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# Location Determination for Mobile Devices

## An Overview of Google Location Services

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# Agenda



- Google Location Source Technologies
  - Overview
  - Cellular Location
  - Wi-Fi Location
  - Coverage and status
  - Future work
- Applications and Services
- Google Location Platform and API
- Summary

A decorative graphic at the top of the slide features four overlapping spheres. From left to right, they are light green, light blue, light red, and light yellow. The spheres are partially cut off by the top edge of the slide.

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# Location Source Technologies



# Google Location Source Technologies

- IP Geolocation
  - City level accuracy
  - Works well on the desktop, no power cost
- Cell Tower Triangulation
  - Neighborhood or city level accuracy
  - Requires a connected mobile device
- Wi-Fi Mac Addresses
  - Street level accuracy
  - Requires a Wi-Fi enabled device
- GPS or Assisted-GPS
  - Best available accuracy
  - Power cost and unavailable indoors



# Cellular Location

Two-step, crowd-sourcing approach:

1. Estimate cellular tower location using crowd-source data
2. At serving time, depends on the content in the query, compute device location using: a: nearest tower, b: neighbor towers and or c: fingerprint

Advantage:

- Crowd sourcing does not required lengthy negotiation and contract with every service providers
- Easier to support various devices

Disadvantage:

- Crowd-source data can be full of noises
- Keeping up with changes in network is still challenging



# Wi-Fi Location

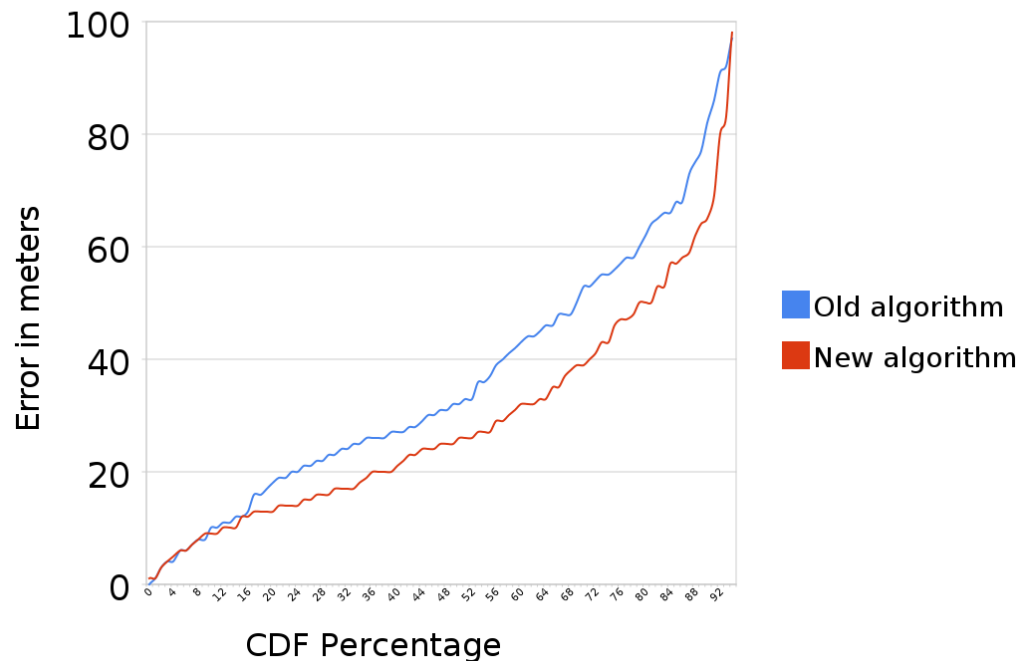
Similar to Cellular, however

- Wi-Fi radius is much much smaller: 30m to 200m vs 500m to 2000m
- Wi-Fi Access Point density distribution is more extreme: extremely high in urban area, extremely low in rural area
- Most Wi-Fi AP are consumer grade, the RF is usually low quality and the radiation patterns among different vendors are usually poor
- Bad MAC address assignment: Ad-hoc, tethering mode, duplicated addresses
- Mobile APs

# Accuracy Case Study: San Francisco

- Old algorithms
  - centroid-based technology
  - used until Q2/2010
  - 60 m at 80% confidence
- New algorithms
  - based on MLE (maximum likelihood estimation)
  - <50 m accuracy at 80% confidence.

**Accuracy improvements**



lower value indicates better accuracy

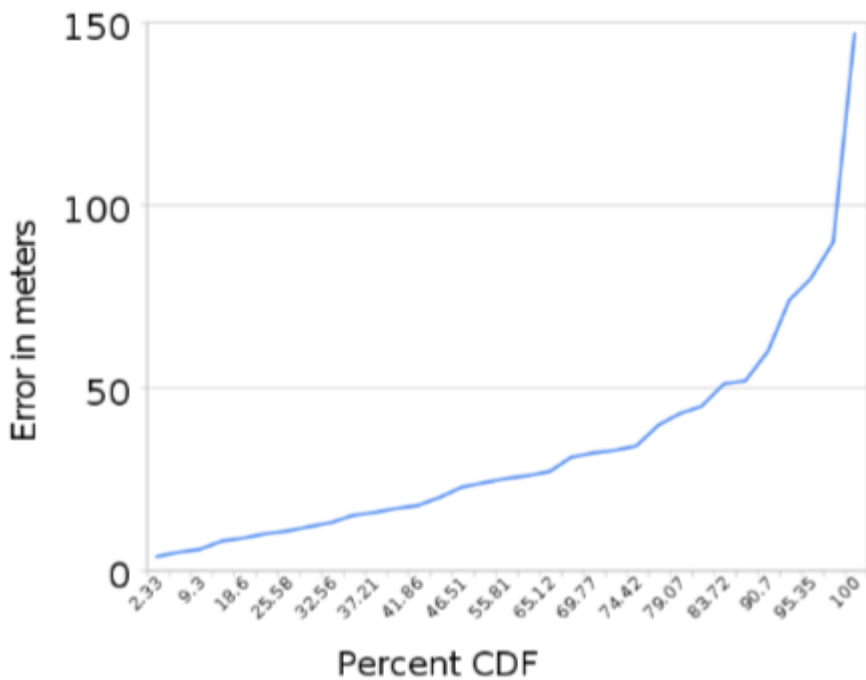
\*data is obtained from internal tests



# Accuracy outside of United States

## Europe and Scandinavia

**NLP Accuracy in Europe**

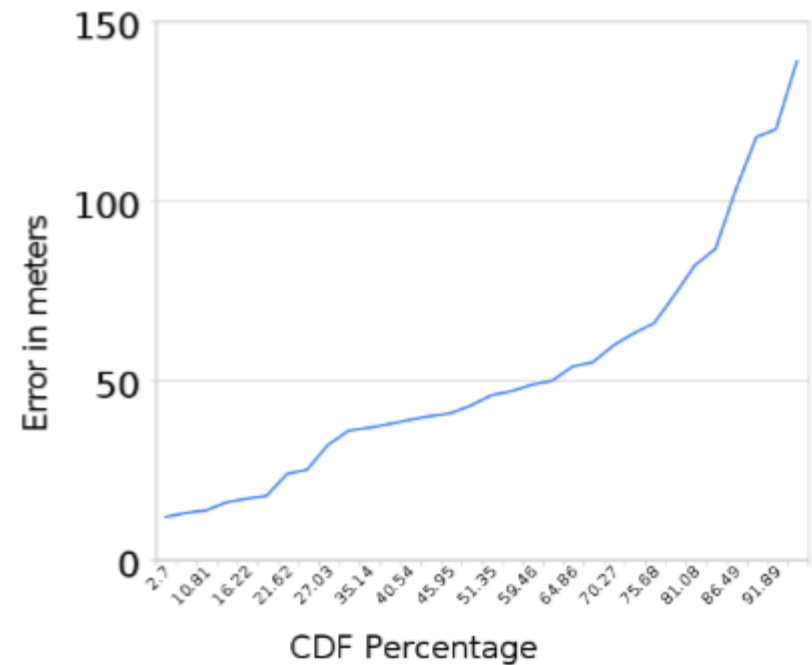


within 60m 90% of the time

\*data is obtained from internal tests

## East Asia

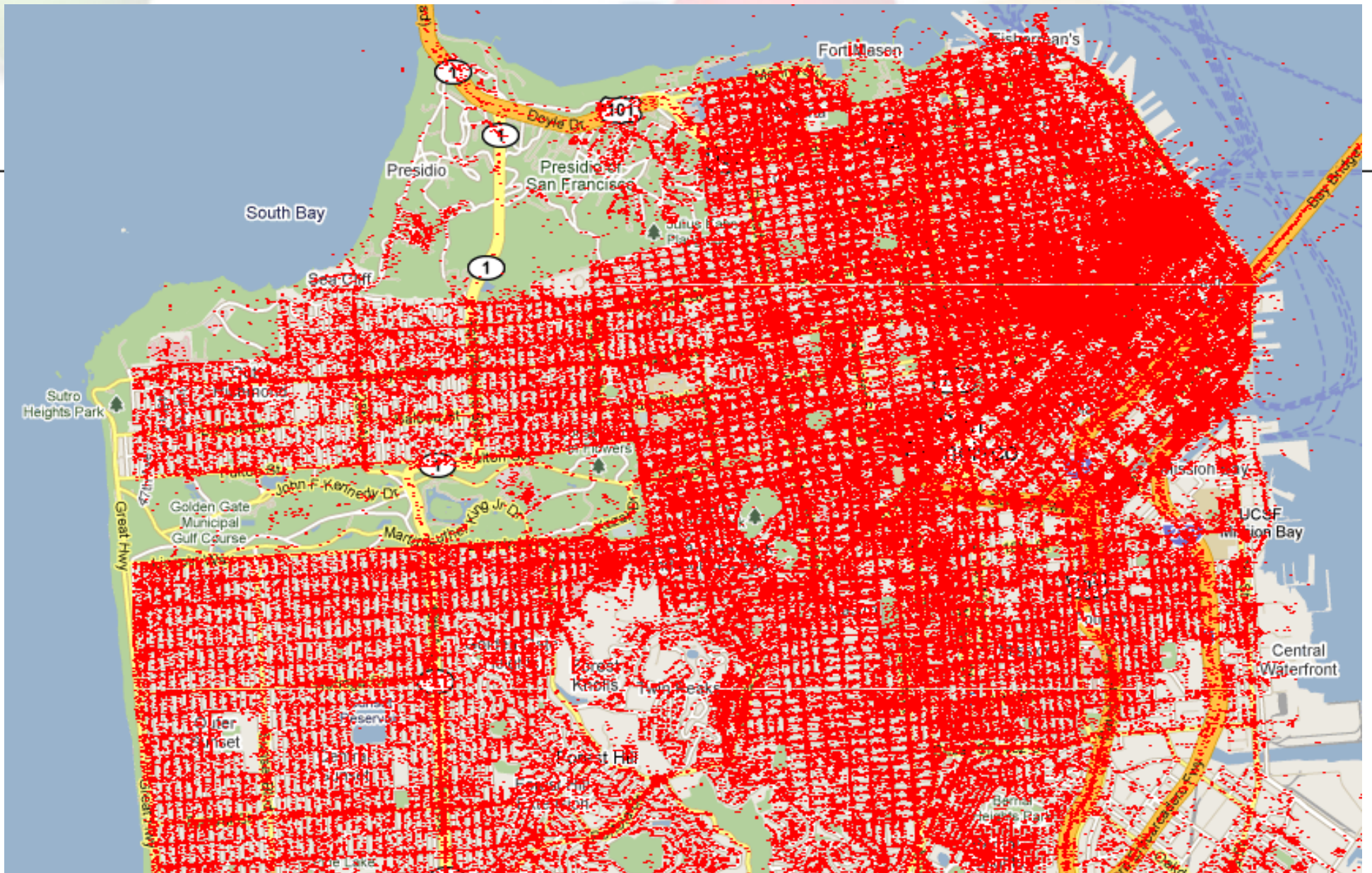
**Accuracy in Asia**



\*data is obtained from internal tests





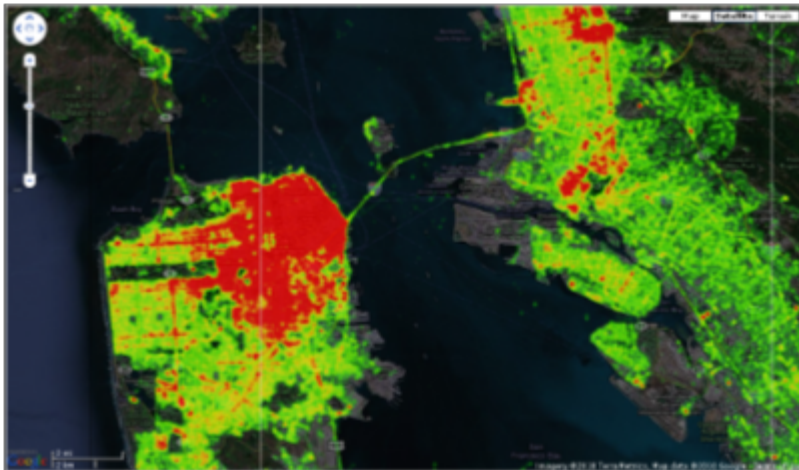


# Google Location Service Coverage

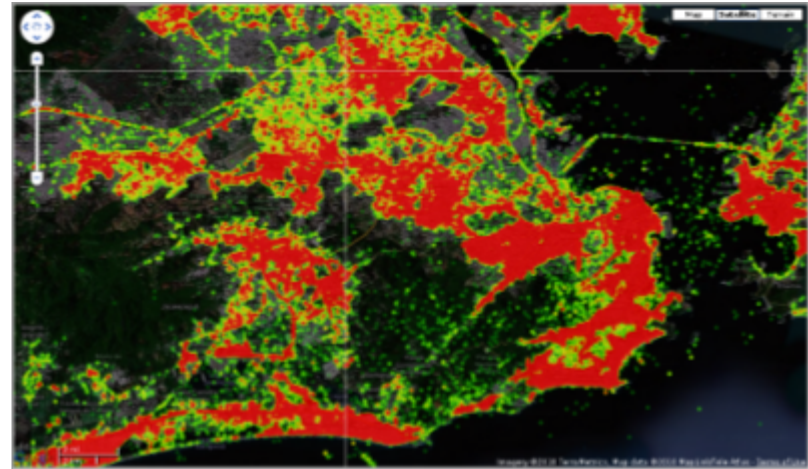
Data collected from:

- Cell towers
- WiFi access points
- Handset manufacturers with participating users

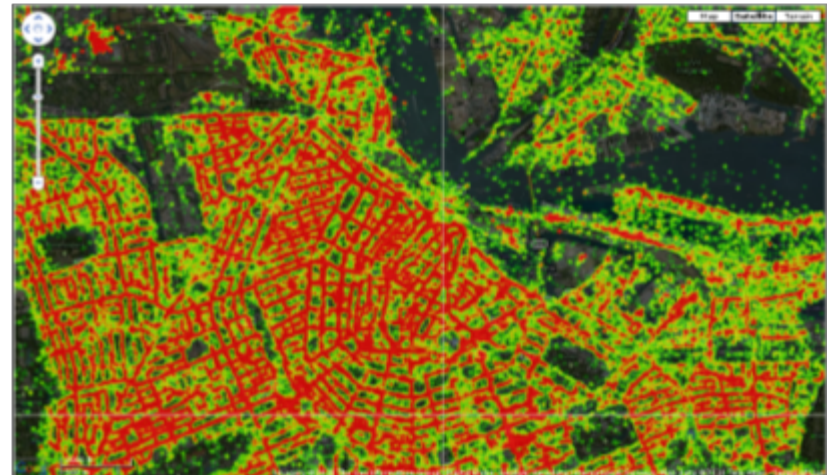
San Francisco, US



Rio De Janeiro, Brazil



Amsterdam, Netherlands



# Future Work



- Further improve accuracy and precision
  - crowd source data quality
  - noise detection and removal algorithms
  - various localization algorithms
- A highly differentiated and accurate approach for indoor location targeting
- Better phone battery life preservation

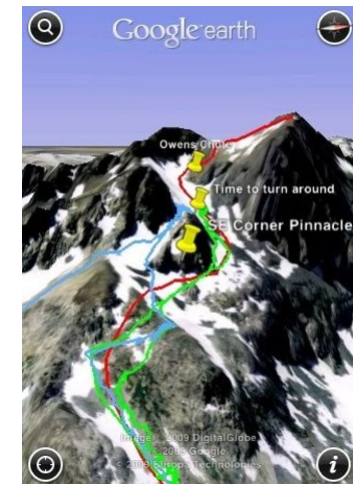
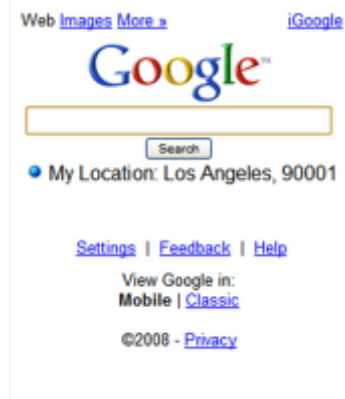
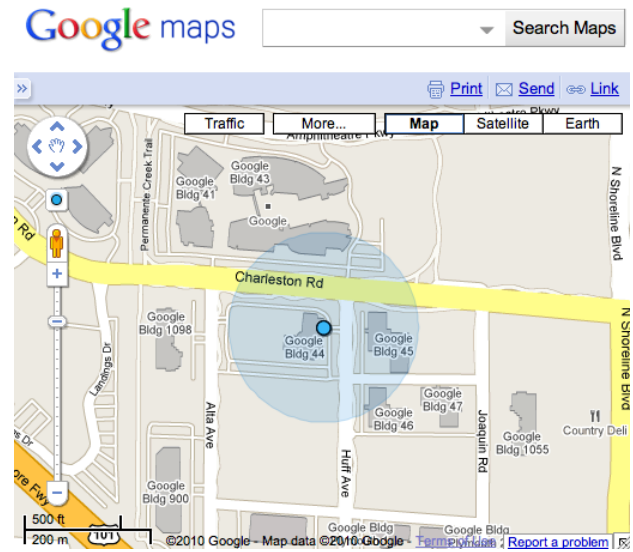
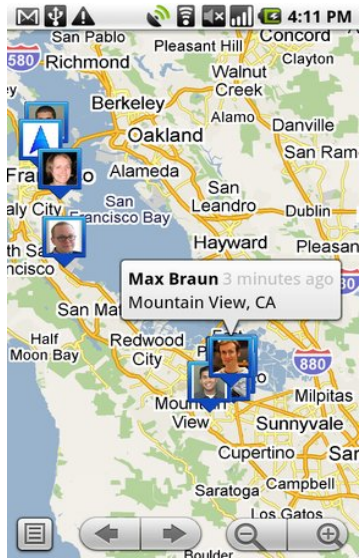
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# Services and Applications

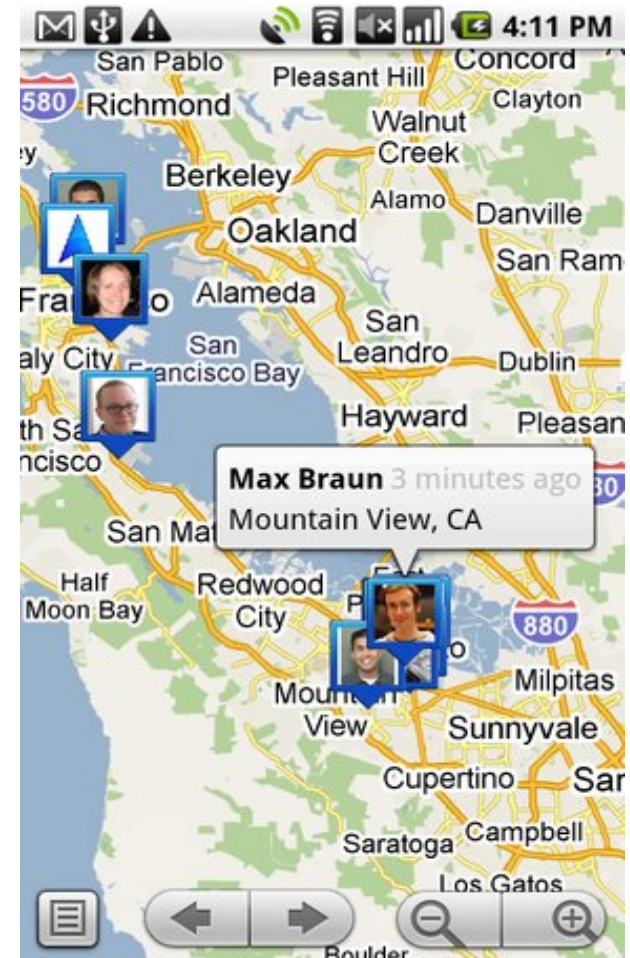


# Used extensively across Google properties



# Google Latitude

- Latitude first launched as way to share your location with friends
- Continuous location reporting on Android, Blackberry, Windows Mobile, Nokia & iGoogle
  - Over 3 million active users
  - Approaching 100 million daily location reports
- Many applications would benefit from this location information, but it's not practical to have multiple location services running on your phone



# Access Google Location Service

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- HTML5 Geolocation
  - Firefox
  - Chrome
  - Android Browser
- Gears Geolocation
  - Safari
  - Internet Explorer
- Internet Explorer w/ Google Toolbar
- Android's native Location Manager
- These APIs determine location through a mix of different location sources



# Google Latitude API

- Launching in May 2010
- Latitude has always put users in charge of their privacy
  - Per-friend sharing and granularity control
- Latitude API follows the same privacy model
  - Users must explicitly authorize each application
    - Current location or location history
    - City level or best available granularity
  - Easy to revoke access at any time
  - No firehose of data
  - No friend locations





# Latitude API Concepts

- The Latitude API is an authenticated RESTful API
- All API operations are based around the concept of user location
- User location is represented by a location resource
- The Latitude API provides two groups of resources:
  - Current Location
  - Location History
- Location can be viewed at either the best available granularity, or city-level only



# What could this enable?

- Automatically geotag your travel photos based on EXIF data joined with your location history
- Receive LinkedIn alerts when anyone in your network is at the same conference
- Improved anti-fraud detection for your credit cards
- iPhone location reporters with iPhone OS 4.0
- AlertMe.com home automation to warm up the house
- University research of travel patterns, health, etc.
- What else?

# What Is a Place

- "Public locations that people care about"
  - Park, monument, beach
  - Restaurant, hospital, shop
  - Country, city, neighborhood, street



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# Places Primer

- Why Care?
  - More compact and meaningful
  - LatLng requires a map
  - Better reflects how people think and communicate
  - Subjective qualities: preferences, status, coolness

***Let's meet at  
33° south, 151° east?***

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# Place Pages




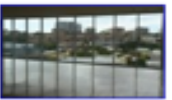

Google maps  Search Maps Show search options  
Find businesses, addresses and places of interest.

[Get Directions](#) [My Maps](#) [Print](#) [Email](#) [Link](#)

## Sydney NSW


Australia  
3:54pm Friday (GMT+10:00)  
[Directions](#) [Search nearby](#) [Save to...](#) [more](#)


### Photos & Videos


 Panoramic  
 Panoramic  
 Panoramic  
 Panoramic  
 YouTube


[More photos >](#) [More videos >](#)



### Popular places

[Hyde Park, Sydney](#) ★★★★★ 137 ratings  
 Hyde Park is a large park in Sydney, New South Wales, Australia. Hyde Park is on the eastern side of the Sydney central business district. It is the southernmost of a chain of parkland that extends north to the shore of Port Jackson (Sydney ... - [Wikipedia](#)

[Sydney Tower](#) ★★★★★ 160 ratings  
 Sydney Tower (also known as the AMP Tower, AMP Centrepoint Tower, Centrepoint Tower or just Centrepoint) is Sydney's tallest free-standing structure, and the second tallest in Australia (with the Q1 building on the Gold Coast being the tallest ... - [Wikipedia](#)

[Sydney Opera House](#)  
 The Sydney Opera House is a multi-venue performing arts centre on Bennelong Point in Sydney, New South Wales, Australia. It was conceived and largely built by Danish architect Jørn Utzon, who in 2003 received the Pritzker Prize, architecture's ... - [Wikipedia](#)

[Queen Victoria Building](#) ★★★★★ 19 ratings  
 The Queen Victoria Building, or QVB, is a late nineteenth century building by the architect George McRae in the central business district of Sydney, Australia. The Romanesque Revival building is 190 metres long by 30 wide, and fills a city block ... - [Wikipedia](#)



[Sydney's Happy Hours](#)  
By [andrea\\_dantas](#)  
List of Happy Hours in Sydney by day of the week  
[maps.google.com](#)

# Places at Google

- Google Maps / Local Search
- Google Place Pages
  - Goal: one page for every place in the world
  - Aggregates the internet around a place
    - Photos and videos
    - Reviews and rating
    - Related pages and maps

# Summary

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- Providing accurate, scalable location solution anywhere, anytime, still presents multi-dimensional challenges.
- There are many ways to access our results: from providing location resolution to end devices, to real-time access of your friends (with their consents), to localized search, nearby places search, etc. We hope there will be something we provide can benefit your research.

# Places and the Maps API

- Where does Google stand?
  - Continuously compile places to build Google Maps
  - Strong relationship with data providers
  - Infrastructure and expertise

***"Organize the world's information,  
and make it universally  
accessible and useful."***

Google™



# Introducing Nearby Places

- Component of Maps API
  - Familiarity
  - Efficiency
- Goals
  - Help developers connect their users to places
  - Allow developers to harness Google's places DB
- Use cases / capabilities
  - Users looking for a place
  - Users looking to learn about a place
  - Users looking to have conversations about a place
- Small but lots of potential



# What About Developers?

- Developer pain points
  - Lack of support for business search in the Maps API
  - Requires separate API (AJAX Search API)
    - Types, data formats, programming conventions
    - No unified concept of a place
    - Different terms of service
- Increased interest for location based services
  - Check-in based social games
  - Location based media and advertising

# More Information

- W3C API: <http://dev.w3.org/geo/api/spec-source.html>
- Latitude API: <http://code.google.com/apis/latitude/>
- Places API: <http://code.google.com/apis/maps/documentation/places/>

