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Title: **Node B Synchronization using Sync Burst: Refinements to the basic approach**

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1 Introduction

This paper refines the basic proposal to synchronize Node Bs and their subordinate Cells using the Synchronization Channel. The following features are discussed, and it is shown how these features remove any perceived risks associated with the concept. They also permit a solution that meets all of the requirements of references [1] and [2],

- Measurements only based on one sync time slot per frame; the one that does not include the broadcast channel.
- Cell may listen for sync bursts from many neighboring cells, potentially detecting all neighbors that transmit sync in the same slot
- Cell may transmit sync burst and listen in the same slot, except for window defined by its transmission time-provided no other dowlink traffic in the slot.
- For overall system approach, use measurements by UEs of relative Time Difference of Arrival to help fill gaps.
- As last resort (not expected to be used) sync bursts can be increased in power to provide the equivalent link performance as the RACH-based approach.

2 Measurements only based on one sync time slot per frame; the one that does not include the broadcast channel.

It is undesirable to suppress transmission of the broadcast channel, even rarely. However, the Sync burst is transmitted twice per frame. The broadcast channel shares one slot per frame with the sync burst, but not both slots. Therefore, this problem is avoided by simply using the slot containing the sync channel, but not the broadcast channel.

3 Cell may listen for sync bursts from many neighboring cells, potentially detecting all neighbors that transmit sync in the same slot

The cell receiver can be designed to detect many sync bursts in the same time slot, taking advantage of the fact that the sync bursts will be distributed among 32 offset times. This means that there can be multiple successful measurements by a cell for a given time slot.

4 Cell may transmit sync burst and listen in the same slot, except for window defined by its transmission time-provided no other downlink traffic in the slot.

The sync transmission format allows for 32 distinct time offsets within a sync slot. Therefore, a cell could transmit its regular sync burst in its assigned time, and, allowing for switching times between transmit and receive, be able to listen for sync bursts from other nodes in at least 29 of the allowable 32 offset positions. This is true, provided that there is no other downlink traffic in the slot.

Therefore, with a modest amount of cell planning, a cell has the potential to receive and detect the sync bursts of all of its neighbors within a single time slot, while also transmitting its sync burst.

Careful analysis, including simulation results, could be presented, but to a simple approximation, if a cell can simultaneously measure N neighbors, this is equivalent to achieving a given level of system performance while performing measurements much less often; i.e. allowing a measurement cycle, N times longer.

Another way of quantifying the benefit of this feature is that, with ability to make multiple measurements at a relatively high rate, the overall tracking process can tolerate a relatively high individual measurement failure rate.

5 For overall system approach, use measurements by UEs of relative Time Difference of Arrival to help fill gaps.

This feature is applicable to both the Sync Approach and the RACH approach. It is more meaningful to the Sync approach, because it fills gaps in the extreme case (e.g. micro cells in urban grid) where the Sync Approach may have inadequate power to provide the required link. between two neighboring cells.

It is proposed that the RNC employ Time Difference of Arrival Measurements by UEs to support the Node B (or Cell) synchronization process. This is an existing measurement, and no changes are needed for the Standard.

Reference [3] shows that the Sync approach enjoys sufficient link margin for Macro Cells.

We expect that there are some pico cell and micro cell scenarios that may create a dilemma; i.e. a UE can have low path loss to each of two cells, but these cells may not be visible to one another. The use of TDOA measurements by the UE will be most useful for these cases.

For the pico cell and micro cell cases, the propagation delay is small compared to the required timing accuracy. Therefore, relative TDOA can be attributed to misalignment in transmission time, with negligible error. For example, a range difference of 200 meters maps into only 0.8 microseconds. If the objective is to maintain cell time accuracy to within 1 to 3 microseconds, this error (i.e. ignoring range difference) is acceptable.

6 Increase power of Sync Burst

We predict that this option will not be needed. However, the fact that this option is available removes all risk from the concept.

Synchronization performance is dependent on the signal to noise ratio of the output of the despreading funtion, which is actually dependent on the ratio of the received energy per burst to the equivalent spectral density of the interference plus noise.   For the purpose of providing a required post-despreading SNR, it makes no significant difference whether the burst has a processing gain = 2400 and a power level = Po or if it has a processing gain = 256 and a power level=Po(2400/256). Similarly, as long as the operating levels are within the specified range of the equipment, the cost of power consumption is virtually identical in each case. (i.e. average power expended = energy/burst x number of bursts/unit time).

Our link analysis indicates that there is generally no need to operate the sync channel at higher power levels than those needed to support sync detection by the UE. This is much lower than the peak capability of a cell. However, if needed, the sync power can be increased significantly. This action, though undesirable, incurs no more penalty than that which accompanies the RACH concept.

According to reference [4], the special 2400 chip synchronization burst is designed to have excellent autocorrelation properties, thus reducing the risk of false detections (i.e. detections on time sidelobes). It had been suggested that the 256 chip sync burst may result in a high incidence of false detections. In reference [5], it is shown that this is not the case; misdetections are not a significant performance impact.

7 Conclusion

- This paper has identified five features to enhance the process of node B synchronization based primarily on the existing sync channel.
- Reference [5] proves that false detections due to the (shorter) 256 chip synchronization burst are a non-issue.
- All identified risk concerns have been removed.
- Each of these features can be implemented by the designer, without the need to change the Layer 1 Standard.

- See Annex A –list of criteria from reference [2]

Annex A

Criteria for over-the-air cell synchronization methods

1. **Accuracy:** For both the RACH concept and the Sync Burst Concept , measurements will be to a fraction of a chip, supporting required accuracy of 1-3 microseconds.
2. **Deployment constraints:** Virtually none, other than those which would be desirable for other reasons; e.g. neighboring cells should have reasonably different values for Toffset
3. **Constraints on the allocation of resources:** Only the requirement that, occasionally one of the slots containing the sync burst contain no uplink traffic**.**
4. **Implementation costs:**
   - **Function split**: What functionality's have to be added to each network element (UE, node B, RNC)
     - None on the UE
     - Several new messages between RNC and Node B
     - A reasonably competent algorithm in the RNC
   - **Complexity**:
     - A competent algorithm in the RNC – no measurable complexity impact
     - A more sophisticated processing algorithm in node B; minor complexity impact
   - Are there any **new network devices** needed – No, other than the accurate time source for the master; same as for the RACH –based concept. A calibration UE may be desirable, but is not necessary.
5. **Signaling load on interfaces**: What messages are required between RNC and Node Bs and how frequently do they have to be transmitted? Minor differences from those originally proposed.
6. **System Performance loss due to resource stealing**:- virtually none.

7. **How is a network start-up performed:**
   - How is it done? **Very straightforward; a new Node B listens and acquires time, then joins network.**
   - How long does it take? –Not analyzed in detail, but will be faster than for RACH approach.
8. **Seamless introduction of new network elements (cells or Node Bs):**
   - How are new cells or Node Bs added? See above; node B/cell listens; acquires and then joins.
   - Are there any service interruptions or additional interference for ongoing calls or in existing cells? No!
   - Is there any other impact on the network during the addition of a new cell, like handover, cell search, ...?No.
9. **Assistance by UEs**: Is it possible and how, that in certain scenarios UEs can assist with measurements? Yes; This is desirable.
10. **Wired synchronization**: Is it possible and how, that certain nodeBs are synchronized via the sync port. This is possible.
11. **Robustness of Solution;** What is the likelihood of a catastrophic system failure associated with this concept? Very unlikely.

References

[1] R1-00-0957, “Proposed TR on Node B Synchronisation for TDD”, InterDigital Comm. Corp. Oulu, Finland, July 4-7, 2000.
[2] R1-00-0770, “Criteria for TDD cell synchronization methods Tokyo”, Siemens, InterDigital Comm. Corp., Japan, 22-25 May, 2000,
[3] R1-00-1076, “Node B Synchronisation Link Analysis”, InterDigital Comm. Corp. Berlin, Germany, 22-25 August, 2000,
[4] R1-99G42 “Synchronisation of Node B’s in TDD via Selected PRACH Time Slots”, Siemens, New York, USA, October 12 - 15, 1999
[5] R1-00-0984, Berlin, Germany, August 21-25, 2000, InterDigital Communications Corporation, Node B Synchronization using Sync Burst: False Detection Reduction