IOT Seminar Day Two

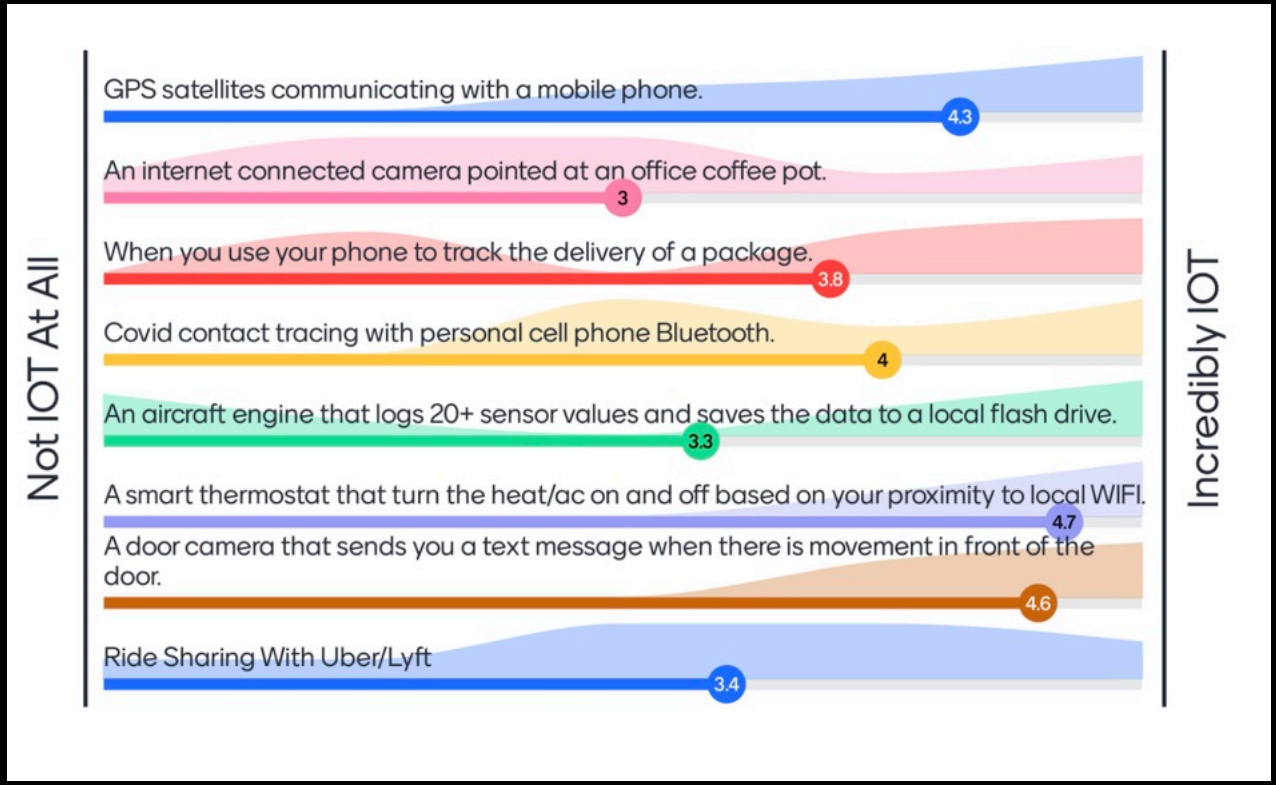
Todays Topics

- Survey review for “What topics do you want covered”
- Phones have lots of sensors, actuators, and networks
- How does your phone know where it is (GPS + Cellular + Wifi)?
- When an IOT goes wrong - Jan 6 insurrection in Washington DC
- **Ride-share as an IOT**

Survey Review

Rate the following on the level of IOT-ness

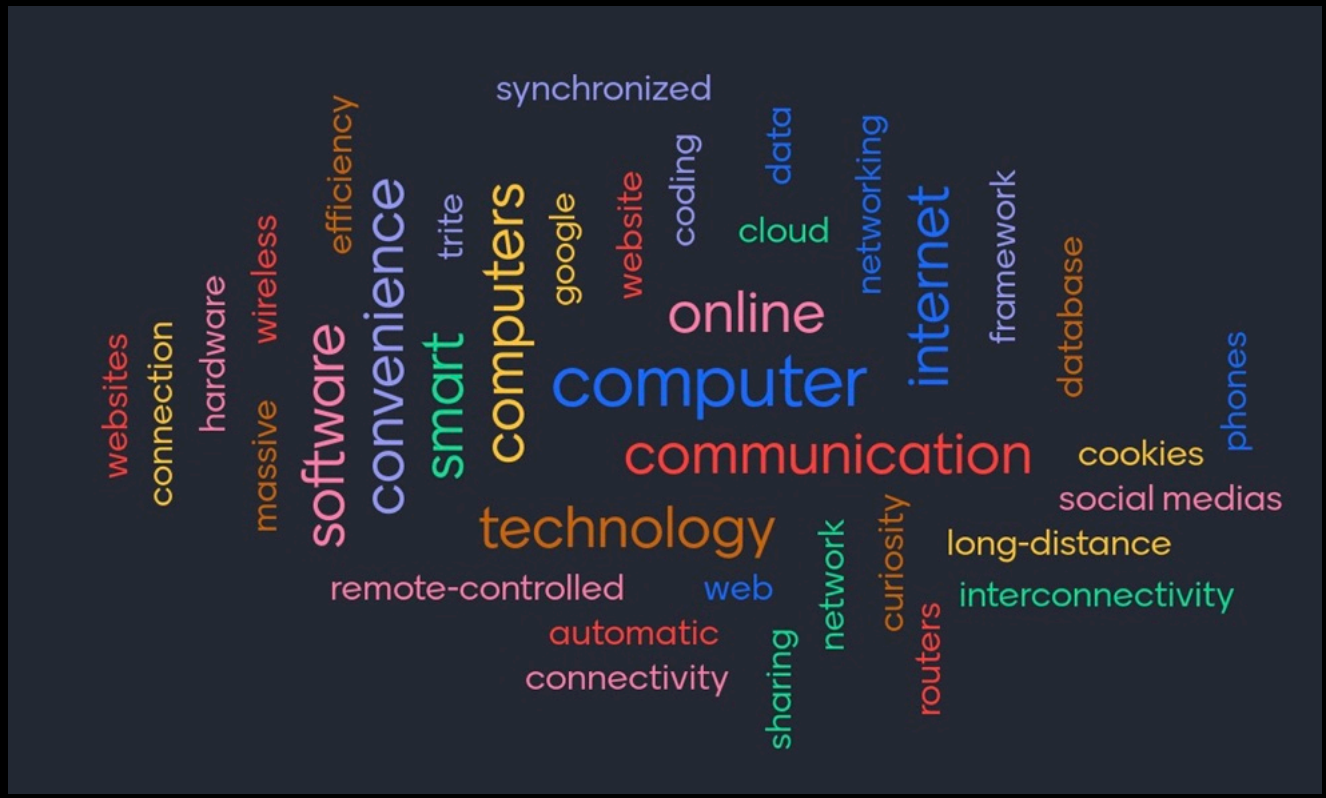
- Mobile phone GPS scored high
- Ride-sharing scored lower on IOT-ness
- But ride-sharing uses two different GPS positions (rider and driver)



Survey Review

Enter Five Words You Think Of When You Hear "The Internet Of Things".

- Very qualitative but fun to look at for ideas
- We will take this again, midway through and at end to see how it changes



We did not get this last class …

What topics do you want to cover?

https://www.menti.com/suz9qkrxvx

Cell Phone Sensors, Actuators, and Network

Cell phones are packed with them

Sensors (input)

- Touch-Screen
- Microphone
- Camera
- Gyroscope (can be used to control games, augmented reality, and determine which way is down)
- Magnetic (compass)
- GPS

Actuators (output)

- Screen
- Speaker
- Haptic feedback (vibrate) including the “button” on older iPhones
- Flashlight / camera flash

Cell Phone Sensors, Actuators, and Network

Cell phones are packed with them

- **<u>Your cell phone networks (from long range to close)</u>**
  - Cellular (longer range, usually line of sight to a cell tower, sometimes in miles)
  - Wifi (medium range, within tens of feet)
  - Bluetooth (close range within 10’s of feet)
  - Near-field communication (close range, less than 2 inches or about 4 cm)

How does a phone know where it is?

And if you have your phone, it knows where you are!

- Uses three system
  - GPS
  - Cell/Data towers
  - WiFi

https://www.macworld.com/article/211990/how-iphone-location-works.html/amp

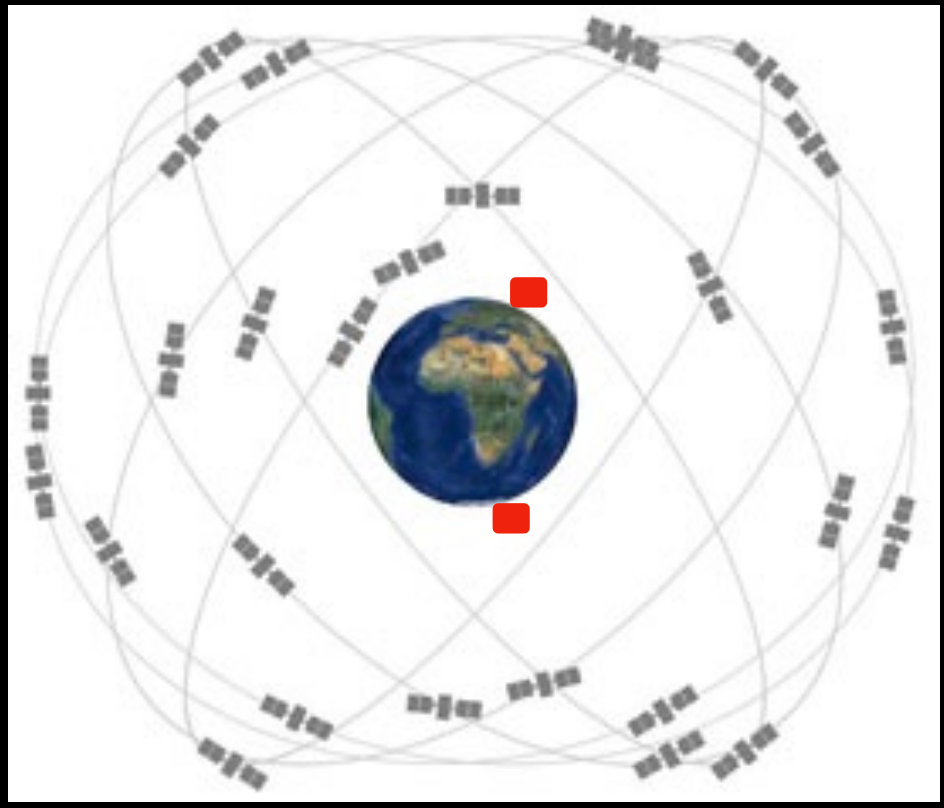
Global Positioning System (GPS)

US GPS as an example

- GPS satellites fly in medium-earth orbit at an altitude of approximately **12,550 miles** (20,200 km). Each satellite circles the Earth about twice a day.
- Made of a 24 satellite constellation (sometimes more)
- Satellites are positioned to ensures users can view at least **four** satellites from virtually any point on the earth

Question:

What altitude is Hubble, the International Space Station, or Starlink?



We put a lot of stuff into space

All distances are approximate

The international-space-station is in near-earth orbit at an altitude of **220** miles (350 km)

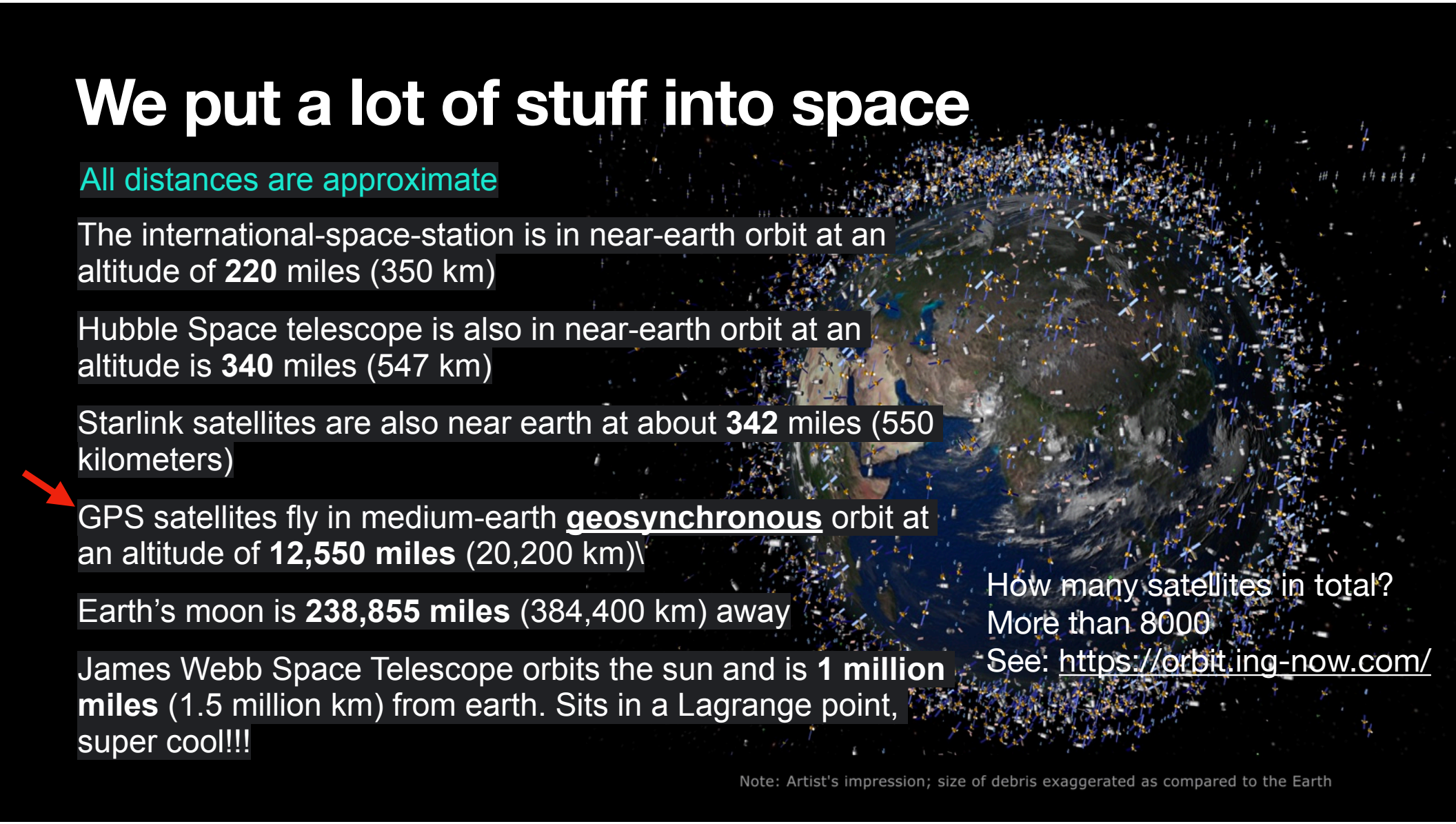
Hubble Space telescope is also in near-earth orbit at an altitude is **340** miles (547 km)

Starlink satellites are also near earth at about **342** miles (550 kilometers)

GPS satellites fly in medium-earth **geosynchronous** orbit at an altitude of **12,550 miles** (20,200 km)\

Earth's moon is **238,855 miles** (384,400 km) away

James Webb Space Telescope orbits the sun and is **1 million miles** (1.5 million km) from earth. Sits in a Lagrange point, super cool!!!



How many satellites in total?
More than 8000
See: https://orbit.ing-now.com/

Note: Artist's impression; size of debris exaggerated as compared to the Earth

Global Positioning System (GPS)

Who owns the GPS satellites?

- The United States government owns the satellites

  Specifically the ~~Air Force~~ Space Force

- They provide two different layers of signals

  1) Standard Positioning Service (low accuracy)

     Available to all users on a continuous, worldwide basis, free of any direct user charges

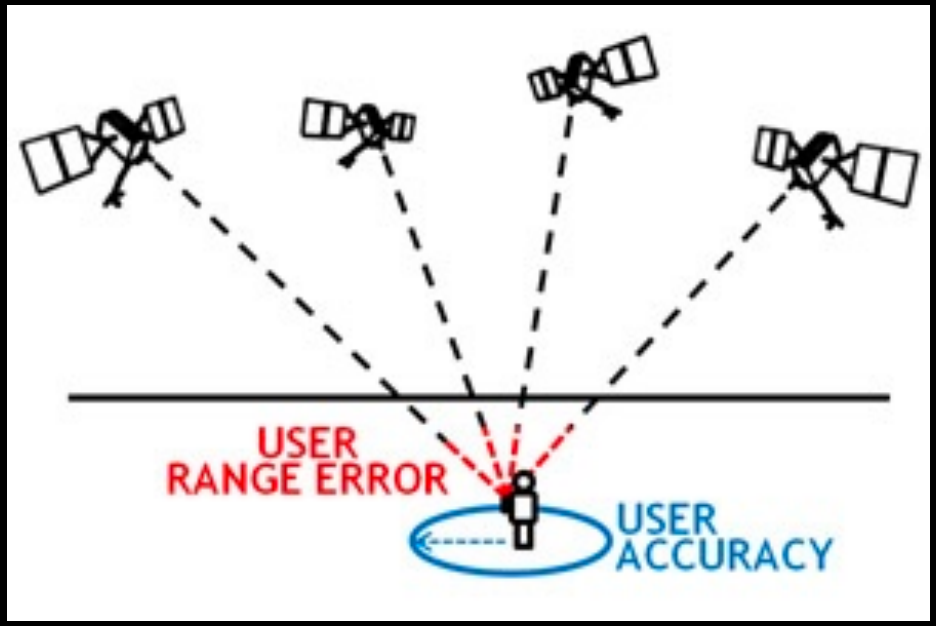
  2) Precise Positioning Service (high accuracy)

     Access to is restricted to US Armed Forces, US Federal agencies, and selected allied armed forces and governments. Currently includes the Ukraine military

Cell Phone GPS

How accurate is GPS?

- Complicated answer
- US Government guarantees at least 6 foot accuracy
- On a good day can be 2 feet
- Special techniques to get it down to inches (used by surveyors for example)
- Accuracy is decreased by atmosphere (storms), tree cover, and buildings



Cell Phone GPS

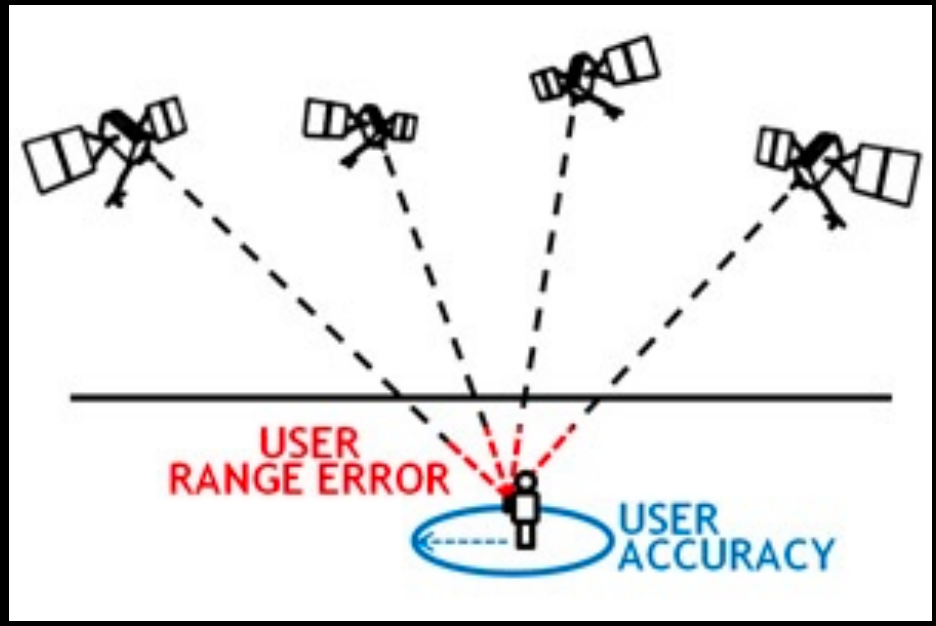
How does it work?

Every 30 seconds, GPS satellites broadcast a “ping” signal

1) Precise time signals using a built-in atomic clock

2) The location of all other satellites in the sky, called the almanac

This goes on and on, all day, every day



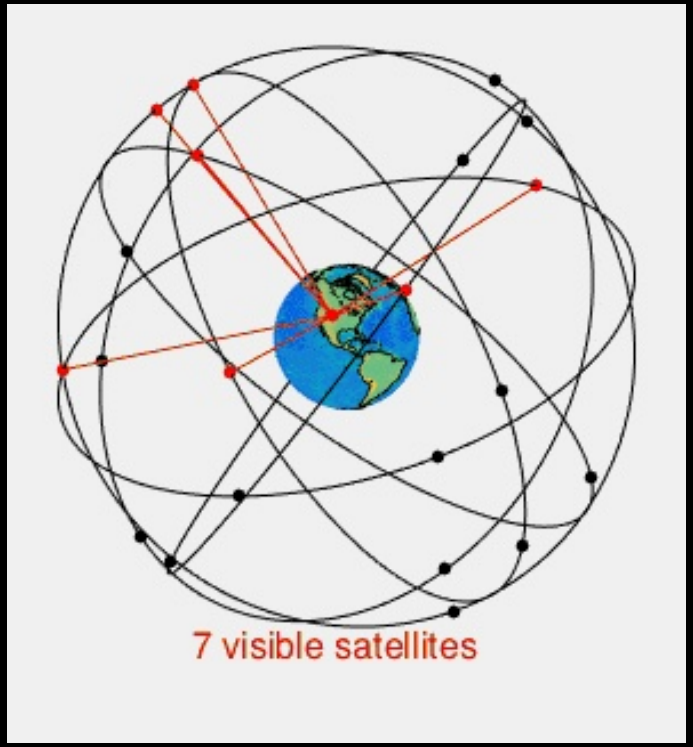
GPS Satellites transmit signal at:
L1, at 1575.42 MHz
L2, at 1227.6 MHz
WiFi is at 5100 MHz (rougly)

https://www.macworld.com/article/211990/how-iphone-location-works.html/amp

Cell Phone GPS

How does your phone know its location?

- Your phone has a GPS receiver (it is an **input** sensor, it does **not transmit** or output anything)
- Using some code employing basic trigonometry and physics, when your phone receives time/position information from at least **4 GPS satellites** it can calculate its current lat/long and altitude **position to within about 30 feet**
- If it only has 3 GPS satellites it can get lat/long
- Again, GPS in your phone is just a receiver, on its own can not be used to track you. Now that your phone has its location you need to be aware you can allow that information to be sent out via installed apps



Cell Phone GPS

Calling 911 in North America Transmits your location

- If you call 911, they get your current GPS coordinates
- This is called “enhanced 911”
- Used to dispatch police, fire, emergency, or other services.
- This actually uses both GPS and Cellular towers to triangulate your phones location more accurately

https://en.wikipedia.org/wiki/Enhanced_9-1-1#Wireless_transmission

In addition to US GPS, there are other positioning systems

All these have a free publicly available tier,
each system can require a different receiver.

- China: BeiDou Navigation Satellite System (BDS)
- Russian: Global Navigation Satellite System (GLONASS)
- European Union: Galileo

Why am I babbling on about GPS?

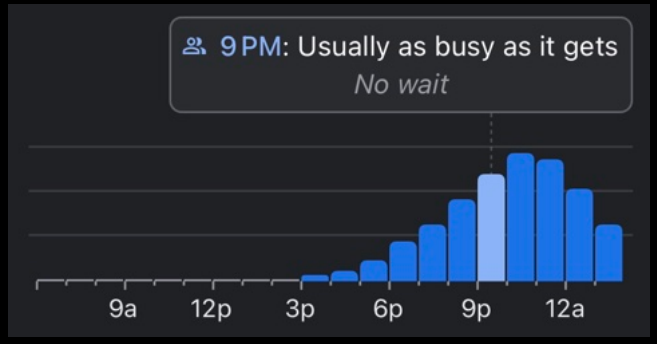
Cellphone GPS opens up a number of IOT systems

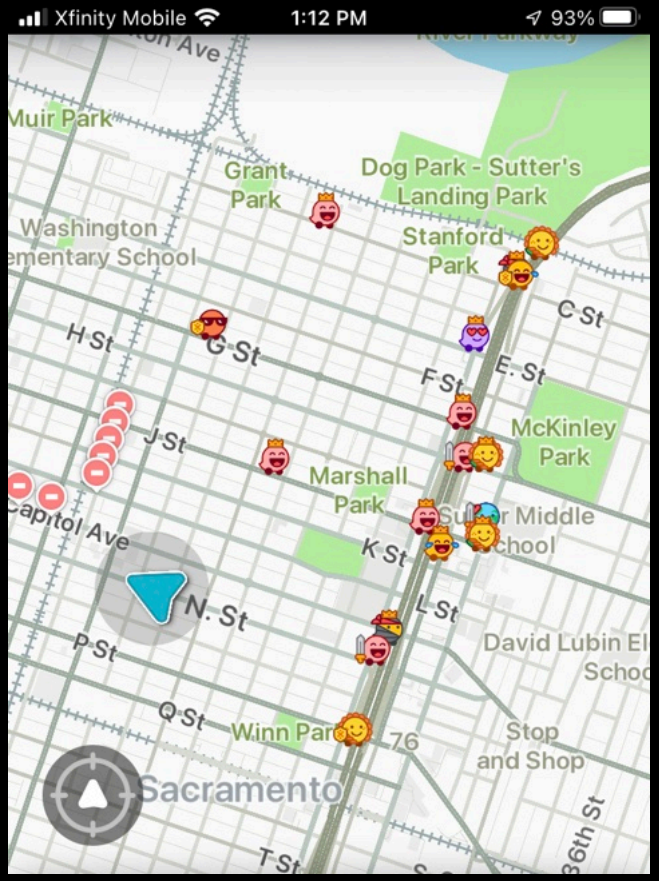
All kinds of map data

Google Maps, Apple Maps, Waze, etc, etc

To different extents, these aggregate individuals position and speed (when driving) in real-time to dynamically adjust directions to a destination and to show other users traffic flow and congestion.

Used to indicate if a business is busy or not.





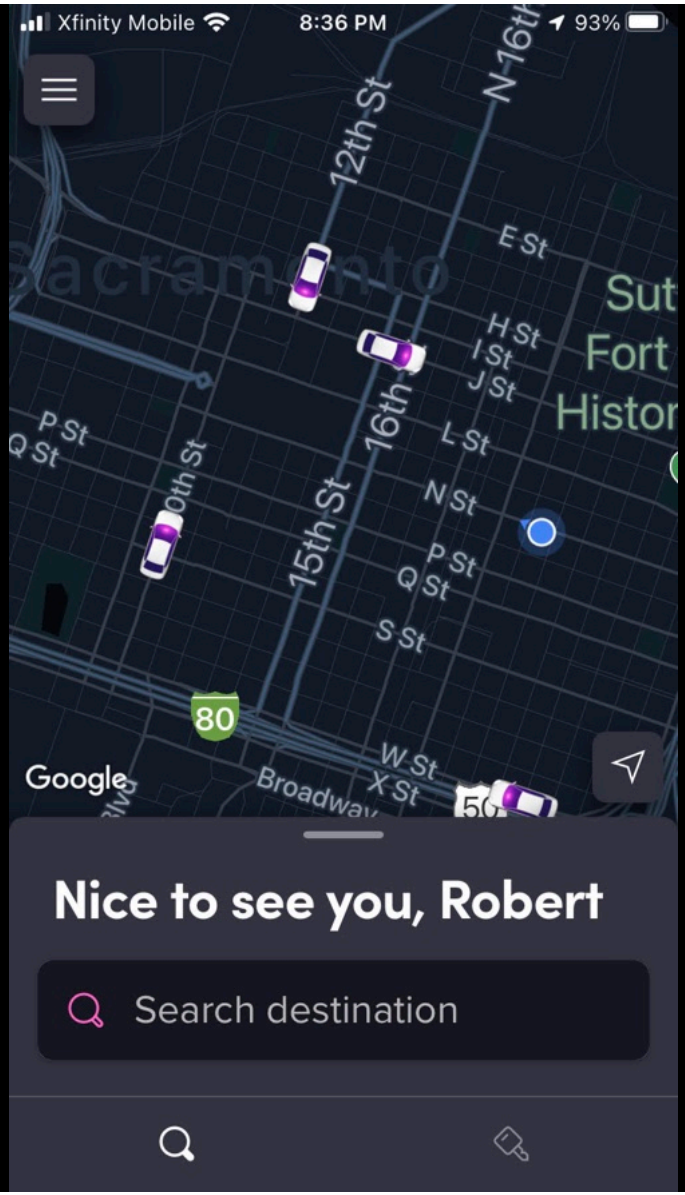
Ride sharing as an IOT

Finally!!!

Ride sharing as an IOT

- Rider GPS location
- Driver/car GPS locations
- All brought together with a rider/driver cell phone app

Has anyone driven for Uber or Lyft?



Ride sharing as an IOT

From network architecture to economic and social impacts!

- Two parties (rider and driver) are paired over the internet based on their current GPS location using a commercial cell-phone app
- Pairing rider/driver is a potentially complex algorithm done in the **cloud** (on ride-share companies computers)
- I will assume the company wants to maximize **profit** by maximizing **efficiency (IDK)**
- Efficiency is not just location but potentially how willing you are to pay surge pricing, how good of a tipper you are, maybe your rating
- **Important**: All of these calculation could be based on location (not you in particular). For example, if you are in front of an expensive restaurant at 9pm on a Friday.
- **Robert's Tip**: When arriving late at Sac airport and Uber is 4x normal price with 40 min wait. Ask a traditional Taxi driver for a fixed/flat rate to your destination. It is often cheaper than ride-share and they are immediately available.

Ride sharing as an IOT

Is Uber big data?

- Yes, they are building a spatial/temporal database of a cities potential for consumers to get rides including:

  When was the ride, from where, too where, the riders spending habits?

- Like Amazon, Google, Apple, and Facebook will sell a database of users "clicking" behavior

  I predict: Uber will begin to sell a database of profitability of a location?

  Could be purchased by real estate developers and potential business owners looking for a profitable location?

Bottom line: We have gone from an IOT company to socio/economic impact!

How ride-sharing has transformed the economy

From the assigned reading - Uber Displaced Taxis

- San Francisco, 2012, taxi revenues were **$200 million**.
- After Uber, taxi revenues were **$120 million**, they were down **$80 million**.
- What were Uber revenues in SF that year? Were they the difference, e.g. $80 million?
- No, they were actually **$500 million**.
- Thus, with Uber and taxis combined, personal transportation sales went from **$200 million to $620 million**.
- Who got screwed? Taxis. Parking garages. Car dealers and manufacturers. Insurance companies.
- If you don't have a car, you don't buy insurance. The city issued fewer parking tickets, less meter revenue, less use of public transportation.
- This is why Uber is "transformative", with big winners and losers
- Uber got to the core need: many people don't want a car, they want transportation.

The societal impacts of ride sharing

Ride sharing uses “Gig Workers”

- **Definition**: Gig workers enter into formal agreements with on-demand companies to provide services to the company's clients
- Pros:
  - Can choose your hours, work when you want (high level of flexibility and autonomy)
  - No office, your on your own in your car
- Cons:
  - Salary is not guaranteed from day to day. Many Uber drivers make below the minimum wage
  - No system of health-benefits (even if you work 40+ hours a week)
  - No paid time off or sick leave. Imagine not driving for a week because you got Covid

The societal impacts of ride sharing

Ride sharing uses “Gig Workers”

- Companies want to call drivers “independent contractors”
- Labor advocates want drivers to be called “employees”
- This has lead to years and ongoing negative publicity for Uber. Yet, their profits and use continue to soar.

The societal impacts of ride sharing

Should ride-sharing companies be regulated?

- In San Fancisco, driving a taxi before Uber, a driver could make somewhere between $5,000 and $7,000 a month
- In 2010 the SFMTA started selling medallions for $250,000 (by then-Mayor Gavin Newsom).
- Since 2010, the SFMTA has sold around 700 medallions to drivers. And the city brought in $64 million.
- Ride sharing (Uber and Lyft) are not part of this system? No medallions have allowed Uber/Lyft to flood the market with drivers.

https://www.kqed.org/news/11694401/san-francisco-made-millions-selling-taxi-medallions-now-drivers-are-paying-the-price

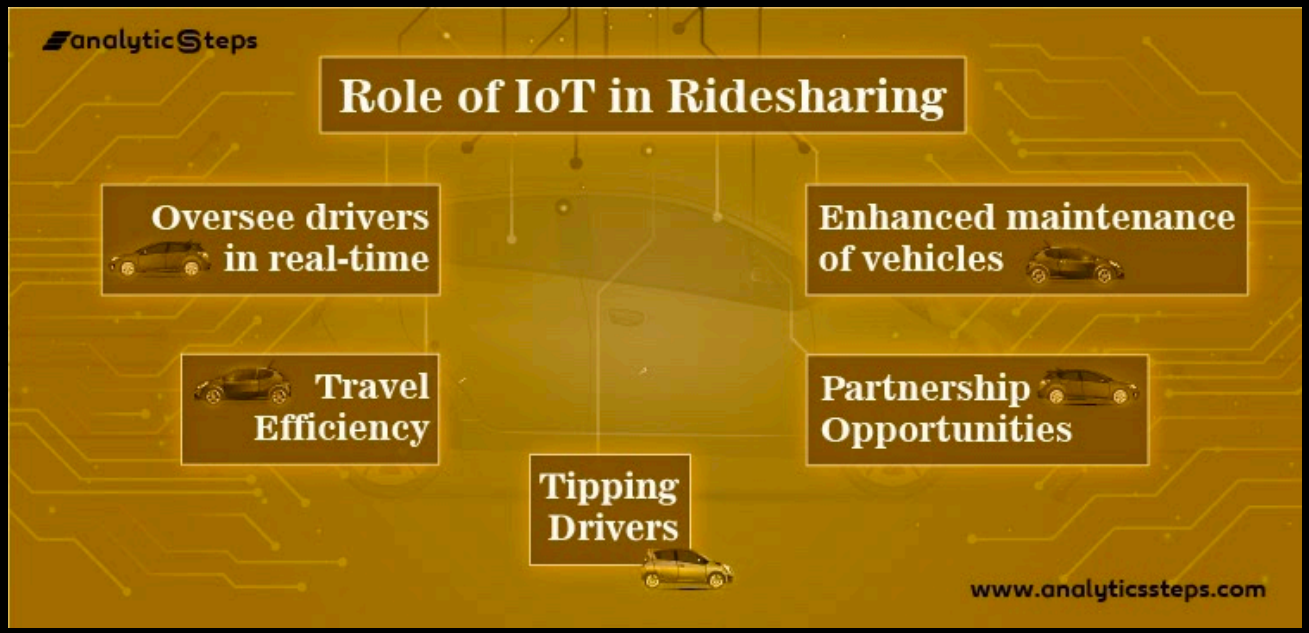
The societal impacts of ride sharing •SKIP

“Measuring the Benefits of Ridesharing Services to Urban Travelers: The Case of The San Francisco Bay Area “
From: Hutchins Center Working Paper #70, October 2022

- The rapid growth of ridesharing services has caused the contraction of the taxi industry and reduced public transit’s share of passengers.
- This suggests that utility-maximizing travelers have improved their welfare by shifting to a new mode.
- We quantified those benefits in San Francisco Bay Area markets, accounting for travelers’ complete set of transportation options.
- We found that travelers have gained roughly $1 billion annually from Uber’s service.
- Thus, Uber has provided positive social benefits.
- Thus, regulations to limit ridesharing operations are against the public because they intefere with a consumers informed and self-interested transportation choices.
- “After decades of inefficiency and technological stagnation in urban transportation, ridesharing is a welcome innovation that may be followed by other transportation innovations. It would be unwise to discourage the innovative efforts of entrepreneurs by trying to protect the less efficient modes that are being displaced. “

Future “big data” to come out of ridesharing

- **Uber fleet**. General purpose vehicle fleet management
- **Uber health.** Pairing patients with health-care visits
- Free Uber rides to Covid vaccines and medical appointments. Uber during car maintenance, Uber to get you safely home in the evening.



Ride Sharing

Review

- Network architecture: Simple, using cell phone apps to pair rider with driver based on their GPS coordinates
- Cloud Computing: Companies dynamically decide who to pair and decide how much to charge (surge pricing)
- Big Data: After a decade of collecting rider/driver behavior, it is possible this will be sold to benefit other sectors (restaurants, cities, real-estate)
- Economic: Displaced taxis and create a 3x profit
- Social: Riders are happy, they get from point A to B and cheap. Are drivers happy?
- Social: Moving forward, as profits are maximized, both riders and drivers may see decreased utility (as I see is happening with Air-BNB).
- Regulation: Why is ride-sharing not regulated like taxis are?

Reading assignment review

A Future Where Everything Becomes a Computer Is as Creepy as You Feared
From: The New York Times 2018

- “the internet of things is growing quickly. It is wiser — to imagine the worst — that the digitization of just about everything is not just possible but likely, and that now is the time to be freaking out about the dangers.”
- “I can think of no industry in the past 100 years that has improved its safety and security without being compelled to do so by government,”
- “In our government-can’t-do-anything- ever society, I don’t see any reining in of the corporate trends,”
- “It used to be difficult to add internet connectivity to home devices, but in the last few years the cost and complexity of doing so have plummeted. Today, off-the-shelf minicomputers like the Arduino can be used to turn just about any household object ‘smart.’ “
- “the cost of adding computers to objects will get so small that it will make sense for manufacturers to connect every type of device to the internet.“
- “Regulation and government oversight slow down innovation — that’s one reason techies don’t like it. But when uncertain global dangers are involved, taking a minute isn’t a terrible idea.”

Reading assignment review

A Future Where Everything Becomes a Computer Is as Creepy as You Feared
From: The New York Times 2018

- Typical of media coverage of IOT? Says is both the future and the end.
- Because of cheap computers/sensors, predicts that everything will be part of IOT. Will that be true?
- Predicts massive security problems? Is that real?
- Raises some pros and cons around the idea of government regulation
- Robert's Opinion: They will eventually be regulated but the government is slow to react.

When an IOT goes wrong

I will pepper the lectures with “when an IOT goes wrong”

I think it is important to be aware of and to understand these blunders

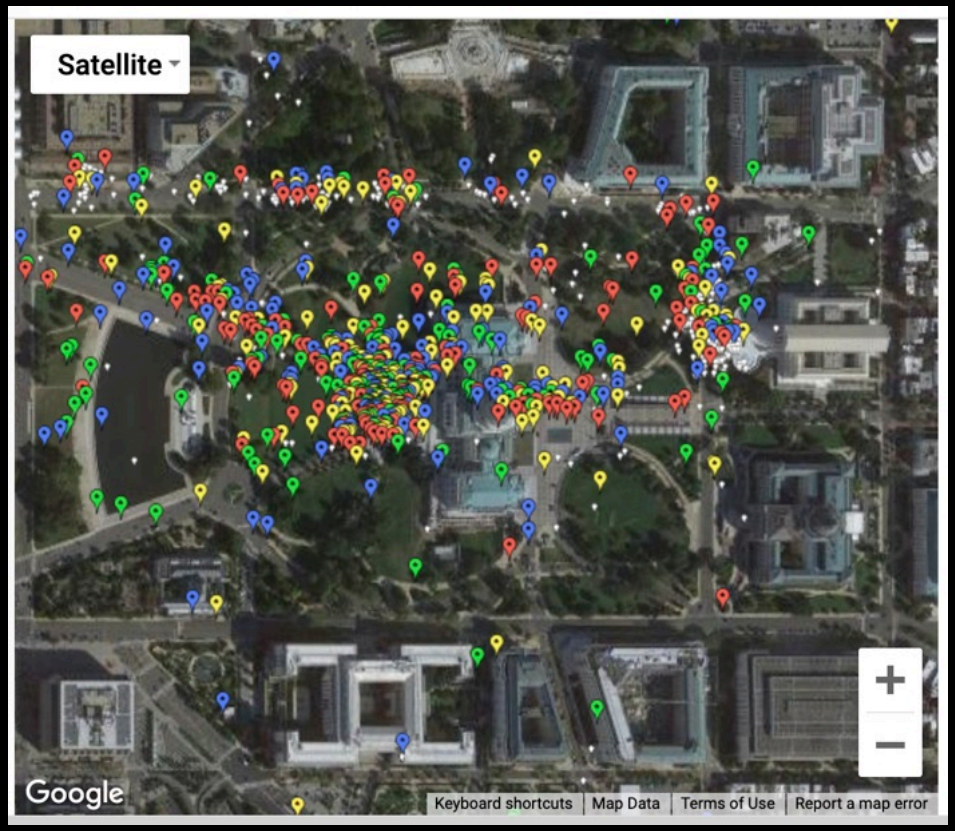
When an IOT goes wrong

Jan 6, 2021 US Capitol Insurrection

- This is an interactive map of uploaded videos during the Jan 6 2021 “insurrection” on the capitol building in Washington DC
- They include username and GPS position from where each video was taken

Where did this map come from?

Who made it?



https://techcrunch.com/2021/01/11/scraped-parler-data-is-a-metadata-goldmine/

When an IOT goes wrong

Jan 6, 2021 US Capitol Insurrection

- Users of social media site **Parler** were posting text messages and videos.
- Parler engineers had made ~~some~~ critical mistakes in securing their website
- A number of programmers/hackers were able to scrape/download millions of posts including GPS position and in some cases the users personal information
- This download was **not illegal**, Parler had no limitations on download rate and was not removing users GPS location (as Twitter/X does?).

Person Who Scraped the Data: https://twitter.com/donk_enby

Person Who Made The Maps: https://twitter.com/patr10tic

Lets look at the results:

- https://thepatr10t.github.io/yall-Qaeda/map.html

Next Class

Scooter/Bike/Car Sharing

- Network architecture
- Social impact
- Economic impact