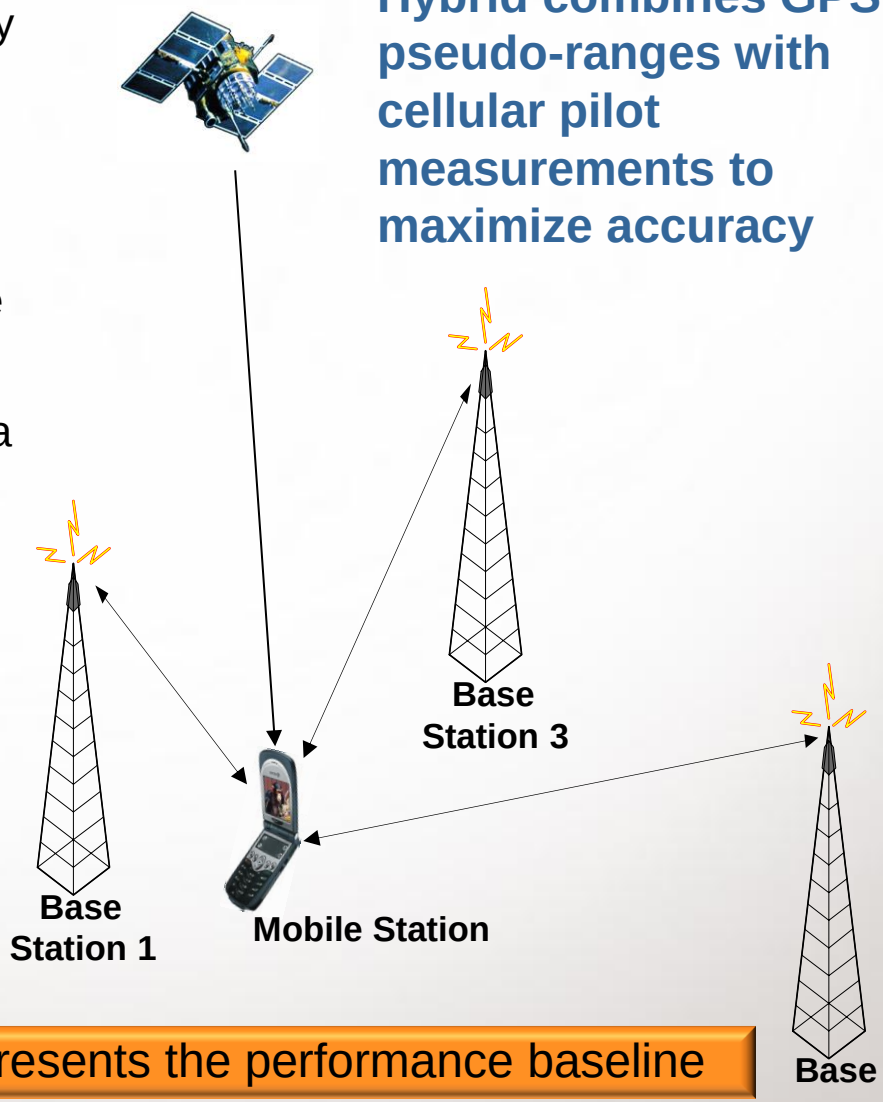
Discussion on E911 Indoor Location Accuracy

November 18, 2013

Today's Hybrid A-GPS/AFLT

- Outdoor fixes are rely predominantly on 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



This positioning technology represents the performance baseline

Today's Best Indoor Accuracy

- From The CSRIC Report

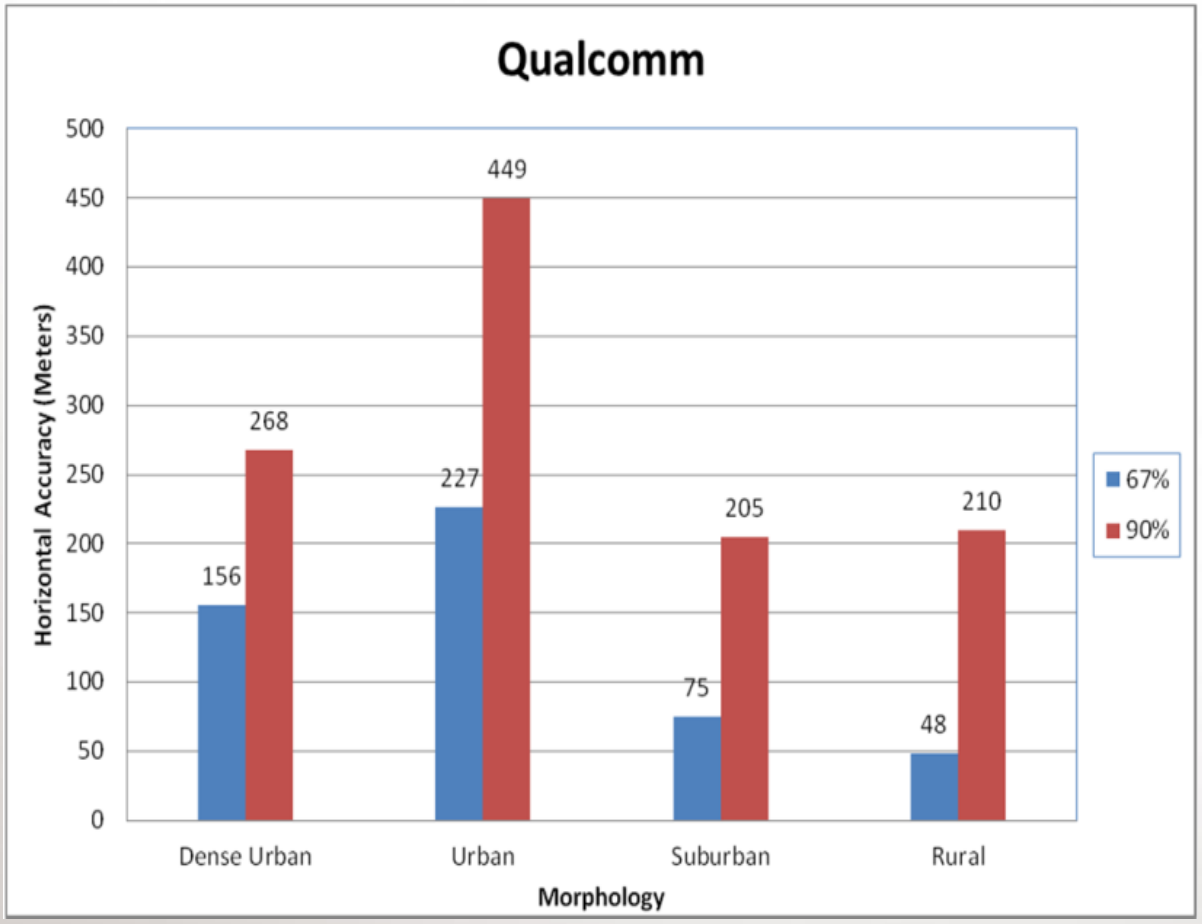


Figure 6.1.2-7. Indoor Accuracy by Morphology for Qualcomm

Newer methods (such as OTDOA and WLAN) improve E911 indoor performance

New Technologies Improving Indoor 911 Accuracy

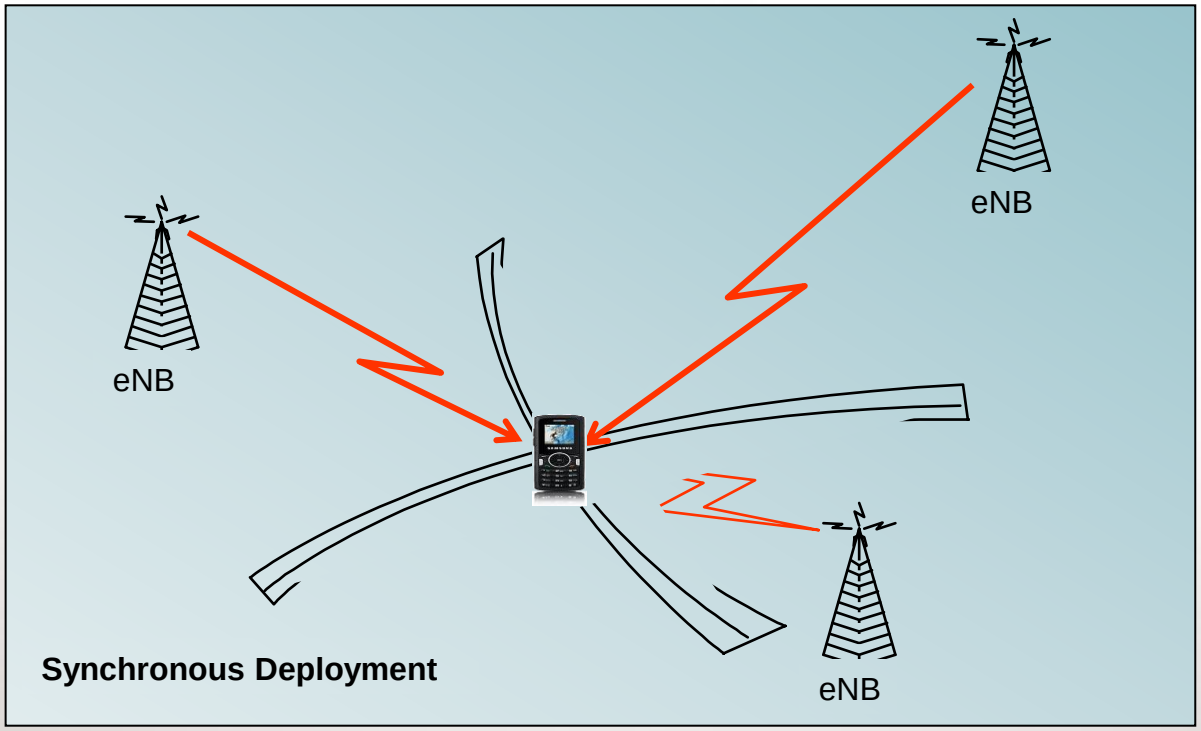
- New Access Networks
  - 4G/LTE with OTDOA
  - WLAN
    - Signal strength and ranging measurements will be key for indoor positioning
- Support for New Technologies
  - LTE OTDOA is based on a highly detectable reference signal
  - Signaling associated with these new access networks allows for:
    - Better support for Multi-RAT / Hybrid positioning methods
    - Mobile provided solutions to be sent to the server
- Changes to Network Topologies
  - Small cells (Femto / Pico Cells) – aka “Hetnets” per the 3GPP standards
  - WLAN data offloading
  - Small Cells and Managed Access Points are a powerful positioning asset for wireless operators

Key Benefits of Wireless WAN (WWAN)

- 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
  - WWAN positioning coverage for 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

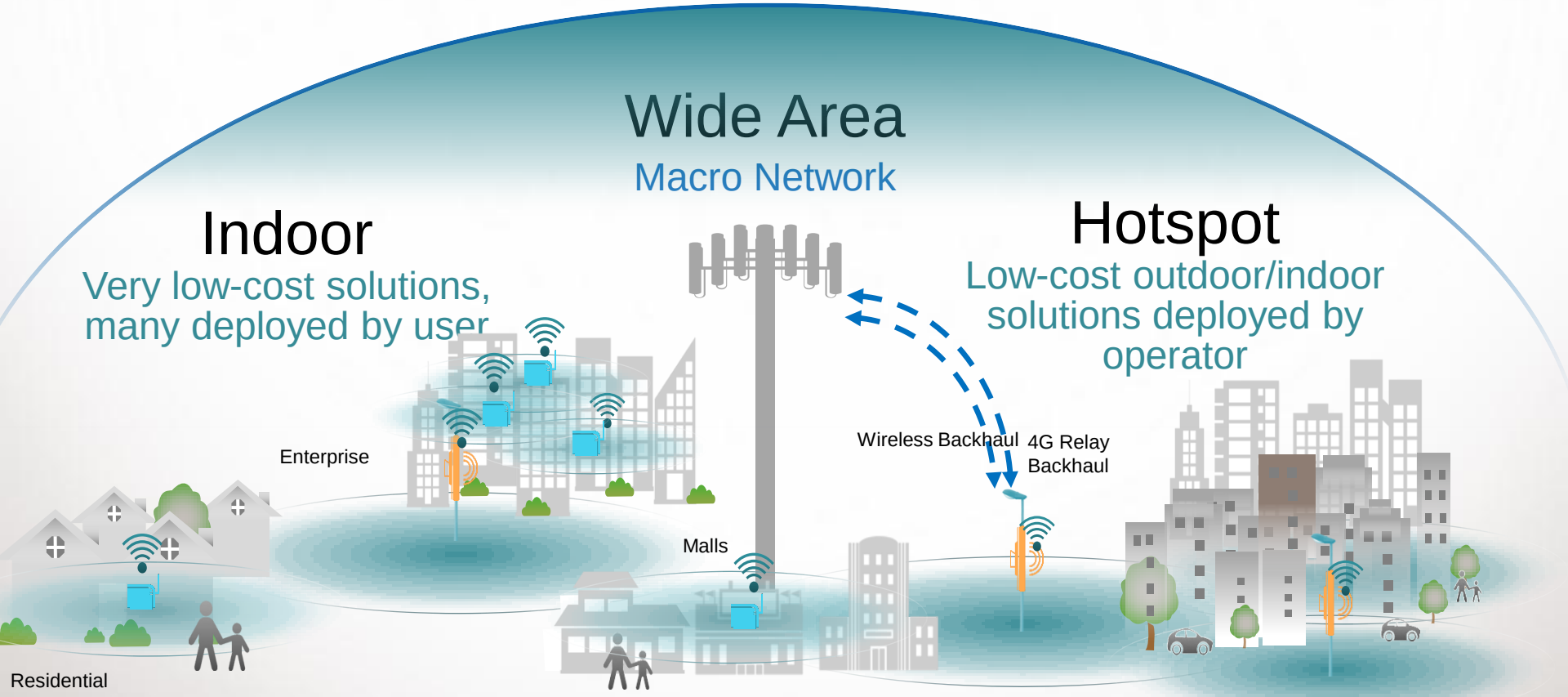


LTE OTDOA Advantages

- **Detectability of distant eNBs**
  - PRS was designed for a high level of hearability
    - Scrambling code isolation (cell specific)
    - Frequency re-use factor
      - » 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; thus lower 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 most scenarios a receiver can differentiate two clean multipaths ~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

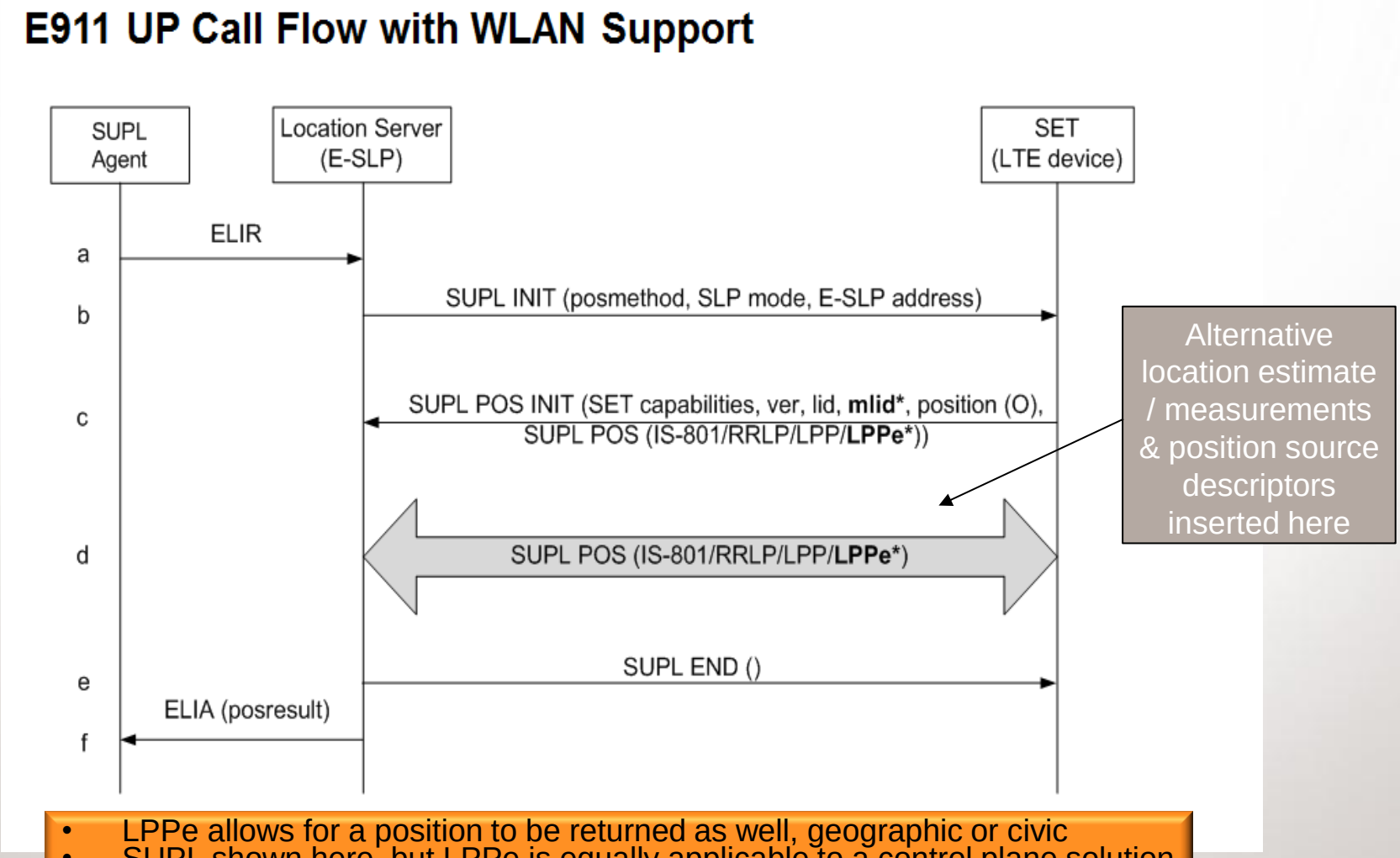
Leveraging Heterogeneous Networks – HetNets

How to Leverage Wireless LAN (WLAN)

- **WLAN information may be used to supplement cellular indoor positions**
  - Specification of how to report WLAN MAC address as well as signal strength and time measurements along with the Cellular and GPS information
  - Specification of how to describe an alternative (potentially consumer LBS) position sent back to the server, be it from sensor aided, device specific database solutions, etc.
- **Challenges**
  - Multiple decentralized WLAN databases of unvalidated accuracy exist today
  - The need for and the issues with creating centralized WLAN 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 solutions can be cross checked**
  - Existing OTDOA / A-GPS methods can be used to validate the WLAN solution

WLAN Information in a 911 Call

Source: CSRIC Report on Indoor Location



- LPPe allows for a position to be returned as well, geographic or civic
- SUPL shown here, but LPPe is equally applicable to a control plane solution

Thank You

QUALCOMM Incorporated, 5775 Morehouse Drive, San Diego, CA 92121-1714