QUALCOMM Incorporated

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August 15, 2013

Ms. Marlene Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: **Ex Parte Presentation** - Amending the Definition of Interconnected VoIP Service in Section 9.3 of the Commission's Rules - GN Docket No. 11-117; Wireless E911 Location Accuracy Requirements - PS Docket No. 07-114; E911 Requirements for IP-Enabled Service Providers - WC Docket No. 05-196

Dear Ms. Dortch:

QUALCOMM Incorporated ("Qualcomm") met with staff from the Commission's Public Safety and Homeland Security Bureau ("PSHSB") on August 13, 2013, to discuss E911 indoor location technology and the field testing that the Commission's Communications Security, Reliability and Interoperability Council III ("CSRIC III") conducted. *See* CSRIC III Working Group 3 E911 Location Accuracy Indoor Location Test Bed Report (March 14, 2013).

Cormac Conroy, Kirk Burroughs, Bruce Wilson, and the undersigned from Qualcomm met with the following FCC staff: David Furth, Nicole McGinnis, Erika Olsen, Henning Schulzrinne, David Siehl, and Dana Zelman.

Qualcomm presented the attached slides covering the CSRIC III E911 Indoor Location Test Bed Report, new technologies improving E911 indoor location accuracy, such as OTDOA, the incorporation of WLAN capabilities, and practical requirements for testing E911 indoor location accuracy.

Respectfully submitted,

John W. Kuzin

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Senior Director, Government Affairs – Regulatory

Att.

cc w/ Att. (via email)
David Furth
Timothy May
Nicole McGinnis
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Dana Zelman

Discussion on E911 Indoor Location Accuracy

August 13, 2013

Agenda

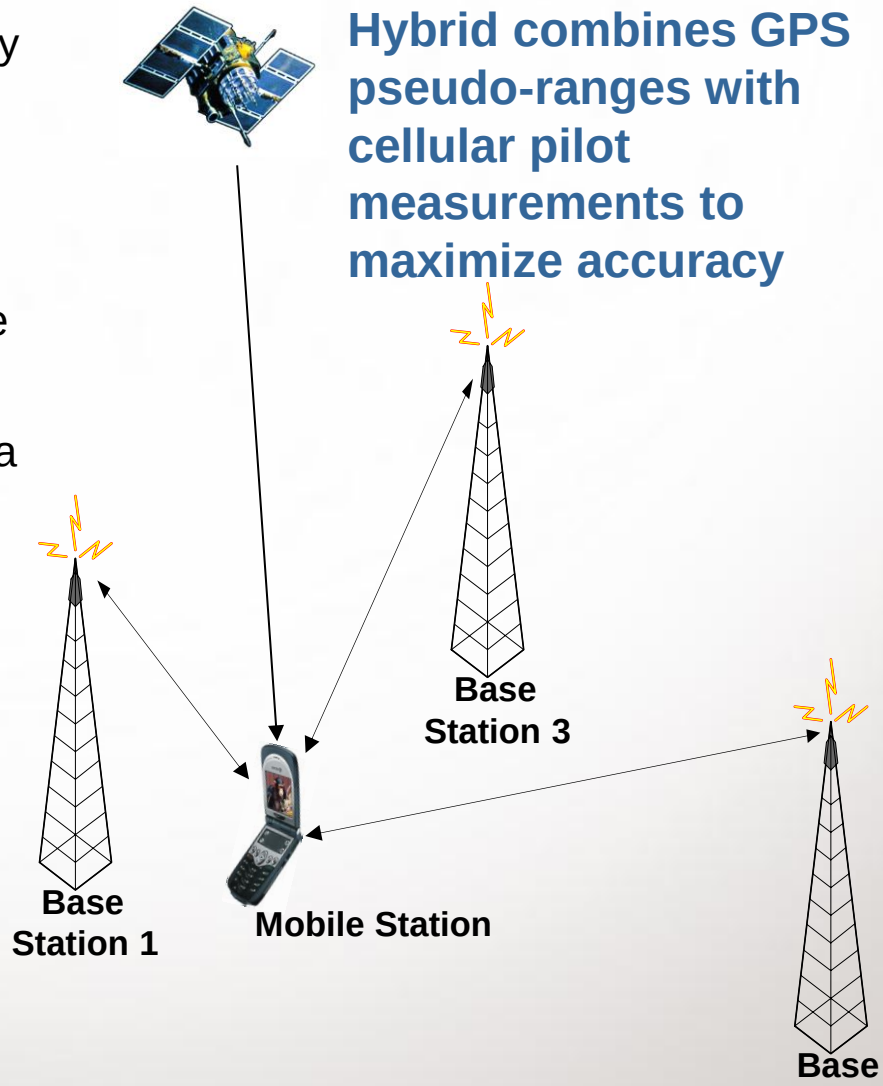
- Indoor Location Accuracy Roadmap
- Practical Requirements for Indoor Location Accuracy
- Confidence and Uncertainty in a multi location determination platform environment

Indoor E911 Positioning via OTDOA, WLAN and Small Cells

Today's Hybrid A-GPS/AFLT

- Outdoor fixes are dominated by GPS measurements and highly accurate GPS only fixes are produced
- Hybrid fixes use both GPS pseudo-ranges and CDMA Pilot measurements in the same trilateration calculation when an insufficient number of GPS pseudo-ranges are available for a GPS-only fix
- Hybrid allows the maximum accuracy when a GPS-only solution is not possible (e.g., two or fewer GPS pseudo-ranges are available)
- Hybrid, perhaps AFLT only in some cases, allows for indoor coverage and nearly 100% yield.
- Enhanced Cell ID and Cell ID provide 100% yield
- Carriers without AFLT today just use GPS E-CID, and CID

Hybrid combines GPS pseudo-ranges with cellular pilot measurements to maximize accuracy



Today's Best Indoor Accuracy

- From The CSRIC Report

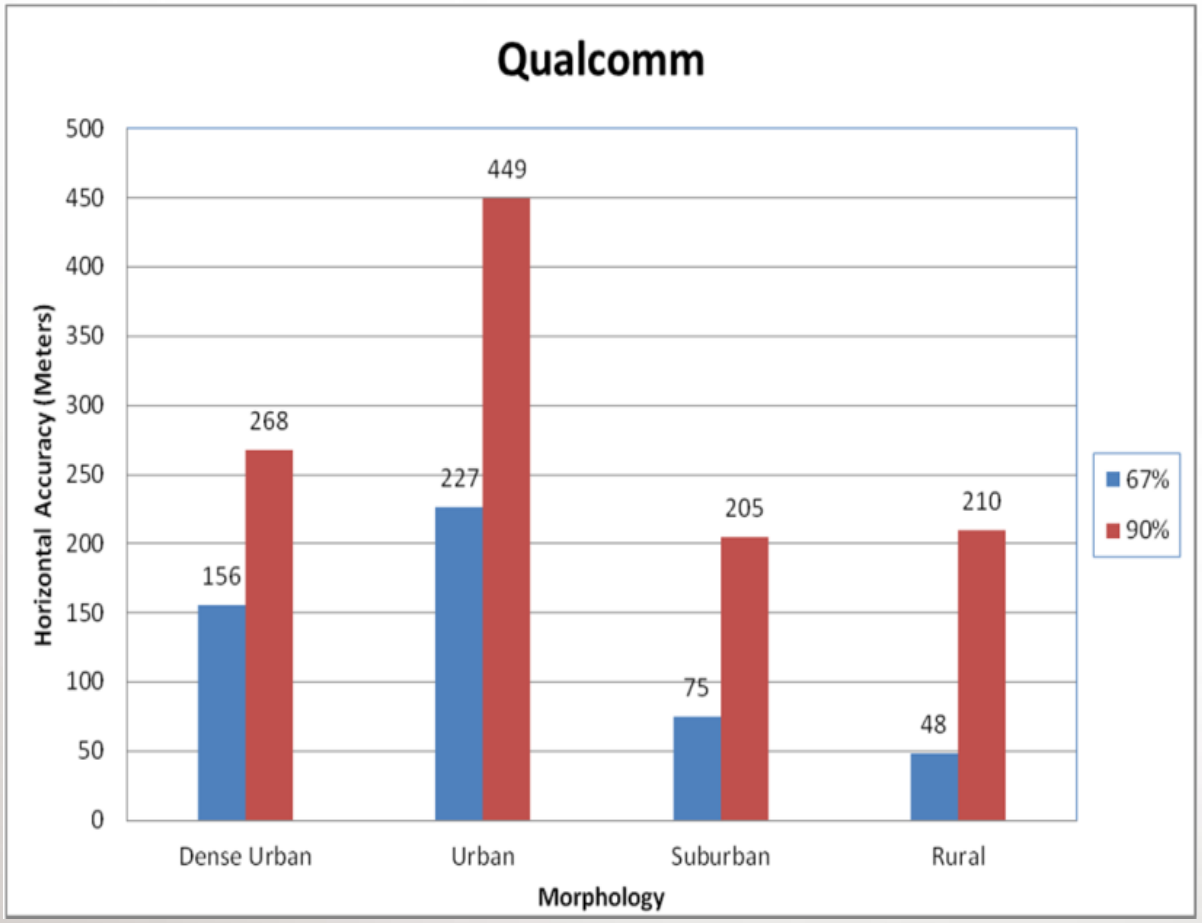


Figure 6.1.2-7. Indoor Accuracy by Morphology for Qualcomm

Goal

- 50 / 150
- 67% / 90%

New Technologies Impacting Indoor 911 Location Accuracy

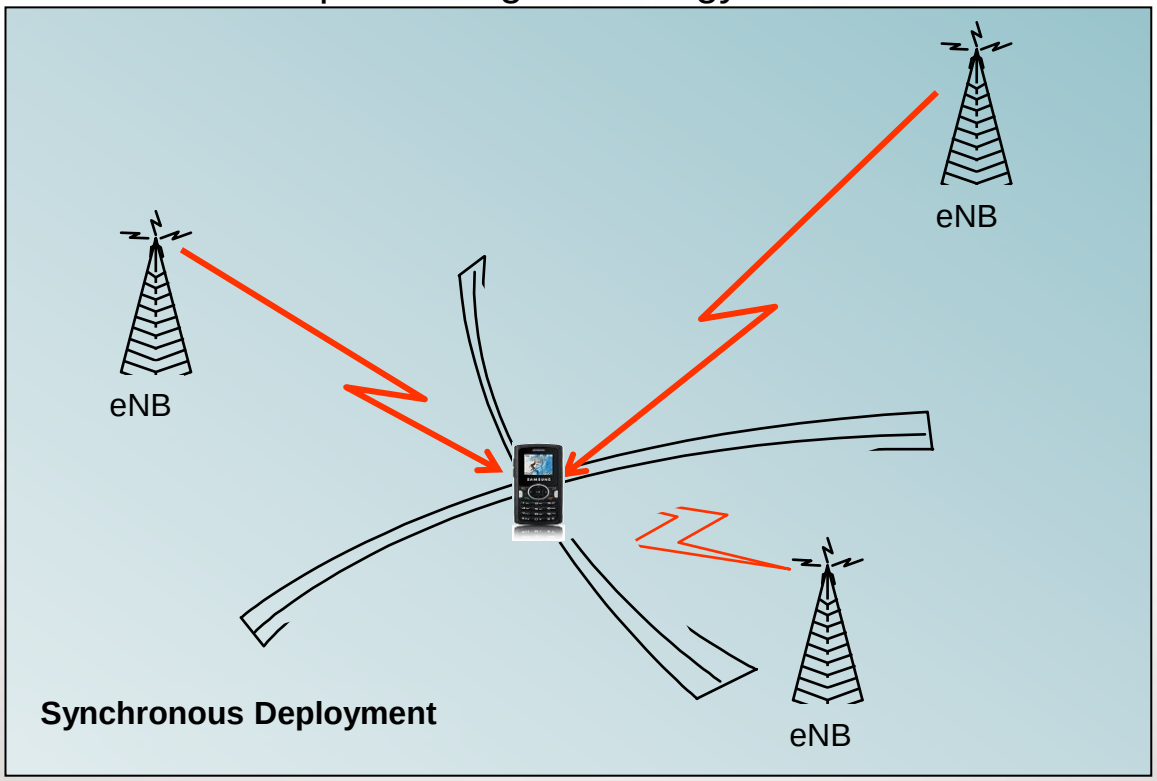
- New Access Networks
  - 4G/LTE with OTDOA
  - WLAN allowing for Signal strength and ranging measurements to be used for indoor positioning
- Support for New Technologies
  - LTE OTDOA is based on a highly detectable reference signal
  - 9-1-1 “User Plane” solution exists for these new access networks
  - Better support for Multi-RAT / Hybrid positioning methods
- Changes to Network Topologies
  - Small cells (Femto / Pico Cells) – aka “Hetnets”
  - WLAN data offloading
  - Small Cells and Managed Access Points are a powerful positioning asset for wireless operators

Key Benefits of Wireless WAN

- Penetrates buildings – deep indoors
- If cellular networks are synchronized, ranging is possible from cell towers giving a position indoors
  - 4G/LTE networks are rolling out with synchronized base stations and such WWAN positioning coverage for the mobile user base will grow quickly
- Leverages existing infrastructure to do positioning
- Leverages existing LTE handsets (e.g., uses LTE modem, no new handset hardware)
- Leverages trusted, accurate cell tower base station almanac of wireless operators
- Multiple bands available for ranging
- Strong ecosystem exists

Observed Time Difference of Arrival (OTDOA)

- Downlink positioning method (similar to AFLT) – but for 4G/LTE networks
- UE measures OTD's (difference of TOA) from between eNB pairs
- Measurements are made on highly detectable Positioning Reference Signal (PRS)
- Designed to outperform AFLT (higher bandwidth, increased hearability, inter-frequency, etc.)
- OTDOA will be a useful indoor positioning technology

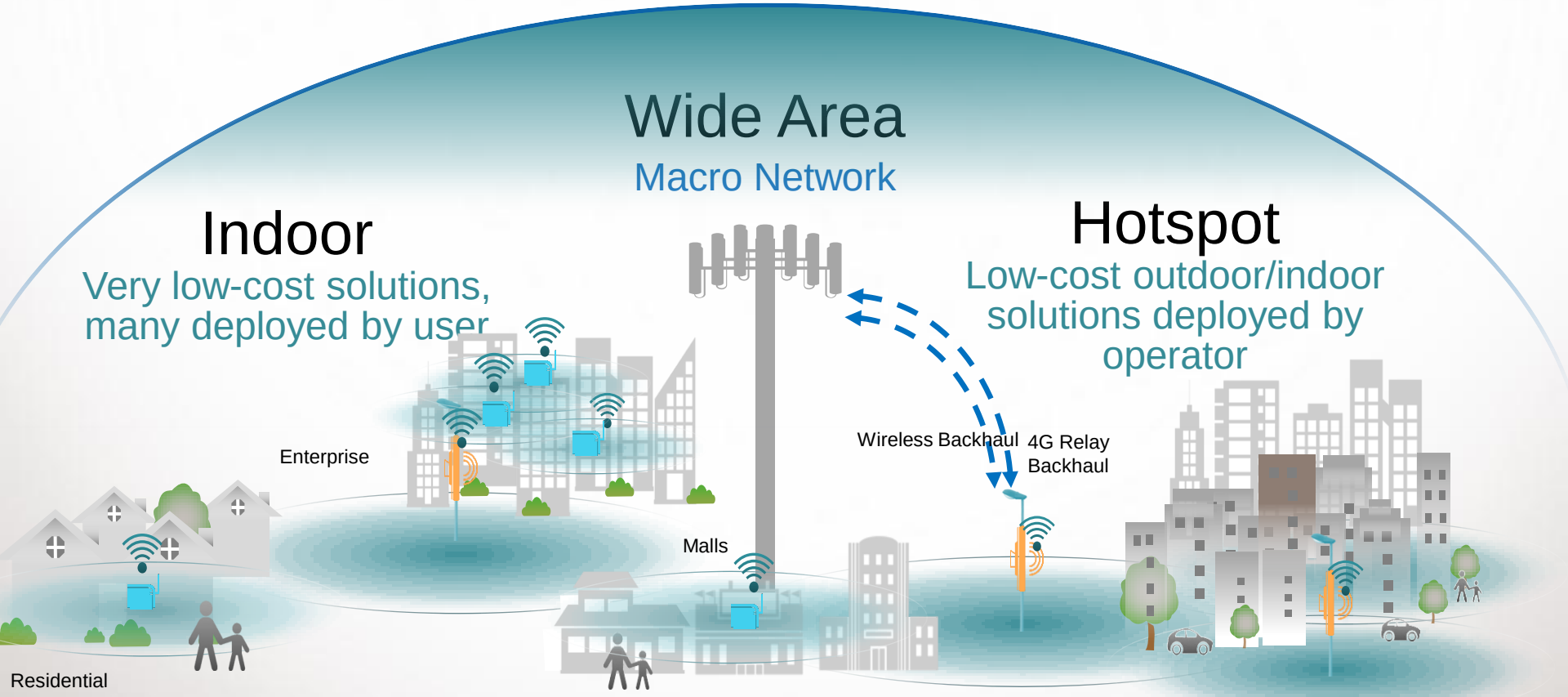


LTE OTDOA Advantages

- **Detectability of distant eNBs**
  - PRS was designed for a high level of hearability
    - Scrambling code isolation (cell specific)
    - Frequency re-use factor
      - » Meaning there are 6 separate frequency bins that can separate PRS tones of neighbor cells
      - » Each cell transmits PRS in one (cell specific) frequency bin and is not transmitting anything in other frequency bins -- this reduces significantly inter-cell interference
    - PRS muting
      - » During some PRS occasions, some cells will not transmit any PRS and further reduce inter-cell interference
  - 1x CDMA AFLT uses only code isolation
- **Inter-Frequency OTDOA**
  - LTE Inter-Frequency Measurement Gaps as well as Carrier Aggregation allow UE to collect PRS measurements on multiple frequencies/bands in the same OTDOA fix
    - More cells can be detected
    - Provides frequency diversity of cells detected on multiple frequencies
  - 1x CDMA can not enable such a comparable Inter-Frequency AFLT
- **Multipath resolvability**
  - PRS with wider BW can resolve multipath more accurately
    - 20 MHz PRS has ~14 times better resolution for resolving multipath than 1.4 MHz
    - For 20 MHz PRS, in majority of scenarios a receiver can differentiate two clean multipaths that are ~10m apart
  - 1x CDMA AFLT multipath resolvability is limited to ~120 m

More Small Cells – Bring Network Closer to User

If the coverage area of the small cell is small enough no position technology is needed per se



Indoor small cell for Residential / enterprise

Wi-Fi integrated with 3G/4G for indoor and hotspot offloading

Relay and Pico/Metro/RRH small cells for hotspots

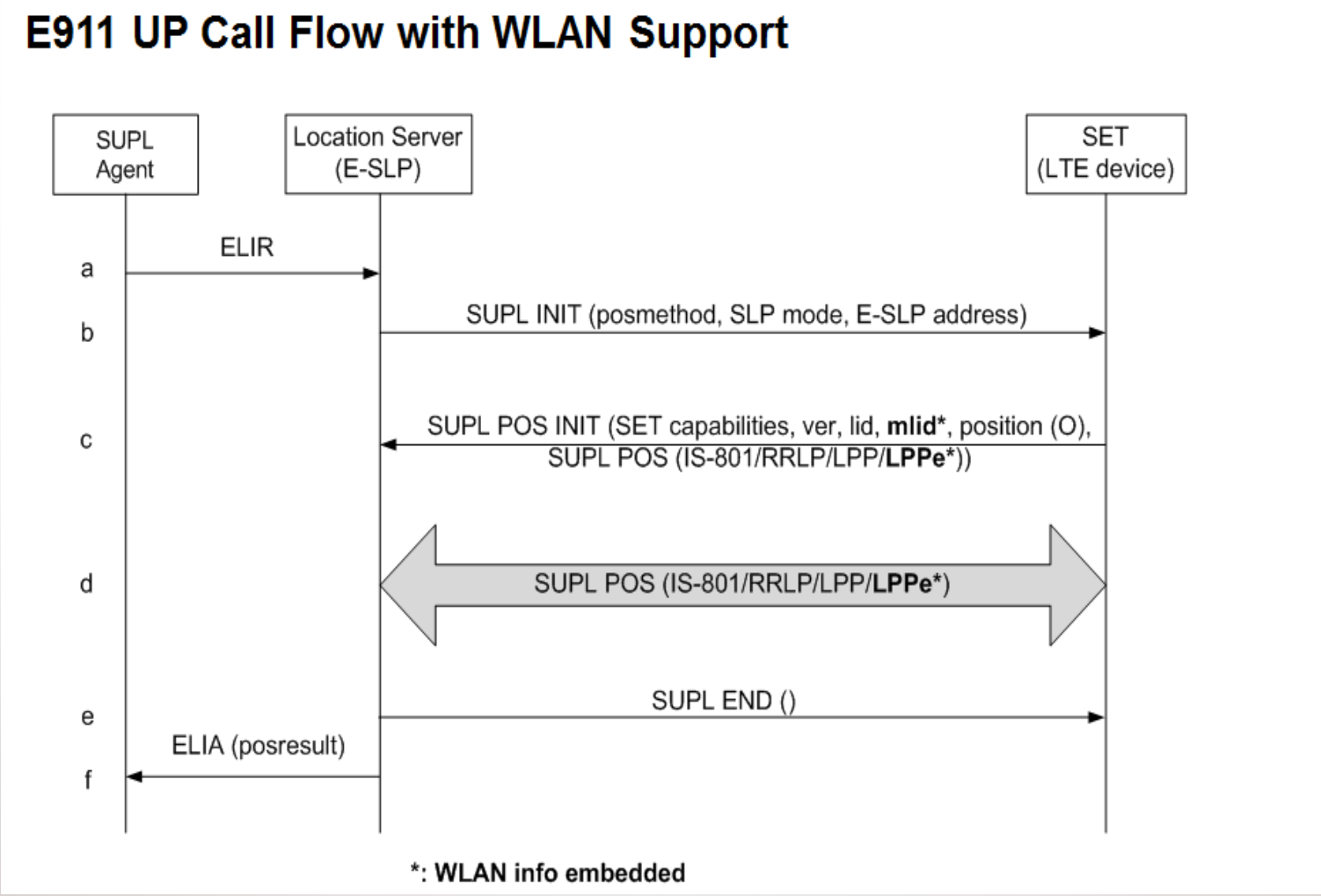
Leveraging Heterogeneous Networks – HetNets

How to Leverage WLAN

- WLAN information may be used to supplement cellular indoor positions
  - Specifically Wi-Fi MAC address, signal strength and timing measurements
- Challenges
  - Multiple decentralized WLAN databases of unvalidated accuracy exist today
  - The need for and the issues with creating centralized Wi-Fi database(s)
  - Legal clarification of liability for an inherently unreliable source
- Targeted / Phased Rollouts Possible
  - WLAN Data Offloading provides the carriers with managed WLAN databases to use for location

WLAN Measurements in a 911 Call

Source: CSRIC Report on Indoor Location



Practical Requirements for Testing Indoor Location Accuracy

Indoor Testing is Difficult

- Indoor accuracy testing is quite difficult due to many issues including privacy, security, and access
- Desirable to use test results from a small region to extrapolate over a larger region
- From CSRIC test report
  - Testing in just a single geographical test area required months to plan and execute the tests – even with complete cooperation and support from vendors, carriers, and public safety.
  - Logistical indoor testing challenges include:
    - Identification of buildings for testing
    - Privacy, security, and building access issues
    - Obtaining accurate indoor ground truth
    - Large variations in structure types
    - Substantial time and cost required to plan, collect, and analyze indoor test data

Morphology

- Implies similar attenuation and similar accuracy
- Similar attenuation of external GPS and Cellular signals implies similar accuracy
- Do “glass and steel building” accuracy results apply to other buildings?
  - As long as the signals used for positioning are affected the same way in both buildings, similar accuracy will be provided in both buildings
  - Typically a 2 foot thick granite wall will have dramatically different attenuation than a glass building – thus they need to be tested separately
  - Brick residencies will have more attenuation than wood frame – these need to be tested separately
- Large areas of a city will have roughly similar construction techniques
  - Residential 1 story wood frame can be tested once and apply to whole region, for example
- Attenuation due to building size, interior walls – Morphology groups (per CSRIC)
  - **Rural** –often 1 or 2 stories; reasonable GPS penetration, poor cellular accuracy due to poor geometry – single tower
  - **Suburban** – often 1 or 2 stories; reasonable GPS penetration, good cellular accuracy - multiple overlapping towers
  - **Urban** - < 10 stories, poor GPS penetration, medium cellular accuracy due to sparse tower spacing and weaker signals.
  - **Dense Urban** - > 10 stories, poor GPS penetration, good cellular accuracy with dense tower spacing

How Much Testing is needed?

- How many morphology groups are needed?
  - Are the 4 morphology groups from the CSRIC 3 report sufficient or are more needed?
  - CDG in 2000 defined finer granularity environments **"CDG Test Plan Document for Location Determination Technologies Evaluation"**
    - Rural had 21 scenarios – covering flat or hilly, wooded or not
    - Suburban had 15 scenarios – covering wood or brick houses, office buildings, warehouses and parking garages
    - Urban had 29 scenarios – covering residential, low rise, high rise; low or high floor; interior or exterior rooms
    - Dense urban was part of urban
- How many geographical regions are needed to capture climate influenced building practices?
  - Suburban U.S. Northeast with harsh winters will have more RF attenuation than Suburban U.S. Southwest using lighter construction
  - Flat prairie rural will have different RF propagation than mountainous rural
  - Dense urban might all be similar (Manhattan, Chicago inner loop, San Francisco Financial District) but testing will be required

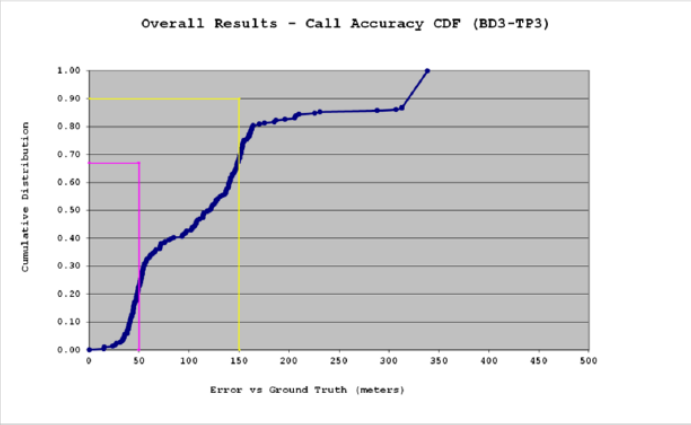
Confidence and Uncertainty

Different technologies can be combined (“Hybrid”)

- Error distributions of different technologies can be combined when scaled to the same level of confidence
- Distribution will have “Step function” from each technology
- GPS + AFLT example below; would apply to GPS + OTDOA

Std Deviation	Relative Size
GPS	Small
AFLT	Medium
Cell Sector	Large

Page 103 - Qualcomm per Test Point Results—BD3



Page 101 - Qualcomm per Test Point Results—BD3

PDE Position Fix Type										
Test Point ID		Cell Sector	AFLT	Hybrid	GPS	Mixed Cell Sector	Safety Net	Mixed Mode	Invalid	Total
Qualcomm_BD3_TP1	Number of Calls	24	17	256	25	1	0	2	0	325
	Percentage	7.4%	5.2%	78.8%	7.7%	0.3%	0.0%	0.6%	0.0%	100.0%
Qualcomm_BD3_TP2	Number of Calls	24	10	135	2	22	1	112	0	306
	Percentage	7.8%	3.3%	44.1%	0.7%	7.2%	0.3%	36.6%	0.0%	100.0%
Qualcomm_BD3_TP3	Number of Calls	30	5	48	0	68	0	73	0	224
	Percentage	13.4%	2.2%	21.4%	0.0%	30.4%	0.0%	32.6%	0.0%	100.0%
Qualcomm_BD3_TP4	Number of Calls	20	132	2	0	199	6	13	0	372
	Percentage	5.4%	35.5%	0.5%	0.0%	53.5%	1.6%	3.5%	0.0%	100.0%

Combining GPS / WWAN with WLAN

- Hybrid is the combination of two or more technologies
  - Today, GPS and AFLT and ECID are combined in hybrid position fixes with a smooth transition from one kind of fix to another
- Smooth Transition from Outdoor -> Boundary -> Indoor
  - Measurements from all of GPS + Cellular + WLAN can be combined into one solution
  - Outdoors the GPS measurements will dominated
  - Indoors the Cellular and WLAN measurements will dominate the solution
    - Combined Cellular and WLAN in a fallback to GPS has potential for E-911 reliability

Challenges Combining GPS / WWAN with WLAN

- WLAN has potential for good accuracy
  - Small coverage area provides good accuracy
- Indoor WLAN and Outdoor GPS / WWAN can be integrated
  - WLAN error distributions will have to be measured and scaled to the same levels of confidence as GPS / WWAN
- WLAN by itself
  - Unmanaged Databases of WLAN positions today have unlimited large and / or undetected errors
  - Managed WLAN deployments are easier to integrate
  - Commercial or home access points have no inherent E-911 reliability requirements and may move without notification
- WLAN in hybrid with WWAN
  - WLAN large errors can be detected by comparing WWAN based positions with WLAN based positions to detect large errors
- Testing will be required to see how effectively WLAN can be brought into E-911 reliability requirements

More Morphologies

- Indoor signal density will split morphologies
- Adding indoor WLAN (or indoor small cells) will change what “equivalent” means
- If one 10 story building has 50 WLAN access points, accuracy will be dramatically better than a building without any WLAN access points
- Testing will be required to define the impact of zero, one, a few, or many WLAN access points to indoor accuracy
- Testing will be required to define whether small cells indoors need to be treated separately than macro cells for indoor E-911 accuracy

Thank You

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