TSG-RAN Working Group 3 meeting ***TSGR3#7(99)B81***
September 20th – 24th 1999
Sophia Antipolis, France

Title: **TDD Synchronisation on air**

Source: **Italtel / Siemens**

Agenda Item: **6.3**

Document for: **Approval**

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1. Introduction

The different proposals to achieve synchronisation in TDD can be grouped into two main classes:

- Synchronisation of nodes B to an external reference;
- Synchronisation of nodes B on the air interface, e.g. through nodes B cross measurements or assisted by UEs.

Each of them has some advantages and some drawbacks; therefore a combined solution is needed.
A basic proposal has been submitted by Interdigital (R3-99905) during meeting #6 and is based on the synchronisation of a number of node B (masters) to an external reference (Italtel/Siemens have proposed in R3-99959 that this synchronisation to the external reference is achieved via a standardised synchronisation port). The other nodes B are synchronised either to the reference or to already synchronised nodes B via the air interface through cross measurements of cell Physical Synchronisation Channels (PSCHs).
Some extensions to Interdigital concept have been proposed by Italtel/Siemens in R3-99882.
A complete description of the extended method is however still missing in TS 25.401.
This contribution therefore proposes a detailed description of the complete synchronisation procedure.
A confirmation on the effectiveness of the method is still waited by WG1 and WG4.

2. TDD Synchronisation

The method is based on the synchronisation of a number of node B (masters) to an external reference (e.g. GPS) via a standardised synchronisation port. The other nodes B are synchronised either to the reference or to already synchronised nodes B via the air interface.

The following assumptions are taken:

- Each node B may be synchronised through an external reference (e.g. GPS) connected to the synchronisation port;
- All the cells belonging to the same node B are synchronised among each others;
- All the nodes B that are synchronised through the external source become Reference; all the other nodes B are synchronised via the air through a master-slave mechanism;
- In order to get synchronised a node B shall listen at an active cell belonging either to a reference node B or to an already synchronised node B (that acts as a master of the synchronisation process for the unsynchronised node B, i.e. the slave Node B);
- All the nodes B that cannot listen to cells belonging to other nodes B shall be synchronised through their synchronisation port (i.e. they are References as well).

The former assumptions are shown in figure 1.

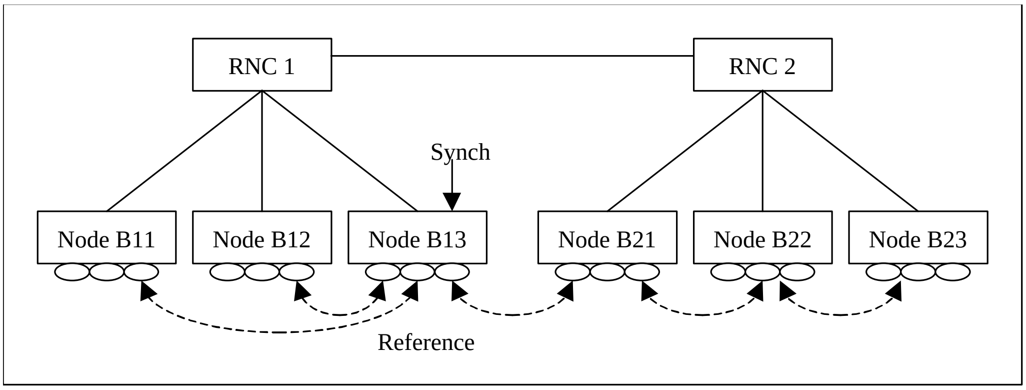

Figure 1: TDD synchronisation

In this example Node B13 is the only Reference, i.e. it is the only one that is synchronised through an external source. Node B11, Node B12 and Node B21 can listen at least to one cell of Node B13. This means that they can get synchronised over the air directly to the Reference Node B. On the contrary Node B22 can listen only to a cell belonging to Node B21. This means that it can get synchronised only to Node B21 that acts as a master for B22 (second hierarchical level of synchronisation), while node B23 can get synchronised only to Node B22 that acts as a master for B23 (third hierarchical level of synchronisation).

The Node B synchronisation procedure on air makes use of the Physical Synchronisation CHannels (PSCHs) and goes through the following steps:

1) Upon reception of NEIGHBOR CELL MEASUREMENT REQUEST, the requested node B search the cell indicated by the CRNC. The detection of its PSCH allows the measuring Node B to derive the frame timing and, by reading the associated BCCH, the cell identity of the measured cell (this is required only at power on or reset; otherwise detection of the PSCHs only is needed; see step 7).

2) The measuring Node B reports to the CRNC, in the NEIGHBOR CELL MEASUREMENT RESPONSE message, the measured relative frame timing difference together with the Cell identity of the measured cell.

3) Based on the reported relative frame timing difference, CRNC sends to the Node B that has to be synchronised (slave), the frame timing adjustment to perform an initial frame synchronisation (SYNCHRONIZATION ADJUSTMENT REQUEST). In addition this message contains the master cell identity (Master Cell ID) of the cell that has been selected by the CRNC as master for that node B. At this stage, the frame alignment is affected by an error due to the propagation delay, which cannot be separated from the real phase offset between the slave and the master Node Bs.

4) The slave Node B acknowledges to the CRNC the execution of the required frame timing adjustment by sending a SYNCHRONIZATION ADJUSTMENT RESPONSE, and starts transmitting. At this stage, the Node B is frame synchronised (however the propagation delay still needs to be compensated).

Steps 1-4 are shown in Figure 2.

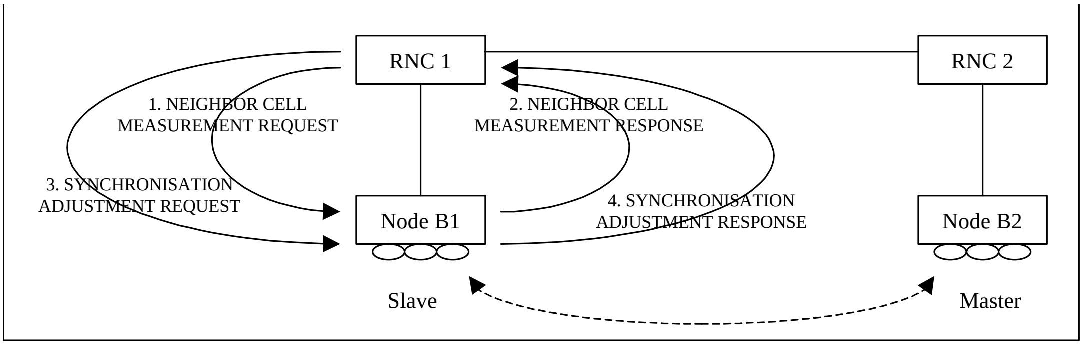

Figure 2: TDD synchronisation on air (1)

5) The CRNC may ask to the master cell (through the NEIGHBOR CELL MEASUREMENT REQUEST message containing the pertaining Cell identity as in step 1) to detect the locked slave Node B frame timing, so that by comparing the reported relative time difference with the one as indicated before by the currently locked slave Node B, the propagation delay can be estimated.
This procedure can also involve the Iur in case the master cell and slave cell do not belong to the same CRNC (as in Figure 3).

6) The CRNC refines the initial synchronisation by sending a SYNCHRONIZATION ADJUSTMENT REQUEST to the locked slave Node B (as in step 4) containing the estimated propagation delay. As before, the slave Node B acknowledges the execution of the required frame timing adjustment with a SYNCHRONIZATION ADJUSTMENT RESPONSE.

Steps 5-6 are shown in Figure 3.

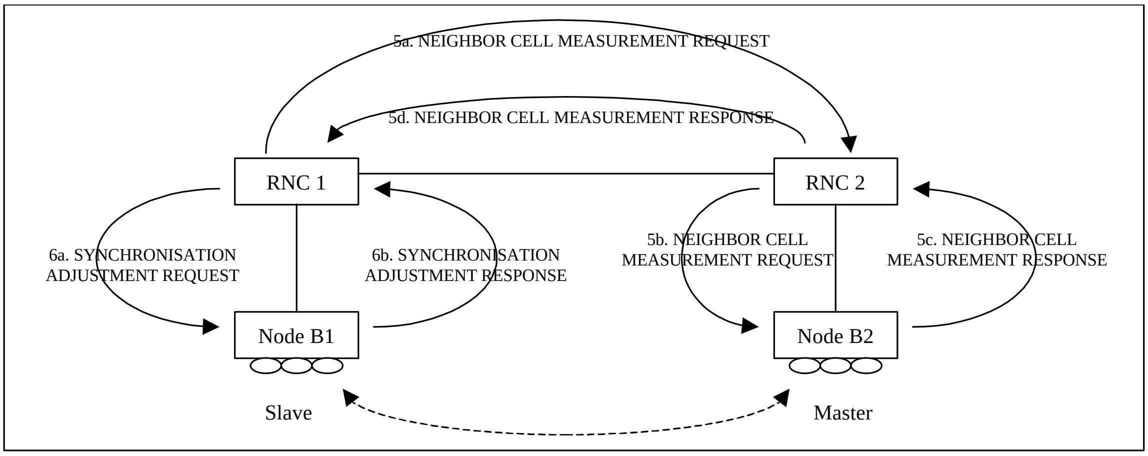

Figure 3: TDD synchronisation on air (2)

7) Whether the locking to the master cell gets lost (e.g. this may happen in case the master cell is detected at a relative time difference over a pre-configured window), the slave Node B signals the event to the CRNC by means of the NODE B OUT OF SYNC INDICATION message, but still remaining active on the air interface (i.e. without suspending transmission).
   The synchronisation procedure restarts from step 1 even if the slave Node B does not suspend transmission. It can be assumed that in this state the slave Node B monitors the PSCHs only, without detecting the associated BCCH, in respect to what is done at the power on.

8) In case a suitable master cell cannot be identified, the CRNC may send the NODE B SYNCHRONIZATION RESTART REQUEST message which makes the slave Node B stop transmitting and the synchronisation procedure restart from step 1 as if at the “power on” state.

Steps 7-8 are shown in Figure 4.

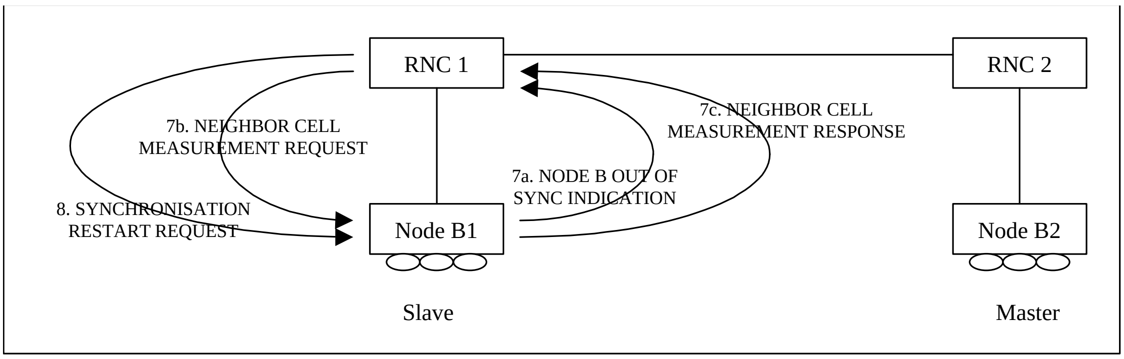

Figure 4: TDD synchronisation on air (3)

3. Proposal

It is proposed to add section 2 of this contribution to section 9.7 of 25.401.