GPS: Mass market user perspective

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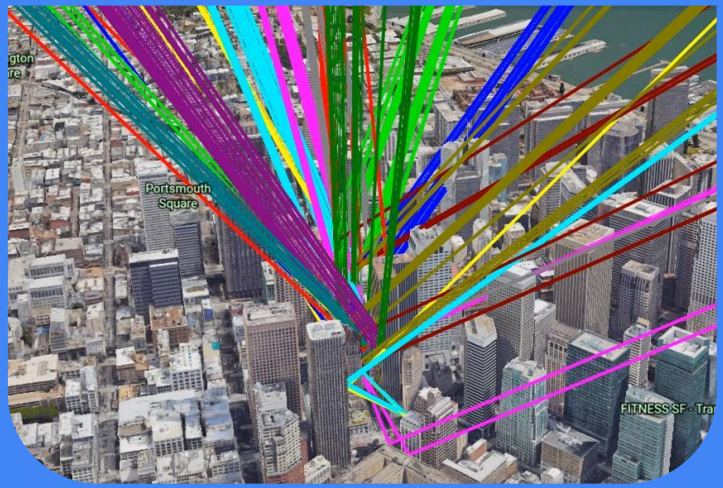
Civil GPS Service Interface Committee, Sep 2022

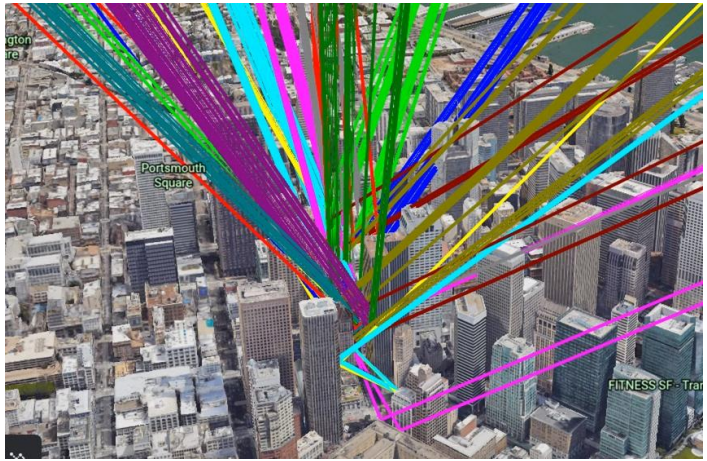
Outline

1. Review of where we are
2. Technical trends
3. Mass market carrier phase DGNSS
4. WiFi RTT
5. Resources for developers
6. Summary

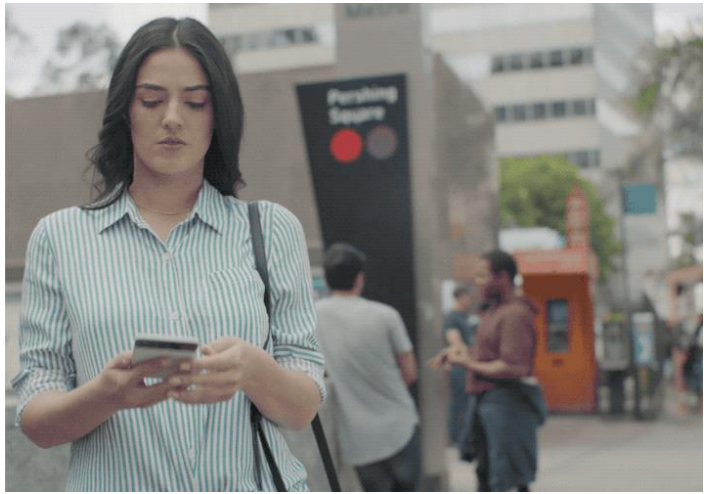


Review of where we are:

- Every smartphone has GNSS, WiFi, Inertial and Pressure sensors
- GNSS-WiFi integration is standard for indoor location
- Emergency Location Service integrated into phones
- 3DMA is standard in Android phones
- Visual positioning and Augmented Reality is standard in Google Maps.



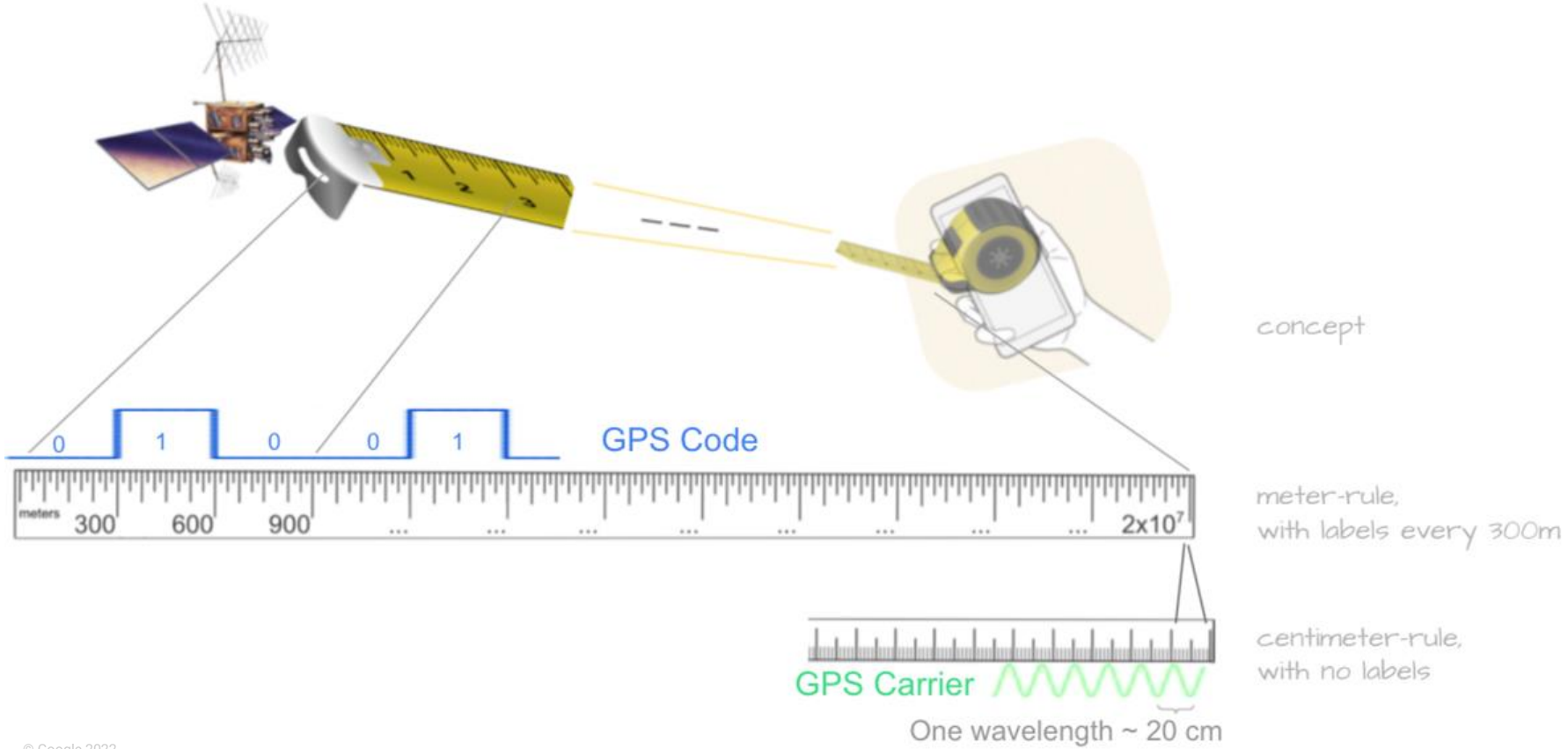
InsideGNSS and Youtube, ION ITM Plenary 2021: Google's use of 3D building models



3DMA: 3D Mapping Assistance, use of 3D models to remove reflection errors

Technical trends in consumer GNSS:

L1,L5; and Carrier Phase measurements.

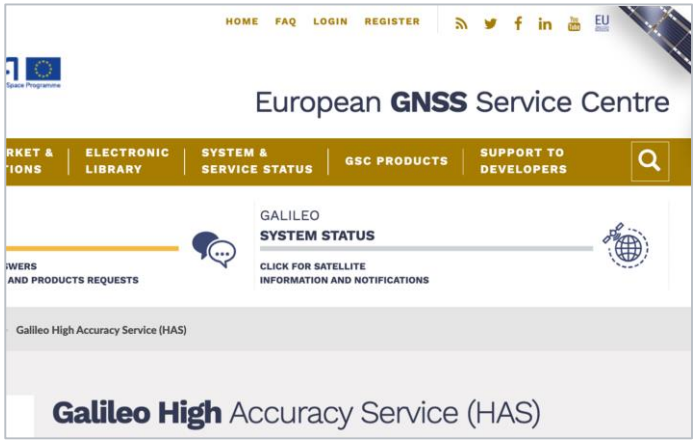


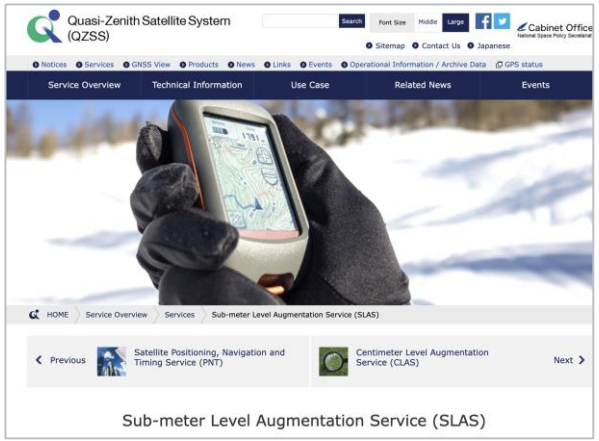
android

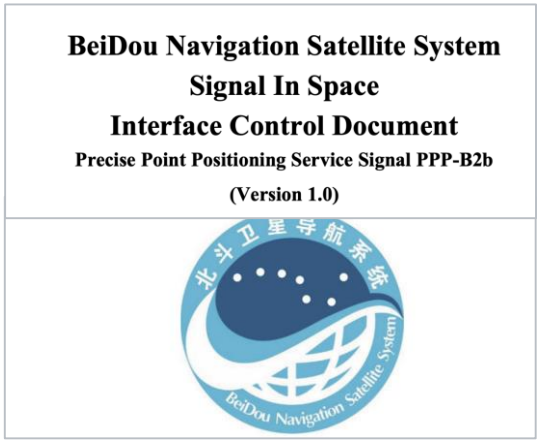
DGNSS for the mass market

Galileo, QZSS, BeiDou: all provide High Accuracy Services in their broadcast signals.

Galileo HAS will also be distributed over the internet.

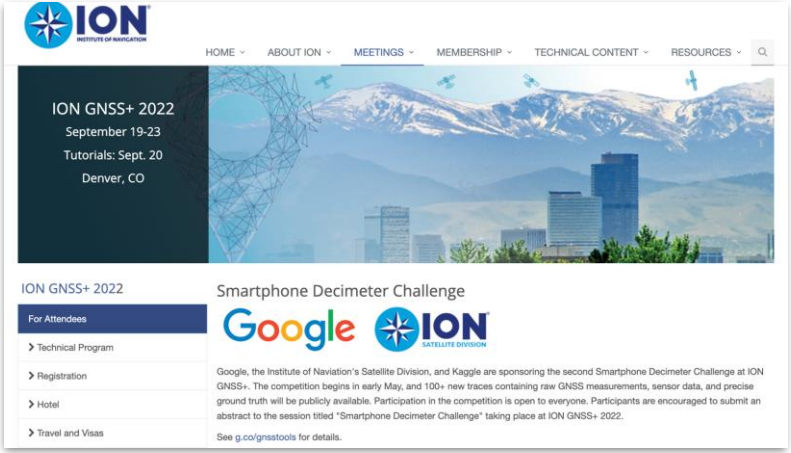






GPS PNT Advisory Board investigating a similar service for GPS

Smartphone Decimeter Challenge (SDC)



Summary:
submeter accuracy (median) from smartphones.

Wednesday afternoon, Session E2a
1:45 - 5:30 pm.
Smartphone Decimeter Challenge

Capitol Ballroom 5-7 (4th floor)

SDC Legacy

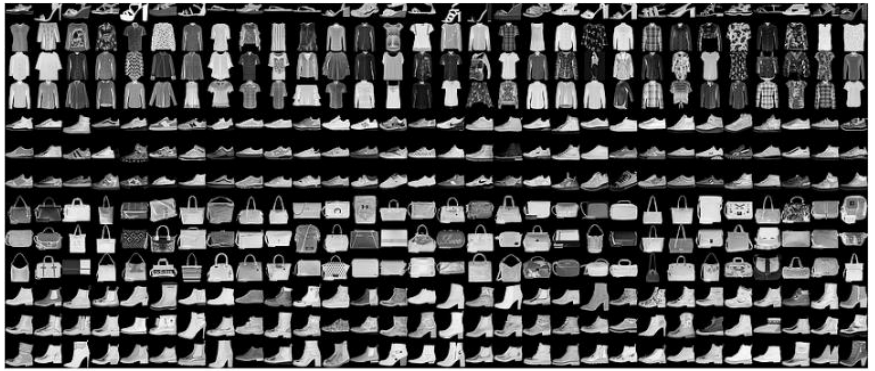
AI researchers, especially machine learning, use open datasets for standardized testing of models.

The GNSS community has not yet adopted similar standards.
A typical ION paper will have:

- very few real datasets to show results
- inconsistent metrics (50% here, rms there, etc)

Kaggle and the collection of >100 labeled datasets (~200,000 epochs) with verified GT can bring GNSS to the R&D standards of AI.

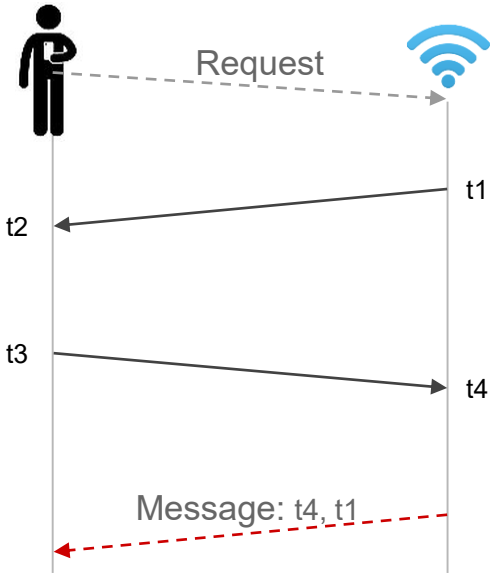
https://www.tensorflow.org/tutorials/keras/classification
70,000 grayscale images of clothing in 10 categories.
Fashion-MNIST samples (by Zalando, MIT License).



https://www.kaggle.com/competitions/...
>100 labeled traces (~200,000 epochs) with verified ground truth
Image: courtesy Taro Suzuki, ION GNSS+ 2022

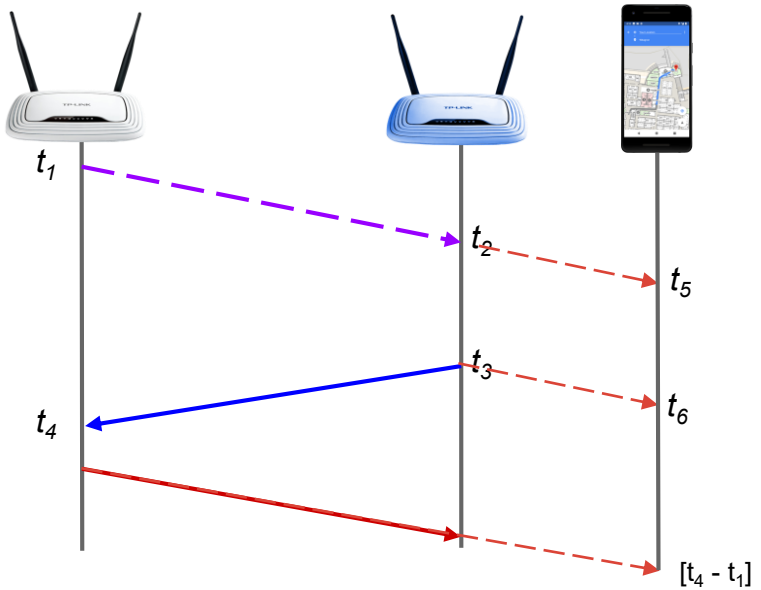
Indoor Positioning with Wi-Fi RTT

2017: IEEE 802.11mc



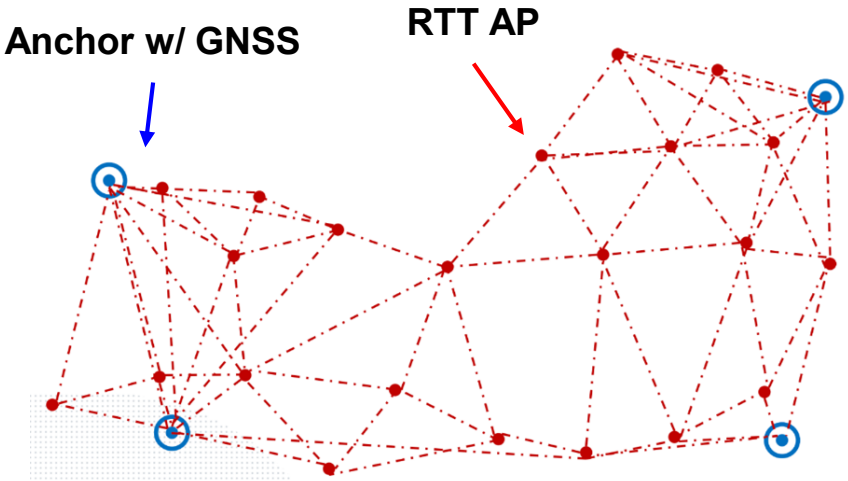
Active Mode: phone transmits & receives

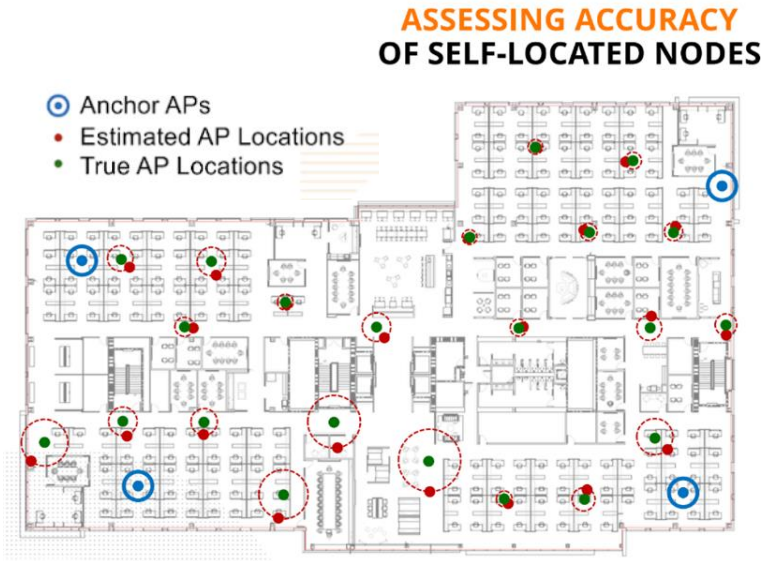
2023: IEEE 802.11az; scalable passive mode



Passive Mode: phone only listens

Wi-Fi RTT & Aruba's *OpenLocate*: A Complete Positioning System





Enables large-scale self-maintained Wi-Fi positioning infrastructure

AP mesh formed using RTT relative to four APs anchored by GNSS near windows

Civil GNSS : WiFi RTT 802.11 az

Feature/Attribute	GNSS	WiFi RTT
Time-of-flight trilateration	Yes	Yes
“Satellite-to-satellite” comm’s	Yes	Yes
Broadcast ephemeris	Yes	Yes
Multi-user	Yes	Yes
Bandwidth	2 – 50 MHz	20 – 160 MHz
Nav message authentication	Yes*	Yes
Code encryption	No	Yes
Common mode (clock) error	Yes	No

* coming to Galileo

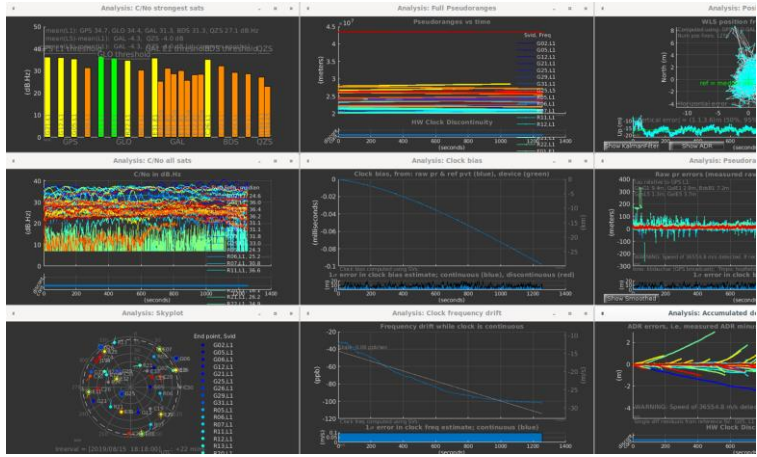
Summary:

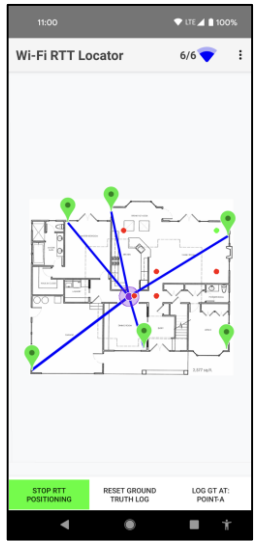
WiFi RTT is not a “signal of opportunity”, it is a complete location system

GNSS (outdoors) + WiFi RTT (indoors) = a truly ubiquitous navigation system.

Resources for developers

- Raw measurements, incl. carrier phase, from Android phones.
- GNSS tools
  - GnssLogger: log raw GNSS measurements on Android
  - GNSS Analysis Tools: desktop app for measurement analysis
- Standard test cases, with Ground Truth, on Kaggle platform.
- WiFi tools
  - WifiRttScan: phone-to-access-point distance
  - WifiRttLocator: positioning with 802.11mc





Summary

Technology for sub-meter accuracy in phones (and cars and watches) is now in place, both indoors and outdoors.

The next decade will see an explosion of high-accuracy mass-market applications.