9-1-1 Location Technologies: Today and Tomorrow

03/11/2015

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TeleCommunication Systems (TCS)

Topics

- Is 9-1-1 Location Technology Failing Us?
- The Challenge with Call Routing
- The Challenge with Enhanced Location
- The Challenge with Indoor Location
- What Can a PSAP Manager Do?
- Questions

TCS

CALL ROUTING CHALLENGE

Wireless E911 Call Baseline

1: Person dials 9-1-1

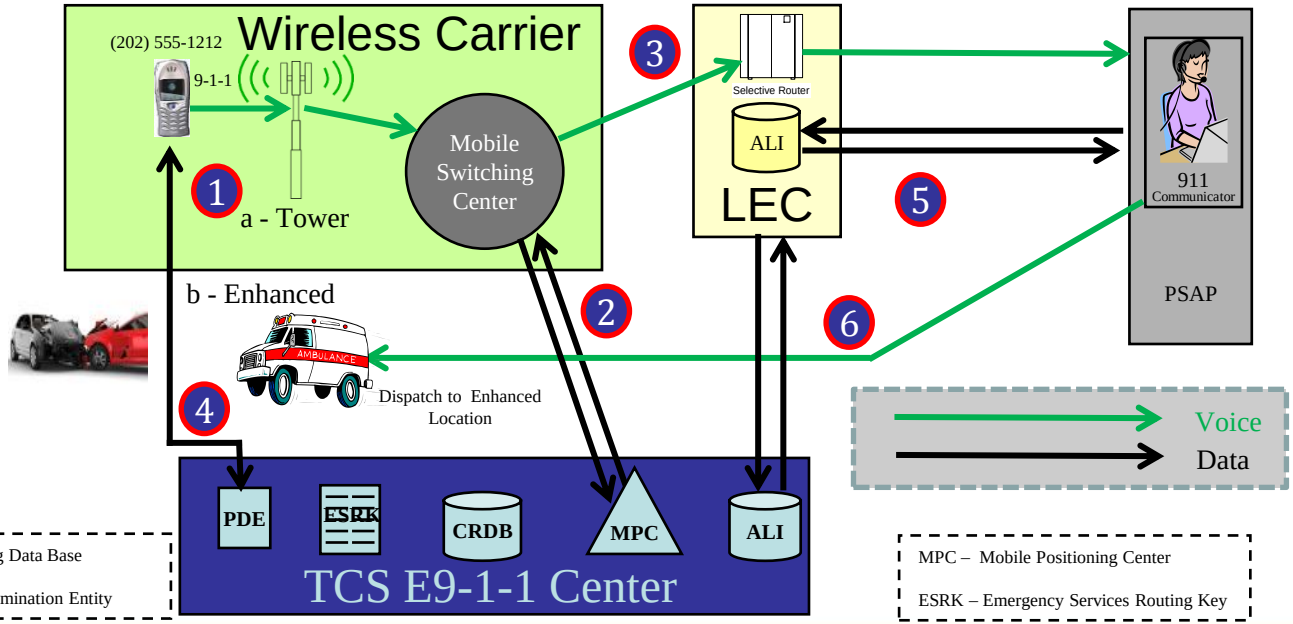
2: MSC requests routing instructions

3: MSC routes call to nearest PSAP

4: E9-1-1 Center gets enhanced location

5: PSAP queries for enhanced location

6: PSAP dispatches assistance

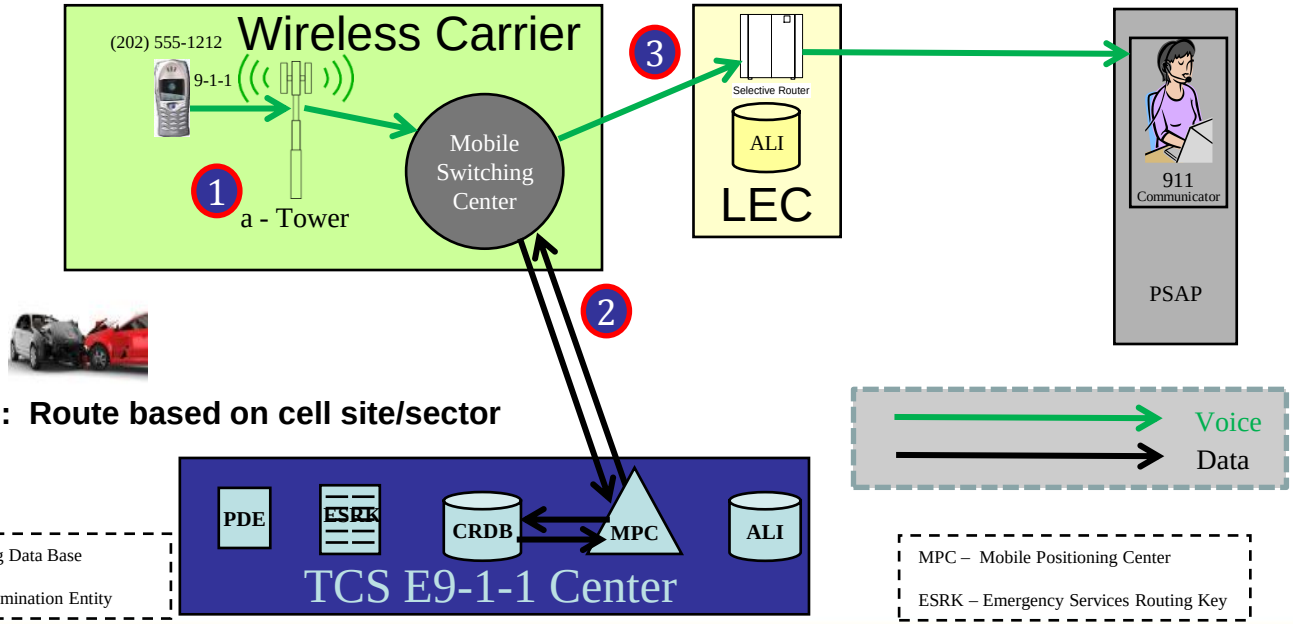


Wireless Call Routing Challenge

1: Person dials 9-1-1

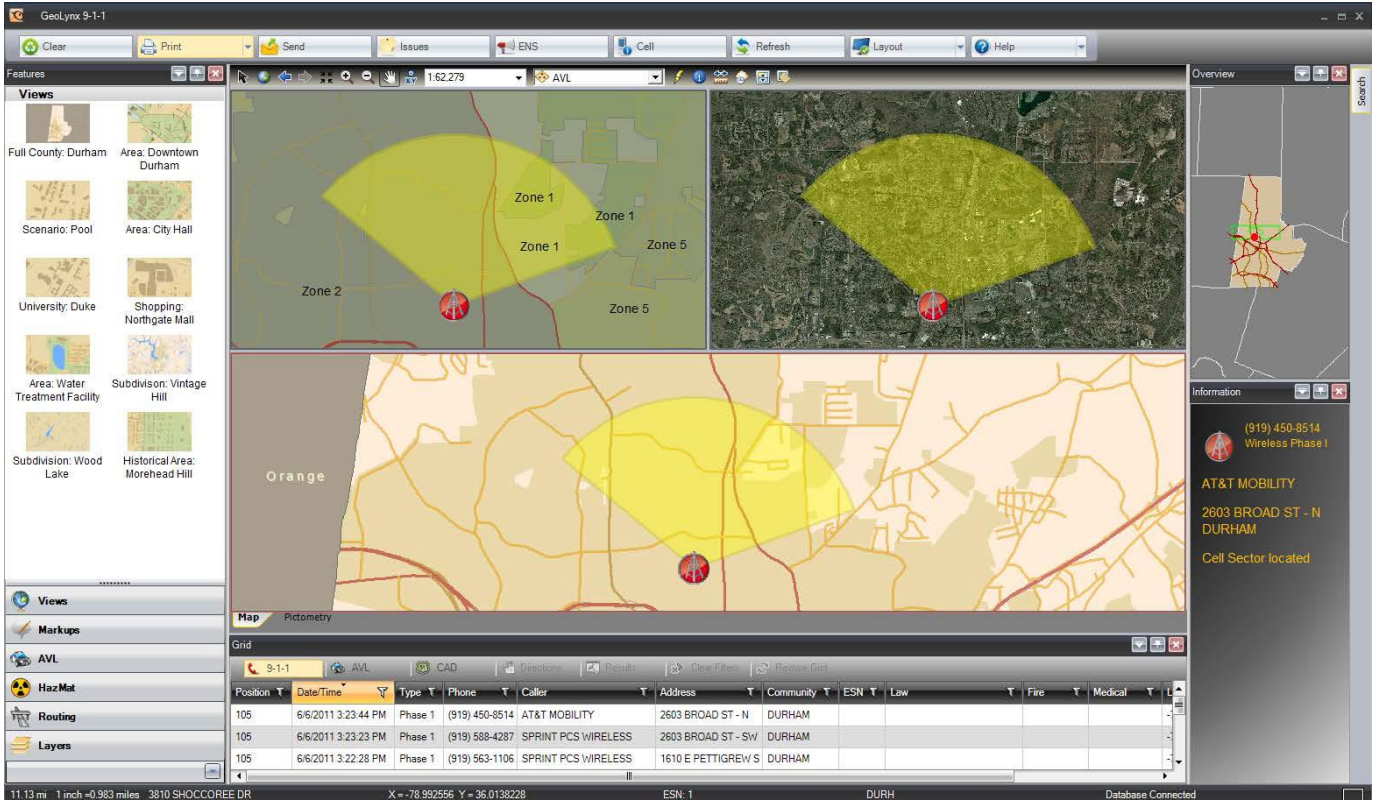
2a: MSC requests routing instructions

3: MSC routes call to nearest PSAP



2b: Route based on cell site/sector

Determining Call Routing



- Cell site plotted
- Cell sector faced
- PSAP boundaries
- Primary PSAP
- Determine route

GeoComm
TCS

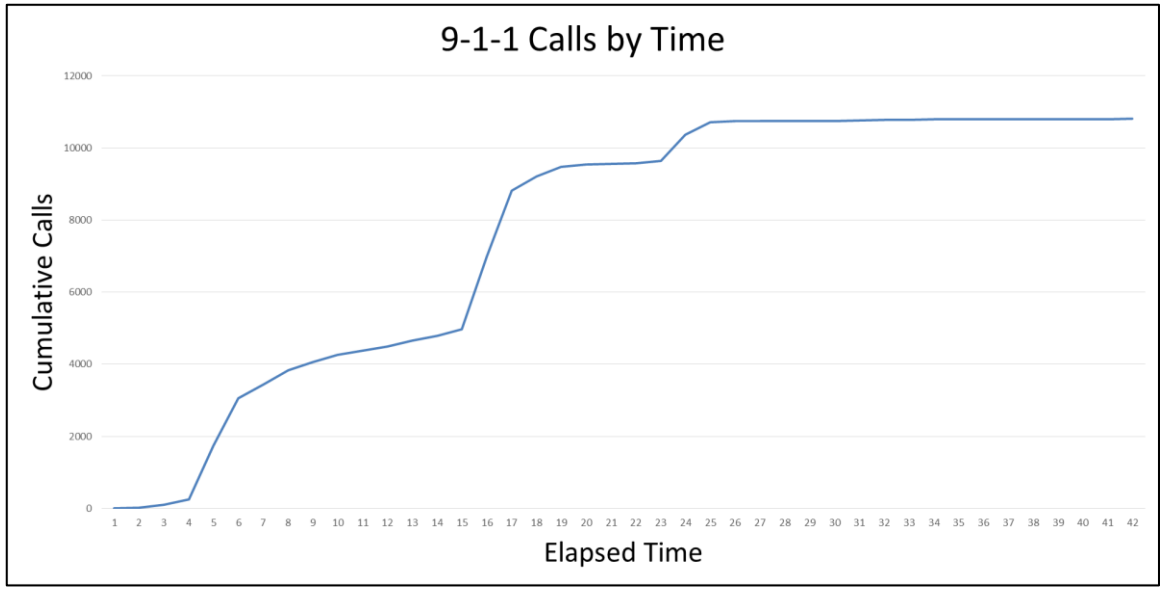
Improving Location Routing

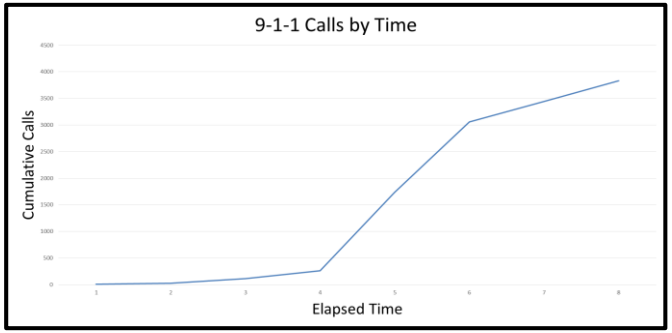
- Today's solutions:
  - CPE Option: Delay the call routing
    - But how long can we afford to wait?

Call Routing Delay

Washington DC
May, 2013
Single carrier

11,585 calls
10,812 bids
6.7% abandoned





Phase II Initial Route:
260 calls in 4 seconds
2.4%

1 second delay: +1474 calls	= 16.0%
2 second delay: +1324 calls	= 28.3%
3 second delay: +384 calls	= 31.8%
4 second delay: +387 calls	= 35.4%

Delay <u>not enough!</u>

Improving Location Routing

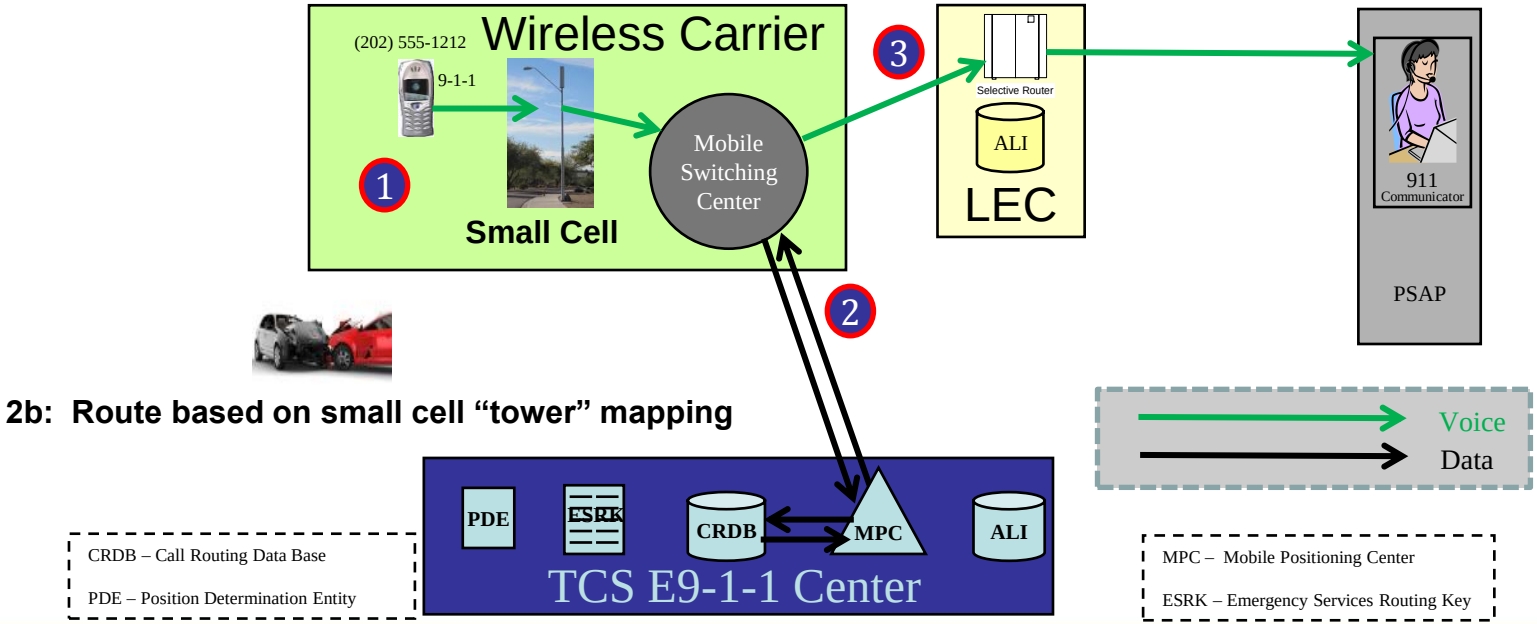
- Today's solutions:
  - CPE Option: Delay the call routing
    - But how long can we afford to wait?
  - Wireless Infrastructure Option: Faster CRDB lookup
    - Small cells

Small Cell – Just Another Tower

1: Person dials 9-1-1

2a: MSC requests routing instructions

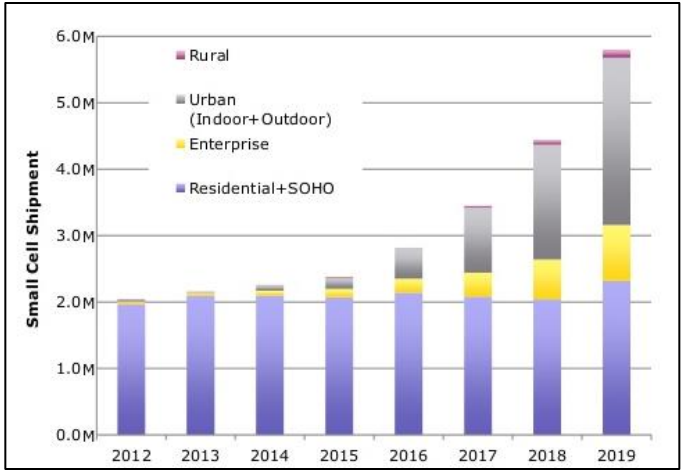
3: MSC routes call to nearest PSAP



2b: Route based on small cell "tower" mapping

Strong Small Cell Growth

Overall, the Macquarie analysts estimated that there are about 40,000 small cells deployed in the United States today. *FierceWireless 1/13/15*



Small Cell Forum 12/14

AT&T has committed to deploying more than 40,000 low-power small cells by the end of 2015 as part of Project Velocity IP (VIP), a multibillion-dollar overhaul program for both its wireless and wired networks. *FierceWireless 12/19/13*

Verizon is putting aside $500 million for network densification, led by small cells, in certain markets, the carrier's CFO said Tuesday. *LightReading 2/17/15*

Sprint is preparing to add small cells to its network to expand the reach of its LTE service, and that effort will most likely cost the carrier around $500 million per year…. *FierceWireless 1/13/15*

Improving Location Routing

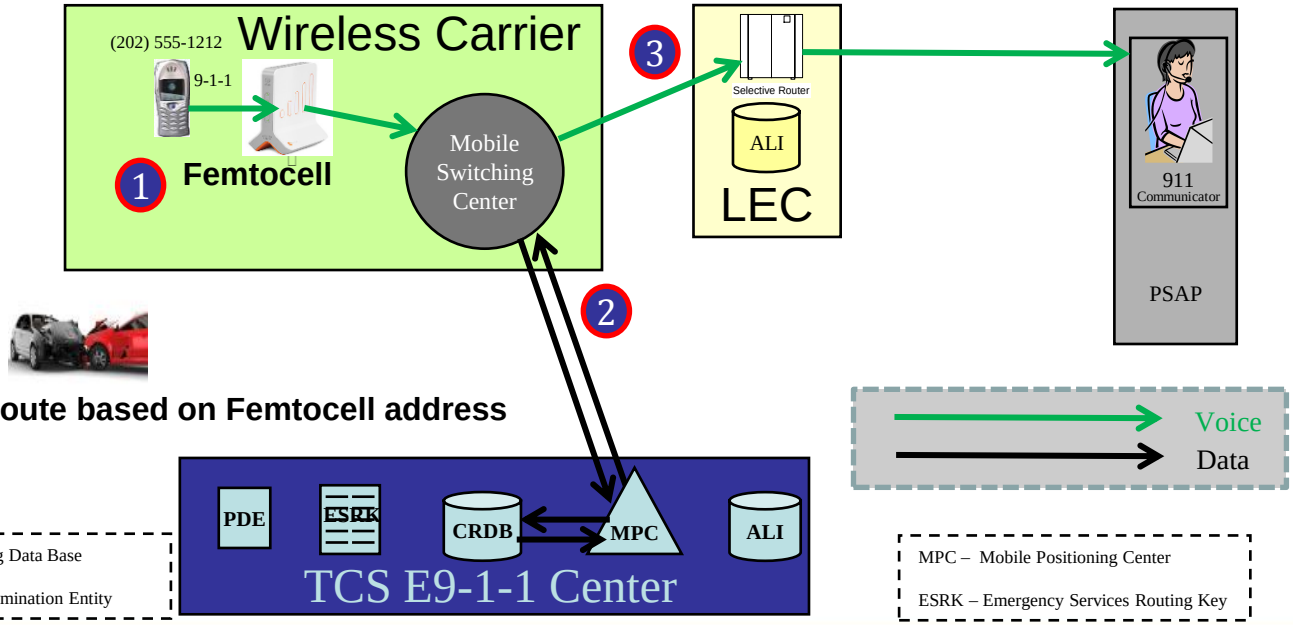
- Today's solutions:
  - CPE Option: Delay the call routing
    - But how long can we afford to wait?
  - Wireless Infrastructure Option: Faster CRDB lookup
    - Small cells
- Tomorrow's solutions:
  - Femtocells

Femtocells – A VoIP Call Model

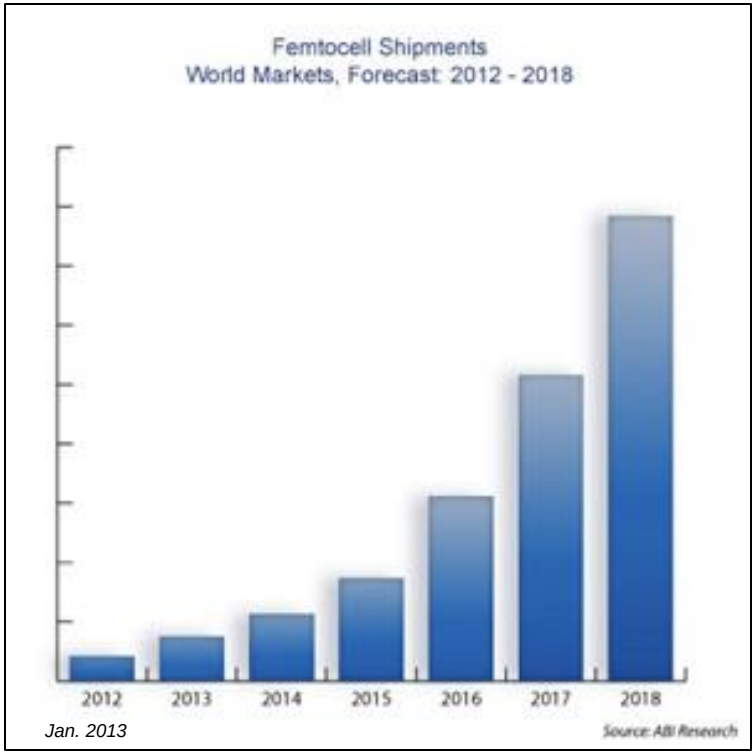
1: Person dials 9-1-1

2a: MSC requests routing instructions

3: MSC routes call to nearest PSAP



Strong Femtocell Growth



- Femtocells for home use
- Support specific users
- Generally located via GPS
- Typically associated with cell tower

- Dispatchable location possible
  - Follow VoIP registration process

Improving Location Routing

- Today's solutions:
  - CPE Option: Delay the call routing
    - But how long can we afford to wait?
  - Wireless Infrastructure Option: Faster CRDB lookup
    - Small cells
- Tomorrow's solutions:
  - Femtocells
  - Indoor location techniques…

ENHANCED LOCATION CHALLENGE

Wireless Location Challenge

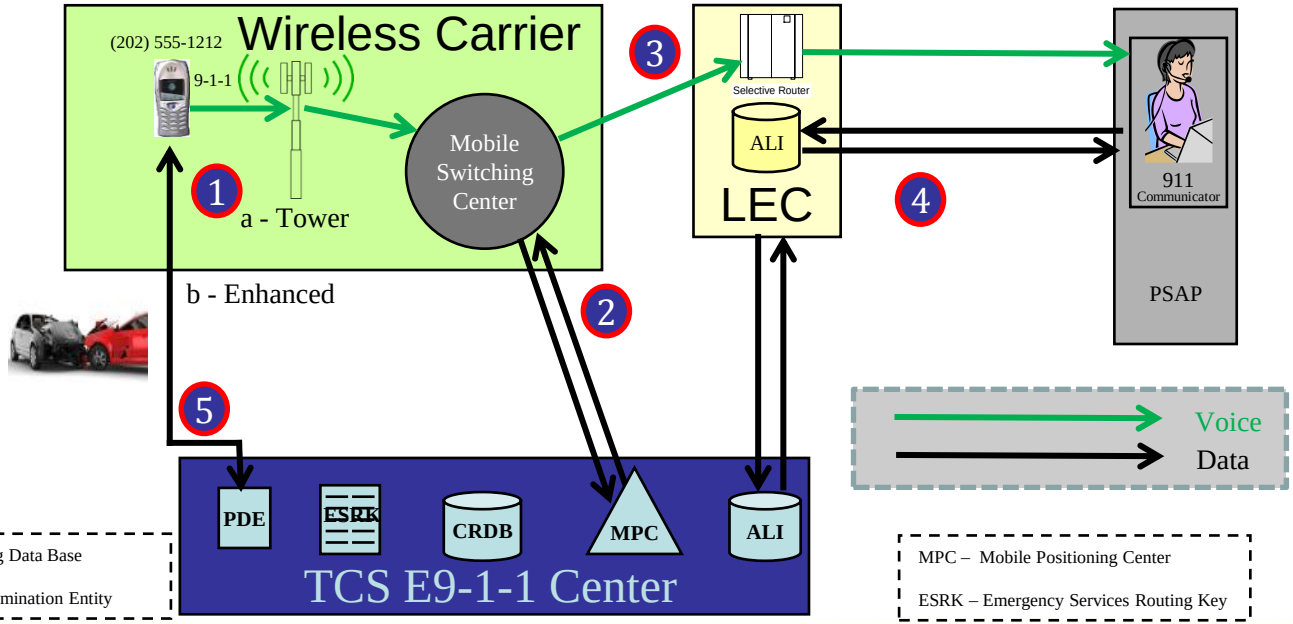
1: Person dials 9-1-1

2: MSC requests routing instructions

3: MSC routes call to nearest PSAP

4: PSAP queries for enhanced location

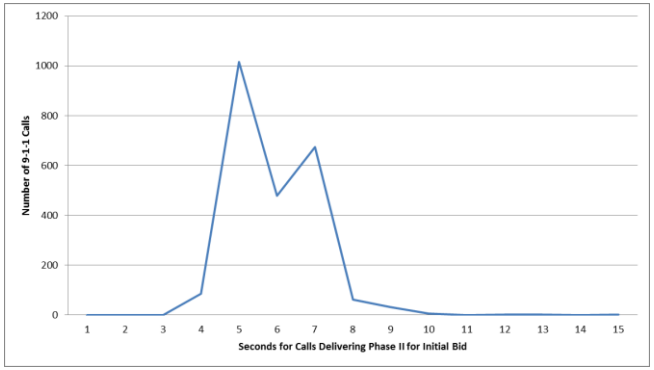
5: E9-1-1 Center gets enhanced location



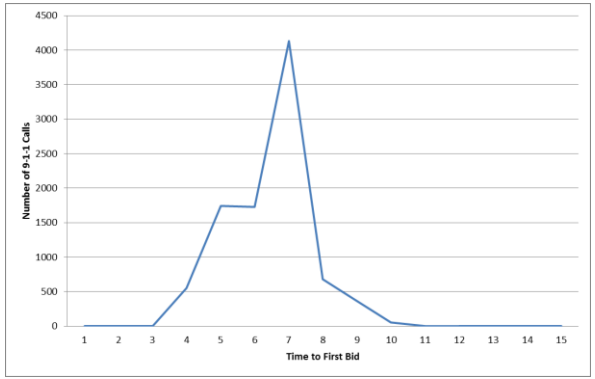
Initial Bid Timing vs. Location Fix

Washington DC
May, 2013
Single carrier

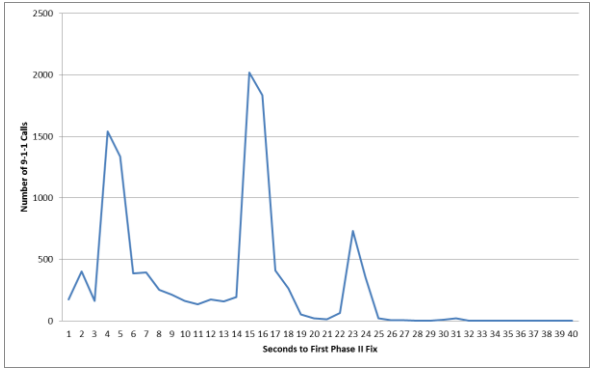
11,585 calls
10,812 bids
6.7% abandoned



Initial Bid generally <8 sec



…but location fixes can take up to 24 seconds



Phase II Initial Bids: 2386
22.1%

1 second delay: +283 calls	= 24.7%
2 second delay: +304 calls	= 27.5%
3 second delay: +134 calls	= 28.7%
4 second delay: +125 calls	= 29.9%

Delay <u>not</u> helpful!

Improving Enhanced Location

- Today's solutions:
  - CPE options
    - Re-bidding

Importance of Location Rebids

- Rebidding often is not done
  - Washington DC: 1.8% (191 of 10,811 calls)
  - CalNENA policy not to re-bid: 2006 thru 2014
  - Dispatch info sometimes overwritten by re-bids

On initial bid

75.4%	Phase I
0.7%	Poor Phase II
21.8%	Phase II A-GPS
2.1%	Phase II AFLT

After 30 seconds:
10,794 of 10,811 calls = 99.8%

11.1%	Phase I	
1.7%	Poor Phase II	
73.2%	Phase II A-GPS	87.1%
13.9%	Phase II AFLT	

Improving Enhanced Location

- Today's solutions:
  - CPE options
    - Re-bidding
  - Wireless Infrastructure Option: Faster enhanced location techniques
    - Improved A-GPS

A-GPS Is Improving

- Adding GLONASS improves accuracy and timing

Using dual GPS/GLONASS receivers and antennas **accelerates the time to first fix**, and the M2M device may have as many as twice the satellites at its disposal for determining location.
http://electronicdesign.com/test-amp-measurement/real-world-drive-tests-declare-verdict-gpsglonass

In 24 hours

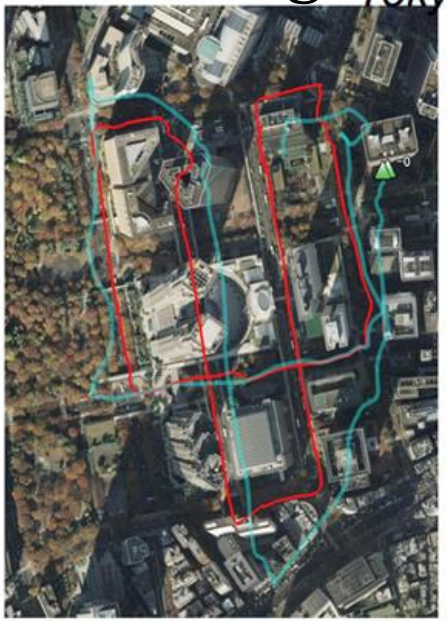
2.5x better

Horizontal Dilution of Precision

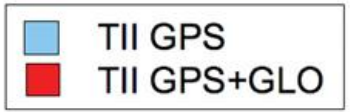
Constellation	GPS	GPS + Glonass
Visible Satellite*	4.4	7.8
No Fix	380 minutes	Never
HDOP*	5.3	2.1
Error*	x meter	(x* 0.4) meter

http://gpsworld.com/gnss-systemreceiver-designconsumer-gpsglonass-12359/

Tokyo



Teseo II single-chip GPS receivers

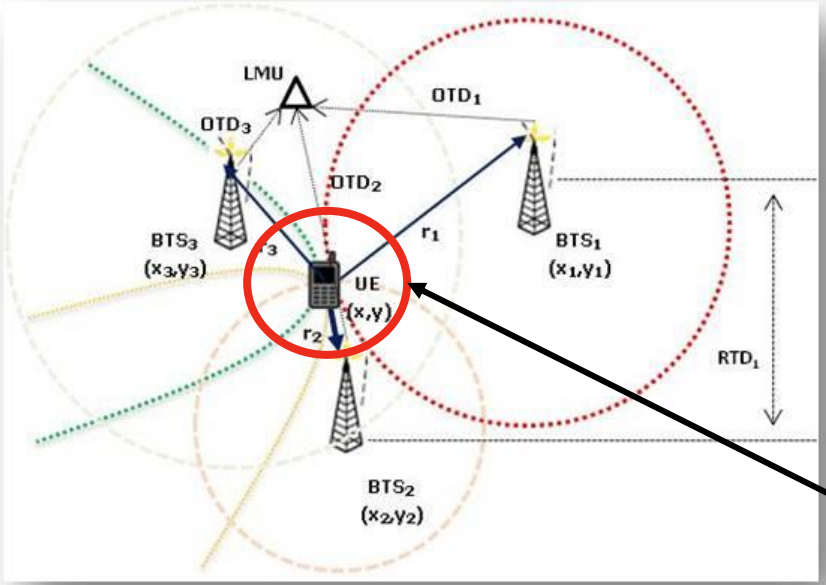


Improving Enhanced Location

- Today's solutions:
  - CPE options
    - Re-bidding
  - Wireless Infrastructure Option: Faster enhanced location techniques
    - Improved A-GPS
- Tomorrow's solutions:
  - Observed Time Difference of Arrival (OTDOA)

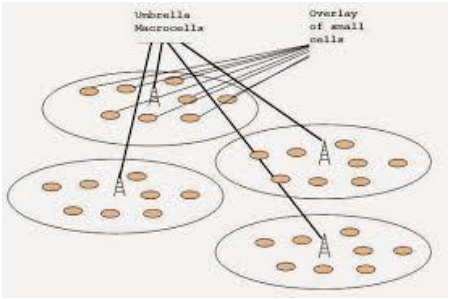
OTDOA – Part of LTE

Observed Time Difference of Arrival



Part of LTE standard

3GPP Release 9+



Macro cells coordinate a dense group of small cells

Reasonable location accuracy from close small cell proximity

Location accuracy determined by propagation errors

Improving Enhanced Location

- Today's solutions:
  - CPE options
    - Re-bidding
  - Wireless Infrastructure Option: Faster enhanced location techniques
    - Improved A-GPS
- Tomorrow's solutions:
  - Observed Time Difference of Arrival (OTDOA)
  - NG9-1-1

NG9-1-1: Push Rather Than Pull

NG9-1-1 brings two benefits to improving location

- Location data is pushed rather than pulled
  - No need for re-bid strategy
  - Location information can be presented as it becomes available

- Multiple location elements can be sent – courtesy of PIDF-LO
  - A-GPS fix
  - OTDOA fix
  - Street address from indoor location techniques
  - Billing/work addresses

Presence Information Data Format - Location Object

Improving Enhanced Location

- Today's solutions:
  - CPE options
    - Re-bidding
  - Wireless Infrastructure Option: Faster enhanced location techniques
    - Improved A-GPS
- Tomorrow's solutions:
  - OTDOA
  - NG9-1-1
  - Indoor location techniques….

INDOOR LOCATION CHALLENGE

Indoor Location Challenge

1: Person dials 9-1-1 from indoors

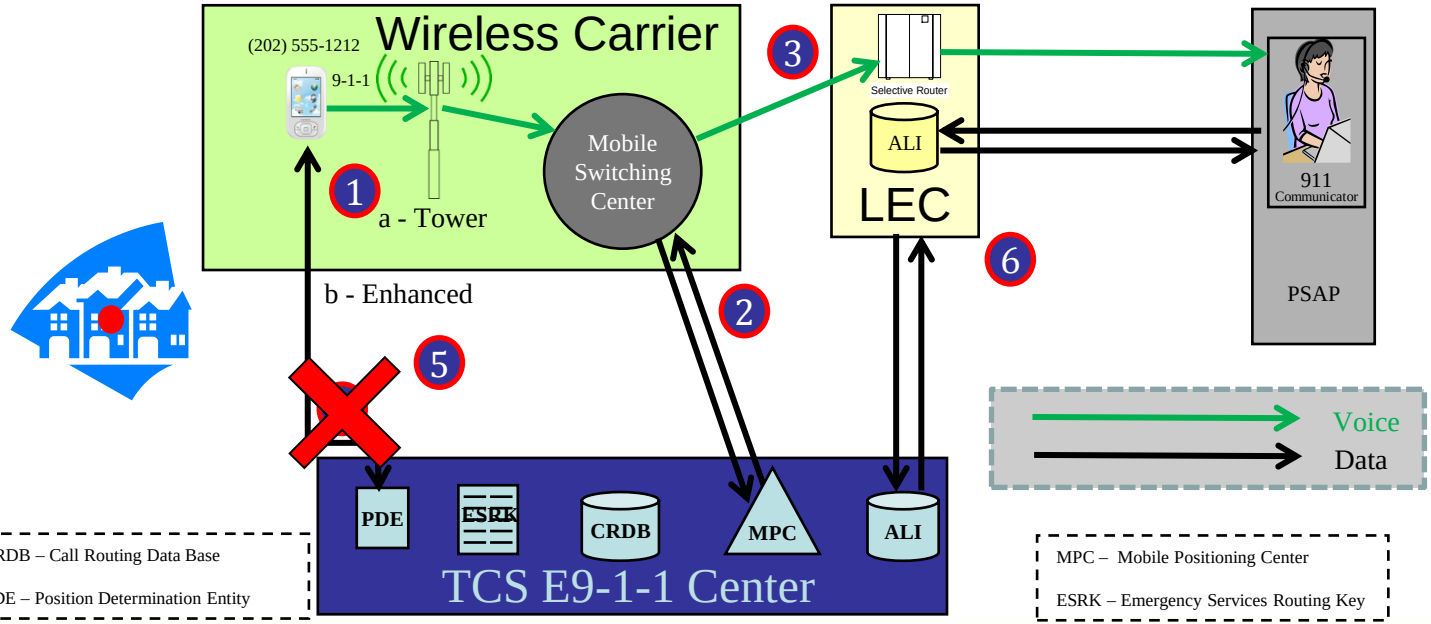
2: MSC requests routing instructions

3: MSC routes call to nearest PSAP

4: E9-1-1 Center gets enhanced location

5: A-GPS location technique is blocked in some indoor settings

6: PSAP queries for enhanced location – but only gets Phase I



Indoor Location Challenge

- Is there an Indoor Location problem?

Indoor Location Problem?

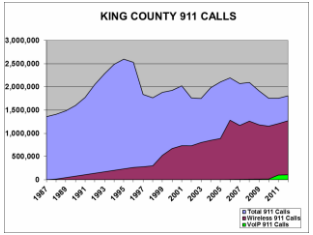
- Evidence of a Problem
  - Statistics tell a story
  - Analyzing real-world 9-1-1 data
  - Long-term 9-1-1 data comparison
  - 9-1-1 data trending
  - Comparing urban/suburban to dense urban

Statistics Tell a Story

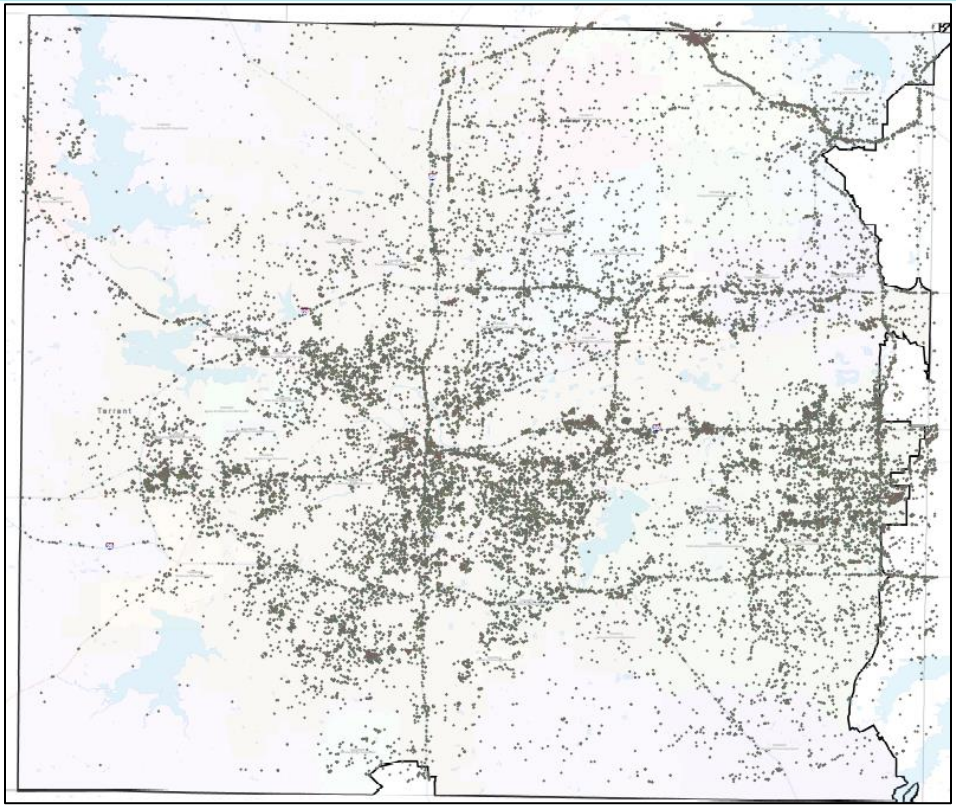
We "should" have an Indoor Location challenge

- 40% of US population has "cut the cord"
  - 2013 CDC study (37% of adults; 45% of children)
  - http://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless201306.pdf

- 70% of 9-1-1 calls come from wireless
  - 2012 King County, WA statistic



Real-world 9-1-1 Call Analysis



- Actual 911 calls
- Tarrant County
- All carriers
- August, 2013

Color-code X/Y locations (using HUNC)

Brown = Phase I only
Green = meets stricter requirement.
Red = misses looser requirement.
Yellow = between strict/loose

Which are Indoors?
Which are Outdoors?

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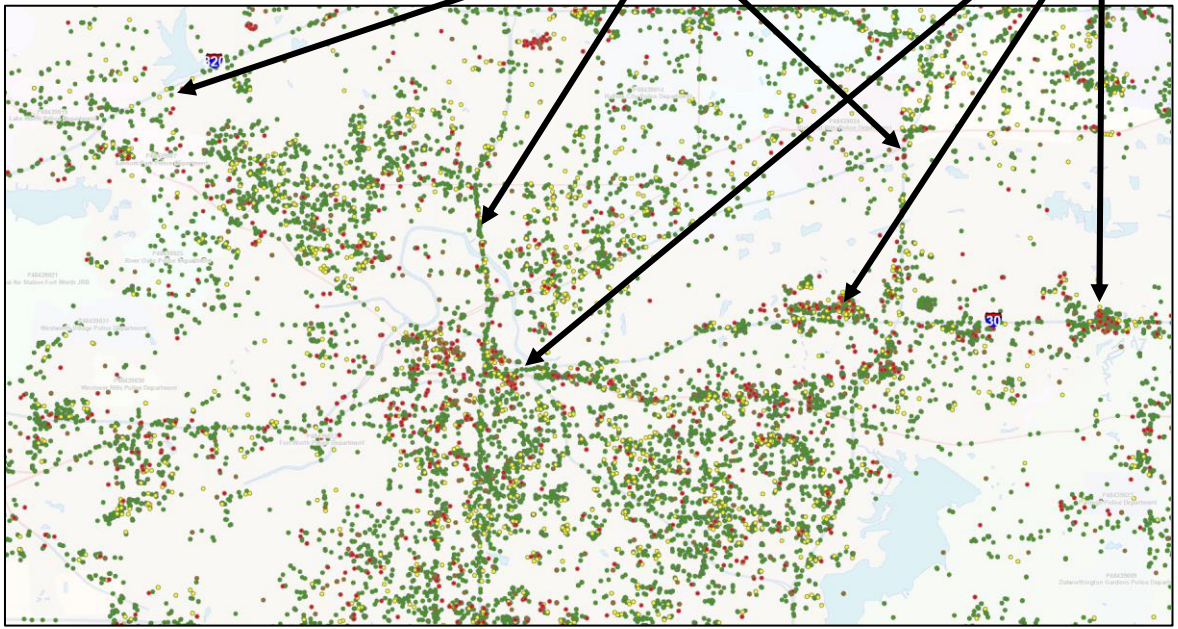
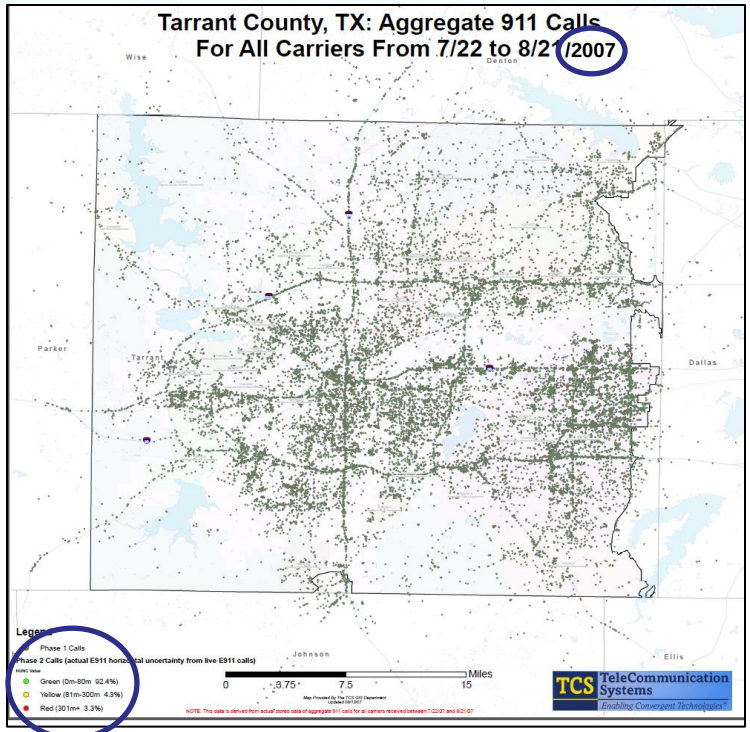
Uncertainty Tells a Story

- Uncertainty/Accuracy correlates
  - Can draw roadways
- Uncertainty error clusters

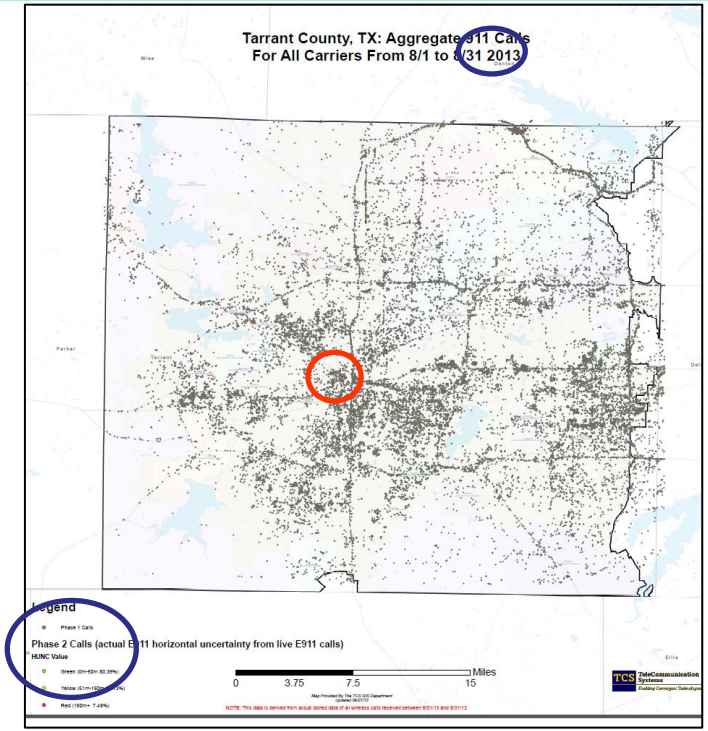


Tarrant County, TX – Multiple wireless carriers – August, 2013 data

Uncertainty Error Clusters



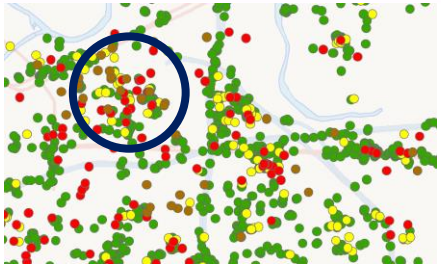
3.3% exceeded Phase II upper bound (red)

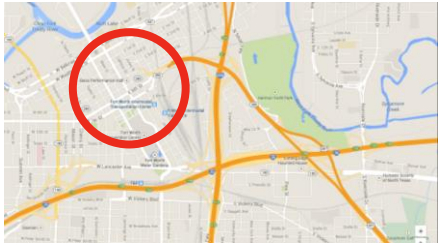


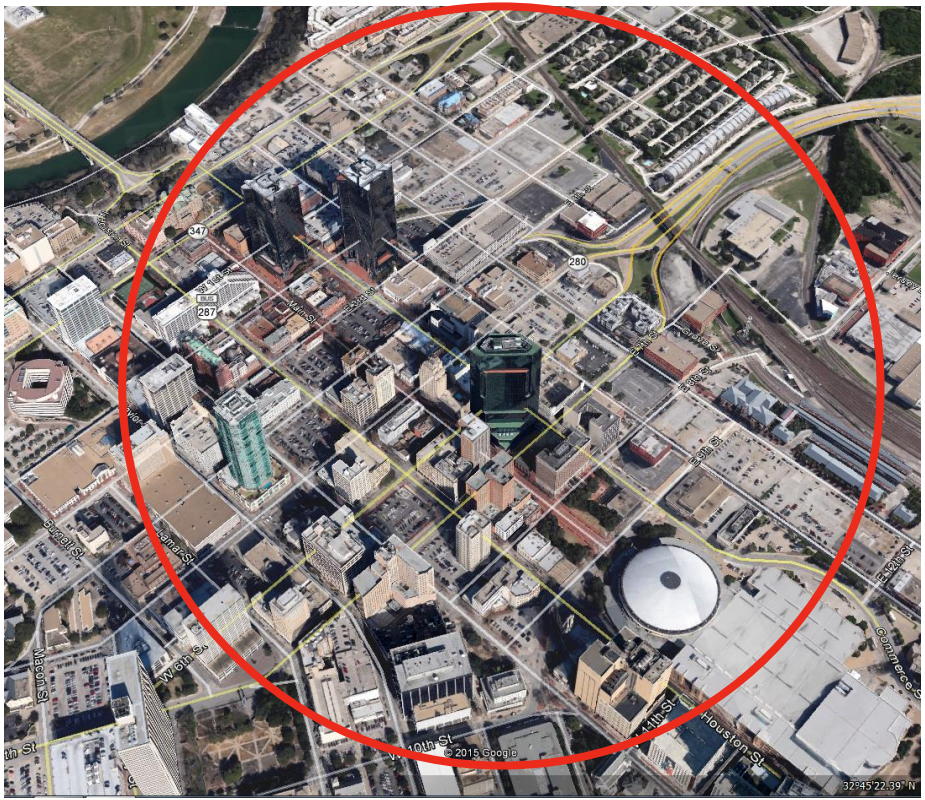
7.5% exceeded Phase II upper bound (red)

3.3% → 7.5%
(more calls from indoor locations?)

The Maps Tell a Story

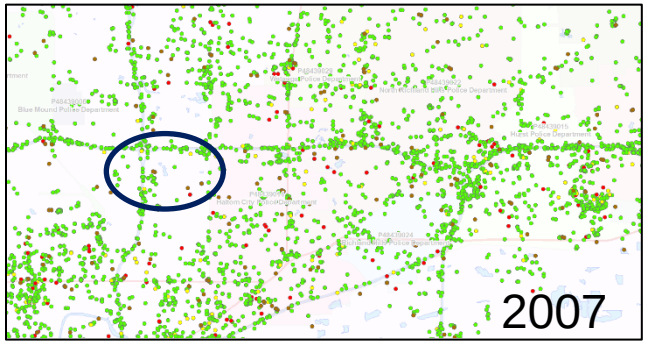




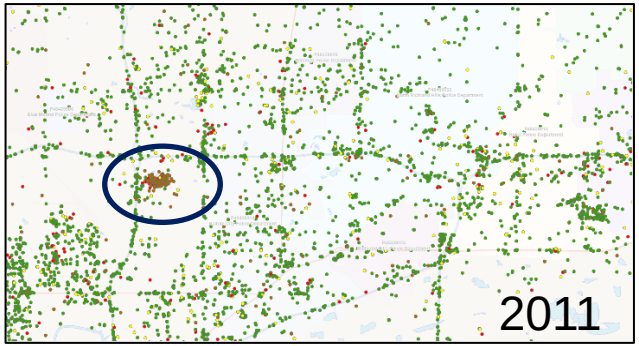


Tarrant County, TX
9-1-1 Calls –
August, 2013

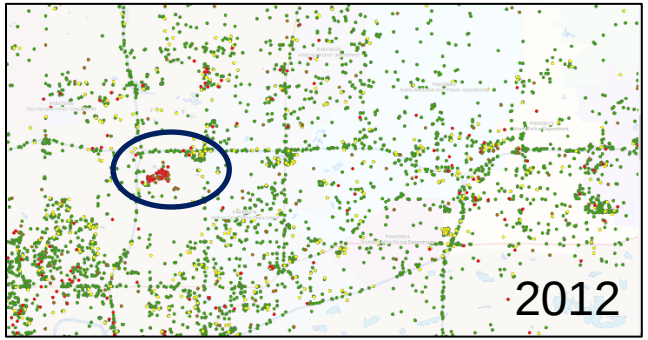
Data Trends Tell a Story



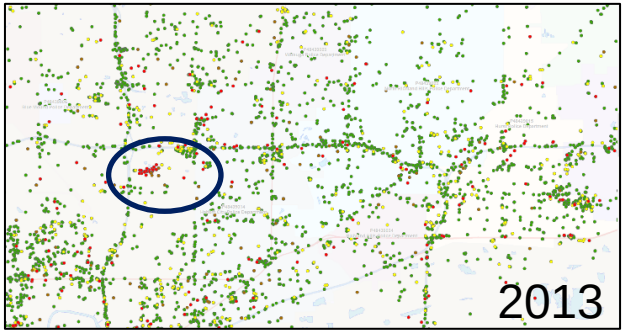
Nonexistent in 2007



Major problem area in 2011



Improved in 2012



Greatly improved in 2013

Problem area seen in 2011

Goodrich Warehouse
Built in 2007

Dense Urban Tells a Story

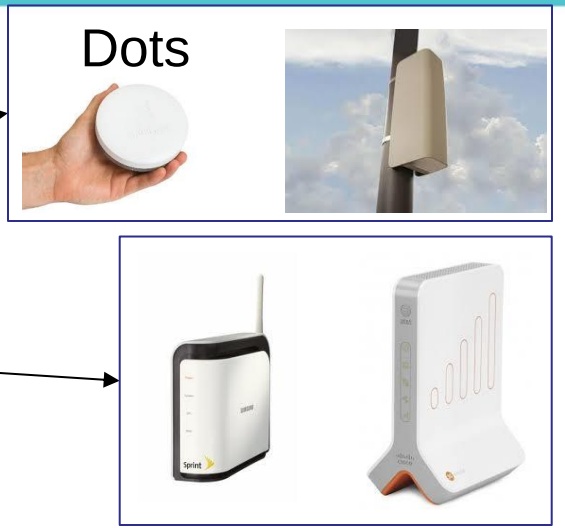
- Baltimore 9-1-1 calls (Nov, 2014)
- Tarrant County 9-1-1 calls (Aug, 2013)

	Tarrant County	Baltimore
HUNC <= 50m	80.4%	45.3%
HUNC 50m<-->150m	12.1%	11.2%
HUNC > 150m	7.5%	43.5%
Total	100.0%	100.0%

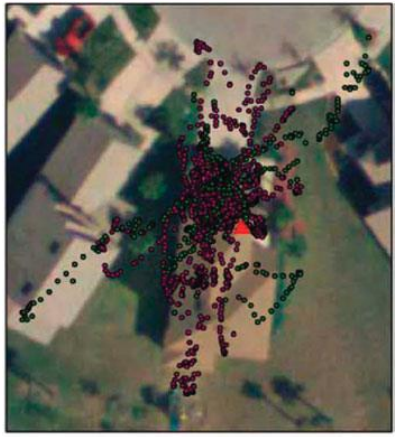
HUNC is a distance/range calculated by the Location Engine
Determines the range of location "error" based on Confidence value
Confidence (90%) expresses likelihood to find device within HUNC range

Indoor Location Challenge

- Is there an Indoor Location problem?
- Today's Solutions:
  - Small cells
  - Femtocells
  - Using A-GPS (yes, it can work indoors)



A-GPS Even Works Indoors



Legend

- True Location
- Motorola
- Sanyo

0 10 20 40 60 80 Meters

0 5 10 20 30 Meters

NO. 3 POSITIONAL ACCURACY OF ASSISTED GPS 395

Table 3. Horizontal error statistics for static indoor tests.

Unit Type	GPS Type	Sample Size	% GS Fixes	Horizontal Error Statistics (meters)						
				Min	Max	Avg	50th	68th	95th	RMSE
Motorola	Assisted	478	99·8	0·74	90·69	15·16	9·78	15·15	47·90	21·64
Sanyo	Assisted	1513	99·9	0·16	32·04	8·78	6·23	9·33	24·44	11·33
Garmin	Autonomous	319	17·7	0·41	23·22	9·11	7·62	10·03	20·86	10·61
Juno	Autonomous	1800	100·0	0·35	18·94	5·10	4·02	5·64	12·86	6·16

Royal Institute of Navigation
The Journal of Navigation
July, 2011 Vol. 64 No. 3
pp. 381-399

In the **static indoor test**, mobile phones and GPS units were placed in very close proximity on top of a regular wooden desk on the **second floor of a two-story residential structure**. The second floor of the structure consisted of a **wood frame with cement stucco** while the **roof consisted of a wood frame with asphalt shingles**. While GPS signal reception within this structure is possible (even without using a high-sensitivity chipset), the reception was severely affected by the building materials, resulting in lower expected accuracy.

More Satellites = Better Indoors

- GLONASS - Deployed now
  - Russian ownership
  - Full global coverage
  - 21+3 satellites
  - 4-7m horizontal; 10-15m vertical precision

- Galileo – Deploying
  - European Union ownership
  - Full global coverage
  - 4 satellites now; 27+3 by 2019
  - 4m horizontal; 8m vertical precision (paid)

- Beidou – Deploying (COMPASS)
  - Chinese ownership
  - Regional, expanding to global coverage
  - 30+5 satellites
  - 25m horizontal; 30m vertical precision

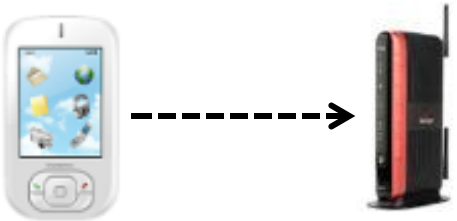
Combining satellite systems is expected to double precision

Indoor Location Challenge

- Is there an Indoor Location problem?
- Today's Solutions:
  - Small cells
  - Femtocells
  - Using A-GPS (yes, it can work indoors)
- Tomorrow's Solutions:
  - Wi-Fi®
  - Bluetooth®

Wi-Fi Location Techniques

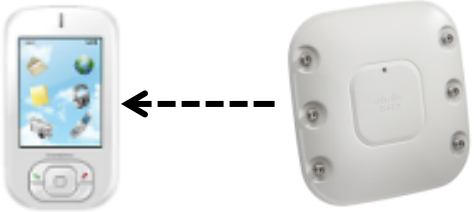
- Smartphone locates nearest Wi-Fi Access Point



Smartphone detects Wi-Fi AP

- AP presents its MAC ID
- Smartphone measure signal strength
- Smartphone presents info to location server

- Nearest Wi-Fi Access Point locates nearby smartphone

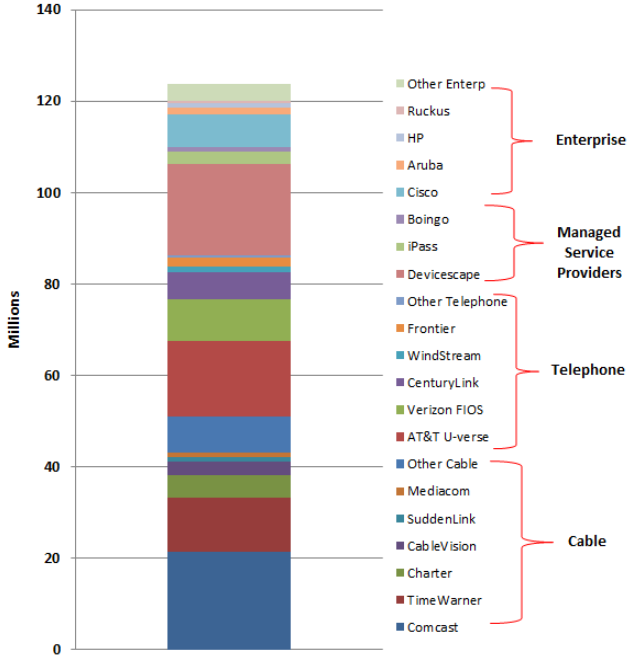


Wi-Fi AP detects smartphone

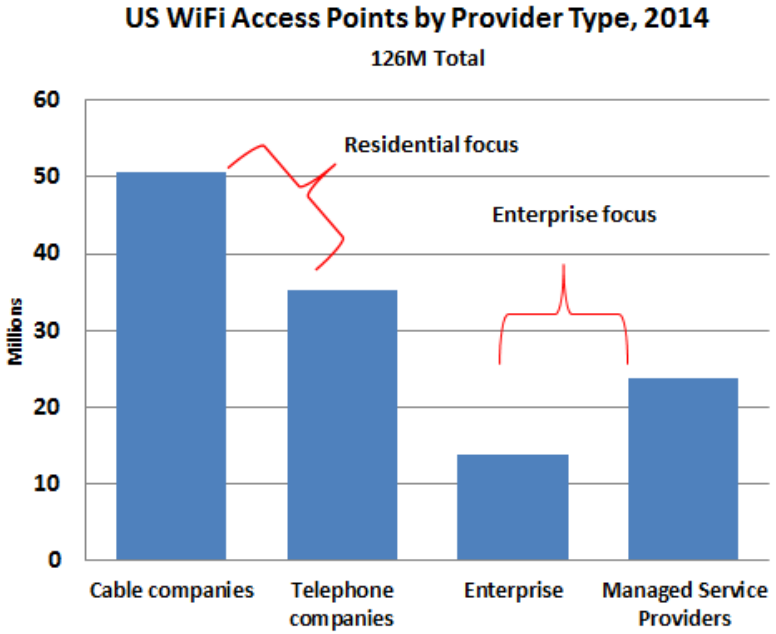
- Smartphone presents its MAC ID
- AP measure signal strength
- Multiple APs can triangulate the smartphone
- AP system presents info to location server

Wi-Fi Availability in the U.S.

There are over 126M WiFi Access Points in the US from identifiable residential and enterprise providers. Approximately 86M are deployed in residences and 40M in enterprises/public access areas.

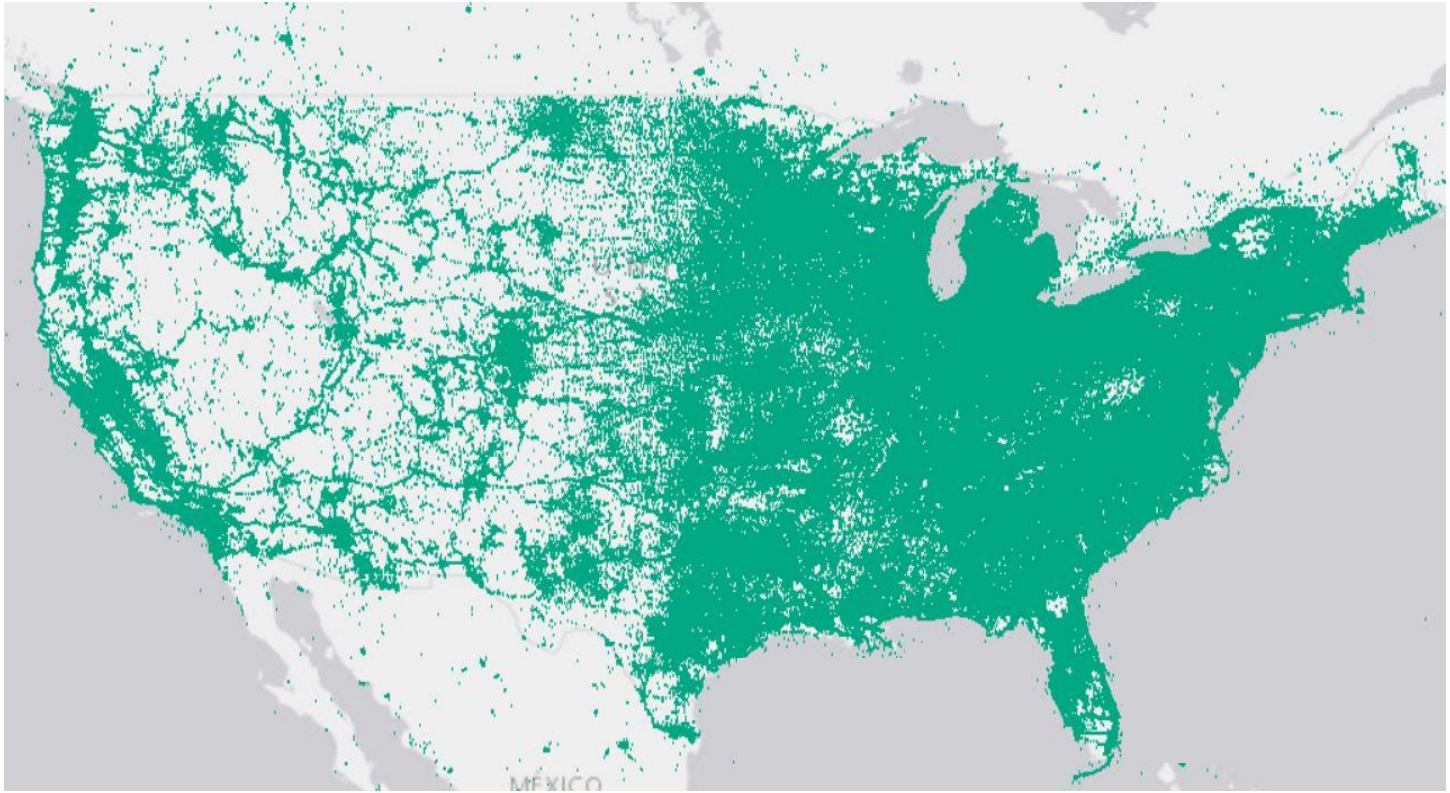


Wi-Fi Access Points by Provider, 2014



Source: company information and ABI Research, 2014

TCS Wi-Fi Access Point Database



149M Access Points

Wi-Fi coverage exists
And it Maps to population

TCS

Wi-Fi Put to the Test

Actual 9-1-1 call
Actual Wi-Fi data

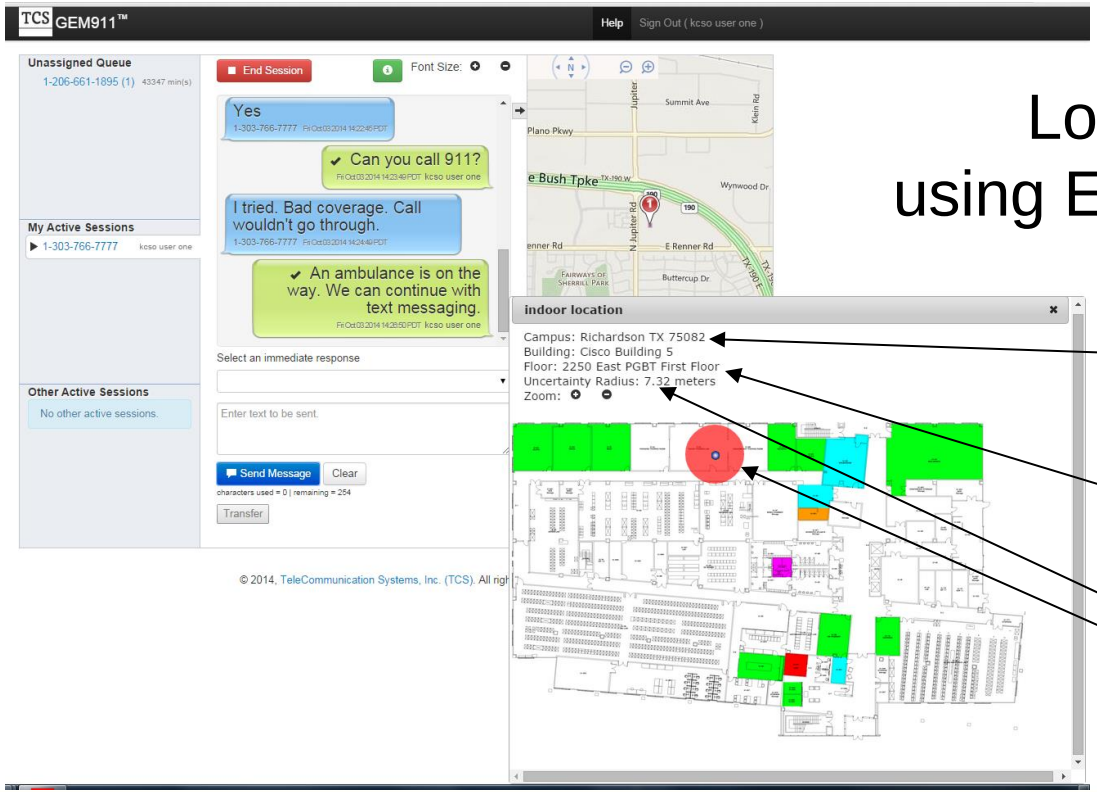
Wi-Fi hotspots in TCS probe database

50m radius

Baltimore 911 call

TCS

Enterprise Wi-Fi Location



Locating Wi-Fi device using Enterprise Access Points

Street address

Floor number

Uncertainty radius

ENTERPRISE WI-FI DEMO

WHAT CAN A PSAP MANAGER DO?

What Can a PSAP Manager Do?

- To help with call routing:
  - Pay attention to boundaries
  - Track call transfers – if too many, change boundaries
- To help with caller location:
  - Determine a rebid policy/strategy for your center
  - Get data; look for error clusters; encourage small cell use
- To help with Indoor Location:
  - Help get addresses in the NEAD (National Emergency Address Database)
- Get GIS maps for neighboring counties!

TCS

Questions?

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