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Title	**Minimizing the Non-synchronized Ranging Procedure Requirement during Handover**
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Re:	802.16-08/033 Call for Contributions and Comments on Project 802.16m System Description Document (SDD)
Abstract	This contribution discusses access operations during handover to avoid delay and unnecessary use of physical resources resulting from use of the ranging channel for non-synchronized MSs.
Purpose	Discuss and adopt the proposed text into the SDD.
Notice	
Release	
Patent Policy	

Minimizing the Non-synchronized

Ranging Procedure Requirement during Handover

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Introduction

This contribution discusses access operations during handover to avoid delay and unnecessary use of physical resources resulting from use of the ranging channel for non-synchronized MSs.

Background

During the handover process, the uplink (UL) timing offset must be adjusted before initial data transmission in the target cell. The requirement of non-synchronized ranging results in increased handover latency and disruption of on going transmissions. This is especially important for real time services such as VoIP. Too often, scheduling of the random access in UL will also cause a waste of radio resources and unnecessarily increase the collision rate. Thus, we think it is important to minimize the interruption time and required signalling resulting from UL timing offset adjustment in the target cell during handover.

Discussion

Non-synchronized random access will cause latency and has resource efficiency problems. This latency in non-synchronized random access is mainly caused by the waiting time after an MS is ready to transmit in the UL for UL synchronization and before the UL ranging channel occurs in the frame structure, as well as time spent in collision resolution. The amount of resources needed to achieve the reasonable delay will probably be very high in real deployments.

Thus, when non-synchronized random access is used during handover, it will inevitably lead to long delays and extra demand of radio resources. This will bring adverse impact to handover of real time services such as VoIP, gaming, etc, or handover during high mobility cases.

Non-synchronized random access procedure is not needed when the source and target cells are synchronized or when the relative time difference between the source and target cells is known. In these cases, it is proposed that the MS may autonomously perform timing advance during handover by adjusting the source cell timing advance by the relative difference in channel reception between the source and target cells, and the relative difference in source and target cell timing when the cells are not synchronized (details on the timing advance adjustment and accuracy are included in Appendix A).

Upon entering the target cell, the MS may avoid using the ranging channel for non-synchronized timing offset adjustment and may instead use the ranging channel for synchronized mobile stations for initial access the target cell.

Please refer to Appendix A for detailed feasibility analysis when the autonomous timing advance scheme is used during handover.

Conclusion

We propose to eliminate the requirement for the ranging channel for non-synchronized mobile stations during handover when autonomous timing advance adjustment is possible, so that initial access in the target cell may apply the synchronized random access procedure. The proposed procedure will reduce target cell access latency, interruption in on going transmissions and unnecessary radio resource demand.

Text Proposal

It is proposed to add the following description to the SDD under "11.9.2.4 UL Ranging Channel":

"In the case where the source and target cells are synchronized or the relative time difference is known to the MS, synchronization to the target cell shall not require the non-synchronized ranging channel."

Appendix A: Feasibility Analysis for Autonomous Timing Offset Adjustment During Handover

Propagation delay and FSP timing

Let t_i denote the timing at the BS i, and p_i denote the one-way propagation delay from the BS to the MS. Suppose the distance between the MS and BS i is D_i . The propagation delay $p_i = D_i / c$, therefore is not affected by frequency. In order to maintain proper operation of downlink, the downlink timing at the MS has to be locked to the first significant path (FSP) of the multi-path channel. This can be achieved easily by the MS performing channel estimation after cell search coarse timing detection and obtain the power delay profile of its multipath channel and lock to the FSP.

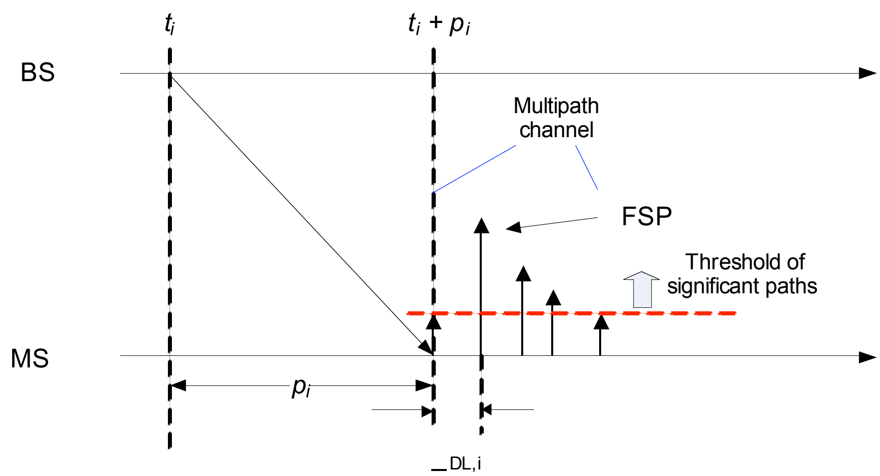

Figure 1: Propagation delay and FSP timing.

The downlink timing that the MS detects for BS i is $T_{DL,i} = t_i + p_i + \Delta_{DL,i} + \varepsilon_{CS,i}$, where $\varepsilon_{CS,i}$ is the downlink timing acquisition error in cell search and $\Delta_{DL,i}$ is the difference between arrival time of the FSP in the downlink and propagation delay when the timing detection was performed. The $\Delta_{DL,i}$ part depends on frequency and environment. The FSP of uplink signal will arrive at the BS with a uplink delay of $p_i + \Delta_{UL,i}$, where $\Delta_{UL,i}$ is the difference between arrival time of the FSP in the uplink and propagation delay when BS detect uplink timing. It is reasonable to assume $\varepsilon_{CS,i}$ is limited to a very small range, such as a few OFDM samples (0.1 ~ 0.3 μs).

Regular Timing Advance Case

In order for the MS to align its uplink timing with other MSs at the BS i, it needs to perform timing advance by the amount of

$$TA_i = 2p_i + \Delta_{DL,i} + \Delta_{UL,i} + \varepsilon_{CS,i} + \varepsilon_{T,i}\,, \qquad (1)$$

where $\varepsilon_{T,i}$ is the error produced by timing estimation at BS (due to limited timing detection granularity) and time offset between oscillators at the MS and BS.

In this way, its uplink transmitted signals arrive at the time of $T_{UL,i}$, which is given by

$$\begin{aligned} T_{UL,i} &= t_i + p_i + \Delta'_{DL,i} + \varepsilon_{CS,i} - (2p_i + \Delta_{DL,i} + \Delta_{UL,i} + \varepsilon_{CS,i} + \varepsilon_{T,i}) + p_i + \Delta'_{UL,i} \\ &= t_i + (\Delta'_{DL,i} - \Delta_{DL,i}) + (\Delta'_{UL,i} - \Delta_{UL,i}) - \varepsilon_{T,i}\,, \qquad (2) \end{aligned}$$

where $\Delta'_{DL,i}$ and $\Delta'_{UL,i}$ are the counter part of $\Delta_{DL,i}$ and $\Delta_{UL,i}$ at the time of uplink transmission.

Editor's note: the cell search timing error is cancelled out, therefore has no impact on timing advance in normal operation.

Use $\varepsilon_{f,i}$ to denote timing error produced by different fading profiles at the times of timing advance and later on uplink transmission. We have

$$\varepsilon_{f,i} = (\Delta'_{DL,i} - \Delta_{DL,i}) + (\Delta'_{UL,i} - \Delta_{UL,i}). \qquad (3)$$

Therefore, equation (1) can be rewritten as

$$T_{UL,i} = t_i + \varepsilon_{f,i} - \varepsilon_{T,i}\,. \qquad (4)$$

Hence, the uplink timing misalignment, denoted by $T_{M,i}$, is given by

$$T_{M,i} = \varepsilon_{f,i} - \varepsilon_{T,i}\,. \qquad (5)$$

The maximum timing misalignment can be written as

$$\left|T_{M,i}\right|_{\max} \le |\varepsilon_{f,i}|_{\max} + \left|\varepsilon_{T,i}\right|_{\max}. \qquad (6)$$

As established in [1, 2], timing misalignment between MSs should be less than the CP duration so that the BS can the process the MSs signals with a single FFT without severe performance degradation. As in [1], the uplink CP length is no less than the timing misalignment caused by $|\varepsilon_{f,i}|_{\max} + \left|\varepsilon_{T,i}\right|_{\max}$ plus a timing margin, denoted as $Margin$, of 1 µs. That is

$$|\varepsilon_{f,i}|_{\max} + \left|\varepsilon_{T,i}\right|_{\max} + Margin \le L_{CP}\,. \qquad (7)$$

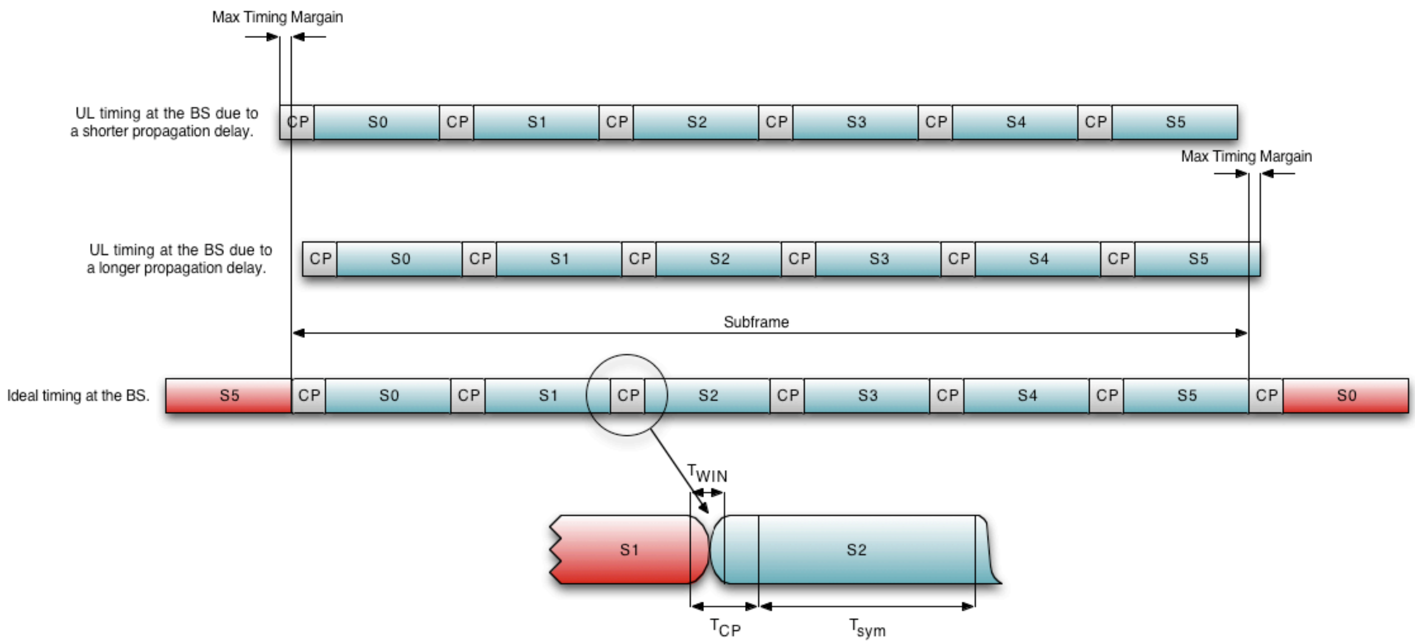

Figure 2: Timing margin and uplink timing drift [2].

Timing Advance during HO Case

Consider the case that the MS handovers from the source BS i to target BS j. The MS knows downlink timings of both BSs, $T_{DL,i}$ and $T_{DL,j}$.

$$T_{DL,i} = t_i + p_i + \Delta_{DL,i} + \varepsilon_{CS,i} , \tag{8}$$

$$T_{DL,j} = t_j + p_j + \Delta_{DL,j} + \varepsilon_{CS,j} , \tag{9}$$

The MS is tightly time-synchronized with the source BS i. Then, the MS knows the value of timing advance $TA_i = 2p_i + \Delta_{DL,i} + \Delta_{UL,i} + \varepsilon_{CS,i} + \varepsilon_{T,i}$ in its source BS. The difference of downlink timing measured by the MS is given by

$$\Delta T_{meas} = T_{DL,j} - T_{DL,i} = (t_j - t_i) + (p_j + \Delta_{DL,j} - p_i - \Delta_{DL,i}) + (\varepsilon_{CS,j} - \varepsilon_{CS,i}). \tag{10}$$

Equation (10) can be rewritten as

$$\Delta T_{meas} - (t_j - t_i) = (p_j + \Delta_{DL,j} - p_i - \Delta_{DL,i}) + (\varepsilon_{CS,j} - \varepsilon_{CS,i}). \tag{11}$$

We assume that the MS is informed of the value of $(t_i - t_j)$ with handover command.

The MS can estimate the timing advance TA_j for the target BS j based on values of TA_i , ΔT_{meas} and $(t_j - t_i)$ as

$$TA_j = TA_i + 2(\Delta T_{meas} - (t_j - t_i)). \tag{12}$$

Plugging in equations (1) and (11) into (12), we have

$$\begin{aligned} TA_j &= 2p_i + \Delta_{DL,i} + \Delta_{UL,i} + \varepsilon_{CS,i} + \varepsilon_{T,i} + 2(p_j + \Delta_{DL,j} - p_i - \Delta_{DL,i}) + 2(\varepsilon_{CS,j} - \varepsilon_{CS,i}) \\ &= 2p_j + 2\Delta_{DL,j} + (\Delta_{UL,i} - \Delta_{DL,i}) + \varepsilon_{T,i} + (2\varepsilon_{CS,j} - \varepsilon_{CS,i}). \end{aligned} \tag{13}$$

Hence, the uplink signal of the MS will arrive at BS at

$$\begin{aligned} T_{UL,j} &= t_j + p_j + \Delta'_{DL,j} + \varepsilon_{CS,j} - TA_j + p_j + \Delta'_{UL,j} \\ &= t_j + (\Delta'_{DL,j} + \Delta'_{UL,j} - 2\Delta_{DL,j}) + (\Delta_{DL,i} - \Delta_{UL,i}) + (\varepsilon_{CS,i} - \varepsilon_{CS,j}) - \varepsilon_{T,i}. \end{aligned} \tag{14}$$

Let $\varepsilon_{CS,Accum}$ denote the accumulated cell search timing error term $\varepsilon_{CS,i} - \varepsilon_{CS,j}$. Therefore, the uplink timing misalignment, denoted by $T_{M,j}$, is

$$T_{M,j} = (\Delta'_{DL,j} + \Delta'_{UL,j} - 2\Delta_{DL,j}) + (\Delta_{DL,i} - \Delta_{UL,i}) + \varepsilon_{CS,Accum} - \varepsilon_{T,i}\,. \tag{15}$$

We can argue that

$$|\Delta'_{DL,j} + \Delta'_{UL,j} - 2\Delta_{DL,j}| \approx |(\Delta'_{DL,j} - \Delta_{DL,j}) + (\Delta'_{UL,j} - \Delta_{UL,j})| \le |\varepsilon_{f,j}|_{\max}\,. \tag{16}$$

Since the error $\varepsilon_{T,i}$ is i.i.d. in each BS, then $\left|\varepsilon_{T,i}\right|_{\max} = \left|\varepsilon_{T,j}\right|_{\max}$.

Then, the maximum timing misalignment can be written as

$$\left|T_{M,j}\right|_{\max} \le |\varepsilon_{f,j}|_{\max} + \left|\varepsilon_{T,j}\right|_{\max} + \varepsilon_{CS,Accum} + |\Delta_{DL,i} - \Delta_{UL,i}|. \tag{17}$$

Note: the cell search timing error cannot be cancelled out, therefore affects the autonomous timing advance in handover. This is different than the case of TA in normal operation. If the cell search timing error is small enough, then the misalignment can be tolerated.

In order to support our autonomous timing advance idea, we need to assume that

$$|\Delta_{DL,i} - \Delta_{UL,i}| + \varepsilon_{CS,Accum} \le Margin \text{ (i.e., 1 µs)}. \tag{18}$$

With this assumption, timing misalignment caused by MS autonomous timing advance will fall within the CP length as in the regular timing advance case, as established in equation (7)

$$\left|T_{M,j}\right|_{\max} | \le |\varepsilon_{f,j}|_{\max} + \left|\varepsilon_{T,j}\right|_{\max} + Margin \le L_{CP}\,. \tag{19}$$