

Address, City, State, and/or Zip
3405 Michigan Union 530 S. State Street

Current City: Ann

- Ann Arbor, Michigan
51,001 like this · 752,64...
- Lake Ann, Michigan
785 like this · 8,350 wer...
- Saint Ann'S Bay, Saint A...
742 like this · 3,583 wer...
- Saint Ann, Missouri
533 like this · 3,920 wer...

Location: Ann Arbor, MI
Where in the world are you?

家乡: 安

- 安庆
- 安顺
- 安康

SKYHOOK
WIRELESS

DBpedia

YAHOO!
BOSS

Google
Developers

Positioning

Spatial Computing – University of Minnesota



Positioning

Spatial Computing – University of Minnesota

Learning Objectives

1. Know how your smartphone can figure out where you are (Hint: It's not just GPS!)
 - Never use the term “GPS” incorrectly ever again!
2. Be familiar with an important frontier in positioning: content-based positioning

Positioning is about a simple question:

“Where?”



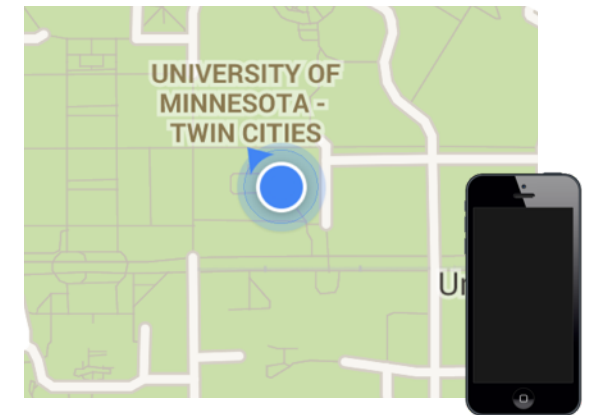
Where is this property line?



Where should this missile go?



Where is this animal?



Where is this smartphone user?

$\langle x, Z, z(x) \rangle$

the “geo-atom”

(Goodchild et al. 2007)

$\langle x, z, z(x) \rangle$

**Main
subject of
this module!**

Presence of cholera

Temperature

Population

Air Quality

Tweet content

Wikipedia article text

10°C
-10°C



User **position** is a particularly important type of **x**.

x

Spatial Computing

@SpatialCompMOOC

The Twitter account for the University of Minnesota's Spatial Computing MOOC taught by Dr. [@bhecht](#) and Dr. Shashi Shekhar

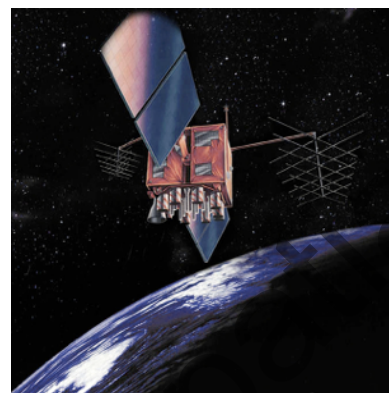
Minneapolis, MN

coursera.org/course/spatial...

x is a vector, not a single value!

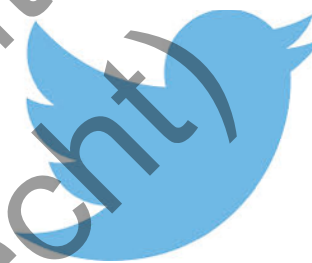
$\langle \mathbf{x}, z, z(\mathbf{x}) \rangle$

(44.97428, -93.232502, 264m, 10:33am)



Signal-based
Positioning

102.111.321.5



flickr

Content-based
Positioning

Positioning

Spatial Computing – University of Minnesota

Attributions

"Cell tower in jovel chiapas" by Leogeograph - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Cell_tower_in_jovel_chiapas.JPG#mediaviewer/File:Cell_tower_in_jovel_chiapas.JPG

["Wifi"] By RRZEicons (Own work) [CC-BY-SA-3.0 (<http://creativecommons.org/licenses/by-sa/3.0>)], via Wikimedia Commons

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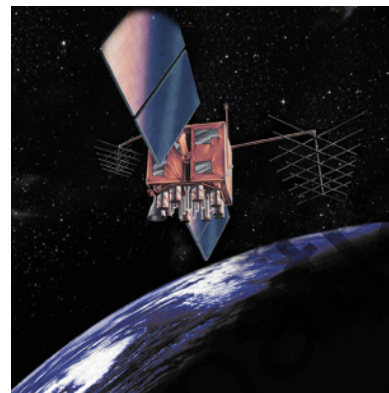
YAHOO!
BOSS

Google
Developers

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Signal-based
Positioning

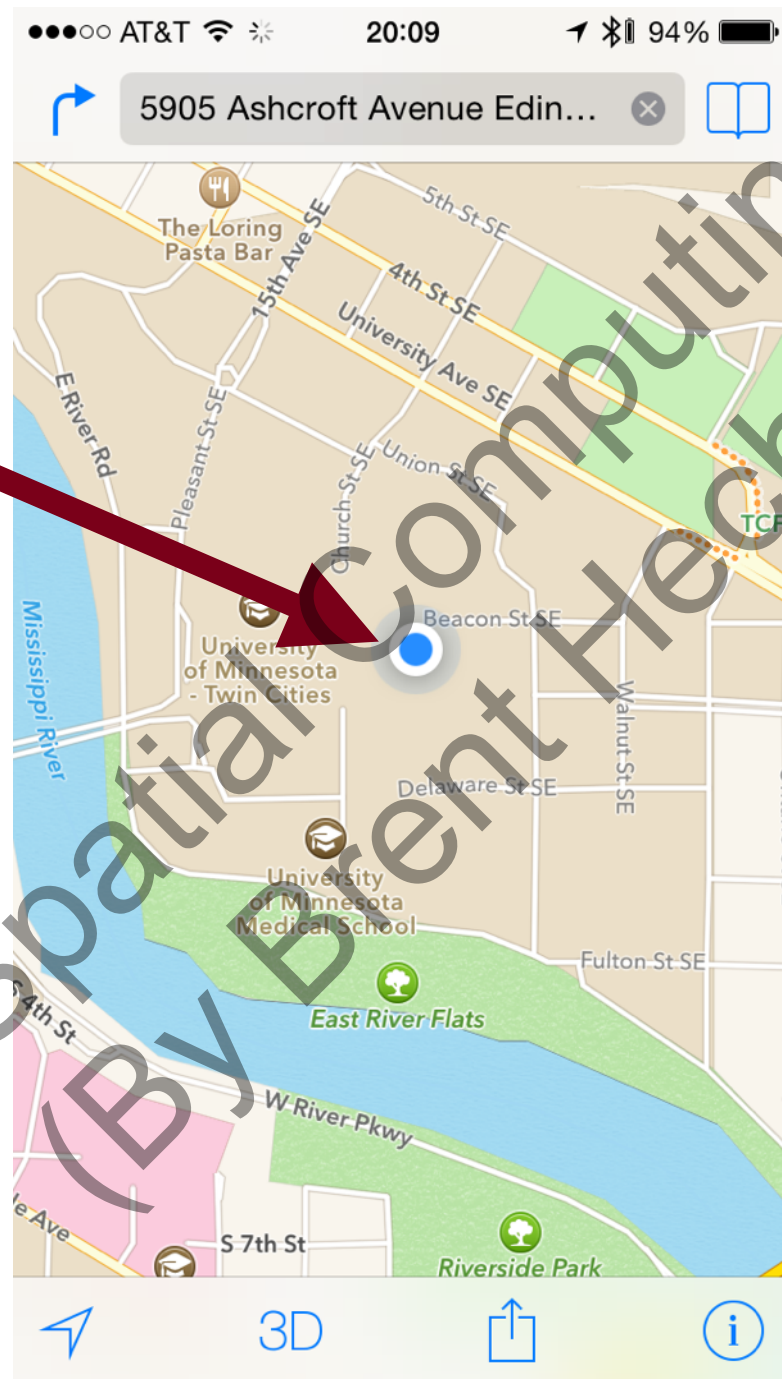
Content-based
Positioning





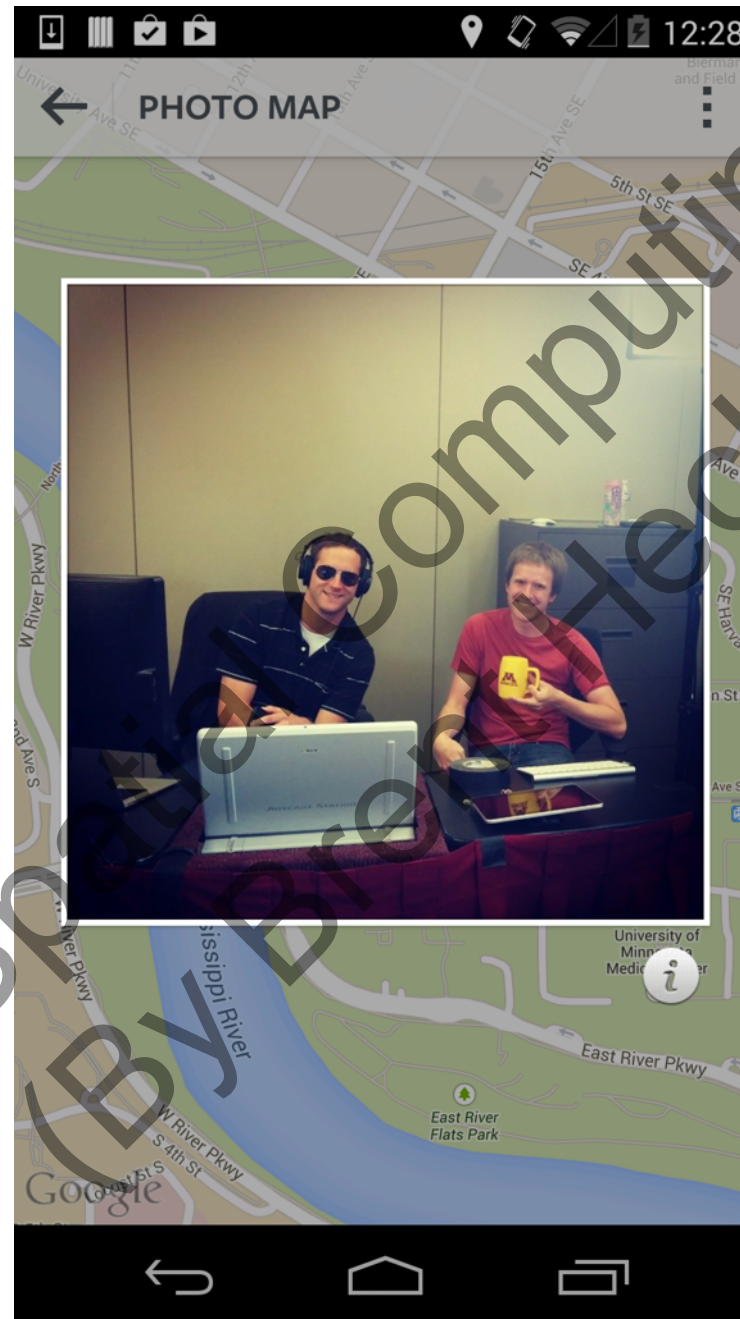
Signal-based positioning is how your smartphone knows where you are!

Signal-based positioning is responsible for....



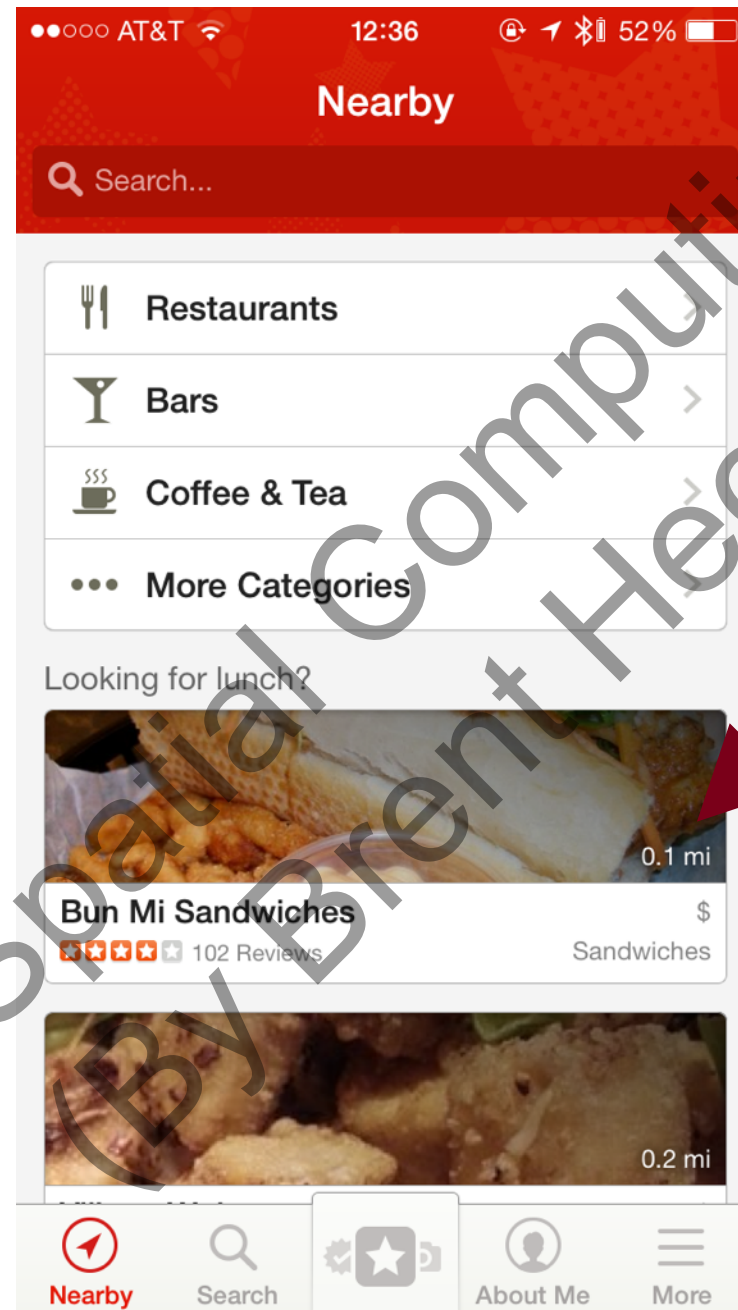
...the little blue dot in mobile map applications

Signal-based positioning is responsible for....



... correctly geotagging Instagram photos, tweets, and other social media VGI.

Signal-based positioning is responsible for....



... helping determine what's nearby in location-based services like Yelp, Foursquare, and so on.

Signal-based positioning is responsible for....



... helping scientists understand how species migrate.

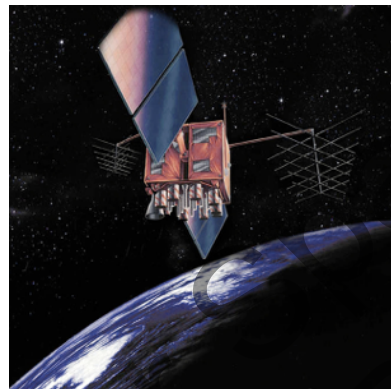
Signal-based positioning is responsible for....



...allowing farmers to implement optimal strategies for their crops.

Key Types of Signal-based Positioning

in your smartphone and in general



1. Satellite-based Positioning
2. Wifi Positioning
3. Cellular Positioning

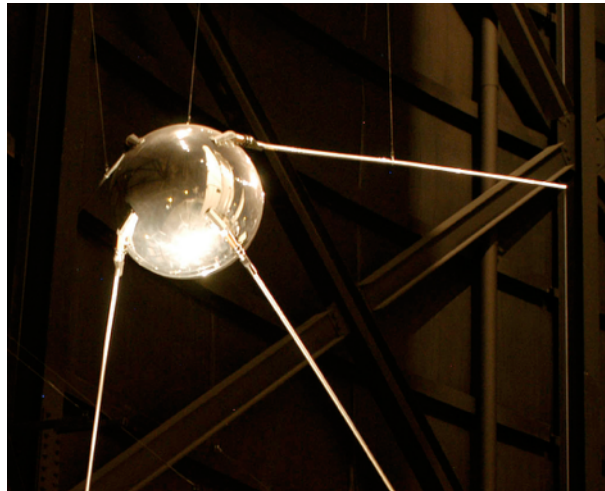
Signal-based
Positioning

Global Navigation Satellite System (GNSS)

Slides for Spatial Computing MOOC
(Byzantine Heuristics)

First GNSS GPS

Global Positioning System



Scientists in America figure out how to track Sputnik using its radio transmissions



The U.S. wanted to be able to better target missiles (among other military applications)



KAL 007 shot down after drifting into Soviet space

GPS is a U.S. government technology born out of the Cold War



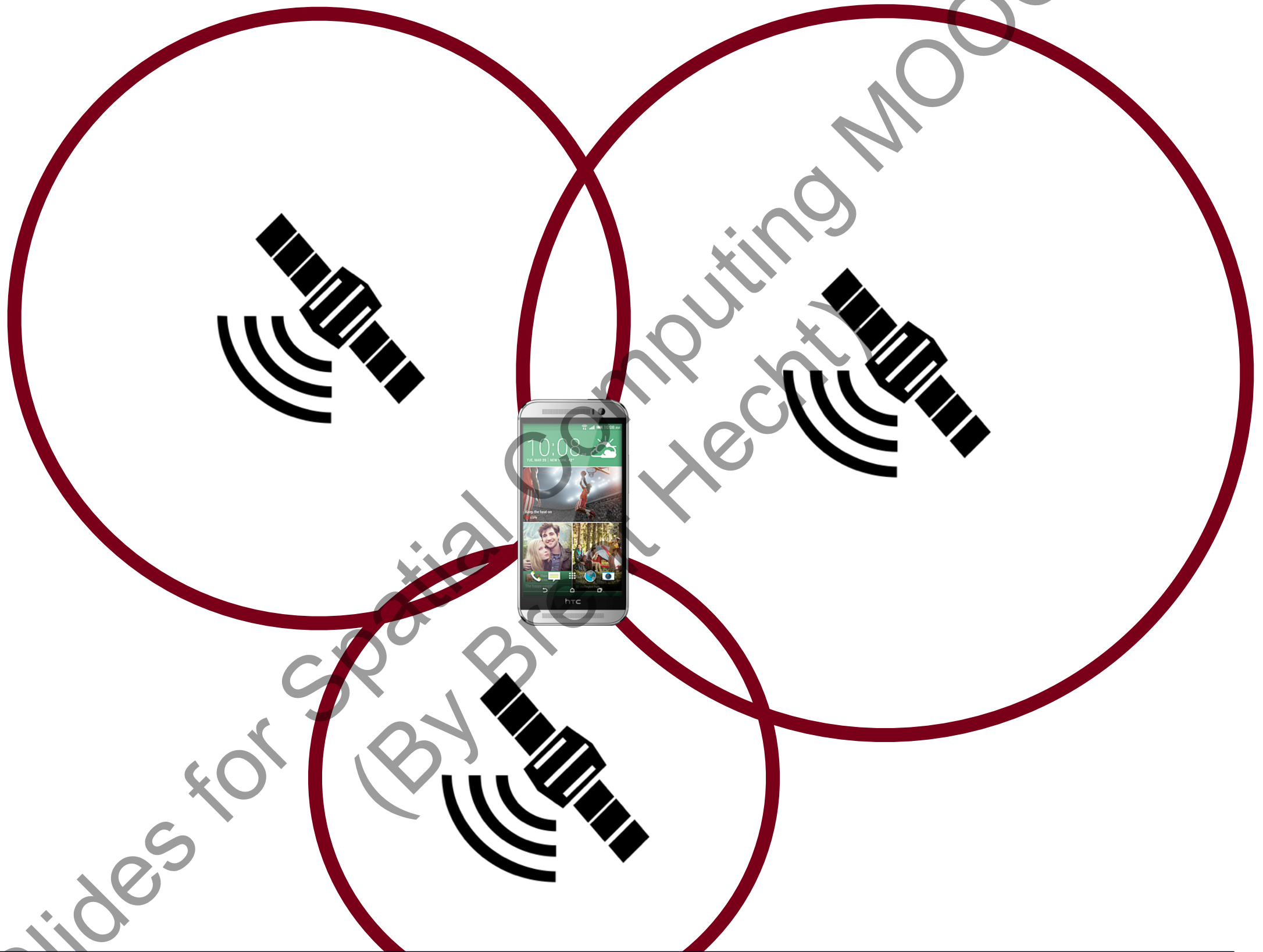
GPS BFFs

GPS is a U.S. government technology born out of the Cold War

How does GPS work?



- 24 satellite (+ some extras)
- each is on fixed, 12-hour orbit
- transmit radio signals at fixed intervals
- devices use trilateration



The more satellites, the better (3 = minimum)

GPS is failing you
right now!

GPS limitations

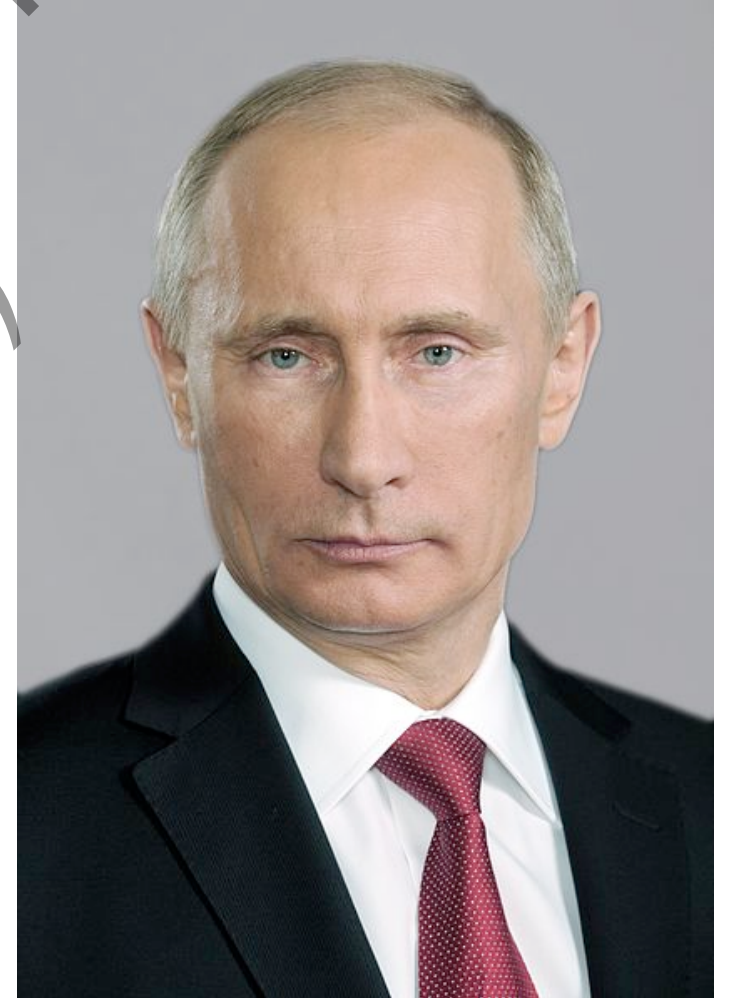
1. Does not work well indoors
(that's changing a bit)
2. Accuracy can be limited
3. Time-to-first-fix stinks
4. Multipath issues (urban
canyon effect)

Hard for a smartphone to see satellites down there!

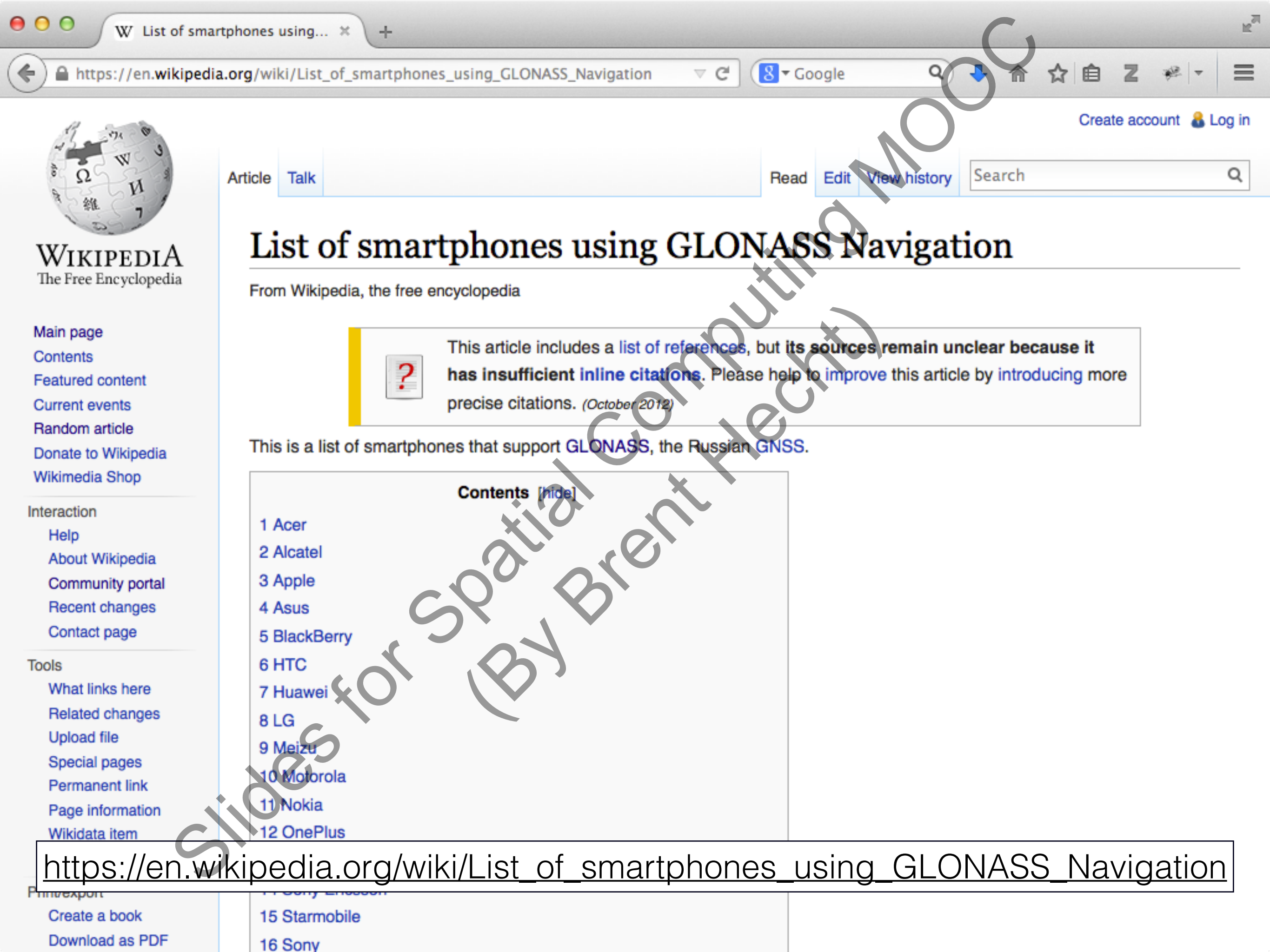


GPS limitations

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3. Time-to-first-fix stinks
4. Multipath issues (urban
canyon effect)
5. Drain on power



GPS BFFs?



WIKIPEDIA
The Free Encyclopedia

Main page
Contents
Featured content
Current events
Random article
Donate to Wikipedia
Wikimedia Shop

Interaction

Help
About Wikipedia
Community portal
Recent changes
Contact page

Tools

What links here
Related changes
Upload file
Special pages
Permanent link
Page information
Wikidata item

Article Talk

Read

Edit

View history

Search



List of smartphones using GLONASS Navigation

From Wikipedia, the free encyclopedia



This article includes a **list of references**, but **its sources remain unclear because it has insufficient inline citations**. Please help to **improve** this article by **introducing** more precise citations. *(October 2012)*

This is a list of smartphones that support **GLONASS**, the Russian **GNSS**.

Contents [hide]

- 1 Acer
- 2 Alcatel
- 3 Apple
- 4 Asus
- 5 BlackBerry
- 6 HTC
- 7 Huawei
- 8 LG
- 9 Meizu
- 10 Motorola
- 11 Nokia
- 12 OnePlus

https://en.wikipedia.org/wiki/List_of_smartphones_using_GLONASS_Navigation

Print/export

Create a book
Download as PDF

- 13 Sony Ericsson
- 14 Sony
- 15 Starmobile
- 16 Sony



Galileo



**Beidou-2 /
COMPASS**

Positioning

Spatial Computing – University of Minnesota

Attributions

"Cell tower in jovel chiapas" by Leogeograph - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Cell_tower_in_jovel_chiapas.JPG#mediaviewer/File:Cell_tower_in_jovel_chiapas.JPG

"new holland tractor" by Dan Davison / CC BY 2.0 (<https://flic.kr/p/8qXrXN>)

"Boeing 747-2B5B, Korean Air Lines AN0600191" by Michel Gilliand - Gallery page <http://www.airliners.net/photo/Korean-Air-Lines/Boeing-747-2B5B/0600191/LPhoto> <http://cdn-www.airliners.net/aviation-photos/photos/1/9/1/0600191.jpg>. Licensed under GNU Free Documentation License 1.2 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Boeing_747-2B5B,_Korean_Air_Lines_AN0600191.jpg#mediaviewer/File:Boeing_747-2B5B,_Korean_Air_Lines_AN0600191.jpg

["Wifi"] By RRZEicons (Own work) [CC-BY-SA-3.0 (<http://creativecommons.org/licenses/by-sa/3.0/>)], via Wikimedia Commons

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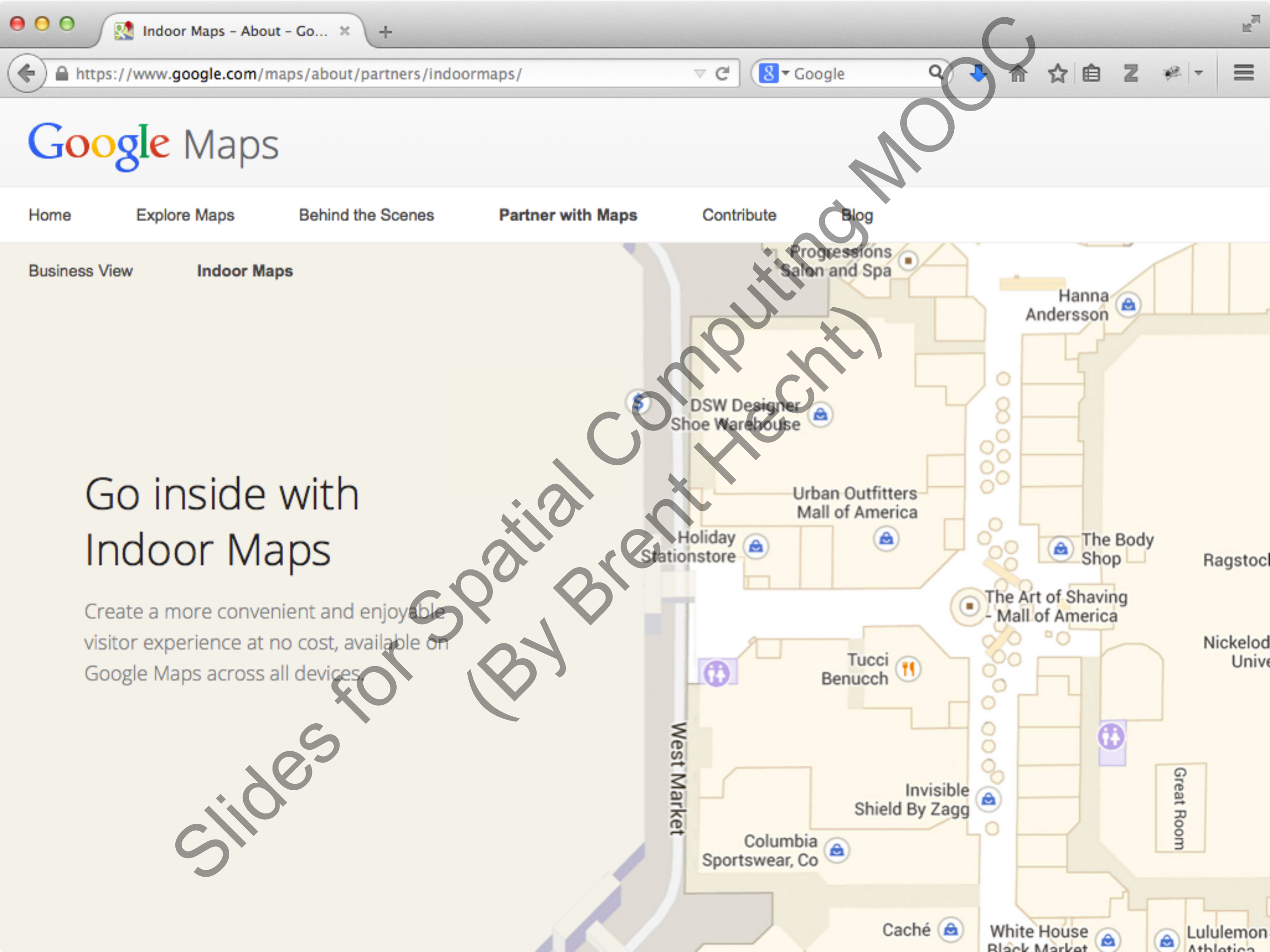
Positioning

Spatial Computing – University of Minnesota

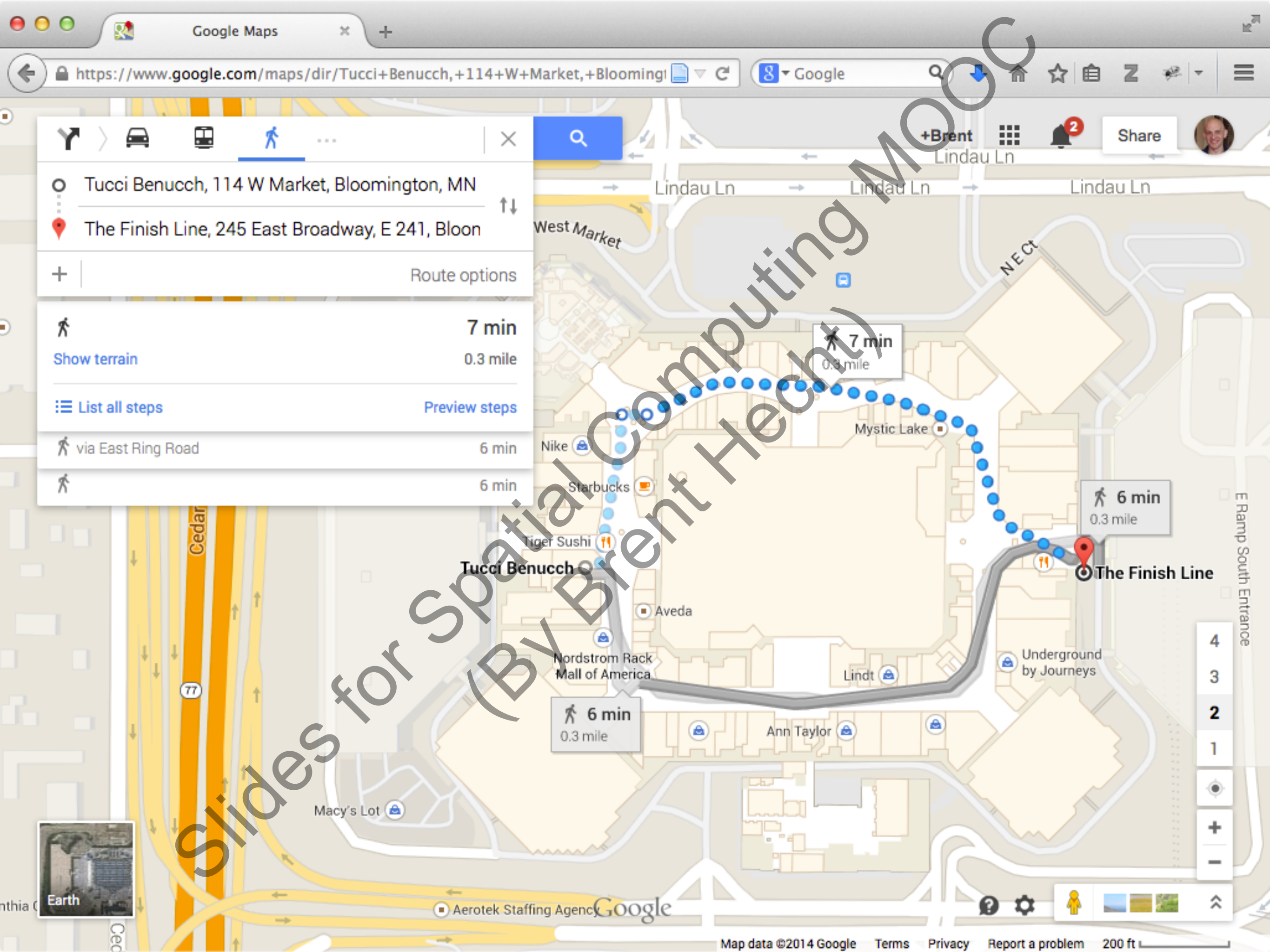


GPS limitations

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2. Accuracy can be limited
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4. Multipath issues (urban
canyon effect)
5. Drain on power



Slides for Spatial Computing MOOC
(By Brent Hecht)



Wifi positioning to the rescue!

Slides for Spatial Computing MOOC
(By Brent Recht)



Coit Tower



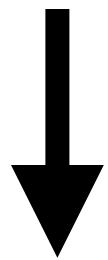
Candlestick Park



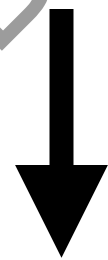
Golden Gate Bridge



Coit Tower



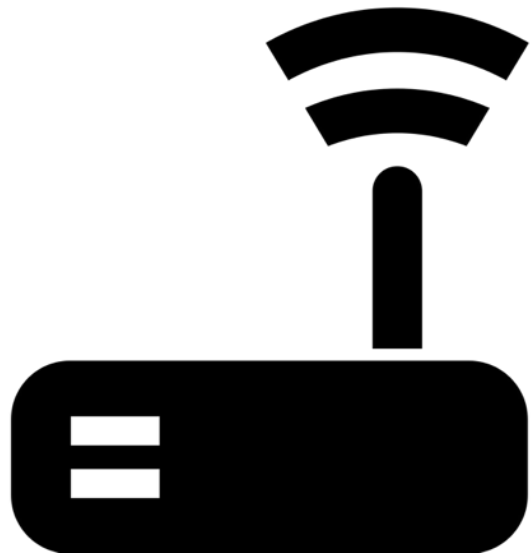
Candlestick Park



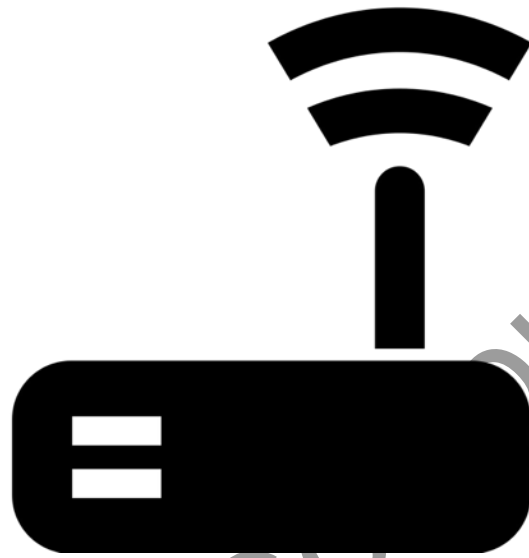
Golden Gate Bridge



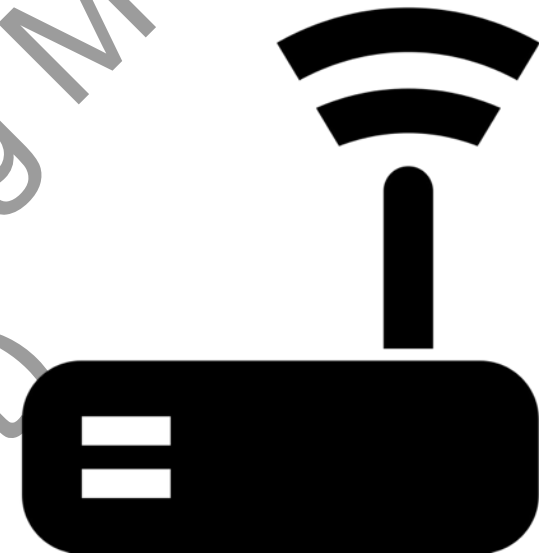
San Francisco, CA



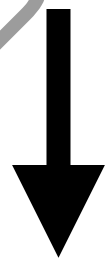
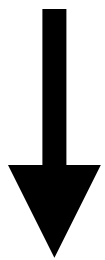
Unique MAC
Address



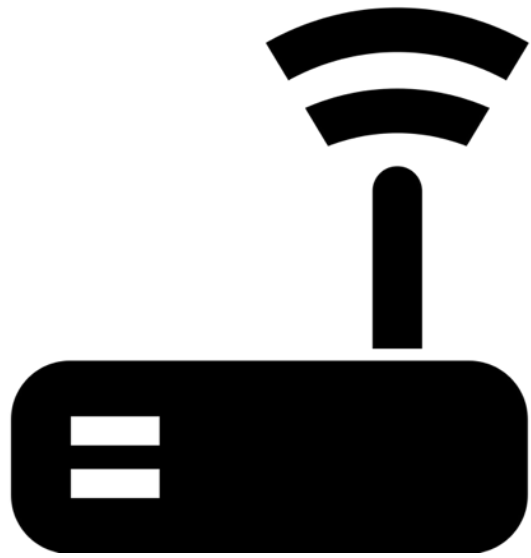
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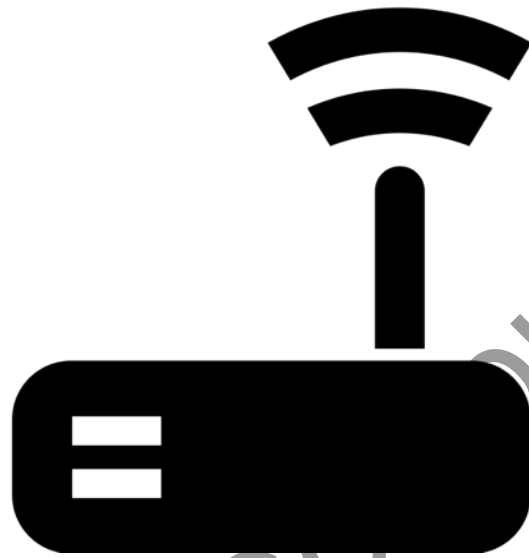
Unique MAC
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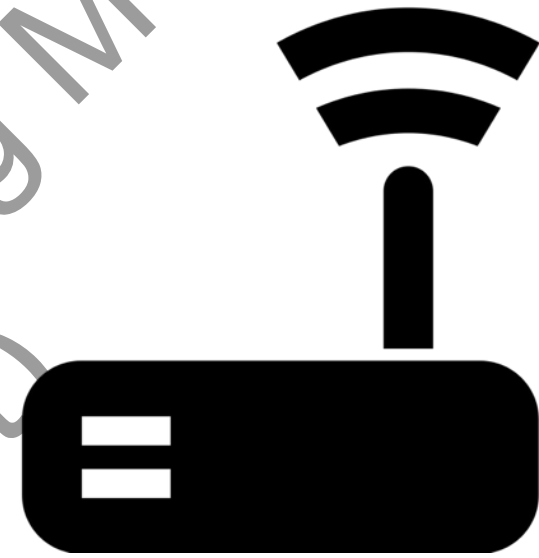
San Francisco, CA



Unique MAC
Address



Unique MAC
Address



Unique MAC
Address



Approx. Lat / Lon

How does wifi positioning work?



PHASE 1

calibration phase

PHASE 2:

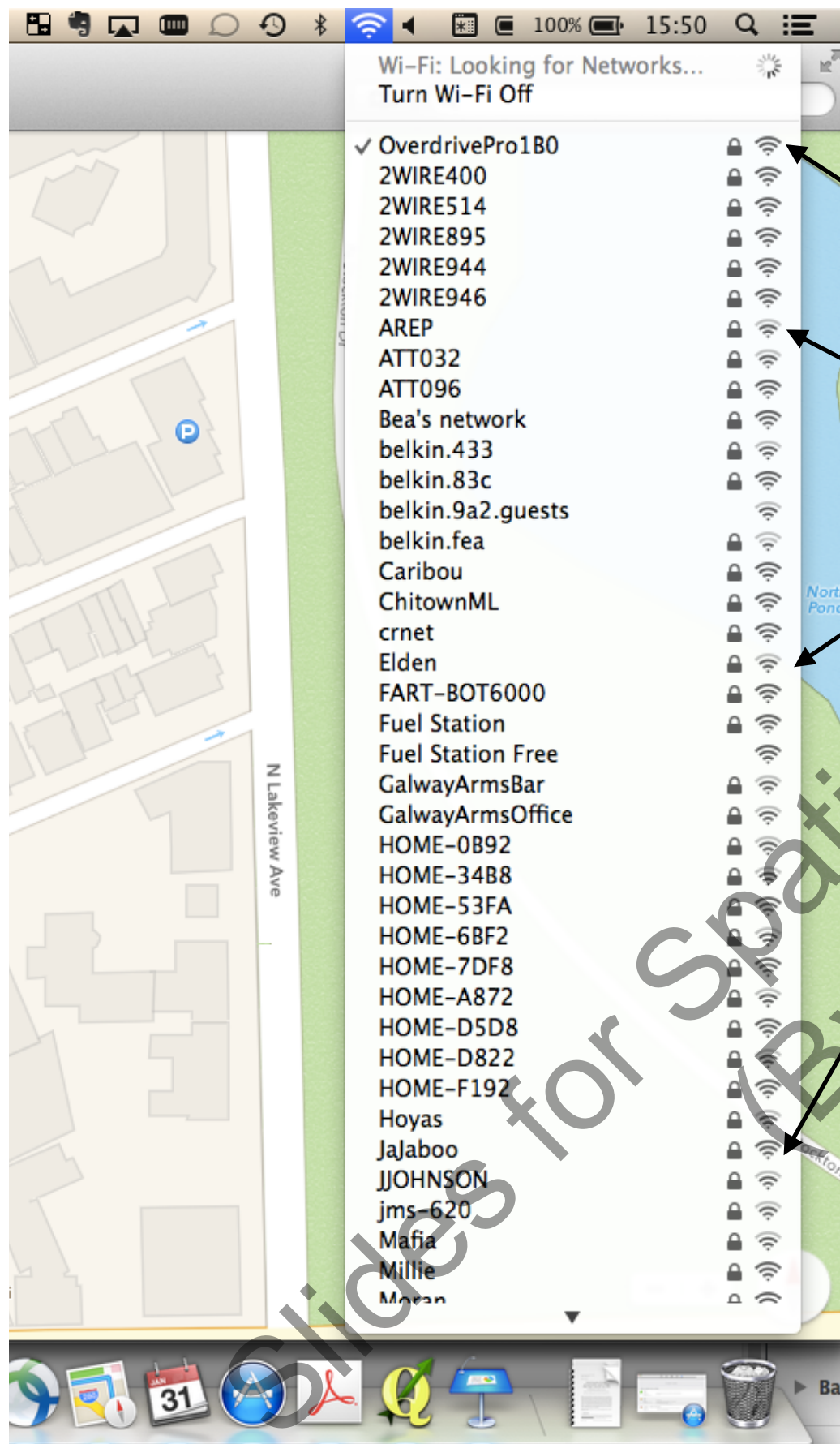
positioning phase

Fingerprinting!

Wifi Fingerprint

Collecting these is goal of Calibration stage

(MAC addresses, signal strengths, location of fingerprint collector)



Two-Thirds of a Wifi Fingerprint
(missing the location at which this reading was taken)

Calibration Phase

aka collecting fingerprints



War Driving

Google Street View cars: also used to collect Wi-Fi fingerprints



Edition: UK US AU Sign in Beta

Sign into the Guardian using your Facebook account

\$20 OFF on weekly rentals BOOK NOW



Hertz.

theguardian

Google™ Custom Search Search

News US World Sports Comment Culture Business Money Environment Science Travel Tech Media Life & style Data

News Technology Google Street View

Google told to delete Street View payload data or face UK prosecution

Information commissioner's office says it will launch contempt of court proceedings if data is not deleted within 35 days

Josh Halliday
theguardian.com, Friday 21 June 2013 07.45 EDT
Jump to comments (380)



Share 2
Tweet 1
g+1 24
Pin it
in Share 0
Email

Article history

Technology
Google Street View · Google

UK news
Information commissioner



Sounds good to me!

WANTED: Wi-Fi
fingerprint collector. Hr
= 24hrs/day, 7days a
week. Wage = **\$0/hr**



The New Street View
Car Driver

“[Positioning calculations] are performed live on the iPhone using a crowd-sourced database of Wi-Fi hotspot and cell tower data that is generated by tens of millions of iPhones sending the geo-tagged locations of nearby Wi-Fi hotspots and cell towers in an anonymous and encrypted form to Apple.”

(Apple, Inc. 2011)





Consolidated.db scandal

TIVO+NETFLIX.
Get cable TV + streaming content together.

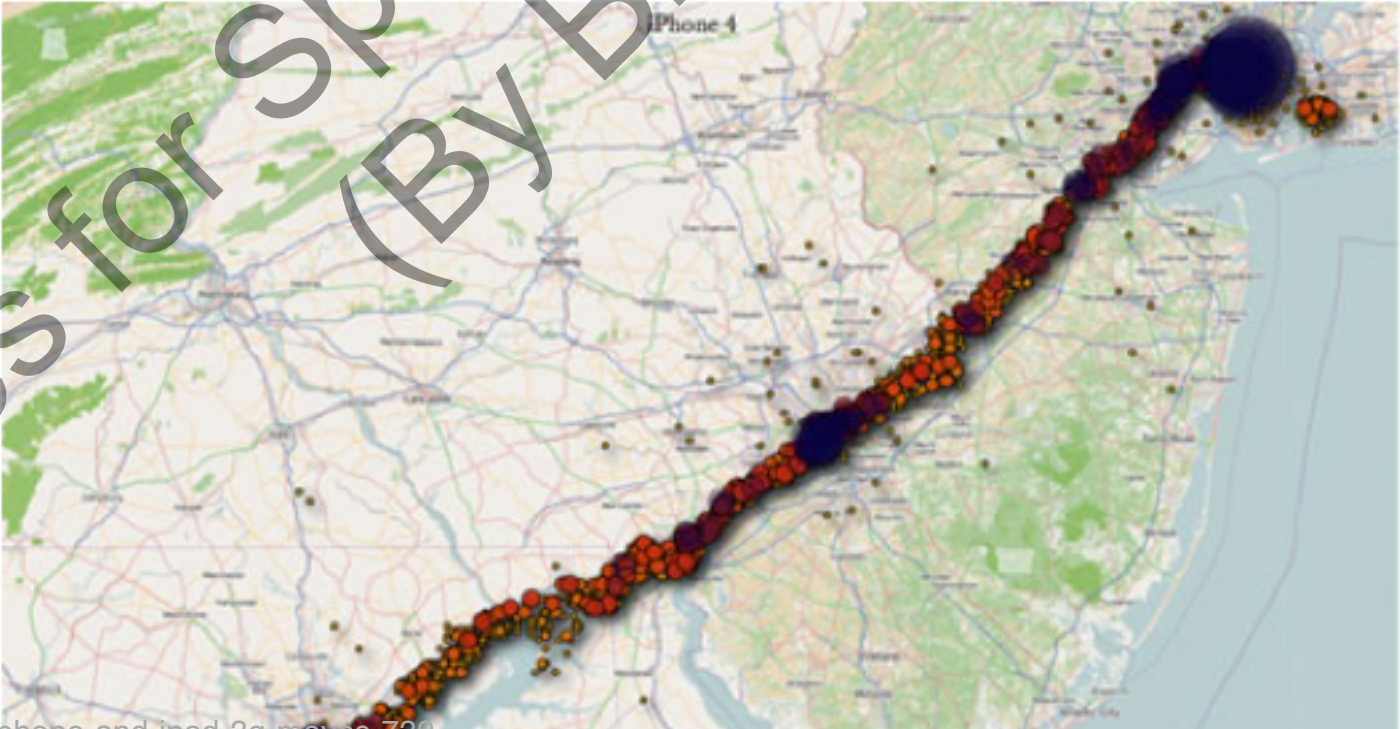
Shop Now



Search Bits

3G Apple iOS Devices Are Storing Users' Location Data

By NICK BILTON APRIL 20, 2011 3:04 PM 109 Comments



PREVIOUS POST
News.Me, Social News Service, Debuts for iPad

SCUTTLEBOT *News from the*

In 2004, Loving Google but Not
NYTIMES.COM | Before Google's I.P.C. everyone in Silicon Valley was better
Ashwin Seshagiri

In the Sharing Economy, a Rift C
Classification
BOSTON GLOBE | Are platforms like U marketplaces for contractor services
Natasha Singer

How does wifi positioning work?



Fingerprinting!

PHASE 1

calibration phase

PHASE 2:

positioning phase

Positioning Phase

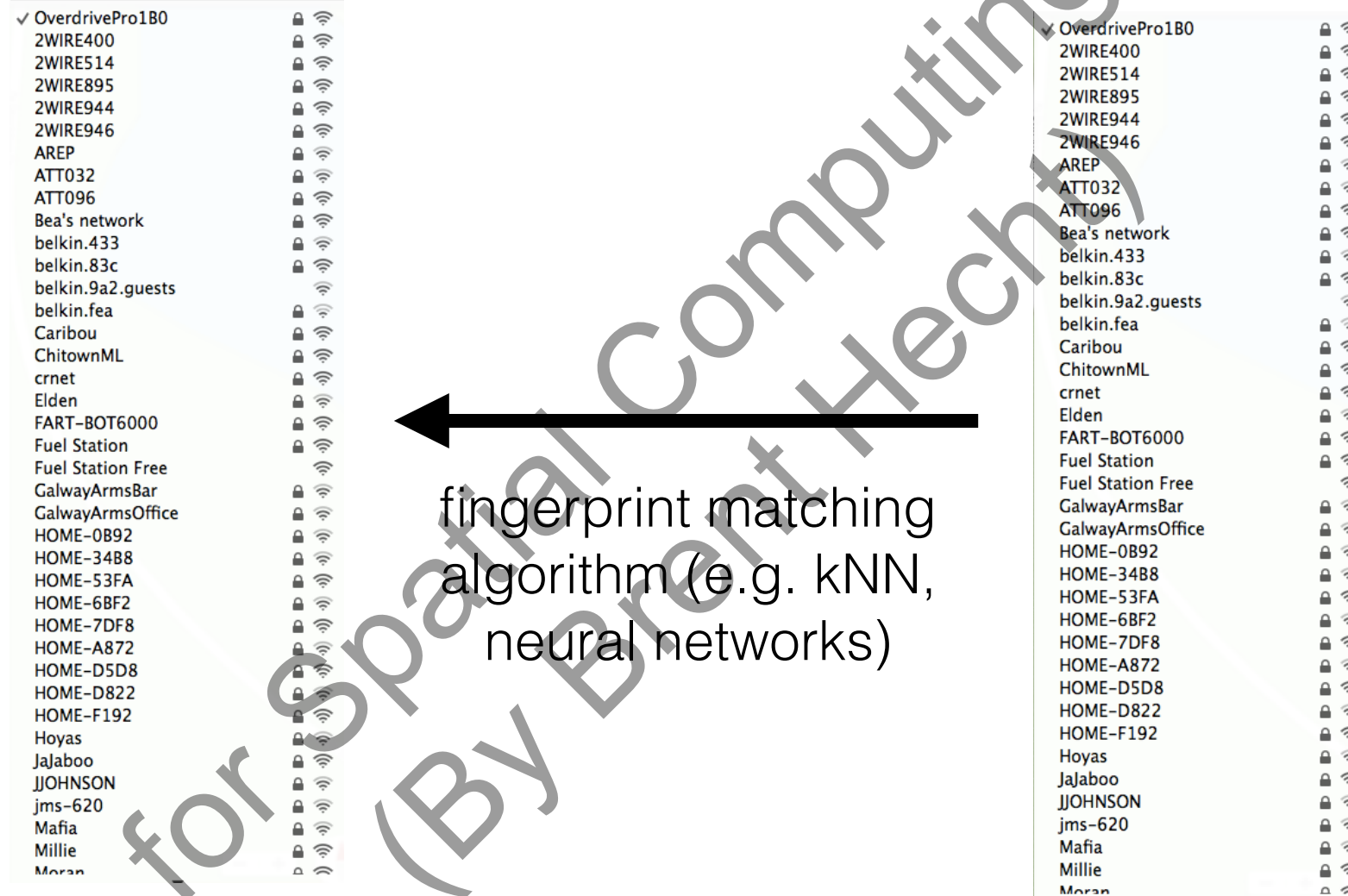
aka using machine learning to determine position



These Wi-Fi networks are in range, so where am I?

Positioning Phase

aka using machine learning to determine position



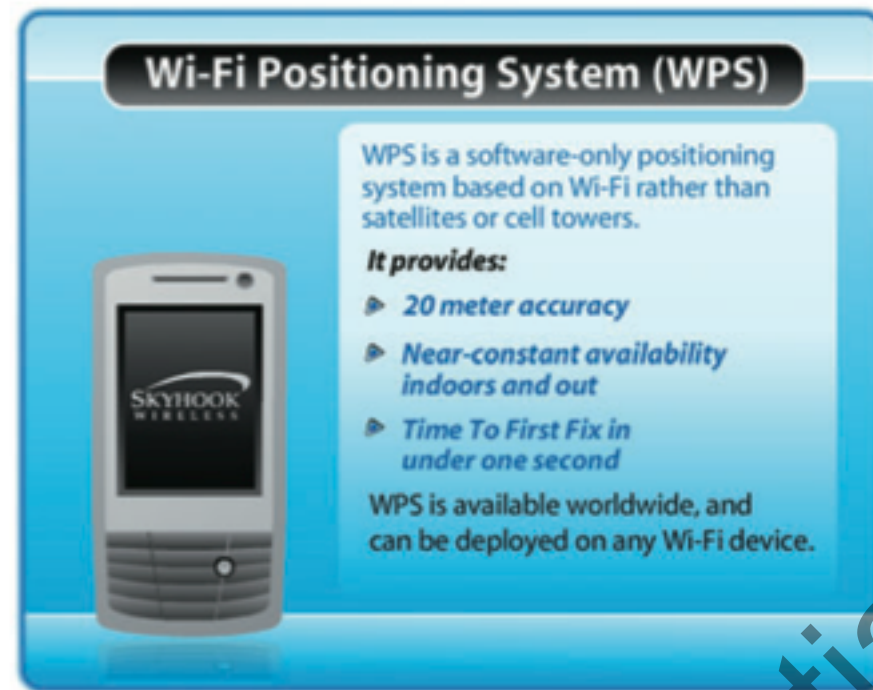
Available Wi-Fi
Networks and Signal
Strengths

Lat/Lon =
41.93635, -87.64332

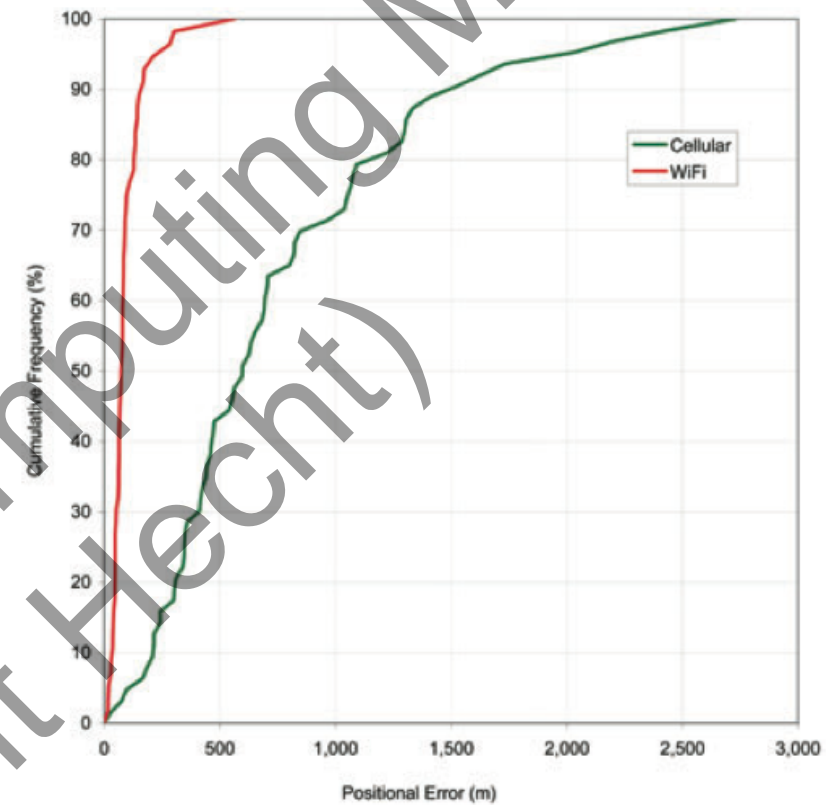
Wi-Fi Positioning Accuracy

Worse than GPS, better than cellular

Slides for Spatial Computing MOOC
(By Brent Hecht)



20m accuracy



74m accuracy
(median)

Images from "Accuracy of iPhone Locations: A Comparison of Assisted GPS, WiFi and Cellular Positioning" by Paul Zandbergen. *Transactions in GIS*, 2009, 13(s1): 5–26

Wi-Fi Positioning Accuracy

Worse than GPS, better than cellular

Can be used *in combination with*
GPS for improved accuracy

“Skyhook Location’s hybrid positioning improves upon Wi-Fi positioning accuracy up to 35% in difficult environments by leveraging signals from as few as two GPS satellites. In deep urban settings Skyhook Location uses weak GPS signals and WiFi to acquire a location 100% of the time (A-GPS works only 70% of the time). From a complete cold start, Skyhook Location delivers a full hybrid location in 4 seconds (compared to 30-60 seconds for A-GPS).”

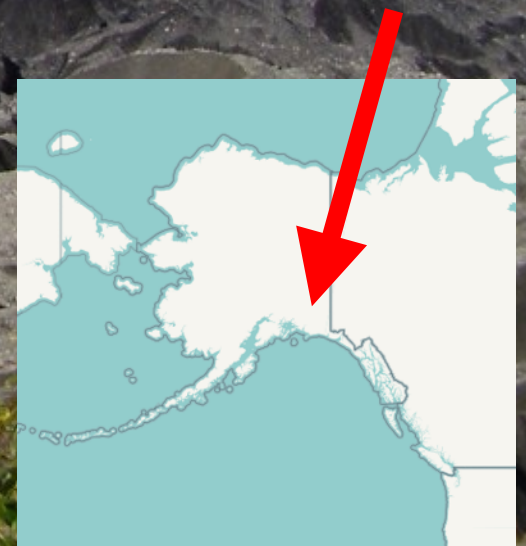
(Skyhook Wireless 2014)

SKYHOOK°

Predictors of Performance

1. Number of access points
2. Quality of fingerprint database (degrades over time, conditions)
3. Quality of machine learning algorithm in positioning phase

No Wi-Fi hotspots in range out here...



Wi-Fi Positioning provides positioning for devices without GPS.....



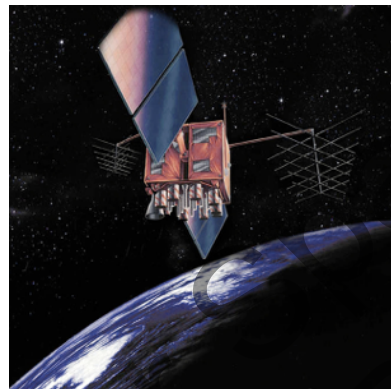
Tablets



Computers
(e.g. MacBooks)

Key Types of Signal-based Positioning

in your smartphone and in general



Signal-based
Positioning

- 1. Satellite-based Positioning
- 2. Wifi Positioning
- 3. Cellular Positioning

Cellular Positioning



1. Algorithms: Location of tower with strongest signal, Time Difference on Arrival, Angle of Arrival, Fingerprinting
2. Accuracy highly-dependent on number of towers
3. Least accurate of all three

74m accuracy
(median)

Wifi Positioning

599m accuracy
(median)

Cellular Positioning

(Zandbergen 2009)

Positioning

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Attributions

"IPad Air" by Zach Vega - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:IPad_Air.png#mediaviewer/File:IPad_Air.png

Fingerprint by Wilson Joseph from The Noun Project

"Blue iPod touch 5th Generation" by Guess Who - Created in Photoshop CS6.. Via Wikipedia - http://en.wikipedia.org/wiki/File:Blue_iPod_touch_5th_Generation.png#mediaviewer/File:Blue_iPod_touch_5th_Generation.png

"Coittower1" by en:user:Kkmd - en:Image:Coittower1.jpg. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - <http://commons.wikimedia.org/wiki/File:Coittower1.jpg#mediaviewer/File:Coittower1.jpg>

Router by Pedro Lalli from The Noun Project

"Candlestick Park 2006-08-11" by User Fds527 on en.wikipedia - From en.wikipedia; description page is (was) here. Licensed under Public domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Candlestick_Park_2006-08-11.jpg#mediaviewer/File:Candlestick_Park_2006-08-11.jpg

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SKYHOOK
WIRELESS



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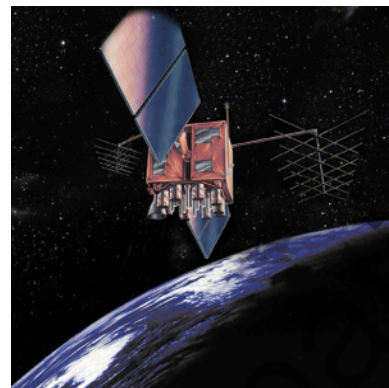


102.111.321.5



flickr

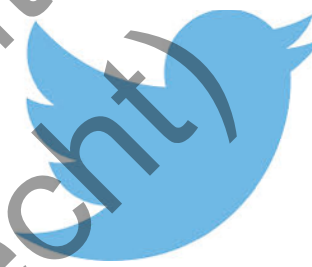
Signal-based Content-based
Positioning Positioning



Signal-based Positioning

Determining the location of a client's device
(e.g. for a mobile map, location-based service, scientific application)

102.111.321.5



flickr

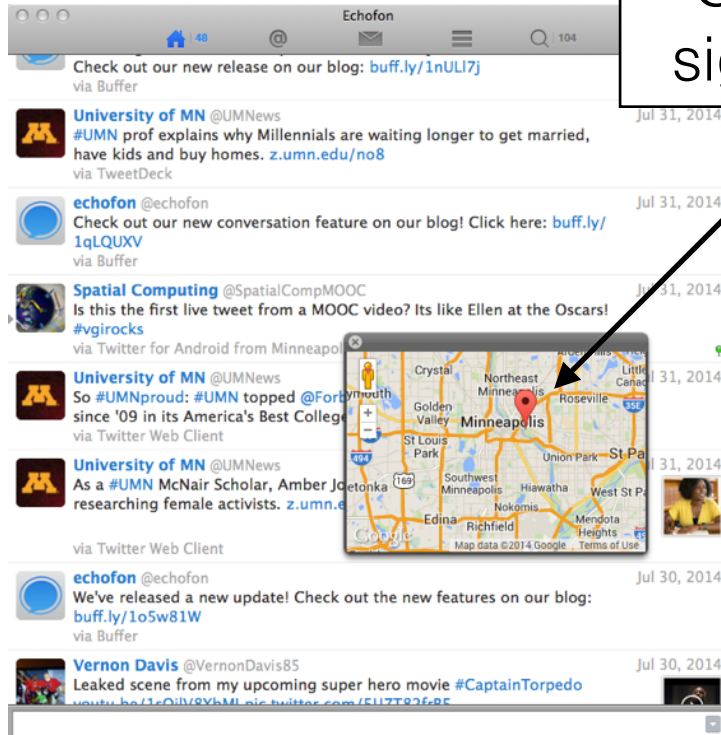
Used when no signal-based position is available

(e.g. location inference in online communities)

Content-based Positioning

Used when signal-based positioning is not useful for your needs
(e.g. need "home" not "current" location)

Geotags in tweets generally come from signal-based positioning in smartphones



Twitter API

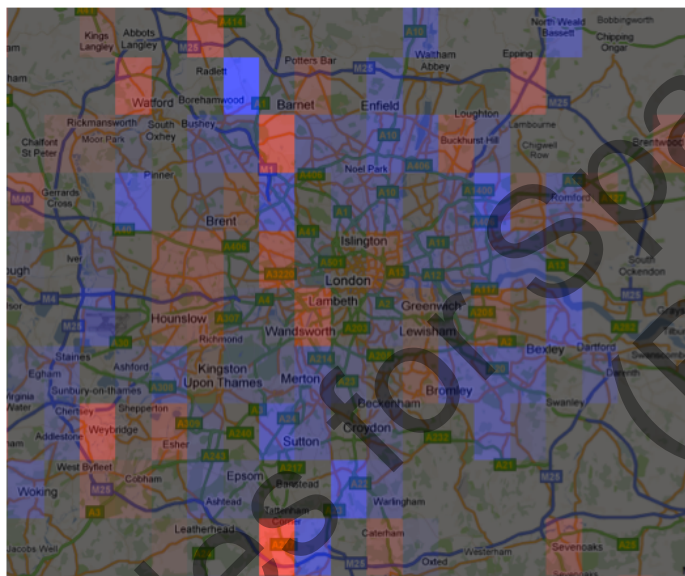
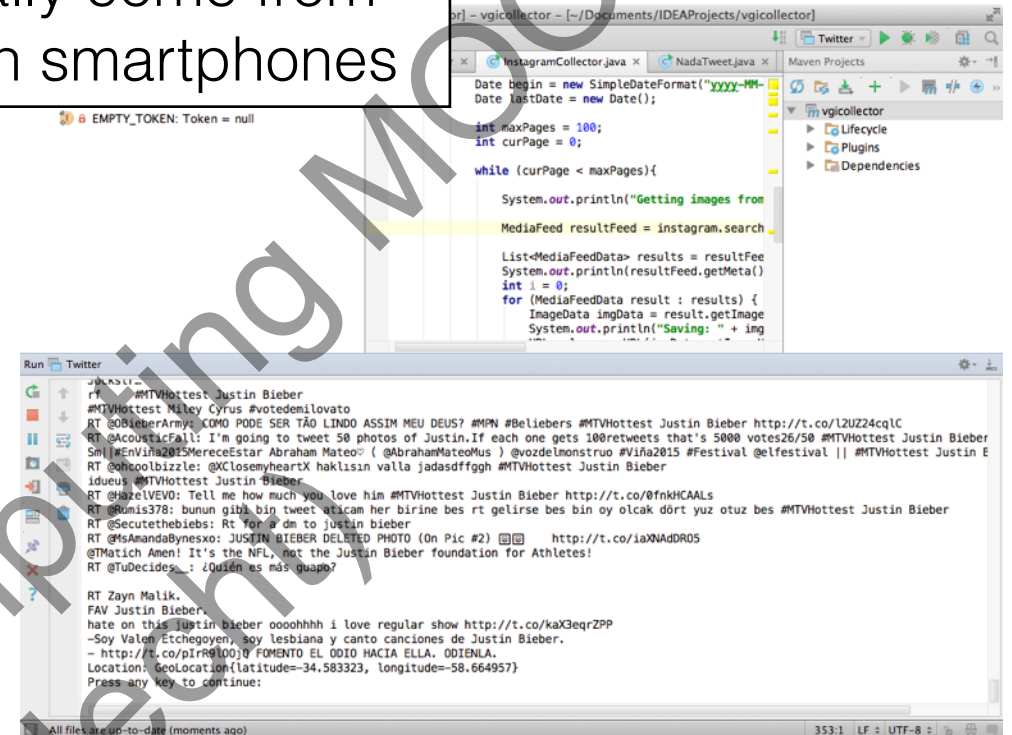
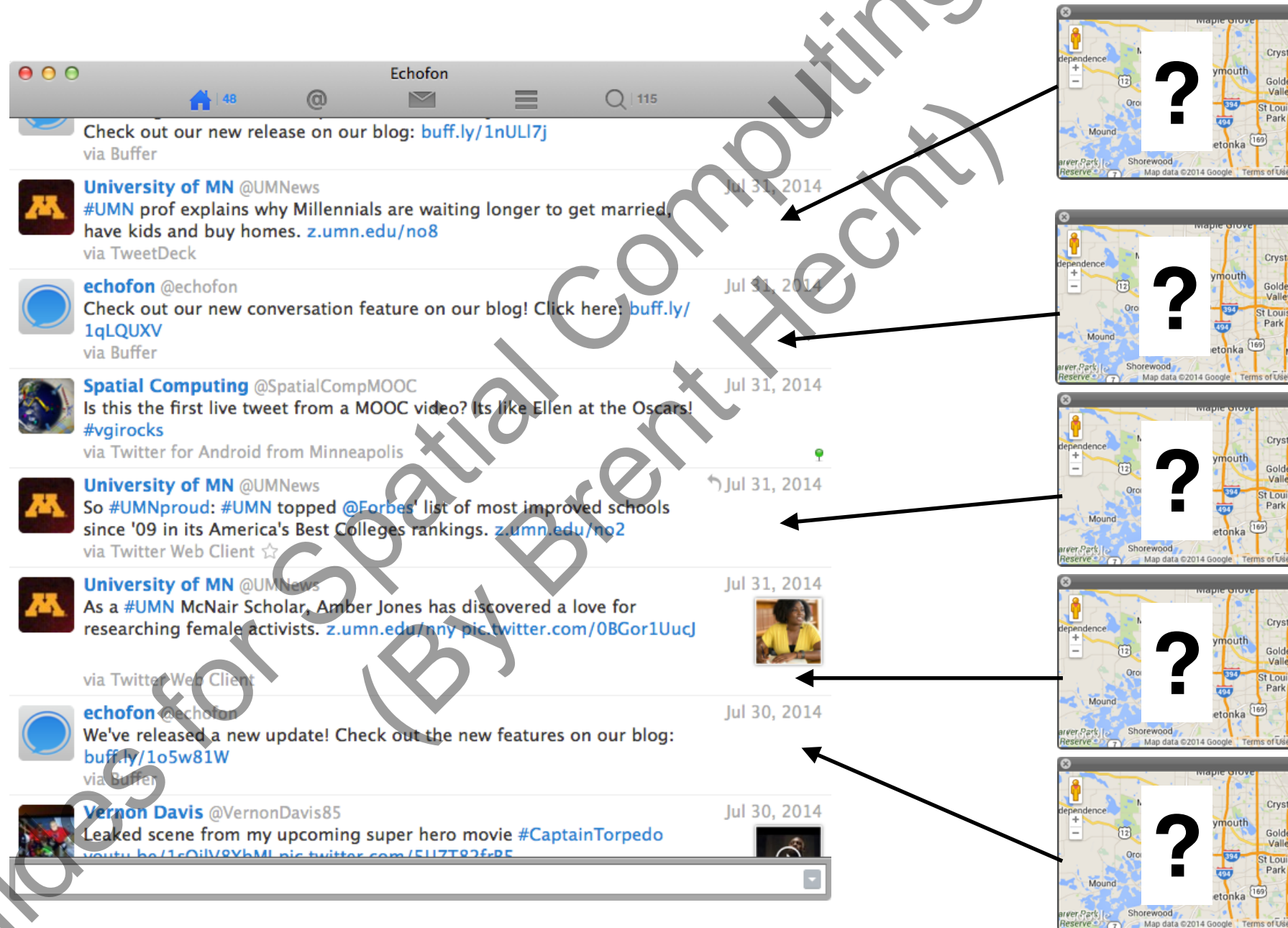


Figure 2. Mapping “Gross Community Happiness” in Greater London (best seen in color).

(Quercia et al. 2012)

Sentiment Analysis Algorithms

Only 1-3% of tweets are geotagged!



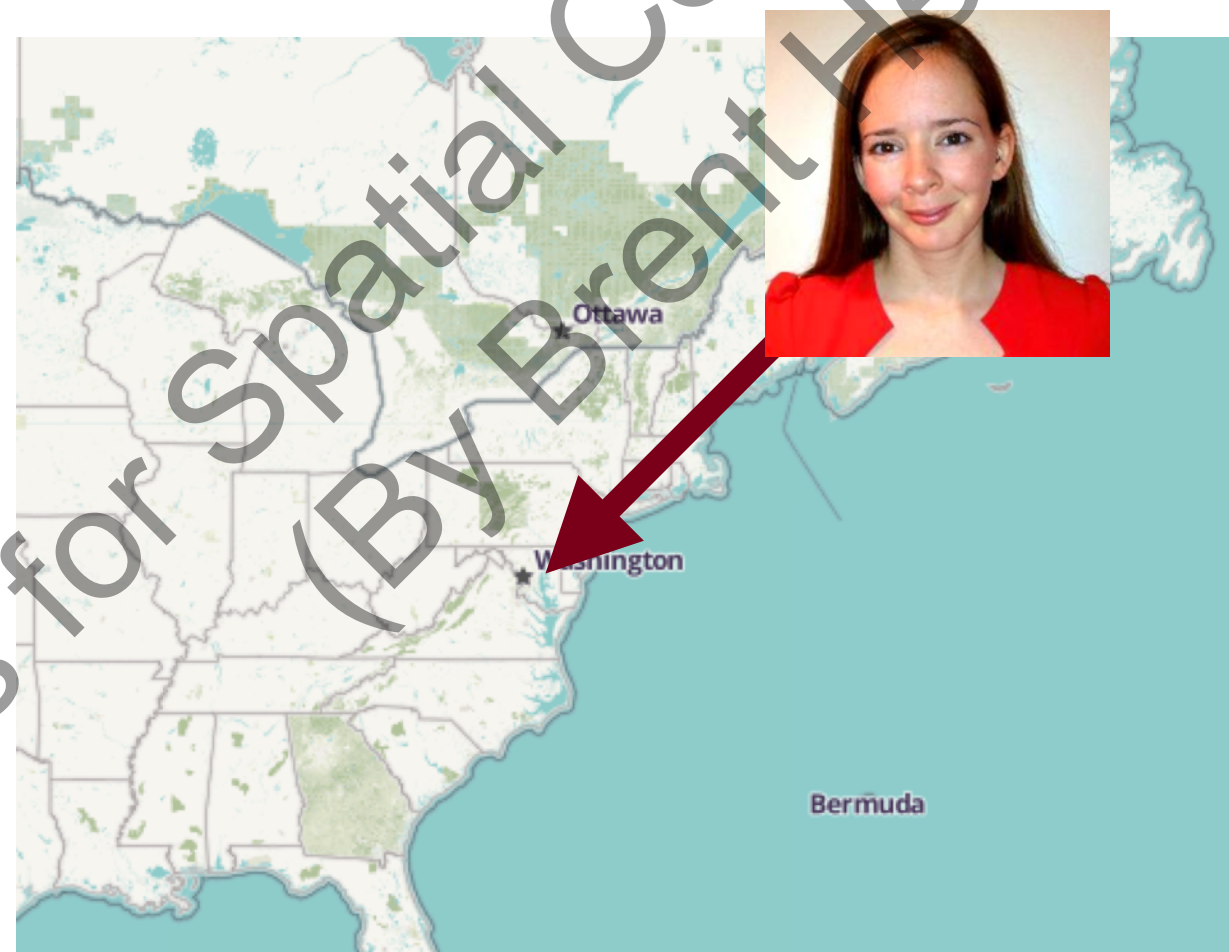


edchi edchi

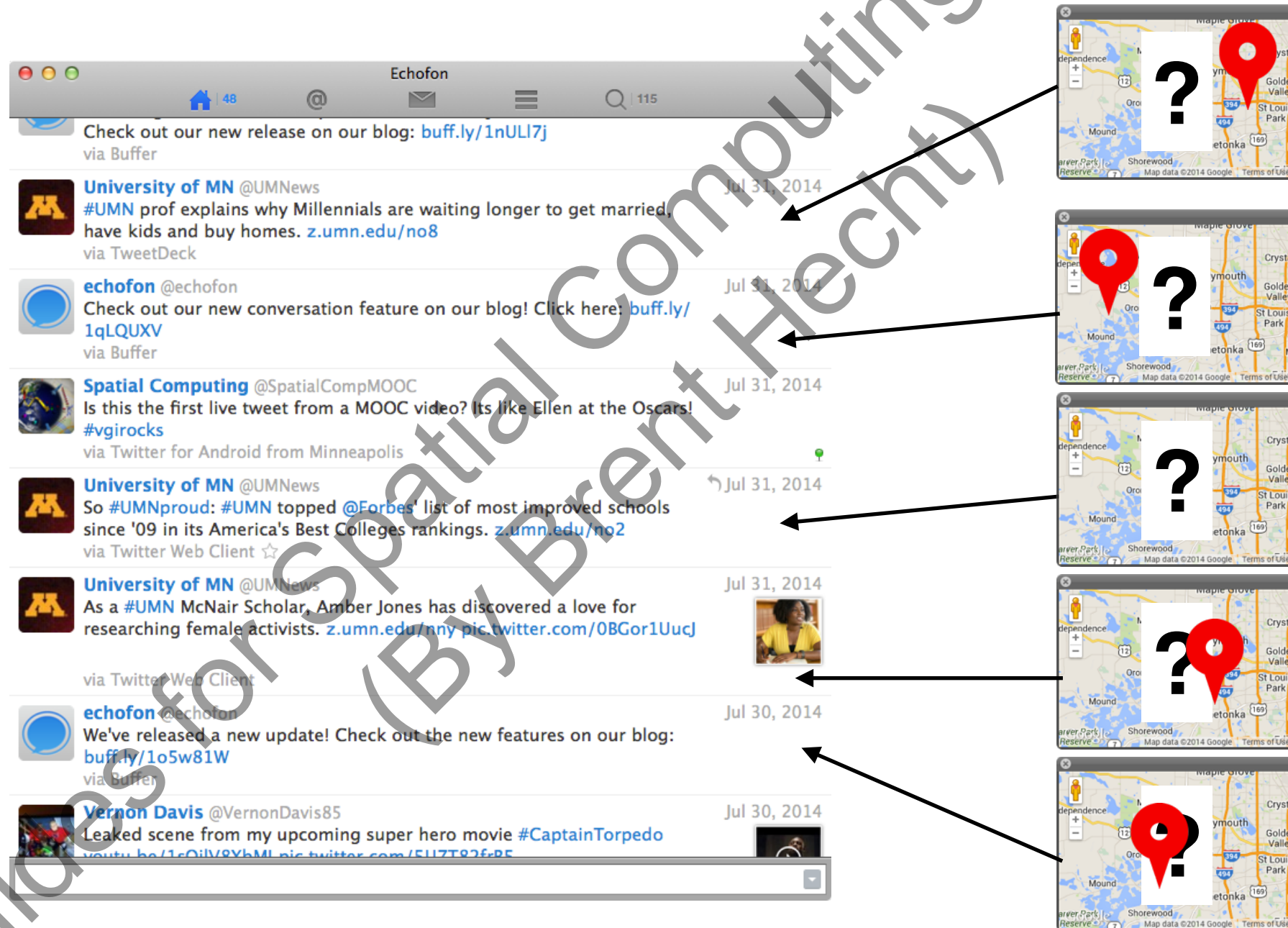
wonderful afternoon at the 20th anni. of HCI at StanfordU. Terry Winograd toasted by many, inc. my ex and current boss: S.Card and L.Page.

21 Feb

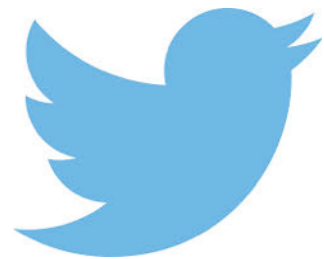




Only 1-3% of tweets are geotagged!



102.111.321.5



flickr

Content-based Positioning

The use of implicit and explicit geographic information contributed or consumed by Internet users to generate a position for these users (with or without their knowledge or consent).

We'll cover the following content-based positioning-related topics:

1 Geoparsing: Extracting place names from natural language text

2 “Home Locations”: The dynamics of location fields in user profiles (and more)

Positioning

Spatial Computing – University of Minnesota

Attributions

Twitter location maps © OpenStreetMap contributors (www.openstreetmap.org/copyright)

"Cell tower in jovel chiapas" by Leogeograph - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Cell_tower_in_jovel_chiapas.JPG#mediaviewer/File:Cell_tower_in_jovel_chiapas.JPG

["Wifi"] By RRZEicons (Own work) [CC-BY-SA-3.0 (<http://creativecommons.org/licenses/by-sa/3.0>)], via Wikimedia Commons

Address, City, State, and/or Zip
3405 Michigan Union 530 S. State Street

Current City: Ann

- Ann Arbor, Michigan
51,001 like this · 752,64...
- Lake Ann, Michigan
785 like this · 8,350 wer...
- Saint Ann'S Bay, Saint A...
742 like this · 3,583 wer...
- Saint Ann, Missouri
533 like this · 3,920 wer...

Location: Ann Arbor, MI
Where in the world are you?

家乡: 安

- 安庆
- 安顺
- 安康

SKYHOOK
WIRELESS

DBpedia

YAHOO!
BOSS

Google
Developers

Positioning

Spatial Computing – University of Minnesota



We'll cover the following content-based positioning-related topics:

1 Geoparsing: Extracting place names from natural language text

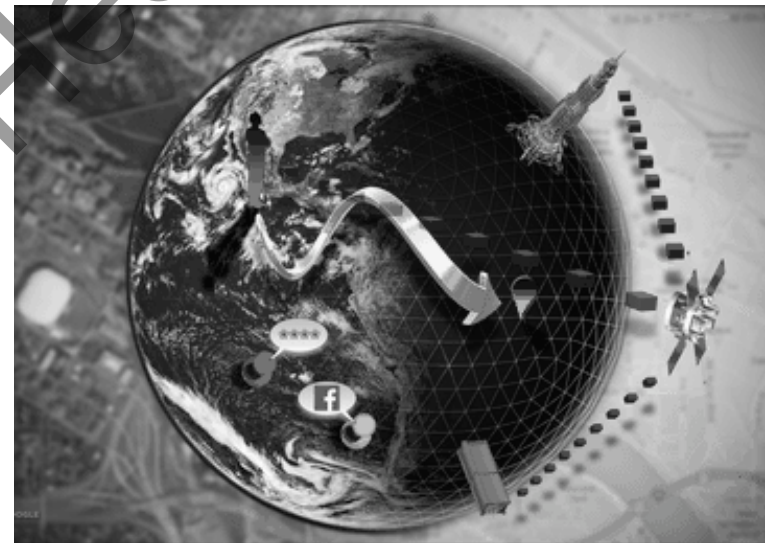
2 “Home Locations”: The dynamics of location fields in user profiles (and more)

Geographic Information Retrieval (GIR)



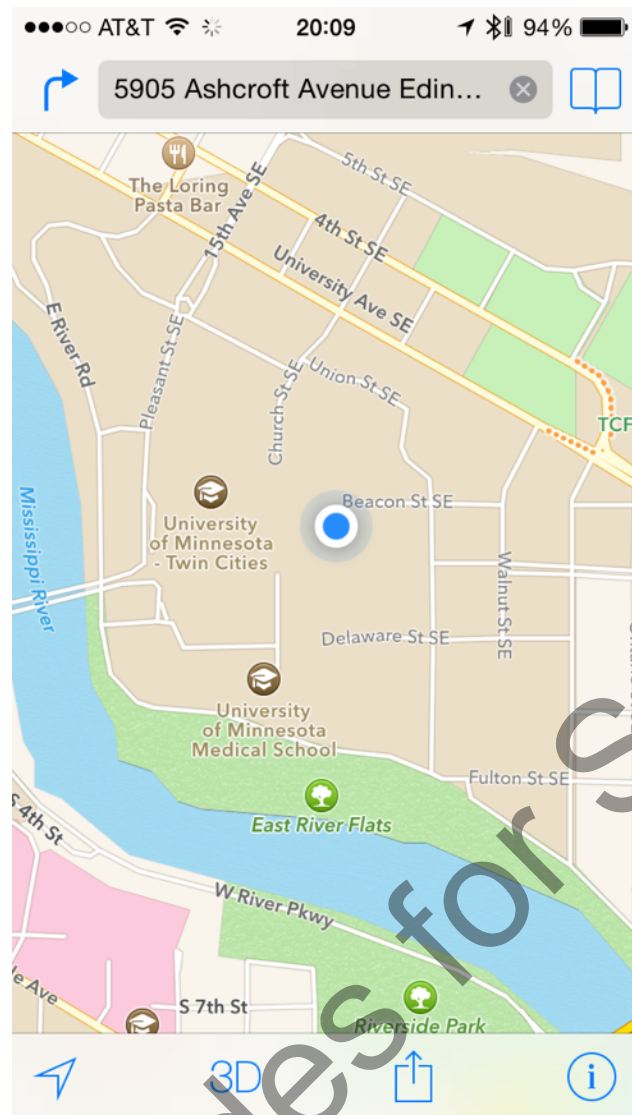
Search

+

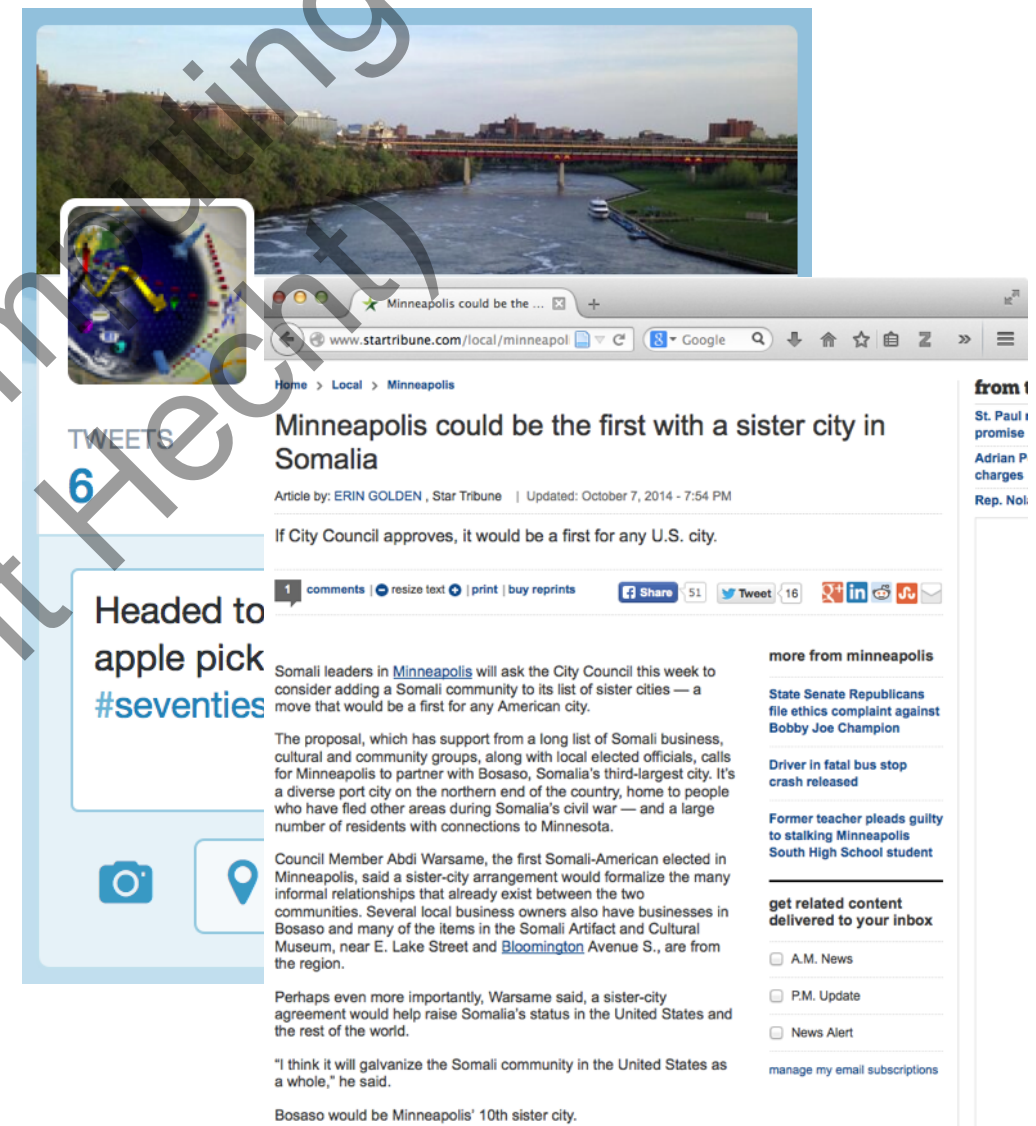


Spatial
Computing

Geoparsing and geocoding are useful for both...



...positioning for **users**



...positioning for **documents**



Spatial Computing

@SpatialCompMOOC

TWEETS

6

FOLLOWING

8

FOLLOWERS

133

Headed to Washington to do some
apple picking, jamming out to Chicago!
[#seventiesmusic](#) [#itsraining](#)

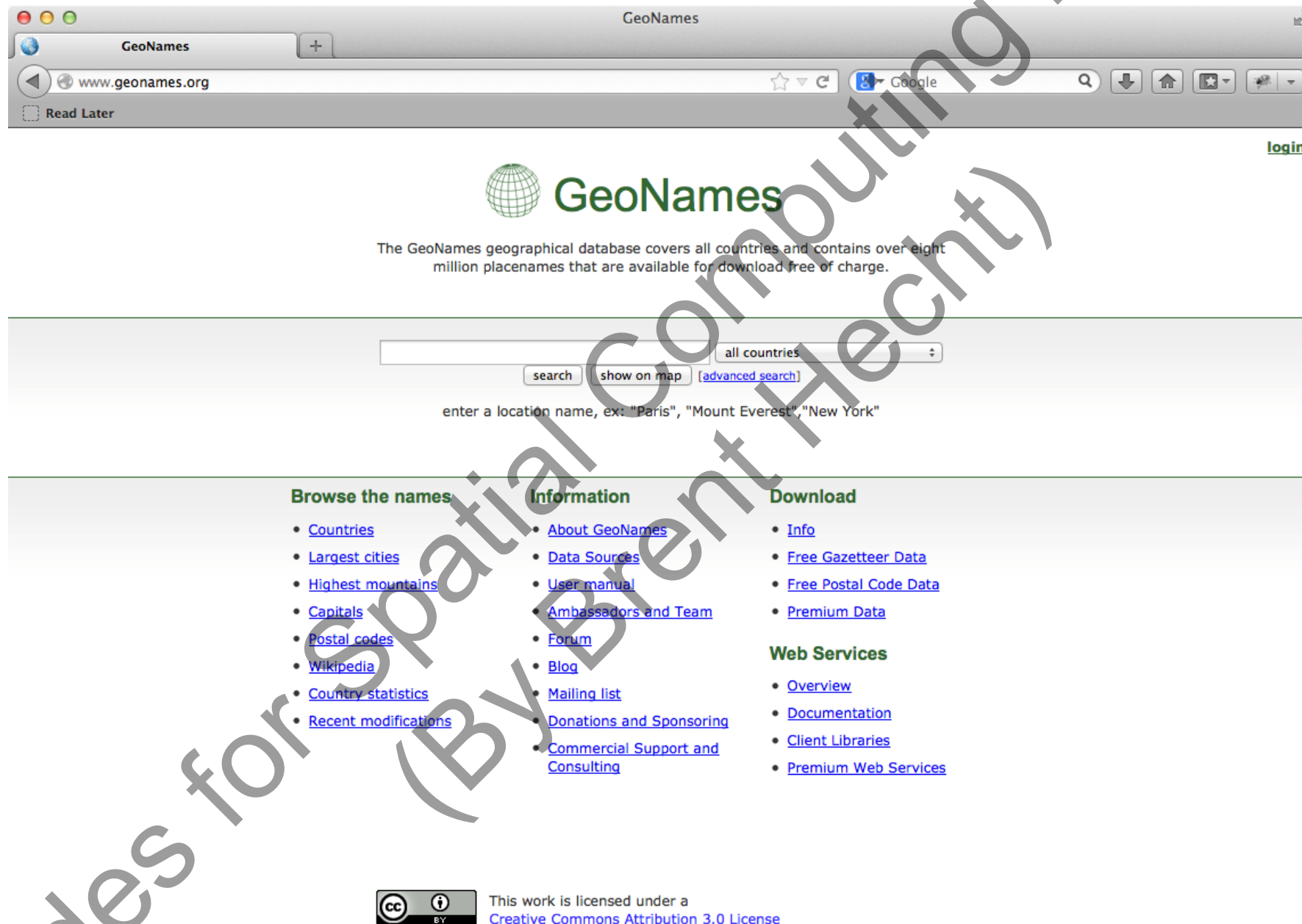


42



Tweet

Gazetteers



geonames.org

Gazetteers

<place name,
spatial footprint (**x**)>

<“Minneapolis, MN”
(44.9833, -93.2667)>

<place name,
spatial footprint (**x**)>

<“McCarthy, AK”,
(61.4328° N, -142.9108)>

<place name,
spatial footprint (**x**)>

<“Riga, Latvia”,
(56.9489, -24.1064)>



Spatial Computing

@SpatialCompMOOC

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133

Headed to **Washington** to do some
apple picking, jamming out to **Chicago!**
[#seventiesmusic](#) [#itsraining](#)



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Tweet

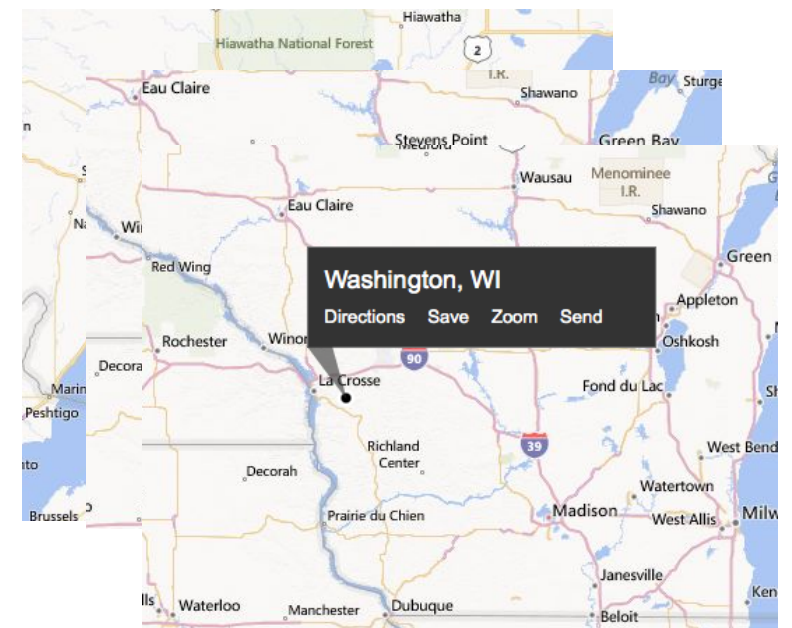
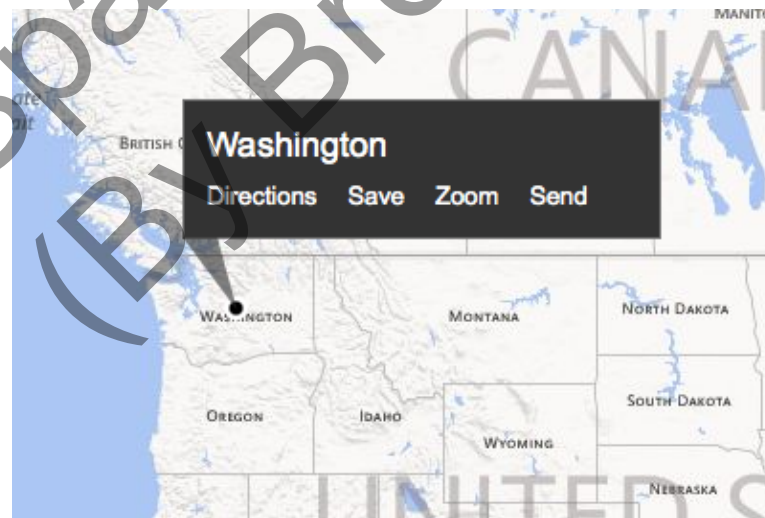
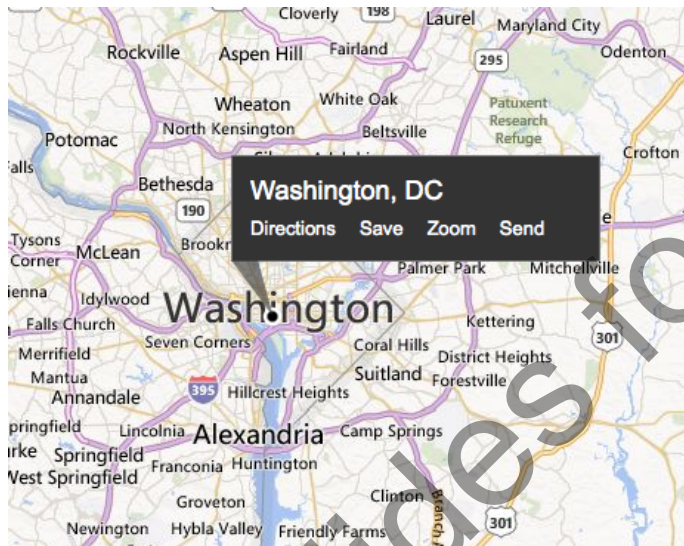
Ambiguity

Ambiguity is a fundamental problem in
geographic information retrieval
(and information retrieval and natural language
processing more generally)

Geo/Geo Ambiguity

one place name (toponym) → more than one place

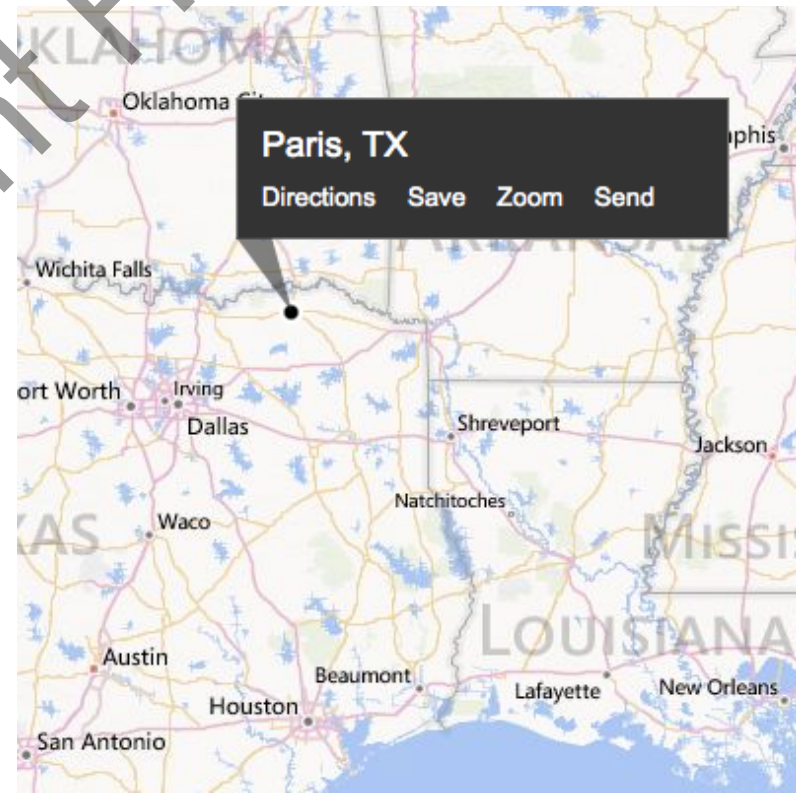
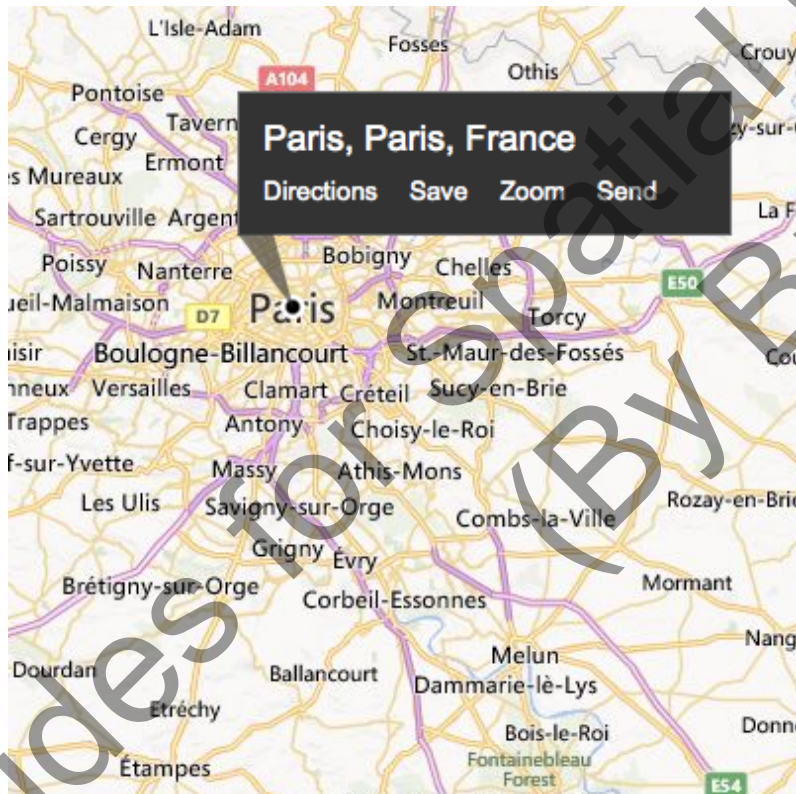
“Washington”



Geo/Geo Ambiguity

one place name (toponym) → more than one place

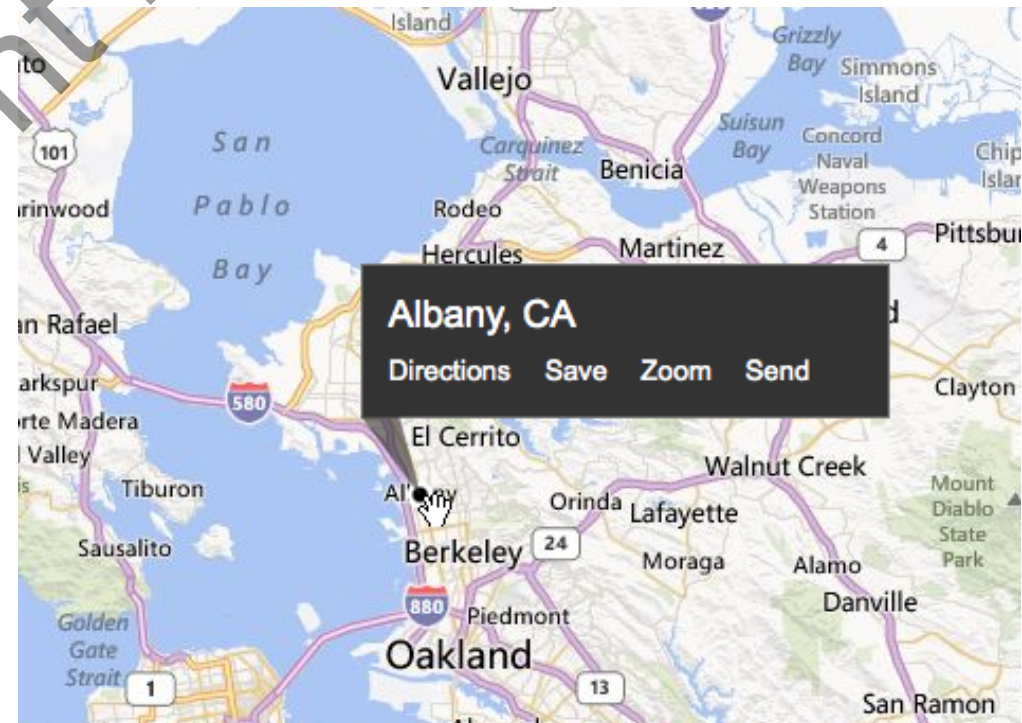
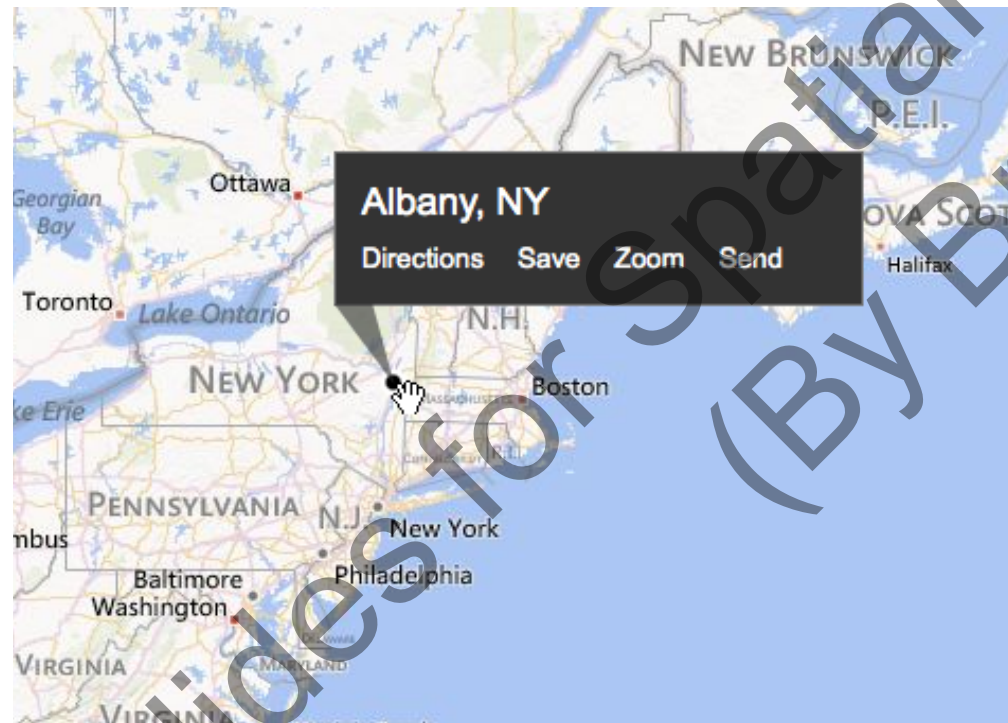
“Paris”



Geo/Geo Ambiguity

one place name (toponym) → more than one place

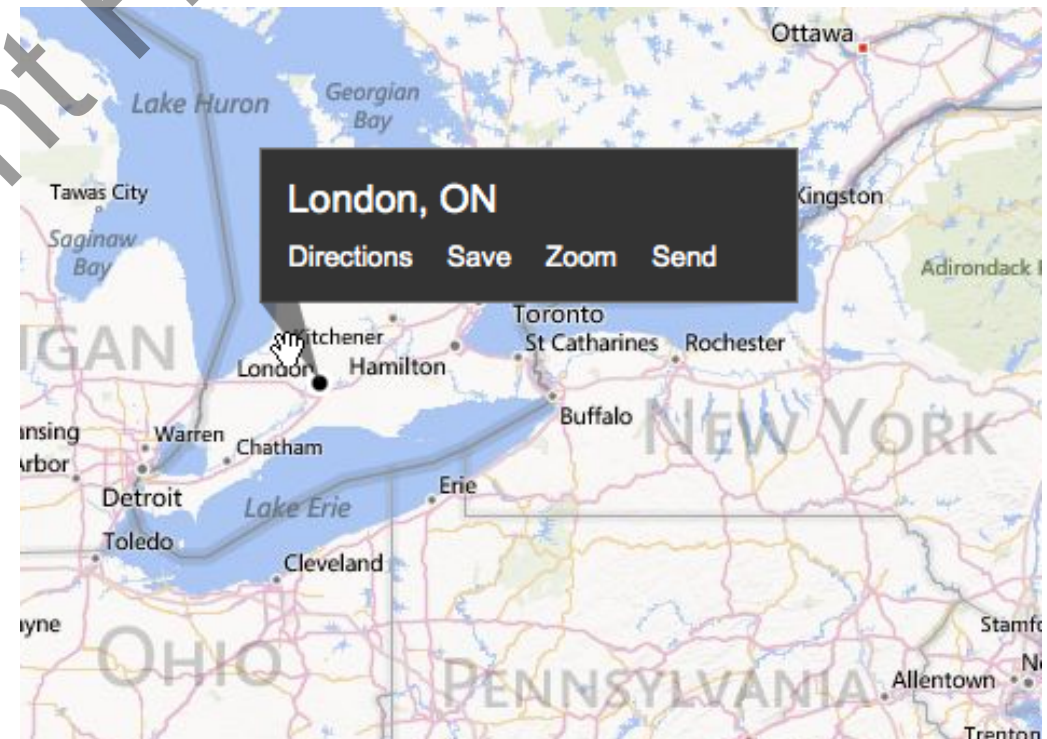
“Albany”



Geo/Geo Ambiguity

one place name (toponym) → more than one place

“London”



Geo/Non-Geo Ambiguity

one term $\rightarrow$ a place name and ≥ 1 other meaning

Slides for Spatial Computing MOOC
(By Brent Hecht)



Spatial Computing

@SpatialCompMOOC

TWEETS

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Headed to Washington to do some
apple picking, jamming out to **Chicago!**
[#seventiesmusic](#) [#itsraining](#)



42

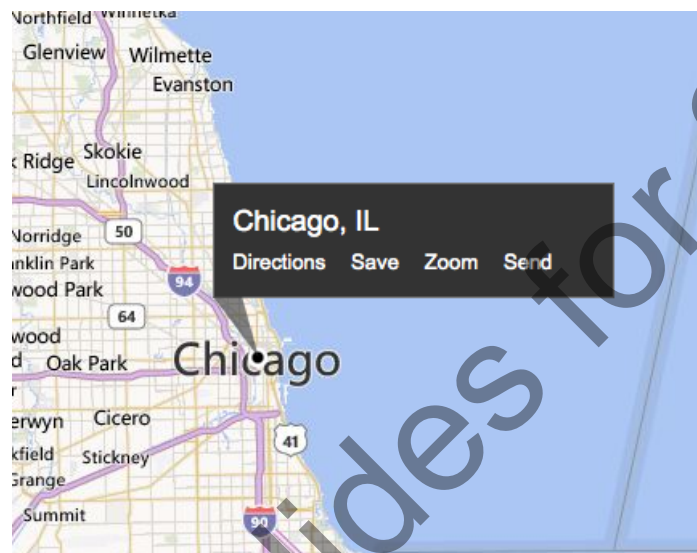


Tweet

Geo/Non-Geo Ambiguity

one term → a place name and ≥ 1 other meaning

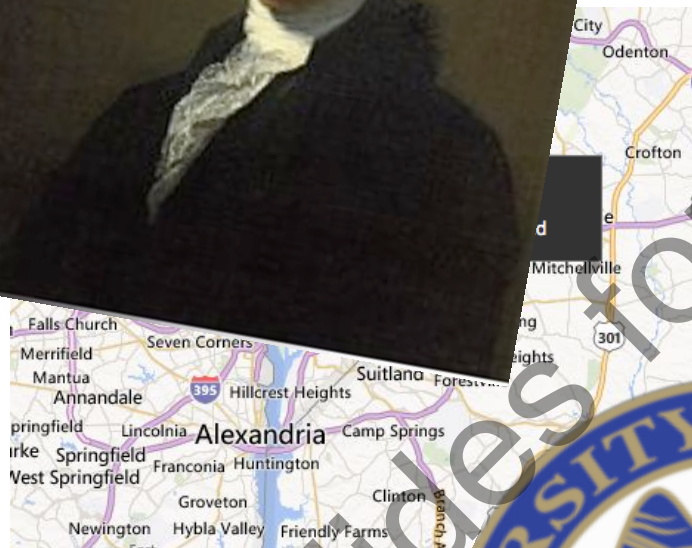
“Chicago”

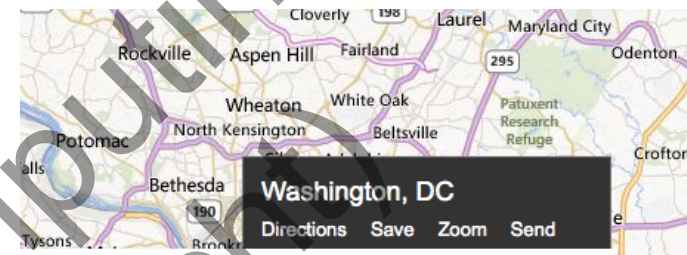
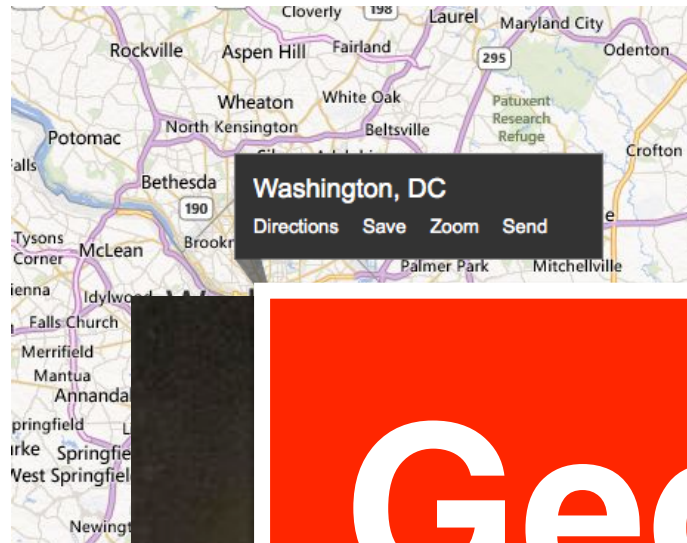


Geo/Non-Geo Ambiguity

one place name (toponym) → more than one place

“Washington”

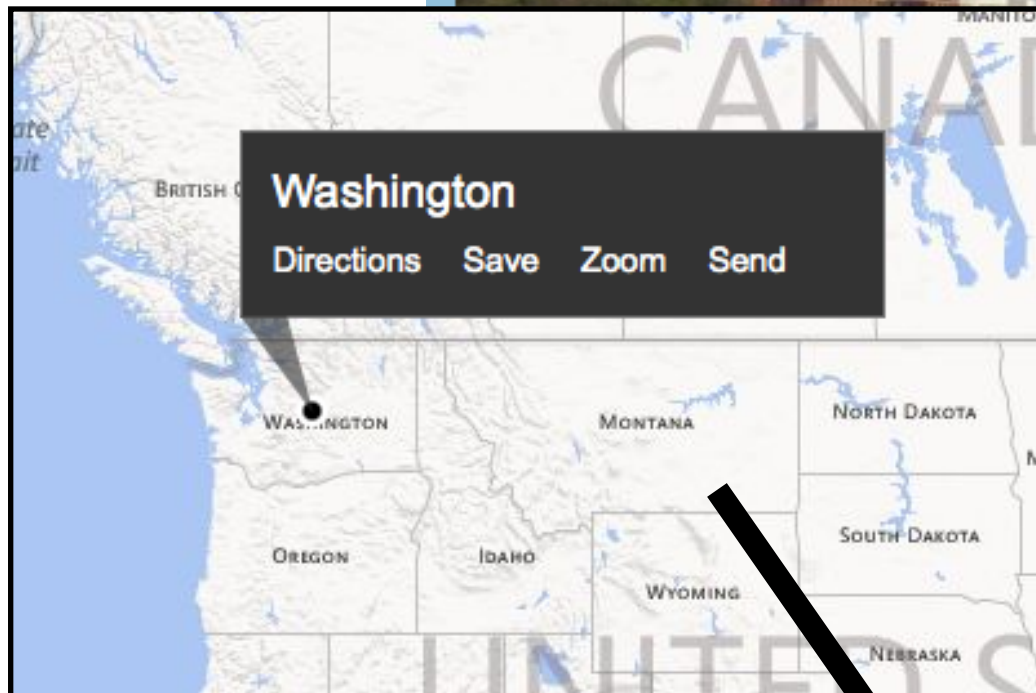




Geoparsing!

Geo/Non-Geo
Ambiguity

Geo/Geo Ambiguity



Spatial Computing
SpatialCompMOOC
FOLLOWING 6
FOLLOWERS 8
133



Headed to Washington to do some
apple picking, jamming out to Chicago!
#seventiesmusic #itsraining



42

Tweet

SemanticRelatedness(A, B) =

A single numeric estimate of the number and strength of relationships between concepts A and B.

CONCEPT A



CONCEPT B



**$SR(A, B)$
= High**

Dr. Shashi Shekhar

Spatial Computing

SemanticRelatedness(A, B) =

A single numeric estimate of the number and strength of relationships between concepts A and B.

CONCEPT A



Dr. Shashi Shekhar

CONCEPT B



Garth Brooks

SR(A,B)

= High

LOW



Spatial Computing

@SpatialCompMOOC

TWEETS

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FOLLOWING

8

FOLLOWERS

133

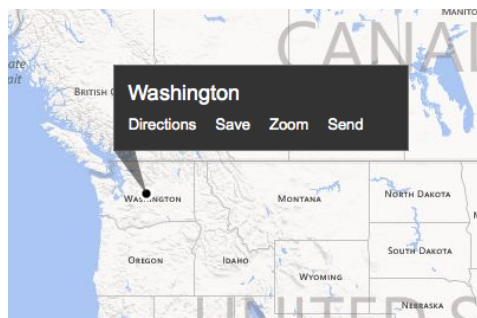
Headed to Washington to do some
apple picking, jamming out to Chicago!
#seventiesmusic #itsraining



42



Tweet



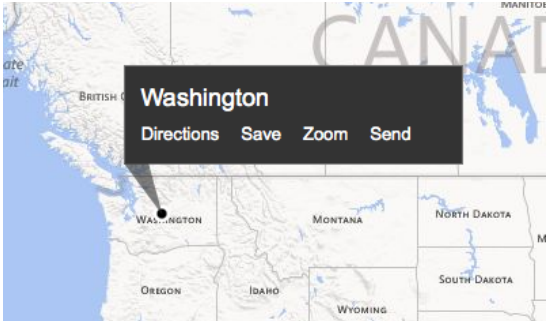
Washington state is well-known for...

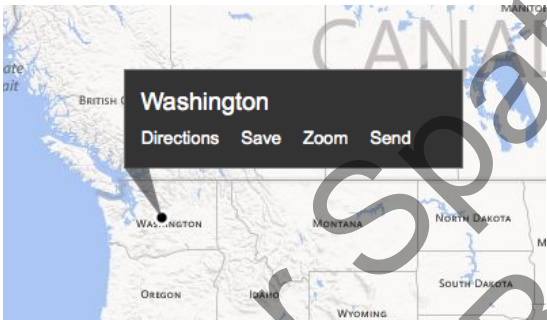


...Apples

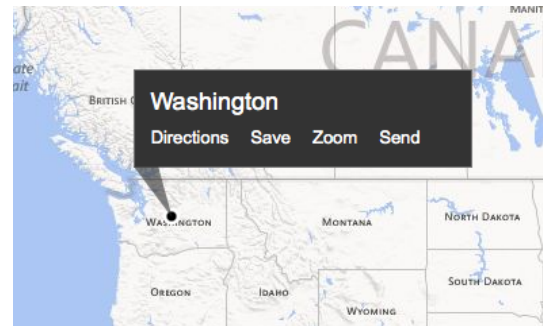


...Rain

SR( , “apple picking”) = High

SR( , “#its raining”) = High

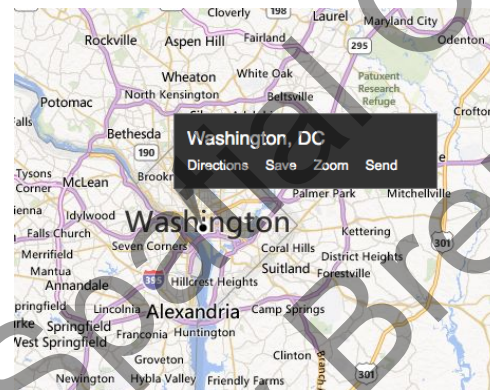
SR(



, “apple
picking”)

>

SR(

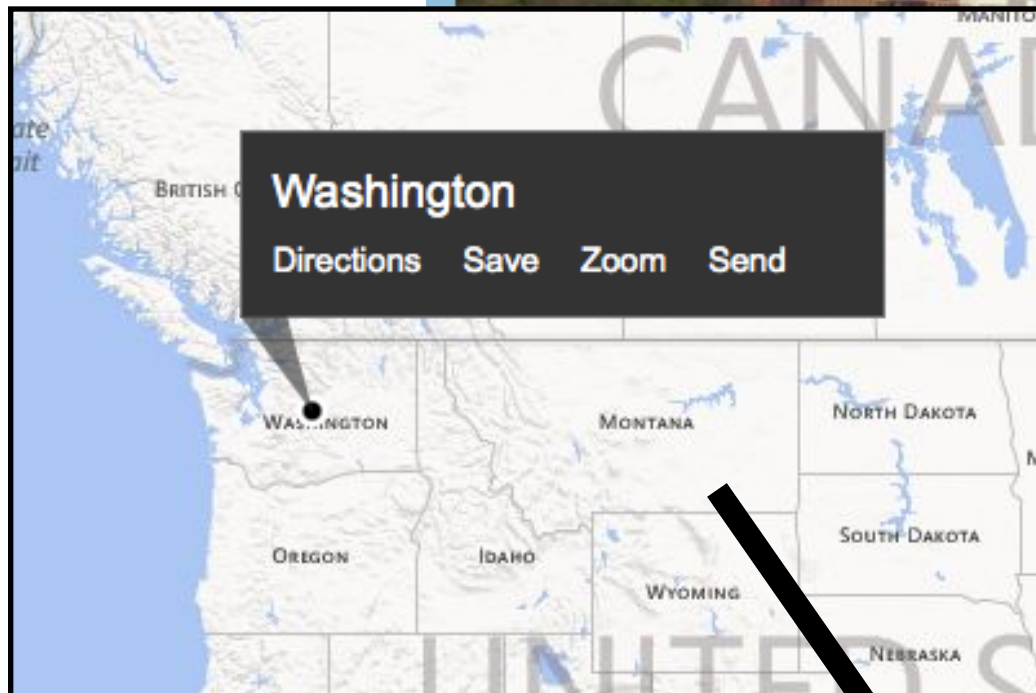


, “apple
picking”)

SR(



, “apple
picking”)



Spatial Computing

SpatialCompMOOC

6 FOLLOWING

8 FOLLOWERS

6

8

133

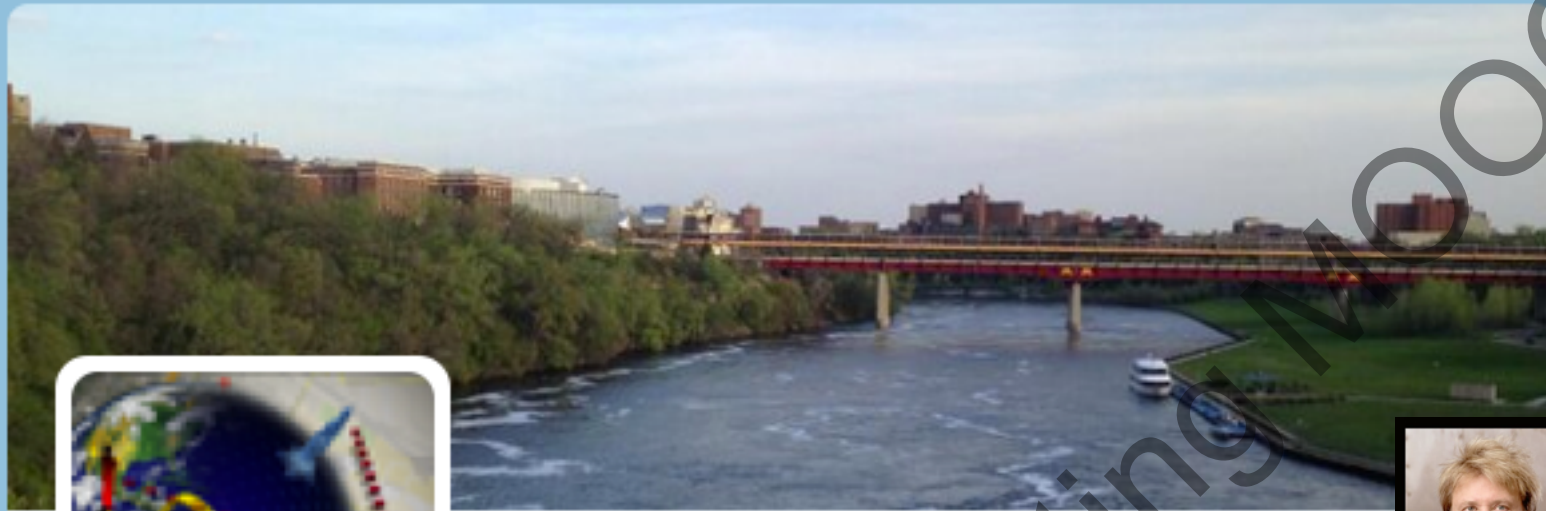
Headed to Washington to do some
apple picking, jamming out to Chicago!
#seventiesmusic #itsraining



42



Tweet



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@SpatialCompMOOC

TWEETS

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FOLLOWING

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133



Headed to Washington to do some
apple picking, jamming out to Chicago!
#seventiesmusic #itsraining



42

 Tweet

Tools



DBPedia Spotlight



Geoparsing
coming soon!

WikiBrain

BOSS PlaceSpotter API

PlaceSpotter is a web service that identifies places mentioned in text, disambiguates those places, and returns unique identifiers (WOEIDs) for each. This also includes information about how many times the place was found in the text, and where in the text it was found.

Yahoo! BOSS
PlaceSpotter API



Berico Technologies'
CLAVIN

Positioning

Spatial Computing – University of Minnesota

Attributions

Search by Marcos Folio from The Noun Project

"Redskins uniforms12" by Washington Redskins (logos and uniforms)Fma12 (vector graphics image) - Own work.
Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Redskins_uniforms12.png#mediaviewer/File:Redskins_uniforms12.png

"Red Apple" by Abhijit Tembhekar from Mumbai, India - Nikon D80 Apple. Licensed under Creative Commons Attribution 2.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Red_Apple.jpg#mediaviewer/File:Red_Apple.jpg

"22 Regen ubt" by Tomasz Sienicki [user: tsca, mail: tomasz.sienicki at gmail.com] - Own work. Licensed under Creative Commons Attribution 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:22_Regen_ubt.jpeg#mediaviewer/File:22_Regen_ubt.jpeg

Address, City, State, and/or Zip
3405 Michigan Union 530 S. State Street

Current City: Ann

- Ann Arbor, Michigan
51,001 like this · 752,64...
- Lake Ann, Michigan
785 like this · 8,350 wer...
- Saint Ann'S Bay, Saint A...
742 like this · 3,583 wer...
- Saint Ann, Missouri
533 like this · 3,920 wer...

Location: Ann Arbor, MI
Where in the world are you?

家乡: 安

- 安庆
- 安顺
- 安康

SKYHOOK
WIRELESS



Positioning

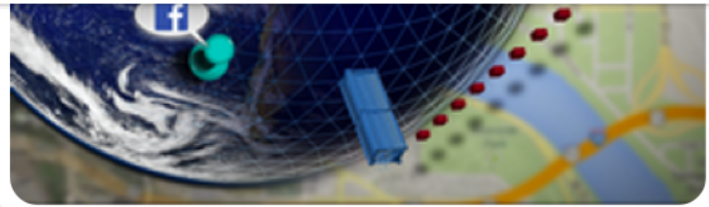
Spatial Computing – University of Minnesota



We'll cover the following content-based positioning-related topics:

1 **Geoparsing:** Extracting place names from natural language text

2 **“Home Locations”:** The dynamics of location fields in user profiles (and more)



Spatial Computing

@SpatialCompMOOC

The Twitter account for the University of Minnesota's Spatial Computing MOOC taught by Dr. @bhecht and Dr. Shekhar Shekhar

Minneapolis, MN

coursera.org/course/spatial...

1 Photo or video



Who to follow · Refresh · View all



reed.co.uk @reedcouk

Tweets

Tweets & replies

Photos & videos



Spatial Computing @SpatialCompMOOC · Sep 29

Module 2 opens in < 1 hour! This week, we'll cover the critical spatial query languages (think SQL, but optimized for spatial)

1



Spatial Computing @SpatialCompMOOC · Sep 25

Learn more about your instructors at their websites: @bhecht /1t0OUUpV and Dr. Shekhar: bit.ly/1t0OUUpU



Spatial Computing @SpatialCompMOOC · Sep 22

Welcome to Module 1 of the University of Minnesota's Spatial Computing MOOC!

2



Spatial Computing @SpatialCompMOOC · Jul 31



Brent Hecht



Brent

Home



Brent Hecht

Update Info

View Activity Log

10+



Timeline

About

Photos

Friends 460

More ▾



About

Overview

Work and Education

Places You've Lived

Contact and Basic Info

Family and Relationships

Details About You

Life Events

CURRENT CITY AND HOMETOWN

Current City



Minneapolis, Minnesota

Friends ▾

Save Changes

Cancel

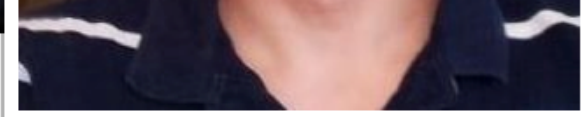


Add your hometown

OTHER PLACES LIVED



Add a place



Timeline

About

Photos

Friends 29 Mutual

More ▾

ABOUT

 **Assistant Professor at University of Minnesota - Twin Cities**

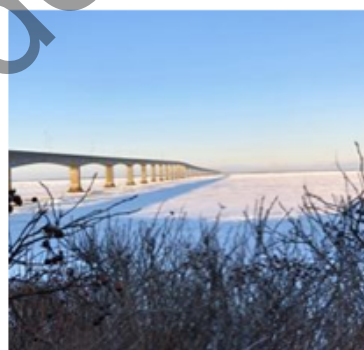
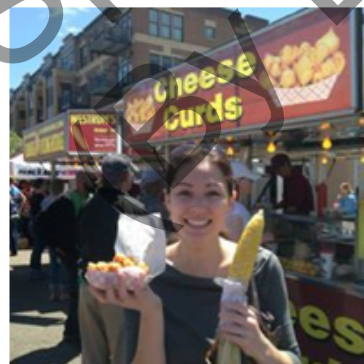
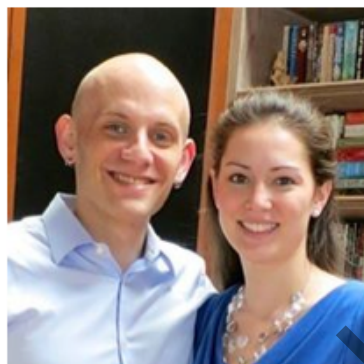
Past: Northwestern University and Microsoft Research

 **Studied Computer Science at Northwestern University**

Past: University of California, Santa Barbara and Macalester College

 **Lives in Minneapolis, Minnesota**

PHOTOS · 100



Brent Hecht shared a link.

March 10

A Crash Course in Modern Geography for Researchers and Practitioners

Thanks to the rise of ubiquitous computing, location-based ser content, and related phenomena, geography plays an increasi the work of HCI researchers and practitioners. Through recent integrate the geography and HCI communities like last year'...

[SITES.GOOGLE.COM](#)

Unlike · Share

 You and 6 others like this.

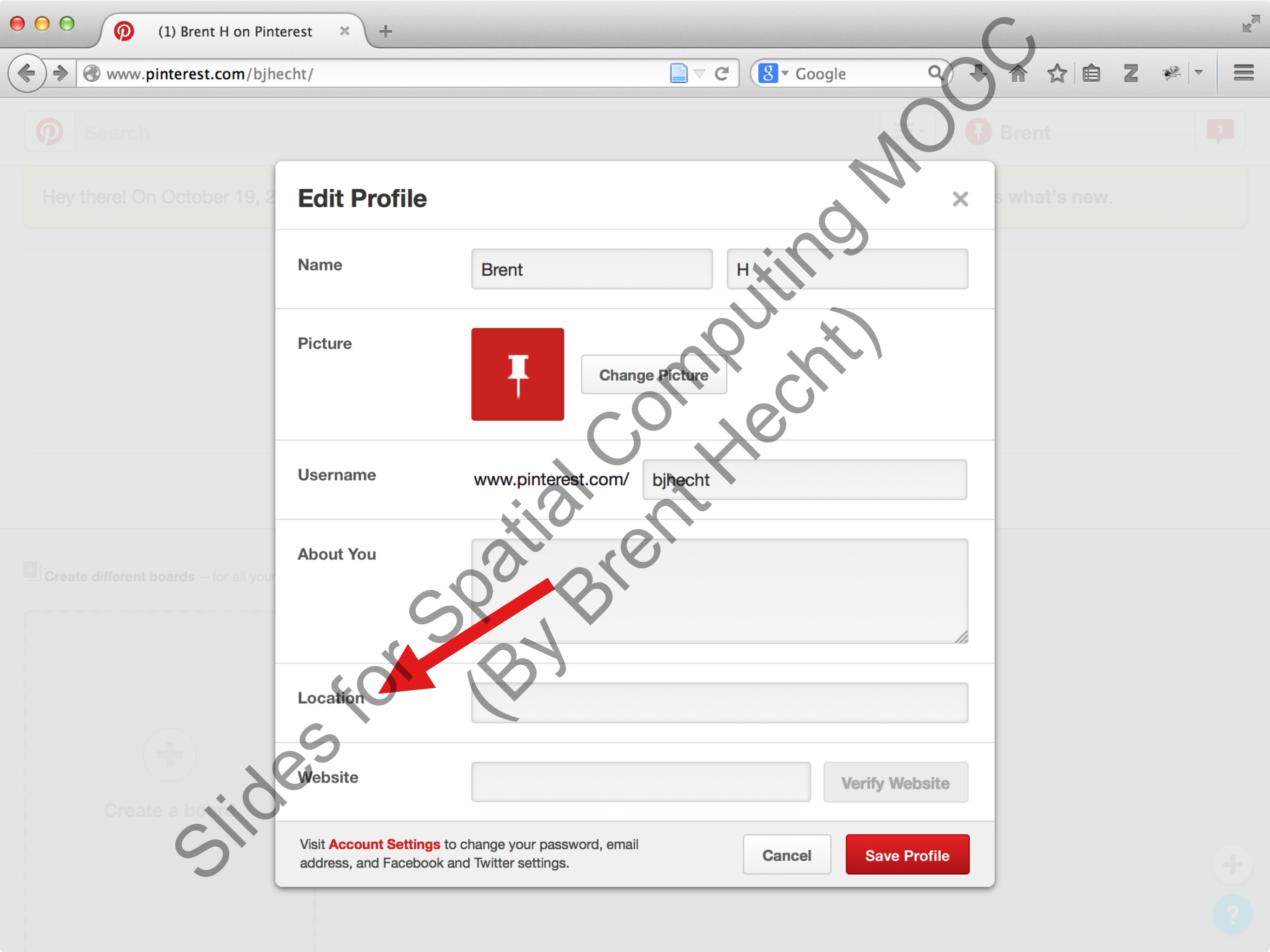


Brent Hecht

March 3

Happy to announce that Steph and I are engaged! — w





Search



Brent



Hey there! On October 19, 2018

what's new.

Edit Profile



Name

Brent

H

Picture



Change Picture

Username

www.pinterest.com/

bjhecht

About You

Location

Website

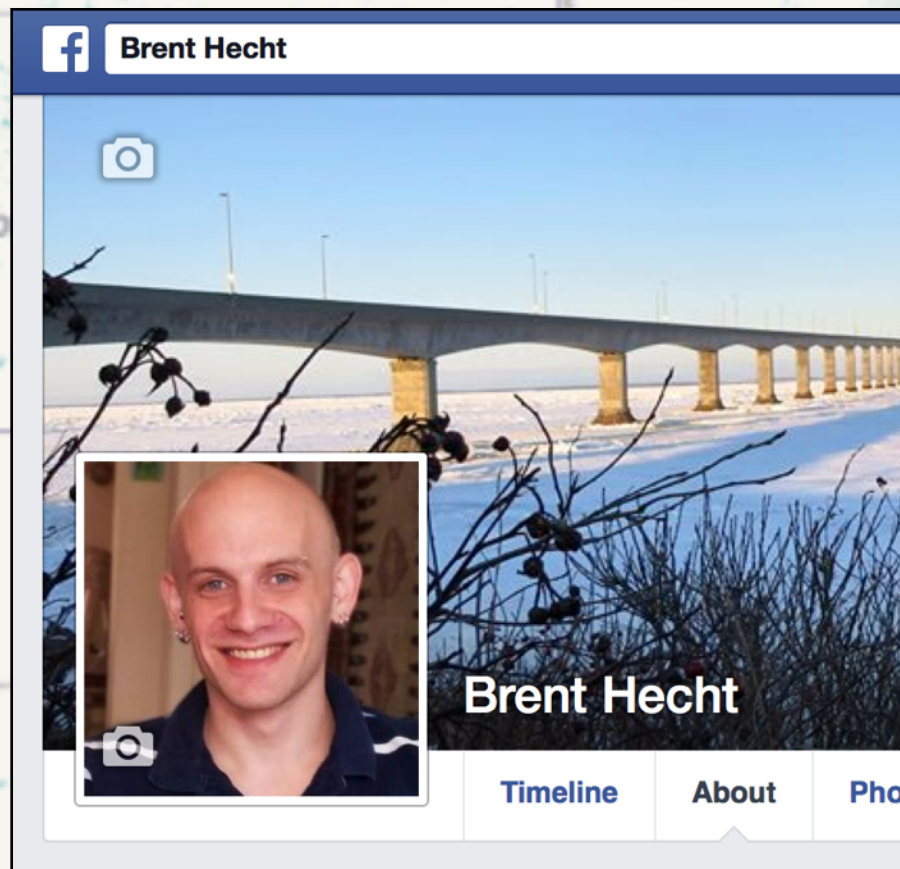
Verify Website

Visit **Account Settings** to change your password, email address, and Facebook and Twitter settings.

Cancel

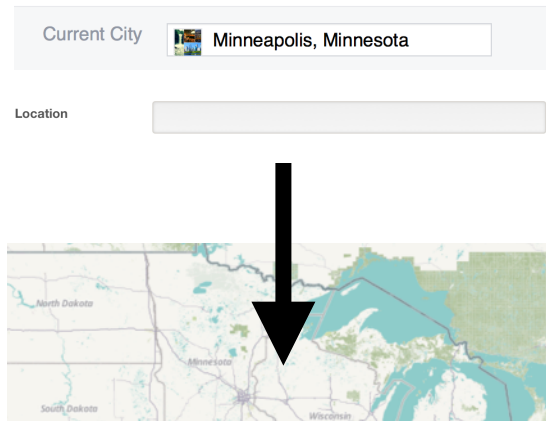
Save Profile

Slides for Spatial Computing MOOC (By Brent Hecht)



Slides for Spatial Computing MOOC
(By Brent Hecht)

Structure of the rest of this video:



Go over **how** to use location fields to position users.



Understand the **advantages** and **disadvantages** of location field positioning.

Wrap-up positioning with discussion of **location-inference attacks**.

Brent Hecht

Update Info

View Activity Log

10+

Timeline

About

Photos

Friends 460

More

CURRENT CITY AND HOMETOWN

Current City



Minneapolis, Minnesota

Friends

Save Changes

Cancel

+

Add your hometown

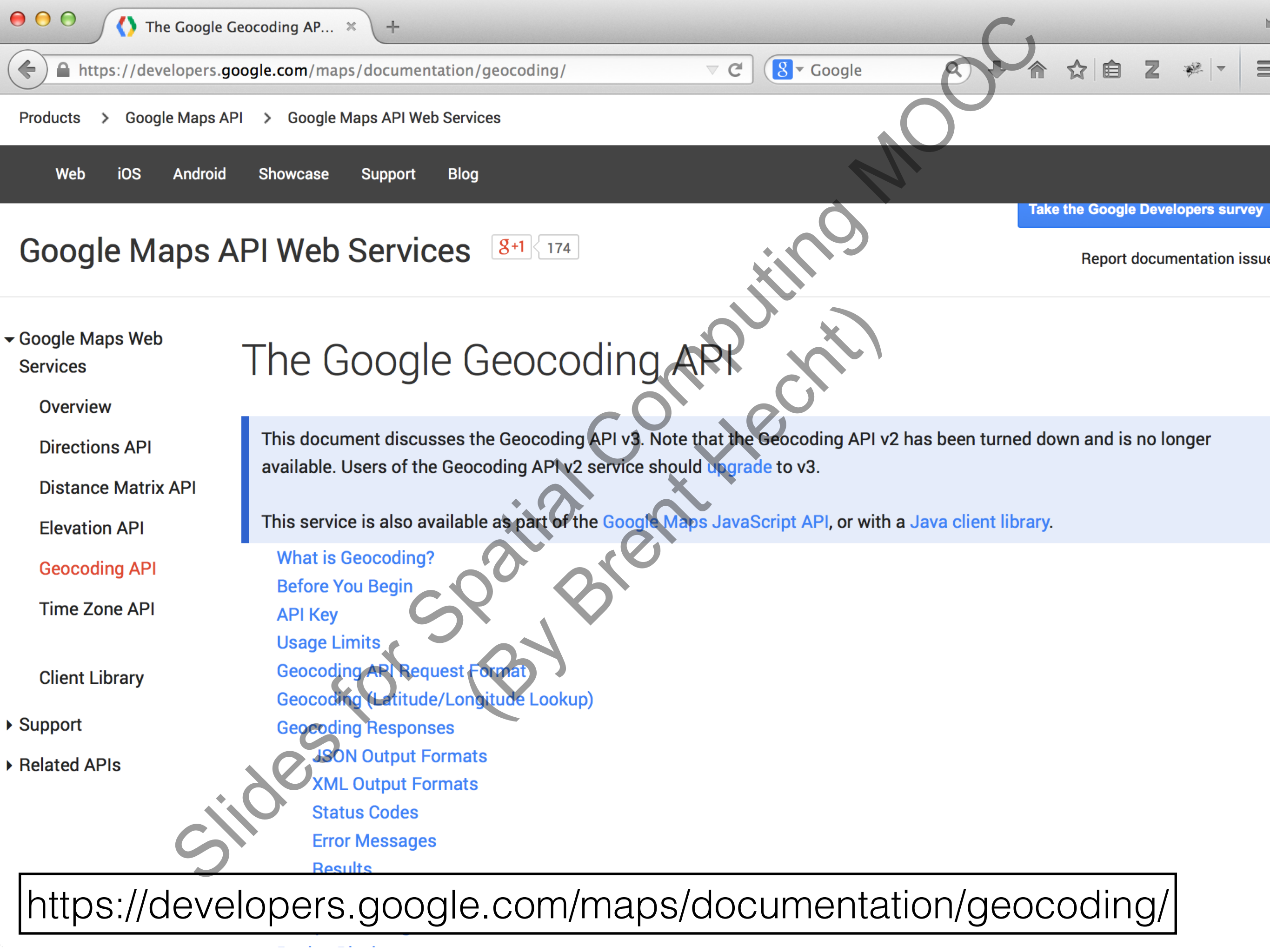
OTHER PLACES LIVED

+

Add a place

(44.98, -93.27)

Machine-readable Representation
(e.g. lat/lon coordinate)



Google Maps API Web Services g+1 174

Report documentation issue

Google Maps Web Services

- Overview
- Directions API
- Distance Matrix API
- Elevation API
- Geocoding API**
- Time Zone API
- Client Library

- Support
- Related APIs

The Google Geocoding API

This document discusses the Geocoding API v3. Note that the Geocoding API v2 has been turned down and is no longer available. Users of the Geocoding API v2 service should [upgrade](#) to v3.

This service is also available as part of the [Google Maps JavaScript API](#), or with a [Java client library](#).

- [What is Geocoding?](#)
- [Before You Begin](#)
- [API Key](#)
- [Usage Limits](#)
- [Geocoding API Request Format](#)
- [Geocoding \(Latitude/Longitude Lookup\)](#)
- [Geocoding Responses](#)
- [JSON Output Formats](#)
- [XML Output Formats](#)
- [Status Codes](#)
- [Error Messages](#)
- [Results](#)

https://developers.google.com/maps/documentation/geocoding/

Export (0)

Print

Locations API

Bing

11 out of 22 rated this helpful – [Rate this topic](#)

Use the Locations API to get location information.

For an example of how to use the Locations API with Bing Maps AJAX Control 7.0, see [Displaying Location Search Results Using the REST Services](#).

In this section

Find a Location by Address	Use these URL templates to get latitude and longitude coordinates for a location by specifying values such as a locality, postal code, and street address.
Find a Location by Point	Use this URL template to get the location information associated with latitude and longitude coordinates.
Find a Location by Query	Use these URL templates to get latitude and longitude coordinates that correspond to location information provided as a query string.
Location Data	Use this description to understand the results returned in the response to a Locations API request.

MapQuest Geocoding API

LICENSED DATA APIs

» GEOCODING API WEB SERVICE

Geocoding is the process of matching addresses with geographic coordinates. You can easily access the MapQuest geocoder through a simple HTTP request. The Geocoder has three functions: address, reverse, and batch.

Geocoding API Resources

[Documentation](#)

Instructions, code samples, and demos all combined in easy-to-follow, easy-to-use documentation.

[Forums](#)

Discuss and collaborate with developers who are using the Geocoding API.

Features

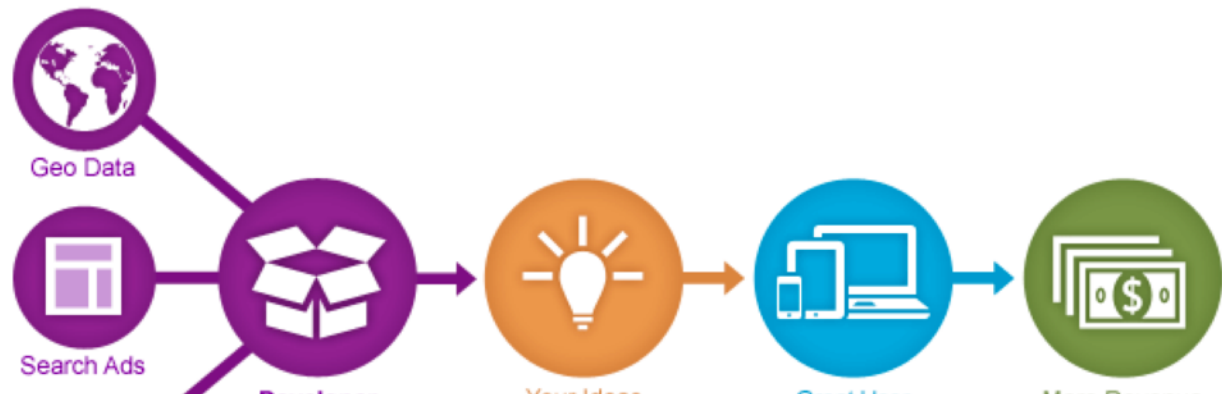
Address geocoding

Provide either a single-line address or an address broken down into its component parts. The geocoder returns geocodes in order of confidence.



Yahoo BOSS Geo Services

Yahoo BOSS is a suite of services that provides Developers premium API's that can support Search and Content applications. BOSS Geo services include two primary offerings today, Placefinder and PlaceSpotter, which allow developers to geo-enrich their applications and make them more location aware. Learn more about our offerings below.



“200 Union St. SE,
Minneapolis, MN”

“United States”

“Minnesota”

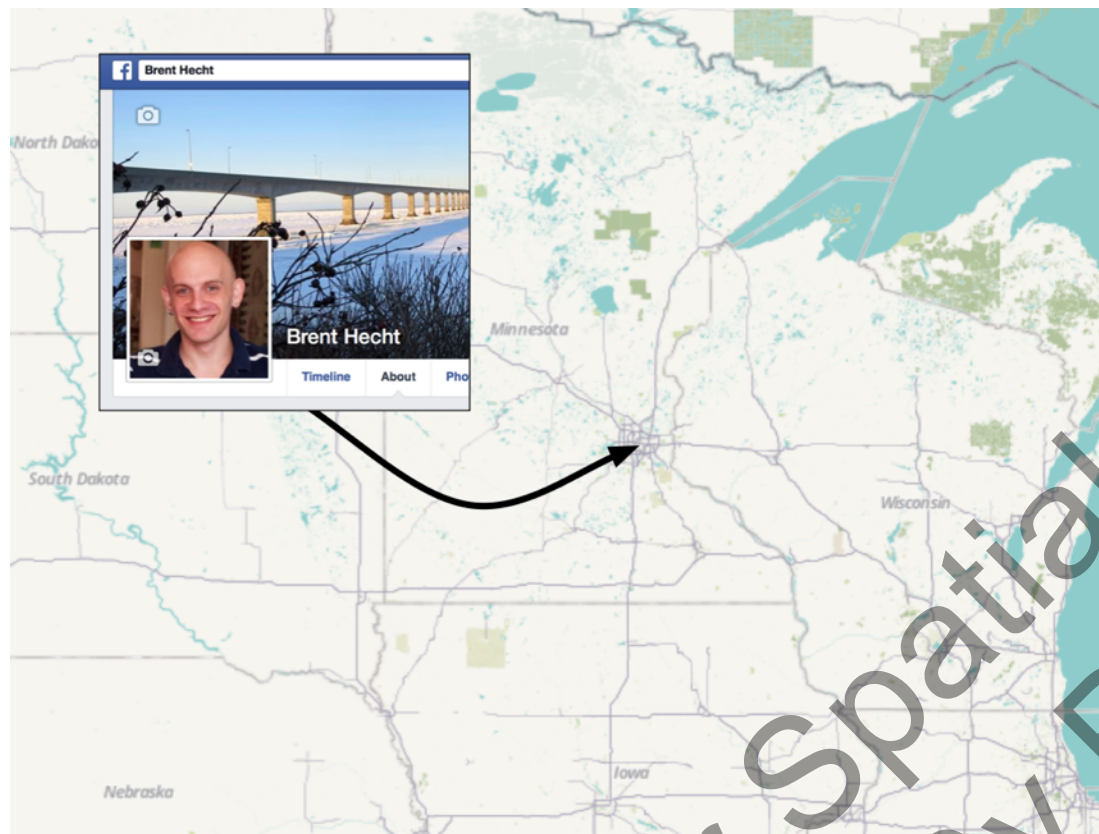
“Minneapolis, MN”



The Google Geocoding API



```
{
  "address_components" : [
    {
      "long_name" : "Minneapolis",
      "short_name" : "Minneapolis",
      "types" : [ "locality", "political" ]
    },
    {
      "long_name" : "Hennepin County",
      "short_name" : "Hennepin County",
      "types" : [ "administrative_area_level_2", "political" ]
    },
    {
      "long_name" : "Minnesota",
      "short_name" : "MN",
      "types" : [ "administrative_area_level_1", "political" ]
    },
    {
      "long_name" : "United States",
      "short_name" : "US",
      "types" : [ "country", "political" ]
    }
  ],
  "formatted_address" : "Minneapolis, MN, USA",
  "geometry" : {
    "bounds" : {
      "northeast" : {
        "lat" : 45.05125,
        "lng" : -93.1945439
      },
      "southwest" : {
        "lat" : 44.890144,
        "lng" : -93.32916299999999
      }
    }
  },
  "location" : {
    "lat" : 44.983334,
    "lng" : -93.26666999999999
  },
  "location_type" : "APPROXIMATE",
  "viewport" : {
    "northeast" : {
      "lat" : 45.05125,
      "lng" : -93.1945439
    },
    "southwest" : {
      "lat" : 44.890144,
      "lng" : -93.32916299999999
    }
  }
}
```



Map users

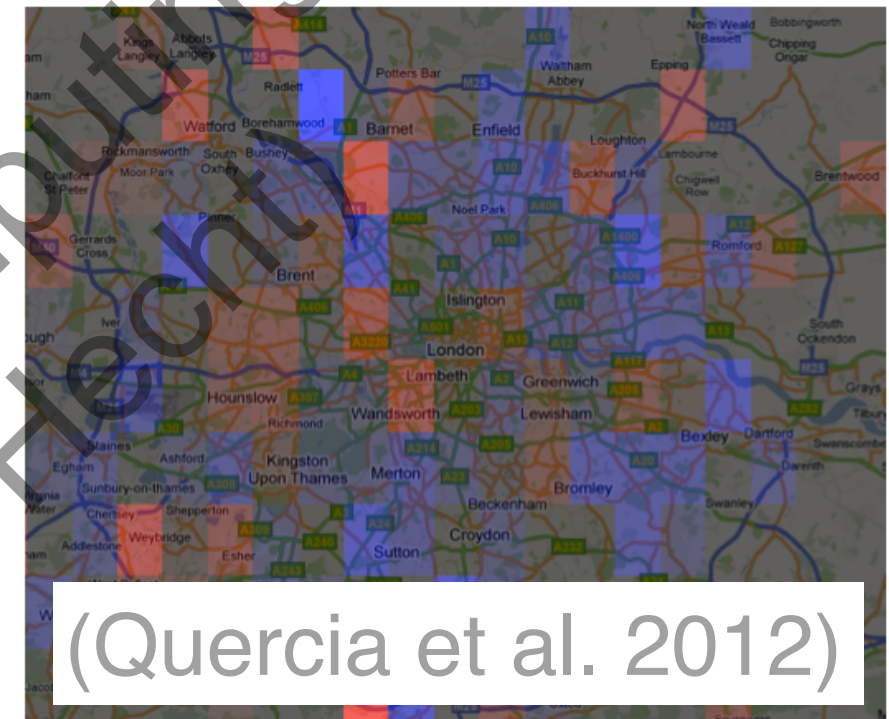


Figure 2. Mapping “Gross Community Happiness” in Greater London (best seen in color).

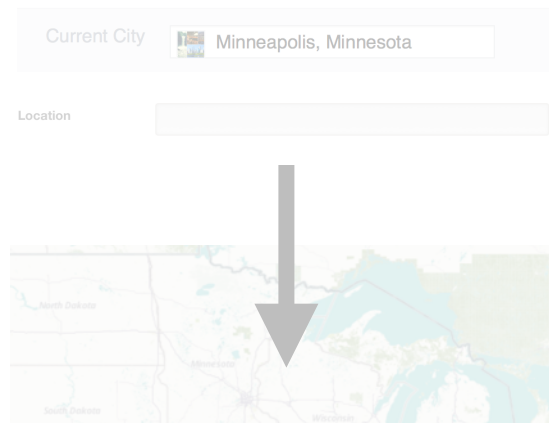
Do a geographic sentiment analysis

Questions you may be asking yourself at this point:

What do you mean by **some** applications?

How is **geo/geo ambiguity** dealt with?

Structure of the rest of this video:



Go over **how** to use location fields to position users.



Understand the **advantages** and **disadvantages** of location field positioning.



Wrap-up positioning with discussion of **location-inference attacks**.

Location Field Positioning



PROS



CONS



Many location fields
are blank

Slides for Spatial Computing MOOC
(By Brent Hecht)



No Location



No Location



No Location



No Location



No Location



No Location

18% of Twitter user profiles have
nothing in their location field

(Hecht et al. 2011)

Location Field Positioning



PROS



CONS



Many location fields
are blank

Scale is sometimes
insufficient

Slides for Spatial Computing MOOC
(By Brent Hecht)



Jessica Vitak

@jvitak FOLLOWS YOU

Asst Prof at Maryland
(@UMD). Research
HCI/CMC/CSCW, c
privacy & identity. s
O's/Ravens! PhD fr

📍 Maryland

🌐 jessicavitak.com

🕒 Joined Decemb

✉ Tweet to



Kiri Carini

@tomatopurl FOLLOWS YOU

Just an Oregon tree-hugger trying to
survive on the flat land of Maryland's
Eastern Shore. Employed @ Dorchester
County Tourism & UMCES. | #GISTribe

📍 Maryland

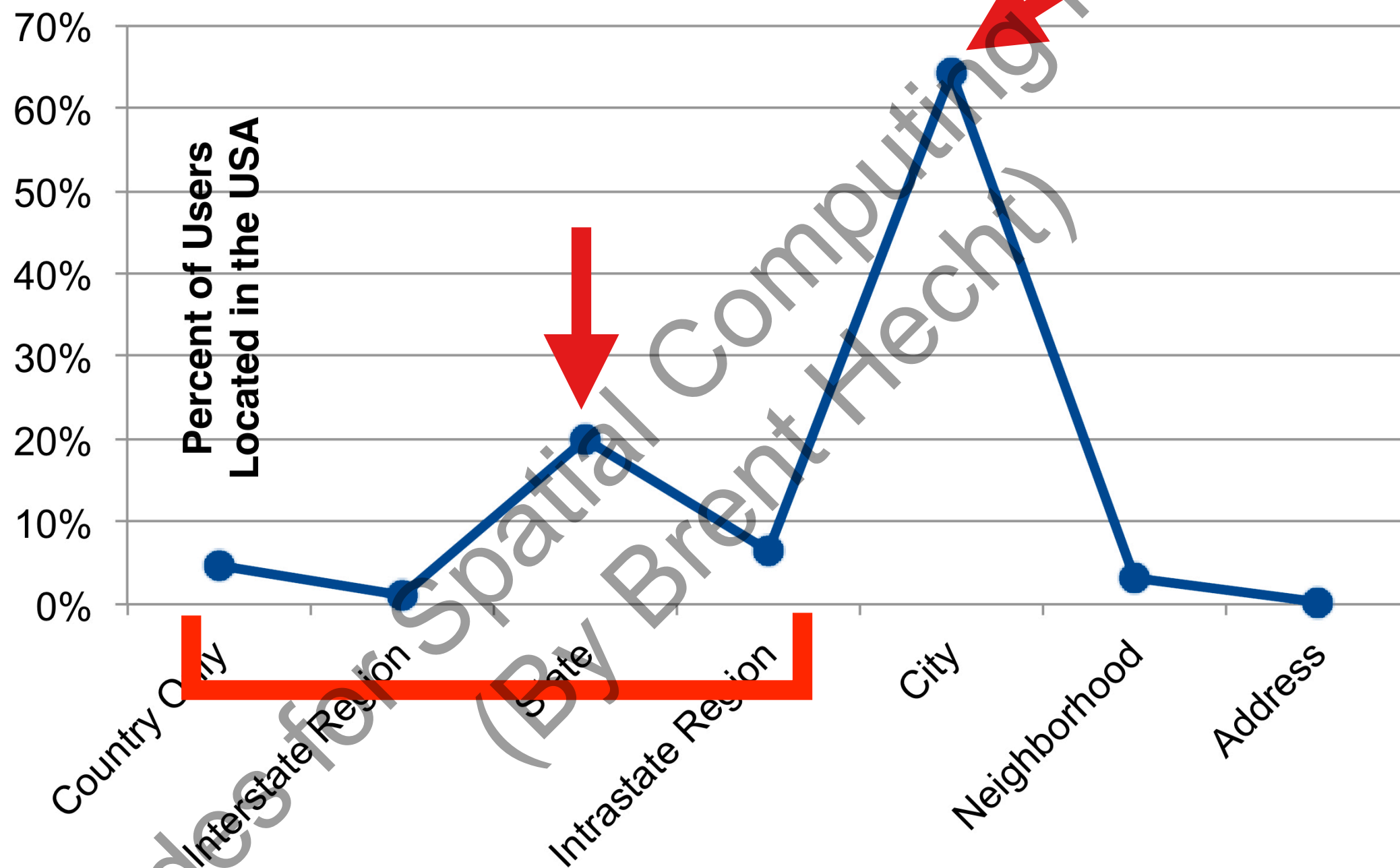
🌐 goo.gl/qiLtVV

🕒 Joined March 2008

✉ Tweet to

✉ Message

Geographic Scale (In Order of Increasing Localness from Left to Right)



(Hecht et al. 2011)

Geoweb Scale Problem

“Alaska”

“Minneapolis, MN”

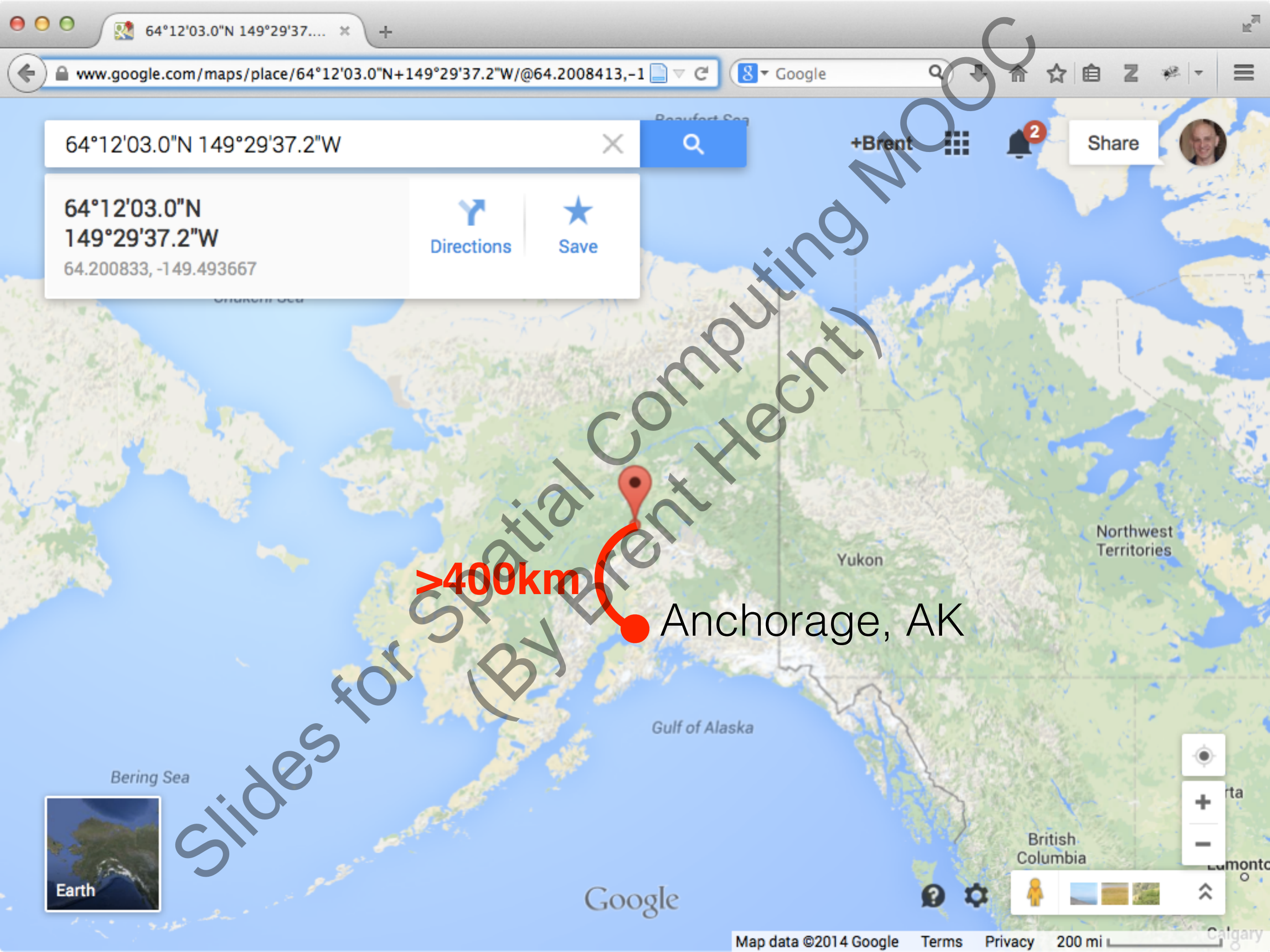
“200 Union St. SE,
Minneapolis, MN”



Google
Developers

The Google Geocoding API

```
{
  "address_components": [
    {
      "long_name": "Alaska",
      "short_name": "AK",
      "types": [ "administrative_area_level_1", "political" ]
    },
    {
      "long_name": "United States",
      "short_name": "US",
      "types": [ "country", "political" ]
    }
  ],
  "formatted_address": "Alaska, USA",
  "geometry": {
    "bounds": {
      "northeast": {
        "lat": 71.3902351,
        "lng": -129.9945562
      },
      "southwest": {
        "lat": 51.214766,
        "lng": 172.4445167
      }
    },
    "location": {
      "lat": 64.20084129999999,
      "lng": -149.4936733
    },
    "location_type": "APPROXIMATE",
    "viewport": {
      "northeast": {
        "lat": 71.3902351,
        "lng": -129.9945562
      },
      "southwest": {
        "lat": 51.214766,
        "lng": 172.4445167
      }
    }
  },
  "types": [ "administrative_area_level_1", "political" ]
}
```



64°12'03.0"N 149°29'37.2"W

64°12'03.0"N
149°29'37.2"W

64.200833, -149.493667

Directions Save

>400km

Anchorage, AK

Northwest Territories

Yukon

Gulf of Alaska

Bering Sea

British Columbia

Google

Map data ©2014 Google

Terms

Privacy

200 mi

Calgary

Geoweb Scale Problem

The GSP occurs when latitude and longitude coordinates – the foundation of spatial representations on the geoweb – are not appropriate for the desired scale of a given spatial computing research project or application.

(Hecht and Gergle 2011)


```
    "types" : [ "administrative_area_level_1", "political" ]
  },
  {
    "long_name" : "United States",
    "short_name" : "US",
    "types" : [ "country", "political" ]
  }
],
"formatted_address" : "Alaska, USA",
"geometry" : {
  "bounds" : {
    "northeast" : {
      "lat" : 71.3902351,
      "lng" : -129.9945562
    },
    "southwest" : {
      "lat" : 51.214766,
      "lng" : 172.4445167
    }
  },
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    "lat" : 64.20084129999999,
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  },
  "location_type" : "APPROXIMATE",
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      "lat" : 71.3902351,
      "lng" : -129.9945562
    },
    "southwest" : {
      "lat" : 51.214766,
      "lng" : 172.4445167
    }
  }
},
"types" : [ "administrative_area_level_1", "political" ]
```

Location Field Positioning



PROS



CONS



Many location fields
are blank

Scale is sometimes
insufficient

Lots of non-geographic
information

Slides for Spatial Computing MOOC
(By Brent Hecht)

16% of Twitter location fields contain
non-geographic information

(Hecht et al. 2011)

Location: “Loserville :)”

Location: “With God”

Location: “Middle Earth”

Location: “justin biebers heart”

Popular Culture References

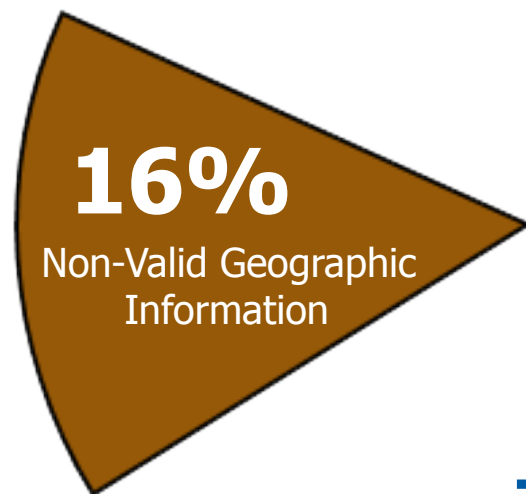
“BieberTown”
“PLZ Justin follow me”
“Bieberland...love!”
“JaeJoongs heart”
“Next to Waldo :D”
“Schrute Farms”

Privacy References

“Stalker City”
“MindingMyOwn”
“UM...STALKER!”
“kgb answers”
“stalker much?”
“for me to know n u to find out”

Negative Emotions Towards Current Location

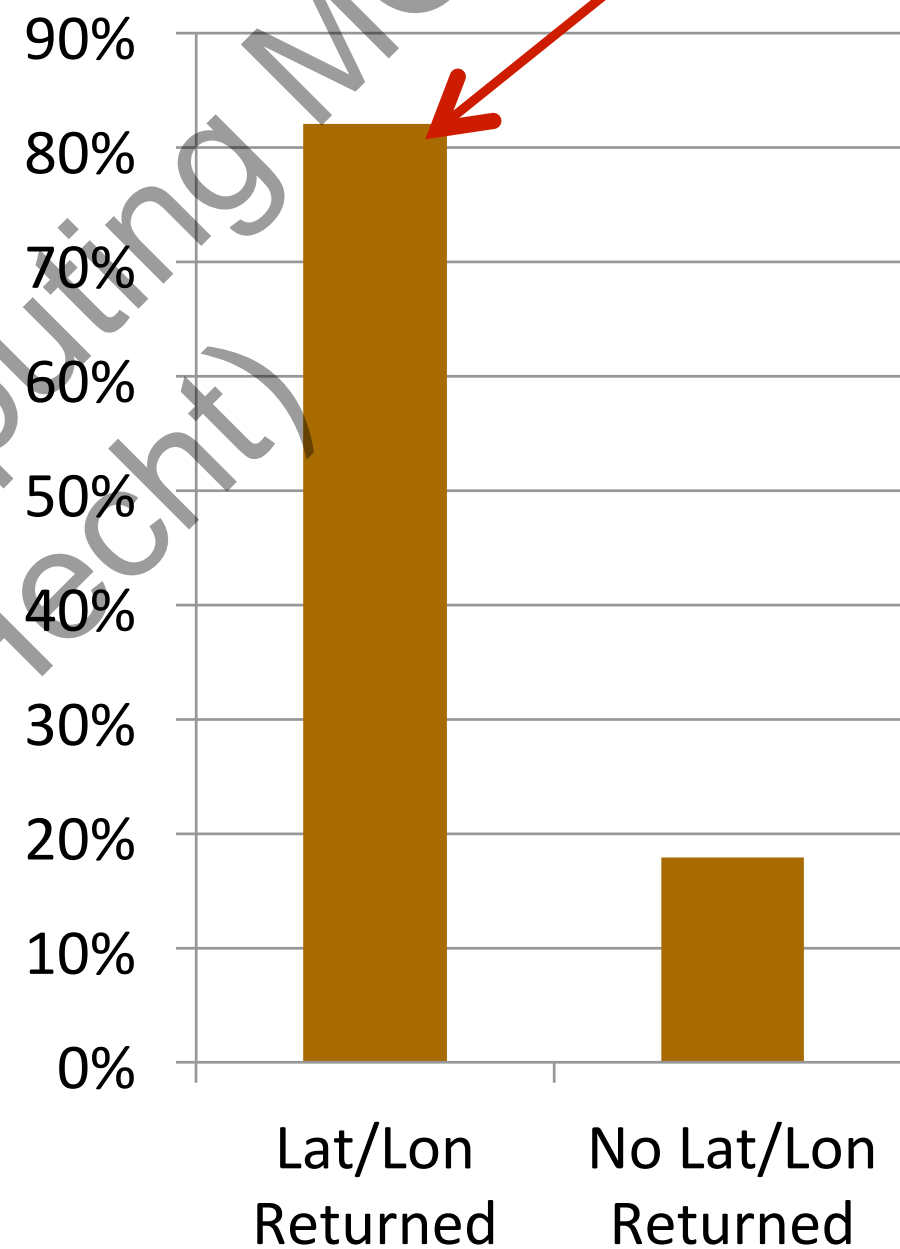
“preferably anywhere but here”
“a hole in the ground”
“swirling in the abyss”
“Loserville :)”



“Stalker City”, “NONE YA BISNESS”, “Justin Biebers Heart”, “The Void”, “Redneck Hell”, “In the Middle of Nowhere”, “yer mum”, “BSNBC”, “in God’s Graces”, etc...



Yahoo! Geocoder



Location Field Positioning



PROS



CONS



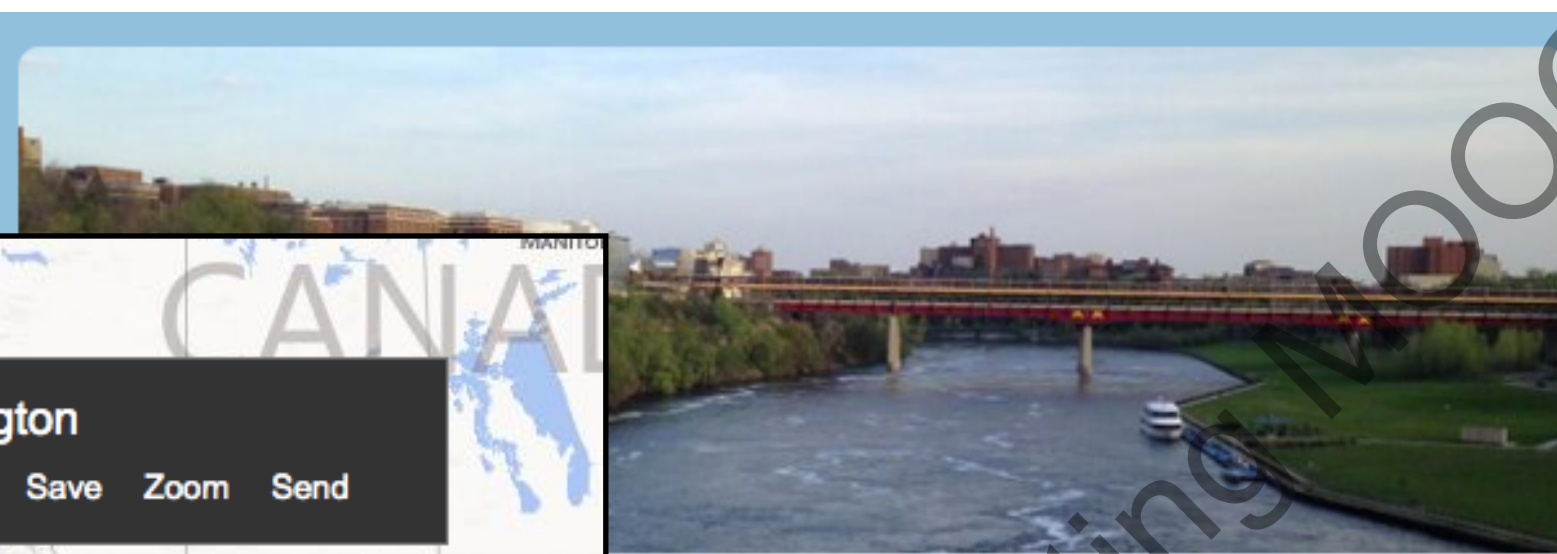
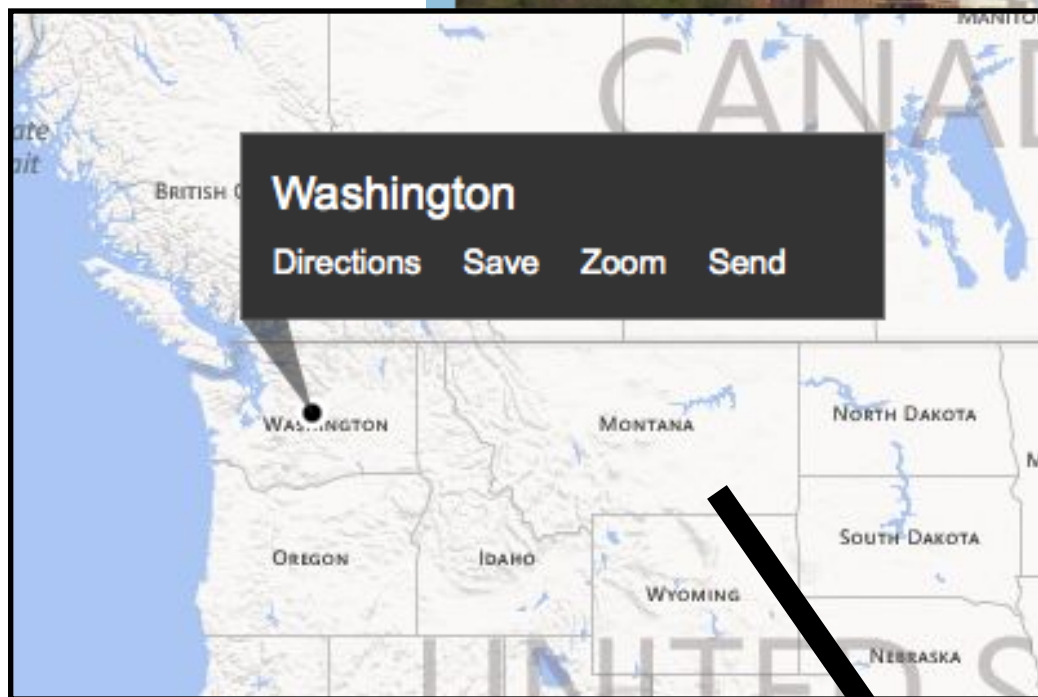
Many location fields
are blank

Scale is sometimes
insufficient

Lots of non-geographic
information

Disambiguation is hard

Slides for Spatial Computing MOOC
(By Brent Hecht)



Spatial Computing

SpatialCompMOOC

6 8 FOLLOWERS

6 8 133

Headed to Washington to do some
app picking, jamming out to Chicago!
#squaresmusic #its...



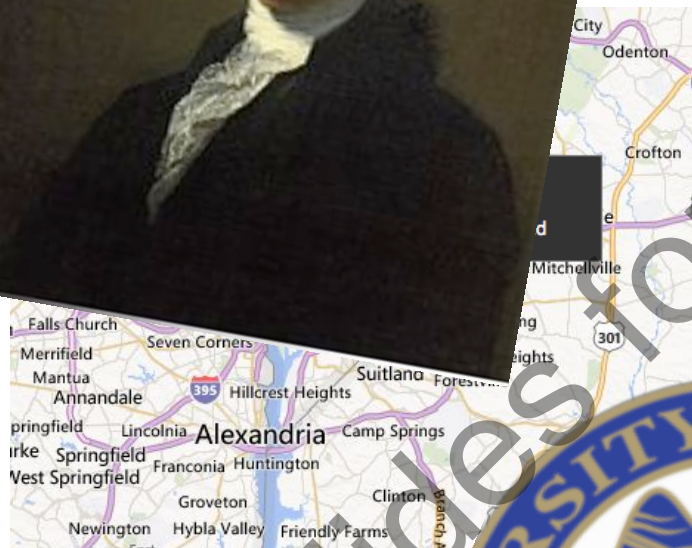
42

 Tweet

Toponym Ambiguity

one place name (toponym) → more than one place

“Washington”



Location Field Positioning

PROS

Sometimes is only way
to position users

CONS

Many location fields
are blank

Scale is sometimes
insufficient

Lots of non-geographic
information

Disambiguation is hard

Slides for Spatial Computing MOOC
(By Brent Hecht)

Location Field Positioning

😊 PROS 😊

Sometimes is
only way to
position users

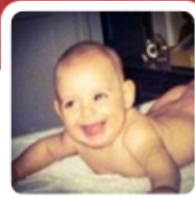
😞 CONS 😞

Many location fields
are blank

Scale is sometimes
insufficient

Lots of non-geographic
information

Disambiguation is hard



Following

Brad Paisley ✓

@BradPaisley

In 1972, a crack commando unit was sent to prison by a military court for a crime they didn't commit. I was also born.

Nashville, TN bradpaisley.com

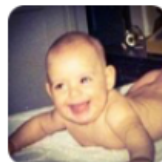
87 FOLLOWING

2.9M FOLLOWERS

Tweets

Photos

Favorites



Brad Paisley @BradPaisley

14h

I see you're shocked I used an emoji. I'm sorry. It's just..so convenient on the new IOS. I regret any pain or confusion it may have caused.

112

713



Brad Paisley @BradPaisley

15h

Got to ride on a real fire truck and everything! Take that @carrieunderwood



#cmaawards youtube.com/watch?

Only easily
accessible
geographic
information

No geotags!



Timelines



Notifications



Messages



Me

Location Field Positioning

😊 PROS 😊

Sometimes is
only way to
position users

Unique
spatiotemporal scale

😞 CONS 😞

Many location fields
are blank

Scale is sometimes
insufficient

Lots of non-geographic
information

Disambiguation is hard

Go Gophers! Beat
the Badgers!

Doing some
recording for
@SpatialComp
MOOC

At dentist appt.
#toothfail

OMG! Just
drove on a lake!
#itscold



Brent Hecht
@bhecht

Assistant Professor of Computer
Science at the University of
Minnesota



Slides for Spatial Computing MOOC
(By Brent Kiecht)

Go Gophers! Beat
the Badgers!

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recording for
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At dentist appt.
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#itscold

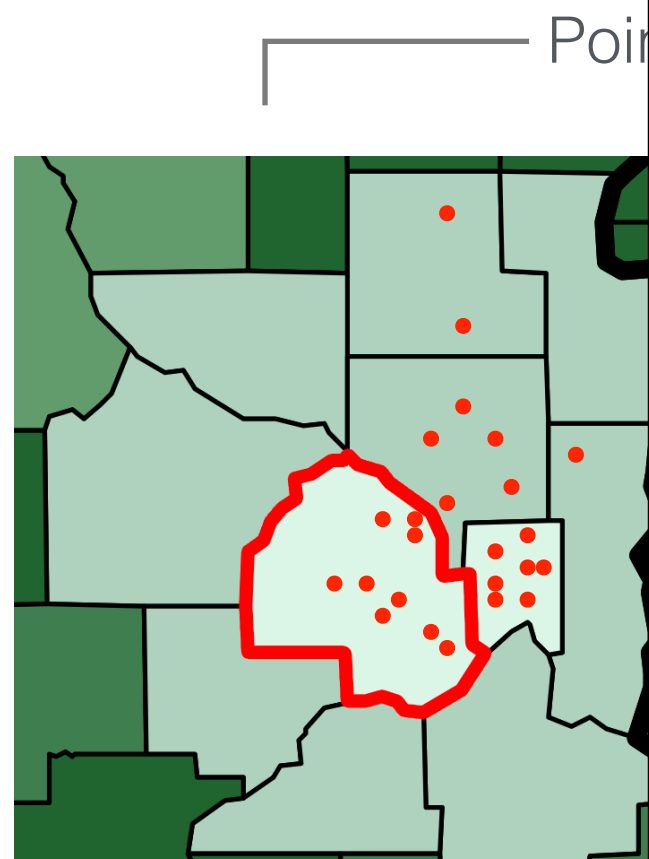
Headed to
#Amsterdam!



Brent Hecht
@bhecht

Assistant Professor of Computer
Science at the University of
Minnesota

Data-driven ways to determine home region



Region of Greatest Activity
(e.g. Musthag and Ganesan 2013)



Brent Hecht

@bhecht

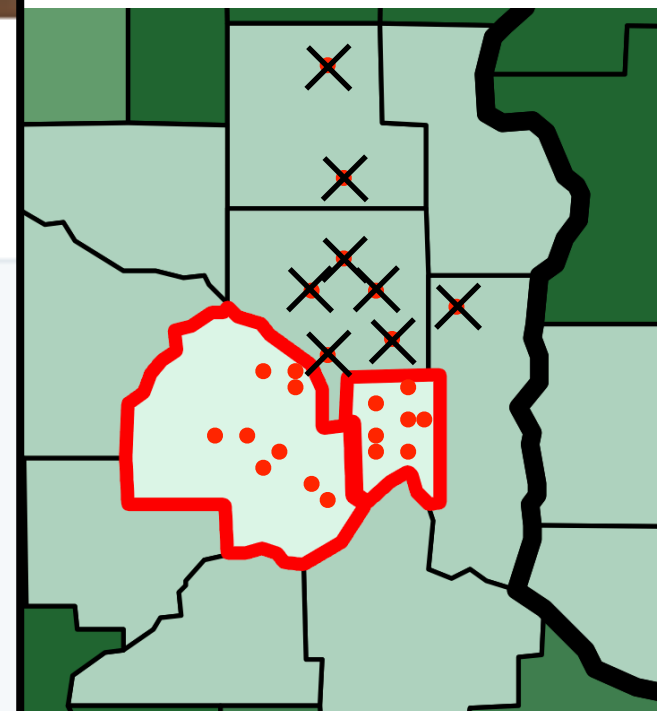
Assistant Professor of Computer Science
at the University of Minnesota

Minneapolis, MN

cs.umn.edu/~bhecht/

Joined April 2008

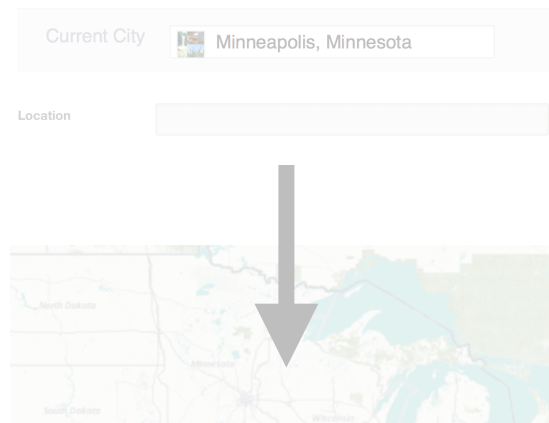
Spatiotemporal



Spatiotemporal Threshold
(e.g. Li and Goodchild 2013)



Structure of the rest of this video:



Go over **how** to use location fields to position users.

Understand the **advantages** and **disadvantages** of location field positioning.

Wrap-up positioning with discussion of **location-inference attacks**.



Ayim Notellingü

@geoprivacy

📍 I never reveal my location

TWEETS
5

FOLLOWING
39

FOLLOWERS
1

Tweets

Tweets & replies

🔒 Ayim Notellingü @geoprivacy · 35s

Just picked up some local wildlife from Lunds!

🔒 Ayim Notellingü @geoprivacy · 52s

Just had Snickers-on-a-stick at the fair, youbetcha!

🔒 Ayim Notellingü @geoprivacy · 1m

Still happy the Gophers won last night!

🔒 Ayim Notellingü @geoprivacy · 2m

Sure am loving these cheese curds!



Ayim Notellingü

@geoprivacy

📍 I never reveal my location

TWEETS
5

FOLLOWING
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FOLLOWERS
1

Tweets

Tweets & replies



Ayim Notellingü @geoprivacy · 35s

Just picked up some local wild rice from
Lunds!



Ayim Notellingü @geoprivacy · 52s

Just had Snickers-on-a-stick at the fair,
youbetcha!



Ayim Notellingü @geoprivacy · 1m

Still happy the Gophers won last night!



Ayim Notellingü @geoprivacy · 2m

Sure am loving these cheese curds!

Sampling Strategy	Model Selection	Accuracy	Baseline Accuracy	% of Baseline Accuracy
Country-Uniform-2500	Calgari	72.71%	25.00%	291%
Country-Uniform-2500	Count	68.44%	25.00%	274%
Country-Random-20K	Calgari	88.86%	82.08%	108%
Country-Random-20K	Count	72.78%	82.08%	89%
State-Uniform-500	Calgari	30.28%	5.56%	545%
State-Uniform-500	Count	20.15%	5.56%	363%
State-Random-20K	Calgari	24.83%	15.06%	165%
State-Random-20K	Count	27.31%	15.06%	181%

Table 2: A summary of results from the country-scale and state-scale experiments. The better performing model selection algorithm is bolded for each experiment. The CALGARI result reported is the best generated by $MinU = 2$ or $MinU = 5$.

(Hecht et al. 2011)



Ayim Notellingü

@geoprivacy

I never reveal my location

TWEETS

5

FOLLOWING

36

FOLLOWERS

3

Edit

Who to follow · Refresh · View all



MOCA @MOCAlosangeles

Follow



Art in America @AiANews

Follow



TheCurrent

@TheCurrent

The Current, a non-commercial radio station in Minnesota, plays the best new music next to the music you already love, from local to legendary. 89.3...

Following



Minnesota State Fair

@mnstatefair

The official Twitter of the Great Minnesota Get-Together. Visit us Aug. 27-Labor Day, Sept. 7, 2015! #mnstatefair

Follow



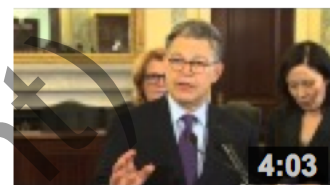
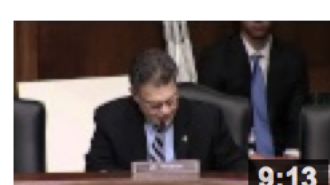
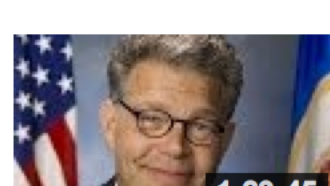
Chairman Franken's Opening Statement on Mobile Privacy



Sen. Al Franken
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2,084

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<http://www.franken.senate.gov/?p=video&id=1497>

Positioning

Spatial Computing – University of Minnesota

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Slides for Spatial Computing MOOC
(By Brent Hecht)