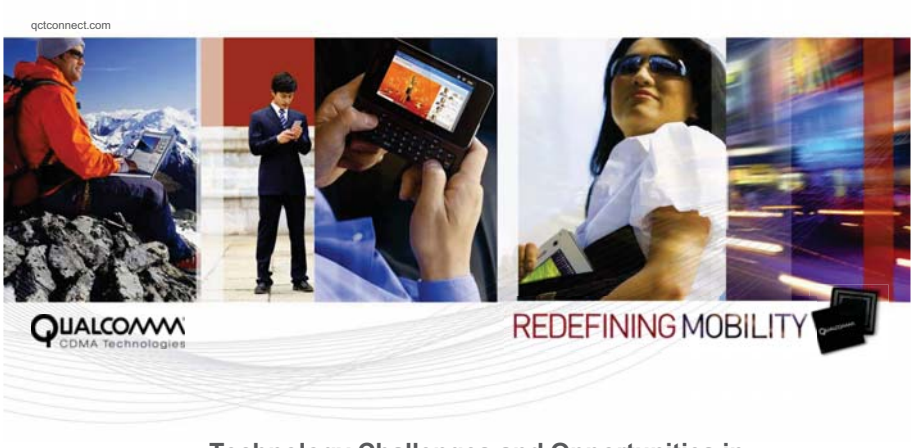

Technology Challenges and Opportunities in Indoor Location

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2nd Invitational Workshop on
Opportunistic RF Localization for Next Generation Wireless Devices
Future Directions, Technologies, Standards and Applications, June 14, 2010

Introduction

- **This presentation represents the author's perspective on technology challenges and opportunities in indoor location and general directions that industry might go to meet these challenges**
- **Now that outdoor positioning is "completely solved", industry is turning its focus on pedestrian and indoor positioning and navigation**
- **There are lots of technologies being pitched as panaceas, but most industry experts believe that a hybrid of multiple location technologies will represent the answer to ubiquitous, available and accurate indoor positioning**

Outline

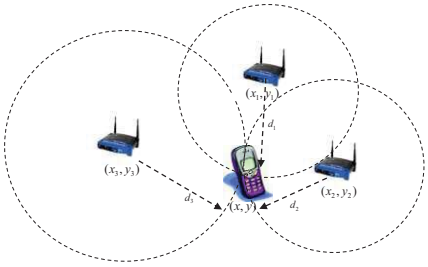
- **Drivers for Indoor Positioning**
- **Indoor Beacon Technology & Challenges**
- **Sensor Technology & Challenges**
- **Hybrid Positioning**
- **Conclusion**

Location on Mobile Devices in 2020

Drivers for Indoor Positioning

- **E911**
  - It is claimed that > 50% of cellular E911 calls occur indoors
  - Potential FCC mandated levels of indoor testing towards compliance
  - Target 50m or better accuracies
- **Indoor Location**
  - Single shot or low rate positions
  - "Where am I" on indoor maps
  - Location sensitive search / point of interest
  - Target ~20m or better accuracies
- **Indoor Navigation**
  - High rate positions
  - Navigation, routing
  - Target ~5m or better accuracies
  - Low Power

Indoor Beacon Technology



- **Indoor beacons are passive or active fixed devices situated indoors and observable at a mobile device. Examples:**
  - Radio (WLAN, WPAN, UWB, RFID, Femto/Pico)
  - Optical/Laser
- **Beacon location technology options**
  - Proximity
  - RSSI/Finger Printing
  - AOA/Ranging/RTT/Trilateration/Etc.

Challenges with Beacon Technology

- **Cost**
  - Public WiFi – already out there; "free"
  - Other beacons – deployment (device and installation) cost
- **Power**
  - RFID typically does not require power
  - Other beacons – require power source; impacts installation cost and limits deployment locations
- **Provisioning**
  - Beacon Almanac – cost associated with provisioning position information in beacons or maintaining beacon position almanac
- **Mobile Device Impact**
  - WiFi, BT high attach rate in phones, especially smartphones
  - Other beacon transceivers – if not already in phone, costly to add
- **Accuracy**
  - Very challenging to meet indoor accuracy needs subject keeping within practical beacon and mobile device costs constraints

Femto Cell Opportunities

- **Femto cells provide WWAN coverage to indoor locations**
  - Connected to broadband internet back haul
  - Must have known positions in network to facilitate E911 call routing
- **With short range femto cells, proximity detection alone may provide a reasonable indoor position accuracy**
  - Example: E911 call over a home femto; the known femto position can be used both to route the call to the appropriate PSAP and to provide to the PSAP for dispatch of emergency personnel
  - For femto radius of coverage < 50m, this will improve FCC compliance
- **Pico/Micro cells are used for larger indoor coverage areas**
  - Pico cell position can be used in combination with other indoor location technologies to augment the position solution or provide a fallback option

Sensors Relevant to Indoor Positioning

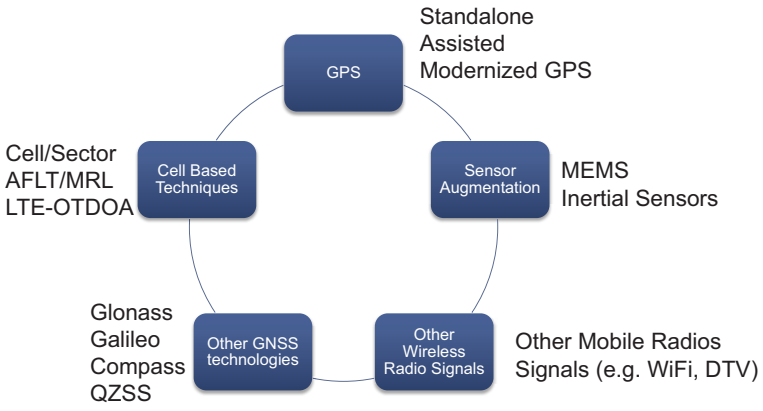
- **Barometric Pressure Sensor**
  - Measures atmospheric pressure
    - Altitude / floor determination
    - Weather
- **Accelerometer**
  - Measures acceleration in a particular direction
    - Linear and angular movement
    - Tilt (Roll, Pitch) sensor
    - Shock and free-fall sensing
- **Gyroscope**
  - Measures Coriolis effect
    - Heading Changes
    - Rotation
- **Magnetic Field Sensor**
  - Measures direction of magnetic field
    - Compass
    - Absolute Heading

Inertial MEMS Sensors & Challenges

- **MEMS sensors are becoming prevalent in smart phones today**
  - Tilt sensors, etc.
- **However, better accuracy in such sensors may be needed to enable acceptable accuracies in indoor navigation**
- **MEMS technology is on a good trajectory towards such accuracy improvements hand-in-hand with improvements in size, power and cost**
- **There is a great deal research in the area of Inertial MEMS sensor based Pedestrian Dead Reckoning (PDR) that can be leveraged to make indoor navigation a reality**
- **Some of the challenges in PDR are**
  - **Accuracy/Bias/Drift**
    - **Calibration**
  - **Power consumption**

Other Measurement Sources

- **GNSS & WWAN (including femto/pico cells)** may be available indoors and can help augment other indoor positioning technologies
- **Hybrid** is the key to indoor location



Hybrid Positioning

- **Some form of beacon technology will be key to indoor location**
  - GNSS and WWAN won't provide needed availability or accuracy
- **Some beacon + IMU/MEMS solution will be key to indoor navigation**
  - Practical cost beacon deployment won't be accurate enough
  - Sensors alone won't work for long periods of time
- **Other positioning technologies (WWAN, GNSS, etc.) will help improve accuracy and availability of indoor positioning**
- **Hybrid is the key**
- **Managing power consumption will also be critical**
  - Hybrid technology selection must adhere to power constraints to manage an acceptable "energy per location fix"

Conclusion

- **New indoor technologies will be required to meet accuracy and availability requirements for emerging indoor LBS applications (and possibly new E911 mandates)**
  - A combination of beacon technology and sensors will be key components of the indoor solution with augmentation from other location technologies
  - To be deployed wide-scale, this technology must also have a practical deployment cost – both in the mobile device and in the network – and have acceptable power consumption
- **LBS has already exploded in cellular devices for outdoor applications**
  - There is no question that a highly available and accurate indoor location solution will be of significant value, enabling many new LBS applications