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OTDOA or UTDOA?
- Performance and Implications on LBS Strategy

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Outline

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- Expecting better performance of DL-OTDOA in LTE
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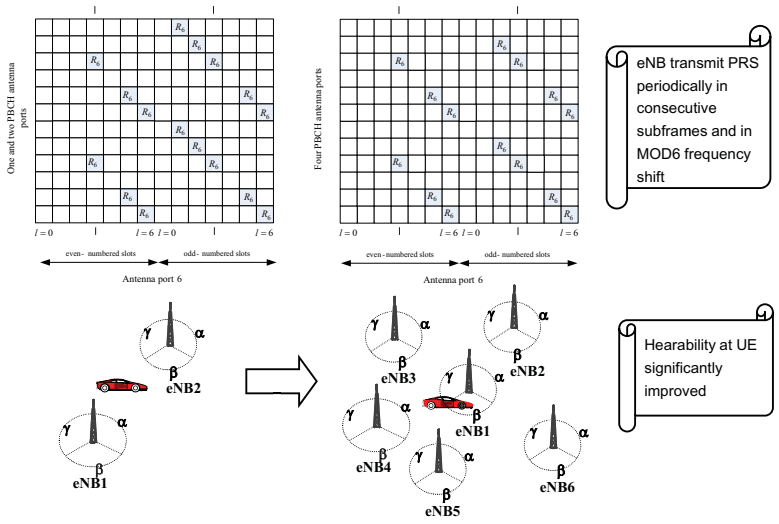
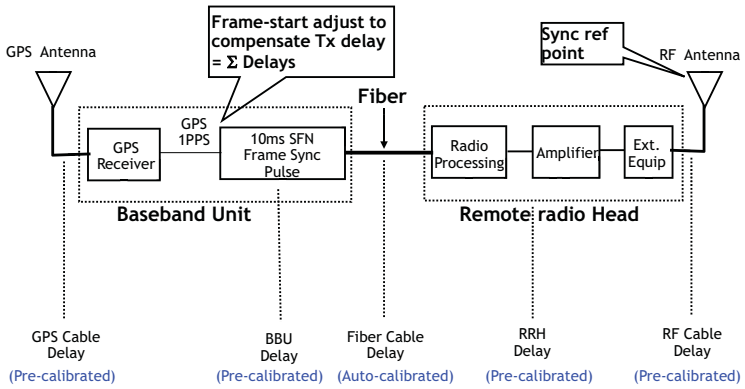
Background: DL and UL TDOAs deployed in 2G E911

- AFLT in CDMA, which is a downlink OTDOA. Supplementary to AGPS and ECID, the packaged solution satisfies the accuracy of FCC E911 mandate as a handset based solution 50m 67% and 150m 95%.
- Uplink TDOA (UTDOA) in GSM, which is a pure RF method as an overlay solution with stand-alone LMU. It satisfies the accuracy of FCC E911 mandate as a network based solution 100m 67% and 300m 95%.
- The DL-OTDOA, together with AGPS and ECID, has been specified by 3GPP in Release 9 (at the end of 2009). UTDOA is in a study phase in R10 and is unlikely to be standardized before the end of 2011.
- What are the performance expectation? What are the implication?

Hearability Improvement by PRS (TS36.211)

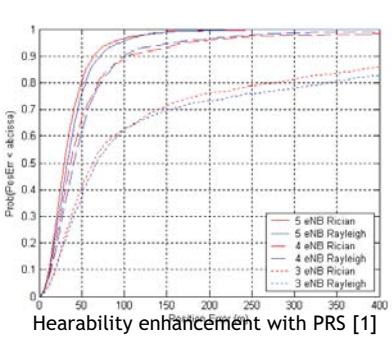


Tight eNB synchronization to GPS time



- In CDMA iS-95/2000, the recommended base station sync accuracy is 3 μs. ALU's internal requirement is 1 μs.
- In LTE, 3GPP did not specify eNB sync accuracy. ALU's internal requirement is 100ns.

Expected DL-OTDOA accuracy through simulations

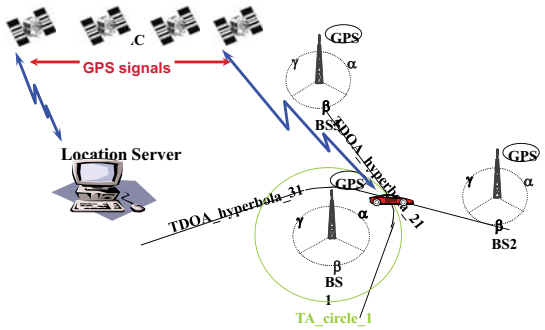


Hearability enhancement with PRS [1]

Simulation modeling:

- eNB sync error = 100ns
- Inter eNB separations 500m
- Multipath effect is handled by "center of gravity" of the arrival time of the PRS signals at the UE

AGPS+DL-OTDOA+ECID will meet FCC E911 mandate



- With PRS hearability will be significantly improved. The tight eNB sync provides a solid time reference. DL-OTDOA in LTE is expected to perform much better than AFLT in CDMA
- AGPS+DL-OTDOA+ECID should meet the FCC mandate of 50m 67% and 150m 95% in most of environment

Potential issues and resolutions for DL-OTDOA

- Handset from different vendors may display variations in RFTD (Reference Signal Time Difference) measurement accuracy. 3GPP RAN4 has recently approved the RSTD accuracy to be +/- 5Ts (1 Ts = 32ns), or +/- 48m.
- PRS transmission has impact to system capacity. Long interval in periodical transmission can reduce the impact. Handset will need to implement efficient algorithm for coherent integration.
- Early lab/field trial can reveal performance deviation.
- Indoor positioning remains a challenge. Leverage of RFPM and WiFi, and later HeNB positioning can help.

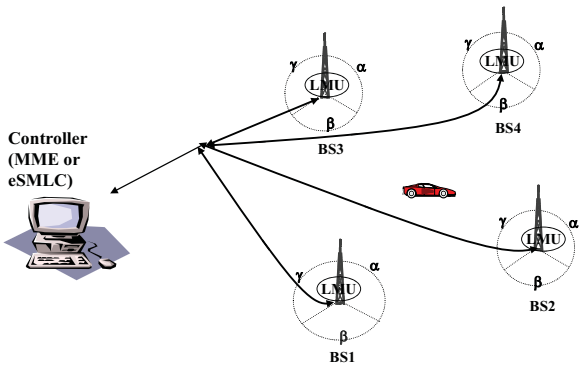
Why study UTDOA in LTE

- New LBS envisioned in LTE, tailored to enterprise customers by providing user geographical behavior that can be useful in relevant applications:
  - Efficient mobile advertizing,
  - Real-time traffic jam prediction,
  - Minimize driving test (MDT) for low-cost performance monitoring
  - New business development
- Strategic alternative to meet FCC mandate by use of the network based solution:
  - Only to satisfy 100m 67% and 300m 95%
  - No change at all to low-end handsets
  - Still can leverage AGPS in the high-end handsets by UE based AGPS

Obstacles to extend stand-alone LMU into LTE

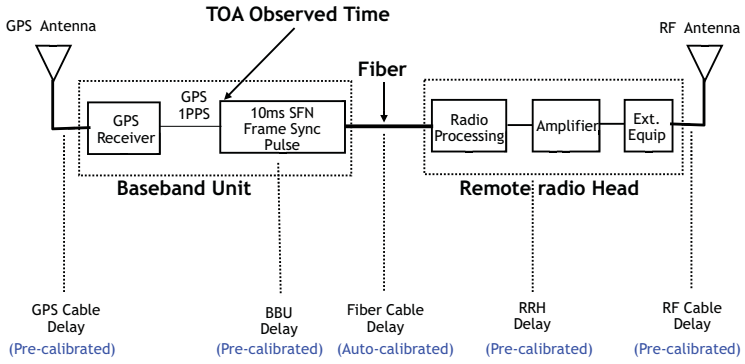
- High deployment cost for stand-alone LMUs for each eNB in LTE
- Unlike in GSM, it is extremely difficult for a stand-alone LMU in LTE to know before hand the overhead / configuration of the UL signal used for positioning.
- Consequently, a large amount of user uplink data to be passed to the positioning module for filtering and cross-correlation, and the long-time accumulation of the data for hearability improvement will result in even larger volume of user data, which can translate into higher cost at HW/SW at LMU.
- High maintenance cost for a stand-alone LMU network.

New Generation of UTDOA with Integrated LMU



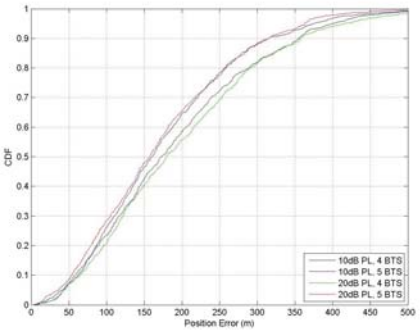
- LMU has been integrated into eNB to take advantage of existing GPS and the calibrated Rx path
- Deployment cost reduced and maintenance cost removed

Architecture of the Integrated LMU – Embedded in eNB



Time of Arrival = TOA Observed Time - Σ Delays

Expected UTDOA accuracy through simulations [2]



- BTS sensitivity= -93.5dBm
- Inter eNB separations 500m
- NLOS effect is modeled by "center of gravity"
- Performance improvement is expected by interference randomization and cancellation.
- UE transmitting power 23 dBm
- eNB sync error = 100ns

Potential issues and resolutions for UTDOA

- UTDOA is evaluated in 3GPP standard as a potential terrestrial positioning technology
  - UTDOA is a Rel-10 Work Item with 6-month study phase.
- UTDOA is an interesting candidate of positioning technology since it is transparent to the UE. However, eNB needs to detect and measure the arrival time of UL signals.
- Advanced signal processing algorithms can help to improve UTDOA performance in terms of SRS detection and hearability enhancement at eNB.
  - For example, interference randomization or cancellation
- Early planning of UTDOA upgrade (after deployment of DL-OTDOA) can significantly limit the cost of UTDOA deployment.

References

1. 3GPP R1-090768 “Performance of DL OTDOA with Dedicated LCS-RS”, Athens, Greece, February 9th-13th, 2009
2. “LTE UTDOA Technologies”, ALU Tech Memo by Fang-chen Cheng and Ren Da, June 9, 2010
3. “UTDOA for LTE - Initial Investigation Results”, ALU Tech Memo by Ren Da, Fang-chen Cheng and Byron Chen, March 2, 2010

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Use Cases for Class 3 LBS

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December 2009

Migration of Location Based Service (LBS): Past, Present and Future

- Class 1: E911 service – Control Plane (Not for profit)
- Class 2: LBS for Individual End-Users – User Plane (Limited profit)
  - Personal locator service/ personal security
  - Friends/family circles
  - Location assisted yellow pages
  - On line navigation and directions services
  - Fleet management (AVL - automatic vehicle location)
- Class 3: LBS for enterprise Customers – Integrated Control Plane and User Plane to provide Geographic User Behavior. (Potential profit)
  - Geographic User Behavior – combining UE location with UE Presence, where they are and what they do.
  - Applications tailored to enterprise users: Efficient wireless advertisement, MDT wireless system performance optimization, new business development, and so forth.

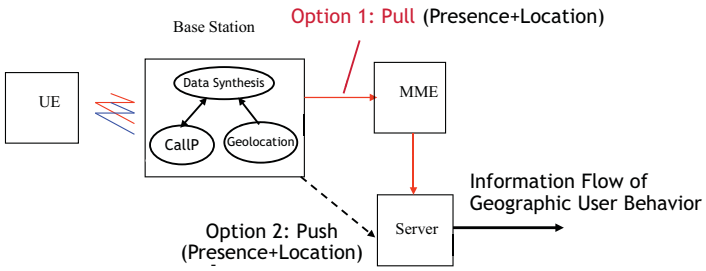
Observe Geographic User Behavior at eNB

3GPP TS 23.203 specifies the following QCIs and associated L2 parameters:

MIM LABEL	3GPP QCI value	3GPP Priority	3GPP L2 PACKET DELAY BUDGET (PDB)	3GPP L2 PACKET LOSS RATE (PLR)	3GPP EXAMPLE SERVICES
GBR-1	1 (GBR)	2	100 ms	10-2	Conversational Voice
GBR-2	2 (GBR)	4	150 ms	10-3	Conversational Video (Live Streaming)
GBR-3	3 (GBR)	3	50 ms	10-3	Real Time Gaming
GBR-4	4 (GBR)	5	300 ms	10-6	Non-Conversational Video (Buffered Streaming)
GBR-5	5 (non-GBR)	1	100 ms	10-6	IMS Signalling
GBR-6	6 (non-GBR)	6	300 ms	10-6	Video (Buffered Streaming) TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.)
GBR-7	7 (non-GBR)	7	100 ms	10-3	Voice, Video (Live Streaming) Interactive Gaming
GBR-8	8 (non-GBR)	8	300 ms	10-6	Video (Buffered Streaming) TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.)
GBR-9	9 (non-GBR)	9			

Where QCI – QoS (quality of service) Class Identifier
GBR – Guaranteed Bit Rate

Combine Accurate UE Location with UE Behavior



Geographic User Behavior ~ {eNB ID, Cell ID, UE ID, Time Stamp, UE Location, UE Presence}

Where

- UE Location = [latitude, longitude, altitude]
- UE Presence = [active state, QCI value, TBD]

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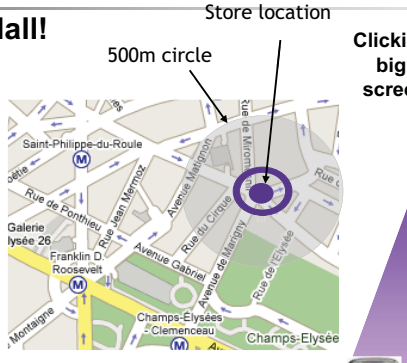
Class 3 LBS Use Case 1: Location Based Advertising

Black Friday at Mall!

Mobile Advertizing Company (MAC) subscribed from ALU Ecos Data Service, which provides accurate, low-cost location-based advertizing.

Stores in the Mall prepared geo_ads to let MAC deliver the ads to mobiles within 500m radius for a limited time.

Starting at 4:30pm on Black Friday, MAC will send the geo_ads to all mobiles within 500m circle if they allowing unsolicited advertisement.



Clicking the alert, a list of big sales shown on the screen with store names and time limit

A user Gets an alert of geo_ads in IM or a SMS from MAC

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Class 3 LBS Use Case 2: Real-Time Traffic Alert

Attending an Important Meeting!

Traffic Alert Company (TAC) subscribed from ALU Ecos Data Service, which provides a continuous data flow of ALL mobile positions.

TAC put all UE positions continuously onto the map and monitors the speed of mobiles on major roads to generate geo_alert.

A user subscribe to TAC receives real-time geo_alert on the screen with a map showing which road has jam.

Arriving at the meeting just on time!

The user takes a detour to bypass the jam.

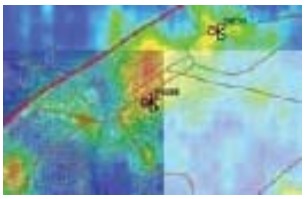
Class 3 LBS Use Case 3: Location+Presence for Network Performance Monitoring

Why So Many Call Drops There!

VAS outsourced its wireless network maintenance to a 3rd company called WMC.

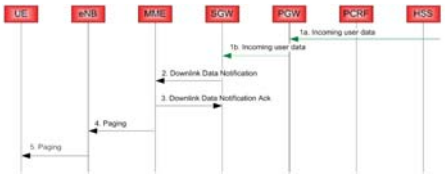
WMC subscribed ALU's Ecos Data Service, which provides PCMD data flow with real-time locations for all mobiles periodically.

The association of UE locations with their call attributes reveal where the call drops happens and possible reasons.



Data synthesis to find the reasons for call drops in this geographic area.

Call Flow Analysis



Class 3 LBS Use Case 4:
Location+Presence for Content Delivery

When and Where People Watch Video Clip?

Safari Video Company (SVC) subscribed from ALU of raw or processed (additional fee) Ecos data which provides both location and presence for all UEs.

SVC delivers video clips of wild animals and want to have an idea where and when users are most likely to watch video clips.

SVC requested specific bandwidth and time period from the wireless communication service.

Users watch videos on NJ PATH in rush hours and in airports from 2:00pm – 2:00am the most.

Class 3 LBS Use Case 4:
Location+Presence for Business Development

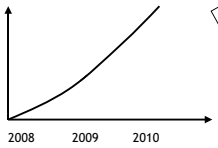
Open a Pet Shop Here?

Business Assistance Company (BAC) subscribed from ALU Ecos data with designated statistics (additional fee).

Pets Cute company (PCC) wants to know if it is a good plan to open a PCC franchise locally, but there is already a Petsmart store.

SMC goes to BAC to purchase report of traffic flow pattern (volume vs time period) at the store site (parking lot and store).

A new PCC store opened!



Summary

- Smart phones will have many functions currently available at the laptops (content, search, mapping, online shopping, etc)
- Geographic User Behavior will become an increasingly important information for enterprise users for efficient mobile advertisement, business development and planning, network performance optimization, and so forth.
- UTDOA can be one of the enabling technologies to obtain ubiquitously the Geographic User Behavior for all UEs that are active. Because of the investment at eNB to support E911 service, integrated LMU becomes a low cost solution. A hybrid of UTDOA with RFPM for HetNet small cells (WiFi, HeNB, pico, and Femto) seems more promising.
- Infrastructure vendors can help unlock the "locked" value chain in creating the information flow of the Geographic User Behavior
- New partnerships between infrastructure vendors and service providers can monetize the Geographic User Behavior for enabling the Class 3 LBS.

Acknowledgement

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