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Agenda Item: Ad-hoc 17

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Title: Positioning method proposal

Document for: **Discussion**

Introduction

This proposal belongs to the larger family of OTDOA based methods which will be standardized. It can operate with the network configured to have zero idle slots. It is based on network elements - called positioning elements (PEs) - in known positions other than those of the base stations. Each of the PEs transmits a unique 256 chip symbol on the downlink at known intra cell timing instances (i.e. based on timing of cell's base station). The symbol is repeated with predetermined pattern within a multiframe.

System issues

Modes of operation

The PEs can transmit either on demand or periodically. When transmitting on demand there is no effect on the downlink of the system at times when the network does not wish to position any mobile and no mobile has requested to be positioned. If the network wishes to collect positioning information regularly, the PEs will transmit in every multiframe and will not expect to be alerted via the PICH.

The process with which the 16 S-SCH codes (symbols) are generated produces another 240 codes which are not in use by the system. The number of codes permits easy planning of the symbols that will be transmitted by PEs in adjacent cells.

Information on the symbols and associated patterns transmitted by the PEs in the serving and adjacent cell can be acquired by the mobile either via higher layer signaling or via the BCH. The positioning operation is not affected when a UE is in soft handover.

Transmission patterns

The patterns will be chosen in such a way as to accommodate fading patterns of fast as well as slow mobiles and to accommodate reliable reception of the first path. An example configuration may involve a symbol being transmitted at the beginning of the first slot of the first frame of a multi frame, another symbol transmitted at the beginning of the 8^{th} slot of the first frame and another symbol to be transmitted at the beginning of the first slot of the 10^{th} frame.

Advantages

- No need for the network to acquire and relay to the mobiles timing relations of adjacent BTSs.
- Smaller interruption of the downlink compared to idle-slots. Even if transmission of the positioning symbols leads to erasure of a downlink symbol in many down links, there is a much higher probability of FEC recovering that information compared to when the information in a whole slot is lost.

- The power control procedure is not interrupted
- No modification is needed to the AGC algorithm
- No requirement to have exact information on timing of other BTSs in the system
- Smaller UE complexity
  There is no need to generate portions of adjacent cell scrambling codes for correlation over the idle slots. The UE only has to configure the matched filter to search for a small number of 256 chip codes. The pattern for which the UE is searching for is short and does not change in successive measurements PEs will be placed in each cell and this will make the distance of the PEs to any UE being positioned in that cell smaller to the distance between that UE and base stations in adjacent cells. Correspondingly, the time window within which the UE has to search for the positioning signals is smaller than that in the IPDL method.
- Positioning can be provided in 'difficult' locations where signals from adjacent base stations may suffer too much attenuation. This could be the case of users indoors maintaining a link with an outside serving BTS but not being in a position to read signals from other BTSs even during idle slots.

Simulations will be performed to verify the first claim.

The Positioning Elements (PEs)

These are small sized transceivers which are placed within a cell. The position and number of Pes will be determined by terrain characteristics and availability of locations (lamp posts, walls, roofs, etc.) They are capable of receiving and transmitting on the same frequency – the cell's downlink frequency - in non-overlapping time intervals. For reception purposes the PEs need to be able to monitor the PICH and read the FACH. For transmission purposes, they only need to be able to generate and transmit a 256 chip symbol at a given power level. If the reconfiguration process requires acknowledgements, the PEs will need to be able to use the uplink frequency and send messages on the RACH.

The power level for the transmission of the symbols will be pre-set but can also be re-configured by the network according to dynamic parameters (downlink load of own and surrounding cells, measurement report by UE).

The positions of the PEs is known to the network. All positioning elements belong to the same paging group. They monitor the paging channel and in response to the paging indicator for their group being set they transmit a known sequency of their pre-assigned symbol in the next multiframe.

The PEs rely on the air interface for reconfiguration so there is no requirement for wired connections to them. They perform simple operations and because of that may even be able to operate long enough on large batteries in order not to require power supply connection.

Procedures

Procedure for network for on-demand positioning operation

When a positioning request is received, the network sends a higher layer message to the UE informing it of the SFN and slot number during which the transmissions from the PEs will occur (If the pattern is fixed within a multiframe such a higher layer message may not be required). It then sets the paging indicator for the paging group to which the PEs belong to. Only the PEs within one cell – the one in which the UE has made the positioning request – are activated.

The network will have configured the Tx delays for the PEs in such a way that there is enough time for a successful transmission of a higher layer message to the UE alerting it to the time interval it has to monitor.

The network receives the UE's measurements of time of arrival of the different symbols transmitted from the PEs. The measurements are given relative to the time that the UE receives the first ray of the BCH frame boundary from the BTS. If not enough measurements

are received, the procedure is repeated with the network sending a new message to the UE asking it to monitor for PE transmissions again, and again sets the PE paging group indicator. The gap between two measurement attempts is kept longer than [30] frames.

The possibility exists to reconfigure the Tx power of the PE which was not received by the UE. To do this the network violates the convention that the paging indicator for the PE group will not be set twice within [30] frames (the exact number to be investigated). When this happens, the PEs read the S-CCPCH and they follow the same procedure as a paged mobile in order to establish contact with the base station and receive the reconfiguration message.

The PEs have fixed positions which allows deduction of the time at which they receive the frame boundary from the BTS. They transmit with known delay from the time they receive the frame boundary from the BTS which means that the BTS has accurate knowledge of the time – relative to its own frame timing – at which each PE transmits its symbol. When the UE reports the difference of symbol arrival time to BTS frame boundary arrival time, the BTS can deduct the propagation delay between the PE and the UE and hence the distance between each PE and the UE. Such information for two PEs and the distance from the own BTS – given by the round trip delay – allows positioning for the UE based on triangulation.

Procedure for UE

The UE samples the DL at the time interval commanded by the network. It correlates the samples with all the possible codes/symbols used by the PEs in that cell (or in adjacent cells two if in soft handover) in a running window with sampling length resolution. When the correlation output crosses a set threshold, the reception of a positioning symbol is recorded. The time of arrival with respect to the time of arrival of the frame boundary from the serving BTS is recorded. All recorded measurements are reported to network as soon as possible after the measurement/processing is completed.

Procedure for PE

Each PE will read the paging channel. When the paging indicator for the group to which all PEs belong to is set, the PE will transmit its pre-assigned 256 chip symbol with the predetermined offset and predetermined pattern. The PE then goes back to reading the paging indicators. If two consecutive paging indicators are set within [30] frames, the PE will read the paging message and will contact the base station if its ID is found on the S-CCPCH.

Conclusion

A positioning method has been proposed that relies on additional network elements called positioning elements. Each of the PEs transmits a S-SCH like code - which identifies it - at predetermined instances relative to the timing with which it receives the common control channels in the cell. The process relies on intra cell timing only. A number of other advantages have also been claimed. Simulations will be performed to evaluate the required density of PEs, the required Tx power and transmission patterns. The method is compatible with the agreement in WG2 to standardize OTDOA methods and will not require many modifications to WG1 specifications.