Positioning within the GSM - Network

FIG Regional Conference

TS 08
Positioning and Measurements

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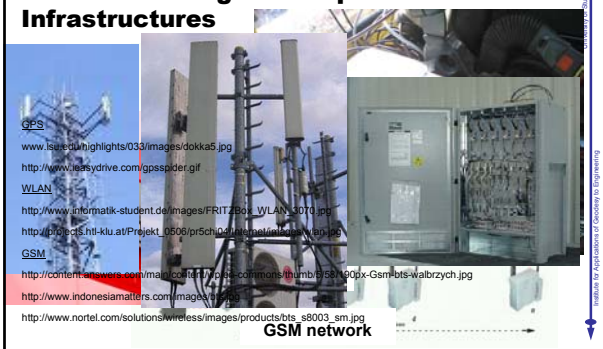
New Positioning Techniques and Infrastructures



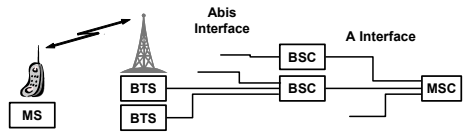
GPS
www.lsr.edu/highlights/033/images/dokka5.jpg
http://www.easydrive.com/gpsspider.gif
WLAN
http://www.informatik-student.de/images/FRITZBox_WLAN_3070.jpg
http://projects.htl-klu.at/Projekt_0506/pr5ch03/Hardware/Hardware.jpg
GSM
http://content.answers.com/main/content/wp/de/commons/thumb/3/38/100px-Gsm-bts-walbrzych.jpg
http://www.indonesiamatters.com/images/gsm.jpg
http://www.nortel.com/solutions/wireless/images/products/bts_s8003_sm.jpg

GSM network

Structure

- Motivation
- Structure of GSM Network
- Positioning Measurements
- Positioning Methods
- Net-based Positioning
- Example – Project Do-iT

Structure of GSM Network



- **MS = Mobile Station (Cell Phone)**
- **BTS = Base Tranceiver Station (Antenna)**
  controls one antenna respectively cell
- **BSC = Base Station Controller**
  controls several BTS
- **MSC = Mobile Switching Centre**
  controls several BSC = one Location Area (LA)

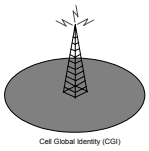
Measurements usable for Positioning

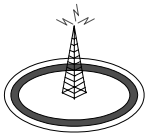
- **Cell ID**
  - unique number assigned to one cell resp. BTS
- **Handover**
  - point of time when a MS changes from one cell (BTS) to another one
- **Location Area Update**
  - point of time when a MS changes from one LA (MSC) to another one
- **Timing Advance (TA) value**
  - approximation of the distance between MS and the serving BTS, resolution of approx. 550 m
- **Received Signal Strength (RXLEV-value)**
  - signal attenuation between MS and up to 7 BTS, resolution 1 dB

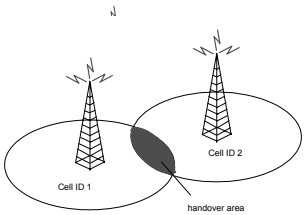
Positioning Methods

denomination within cellular positioning	geodetic analogy	measurements	restrictions
Cell Global Identity (CGI)	-	cell ID	none
Handover / Location Area Update	-	two cell IDs / two LA-IDs + one cell ID	available at special events
Time-of-Arrival / TOA	arc section	distances	none
Time-Difference-of-Arrival / TDOA	hyperbola section	distance differences	BTSs have to be synchronised
Angle-of-Arrival / AOA	intersection	angles	need for 2 antennas at a BTS
Signal Strength Matching	-	RXLEV (signal strength)	reference data has to be available

Positioning Methods





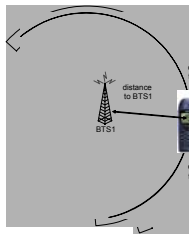


Positioning during handover event (Czommer et al. 2006)

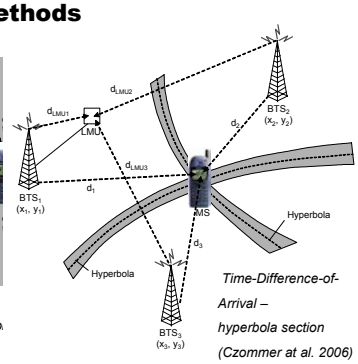
Location area update works in the same way !

Cell Global Identity and extended cell positioning (Czommer et al. 2006)

Positioning Methods



Time-of-Arrival – arc sectio

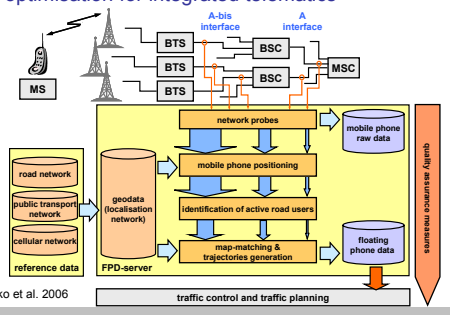


Time-Difference-of-Arrival – hyperbola section (Czommer at al. 2006)

Net-based Positioning Availability

measurement	mobile station	interface	positioning method
Location Area Update	passive	A / Abis	location area update
Handover	active	A / Abis	handover area
Cell ID	active	Abis	cell global identity
TA-value	active	Abis	arc section
RXLEV-values	active	Abis	arc section / signal strength matching

Example for Net-based Positioning
Project Do-iT
Data optimisation for integrated telematics



Source:
Wiltschko et al. 2006

RX – Matching / Signal Strength Matching

Least squares adjustment

$$\min_{y,x \in A} \sum_{i=1}^{n} (rx_{ref}(y,x)_i - rx_{meas,i})^2$$

with

A : search area

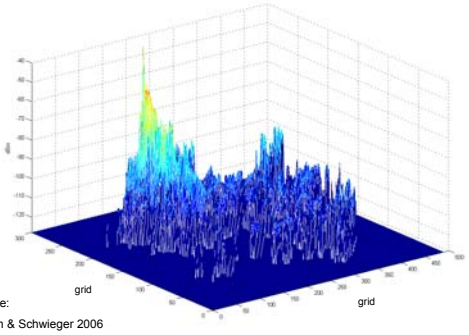
n : number of measured neighbouring cells

$rx_{ref,i}$: reference signal strength of BTS i depending on (y,x)

$rx_{meas,i}$: measured signal strength of BTS i

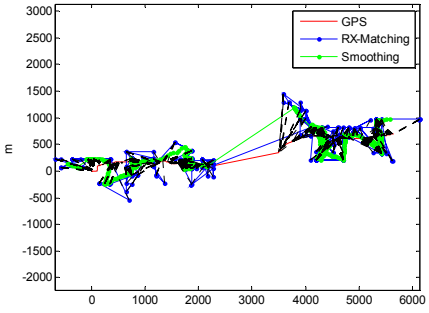
➡ **Further improvement by smoothing (moving average filter) and Kalman filtering**

RX – Matching / Signal Strength Matching



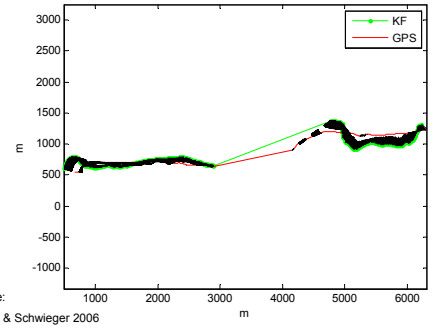
Source:
Ramm & Schwieger 2006

Exemplary Results – RX-Matching



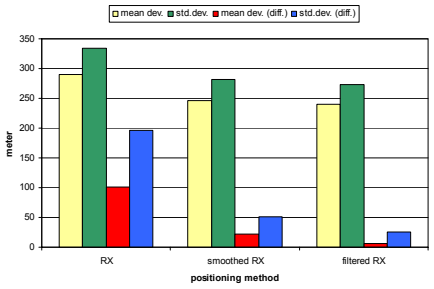
Source:
Ramm & Schwieger 2006

Exemplary Results – Kalman Filter

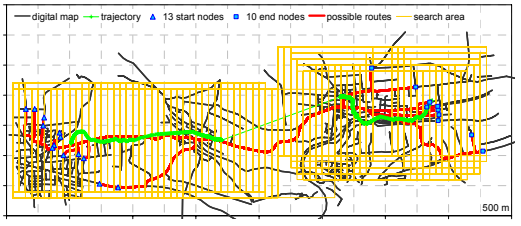


Source:
Ramm & Schwieger 2006

Exemplary Results – Summary



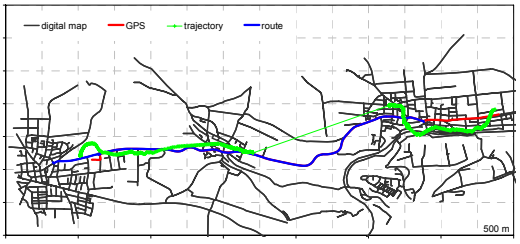
Exemplary Results – Map Aiding



Source: Ramm & Schwieger 2006

- projection of trajectory onto digital road map → search area
- 13 start nodes and 10 end nodes → 130 possible routes

Exemplary Results – Map Aiding



Source: Ramm & Schwieger 2006

- reference to the correct road element is possible in suburban areas
- the standard deviation is approx. 120 m (plumb lines)

Conclusions

- **GSM network may be used for positioning**
- **Classification of positioning methods is presented; based on GSM network structure and available measurements**
- **Availability of positioning methods for net-based anonymous approach is limited**

- **Results within project Do-iT based on RX-matching and smoothing resp. Kalman Filter are presented**
- **Standard deviation ca. 300 m for a 4 km track**
- **Map-Aiding improves accuracy to ca. 100 to 200 m**

Thank you very much for your attention !

CONTACT

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