



9-1-1 Location Technologies: Today and Tomorrow 03/11/2015

Tim Lorello TeleCommunication Systems (TCS)





- 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





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

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- 2a: MSC requests routing instructions
- 3: MSC routes call to nearest PSAP





Determining Call Routing



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Improving Location Routing

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





Call Routing Delay



March 10-11, 2015 • Dallas, TX



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

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- 2a: MSC requests routing instructions
- 3: MSC routes call to nearest PSAP





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 multibilliondollar 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



Emerging Technology Forum 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 Tokyo

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



http://gpsworld.com/gnss-systemreceiverdesignconsumer-gpsglonass-12359/

Teseo II single-chip GPS receivers



TII GPS+GLO





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





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

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- 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







We "should" have an Indoor Location challenge

- 40% of US population has "cut the cord"
 - 2013 CDC study (37% of adults; 45% of children)
 - <u>http://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless20130</u>
 <u>6.pdf</u>
- 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?





Uncertainty Tells a Story





Uncertainty Error Clusters



 $3.3\% \rightarrow 7.5\%$ (more calls from indoor locations?)





The Maps Tell a Story





Data Trends Tell a Story



Nonexistent in 2007



Major problem area in 2011

Problem area seen in 2011





Improved in 2012



Greatly improved in 2013

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)







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A-GPS Even Works Indoors



Legend

True Location

Motorola

Sanyo

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

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- 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

TCS



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.



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Emerging Technology Forum TCS Wi-Fi Access Point Database



149M Access Points

Wi-Fi coverage exists And it Maps to population





Wi-Fi Put to the Test







Enterprise Wi-Fi Location





ENTERPRISE WI-FI DEMO





WHAT CAN A PSAP MANAGER DO?





• To help with call routing:

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- 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!



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