3GPP TSG RAN WG1#17 R1-00-1370

Stockholm / Sweden
November 21st - 24th, 2000

Agenda Item: **AH30**

Source: **Mitsubishi Electric**

Title: **Node B sync in UTRA TDD with multiple measurement occasions**

Document for: **Information**

---

1 Summary

The option that several Node B's within one RNS could transmit their cell sync bursts simultaneously, i.e. in the same PRACH timeslot has been proposed recently [1]. The introduction of this option into the current Node B sync concept could allow a more efficient usage of the allocated resources - the reserved UL PRACH timeslots - and could also allow more frequent measurement occasions.

In this document we want to provide a basic analysis for both the original Node B sync concept and the proposal in [1]. The basic assumption made here is that no averaging is applied on the timing offset measurements, i.e. the analysis tries to answer the question "How long does it take to determine all independent timing offsets once ?". With averaging on the timing offset measurements applied, the impact onto the 2 above methods is expected to be the same and as such the comparison is expected to remain valid.

2 Introduction

Node B synchronisation via the air interface in UTRA TDD is assumed to be achieved within an RNC-area, i.e. within a Node B cluster. Each Node B cluster contains at least one Node B synchronised to an external time reference.

Inside a Node B cluster, there are *N* Node B's whose respective transmission timing instants deviate one from another. These timing offsets are here denoted as $???_{ij}$, where $??_{ij}$ represents the mutual timing offset of the i^{th} and the j^{th} Node B. The entire set of respective timing offsets can be represented as a timing offset matrix $??$:

$$???\begin{bmatrix} ??_{1,1} & ??_{1,2} & \cdots & ??_{1,N-1} & ??_{1,N} \\ ??_{2,1} & ??_{2,2} & \cdots & ??_{2,N-1} & ??_{2,N} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ ??_{N-1,1} & ??_{N-1,2} & \cdots & ??_{N-1,N-1} & ??_{N-1,N} \\ ??_{N,1} & ??_{N,2} & \cdots & ??_{N,N-1} & ??_{N,N} \end{bmatrix}$$

Figure 1: Matrix of timing offsets for N Node B's in a cluster

The total number of independent timing offsets and consequently the number of independent matrix elements is obviously reduced to *(N-1)*N/2* elements, taking into account that $??_{ij} = ???_{ji}$ and $??_{ii}=0$.

$$??'?\begin{bmatrix} 0 & ??_{1,2} & \cdots & ??_{1,N-1} & ??_{1,N} \\ & 0 & \cdots & ??_{2,N-1} & ??_{2,N} \\ & & \cdots & \cdots & \cdots \\ & & & 0 & ??_{N-1,N} \\ & & & & 0 \end{bmatrix}$$

Figure 2: Matrix of independent timing offsets for N Node B's in a cluster

Based on the proposal in [1] and on the off-line discussions held during TSG RAN WG1#16 in Pusan/Korea, 2 basic methods were identified to determine these timing offsets. The first method of determining the timing offsets is the original Node B sync approach, e.g. only a single Node B transmits its cell sync burst in a particular PRACH timeslot. The second discussed method is an extension of the first method and consists in letting open the possibility for several Node B's to transmit simultaneously their respective cell sync bursts in one particular PRACH timeslot.

In the following 2 sections, a basic analysis for both the original Node B sync concept and the proposal in [1] is given. The basic assumption is here that no averaging is applied on the timing offset measurements, i.e. the analysis tries to answer the question "How long does it take to fill in the timing offset matrix once ?". With averaging on the timing offset measurements applied, the impact onto the 2 above methods is expected to be the same and as such the comparison is expected to remain valid.

3 Single Node B transmission approach

In this simple scenario, one row of the matrix (or equivalently one column) is determined each time a Node B transmits its cell sync burst.

An example for this Node B sync scenario is given in Figure 3 for a cluster containing *5* Node B's.

$$? ?? = \begin{pmatrix} 0 & ? ?_{1,2} & ? ?_{1,3} & ? ?_{1,4} & ? ?_{1,5} \\ & 0 & ? ?_{2,3} & ? ?_{2,4} & ? ?_{2,5} \\ & & 0 & ? ?_{3,4} & ? ?_{3,5} \\ & & & 0 & ? ?_{4,5} \\ & & & & 0 \end{pmatrix}$$

1st synchronisation slot : Node B # 1 transmits
2nd synchronisation slot : Node B # 2 transmits
3rd synchronisation slot : Node B # 3 transmits
4th synchronisation slot : Node B # 4 transmits

Figure 3: Timing offset determination for a cluster of 5 Node B's with single Node B transmission

Note that each element of the timing offset matrix is represented in the colour corresponding to the cell sync timeslot in which it has been determined.

Hence, a total of *N-1* cell sync burst transmissions are needed to determine all the independent elements of the timing offset matrix.

4 Multiple Node B transmission approach

When several Node B's transmit their respective cell sync bursts in the same cell sync timeslot, the goal is to exploit more efficiently the available cell sync timeslots. Up to *16* Node B's in a cluster would be allowed to transmit simultaneously, even if the case of only around *4* or *5* Node B's transmitting simultaneously is more likely in most deployment scenarios.

Several schemes for multiple Node B transmission are possible in order to determine the *(N-1)*N/2* elements of the timing offset matrix. An example for a Node B sync scenario is given in Figure 4 for a cluster containing 8 Node B's.

$$? ?? = \begin{pmatrix} 0 & ? ?_{1,2} & ? ?_{1,3} & ? ?_{1,4} & ? ?_{1,5} & ? ?_{1,6} & ? ?_{1,7} & ? ?_{1,8} \\ & 0 & ? ?_{2,3} & ? ?_{2,4} & ? ?_{2,5} & ? ?_{2,6} & ? ?_{2,7} & ? ?_{2,8} \\ & & 0 & ? ?_{3,4} & ? ?_{3,5} & ? ?_{3,6} & ? ?_{3,7} & ? ?_{3,8} \\ & & & 0 & ? ?_{4,5} & ? ?_{4,6} & ? ?_{4,7} & ? ?_{4,8} \\ & & & & 0 & ? ?_{5,6} & ? ?_{5,7} & ? ?_{5,8} \\ & & & & & 0 & ? ?_{6,7} & ? ?_{6,8} \\ & & & & & & 0 & ? ?_{7,8} \\ & & & & & & & 0 \end{pmatrix}$$

1st synchronisation slot : Node B's # 1, 2, 3 and 4 transmit
2nd synchronisation slot : Node B's # 1 and 5 transmit
3rd synchronisation slot : Node B's # 2 and 6 transmit
4th synchronisation slot : Node B's # 3 and 7 transmit

Figure 4: Timing offset determination for a cluster of 8 Node B's with multiple Node B transmission

Note that each element of the timing offset matrix is represented in the colour corresponding to the cell sync timeslot in which it is determined.

According to this scheme, it is possible to obtain a full knowledge of all independent timing offsets for *N* Node B's in the cluster by CEIL(N/2) cell sync timeslots.

5 Conclusion

The results of the comparative analysis for both the single and multiple Node B transmission approach have been collected in Table 1. Here, N_{TS} denotes the total number of cell sync timeslots needed for measuring all independent timing offsets once. N_{TS} is given as a function of the number *N* of Node B's contained in a cluster to be synchronised.

Number of Node B's per cluster.	N_{TS} with single Node B transmission method.	N_{TS} with multiple Node B transmission method.
$N = 2$	*1*	*1*
$N = 3$	*2*	*2*
$N = 4$	*3*	*2*
$N = 5$	*4*	*3*
$N = 8$	*7*	*4*
$N = 16$	*15*	*8*

Table 1: Number of cell sync bursts needed for determining each timing offset once versus number of Node B's contained in a cluster

Based on this basic analysis, it appears that the multiple Node B transmissions approach is as efficient as the single Node B transmission method for smaller Node B clusters (containing less than *4* Node B's). Although the efficiency gain brought by the multiple Node B transmission method may be smaller than expected, there is still a potential gain for bigger Node B clusters (containing more than *4* Node B's) which makes this option interesting to use.

References

[1] R1-00-1349, "Node B synchronisation for TDD – some refinements", Siemens