Computing with Location

• Navigation

• Global Location
  • All things GPS

• Model-based localization vs. fingerprinting
  • Localization beyond GPS

• Beyond localization
  • Nomatic*IM context
Tools for Navigation

- Navigation Tools
  - Clocks
  - Odometer
  - Electronic Aids
  - Radio navigation aids
    - ground-based
    - space-based
Tools for Navigation

- Who calculates position?
  - User
  - 3rd party
Tools for Navigation

- Who calculates position?
  - User
  - 3rd party
- What’s the impact?
Global Location GPS
Global Location GPS

- Latitude and Longitude
- What are they?
- Datum
Global Location GPS


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Global Location GPS

- Current GPS
  - Fully operational
  - accurate, continuous, global 3-D position and velocity
  - also distributes universal coordinated time
- 24 original satellites
- 6 orbital places
- 4 satellites per plane
- not geosynchronous
- world-wide monitoring stations

Global Location GPS
Global Location GPS

- Current GPS
  - Based on
    - Time Of Arrival (TOA)
    - knowledge of satellite orbits
  - Satellites have atomic clocks on board
  - 2 frequencies
    - L1 1575.42 MHz
    - L2 1227.6 MHz
Intro to Location

Global Location GPS
Global Location GPS

- Current GPS

- Broadcasts
  - Time of transmission
  - Ephemeris: Precise satellite orbital info
  - Almanac: System health info, rough orbital info for all satellites
Global Location GPS
Global Location GPS

• Current GPS

• Receiver requirements
  • Must have local clock
  • 3-D position requires four satellites
    • four unknowns (what are they?)
    • time or height reduces this
Global Location GPS
Global Location GPS

- Basic concept is based on the foghorn paradigm
- but in 3-D
Global Location GPS
Intro to Location

Global Location GPS

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Intro to Location

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Intro to Location

Global Location GPS

1 sec

1.5 sec

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Global Location GPS

• The current and future of GPS
  • WAAS
    • Additional satellites in geosynchronous orbit
  • DGPS assistance from a land based receiver
• Galileo
  • European competitor
  • GPS compatible
• GLONASS
  • Russian competitor
Global Location GPS

• The current and future of GPS
  • BeiDou
    • Chinese competitor
    • centralized system
  • Japanese Quasi-Zenith System
Global Location GPS
Global Location GPS

- GPS accuracy
  - 13 m 95% of the time horizontal
  - 22 m 95% of the time vertical system
  - 40 ns 95% of the time
- How do you design for this?
Global Location GPS

- GPS accuracy
  - 13 m 95% of the time horizontal
  - 22 m 95% of the time vertical system
  - 40 ns 95% of the time
- How do you design for this?
- Urban canyons
  - What are they?
- Japanese response, European response