA2 WI “MBMS Enhancements” in S2-143785).

Single-cell PTM reception

- UE performs the single-cell PTM reception either in idle mode or in connected mode.
- UE knows the TMGI(s) for the group(s) of interest via USD, as Rel-12 GCSE.
- eNB allocates the Group-RNTI for each TMGI upon the reception of MBMS session start message.
- eNB broadcasts the mapping between Group-RNTI and TMGI, hence UE knows which Group-RNTI could be used for single-cell PTM reception.

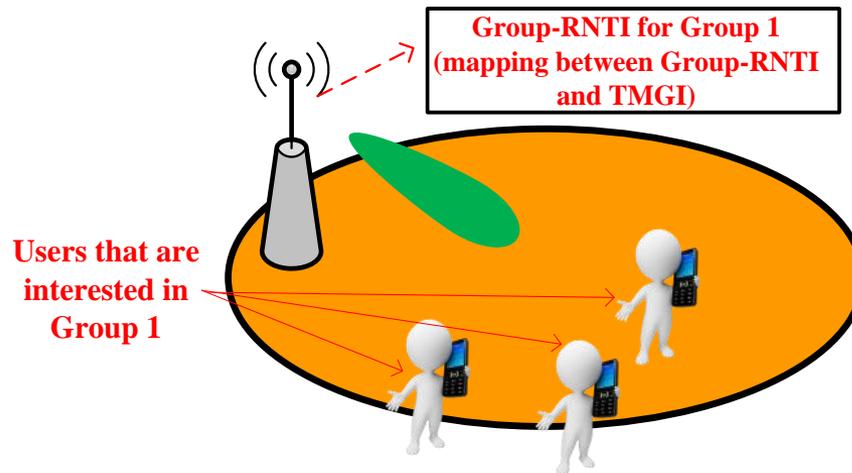


Figure 9: Single-cell PTM reception

To increase the efficiency and coverage, HARQ retransmissions can be considered for single-cell PTM transmission based on the HARQ/CSI feedback from connected mode UEs. Alternatively, DL repetitions could be used to increase the coverage. eNB could also force cell edge UEs to enter into connected mode.

Advantages of Single-cell PTM transmission

With the single-cell PTM transmission, problems caused by eMBMS could be solved, and spectrum resources could be fully utilized:

- Multicast only occurs in cell where the interested user are located.
- Radio resources could be flexibly shared between multicast and unicast.
- Radio resources for multicast could be freely adjusted according to the number of active groups and the traffic load of different groups.
- No radio resource waste occurs.

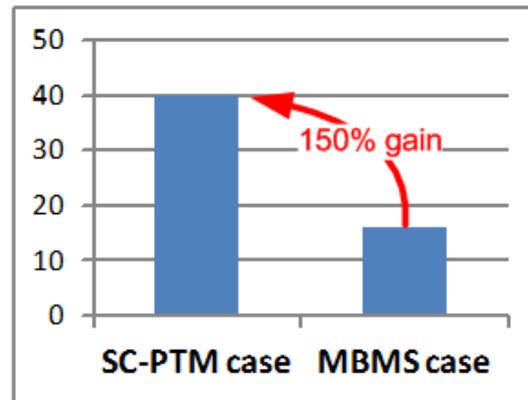


Figure 10: Radio resource utilization gain
(# usable subframes within 40ms for unicast)

Comparing to eMBMS, 150% gain can be achieved for single-cell PTM in extreme case (i.e. 6 MBSFN subframes are configured per radio frame, no TM9/10 UEs exist, no available traffic data to schedule).

Advantages of Single-cell PTM transmission – continue

With the single-cell PTM transmission, the following additional advantages could be observed:

- Shorter group call setup latency and media transport latency comparing to eMBMS.
- Easy network planning and deployment – it is not necessary for the operators to make their network synchronized in order to support MBSFN.
- Existing mature UE chipset can support single-cell PTM transmission with software upgrade.
- Advanced technologies, e.g. MIMO, can be adopted without specification impacts.

Performance: Single-cell PTM transmission vs. Unicast

Table 1: Simulation assumptions (3GPP Case1)

| Carrier Frequency | ISD | Bandwidth | Antenna Config | Multicast Tx scheme | Unicast Tx scheme | Multicast target | UL feedback for Multicast | Traffic Model |
|-------------------|------|------------|----------------|---------------------|-------------------|---------------------------|---------------------------|---------------|
| 2.0GHz | 500m | FDD: 10MHz | 2X2 | TxD | SU-MIMO | 95% coverage with 1% BLER | No HARQ/CSI feedback | Full buffer |

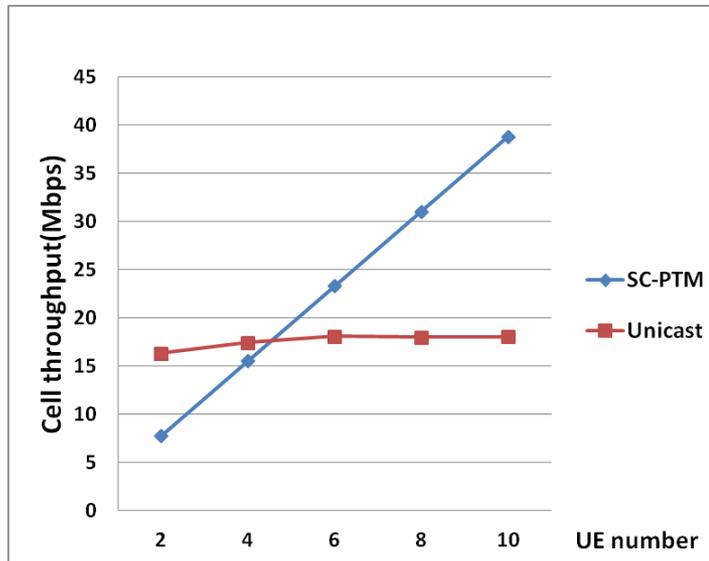


Figure 11: Cell throughput

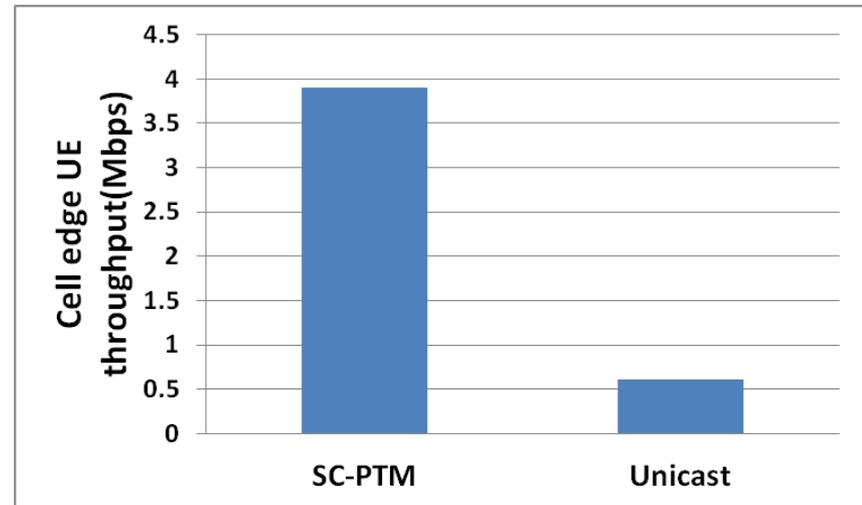


Figure 12: Cell edge UE throughput (UE number=10)

With single-cell PTM transmission:

- When the number of users in a group is > 4 , gain on cell throughput could be achieved.
- Significant gain on cell edge UE throughput can be achieved. The gain increases when the number of users in a group grows.

Performance: Single-cell PTM transmission, additional evaluation

Table2: Performance of SC-PTM
(Burst Traffic, with UE HARQ/CSI feedback,
Carrier Frequency=800MHz, ISD=1732m,
UE number=10)

| | UE speed =3km/h | UE speed =30km/h |
|--------------------------------|--------------------|---------------------|
| Cell throughput (Mbps) | 113.9 | 91.1 |
| Cell edge UE throughput (Mbps) | 11.4 | 9.0 |

Based on these simulation results, Single-Cell PTM transmission can provide quite good cell edge performance

Table 3: Simulation assumptions

| Parameter | Assumption |
|------------------------------|--|
| Channel Model | ITU |
| Deployment scenario | Rural macro-cell |
| Cellular Layout | 19 cell sites, 3 sectors per site |
| Inter-site distance | 1732m |
| Penetration Loss | 0 |
| Carrier frequency | 800MHz |
| Duplex method and bandwidth | FDD 10MHz |
| UE speeds | 3km/h or 30 km/h |
| Macro cell antenna gain | 15.0 |
| UE antenna gain | 0 |
| BS TX power | 46dBm |
| UE TX power | 23dBm |
| Load (User num/sector) | 10 UEs/sector Randomly uniform drop in whole network |
| Traffic Model | Bursty Buffer $\lambda=0.2$ packet size = 0.5 Mbits |
| Downlink transmission scheme | TXD |
| Antenna configuration | 2x2 |
| Antenna configuration at BS | Uncorrelated cross-polarized: Columns with ± 45 deg linearly polarized antennas |
| Antenna configuration at MS | 0.5 wavelengths between antennas at MS |
| Downlink receiver type | MMSE-IRC |
| Downlink HARQ scheme | CC up to 3 re-transmission |
| Overhead consumptions | 0.708 |
| Multicast target | 95% coverage with 1% BLER |

Other commercial use cases

Single-cell PTM reception could also be used for other commercial use cases. Figure 13 gives two examples.



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Mobile Advertising

Figure 13: Example use cases

Those use cases have the following characteristics:

- Users located within a geographical area have a common interest on the service/content.
- Multicast area is dynamic.
- Multicast area may be a single cell

Conclusions

- eMBMS was originally designed for the provision of pre-planned media content in a large pre-planned area, e.g. for mobile TV.
- eMBMS needs enhancements in order to support group communication for critical communications and some commercial use cases.
- Single-cell PTM transmission is more efficient and flexible on the air interface than eMBMS in supporting group communication.
- Nevertheless, operators already planning to deploy eMBMS based group communication can update that with Single Cell PTM solution in order to enhance efficiency and flexibility.
- It is proposed to setup a new RAN2 lead Study/Work Item for Single-cell PTM transmission in 3GPP Rel-13.

Thank you

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