

[Master's Thesis Defence]



[Location Estimation Methods for Open, Privacy Preserving Mobile Positioning]

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- Location Provider - *Service that provides an estimated location using network Location Estimation*

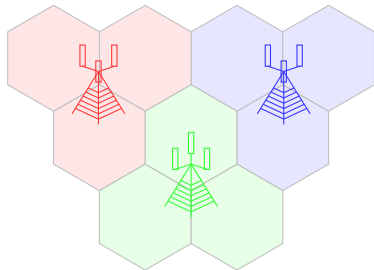
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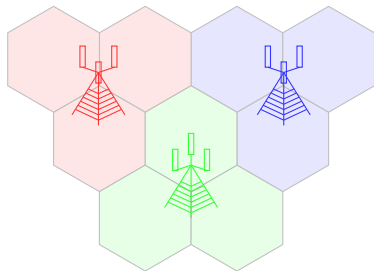
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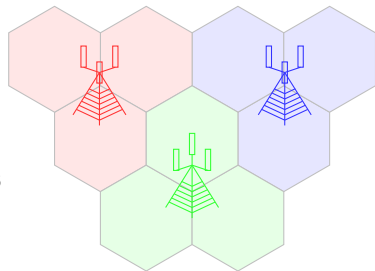
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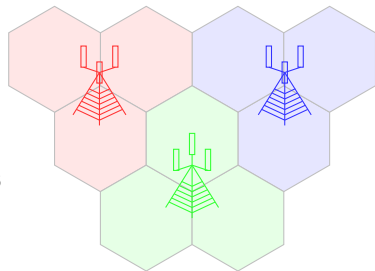
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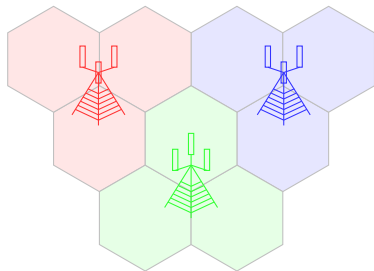
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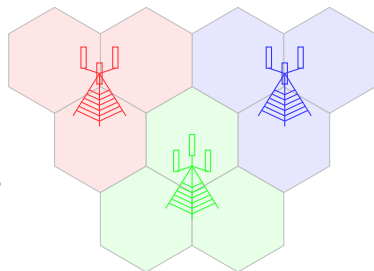
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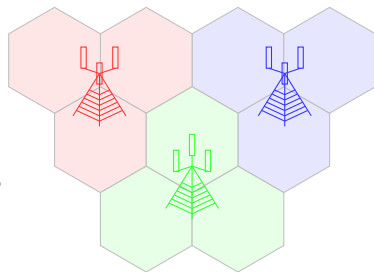


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- Neighboring cell information tracked and used for cell re-allocation

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- In this thesis focus on methods using GSM/UMTS and/or WLAN networks

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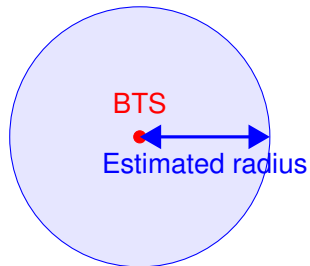
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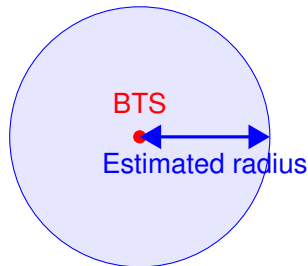
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- Most common methods described in thesis. Here only the tested methods are shown.

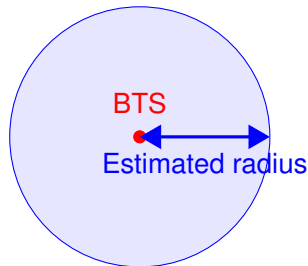
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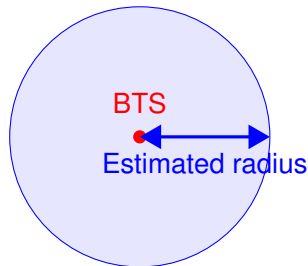
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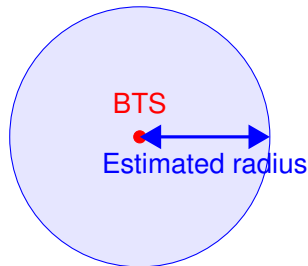
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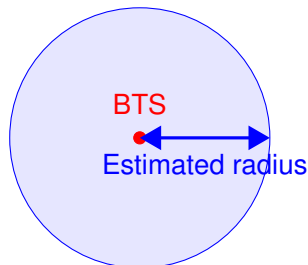
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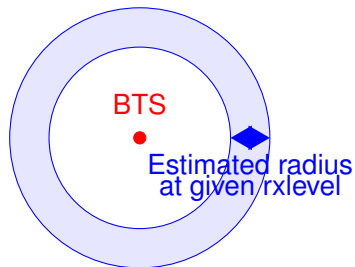
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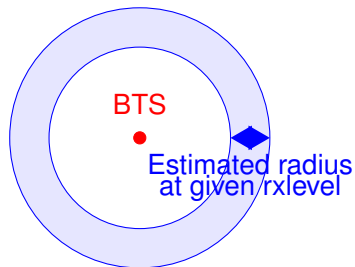
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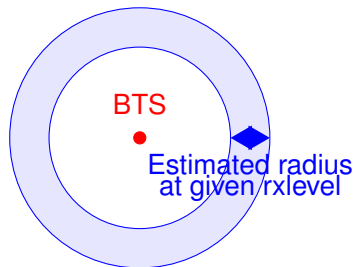
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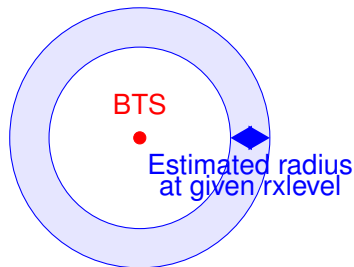
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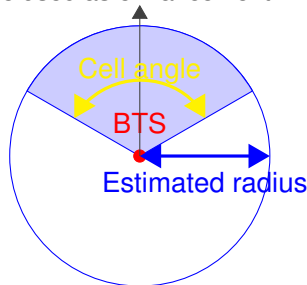
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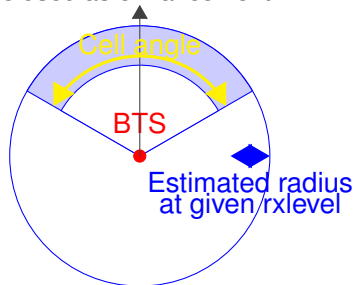
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- Methods generally rely on a trusted third party cloaking service, a private network of clients, or both.

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2. Crowd sourced data and cloaking do not mix. Cloaking degrades crowd sourced data. By separating *location provider* from *LBS* this can be avoided, but then *location provider* must be *privacy preserving* by nature.

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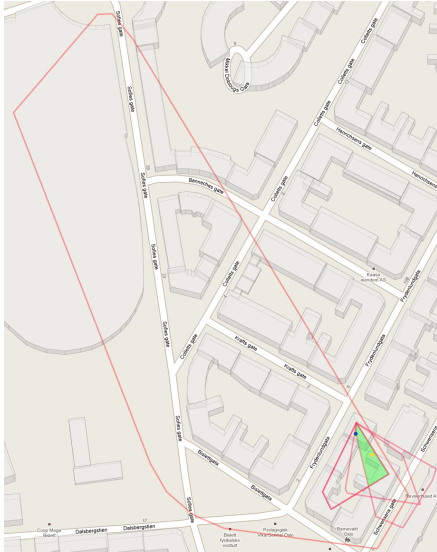
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- Location estimation: The intersection of the areas correlating to the network measurements in incoming fingerprint is calculated. The intersection, or the calculated center of the intersection is used as estimated location.

[Intersecting Areas Method]



- Can fall back to *E-CGI* with no extra data or code when not enough data available

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- Used correctly ensures anonymity and privacy of stored data

- Does not benefit the security and privacy of data transfer other than reducing the amount of updates needed
- *By design:* Precision cannot be gained using heuristics and statistics. Such methods require storing individuals' locations which is not compatible with privacy and open access

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- Created to be able to collect all information about all networks simultaneously in an area, including non-public GSM-networks
- Less portable than mobile phone, but can be powered by any 9-24V power source for a long time

■ Android, Symbian and OpenMoko Phones

■ External or internal GPS

■ Software

■ PC logger software for custom hardware logger

■ OpenMoko logger software for custom hardware logger

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■ Hardware

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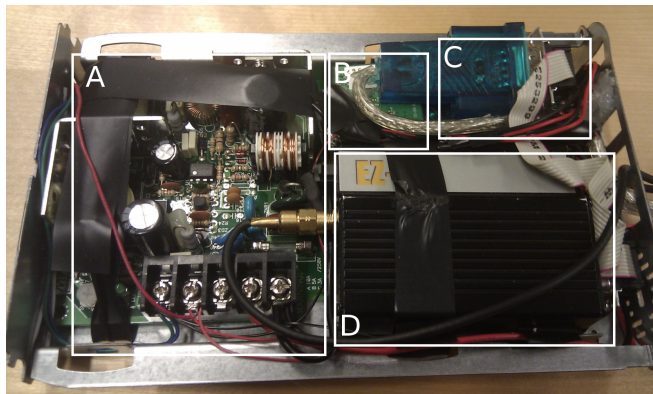
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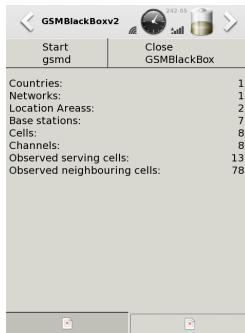
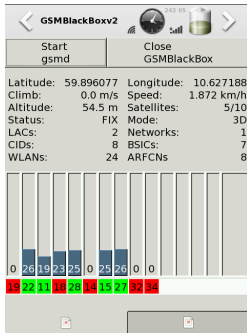
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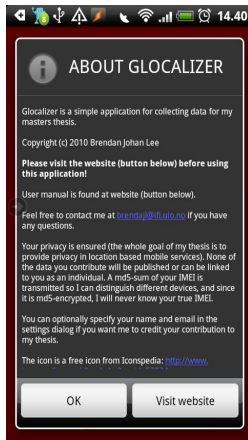
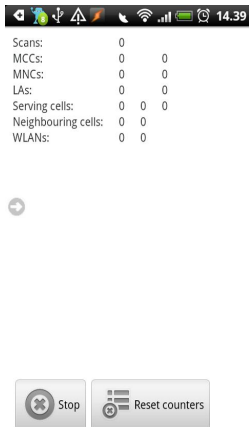
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- PC logger software for custom hardware logger
- OpenMoko logger software for custom hardware logger
- OpenMoko logger software
- Android logger software
- Symbian S60 logger software







```

GSMBlackBox v 2.0
GSM lo... GPS
GSM logging...
Countries: 1 242
Networks: 1 5
Location Areas: 1 2010
Cells: 1 6042
Observations: 29 RXlev: 83
Valg Avslutt
    
```

```

GSMBlackBox v 2.0
GPS WLAN
GSM logging...
Latitude: 59.89570959048
Longitude: 10.627234068091
Satellites: 4 H acc: 169.86
Altitude: 80.50 V acc: 14.00
Speed: 1.95 Acc: 9.46
Heading: 198.15 Acc: 120.46
Valg Avslutt
    
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GSMBlackBox v 2.0
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evalg-ice
prod Nets: 35
itfbu_1 Obs: 78
ITFBU-Simula
avoice
allkopionline
itfbu_1
ITFBU-Online
ITFBU-COMP
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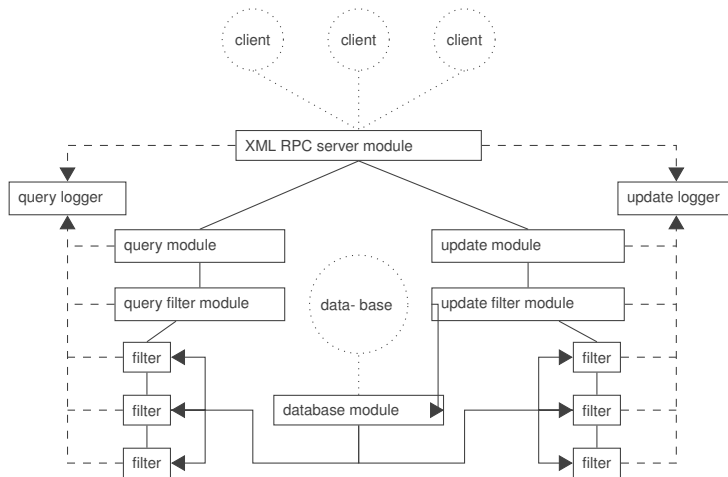
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- All communications and settings are logged so they can be re-played (possibly with different settings or estimation methods) at a later time



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- Renders points, tracks and areas (polygons) on top of imagery
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- Second test

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■ Second test

- Single dataset for Android, three for Symbian Series 60

■ First test

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- Single dataset for Android, three for Symbian Series 60
- Dataset randomly split in two

■ First test

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- Single dataset for Android, three for Symbian Series 60
- Dataset randomly split in two
- Half of set used for training, half for testing

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 2. Run algorithm on measurement and log
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- Single dataset for Android, three for Symbian Series 60
- Dataset randomly split in two
- Half of set used for training, half for testing
- Repeated on the virgin dataset 10 times

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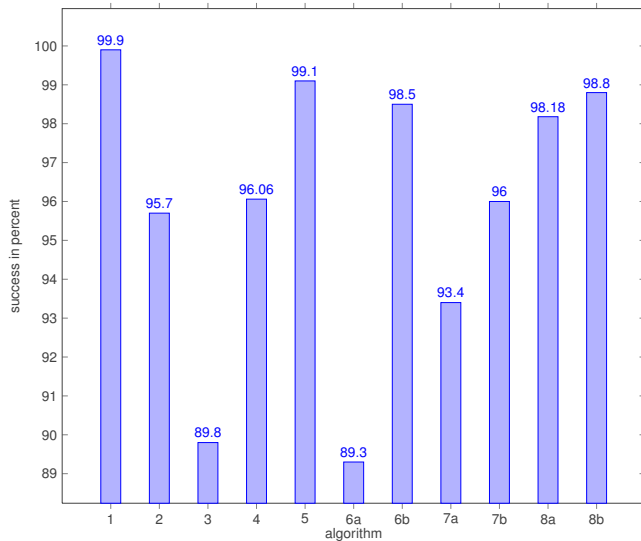
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- Each test was done individually for Android and Symbian S60 data

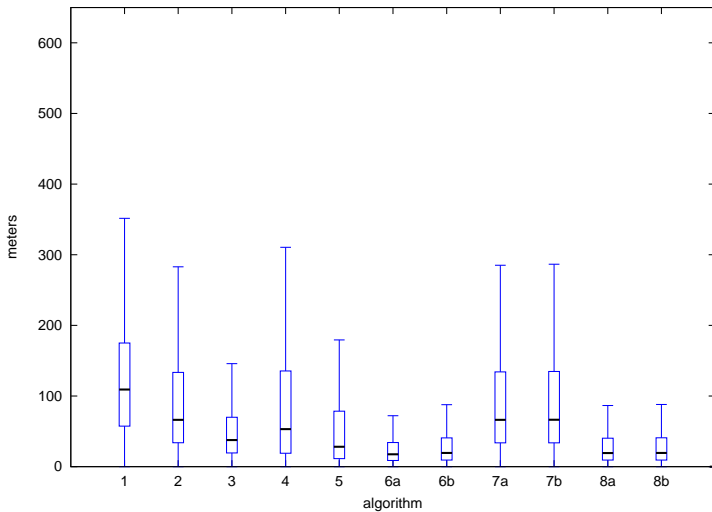
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- The tests were comparable, only the second set of tests is presented here

Algorithm	Time on 8218	time on L7555
1	.000050	.000019
2	.000071	.000038
6	.047350	.017171
6.1	.047350	.017171
7	.027986	.024339
7.1	.027986	.024339
8	.075265	.041472
8.1	.075265	.041472

Algorithm	Time on 8218	time on L7555
1	0.005383	0.008095
2	0.005621	0.008930
3	0.749295	11.088524
4	16.210149	17.802947
5	18.815485	14.625443
6	0.021477	0.023968
6.1	0.037931	0.008301
7	0.003671	0.003938
7.1	0.003632	0.004676
8	0.005185	0.005112
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- We have discovered, and addressed, the need for a flexible location estimation test system allowing tests on any location data with any methods by anybody.

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- This slide show is located at
<http://opengsmloc.org/thesis/defence.pdf>
- The thesis itself is located at
<http://opengsmloc.org/thesis/thesis-final-color-gloss.pdf>
and
<http://opengsmloc.org/thesis/thesis-final-print.pdf>
- The software and code used in this thesis is located at
<http://opengsmloc.org/thesis/code.tar.gz>
- The data used and generated in this thesis is located at
<http://opengsmloc.org/thesis/data.tar.gz>