LOCATION FOR (NG)911

Henning Schulzrinne

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Location is crucial

find correct PSAP

- city-level

dispatch first responders

- meters

FCC location accuracy requirements (47 CFR 20.18)

- Phase I (1998): cell tower + sector only → 1-20 miles
- Phase II (2002): network and/or handset location determination
- Phase II+ (2013): provide confidence and uncertainty
  - “this measurement is within 20 m with 90% certainty”
- Testing only outdoors
  - “drive testing”
  - various exclusions for heavy forestation (< 15% counties)

	67%	90%
Network-based	100 m	300 m
Handset-based	50 m	150 m (80% by 2013, 90% by 2019)

Location types

	Civic	Geo
Example	445 12th Street SW Washington, DC 20554	38.884560 (N), -77.028124 (W)
Nomadic	✔	✔
Mobile	✖	✔
z-axis	room, floor	GPS ~ ± 20m (= multiple floors)
Suitable for dispatch?	✔	after translation
Validation	redundancy plausibility	sometimes

Location requirements

- Accuracy
  - horizontal: identify building or see scene of incident
  - vertical: floor level
- Secure
  - prevent spoofing
- Quick time to fix
  - 10-30s: accurate enough to reach right PSAP
  - 3 min: accurate enough to dispatch first responder
- Cheap
  - per-device cost of < $5?
  - help if it can be re-used for commercial LBS
- Works everywhere
  - indoor (steel beam commercial and stick-built residential) & outdoor
  - urban & rural
  - forested & urban canyons
  - with uninitialized devices

Indoor location

- ~70% of 911 calls are from mobile phones
- ~35% of households are mobile-only
- Indoor location challenging:
  - Need higher accuracy
    - identify building → floor (“z-axis”) → apartment
    - medical & law enforcement (abuse, home invasion) emergencies not obvious
  - Existing technologies limited
    - GPS does not work (except maybe in wood frame buildings)
    - others require new infrastructure or sensors
  - Testing challenging
    - Can’t do drive test

Indoor location

- Broad classes & morphologies
  - dense urban, urban, suburban, rural
  - single/two family residential → GPS *may* work
  - public and semi-public buildings: arenas, airports & malls
  - office buildings → professionally managed
  - MDUs (3+ floors)
  - special cases (parking garages, deep basements, houses of worship, …)
  - see ATIS-0500013 & ATIS-0500011
- CSRIC test (late 2012)
  - 19 buildings, 75 test points
  - 3 location technologies:
    - NextNav: beacons
    - Polaris: RF pattern matching
    - Qualcomm: AGPS & AFLT

CSRIC test: yield

Number of Test Calls and Yield			
Building ID	Total Number of Test Calls Attempted	Total Number of Test Calls with Position Fix Received	Percentage of Test Calls with Fix Received (Yield)
NextNav_All Dense Urban Buildings	5174	4859	93.9%
NextNav_All Urban Buildings	4444	4238	95.4%
NextNav_All Suburban Buildings	3581	3581	100.0%
NextNav_All Rural Buildings	843	820	97.3%
Polaris_All Dense Urban Buildings	5406	5372	99.4%
Polaris_All Urban Buildings	3877	3874	99.9%
Polaris_All Suburban Buildings	3497	3489	99.8%
Polaris_All Rural Buildings	749	726	96.9%
QualComm_All Dense Urban Bldgs	5994	5145	85.8%
QualComm_All Urban Buildings	4776	4338	90.8%
QualComm_All Suburban Buildings	4067	3716	91.4%
QualComm_All Rural Buildings	714	709	99.3%

CSRIC test: accuracy

Horizontal Error Statistics (m)								
Building ID	Total Number of Calls	67th Percentile	90th Percentile	95th Percentile	Average Error	Standard Deviation	Max Error	Min Error
NextNav_All Dense Urban Buildings	4859	57.1	102.4	154.0	57.5	64.9	1059.2	0.6
NextNav_All Urban Buildings	4238	62.8	141.1	196.1	69.5	99.9	4367.2	2.1
NextNav_All Suburban Buildings	3581	28.6	52.9	62.2	27.2	99.7	5854.2	0.4
NextNav_All Rural Buildings	820	28.4	44.9	60.3	70.3	1231.5	35255.9	1.5
Polaris_All Dense Urban Buildings	5372	116.7	400.1	569.3	150.3	193.3	1656.1	2.2
Polaris_All Urban Buildings	3874	198.4	447.8	729.9	203.0	225.9	3131.9	0.4
Polaris_All Suburban Buildings	3489	232.1	420.7	571.4	215.1	161.9	1089.1	8.4
Polaris_All Rural Buildings	726	575.7	3005.1	3072.3	845.6	961.3	5809.2	66.2
Qualcomm_All Dense Urban Bldgs	5145	155.8	267.5	328.1	136.4	94.7	722.5	0.5
Qualcomm_All Urban Buildings	4338	226.8	449.3	507.1	233.9	547.7	18236.7	1.6
Qualcomm_All Suburban Buildings	3716	75.1	204.8	295.7	92.0	173.6	4639.4	0.2
Qualcomm_All Rural Buildings	709	48.5	210.1	312.3	639.9	2999.2	27782.4	1.0

Other location technologies

- WiFi-based (e.g., Skyhook, Google, Apple)
  - only in dense urban and sub-urban environments
  - can be 3-5m accurate with measurements
- IP (network) address
  - only accurate (at best) to DSLAM or headend
- Other technologies: DTV, FM, terrestrial beacons
  - require infrastructure or handset modification
  - may not resolve altitude

Location determination and delivery

- Devices can connect to many different networks ➔
  - Devices need to support *multiple modes*
  - Networks need to support *at least one*
- There is no magic bullet that is
  - universally available
  - accurate (building or room level)
  - does not require carrier cooperation
- W3C location API in every recent web browser

Next steps

- both short & long term goals → foster technology evolution and allow network planning
- Four main issues:
  - “coarse” indoor location (identify *building*)
  - “fine-grained” indoor location (identify *apartment*)
    - may have lower yield and be less secure
  - floor level (“z-axis”)
    - likely separate technology (e.g., barometric pressure, stairs/elevator)
  - testing
    - by technology
    - actual measurement experience

Conclusion

- Accurate indoor location critical as mobile phones replace landlines
  - may be particularly relevant to people with communication-related disabilities
- Short term & long term focus
  - establish goals & expectations soon
  - allow for technology development & infrastructure deployment
    - e.g., barometric pressure sensors, beacons, smoke detectors with