

Source: Motorola
Title: Unicast and MBSFN Subframe Structure Indication
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1. Introduction

During the discussion of mobility measurements, it was decided that measurements would be *transparent* to whether subframes in the serving or other cells are unicast or MBSFN. Mobility measurements are possible, using all of the available reference symbols in subframes 0 and 5 and the first OFDM symbol of any subframe using the default CP without having to read P-BCH or D-BCH in the serving or target cells to identify MBSFN subframes.

This contribution investigates whether knowledge of the MBMS subframe pattern is needed for additional LTE operations, such as the L1/L2 control channel, CQI information, and channel estimation. Furthermore it is proposed that some provisions should be included to allow additional RS to be used for measurements, CQI and channel estimation when no MBSFN is present on a carrier and to permit RS for antennas 3 and 4 to be sent during some MBSFN subframes for CQI measurement purposes.

2. Discussion

Designating subframes as either unicast or MBSFN highlights the ambiguity of using multiple CP lengths and its impact on ancillary functions. For example, not knowing the CP length of symbols in a subframe means there is uncertainty in the timing in the first and second (if present) control symbols. Two solutions are immediately apparent to remedy this situation, 1) Use the default CP length in the PDCCH OFDM symbols in all subframes, 2) OFDM symbols in an MBSFN subframe use the same CP length. Both approaches are discussed in the following sections.

2.1. Approach 1: PDCCH OFDM Symbols Use Default CP in All Subframes

Originally proposed in [1], the UE identifies the default CP from examination of the P/S-SCH combination, and accesses the P-BCH accordingly (indeed, accesses all OFDM symbols in subframes 0 and 5 accordingly). Though UE's accessing MBMS via MBSFN subframes are required to read the MCCH or D-BCH to identify the MBSFN subframe pattern, UE's not accessing MBMS via MBSFN subframes on the cell are not *required* to identify the MBSFN subframe pattern. No information on the MBSFN subframe pattern allocation is contained in the P-BCH, so MBSFN subframe information is not readily available for mobility measurements.

The implications of this approach when MBSFN subframes are present on a carrier are:

- 1) Control – Cat0 is needed on MBSFN subframes to identify the number of PDCCH symbols for RRC_ACTIVE UE's who have not read the MCH structure (and hence MBSFN subframe pattern) on carrier. Cat 0 is also needed to identify subframes as MBSFN subframes so the UE knows that there is no DL assignment region.
- 2) Channel estimation – Limited to intra-subframe RS's for RRC_ACTIVE UE's who have not read the MCH MBSFN structure on the carrier and therefore cannot differentiate subframe types.
- 3) CQI – Limited to 1st OFDM symbol RS's for RRC_ACTIVE UE's who have not read the MCH MBSFN structure on the carrier and cannot differentiate subframe types, hence allows CQI information to be reported only for RS 0 and 1.
- 4) Mobility Measurements – UE can measure 1st OFDM symbol RS's of any subframe of a target cell, plus all applicable RS's in subframes 0 and 5.
- 5) Power Consumption – UE's must monitor the PDCCH fields of every subframe.

- 6) Specification – the UE has to handle more frame configurations and different CP sizes. For example, MBSFN subframes may have Normal CP, Extended CP, Extended CP alternative A (n=1, extra in 2nd OFDM or distributed over remaining) and Extended CP alternative B (n=2, extra in 2nd OFDM or distributed over remaining).

2.2. Approach 2: All OFDM symbols in MBSFN subframes Use the Same CP

The UE identifies the default CP from examination of the P/S-SCH combination, and accesses the P-BCH accordingly (indeed, accesses all OFDM symbols in subframes 0 and 5 accordingly). The MBSFN subframes on a carrier are then identified by the MCCH or the D-BCH. In order to identify this information, the MCCH or D-BCH (or indication for those channels) must be mapped to the default CP subframes 0 or 5, otherwise the CP lengths for MCCH or D-BCH are also unknown. One approach is to specify an MCH-specific “pattern” of subframes on the MCCH or D-BCH in addition to indicating the CP length (1 bit per MCH, or 1 bit applicable to all MCH’s if this is likely to be a common attribute) associated with the MCH (normal, extended) and whether 1 or 2 PDCCH symbols are present (1 bit per MCH). Finally, the MCCH might also indicate whether MBSFN RS pattern or normal unicast RS pattern is in use for MCH. Note that there is no information on the MBSFN subframe mapping in the P-BCH, so MBSFN subframe information is not available for mobility measurements.

The implications of this approach are:

- 1) Control – Cat0 is not needed on MBSFN subframes provided the MCCH or D-BCH description of the MCH includes an indication of the associated number of PDCCH symbols for MCH. However, the MCCH or D-BCH (or an indication) must be mapped to default CP subframes 0 or 5.
- 2) Channel estimation – All UE’s (RRC_CONNECTED or RRC_IDLE) are able to exploit all applicable RS’s from all subframes.
- 3) CQI – All RRC_CONNECTED unicast UE’s are able to exploit all applicable RS’s from all subframes to formulate CQI reports. Note that – following handover, or initial cell search – there may be a delay (whose magnitude depends on MCCH or D-BCH repetition rate) between initial access to a cell, and the identification of MBSFN subframes. During this period, the UE would be limited to measuring RS0 and RS1, but this is not a disadvantage w.r.t. Approach 1, which is always limited in such a way. Note also that – in the case where a layer is not using MBSFN transmissions – this can be indicated and no further delay incurred, as described in [2].
- 4) Mobility Measurements – UE can measure 1st OFDM symbol RS’s of any subframe of a target cell, plus all applicable RS’s in subframes 0 and 5.
- 5) Power Consumption – UE’s must monitor all subframe PDCCH fields. RRC_ACTIVE UE’s which have accessed the MCCH or D-BCH to identify MCH MBSFN subframe allocations can optionally reduce power consumption by skipping the PDCCH on MBSFN subframes where the UE is not expecting a DL ACK/ACK or uplink allocation.
- 6) Specification – No additional impact at the subframe level. Additional information on subframe configuration in MCH MBSFN mode must be delivered on an MCH basis via the MCCH or D-BCH or some other means.

Table 1 summarises the main features of Approach 1 and Approach 2.

Function	Approach 1	Approach 2
CP of PDCCH in MBSFN	Always = default CP (i.e. that of subframes 0 and 5)	Same as rest of subframe
# of MBSFN subframe formats	4 (All Normal, All Extended, Normal n=1, Normal n=2)	2 (All Normal, All Extended)
Cat 0	Needs to identify no DL grants. Needed in MBSFN subframes to identify number of PDCCH symbols.	Can identify e.g. 1,2,3 OFDM symbols. Not needed in MBSFN subframes to identify number of PDCCH symbols.
CQI	Ant 1 and Ant 2 only available for CQI generation	All four antennas available for CQI generation
channel estimation	intra subframe only	Inter-subframe channel estimation enabled
power consumption	Microsleep only feasible	Microsleep + turn off during unscheduled MBSFN subframes when UL ACK or UL grant not expected by UE
Other Cell measurements	Transparent	Transparent

Table 1 - Summary of MBSFN subframe structure options.

3. Conclusion

In conclusion, the MBSFN subframe pattern allocation must be sent via e.g. the MCCH or D-BCH in order for RRC_IDLE devices to access MBMS. Furthermore the MBSFN subframe pattern must be known and the second PDCCH symbol must be present in order for UE's to generate CQI measurements on RS2 and RS3.

One way forward is to require all UE's to read the MBSFN subframe pattern (Approach 2) thereby allowing all OFDM symbols in a subframe to use the same CP length. This approach seems more practical in terms of evolving the specification and reducing impact on ancillary functions such as channel estimation and power consumption.

An alternate way forward (modified Approach 1) is to allow OFDM symbols assigned to the PDCCH to use the default CP length in all subframes but to also require UEs supporting CQI measurements on RS2 and RS3 to read the MBSFN subframe pattern (via e.g. the MCCH or D-BCH). However, there is still the impact of extra MBSFN subframe formats, cat 0 information, power consumption, and channel estimation losses.

In any case, in order to enhance mobility measurements [2] an additional indication should be sent indicating on a per-carrier basis whether MBSFN is present on a carrier frequency or layer. This is especially useful if Approach 1 is selected as the way forward, as a first step in counteracting the deficiencies of Approach 1 in CQI reporting, channel estimation and UE power consumption.

Finally, while a main concern of the paper relates to how CQI information is made available for antennas 3 and 4, we are not advocating that 2 OFDM symbols are reserved and RS for antennas 3 and 4 are sent in every MBSFN subframe. There are a variety of ways to keep the overhead for antennas 3 and 4 RS low, as detailed in [3].

4. References

- [1] R1-071501, NEC Group, "Some issues related to MBSFN sub-frame structure", RAN1#48bis, St Julians, Malta, March 26-30, 2007
- [2] R1-072145, Motorola, "Measurement Period and Implication of DRX", RAN1#49, Kobe, Japan, May 7-11, 2007
- [3] R1-071436, Motorola, "MIMO RS Structure for Unicast/MBMS-Mixed Scenarios", St. Julians, Malta, March 26-30, 2007