

**Agenda Item:** 15.2  
**Source:** Fujitsu  
**Title:** Received Timing Difference in Downlink CoMP Transmission  
**Document for:** Discussion and Decision

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## 1. Introduction

Coordinated multipoint (CoMP) transmission/reception is a key technology to improve spectrum efficiency for LTE-Advanced. The CoMP has been investigated by many contributions [1-5], where the relevant gain was confirmed from a system level simulation point of view. In these studies, there was an implicit assumption that each UE receives signals from coordinated cells simultaneously when a joint transmission is applied. Even if, however, all the eNodeBs are perfectly synchronized, a difference of the received timings between the received signals from coordinated eNodeBs occurs due to the variant distances resulting in different propagation delay. If the received timing difference exceeds the cyclic prefix (CP), the inter-symbol interference (ISI) occurs. Additionally, even if the received timing difference does not exceed the CP, it still causes two issues on downlink CoMP joint transmission. Firstly, per-subband precoding does not work efficiently [6-8]. Secondly, accuracy of channel estimation may not be ensured when a dedicated reference signal is employed [8]. Thus, the impacts and the practical range of the received timing difference should be carefully investigated.

In this contribution, we focus on the discussion of received timing that the UE experiences between two coordinated eNodeBs, and demonstrate the statistic results by means of a system level simulation.

## 2. Simulation Results

The system level simulation is implemented in a cell network formed by 7 clusters; each cluster consists of 19 hexagonal cells and each cell contains 3 sectors. The antenna of the sector is orientated with bore-sight point to the side of hexagon. To accurately model the interferences incident from outer-cells, a wrap around network structure with 7 copies of the centre hexagonal cluster is employed, where the original cluster is placed in the middle and 6 copies are attached on the side symmetrically.

Here, we assume that all the eNodeBs in the network are perfectly synchronized. Thus, the difference of received timings between the received signals from coordinated eNodeBs results from the distance offset between the UE and coordinated eNodeBs.

Two criteria are employed to determine which UEs are served by multiple cells. The first criterion is relevant to the link gap, experienced by each UE. The link gap is defined as the difference in received power between the strongest received signal and the second strongest one among all the received signals. The CoMP is implemented only if the link gap is less than the pre-determined threshold, i.e.,

$$P_0 - P_1 \leq \text{threshold}$$

where  $P_0$  and  $P_1$  are the received power of the strongest received signal and the second strongest received signal, respectively.

The second criterion is relevant to the SINR, experienced by each UE from the serving cell. In this case, the CoMP is implemented only if the SINR is less than the pre-determined threshold, i.e.,

$$SINR = \frac{P_0}{\sum_{i \neq 0} P_i + \sigma^2} \leq threshold$$

where  $\sigma^2$  is thermal noise power.

For simplicity, we assume that the maximum number of coordinated cells is two. Again, For simple exposition, in this contribution, we denote the first criterion as Link Gap basis and the second criterion as PreCoMP SINR basis.

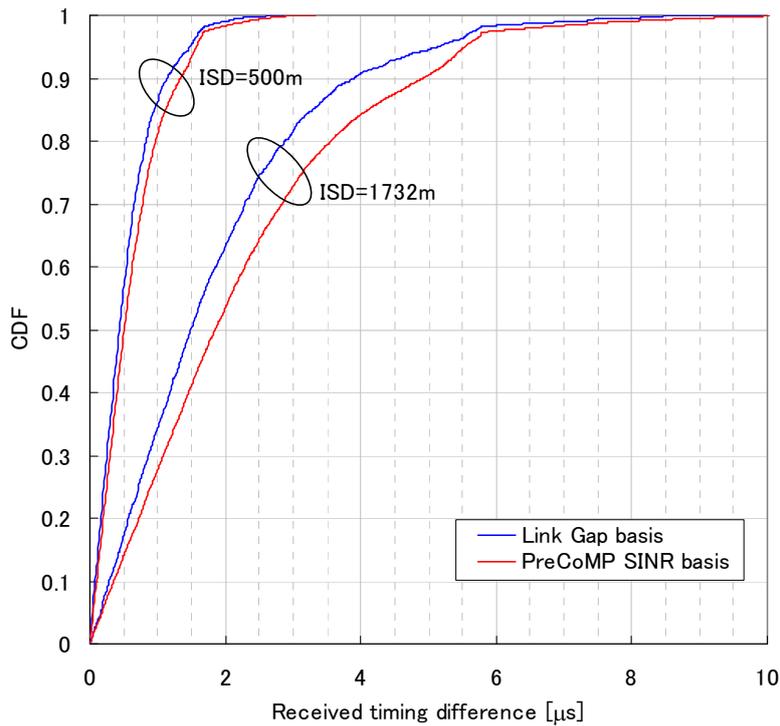
The detailed simulation assumptions are listed in Table 1.

**Table 1 Simulation assumptions**

Number of cells		19
Number of sectors per cell		3
Center frequency		2 GHz
Transmission power		46 dBm
Shadowing	Distribution	Lognormal with 8 dB standard deviation
	Correlation between cells	0.5
	Correlation between sectors	1.0
Noise figure		9 dB
Transmit antenna gain		14 dBi
Receive antenna gain		0 dBi
Pathloss model		$128.1 + 37.6 \log_{10}(R)$
Inter site distance (ISD)		500, 1732 m
Thermal noise density		-174 dBm/Hz
Transmit antenna pattern		70 degrees beam-width
Receive antenna pattern		Omni

Figure 1 shows the CDF of the difference of received timings between the received signals from coordinated cells. The threshold is set to 1dB for both criteria. Several observations can be made as follows:

- Due to the shadowing factor causing a cell selection, it is possible for the UE to experience a distance offset from coordinated cells that could be larger than the ISD. This can be seen as a transition point in the figure. The distance for 500m ISD corresponds to  $1.67\mu\text{s}$  and the distance for 1732m ISD corresponds to  $5.77\mu\text{s}$ .
- Statistically, the UEs on the PreCoMP SINR basis experience larger received timing difference than that on the Link Gap basis. This is because the UEs on the PreCoMP SINR basis are distributed around cell edge while the UEs on the Link Gap basis are distributed around the midpoint between cells, where the UEs receive the strongest signal and second strongest signal.
- The received timing difference at 50%tile and 90%tile CDF are summarized in Table 2. It is noted that the received timing difference at 90%tile CDF on the PreCoMP SINR basis for 1732m ISD exceeds the normal CP duration.



**Figure 1 CDF of the received timing difference**

**Table 2 Summary of Received Timing Difference at 50% and 90% CDF**

ISD	CDF	Link Gap basis	PreCoMP SINR basis
500 m	50%	0.4 $\mu$ s	0.5 $\mu$ s
	90%	1.2 $\mu$ s	1.3 $\mu$ s
1732 m	50%	1.5 $\mu$ s	1.9 $\mu$ s
	90%	3.9 $\mu$ s	4.9 $\mu$ s

### 3. Conclusions

In this contribution, we have investigated how large the received timing difference is for the CoMP transmission by means of system level simulation. It is confirmed that the received timing difference at 90% CDF on the PreCoMP SINR basis is larger than the normal CP for 1732m ISD. As a consequence, in order to sophisticatedly design the CoMP system, the impact on the received timing difference needs to be further studied.

A simple but very useful solution is proposed to deal with the problem which is caused by received timing difference [8].

### Reference

- [1] R1-090141, “Spatial Multiplexing in CoMP Transmission/Reception”, Nortel.

- [2] R1-090047, "Multi-cell Co-operative Beamforming: Operation and Evaluation, and TP for TR36.814", Philips.
- [3] R1-090314, "Investigation on Coordinated Multipoint Transmission Schemes in LTE-Advanced Downlink", NTT DOCOMO.
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- [5] R1-090325, "Coordinated Multi-Point Transmission --- Coordinated Beamforming and Some Performance Results", Motorola.
- [6] R1-090142, "Performance evaluation of CoMP solutions", Nortel.
- [7] R1-090193, "Aspects of Joint Processing in Downlink CoMP", CATT.
- [8] R1-090951, "Pseudo Transmission Timing Control using cyclic shift for Downlink CoMP Joint Transmission", Fujitsu.