Wireless Communication Channels Assignment 3: Positioning

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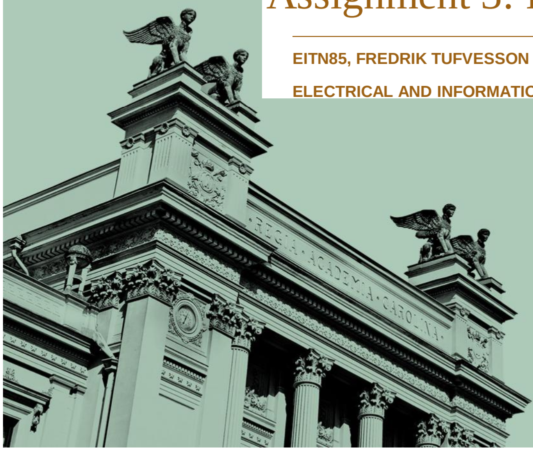
ELECTRICAL AND INFORMATION TECHNOLOGY



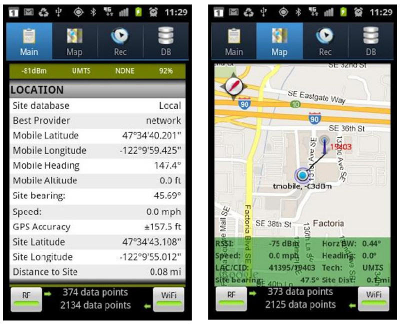
Tasks

This assignment deals with positioning, especially positioning based on received signal strength (RSSI) from different base stations.

- Estimate the propagation exponent from GSM RSSI values
- Find an estimate of the position based on RSSI values from a number of base stations.

Deadline March 5

RF signal tracker



A logger for the RSSI where the current location is stored together with the signal strength.

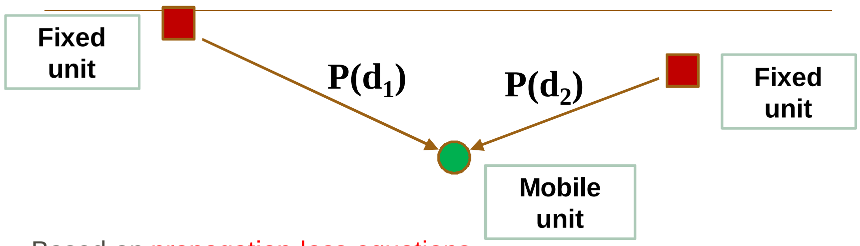
The position of the base station in use is stored together with the current position in geodetic coordinates ("lat, long"-format).

Depending on the actual phone used there is a limited resolution in the RSSI values reported

Coordinate formats

- Instead of geodetic coordinates grid coordinates, such as the Swedish national SWEREF99 coordinate system, can be used.
- In SWEREF99 the earth is given coordinates with a one meter resolution. Each position is represented by a (x,y) coordinate instead, where x is north, and y is east.
- Coordinates in any reference system can be plotted on a map at, e.g., http://latlong.mellifica.se/ where you type lat long coordinates (in the Grad/min/sek field with space) or directly as a link, e.g. http://latlong.mellifica.se/?latlong=59.326617,18.071697

Received signal strength (RSS) based positioning



- Based on propagation-loss equations
- Propagation-loss is often more complex than free-space (1/d^2) loss, e.g., indoors
  - Advanced models required
  - Fingerprinting (learn actual field strength from measurements)
- Feasible implementation: Most radio modules already provide an RSS indicator

vt 2018

The path-loss propagation model

$$P_{RX}(d)dBm = 10log\left[\frac{P_{RX}(d_0)}{0.001W}\right] - 10n\log(\frac{d}{d_0})$$

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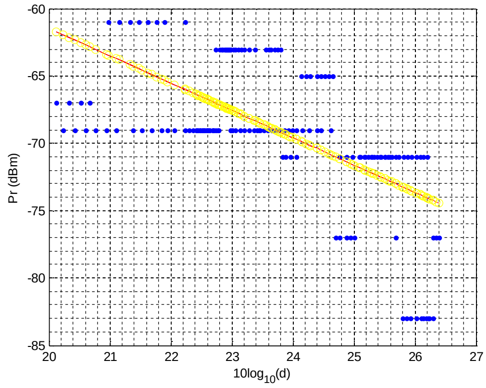
Task 1



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Task 2

Base station	RSSI	Cellid	Cell lat	Cell long	N	E
C0	-73 dBm	5754	55.710226	13.214211	6176968.001	226321.768
C1	-71 dBm	6369	55.708407	13.237082	6176790.908	227762.905
C2	-83 dBm	956	55.698757	13.218047	6175695.418	226585.302
C3	-75 dBm	778	55.721416	13.245211	6178248.307	228247.854
C4	-83 dBm	794	55.7058	13.1924	6176451.474	224959.338

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Special case: 3 BSs

The position of MS is, e.g., estimated by “measuring” the distance (*d*) from multiple BSs and finding the intersection of the circles

In a 2D plane and assuming that BS1 is placed in (0,0), the coordinate (X,Y) of the MS can be estimated as:

$$\begin{bmatrix} x \\ y \end{bmatrix} = 0.5 \begin{bmatrix} x_2 & y_2 \\ x_3 & y_3 \end{bmatrix}^{-1} \begin{bmatrix} x_2{}^2 + y_2{}^2 + d_1{}^2 - d_2{}^2 \\ x_3{}^2 + y_3{}^2 + d_1{}^2 - d_3{}^2 \end{bmatrix}$$

Even better is to calculate the probability density function of the MS position given the ”measured” distances.

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General case : *N* BSs

Having more than three BSs is desirable in order to overcome effects of measurement errors. In this case, the resulting system of linear equations is given by *Ap=b*

where *p* is the MS position, (X_i, Y_i) is the coordinate of the *i*th BSs and, N is the number of BSs.

$$A = \begin{bmatrix} 2(X_1 - X_N) & 2(Y_1 - Y_N) \\ \vdots & \vdots \\ 2(X_{N-1} - X_N) & 2(Y_{N-1} - Y_N) \end{bmatrix}$$

$$b = \begin{bmatrix} X_1{}^2 - X_N{}^2 + Y_1{}^3 - Y_N{}^2 + d_N{}^2 - d_1{}^2 \\ \vdots \\ X_{N-1}{}^2 - X_N{}^2 + Y_{N-1}{}^2 - Y_N{}^2 + d_N{}^2 - d_{N-1}{}^2 \end{bmatrix}$$

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General case : *N* BSs

This system of equations can be solved in a least squares sense as

$$\hat{p}=(A^TA)^{-1}A^Tb$$

However, it is sensitive to outliers, so a manual check or weighted least square is preferred.

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