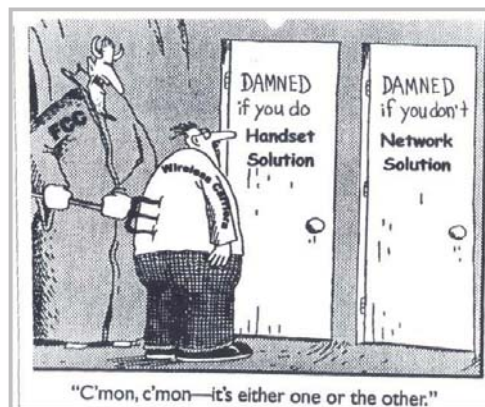




The Location Mashup: Melding Air Interfaces, Bands, Planes & Technologies

Workshop on Opportunistic RF Localization for Next Generation Wireless Devices
Marty Feuerstein
June 14, 2010

When It All Started



Quality of Service Needs

- Safety of life
 - Emergency call, personal security, first responder
- Mission critical
 - Enterprise, surveillance (CALEA/LI), network monitoring & optimization
- Consumer, best effort
 - Location-based services (navigation, POI, friend finder, search, maps)



But That Was Long Ago



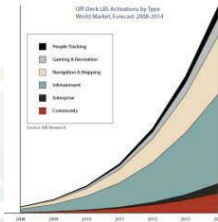
Sophisticated Devices: Smart phones



Better Chips: GPS, Wi-Fi, Bluetooth



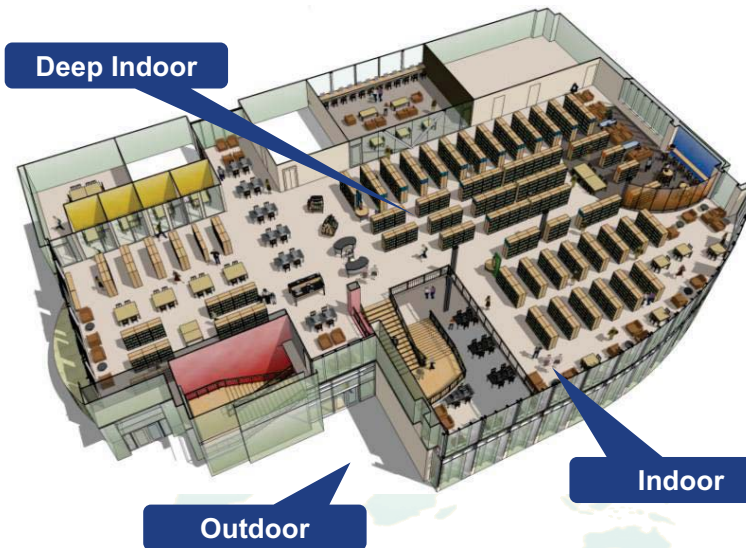
New Networks: 3G/4G, DAS, Femtocells



- Control Plane
- User Plane - SUPL
- Proprietary (applet)

Mass Market Applications

The Indoor Challenge





The Solution: Hybrid Systems



A-GPS



- Excellent outdoor accuracy
- Poor indoor accuracy
- Slow Time to Fix (TTF)
- High Battery Consumption
- Moderate accuracy in dense urban areas



Hybrid algorithms can optimize accuracy, time to fix and battery consumption based on application's Quality of Service needs

RF Pattern Matching (Cellular and WiFi)



- Robust indoor performance
- Fast Time to Fix (TTF)
- Low Battery Consumption
- High accuracy in dense urban areas



- Poor accuracy for sparse area



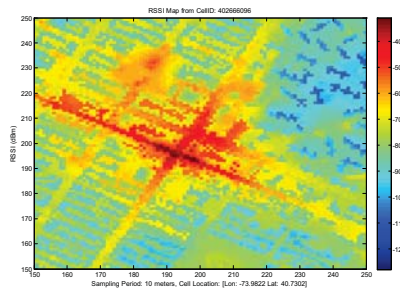
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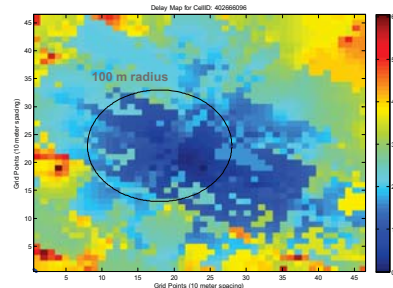
RF Pattern Matching: Site Specific Information



- Signal strength and time delay maps possess significant local structure
- Capture shadowing and non-line-of-sight effects
- Model indoor/outdoor conditions
- Information that should be an integral part of location determination
- 2G, 3G (AFLT, MRs, etc.), 4G (OTDOA, etc.), WiFi, I-RAT, etc.



Example Signal Strength Map



Example Time Delay Map

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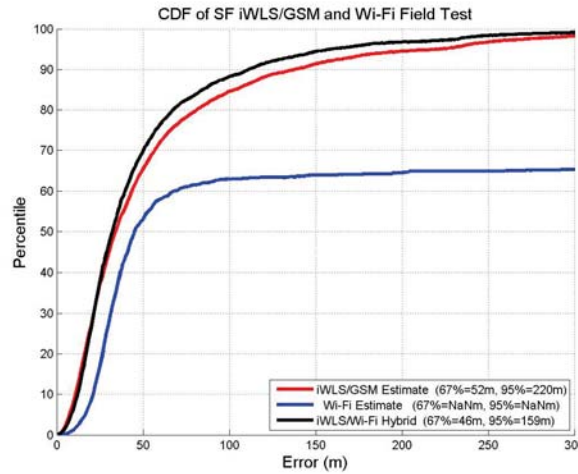


Hybrid Positioning Indoors: Roles of Cellular and WiFi Signals

WiFi location yield is poor deep indoors (~40% default rate) when APs mapped from outdoors

WLS (RF Pattern Matching) with cellular signals performs well alone

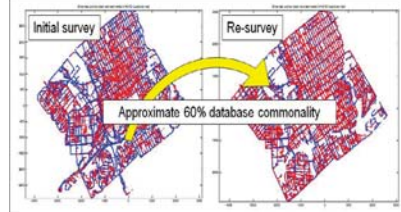
When WiFi can get a fix, the information is useful in Hybrid combination with cellular



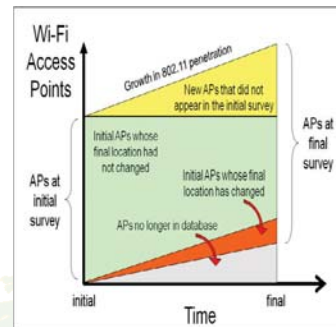
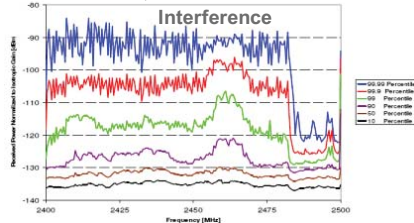
Wi-Fi Access Point Database Aging: Chasing a Changing Network

- Unlicensed band, unplanned, unmanaged local networks
- Dynamic, unpredictable changes
- Interference (microwave ovens, Bluetooth, cordless phones)

Depletion, addition, and movement of Wi-Fi access points

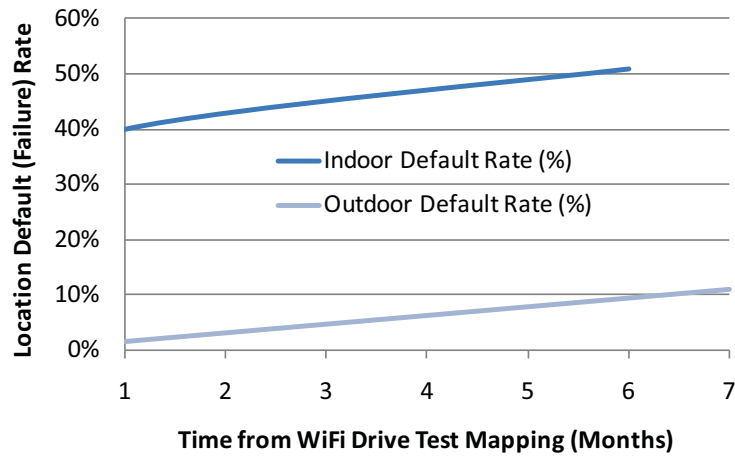


2.4 GHz Industrial, Scientific & Medical Band Interference

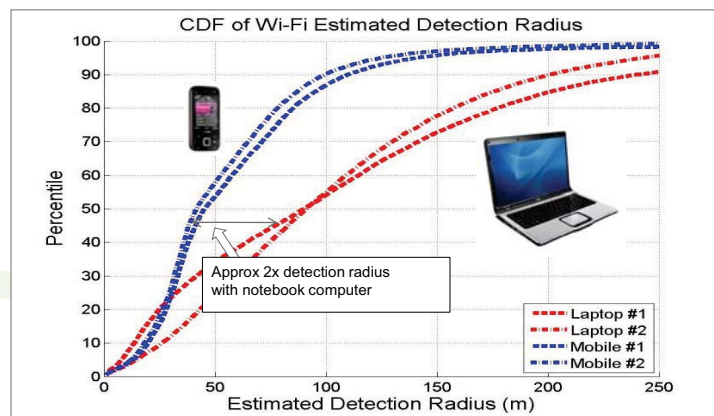




Wi-Fi Database Aging: Effects on Location Performance

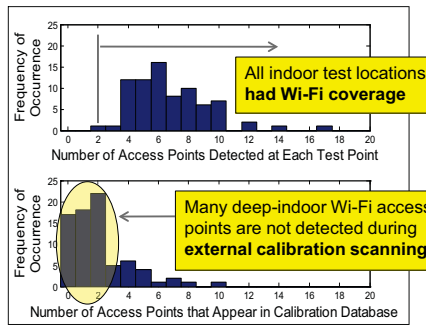


Laptops Far More Sensitive to WiFi Signals Compared to Mobile Handsets





WiFi Alone Has Indoor Dead-Zones: Doesn't Solve The Indoor Problem



Example indoor test location
with significant blockage and
signal attenuation



Same location



WiFi Access Point, but
not detected outdoors

- WiFi location alone has challenges deep indoors where only unmapped Access Points can be measured
- Need to hybrid combine with cellular signals (and GPS) for demanding applications – safety of life, mission critical



Questions?

Thank You!