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Source: Motorola

Title: Time Aligned IP-DL positioning technique

Introduction

This document presents the results from a network simulator that has been used to model a modified version of Idle Period Downlink (IP-DL) location technique [1]. Some advantages of this new technique over standard IP-DL are described. However, a detailed comparison is not attempted here as the results released by Ericsson and Motorola have been run on different simulation platforms. With this in mind, it is also the purpose of this document to suggest the development of a common simulation platform for the evaluation of location techniques in 3GPP standards. Finally, we would like clarify that Motorola commend the work that Ericsson has done in this area and are supportive of the concept of IP-DL.

Time Aligned IP-DL Positioning Method

It is not the purpose of this section to describe the standard IP-DL positioning method in detail. The reader is referred to Ericsson's most recent document on this technique [2]. The differences between standard IP-DL and time aligned IP-DL will be explained.

In standard IP-DL, each node B will pseudo-randomly power-down (i.e. cease transmission) for an idle period. During the idle periods of the serving node B the target mobile is instructed to take measurements of neighbour node Bs. As the serving node B is now no longer transmitting, the chances of detecting the neighbour node Bs are increased.

Consider figure 1a where the transmissions from four node Bs using standard IP-DL are illustrated. The shaded slots are the idle periods and they occur pseudo-randomly. In time aligned IP-DL, rather than pseudo-randomly creating the idle slots it is proposed to time-align the idle periods from each node B. Clearly alignment will not be perfect, as the difference in frame timing between node Bs can drift to any value. However, the periods can be aligned to be closest to some arbitrary time as illustrated in figure 1b.

Idle period alignment requires that the offsets between the frame times of each node B site are known, ideally to a resolution higher than or comparable to a symbol period i.e. 625µs or less. This information then needs to be communicated to each node B so that the idle periods will occur at the correct time. Due to drift between different node Bs the frame time offsets will need to be updated at regular intervals. Typically, the update rate will not be more frequent than every 30 minutes.

Measurement of frame time offsets can be achieved in a number of ways. In a synchronised network, the frame time offsets are known and constant. In an unsynchronised network, the frame time offsets can be calculated from data sent to the network by mobiles before they enter soft handover – frame synchronisation is required to secure that the same downlink frames are sent in the involved node Bs towards the UE. Alternatively, the frame time offsets could be calculated by LMUs (location measurement units) which must be deployed in the network to measure the node B transmission time offsets to enable TOA based location in an unsychronised network.

During the ‘common’ idle period each node B has the option to transmit a signal ONLY useful for location e.g. this could be the BCH or the common pilot. The node B can either be instructed to transmit during the idle period randomly, pseudo-randomly or periodically.

Some of the benefits of time aligned IP-DL over standard IP-DL are listed below:

- Location accuracy is improved for the same measurement time due to the better C/(I+N) of the signals in the idle slots used for location measurements.
- Idle slot periods can be shorter and less frequent for the same location performance thus minimising impact on network performance
- Less processing is required at the handset for the same location performance. This is due to the significant reduction in the number of bursts needed and length of the correlators required in the less challenging C/(I+N) conditions in time aligned IP-DL.
- Location performance is no longer dependent on system load.
- Improved multipath rejection (MPR).
- Measurements are only collected during the idle period (in standard IP-DL the measurements from the serving site must be made separately)

Figure 1a

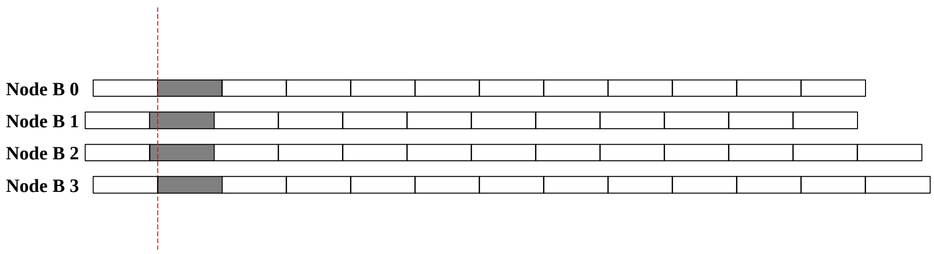

Figure 1b

Figure 1 Occurrence of idle periods for standard IP-DL and time aligned IPDL

Network Simulator

The following section describes the methodology and assumptions used in the network simulator:

The network simulator incorporates a regular hexagonal layout of Base Stations (node B) sites as illustrated in figure 2. The node B site separation defines the node B density in the network. For the Urban environment the node B site spacing has been taken to be 1km, suburban 3km and rural 20km.

The channel model used for the link layer is the model agreed upon in T1P1.5 [3] for the evaluation of GSM location techniques. The initial channel model was proposed by Ericsson and subsequently modified to reflect a large database of Channel Impulse Responses (CIRs) collected by Motorola during field trial work in different types of environments. Only the appropriate changes to reflect the differences in bit/chip rate and carrier frequency have been made to the original channel model for the UMTS simulator.

A target mobile is repeatedly dropped in sector 0 of site 0 at regularly spaced points until all areas of the cell have been covered. At each point the position of the mobile is estimated for a number of independent draws. In the case below the number of regularly spaced positions is 279, and 5 independent draws are made at each position.

Position estimation is performed by making relative time of arrival (TOA) estimates of signals from visible node Bs at the MS and passing these measurements to a weighted least squares (WLS) fixing algorithm. In time aligned IP-DL, measurements are made from all transmitting cells during the common idle period. Each node B site transmits the BCH during the idle period with a probability of 0.3. 10 regularly spaced idle periods occur every second during which time measurements are collected. Each idle period is one half slot i.e. 312.5μs (this excludes guard period). Taking into account time alignment (assumed to be aligned to the nearest symbol) and the mobile distance to different NODE B sites, typically three symbols of the BCH from each site will be received during the common idle period at the mobile (if that site is transmitting).

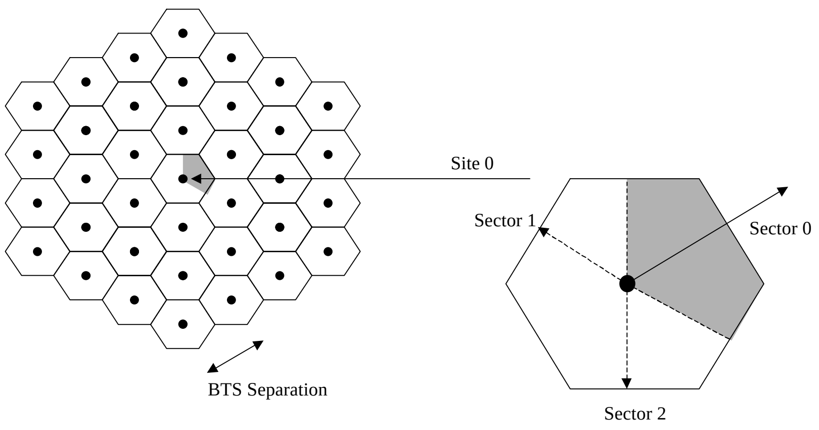

Figure 2 Network simulator layout

Simulation Results

The results from the simulator are presented in the format of a CDF of radial error of the position estimate compared to the true position of the target mobile. In figure 3 results for five environments specified by the channel model in [3] are presented. The 67% error and 90% rms error are listed in table 1. For all cases the mobile speed is 50 km/hr, the measurement collection time is one second, there has been selective weighting of TOA estimates in the WLS fixing algorithm and multipath rejection (MPR) has been applied. Improvement on these results is achieved by increasing the measurement time.

	67%	90% rms error

Rural	8 metres	6 metres
Suburban	6 metres	5 metres
UrbanB	44 metres	39 metres
UrbanA	95 metres	83 metres
Bad Urban	218 metres	193 metres

Table 1 67% error and 90% rms error from CDFs in Figure 3

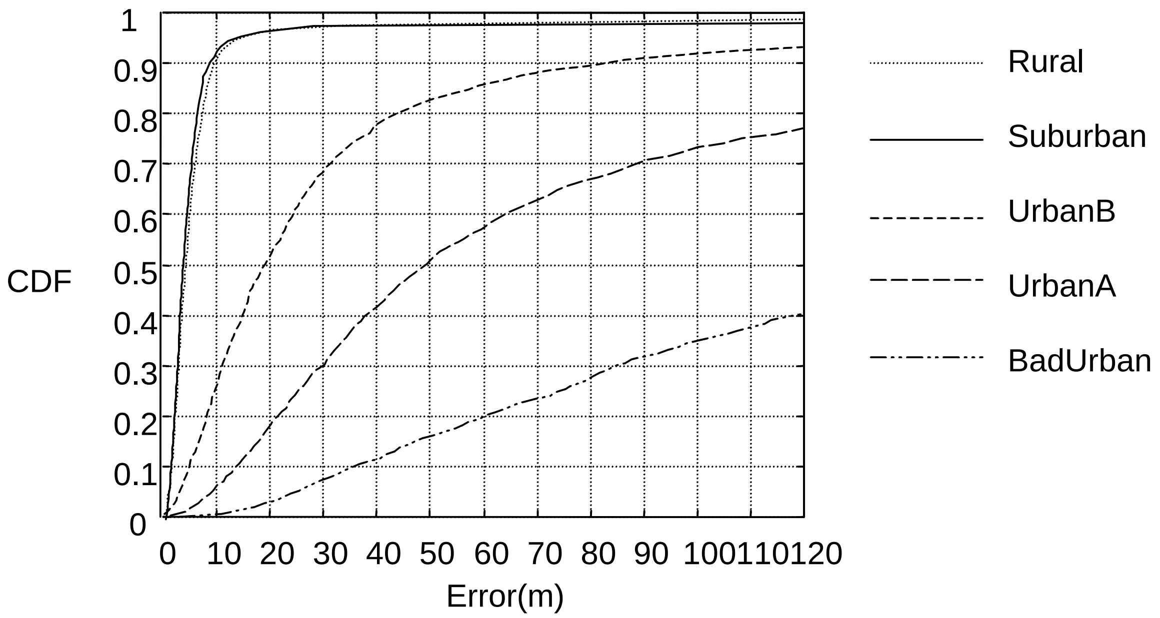

Figure 3 CDF of radial error for all five environments, mobile speed 50km/hr, measurement collection time 1s, MPR applied.

Conclusion

Some benefits of time aligned IP-DL over standard IP-DL have been outlined and preliminary results from time aligned IP-DL using a network simulator have been presented.

The only change to signaling required for time aligned IP-DL, compared to standard IP-DL, is a message from the RNC to the node B providing frame offset times to enable idle period alignment. The frequency of the message is low and the size of the message is small.

A detailed comparison of the performance of time aligned IP-DL and standard IP-DL is difficult unless a common simulation platform is used to evaluate these and other techniques. In the event that this is undertaken we would like to propose that as much as possible is reused from the common simulation platform that was developed in T1P1.5 for comparison of GSM location techniques.

Motorola are supportive of the concept of IP-DL. However, we believe there are significant improvements to be gained from approximate time alignment of the idle periods.

References

[1] Tdoc SMG2 UMTS-L1 327/98, Method for downlink positioning (IP-DL), Ericsson.
[2] TSGR1#4(99)346, Recapitulation of the IPDL positioning method, Ericsson.
[3] T1P1.5/98-110r1, Evaluation of Positioning Measurement Systems, Ericsson.