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Technical Report

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(Release 4)

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Contents

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

This technical report identifies possible UE positioning enhancements and new methods for UTRA TDD and FDD for release 4. It shall build the basis for evaluation and comparison of these methods and enhancements. The report also covers the impacts on Layer1 and UTRAN interfaces.

Finally, CRs to the affected specifications should be created based on this TR.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[1] 3G°TS°25.305: "Stage 2 Functional Specification of Location Services"

[2] 3G°TS°25.225: "Physical Layer, Measurements (TDD)"

[3] 3G°TS°25.224: "Physical Layer Procedures (TDD)"

[4] 3G°TS°25.331: "RRC Protocol Specification"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.

Definition format

<*defined term*>: *<definition>*.

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

Symbol format

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

Abbreviation format

<ACRONYM>	<Explanation>
BCH	Broadcast Channel
DGPS	Differential GPS
GPS	Global Positioning System
LCS	Location Services
OTDOA	Observed Time Difference Of Arrival
PSCH	Primary Synchronisation Channel
UE	User Equipment
SCH	Synchronisation Channel
TDD	Time Division Duplex

4 Main concepts

The main concepts are the same as specified in [1].

4.1 Assumptions

The location services categories are the same as specified in [1].

4.2 Location Services Categories

Location Services in release 4 shall be based on the same principles as apply for release '99. Signal measurements made by the UE, Node B or auxiliary measurement units such as Location Measurement Units (LMUs) are used for location estimation. The location estimation is calculated by a position calculation function in the UE or in the UTRAN.

4.3 Location Services in Release 4

4.4 R4 Enhancements for R99 Standard LCS Methods

4.4.1 OTDOA location method in TDD

The OTDOA method is described in [1]. Basically this method is also already available in release '99 for TDD since OTDOA is based on the SFN-SFN observed time difference type 2 measurement, which is specified in [2]. For TDD it is not specified on which physical channel to perform the measurement. Therefore a UE may make measurements in every slot within a frame. Because of having synchronised cells, a relative time difference between neighbouring cells is not needed for the position estimation.

However, in some conditions a sufficient number of cells may not be available for measurements at the UE. In order to increase the probability to receive signals from neighbouring cells, IPDLs may be applied.

4.4.1.1 Use of Idle Periods

Because of traffic in the serving cell as well as in neighbouring cells and multipath propagation, the UE might be unable to detect an sufficient number neighbouring cells. This is known as the hearability problem. Therefore, probably only UEs that are located on the edge of a cell are able to determine their location by using the OTDOA method.

To overcome the hearability problem, an idle period method may be used. In this method each base station ceases its transmission for short periods of time (idle periods). During an idle period of a base station, terminals within the cell can measure other base stations and the hearability problem is reduced.

The idle periods in TDD are realised by ceasing the transmission within a whole slot. The timing of the idle period occurences is signalled to the UE via RRC signalling, so that the UEs know when to expect the idle period. The operation and specification of the idle periods for TDD can be found in chapter 5.

4.4.2 Almanac-based DGPS method (DGPS-A)

A GPS satellite orbit can be modelled as a modified elliptical orbit with correction terms to account for various perturbations. In a GPS system, the orbit of the satellite can be represented using either ephemeris or almanac parameters. The short-term ephemeris data provides a very accurate representation of the orbit of the satellite. In contrast, the long-term almanac data provides a truncated reduced precision set of the ephemeris parameters. Consequently, raw satellite positions derived from almanac data tend to be much less accurate (~1km) than those derived from the detailed ephemeris data (~1m).

Currently, Release '99 defines information elements for both almanac and ephemeris orbital models. Note that both optional broadcast and point-to-point mechanisms have been specified for the distribution of these almanac and ephemeris messages [4]. Release '99 also specifies a Differential GPS (DGPS) corrections information element that is used to compensate for orbital, clock, and atmospheric perturbations. The UE-Based technology can employ these *ephemeris-based* DGPS corrections ("DGPS-E" corrections) along with ephemeris information in order to obtain corrected positioning results.

An augmentation to the DGPS correction information specified for Release 4 can enable the network to provide the UE with an optional form of *almanac-based* DGPS corrections ("DGPS-A" corrections). The UE-Based technology can employ these DGPS-A corrections along with almanac information in order to obtain corrected positioning results.

The motivation for pursuing the DGPS-A concept stems from the following basic observations:

1) Per satellite, the size of an ephemeris model (~600 bits) is approximately 3 times that of an almanac model (~200 bits). In the case where these orbital models are provided to a UE for 10 visible satellites, about 6000 bits of ephemeris information must be transferred as opposed to 2000 bits of almanac information.

2) The useful lifespan of each ephemeris model may be extended to six hours by incorporating DGPS-E corrections into the UE position computation. In contrast, the useful lifespan of each almanac model may be extended to six days by incorporating DGPS-A corrections into the UE position computation. At first glance, a potential 24-fold reduction in orbital model update rate to the UE seems possible for point-to-point assisted GPS operation.

3) With respect to DGPS-E corrections, DGPS-A corrections can be provided within an equivalent number of bits.

4) With respect to DGPS-E corrections, DGPS-A corrections can be provided with equivalent useful lifespan (e.g., a few minutes or more).

The possible reductions in signalling bandwidth and/or latency realized from broadcasting a combination of almanac information and DGPS-A corrections (instead of ephemeris + DGPS-E corrections) should be assessed for practical UE positioning operations. In a similar manner, the possible reductions in signalling bandwidth and/or latency realized by employing the DGPS-A positioning method in a point-to-point mode should be evaluated for practical use. Note that for the point-to-point assessment, potential reductions in orbital model update rate to the UE may become of interest.

4.5 Other UE positioning Methods

4.5.1 OTDOA based on SCH listening in TDD

The OTDOA method is described in [1]. This OTDOA method is different from the OTDOA method specified for release '99, since the time difference measurements are carried out on the primary synchronisation channel. The definition of the SCH consists of the sum of one primary SCH (PSCH) and three secondary SCH (SSCH). Because of cell sync it will be possible to differentiate the primary SCH on the basis of offset. This is large enough to be unambiguous with respect to range/location.

Depending on the offsets, two or more PSCH transmissions heard by one UE may be partially overlapped in time. Thus the auto correlation properties of the PSCH are of concern. To overcome this problem, planning may be done so that surrounding cells have non overlapping PSCHs but there are probably not enough degrees of freedom in the available number of time offsets, thus probably other solutions have to be found.

In order to evaluate the applicability and performance RAN WG1 should study this method in more detail

4.5.1.1 Use of Idle Periods

As already mentioned in the OTDOA method description for TDD, traffic in the serving and neighbouring cells plus possible multipath propagation might prevent detection of enough PSCHs by the UE, so that only UE at the cell borders might be able to locate itself.

Again, idle periods may be used to overcome this problem.

Feasibility, performance improvement and impacts to the system of these idle periods should be further investigated in RAN WG1.

4.5.2 Angle of Arrival (AOA)

The location method may make use of the angle of arrival of the radio signals to estimate the UE location. This technique may, for example, make use of the sector of the base station used for receiving or transmitting to establish the location region and to assist to resolve ambiguity in other techniques. Some other techniques may make use of narrow beam antennas to resolve the direction between the UE and the base station to a very small angle.

The AOA techniques and the signalling required for their support, are FFS.

4.5.3 Observed Time of Arrival (OTOA)

The location service technique may make use of measurements of the time of arrival of signals. A UE, for example, which has available a suitable reference time, may measure the time of arrival of signals from the base stations and others sources. Some of these may include reference signals from satellites. The time-of-arrival may be used to estimate the distance from the source and hence derive a location estimate.

The OTOA technique may also be used to measure signals transmitted by the UE. Base stations which are able to receive signals from the UE, and which share a suitable reference time, may each measure the time of arrival of signals from the UE. These times-of-arrival may be used to estimate the distance to the UE and hence derive a location estimate.

The OTOA techniques and the signalling required for their support, are FFS.

4.5.4 Reference Node-Based Positioning (OTDOA-RNBP)

The RNBP method is based on the OTDOA. The main principle of the RNBP method is that it chooses a reference node for providing auxiliary measurements for its location calculation. The reference node may be a mobile equipped by a GPS receiver that provides its co-ordinates, a fixed or movable LCS service provider equipment, a mobile capable of using cellular relay technique (e.g. located at the soft handover area).

RNPB can also utilised with other methods. It is especially useful in case of NLOS from/to the required number of neighbouring base stations. This may occur when the UE is located at the area where it may suffer from the hearability effect. Additionally it can support the LCS even in case UTRAN is not equipped by IPDL like mechanism to combat the hearability effect.

4.5.5 OTDOA - Positioning Elements (OTDOA-PE)

The PE method is based on OTDOA and makes use of Positioning Elements (PE) located within the coverage area. PEs are placed in accurately known locations other than those of the Node B equipment. They synchronise to the downlink in a cell and transmit their symbols at predefined - or signalled - offsets with regard to the arrival of the beginning of the BCH frame at the PE location. The offsets may be chosen to have a fixed relation to the occurrence of the idle periods in each cell. Each PE transmits a different and identifying code which is selected from the group of codes to which the 16 SSC codes belong to. The use of other signals (e.g. CIPCH) instead of SSC codes is for further study.

The time difference which is observed and reported by the UE is the difference - with respect to the time of arrival at the UE - between the first path of the BCH from the serving cell and the first path of the 256 chip code transmitted by a PE. The measurements result in an estimate of the UE distance to the PEs.

PE deployment is optional and may be used in conjunction with other methods in order to increase location accuracy in certain areas or to achieve a minimum desired accuracy in locations where reception of satellites and/or base stations other than the serving one is problematic (indoors, edge of cellular coverage, etc.). It may also be used as a stand alone method.

5 Layer 1 impacts

5.1 OTDOA location method in TDD

5.1.1 Impacts of Idle Periods

Editors Note: The following sections should be in incorporated in [3] if it is decided to have IPDLs in release 4.

5.1.1.1 General

To support time difference measurements for location services, idle periods can be created in the downlink (hence the name IPDL) during which time transmission of all channels from a Node B is temporarily ceased. During these idle periods the visibility of neighbour cells from the UE is improved. For TDD it is more reasonable to cease the transmission during a whole time slot. The idle periods must be arranged in such a way that they occur in the same timeslot as the measurement is performed by the UE on the signals of the neighbouring cells. During Idle periods all channels are silent simultaneously. By means of higher layer signalling (e.g. channel reconfiguration) it may be possible to shift all transmission during an idle period to other slots in order to prevent the loss of data.

In general there are two modes for these idle periods:

- Continuous mode, and
- Burst mode.

In continuous mode the idle periods are active all the time. In burst mode the idle periods are arranged in bursts where each burst contains enough idle periods to allow a UE to make sufficient measurements for its location to be calculated. The bursts are separated by a period where no idle periods occur.

5.2 Parameters of IPDL

The following parameters are signalled to the UE via higher layers:

IP_Status: This is a logic value that indicates if the idle periods are arranged in continuous or burst mode.

IP_Spacing: The number of 10 ms radio frames between the start of a radio frame that contains an idle period and the next radio frame that contains an idle period. Note that there is at most one idle period in a radio frame.

IP_Length: The length of the idle periods. For TDD the IP_Length is a constant value of 1 slot.

IP_Slot: The number of the slot that has to be idle [0..14].

Additionally in the case of burst mode operation the following parameters are also communicated to the UE.

Burst_Start: The SFN where the first burst of idle periods starts.

Burst_Length: The number of idle periods in a burst of idle periods.

Burst_Freq: The number of radio frames between the start of a burst and the start of the next burst.

5.3 Calculation of idle period position

In burst mode, the first burst starts in the radio frame with SFN = Burst_Start. The *n*:th burst starts in the radio frame with SFN = Burst_Start + $n \times$Burst_Freq. The sequence of bursts according to this formula continues up to and including the radio frame with SFN = 4095. At the start of the radio frame with SFN = 0, the burst sequence is terminated (no idle periods are generated) and at SFN = Burst_Start the burst sequence is restarted with the first burst followed by the second burst etc., as described above.

Continuous mode is equivalent to burst mode, with only one burst spanning the whole SFN cycle of 4096 radio frames, this burst starting in the radio frame with SFN = 0.

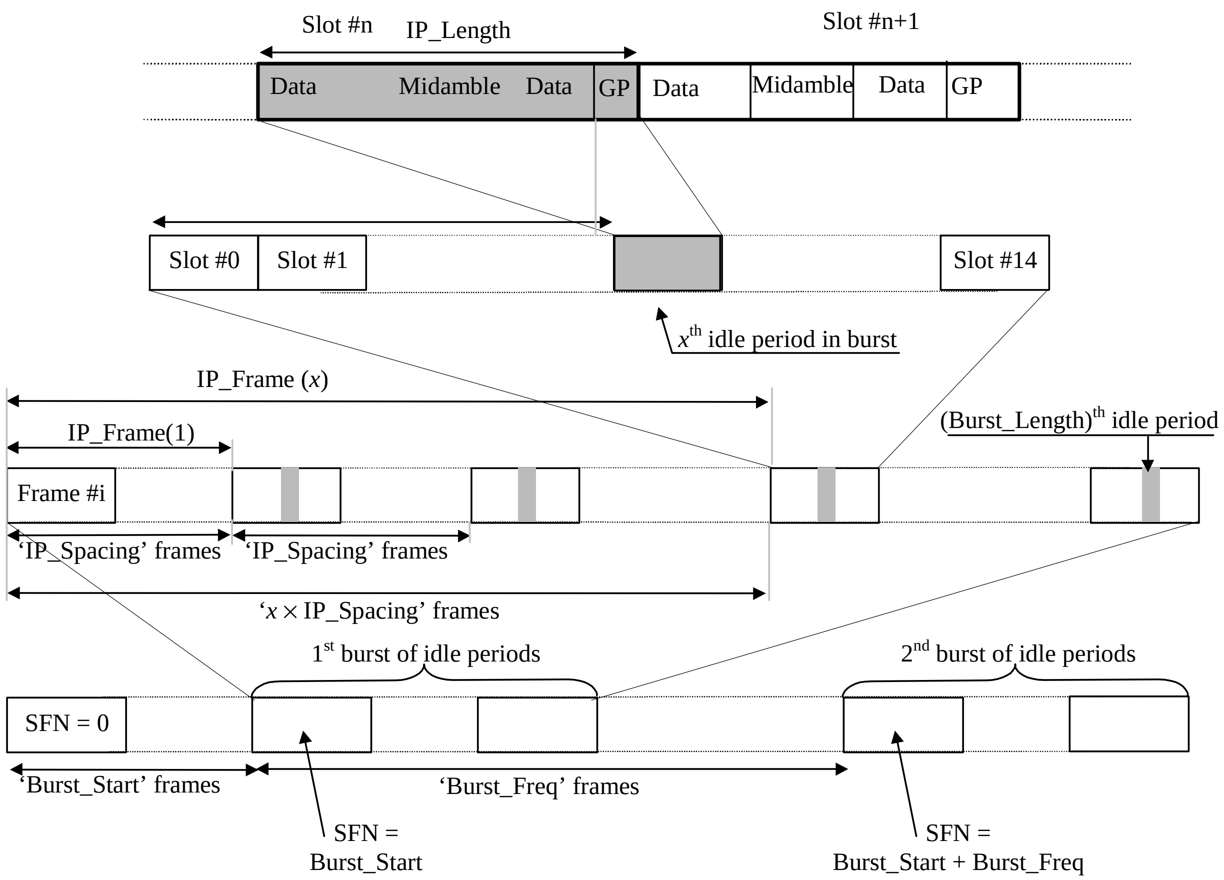
Assume that IP_Frame(x) is the frame with the idle period number x within a burst, where x = 1, 2...,

The positions of the idle periods within each burst are defined by IP_Frame and IP_Slot. IP_Frame(x) is given by the following equation:

$$\text{IP\_Frame}(x) = x \times \text{IP\_Spacing}$$

Note that *x* is reset to *x* = 1 for the first idle period in every burst.

Figure 5.1 below illustrates the idle periods for the burst mode case.



Figur 5.1

6 Impacts on UTRAN interfaces

7 Specification Impacts

History

Document history		
Date	**Version**	**Comment**
November 2000	v.0.2.0	Descriptive text added for IPDL scheme for OTDOA in TDD; Descriptive text added for DGPS-A method
October 2000	v.0.1.0	General text added; Descriptive text for possible methods/enhancements
October 2000	v.0.0.0	First version
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