TSG-RAN Meeting #24 **RP-040164**
Seoul, Korea
2-4 June 2004

Work Item Description

Title

Inclusion of Uplink TDOA UE positioning method in the UTRAN specifications

1 3GPP Work Area

X	Radio Access
	Core Network
	Services

2 Linked work items

UE Positioning

3 Justification

The Uplink TDOA (U-TDOA) location method has been standardized in the GSM circuit switched environment and standardization in the GSM packet switched environment (GPRS) is proceeding. Some carriers have expressed an interest in using the U-TDOA location technology for UMTS. The U-TDOA standardization process should begin in order to facilitate a seamless upgrade path to UMTS networks.

4 Objective

The objective of this Work Item is to include Uplink TDOA as a positioning methodology within the specifications.

The implementation will be a Stand-Alone SMLC (SAS) based overlay network that interfaces to the UTRAN on the Iupc interface as described in the attached presentation.

This work item is intended to complement already standardized location methods and existing location work items.

5 Service Aspects

None

6 MMI-Aspects

None

7 Charging Aspects

None

8 Security Aspects

None

9 Impacts

Affects:	USIM	ME	AN	CN	Others
Yes			X		
No	X	X		X	
Don't know					X

10 Expected Output and Time scale (to be updated at each plenary)

New specifications						
Spec No.	Title	Prime rsp. WG	2ndary rsp. WG(s)	Presented for endorsement at plenary#	Approved at plenary#	Comments
Affected existing specifications						
Spec No.	CR	Subject			Approved at plenary#	Comments
25.305		Stage 2 Functional Specification of UE Positioning in UTRAN			RAN #28	
25.453		UTRAN Iupc Interface: PCAP Signaling			RAN #30	
25.331		RRC Protocol Specification			RAN #32	
25.1XX		LMU Performance Specification			RAN #32	
-		Other specifications as required				

11 Work item raporteurs

Mr. Rhys Robinson, TruePosition, Inc.
Mr. Robert Gross, TruePosition, Inc.

12 Work item leadership

TSG-RAN WG2

13 Supporting Companies

Cingular Wireless, T-Mobile, TruePosition, SBC Communications, InterDigital

14 Classification of the WI (if known)

	Feature (go to 14a)
X	Building Block (go to 14b)
	Work Task (go to 14c)

14a The WI is a Feature: List of building blocks under this feature

N/A

14b The WI is a Building Block: parent Feature

UE Positioning

14c The WI is a Work Task: parent Building Block

N/A

A PROPOSAL TO ADD UPLINK TDOA TO THE UTRAN

Abstract

The Uplink TDOA location method has proven highly accurate for location of wireless subscribers in CDMA based systems. The wider UMTS bandwidth coupled with significant processing gain available to Network Based location systems will provide a higher level of accuracy in UTRAN networks and in situations where other location techniques may not be able to perform as well. This increased accuracy can be realized at reduced complexity over implementations of Downlink OTDOA or A-GPS. Additionally critical for future success of network operators, the Uplink TDOA method provides significant flexibility for implementation of future Location Service enhancements.

The introduction of U-TDOA into the UTRAN specifications is not meant to replace existing methods but to augment overall location services capabilities. The U-TDOA location method performs well in urban, suburban, and indoor environments and less well in rural areas. Conversely, A-GPS does not perform well in some urban or indoor environments but excels in rural environments. This suggests the need for hybrid location solutions that take advantage of the capabilities of both technologies.

This remainder of this document discusses the advantages of Uplink TDOA and describes the functionality to be added to the specifications listed in the Work Item request that are required to include Uplink TDOA.

Advantages of Uplink TDOA in the UTRAN environment

TruePosition has spent over nine years investigating potential location technologies and has concluded that Uplink TDOA is the method that provides the best performance in the widest possible set of circumstances, at the lowest overall complexity and with the least impact on the wireless infrastructure. The following list summarizes the features that make Uplink TDOA the technique of choice:

- The primary difference between Uplink TDOA and Downlink OTDOA is the processing capacity available to analyze signal information and calculate subscriber locations. Handsets have a limited amount of processing power to apply to location determination. Network based location systems combine the DSP power from many LMUs for the location of a single mobile station and, as a result, are capable of significantly more processing applied over much longer periods of time. This increased processing power provides:

    - 20 to 30 dB greater processing gain than a DL-OTDOA solution through long integration times. In the DL-OTDOA system, the MS must make measurements of pilot signals from several sites, one by one, while still providing the other MS functions, the DSP processors of many LMUs work simultaneously to locate a single MS.
    - Sophisticated multipath mitigation techniques
    - Simultaneous location of many subscriber units
    - Acquisition of location information from many more distant location receivers (LMU)

- For User Equipment in the Cell_DCH state, there is no additional interference contribution for location determination. The Uplink TDOA technique locates the UE using the energy associated with the existing bearer and control information, when the signal is transmitted at the normal power level.

- For User Equipment in the idle mode, there is no more contribution to interference than normal subscriber traffic and for a much shorter period of time (100-500 mSec), which is comparable to the amount of data transferred in the assistance and measurement data. Additionally, the interference contribution is relatively low for Uplink TDOA using control channel activity because of the relatively large spreading factors associated with the Signaling Radio Bearers (SRB).

    - There are techniques that could further limit the interference contribution associated with the location of idle mobile. These functionalities could also be used as a trade for QoS accuracy requirements versus interference contribution.

- The Uplink TDOA methodology requires no modification to the Node B or User Equipment, based on current specifications.

- Extensive testing of Uplink TDOA in New York City, New York, USA (Manhattan) has demonstrated that it is superior to A-GPS in environments with limited visibility of the GPS satellites and, more importantly, the high levels of RF attenuation prevalent in urban environments, and building interiors.

- Uplink TDOA is based upon the solution for IS-95 CDMA, which has been tested in rural, suburban, and urban environments, with a demonstrated accuracy of 50m-70m (67%, see table below). The solution proposed for WCDMA has the advantage of wider bandwidth, which is expected to improve performance by 30%.

- Uplink TDOA provides protection against obsolescence. It is far easier and less complex to upgrade the software in RNCs and LMUs than it is to upgrade millions of UEs.

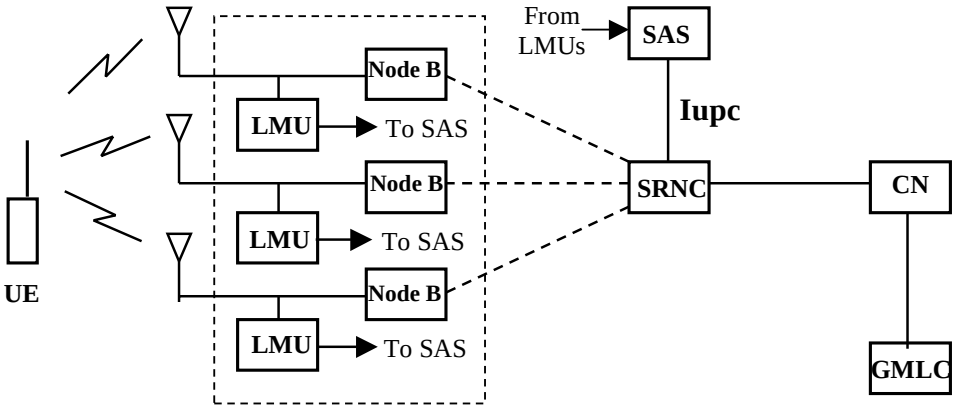
- Additional benefits:

    - Uplink TDOA does not require implementation of the Idle Period, Down-Link (IPDL) functionality. IPDL prevents communication in the DL while allowing the MS to make timing measurements spanning only 256-1025 chips.
    - Uplink TDOA can operate in FDD and TDD networks.
    - The Uplink TDOA solution, when integrated with the Node B will have a very low incremental cost.

The Uplink TDOA Approach for CDMA in UTRAN

TruePosition proposes to enhance the UTRAN Location Services as defined in TS 25.305 to include an Uplink TDOA capability by expanding the definition and functionality of the SMLC.

The following diagram illustrates the proposed topology:



The general procedures associated with UE location using Uplink TDOA are:

- The RNC receives a LOCATION_REQUEST message from the GMLC via the CN

- The RNC establishes whether the requested UE is in the idle mode or Cell_DCH state
  - If the UE is in the Cell_DCH state, Node B identity, scrambling code and all other information necessary to identify the UE's RF energy are passed to the SMLC
  - If the UE is in idle mode, the RNC will cause the UE to transmit for a fixed period of time and pass the Node B identity, scrambling code and all other information necessary to identify the UE's RF energy for that transmission to the SMLC.

- The SMLC will task the Primary LMU (typically associated with the UE's current Node B) with capturing and possibly demodulating a defined amount of the target UE's transmission. The SMLC will also task the Secondary LMUs (those LMU that have the potential to receive the transmission) with capturing the target UE's transmission.

- The Primary and Secondary LMU will time stamp this data and return it to the SMLC

- The SMLC will use the information from the Primary and Secondary LMU's to perform a TDOA calculation of the UE location

- The UE location will be provided to the GMLC for distribution to the client application.

The following section of this document provides a high level description of the changes that are required to implement Uplink TDOA into the UTRAN:

- Include Uplink TDOA functionality in the SMLC and expand the Iupc protocol to include the required TDOA messaging

- Modify RNC functionality to provide the information to the SMLC which will identify the time and coding of a particular subscriber's (UE) RF energy (Cell_DCH state)

- Modify the RNC to interrogate an idle UE (classmark interrogation, measurement report request or other method) for Uplink TDOA location purposes.
  - This may also include, initially, transmission for fixed periods of time but may be eventually enhanced to include variable transmission periods
    - Protection mechanisms must be included to avoid prolonged UE transmission
  - Generically, a dedicated channel could be assigned by the RNC. A combination of the time this channel is assigned, and the target Eb/No, will control the amount of energy transmitted by the MS. The total energy (combination of the number of bits and target requested Eb/No) could be provided to the RNC by the SMLC. The amount of energy requested should be a function of the QoS required for the position. The RNC could assign the appropriate dedicated channel, and control the target Eb/No to obtain the appropriate energy, per the constraints of the system capacity, and the request of the SMLC. The RNC should report the effective data rate and Eb/No for the given time period.

Uplink TDOA Performance and Test Results

A test bed system with over 170 sites has been implemented on major North American carrier's systems. These include dense urban (Manhattan Island, New York, New York, USA), suburban, rural and open water environments. Hundreds of thousands of location events over an area of several thousand square kilometers have been analyzed and used to continuously improve system performance.

The following table summarizes the results of this testing for IS-95 CDMA in an urban, suburban and rural environment. Test calls were made from many scenarios including indoor, out-door pedestrian, in-vehicle stationary, and in-vehicle moving at various speeds. Calls were placed at various distances from the serving cell site to characterize the effect of the near far problem. Our calculations indicate that the wider bandwidth associated with W-CDMA will provide a location accuracy improvement of 30% over the performance achieved in IS-95.

Accuracy results from IS-95 CDMA testing		
Environment	67%	95%
Urban	70m	153m
Suburban	62.5m	183m
Rural	49m	275m

Uplink TDOA Location Capacity

Uplink TDOA locations supports a high location rate for active calls, while having no impact on overall system capacity, as the energy already transmitted by the UE can be used for location.

For idle mobiles, a single location consumes the equivalent air interface capacity of 1 full rate voice circuit for 150 milliseconds, on average. Assuming a high location rate of 1 per second per 5MHz carrier, 1 Mb/s total cell throughput and an average value of 3000 user bits for location purposes, this amounts to a 0.30 % consumption of system capacity.

Inclusion of Uplink TDOA Location Method

TSG-RAN Meeting #24
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RP-040164

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Inclusion of U-TDOA

Objective

The objective is to create a Work Item or Building Block which includes Uplink TDOA as a positioning method within the UTRAN specifications.

The implementation will be a Stand-Alone SMLC (SAS) based overlay network that interfaces to the UTRAN on the Iupc interface.

This work item is intended to complement already standardized location methods and existing location work items.

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U-TDOA Fundamentals

- Uplink Time Difference Of Arrival (U-TDOA) uses MS transmit energy for location purposes
- Energy from an existing connection or from a dedicated channel (SRB or RB) assigned for location purposes (i.e. previously idle mobile) is used
- The channel information (transmitted bits) is captured at the serving cell and used by the location receivers (LMU) at several other sites to identify the energy associated with the target UE
- The Time Of Arrival (TOA) of the UE signal at each LMU is then used to calculate the position of the UE

U-TDOA Advantages

- Independent of UE configuration and capabilities
  - Legacy and low tier UE are provided location support
  - Location support extended to Roamers
- Low Latency
  - Capable of providing fast location on SRB for “XY” location based routing
- Complimentary to existing UE based location methods
  - Performs well in congested urban areas and building interiors where UE based location methods have lower yields

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U-TDOA Advantages

- Capable of enhancing the Service Network
  - Node B network synchronization
  - Enhanced A-GPS performance using Node B-to-GPS synchronization
- Location support can be shared across networks

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Implementation of U-TDOA

- Modifications to TS 25.305 (Stage 2 positioning in UTRAN) include:
  - Addition of a U-TDOA description section
  - Inclusion of U-TDOA in the defined procedures
- Modifications to TS 25.453 (PCAP) include:
  - Inclusion of U-TDOA and hybrid related Information Elements (IE) into the existing PCAP messages
    - Position Calculation Request and Response messages
    - Information Exchange series of messages
  - Creation of U-TDOA Request and Response messages
  - Creation of a Position Calculation Reset message

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Implementation of U-TDOA

Modifications to TS 25.331 (RRC Protocol Specification) include:

- Addition of a U-TDOA to UE Positioning description section
- Inclusion of U-TDOA in the defined procedures

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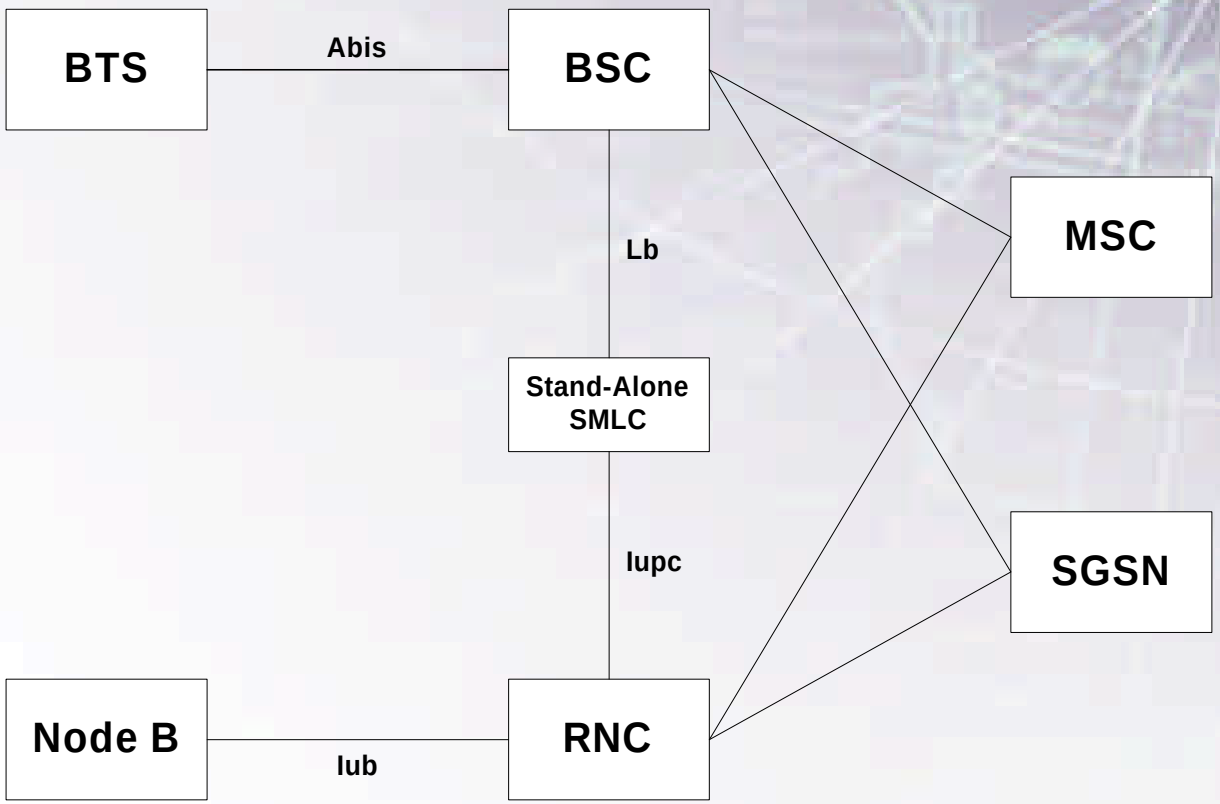
U-TDOA Architecture



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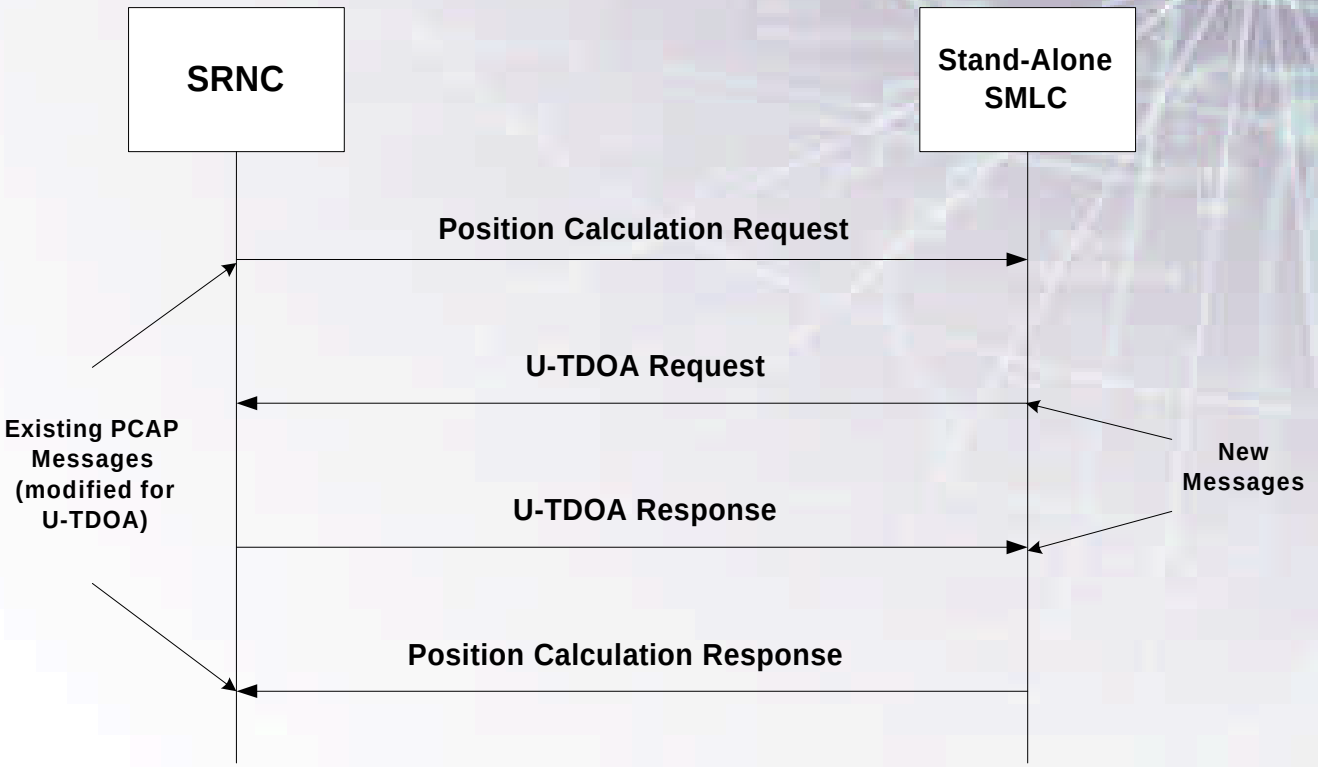
PCAP Signaling on the Iupc interface



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Conclusion

- U-TDOA support should be extended to UMTS in order to provide:
  - Upward migration path for existing GSM/GPRS U-TDOA systems
    - Approximately 40,000 GSM sites equipped in over 100 operator markets
  - High yield, high accuracy location support across all conditions
    - Hybrid location system, I.e A-GPS plus U-TDOA
  - Location support to legacy mobiles and Roamers
  - Low latency UE location

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