How could a hacker figure out where you are when you use GPS from your phone?
Global Location GPS
Global Location GPS

• Basic concept is based on the foghorn paradigm
• but in 3-D
Global Location GPS
Global Location GPS

- Basic concept is based on a foghorn paradigm
- but in 3-D
Global Location GPS
Global Location GPS
Global Location GPS
Intro to Location

Global Location GPS

1.5 sec

1 sec

2 sec

Flickr: maflleen, greenstorm, templarion
Global Location GPS
Global Location GPS

- Basic concept is based on the foghorn paradigm
  - but in 3-D
    - Usually you need 1 more source for every unknown you are solving for
    - $x, y, z, \text{clock error} = 4 \text{ satellites} + 1$
Global Location GPS

• Basic concept is based on the foghorn paradigm
  • but in 3-D
  • Usually you need 1 more source for every unknown you are solving for
  • $x, y, x-x_0, (y-y_0)^2 + (z-z_0)^2 = \left(1 + \varepsilon^2\right)^2$
  • MILES

\[
\begin{align*}
(x-x_0)^2 + (y-y_0)^2 + (z-z_0)^2 &= \left(1 + \varepsilon^2\right)^2 \\
(x-5)^2 + (y)^2 &= t_1 = 9 \\
-5(x-2)^2 + (y-2)^2 &= t_2 = 4
\end{align*}
\]
Global Location GPS
Global Location GPS

- What are the implications of this design on:
  - scalability of the system?
  - privacy of users?
  - security of users?
  - reliability?
  - implications on device?
Global Location GPS

Intro to Location

![Graph showing frequency count against latitude and longitude]
Global Location GPS

Intro to Location

Latitude

Longitude

Frequency Count
Global Location GPS
Global Location GPS

- GPS accuracy
  - 13 m 95% of the time horizontal
  - 22 m 95% of the time vertical system
  - 40 ns 95% of the time
- How do you design for this?
Global Location GPS

- GPS accuracy
  - 13 m 95% of the time horizontal
  - 22 m 95% of the time vertical system
  - 40 ns 95% of the time
- How do you design for this?

- Urban canyons
  - What are they?
- Japanese response, European response
Global Location GPS
Global Location GPS

- The current and future of GPS
- Japanese Quasi-Zenith System
Global Location GPS

- The current and future of GPS
- Japanese Quasi-Zenith System

http://en.wikipedia.org/wiki/File:Qzss-45-0.09.jpg
Global Location GPS

- The current and future of GPS
- Japanese Quasi-Zenith System
Global Location GPS
Global Location GPS

- The current and future of GPS
- WAAS
  - Additional satellites in geosynchronous orbit
- DGPS assistance from a land based receiver
- Galileo
  - European competitor
  - GPS compatible
- GLONASS
  - Russian competitor
Global Location GPS

• The current and future of GPS
  • WAAS
    • Additional satellites in geosynchronous orbit
  • DGPS assistance from a land based receiver
• Galileo
  • European competitor
  • GPS compatible
• GLONASS
  • Russian competitor
# Intro to Location

## Apple iPhone 6

### General

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2G Network</strong></td>
<td>GSM 850 / 900 / 1800 / 1900 - A1549 (GSM), A1549 (CDMA), A1586</td>
</tr>
<tr>
<td></td>
<td>CDMA 800 / 1700 / 1900 / 2100 - A1549 (CDMA), A1586</td>
</tr>
<tr>
<td><strong>3G Network</strong></td>
<td>HSDPA 850 / 900 / 1700 / 1900 / 2100 - A1549 (GSM), A1549 (CDMA), A1586</td>
</tr>
<tr>
<td></td>
<td>CDMA2000 1xEV-DO - A1549 (CDMA), A1586</td>
</tr>
<tr>
<td></td>
<td>TD-SCDMA 1900 / 2000 - A1586</td>
</tr>
<tr>
<td><strong>4G Network</strong></td>
<td>LTE 700/800/850/900/1700/1800/1900/2100/2600</td>
</tr>
<tr>
<td></td>
<td>(1/2/3/4/5/7/8/13/17/18/19/20/25/26/28/29) - A1549 (GSM), A1549 (CDMA)</td>
</tr>
<tr>
<td></td>
<td>LTE 700/800/850/900/1800/1900/2100/2600</td>
</tr>
<tr>
<td></td>
<td>TD-LTE 1900/2300/2500/2600</td>
</tr>
<tr>
<td></td>
<td>(1/2/3/4/5/7/8/13/17/18/19/20/25/26/28/29/38/39/40/41) - A1586</td>
</tr>
<tr>
<td><strong>SIM</strong></td>
<td>Nano-SIM</td>
</tr>
<tr>
<td><strong>Announced</strong></td>
<td>2014, September</td>
</tr>
<tr>
<td><strong>Status</strong></td>
<td>Available. Released 2014, September</td>
</tr>
</tbody>
</table>

### Body

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensions</strong></td>
<td>138.1 x 67 x 6.9 mm (5.44 x 2.64 x 0.27 in)</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>129 g (4.55 oz)</td>
</tr>
<tr>
<td></td>
<td>- Fingerprint sensor (Touch ID)</td>
</tr>
<tr>
<td></td>
<td>- Apple Pay (Visa, MasterCard, AMEX certified)</td>
</tr>
</tbody>
</table>

### Display

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>LED-backlit IPS LCD, capacitive touchscreen, 16M colors</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>750 x 1334 pixels, 4.7 inches (~326 ppi pixel density)</td>
</tr>
<tr>
<td><strong>Multitouch</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Protection</strong></td>
<td>Shatter proof glass, oleophobic coating</td>
</tr>
<tr>
<td></td>
<td>- Display Zoom</td>
</tr>
</tbody>
</table>

### Sound

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alert types</strong></td>
<td>Vibration, proprietary ringtones</td>
</tr>
<tr>
<td><strong>Loudspeaker</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>3.5mm jack</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Card slot</strong></td>
<td>No</td>
</tr>
</tbody>
</table>

---

*CHECK PRICE*

*GSMArena Article*
**Intro to Location**

---

### FEATURES

<table>
<thead>
<tr>
<th><strong>OS</strong></th>
<th>iOS 8, upgradable to iOS 8.1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chipset</strong></td>
<td>Apple A8</td>
</tr>
<tr>
<td><strong>CPU</strong></td>
<td>Dual-core 1.4 GHz Cyclone (ARM v8-based)</td>
</tr>
<tr>
<td><strong>GPU</strong></td>
<td>PowerVR GX6450 (quad-core graphics)</td>
</tr>
<tr>
<td><strong>Sensors</strong></td>
<td>Accelerometer, gyro, proximity, compass, barometer</td>
</tr>
<tr>
<td><strong>Messaging</strong></td>
<td>iMessage, SMS (threaded view), MMS, Email, Push Email</td>
</tr>
<tr>
<td><strong>Browser</strong></td>
<td>HTML5 (Safari)</td>
</tr>
<tr>
<td><strong>Radio</strong></td>
<td>No</td>
</tr>
<tr>
<td><strong>GPS</strong></td>
<td>Yes, with A-GPS, GLONASS</td>
</tr>
<tr>
<td><strong>Java</strong></td>
<td>No</td>
</tr>
<tr>
<td><strong>Colors</strong></td>
<td>Space Gray, Silver, Gold</td>
</tr>
<tr>
<td></td>
<td>- Active noise cancellation with dedicated mic</td>
</tr>
<tr>
<td></td>
<td>- Siri natural language commands and dictation</td>
</tr>
<tr>
<td></td>
<td>- iCloud cloud service</td>
</tr>
<tr>
<td></td>
<td>- iCloud Keychain</td>
</tr>
<tr>
<td></td>
<td>- TV-out</td>
</tr>
<tr>
<td></td>
<td>- Maps</td>
</tr>
<tr>
<td></td>
<td>- Audio/video player/editor</td>
</tr>
<tr>
<td></td>
<td>- Organizer</td>
</tr>
<tr>
<td></td>
<td>- Document viewer/editor</td>
</tr>
<tr>
<td></td>
<td>- Photo viewer/editor</td>
</tr>
<tr>
<td></td>
<td>- Voice memo/dial/command</td>
</tr>
<tr>
<td></td>
<td>- Predictive text input</td>
</tr>
</tbody>
</table>

### BATTERY

- **Non-removable Li-Po 1810 mAh battery (6.9 Wh)**
  - **Stand-by**
    - (2G) / Up to 250 h (3G)
  - **Talk time**
    - (2G) / Up to 14 h (3G)
  - **Music play**
    - Up to 50 h

### MISC

- **SAR US** 1.18 W/kg (head) 1.18 W/kg (body)
- **SAR EU** 0.98 W/kg (head) 0.97 W/kg (body)
- **Price group** ▶️ ▶️ ▶️ ▶️ ▶️
Global Location GPS
Global Location GPS

- The current and future of GPS
- BeiDou
  - Chinese competitor
  - centralized system
Bei-dou
Bei-dou
Bei-dou

Time of arrival

Eureka!
(lat, long)
Bei-dou Position
• What are the implications of this design on
  • scalability of the system?
  • privacy of users?
  • security of users?
  • reliability?
  • implications on device?
How does a phone find your location?

- "Real" GPS
- "Assisted" GPS
  - Help with "Real" GPS
  - Send your position
- Cell-tower based localization
- WiFi based localization
- IP based localization

What are the properties of each?
What are other crazy ideas of how to figure out your location?
Augmenting GPS signals for accuracy improvement

- Sensor fusion

- Satellite augmentation
  - WAAS
  - GEOSYNCHRONOUS
  - QZS
    - JAPAN

- Laser range finders

- Road Mads
Two things seem particularly interesting about Google's approach. First, it relies on very detailed maps of the roads and terrain, something that Urmson said is essential to determine accurately where the car is. Using GPS-based techniques alone, he said, the location could be off by several meters.
What’s the difference between DGPS and A-GPS?
What’s the difference between DGPS and A-GPS?

- DGPS
  - Requires a special receiver, a compatible tower, calculates position on receiver, provides very high accuracy
What’s the difference between DGPS and A-GPS?

- **DGPS**
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  - Doesn’t require GPS on phone, requires a cooperating cell-tower, position is calculated on tower, sent to phone
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- **A-GPS**
  - Requires GPS on phone, Uses cell-tower to hot-start receiver GPS, requires cooperating tower, requires cooperating phone, standard accuracy
What’s the difference between DGPS and A-GPS?

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  - Requires GPS on phone, Uses cell-tower to hot-start receiver GPS, requires cooperating tower, requires cooperating phone, standard accuracy

- All require tower to know where it is
Intro to Location

CARD
NAME/ID
DATE
COMMENTS/QUESTIONS

MULTIPATH PROPAGATION

"PARANOIA"
"DIFFUSION OF INNOVATION"

http://en.wikipedia.org/wiki/File:Qzss-45-0.09.jpg
NO GPS
RELIES ON TELECOM
Global Location GPS

- Intro to Location
  - The current and future of GPS
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    - Russian competitor

No G35
RELIES ON TELECOM