Geolocation in a PicoRadio Environment

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Abstract
Location awareness is essential for the operation scenario envisioned for PicoRadio. The Global Positioning System is an outdoor navigation solution widespread and available today, but is it an appropriate approach?
Outline

- Radionavigation
- Introduction to GPS
- A high performance GPS solution
- Future of GPS
- PicoRadio environment
Radionavigation

Different techniques can be employed for triangulation solutions:

- Signal strength
- Angle of arrival (AOA)
- Time of arrival (TOA)
- Distance of arrival (TDOA)

\[
1 \text{ way: } s = c\Delta t \text{ or 2 way: } s = c \frac{\Delta t}{2}
\]

Must be combined with knowledge of the system behavior to derive accurate solutions.
GPS System Overview

- User, Space and Control segment
- 24 satellite constellation
- Global, 24-hr coverage
- Orbit radius approx. 26,560 km
- 3D position and precision timing
- Civilian SPS (100 m) and military PPS (22 m) services available
- Selective availability reduces accuracy by 30 m
- Line of Sight (LOS)
GPS Transmission Principles

- Direct Sequence Spread Spectrum (DSSS) carrier signals:
  - L1 1575.42 MHz
  - L2 1227.60 MHz
- Pseudorandom noise (PRN) codes
- Datarate 50 b/s
- Code division multiple access (CDMA)
- Correlation Sequences:
  - C/A - code 1.023 Mcps
  - P(Y) - code 10.23 Mcps
- -160 dBW signal power level
GPS Navigation Solution

- 3D-Position yields 3 unknowns: $U_x$, $U_y$ and $U_z$
- Clock Bias Error $c_B$ can be resolved by a fourth range measurement introduced to the navigation solution

\[
\begin{bmatrix}
(X_1 - U_x)^2 + (Y_1 - U_y)^2 + (Z_1 - U_z)^2 \\
(X_2 - U_x)^2 + (Y_2 - U_y)^2 + (Z_2 - U_z)^2 \\
(X_3 - U_x)^2 + (Y_3 - U_y)^2 + (Z_3 - U_z)^2 \\
(X_4 - U_x)^2 + (Y_4 - U_y)^2 + (Z_4 - U_z)^2
\end{bmatrix} = \begin{bmatrix}
(R_1 - c_B)^2 \\
(R_2 - c_B)^2 \\
(R_3 - c_B)^2 \\
(R_4 - c_B)^2
\end{bmatrix}
\]
Enhancing the SPS GPS Performance

- Differential GPS using fixed installations and communication links
  - Uploading ephemeris data to GPS for startup time
  - Correction of position
- Modelling motional behaviour
  - Altitude
  - Urban environment
  - Direction estimates
- Modelling clock behavior
- Multipath mitigation hardware
- Enhanced powersaving modes based on algorithms and usage scenarios
Current Development in GPS Systems

- SiRF Star II - closing the gap to a System on a Chip
- Integrated ARM7TDMI and DRAM
- Integrated Tracking engine
- WAAS support
- Faster startup time (≤45 s)
- Enhanced power modes
- Integrated RF
- Key driver for industry is E911
The PicoRadio Environment

An electromagnetic perspective.

- In- and outdoor
- Open space
- Physical obstruction
- EM emission
- Roaming users
- Many nodes (~100)
- Highly dynamic network
  - Amount of nodes
  - Clustering
  - Isolation
  - Motion
- Fixed basestations?
The Navigation Perspective

The usage scenario calls for a combined approach depending on the type of node.

- Position relative to other nodes
- Position relative to an inertial system
- Utilize the high number of nodes in network
- Employ motion and reconfiguration of nodes
- Integration with the data communication

- Quality of navigation service
  - Update rate
  - Accuracy
  - Availability
  - Startup time
Outlook

- Testbed for indoor ranging measurements
- Simulate multinode navigation
- Link navigation and communication
- Study GPS System integration