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1. Introduction

This contribution proposes some refinements for the NodeB synchronization described in [1]. The main change is the option to use multiple code offsets within one RNS. As mentioned in [2], it is beneficial to allow simultaneous measurements of different cells in parallel. This allows a more efficient usage of the allocated ressources and more frequent measurements. Therefore, the sync concept has been extended by the option to use multiple code offsets within one RNS.

Furthermore, details are given on the initial synchronisation mechanism and the introduction of new NodeBs. These details are given for information and completeness only, since they are originally within the scope of WG3.

2. Terminology

According to the agreed proposal in [1], the NodeB shall transmit specific sync bursts in the PRACH time slots of selected radio frames. For a consistent terminology, in the following the sync bursts are called 'cell sync bursts', the PRACH time slots containing the cell sync bursts are called 'cell sync time slots', and the selected radio frames are called 'cell sync radio frames'.

3. Typical Procedure for NodeB Synchronization:

The proposed and refined procedure for NodeB Synchronisation may operate as follows:

Initial Synchronization

1. The RNC sends a request over the relevant Iub to the cell(s) with GPS reference for a timing signal. The RNC adjusts its clock appropriately, compensating for the known round trip Iub delay.

2. The RNC sends timing updates over the Iub to all the cells, apart from the one containing the GPS, instructing them to adjust their clocks towards its own timing. Each of the timing offsets is again adjusted by the Iub round trip delay for that cell.

3. At this point, none of the cells is supporting traffic so a large proportion of the time can be given over to achieving synchronisation. It is assumed that there is as yet no information available on which to base the generation of a re-use pattern for sync transmissions. Thus all cells are instructed to transmit their cell sync bursts in turn one after the other with *no re-use*, i. e. the same sync burst sequence and offset is used by all cells.

4. All cells listen for transmissions and those which successfully detect a cell sync burst report their timing and received S/(N+I) to the RNC over the relevant Iub. Knowing the schedule, the RNC is able to determine the cell which made the transmission and place a measurement entry in the relevant place in its measurement matrix. After all cells have made their transmissions, the RNC computes the set of updates which will bring the cells nominally into synchronisation.

5. Steps 3 and 4 are repeated several times (typically 10). This serves two purposes:-

   ?? The rapid updates allow the correction of the clock frequencies as well as the clock timings to be adjusted in a short space of time. This rapidly brings the network into tight synchronisation.

   ?? The S/(N+I) values are averaged over this period. This provides more accurate measurements (averaging over noise and fading) which can be used in the automatic generation of a re-use plan.

6. The S/(N+I) values are used, automatically, to plan a re-use pattern. This is performed as follows:-

?? A matrix of minimal connectivity is computed on the basis of designating pairs of cells are minimal neighbours if either their estimated average S/(N+I) exceeds a threshold or if they have mutual neighbours.

?? The set of cells is divided into partitions of cells. Each partition must satisfy the requirement that no pairs of cells within that partition are minimally connected. All cells within a partition transmit the same code offset in parallel.

Steady-State Phase

7. All of the cells in the same partition are arranged to transmit / receive in the same cell sync frames according to the above procedure and they transmit the same code offset in parallel. All cells report the reception times for all relevant code offsets back to the RNC.

8. At the end of each cycle, the RNC collates the information. In general there should always exist a path of bidirectional valid measurements that link every cell either directly or indirectly to the cell with UTC capability. However, the model is arranged such that only those cells which have such a path will be updated on any given occasion.

9. The process of partition transmissions and updating then continues indefinitely.

4. Late-Entrant NodeBs

The scheme for introducing new nodeBs into a synchronized RNS is as follows:

?? There is a specialised sync transmission at regular intervals or event driven. A single common code (i.e. with the same, nominally zero, shift) is transmitted in parallel by *all* NodeBs which are synchronised in the system. The late entrant NodeB will correlate against the specialised sync transmissions. The late entrant NodeB will take the earliest reception as the timing of the system.

?? Thus, at this point, the late entrant NodeB has obtained system time, subject to an unknown propagation delay between it and its nearest neighbour. The late entrant NodeB cannot, at this time, tell which of its neighbours *is* the nearest. However, this level of synchronisation is good enough that from then on the late entrant NodeB can distinguish the overlaid normal sync transmissions unambiguously for the various code shifts.

?? After this time the late entrant NodeB can measure the timings of sync transmissions received from specific NodeBs and report these to the RNC. In turn, the RNC can give the late entrant NodeB its own schedules for sync transmission and to use one or more of these. The RNC can then use the bi-directional sounding, which will then be available, to compute the true timing error and to instruct the NodeB to adjust its timing appropriately.

5. Conclusion

This paper described a typical procedure for the NodeB Synchronisation without prior knowledge of the connectivity matrix. In order to support this algorithm, we propose to define the following items in the WG1 specifications:

?? Definition of a Cell Sync Burst with cyclic shifts

?? Definition of terminology to indicate the selected PRACH time slots (Cell Sync Burst, Cell Sync Slot, Cell Sync Frame)

?? Cells shall transmit the Cell Sync Burst with a particular offset in selected Cell Sync Time Slots, the selection and the offset being signalled by higher layers

?? Cells shall receive the Cell Sync Burst in Cell Sync Time Slots selected by higher layers

?? Definition of timing and S/(N+I) measurements requested by higher layers

6. References

[1] R1-00-0074, "NodeB Synchronisation for TDD", Siemens, Beijing, China, January 18-12, 2000

[2] R1-00-0985, " Effective measurement rate for Node B Synchronisation ", InterDigital Comm. Corp., Berlin, Germany, Aug 22-25, 2000