TSG-RAN Meeting No. 16 ***TSG RP-020372***
4-7 June 2002, Marco Island, Florida, USA

Title: **Software blanking for OTDOA positioning**

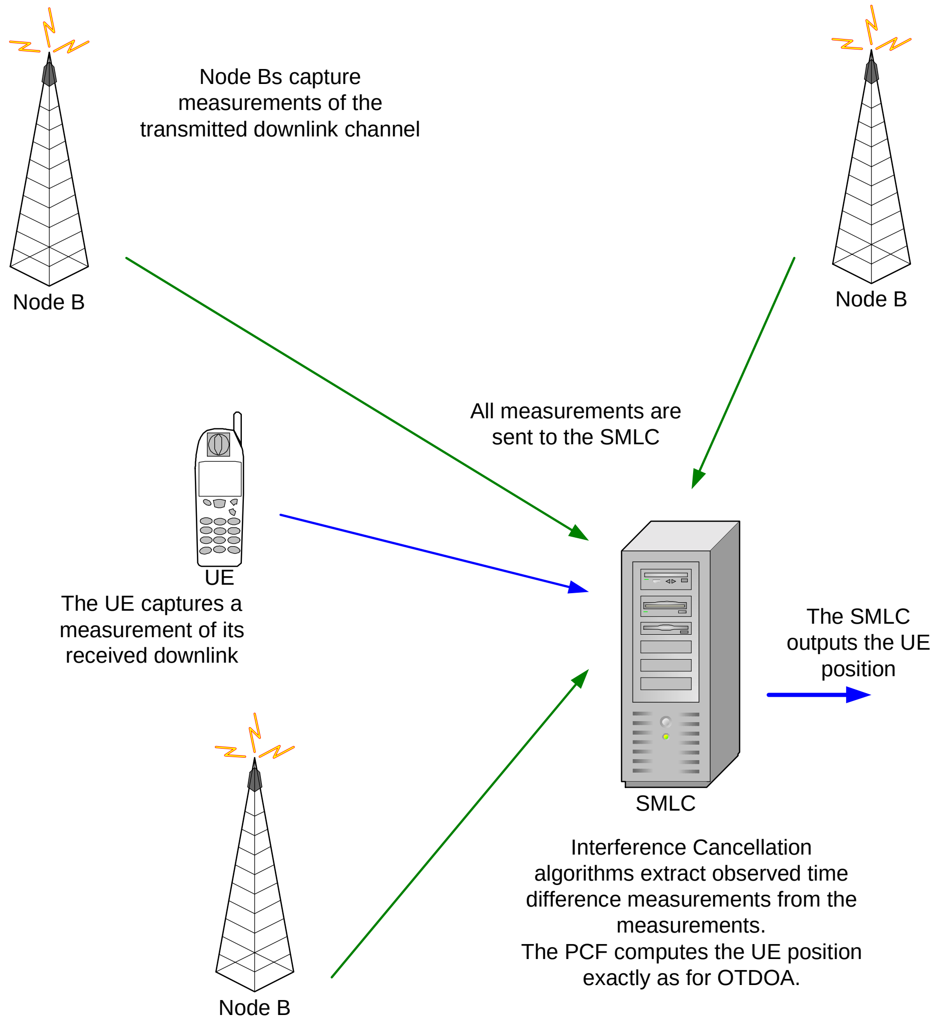
Source: Cambridge Positioning Systems (CPS)
Contact: David Bartlett, (david.bartlett@cursor-system.com)

Agenda: 8.10
Document for: Information

1 How software blanking works

Recent research into location techniques has led to a new approach to UE positioning using virtual blanking of the Node B downlink signals in the software domain, based on the principles of interference cancellation. It improves the performance of 3G OTDOA positioning by significantly enhancing hearability, using signal processing techniques as opposed to periodically turning off base station transmissions as required by IPDL (Idle Period on the Down Link).

Measurements of the downlink signal are taken simultaneously at the handset and at Node Bs whenever a position measurement is initiated. These measurements are returned to the SMLC (Serving Mobile Location Centre) via the RNC. Inside the SMLC, the interference cancellation algorithms significantly attenuate signals from interfering Node Bs, allowing weaker Node B signals to be measured and the observed time differences to be extracted. The algorithms may work iteratively cancelling interfering signals one-by-one starting with the strongest. In this way, multiple Node B signals can be blanked allowing weaker ones to be measured. Once all the timings are known, the position is computed using the standard OTDOA (same as E-OTD) algorithms.



2 A comparison of location techniques

Parameter	**OTDOA**	**IPDL-OTDOA**	**SW blanking OTDOA**	**A-GPS**
Estimated 67% accuracy	50-150 m	30-60 m	15-30 m	10-20 m
Estimated 95% accuracy	Unable to locate	150 m	80 m	Unknown
Coverage failure	Exclusion zone at cell centre: ~30%. Fallback to Cell-ID.	Failures occur around periphery of cell: ~ 5%. No suitable fallback.	Exclusion zone at cell centre: ~5%. Cell-ID suitable fallback.	Indoors or when line of sight to the sky is obscured.
UE complexity	Medium	High	Low	High
Operational complexity	Medium	High – Configuration and management of idle periods.	Medium	Low
Multipath tolerance	Low	Low	Good	Dependent on LoS to satellites
Meets E-911 phase 2 requirements	No	Probably	Yes	Yes
Affect on radio network capacity	Negligible	High: 0.3% to 6% of capacity, typically equiv to 2 voice circuits.	Low	Low - assistance data.

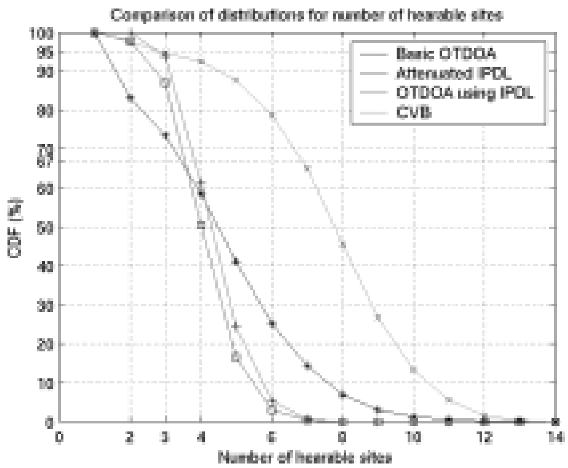
3 Hearability is the key

The UE is positioned using the differences in the arrival times of signals from a minimum of three Node Bs. The time differences are converted into distances based on the propagation speed of radio waves. The accuracy with which the UE may be positioned depends on how accurately the time-of-arrival of the Node B signals can be measured and how reliably these measurements can be converted into distances. The bandwidth of 3G downlink radio signals is sufficient to allow the time measurements to be made to an accuracy of a few metres. However, the signals received by the UE rarely arrive by the shortest path because of buildings and other objects that block their path.

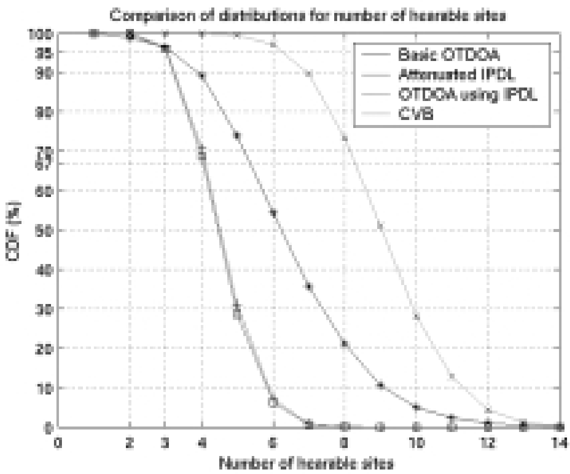
One of the most robust methods of reducing radio propagation effects such as multipath and non-line-of-sight, is to increase the number of Node Bs that are used in a location calculation. This approach uses diversity of radio paths and measurement redundancy in order to compute a more accurate and reliable position for the UE.

The more Node Bs that can be measured the better the results. Extensive field tests with E-OTD on GSM networks shows that using 8 measurements rather than 6 improves accuracy by more than 20%. Increasing this to 12 signals improves accuracy by a further 30%. Using only 3 or 4 signals yields errors approximately twice as large as with 8 signals.

The software interference cancellation approach dramatically improves hearability through its ability to blank multiple Node B signals. This improvement is illustrated in the charts below for suburban and urban environments, in which the CPS implementation of software blanking, called CVB (Cumulative Virtual Blanking) is compared with OTDOA and IPDL.



Suburban



Urban

It can be seen that IPDL yields guaranteed hearability for 2 signals, but since it only blanks the strongest signal, the second strongest tends to mask the rest which means that hearability beyond the first three is not improved much. The ability of software interference cancellation to blank multiple signals is a huge advantage and the charts illustrate how more than 50% of CVB measurements yield a hearability of 8 or more Node Bs, whereas IPDL can seldom measure eight.

4 Benefits of software blanking

The main advantages of software blanking are:-

- Improved accuracy performance, compliance with E-911 phase 2;
- It is simple to implement in the UE;
- It is future proof as software algorithms can be updated in the network without the fear of UE obsolescence;
- It has no impact on downlink capacity and no adverse impact on existing 3G functionality;
- There is zero impact on legacy UEs not implementing the method;
- The ability to blank multiple Node B signals is a major benefit in CDMA systems where hearability is the killer problem;
- The median number of hearable Node Bs for CVB is roughly double that for IPDL, mainly because of its ability to cumulatively blank multiple Node B signals rather than only one;
- It is much more robust in the presence of multipath;
- Operational complexity is reduced compared with IPDL;
- Software blanking works equally well with all transmit formats and line codes (e.g IS-95, W-CDMA, QPSK, QAM).

Thus the use of software interference cancellation to blank interfering signals represents a major step forward for Observed Time Difference location systems in 3G networks.

5 Background

Location Based Services in mobile networks is widely considered a growing opportunity. In the USA the FCC has mandated the introduction of technology that will enable a caller's position to be pinpointed to better than 100m 67% of the time and better than 300m 95% of the time when an emergency 911 call is made. For network assisted solutions these figures are being reduced to 50m 67% and 150m 95% from Q3 2003. More recently Europe has started looking at requirements for an equivalent system to pinpoint the location of emergency calls from mobile phones. New commercial applications are also emerging in which location provides an important ingredient to make the service more attractive to users.

In GSM, two complementary high accuracy location technologies have been adopted: Assisted GPS and E-OTD (Enhanced Observed Time Difference). E-OTD has been extensively trialled and is now being rolled out in several regions of the USA. It has been shown to meet the current requirements of the FCC's E-911 mandate, and by Q3 2003 is expected to meet the higher accuracy requirement that comes into force then.

3GPP has, in a similar way, adopted two complementary high accuracy location technologies for 3G: Assisted GPS and OTDOA (Observed Time Difference of Arrival), which is essentially E-OTD by another name. However, 3G networks use CDMA technology which introduces a new problem for OTDOA which does not occur for E-OTD in GSM: hearability. CDMA technology means that Node

Bs may transmit on the same frequency, their signals distinguished by different codes that allow the UE to discriminate between them. Thus it becomes difficult for the UE to measure weaker signals from more distant Node Bs. In order for OTDOA to be able to position the UE it is essential that the UE receives, and measures, the signals from at least 3 different Node Bs.

The hearability problem that OTDOA suffers means that even with sophisticated measurement processing at the UE, it will not be possible for OTDOA (without IPDL, or another assistance method) to meet the 95% requirements of the FCC. Some 30% of measurement attempts are likely to fail because there are less than three hearable Node Bs.

Although three geographically distinct Node Bs is the theoretical minimum, this yields no indication of errors and thus minimal immunity to non-line-of-sight or false measurements. One of the best approaches to achieving good multipath mitigation is to increase the number of Node Bs hearable by a UE. Increasing the median number of hearable Node Bs from four to nine is expected to double the accuracy.

In late 1998, in response to the hearability problems of OTDOA a study report prepared by ARIB was introduced to 3GPP. This report led to the introduction of a technique called IPDL (Idle Period on the Downlink) which blanks the Node B downlink signals randomly for short periods of time. During the period when the strongest Node B downlink has been blanked the UE is able to make measurements of weaker more distant Node Bs. In this way hearability when the UE is close to a Node B is improved and IPDL assisted OTDOA is able measure at least 3 Node Bs for 95% of the time. Since its introduction IPDL has progressed to the point where, as of June 2002, the work leading to its standardisation is almost complete. It is believed that with careful implementation and deployment IPDL should meet the requirements of E-911 phase 2.

Software blanking using interference cancellation promises to be the next major step forward for UE positioning in 3G. It achieves this performance gain primarily through its ability to blank multiple Node B signals, rather than being limited to one like IPDL.

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