[Master's Thesis Defence]

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

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June 21, 2011

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

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4. Gathering data and testing the suggested location estimation method and some of the more common methods and comparing them

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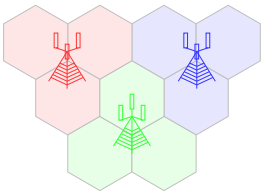
[Background - Cellular Networks]

- Used to increase traffic capabilities



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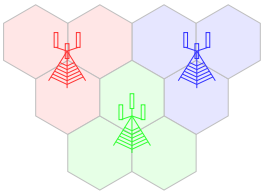

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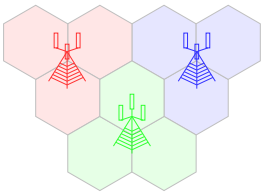

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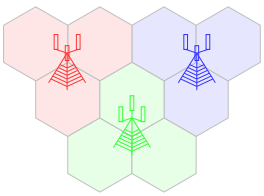

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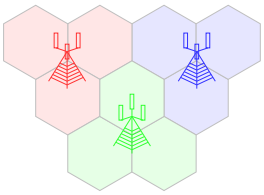

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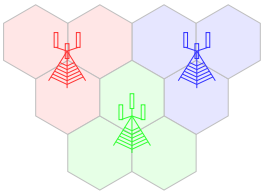

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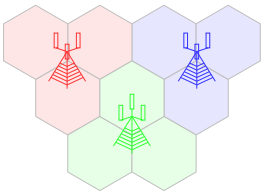

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- Neighboring cell information tracked and used for cell re-allocation

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Brendan Johan Lee IFI.UiO June 21, 2011 5 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 5 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 5 / 36

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

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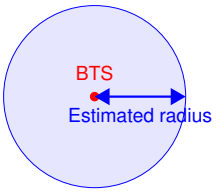

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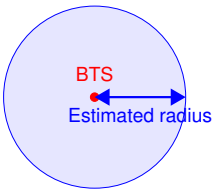

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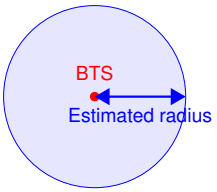

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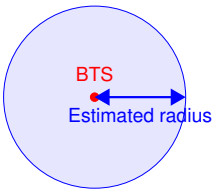

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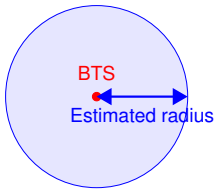

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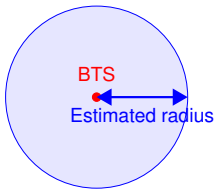

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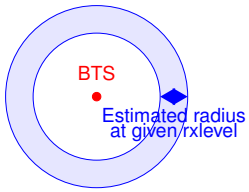

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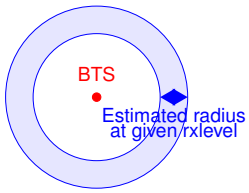

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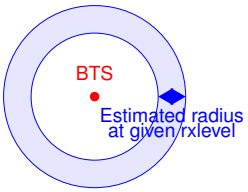

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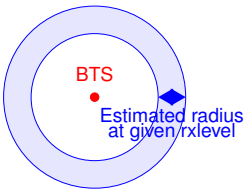

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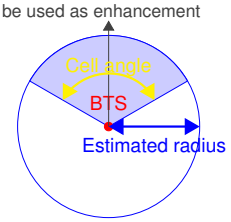

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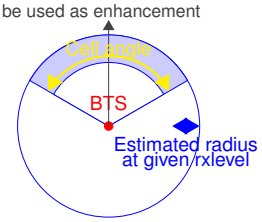

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Brendan Johan Lee IFI.UiO June 21, 2011 7 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 7 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 7 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 7 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 7 / 36

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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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Brendan Johan Lee IFI.UiO June 21, 2011 9 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 9 / 36

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   - *Should be:* You own your own location. You should be able to determine your location freely without selling your privacy to a corporation.
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.

Brendan Johan Lee IFI.UiO June 21, 2011 9 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 10 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 10 / 36

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    - Pre-generated database (estimated or gathered)
    - Clients amend query results if needed

Notes

[Suggested Location Provider (Brief Summary)]

- In addition the following issues where addressed:
  - Data gathering:
    - Direct upload
    - Pre-generated database (estimated or gathered)
    - Clients amend query results if needed
  - Bootstrapping: *If system relies on amending queries, how to bootstrap a new area: No data exists to generate replies that can be amended*

Notes

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Brendan Johan Lee IFI.UiO June 21, 2011 12 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 12 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 12 / 36

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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.

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- Used correctly ensures anonymity and privacy of stored data

Notes

[Intersecting Areas Methods - Limitations]

- 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

Notes

[Test System]

- Consists of three main parts:

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  1. Data collection tools

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  3. Data visualization tool

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[Test System - Data Collection Tools]

- Hardware

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Brendan Johan Lee IFI.UiO June 21, 2011 18 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 18 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 18 / 36

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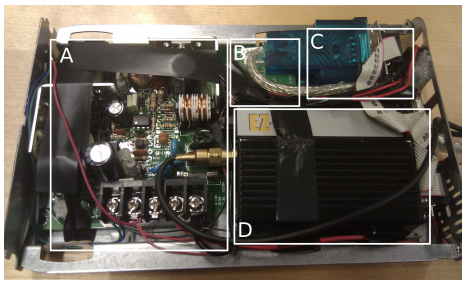
  - OpenMoko logger software
  - Android logger software
  - Symbian S60 logger software

Brendan Johan Lee IFI.UiO June 21, 2011 18 / 36

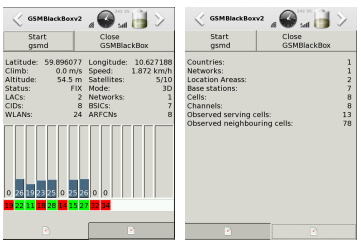
Notes

[Hardware logger]



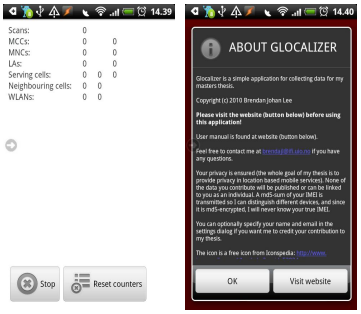
Notes

[OpenMoko Software]



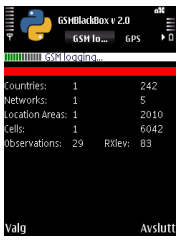
Notes

[Android Software]



Notes

[Symbian Series 60 Software]



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- Four main parts:
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  3. Query handler
  4. Update handler
- 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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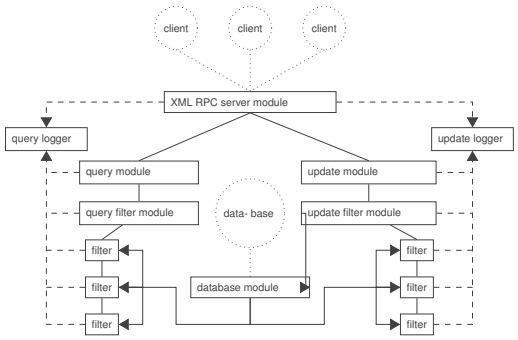

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- Can fetch data directly from back-end database or load from files

Notes

[Tests]

- Data gathered with Android and Nokia handsets

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Notes

[Two Individual Tests]

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Brendan Johan Lee IFI.UiO June 21, 2011 27 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 27 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 27 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 27 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 27 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 27 / 36

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

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[Problems and Results]

- The penalty value for *DCM* is not static over different data sets, different areas and different handsets. Systems should therefore be continuously calibrated, which highly complicates using *DCM*

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

Notes

[Results - Training Time]

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

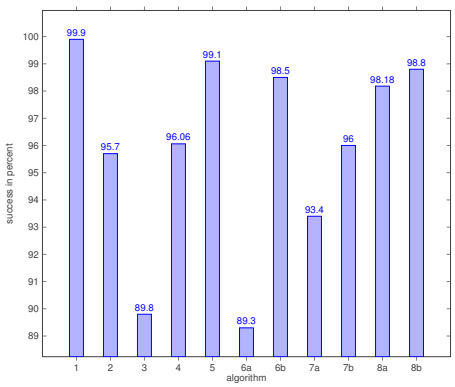
Notes

[Results - Fingerprint Processing Time]

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
8.1	0.005067	0.006172

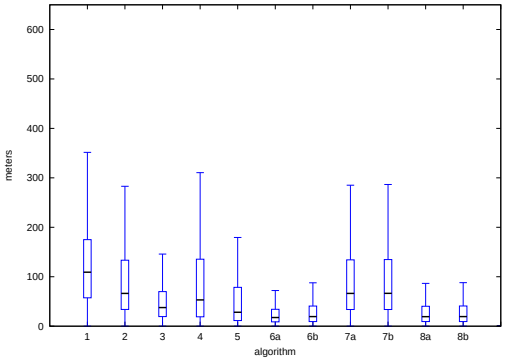
Notes

[Results - Success Rate]



Notes

[Results - Precision]



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  - Privacy
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  - Location cloaking services degrading location estimation services

Notes

[Conclusions]

- The Intersecting Areas method is not only suited for a privacy preserving, open access, crowd sourced location estimation system, but has several other benefits:

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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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Brendan Johan Lee IFI.UiO June 21, 2011 35 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 35 / 36

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Brendan Johan Lee IFI.UiO June 21, 2011 35 / 36

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[Resources]

- 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
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