Location Based Service

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Background

- **E911 and E122**
  - The U.S. Federal Communications Commission (FCC) has made Emergency 911 (E911) as a mandatory requirement for wireless communications services.
  - The European Commission (EC), has similar initiatives for their wireless emergency calls, E112.

- Technologies based on standardization, e.g., 3GPP
Basic Location Technologies
- Angle of Arrival (AOA) positioning

- This technique requires a minimum of two stations (or one pair) to determine a position.
- More than one pair can be used in practice.
Basic Location Technologies
- Time Of Arrival (TOA) positioning

- The TOA method determines the mobile phone position based on the intersection of the distance (or range) circles.
- Two range measurements provide an ambiguous fix, three measurements determine a unique position.
Basic Location Technologies
- Time Difference Of Arrival (TDOA) positioning

- This system uses time difference measurements rather than absolute time measurements as TOA does.
- The signals from at least three BTS units are received by a handset and by a Location Measurement Unit (LMU).
- The handset location is calculated in location server using time differences of arrival of the signals from each BTS at both the handset and the LMU.
Wcdma Location Technologies

Cell Coverage + RTT

IPDL-OTDOA
Measurement error margin

Assisted GPS

UTRAN
Assistance Data
Network
Reference Receiver
GPS Ground Station
SAI + RTT Characteristic

- Cell coverage positioning is the initial capability in UMTS (specified in Release 1999)
- Accuracy depends on the cell size
  - From 100 meters to 10 kilometers
  - Accuracy can be improved with Round Trip Time measurements
    - In one dimension 80 meters
- Cell coverage based location information enables valuable location based services like:
  - Regional services
  - Tariffing applications
  - Local information
  - Routing of (emergency) calls
Service Area Based Location
- With Round Trip Time measurements

- BTS coordinates
- Sector mass center coordinates
- Round Trip Time
- Base station
- Sector
- RTT Measurement error margins

SAI+RTT
Observed Time Difference Of Arrival (OTDOA) in WCDMA (1/2)

• The basic principle is almost the same as in TDOA: MS measures several base stations at a time ⇒ propagation delay determines the distance
• Mobile must hear three base stations
• Needs OTDOA SW in mobiles (3GPP rel4 compatible)
• Accuracy up to 30 meters in good conditions
  • generally 30 to 300 meters
Observed Time Difference Of Arrival (OTDOA) in WCDMA (2/2)

SMLC: Serving Mobile Location Center
LMU: Location Measurement Unit

Position calculation

Error margin

Observation Time Difference Of Arrival (OTDOA) in WCDMA (2/2)

Periodic RTD measurements

Serving base station 1

Serving base station 2

Base station 3

d1

d2

Location estimate

Location Based Service S-72.333 Post-Graduated Course in Radio Communication H. Yin 11
**IPDL-OTDOA Characteristics**

- IPDL = Idle Period Down Link to solve hearing problem when near base station
- During idle period the mobile can measure other base stations
- The frequency and length of the idle periods have been optimised:
  - small loss of system capacity
  - the mobile can measure all base stations efficiently (accuracy vs. delay)
- The idle period costs 0.1 dB BER loss
  1 idle period per 150 slots
Global Positioning Service (GPS)

- GPS is a satellite based location system, where the GPS receiver measures the distances to the GPS satellites using spread spectrum signals.
- The position can be calculated if the position of each satellite and the distance from the satellite (pseudorange) is known.
- There are 24 satellites in 6 orbital planes and connection with 4 satellites enables the 3D co-ordinates to be defined.
- GPS offers very accurate positioning
  - 1 meter to 10 meters outdoor
  - indoor appr. 30 meters if coverage.
- GPS receivers have high battery usage.
- Lacking indoor tunnels and underground coverage.
- Long signal acquisition time (more than 30 s) prevents the usage in obstructed environment (e.g. in cities).
Assisted Global Positioning System Illustration

- Needs GPS hardware in mobiles
- GPS receiver in mobiles causes added costs and battery consumption.
# A-GPS Data Usage

<table>
<thead>
<tr>
<th>Figure of Merit</th>
<th>Standalone GPS</th>
<th>Assisted GPS</th>
<th>Assistance Data</th>
<th>Density of the Reference Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTFF</td>
<td>&gt; 30 s</td>
<td>1–10 s</td>
<td>Ephemeris, (Timing)</td>
<td>Low</td>
</tr>
<tr>
<td>Accuracy</td>
<td>&lt;10 m</td>
<td>1–10 m (indoor 30m)</td>
<td>DGPS</td>
<td>Medium</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>-130 dBmW</td>
<td>-150–155 dBmW</td>
<td>Navigation data, Timing</td>
<td>High</td>
</tr>
<tr>
<td>Coverage</td>
<td>Outdoors only, LOS (line-of-sight)</td>
<td>Indoors, urban environment</td>
<td>Ephemeris, Navigation data, Timing</td>
<td>High</td>
</tr>
</tbody>
</table>
# The Technology Comparison

<table>
<thead>
<tr>
<th>Method</th>
<th>System Accuracy</th>
<th>Commercial Availability (Estimated)</th>
<th>User Controlled Privacy</th>
<th>Response Speed</th>
<th>Network Update Cost</th>
<th>Handset Cost Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-OTD (OTDOA)</td>
<td>50m – 150m</td>
<td>2000</td>
<td>Yes</td>
<td>&lt; 10 s</td>
<td>Medium</td>
<td>-</td>
</tr>
<tr>
<td>Cell-ID</td>
<td>250m - 30km</td>
<td>1999</td>
<td>No</td>
<td>&lt; 10 s</td>
<td>Minimal (MSC interface)</td>
<td>-</td>
</tr>
<tr>
<td>Cell-id / Timing Advance (RTT)</td>
<td>150m - 30km</td>
<td>1999</td>
<td>No</td>
<td>&lt; 10 s</td>
<td>Minimal</td>
<td>-</td>
</tr>
<tr>
<td>Assisted GPS</td>
<td>&lt; 50m</td>
<td>2002</td>
<td>Yes</td>
<td>&lt;10s –60s</td>
<td>Medium (standards compliant)</td>
<td>+40% plus impact on style and battery life</td>
</tr>
<tr>
<td>Time of Arrival</td>
<td>difficult to achieve better than 150m</td>
<td>2002 (non standards compliant)</td>
<td>No</td>
<td>&lt; 10 s</td>
<td>High</td>
<td>-</td>
</tr>
<tr>
<td>Angle of Arrival</td>
<td>unlikely to achieve 150m</td>
<td>2002 (non standards compliant)</td>
<td>No</td>
<td>&lt; 10 s</td>
<td>High</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: CPS
Location Service Standardization

- ETSI mandated the Location Service standardization to US based T1P1 standardization organization in 1997. Location Service Standardization for GSM was conducted in T1P1 during 1997-2000. In 2000 SMG approved the T1P1 material into GSM standard.
- GSM Release 98 and 99 (mirror to GSM R'98): => ready, still some CRs in process
  - Only circuit switched mode support for Location Service
  - CI+TA, TOA, E-OTD, A-GPS
- 3GPP Release 4:
  - GERAN: => ready by Apr 2001?
    - Circuit switched mode for CI+TA, E-OTD, A-GPS
    - Packet switched mode for CI+TA
  - UTRAN:
    - Cell coverage+RTT (same as CI+TA in GSM)
    - IP-DL, A-GPS
- 3GPP Release 5:
  - GERAN: => ready by Nov 2001?
    - Packet switched mode for E-OTD, A-GPS
  - UTRAN:
    - Same as Release 4
Current Location Based Services

- Location of emergency calls (request initiated by authorities). The location of emergency calls can be made more accurate by providing the approximate geographical location of the subscriber/mobile equipment.

- Surveillance of suspected criminals (request initiated by authorities). The legal location and surveillance of suspected criminals can be made more accurate by providing the approximate situation of the person in question.

- Home/office zone applications (request initiated by network operators). The feature provides a more accurate positioning for applications when the operator wants to separate home zones (in case of private subscribers) or office zones (in case of business subscribers) in order to offer cheaper tariffs.

- Network planning applications (request initiated by network operators). With this feature areas where calls are often dropped can be identified with a reasonable accuracy. This way operators get a useful source of information for network planning.

- Electronic yellow pages (request initiated by third party service providers). The functionalities of the feature may enable, for example, SMS-based services through which third party service providers can inform the subscribers about nearby hotels, restaurants, etc. on the basis of the location of the subscribers.
Nokia’s View of LBS New Applications

Navigation applications
- Route description, Turn-by-turn navigation
- Dynamic route guidance with maps

Safety and emergency applications
- Emergency calls, Breakdown services
- Warning about unsafe areas
- Nearest medic center & doctor

Tracking applications
- Find a friend, Fleet management
- Asset tracking, e.g. cargo
- Tracing of stolen property/vehicles
- Person surveillance

Information service applications
- Yellow pages
- Traffic information
- City Guide, Parking, Maps

Operator & Tariff applications
- Home Zone, Tariff Zone
- Traffic measurements
- Network planning

Nokia offering by end 2000
- Address Finder
- Country Finder
- Route Finder
- Find a friend
- City Guide
Charging Pattern for Location Based Services

- **Subscribers:**
  - Single Request Charging
  - Periodic Location Report
  - Accuracy based charging
  - Regional Charging

- **Operators:**
  - Revenue Share
Case Study

Nokia mPosition Solution

Phones
Location methods
Location Middleware
Mobile Location Services
Abbreviation

- A-GPS: Assisted Global Positioning System
- AOA: Angle Of Arrival
- E-OTD: Enhanced Observed Time Difference
- GERAN: GSM/EDGE radio access network
- GPS: Global Positioning Service
- IPDL: Idle Period Down Link
- LBS: Location Based Services
- LMU: Location Measurement Unit
- OTDOA: Observed Time Difference Of Arrival
- RTD: Relative Time Difference
- RTT: Round Time Trip
- SAI: Service Area Identity
- TA: Time Advance
- TOA: Time of Arrival
- TTFF: Time To First Fix
References

- Nokia mPositioning Materials
Question

General description of the OTDOA method.