Assignment 3
Positioning

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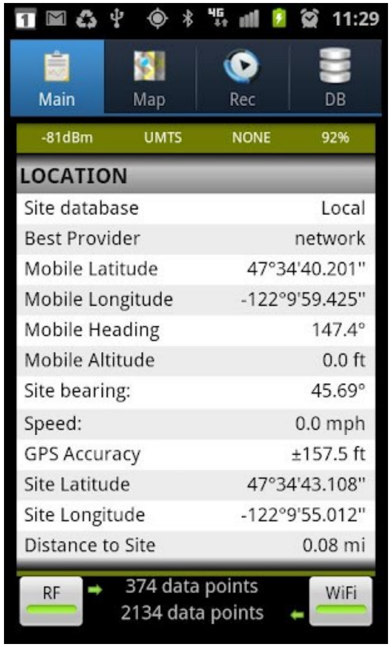
Tasks

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

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

- Deadline March 10

RF signal tracker



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

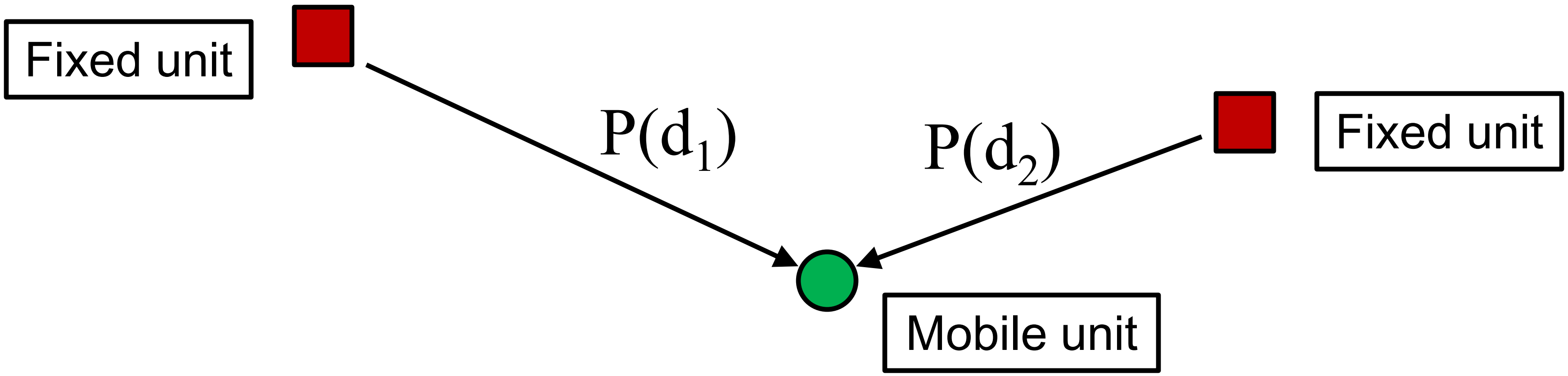
•The position of the base station in use is stored together with the current position in geodetic coordinates (“lat, long”-format).

•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

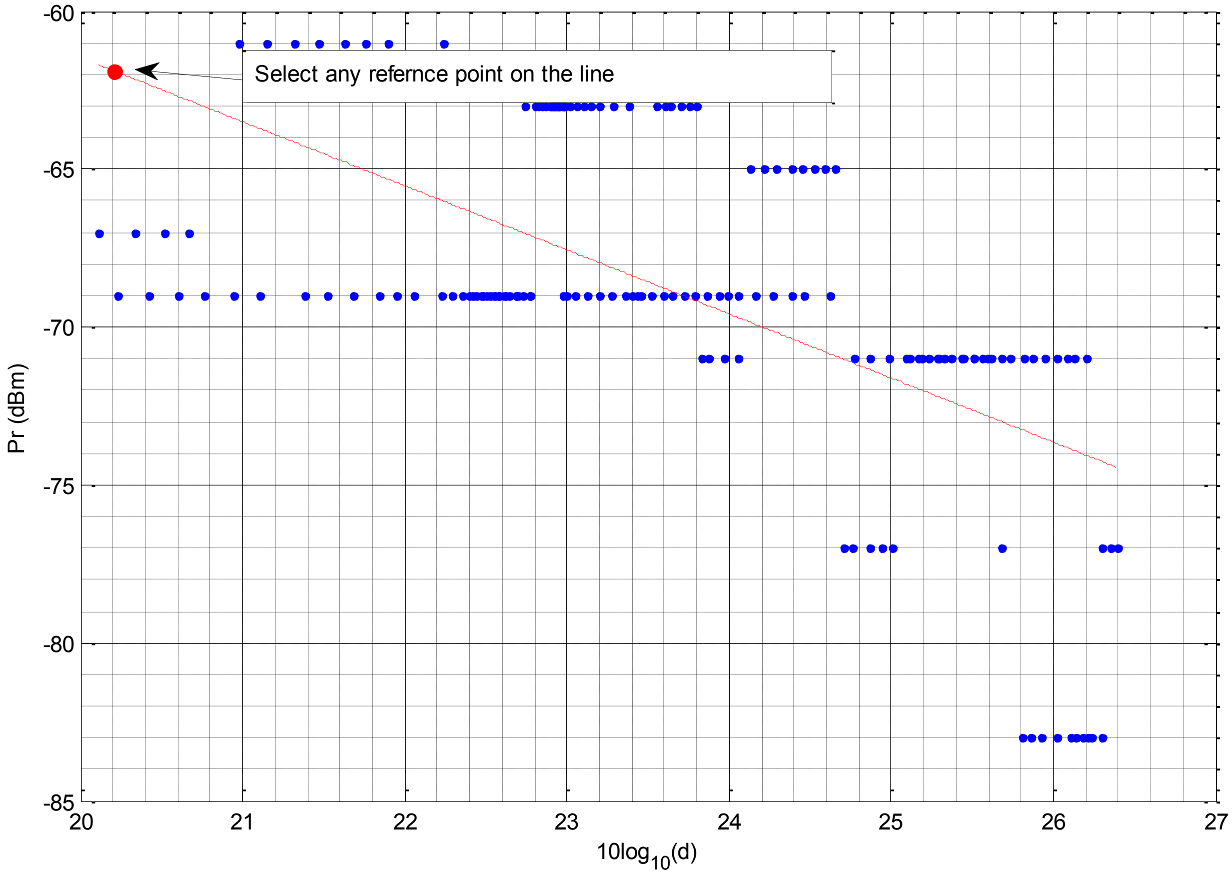


- Based on propagation-loss equations
- Propagation-loss is often more complex than free-space (1/d^2) loss, e.g., indoors
  - Advanced models required
  - Fingerprinting (learn actual field strength from measuerements)
- Feasible implementation: Most radio modules already provide an RSS indicator

The path-loss propagation model

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

Task 1



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

Task 2

BS	RSSI (dBm)	Cell ID	Cell Lat	Cell Long	N	E
C0	-73	5754	55.710226	13.214211	6175274.119	387798.966
C1	-71	6369	55.708407	13.237082	6175034.94	389230.636
C2	-83	956	55.698757	13.218047	6173991.736	388007.153
C3	-75	778	55.721416	13.245211	6176469.534	389777.989
C4	-83	794	55.705800	13.192400	6174817.142	386415.906

Special case : 3 BSs

The position of MS is estimated by measuring the distance (d) from multiple BSs and finding the intersection of the circles

In 2-d plane and assuming that BS1 is placed in (0,0) , coordinates (X,Y) of the MS is:

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

General case : N BSs

Having more than three BSs is desirable in order to overcome effects of measurement error. In this case, the resulting system of linear equations is given by:

$$Ap=b$$

where p is the MS position

General case : N BSs (cont.)

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

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

where, (X_i, Y_i) is the coordinates of the *ith* BSs
and,
N is the number of BSs.