

Source: Motorola
Title: Further Results on EMBMS Transmission Configurations
Document for: Discussion
Agenda Item: 4

1. Introduction

During the RAN2#56 meeting in Riga, an LS was addressed to RAN1 requesting information on the number of guard and assisting cells required for efficient SFN operation and on the efficiency of the following radio techniques [1] for E-MBMS:

Technique 1: Normal PTP Radio Bearer

Technique 2: SFN soft combining

Technique 3: Single cell PTM – No Interference Co-ordination of neighbour cells

Technique 4: Single cell PTM – UE providing Uplink ACK/NACK feedback

Technique 5: Single cell PTM – Interference reduction by not transmitting on neighbour cells

In addition to those listed above, RAN1 has decided to investigate an additional radio technique [2]

Technique 6: Single cell PTM - UE providing Uplink CQI and ACK/NACK feedback

Detailed analysis of the relative performance of each scheme has been presented in [3][4], but no conclusion could be reached since results addressing non-uniform UE spatial distributions were not yet available. This contribution addresses the issue of non-uniform UE distributions and offers conclusions with the objective of completing the final response to [1].

2. Network Simulations

A three ring hexagonal grid layout was simulated assuming a dual port UE receiver operating in spatially uncorrelated channels in a 10MHz bandwidth. Simulations involving Technique 2 and 5a¹ use the extended cyclic prefix (CP) in wide area deployment scenarios while simulations for all other techniques use the normal CP. The normal CP is further used by Technique 2 in the investigated local area deployment mode of Technique 2 described in Section 3.3.

All of the techniques described above are well known, or discussed in [2]; only Technique 2 for the local area deployment scenario of Section 3.3 and Technique 5a for the wide area deployment scenario are newly defined here. Technique 2 in the local area scenario was simulated with the 3 cells surrounding the UE location area forming a 3 cell MBSFN and all other cells acting as interferers. Technique 5a was simulated with UE's located in the center site (i.e. in all 3 sectors). Sectors in the 1st ring of sites whose pointing angle was directed towards the center site used the same time frequency resources as the center site to deliver the common MBSFN transmission. All other cells acted as interferers in this technique.

¹ Note: In technique 5a, sectors not containing UE's may assist in the transmission of the center site rather than act as a guard cell.

In all simulations, two of the available OFDM symbols in the subframe are used for PDCCH transmission. This may be a slightly pessimistic assumption for Technique 2. Each transmission of a transport block is assumed to occupy exactly one sub-frame. Transport block payload calculations assume the presence of reference symbols on antenna 0 on all OFDM symbols eligible to transport reference symbols in a subframe. A unicast PDSCH RS mapping is assumed for Technique 1, Technique 6 and for Technique 2 in Section 3.3 (i.e. local area mode), while an MBSFN RS mapping and overhead according to TS 36.211 was assumed for Technique 2 in Sections 3.1 and 3.2 (i.e. wide area modes), and for Techniques 3 and 5a. Note that this is a somewhat pessimistic assumption given the expected channel length for those cases. Simulations of Technique 1 and Technique 6 also assume up to 4 transmissions of the same codeword, with each transmission spaced 5ms apart, per transport block. A CQI estimate is made 3ms before the first transmission for Technique 1 and Technique 6 and operates without a quantization restriction and without feedback error. The CQI estimate is then used to determine the MCS for all transmissions of a transport block which are Chase combined. The available MCS set with corresponding coded and uncoded bits in a subframe for normal CP are listed in [3].

For Technique 1 (ptp) the selected MCS is the highest rate MCS listed in [3] that achieves a target FER of 30% or better assuming one transmission. For Technique 6 (ptm with CQI and ACK/NACK feedback), the highest MCS that achieves a target FER of 30% or better assuming one transmission is computed for each active UE in the cell. The selected MCS is then the lowest of these per UE MCS's. It should be noted the sole impairment in the modeled CQI feedback process is delay. Since a velocity of 3 kmph is assumed for all UEs this delay is unlikely to be of significant importance during simulations and may lead to optimistic results for Technique 1 and Technique 6. A detailed description of all techniques investigated in this contribution can be found in [3] and [4].

3. Results

The resources required to deliver a 256kbps MBMS service in several scenarios is considered in this section.

3.1. User Distribution Scenario 1

In this scenario, UE's are assumed to have a uniform distribution throughout a network. The cumulative density function (cdf) of the fraction of each cell's radio resources required to deliver an MBMS service at a rate of $R \in \{256kbps\}$ for a mean UE density per cell of $\rho_{UE} = \{0.1, 0.5, 1, 2, 4\}$ is then generated and the mean fraction of cell resources per cell (where the expectation is taken with respect to all cells in the network) required to deliver the service is plotted in Figure 1 for Case 1 and Case 3 deployment scenarios.

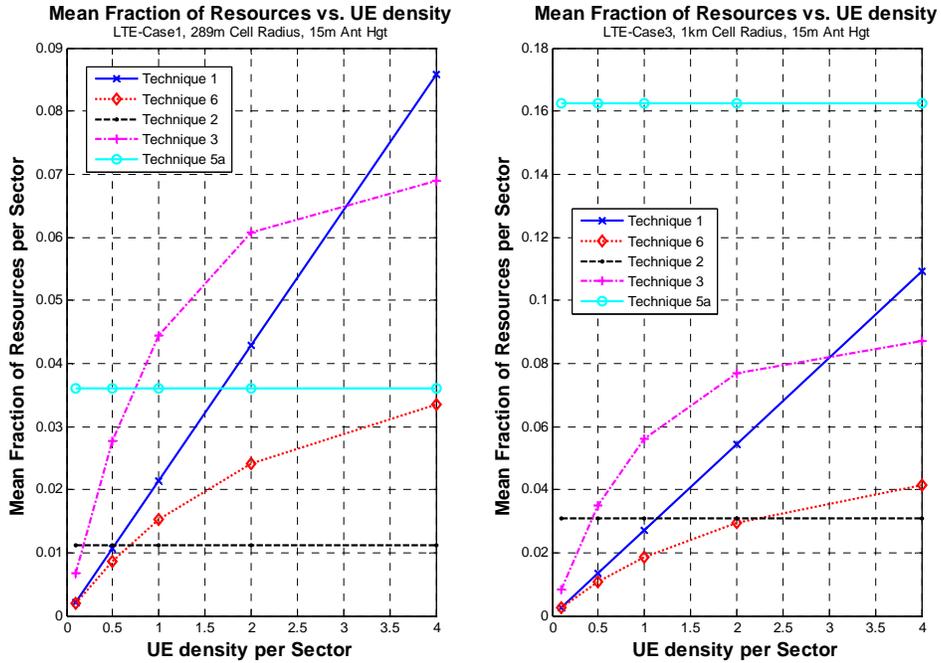


Figure 1 – Mean fraction of cell resources for a uniform UE spatial distribution.

In the simulation, if the instantiation of the UE “drop” did not render a UE to be present in a particular cell, then radio resources for techniques other than Technique 2 and Technique 5a were set to zero in those cells. In other words, counting was effectively applied for those techniques.

It can be seen from the data that for this scenario, Technique 2 generally provided the best performance, except at very small per-cell UE densities. That is, Techniques 1 and 6 were generally only superior for mean UE densities below 2 users per cell, and Technique 6 was only superior to Techniques 1 and 2 over a very small range of UE densities in Case 3.

3.2. User Distribution Scenario 2

In this scenario, UE’s are assumed to have a *three-tier* non-uniform spatial distribution with 25% of UE’s uniformly distributed over 10% of the total network area in the first tier, 50% of UEs uniformly distributed over 40% of the total network area in the second tier and 25% of UEs uniformly distributed over 50% of the total network area in the third tier. This UE spatial distribution was designed to represent a definite but moderate “clustering” of UE’s interested in an MBMS service into localised areas of the network.

The corresponding mean fraction of cell resources required to deliver a rate of $R \in \{256\text{kbps}\}$ for a mean UE density $\rho_{UE} = \{0.1, 0.5, 1, 2, 4\}$ (where the UE density mean is computed over the entire network, taking into account the non-uniform UE density) appears in Figure 2.

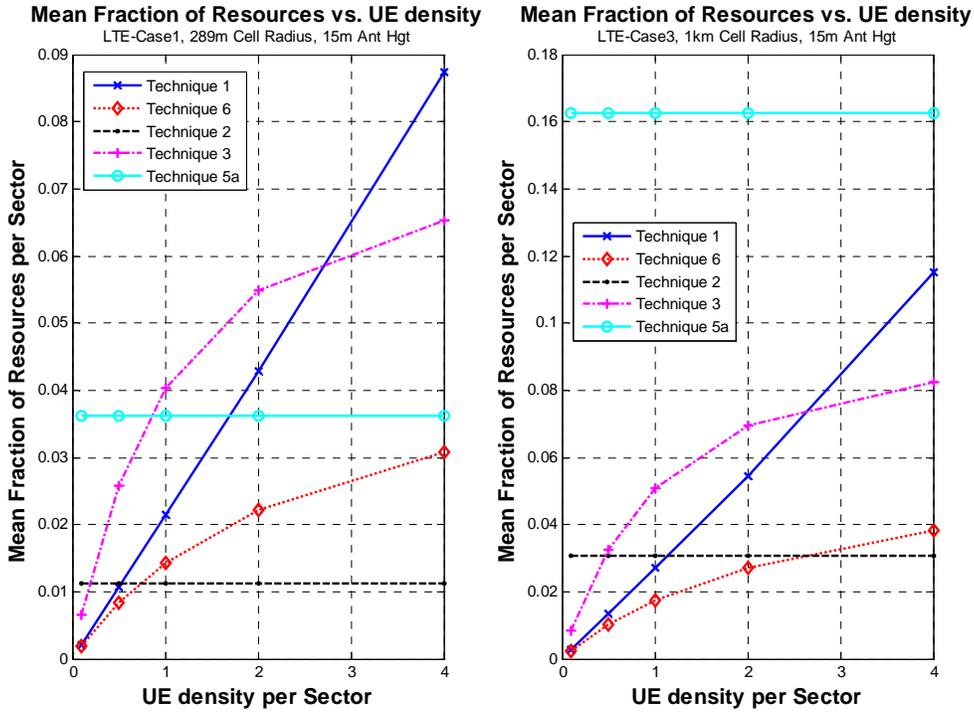


Figure 2 - Mean fraction of cell resources for non-uniform UE spatial distribution.

Comparing Figure 1 and Figure 2, it can be seen that the non-uniform spatial distribution slightly enhances the benefits of Technique 6 for Case 3, but the change is quite limited and has little impact on the mean fraction of cell resources required to support the 256 kb/s service.

3.3. User Distribution Scenario 3

Scenario 3 models a deployment of UE's over a local region shown by the coloured region in Figure 3. The distribution was selected to model the case where a cluster of users interested in a specific MBMS service are in very close proximity. In other words, this is a two-tier non-uniform UE distribution where 100% of the UE's interested in the MBMS service are located in the region identified in Figure 3, with zero UE's interested in the service UE outside that region.

In this instance, Technique 2 was modified to limit the number of sectors N participating in the SFN to the sectors marked 'A', 'B' and 'C' in the figure, where it is assumed that local counting techniques identified the appropriate sectors.

Although UE locations are localized and near the sector edge, it can be seen in Figure 4 that Technique 1 is outperformed by Technique 2 in both deployment scenarios with more than 1 UE per sector. Technique 6 is outperformed by Technique 2 in with at least 3 UEs in each sector for Case 1 deployment scenarios and 6 UEs in each sector for Case 3 deployment scenarios.

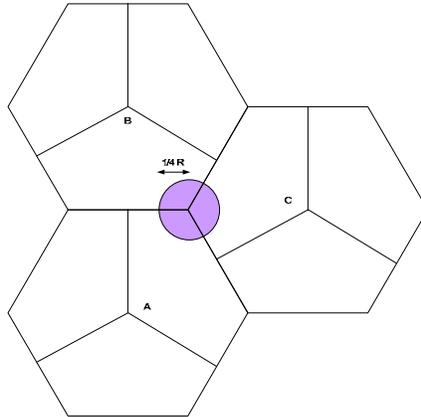


Figure 3 - Scenario 3 deployment

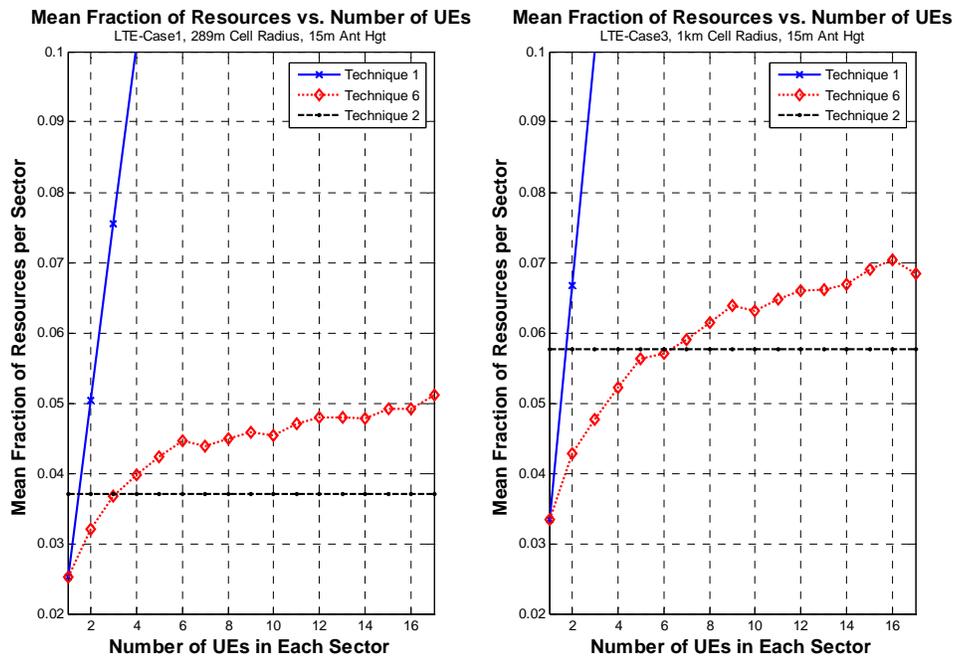


Figure 4 - Mean Fraction of Cell Resources for Scenario 3

4. Discussion

The results of Scenario 1 and Scenario 2 again indicate [3] that Technique 6 does not appear to offer a significant advantage over a combination of Technique 1 and Technique 2 for *wide area* EMBMS service delivery.

Although the fully localized offering of EMBMS as envisaged by Scenario 3 might be considered an extreme case of the non-uniform distribution, it has been mentioned previously as a scenario where Technique 6 could be especially beneficial. Given that, Figure 4 indicates that even for localized EMBMS user distributions Technique 6 offers limited benefit. Further, it is inapplicable to users in RRC_IDLE

mode unless additional loading of the RACH channel is envisaged to provide the common feedback channel and CQI reporting channel.

Additionally for Technique 6, handover to a target cell already offering the same EMBMS service may be a source of concern. More exactly, if the target cell is also offering the same EMBMS service as the source cell, then since Technique 6 does not ensure streaming synchronization between the source and target cell, it is reasonable to assume the target cell could be some time interval ahead or behind in the delivery of the service compared to the cell sourcing the handover. If the target cell is behind the source cell, then no data is lost to the UE engaged in the HO but the UE application layer must be paused to synchronise with the target cell. If the target cell is ahead of the serving cell, then data will be lost to the UE engaged in the HO in addition to any delay associated with handover, since bicasting or data forwarding techniques seem to be inapplicable. In comparison, although UEs using Technique 1 will lose some data at handover (e.g. around 22ms [5]), the issue is less significant since conventional handover data recover techniques are applicable. It should however be noted that both Technique 1 and Technique 6 will face both the handover delay and inter-cell synchronization issue when switching service to or from Technique 2 (MBSFN).

One potential solution to remedy the handover problems for Technique 6 is to rely on upper layer coding, but the redundancy (i.e. overhead) required to mitigate this issue could be significant. It should be noted this overhead was not accounted for in simulations provided in Figure 1, Figure 2 or Figure 4.

Finally, it is worth noting that multi-antenna transmission techniques were not applied to either Technique 1 or 6 here. Clearly, single- or multi-stream MIMO methods (whether 2x2 or 4x2) are applicable to Technique 1, and this would improve the relative efficiency of Technique 1 compared to the other techniques. However, precoded MIMO feedback would seem to be inapplicable to Technique 6, or at least inefficient, and so any MIMO technique applicable to Technique 6 would presumably be limited to open loop methods such as that applied to the CCPCH.

5. Conclusions

Although Technique 6 does provide some benefit over Technique 1, the benefit appears limited to a small range of UE densities per cell, and to very specific deployment modes. Given the ancillary complications associated with Technique 6, such as loss of data during handover, and potential limitations to the application of multi-antenna eNB techniques, the case for Technique 6 does not appear compelling based on the current analysis. Since Technique 1 is essentially provided “for free” it is proposed that MBMS delivery over LTE be specified as a combination of:

- a) Technique 1 : Normal PTP Radio Bearer
- b) Technique 2: SFN soft combining

and that RAN2 be advised that this is the conclusion of RAN1.

6. References

- [1] R2-063503, “LS on Radio efficiency for delivery of Broadcast/Multicast Services”, RAN2, Riga, Latvia, Nov.6-Nov.10, 2006.
- [2] R1-071213, “Response LS on Radio efficiency for delivery of Broadcast/Multicast Services”, RAN1, St. Louis, U.S.A., Feb.12-Feb.16, 2007
- [3] R1-071433, “Additional Results on EMBMS Transmission Configurations”, RAN1#48bis, St. Julians, Malta, March 26-30, 2007.

- [4] R1-070051, "Performance of MBMS Transmission Configurations", RAN1#47bis, Sorrento, Italy, Jan.15-19, 2007
- [5] R2-07xxxx, "LTE Performance verification – Handover Latency", RAN2#58, Kobe, Japan, May 7-11, 2007