Visual Exploration of GPS Traces: Can it Help Reduce Emissions?

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Outline

1. Introduction
2. Data Description
3. High-Level Analysis
4. Mid-Level Analysis
5. Clustering Applications
6. Animations

Transportation and Air Quality

- Transportation is the largest single source of air pollution in the United States
- In 2013, transportation contributed 50% of the carbon monoxide and nitrogen oxides, and 25% of the hydrocarbons emitted into air

- Improving transportation can significantly reduce emissions
  - better transit and carpooling programs $\Longrightarrow$ fewer cars on our streets
  - optimal relocation of taxis $\Longrightarrow$ less cruising of vacant taxis

sources/images: ucsusa.org, deoilit.com, af.mil

Presentation Objective

- Provide a visual overview of information contained in a huge data set of GPS traces
- Discuss how such data can be used to improve various aspects of transportation and thereby reduce emissions

Evaluate/redesign transit routes

Determine O/D pairs for carpool

Allocate taxis to high-demand locations

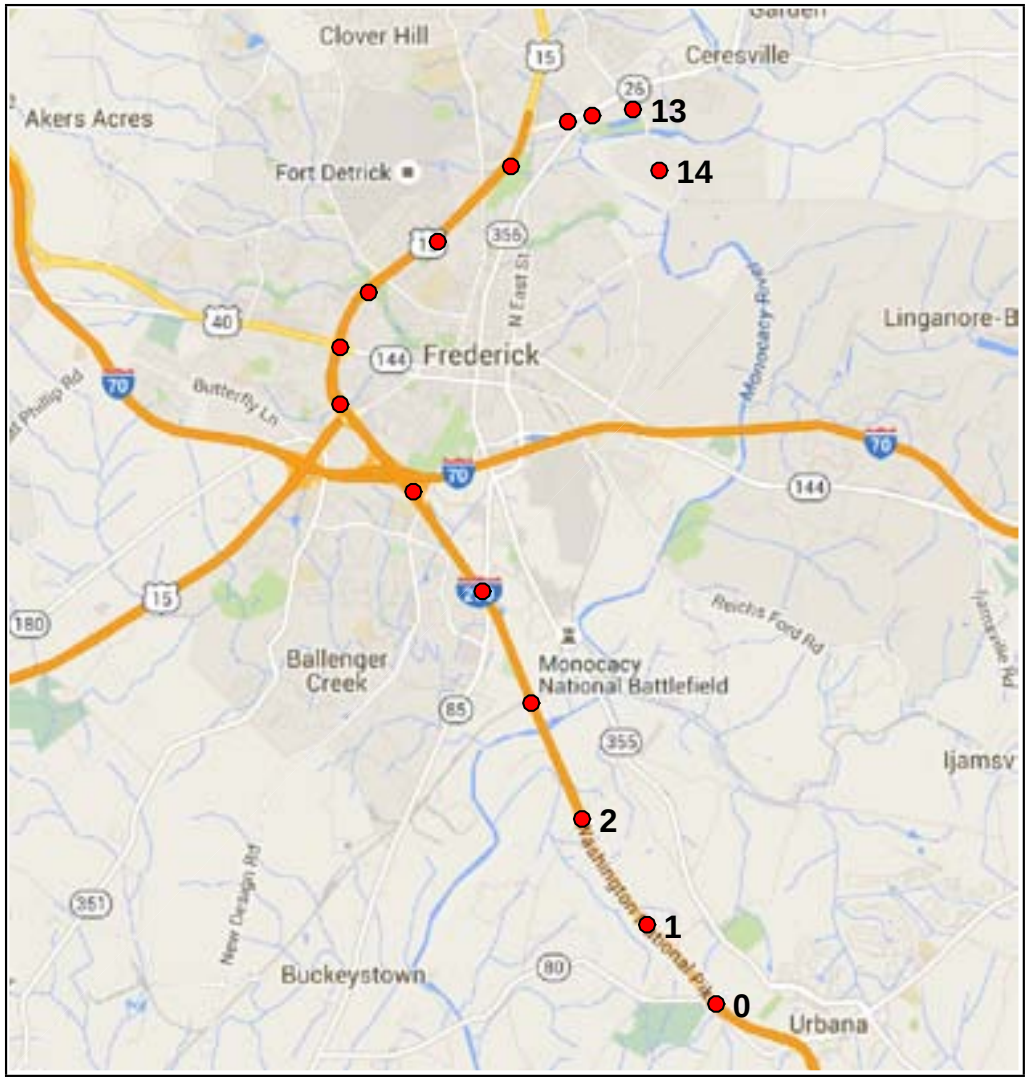
images: annapolis.gov, masalaread, thestreet

Data Source

- INRIX provides Internet services and mobile aps pertaining to road traffic and driver services (speeds, travel times, traffic counts)
- INRIX collects terabytes of data from over 250 million mobile phones, cars, trucks, vans and other fleet vehicles via GPS

- INRIX sold 4 months of trip O/D data to Maryland SHA
  - 20 million trips, which include 1.4 billion waypoints
  - **112 GB** of data

Data Sample: Single Trip



Waypoint locations and order

Trip

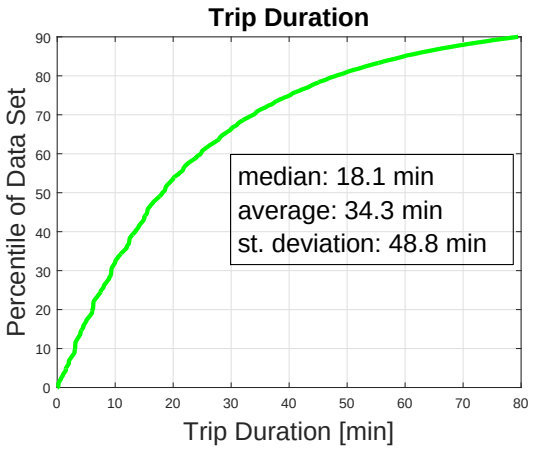
- Unique Id
- O/D locations and times
- Pedestrian or vehicle
- Vehicle: fleet, consumer, mobile
- Vehicle: weight class 1-3

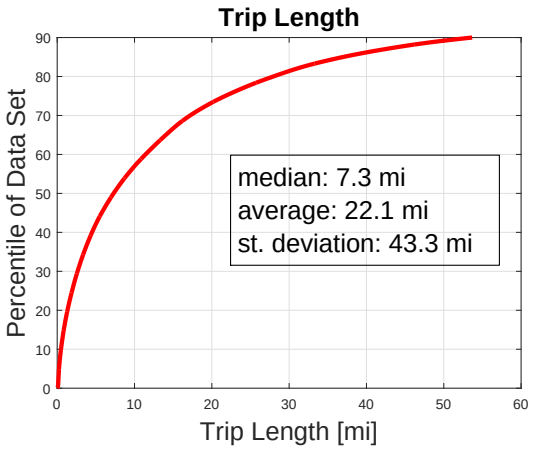
Waypoints

- Order: $0, 1, \ldots, n$
- Latitude and longitude
- Time stamp (sec)

20 Million Trips

Origin locations (July 2015)

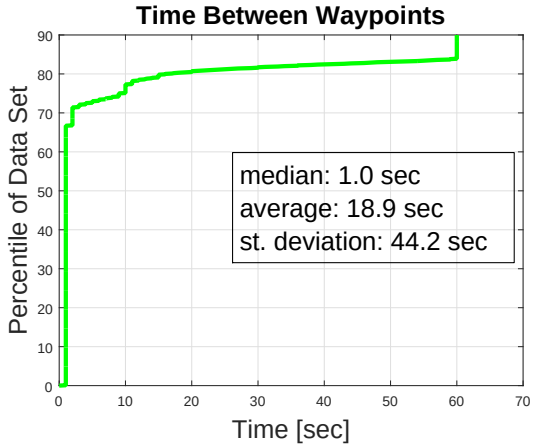


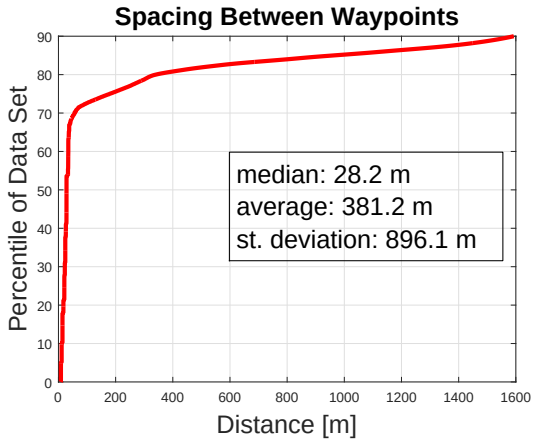


- Trip lengths are computed based on Euclidean distances between waypoints

1.4 Billion Waypoints

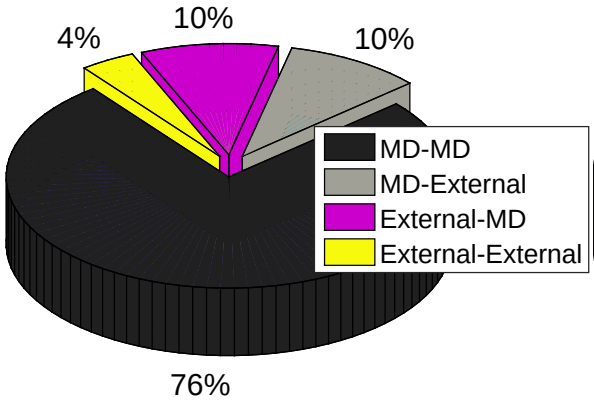
Waypoint locations (June 2015)

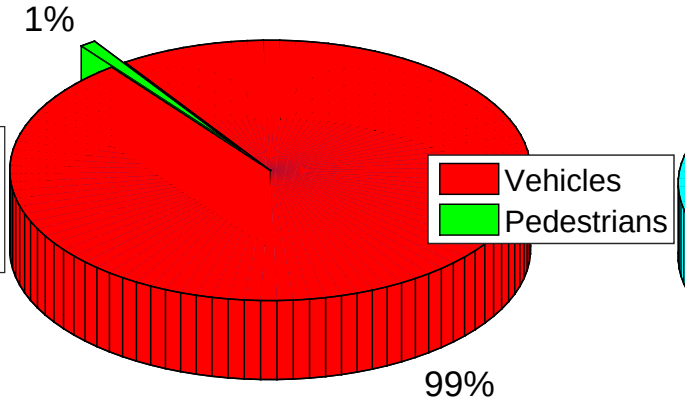


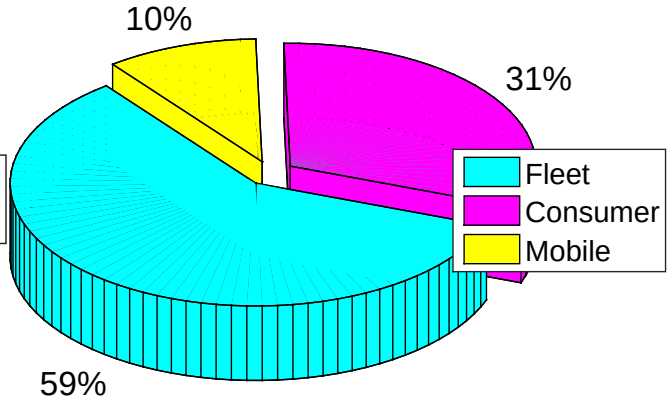


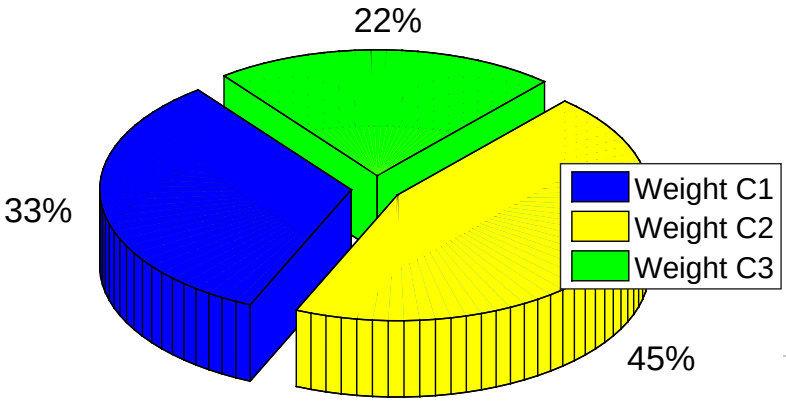
- Percentiles are based on a sample of 500 million waypoints from Feb and Oct

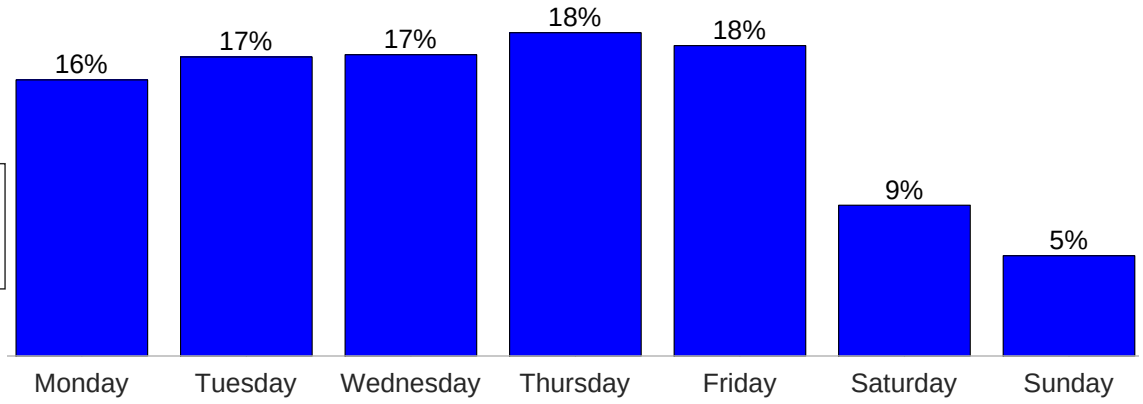
Trip Attributes





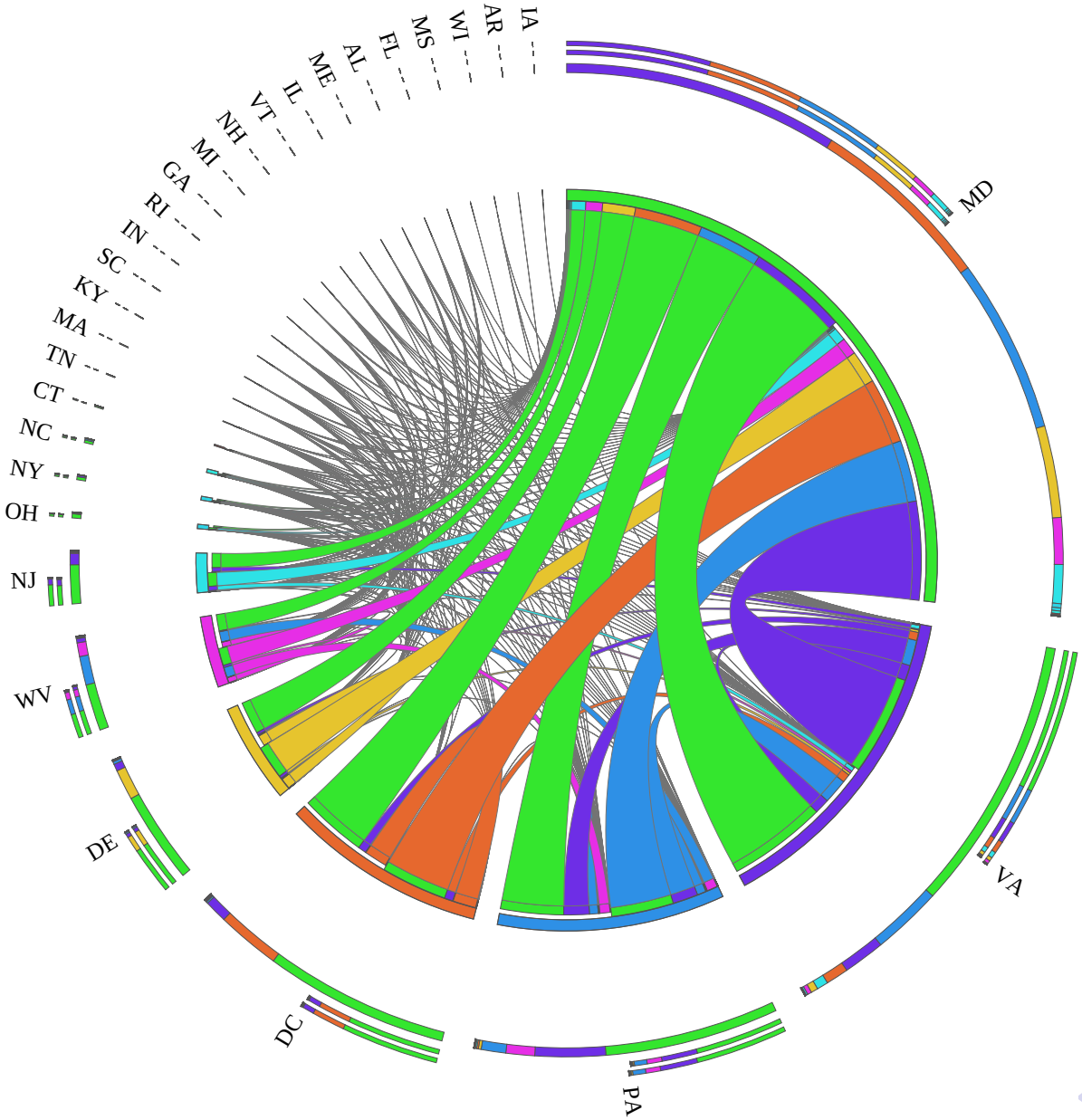






$C1 \leq 14{,}000$ lb, $C3 \geq 26{,}000$ lb

Trips between MD and Other States



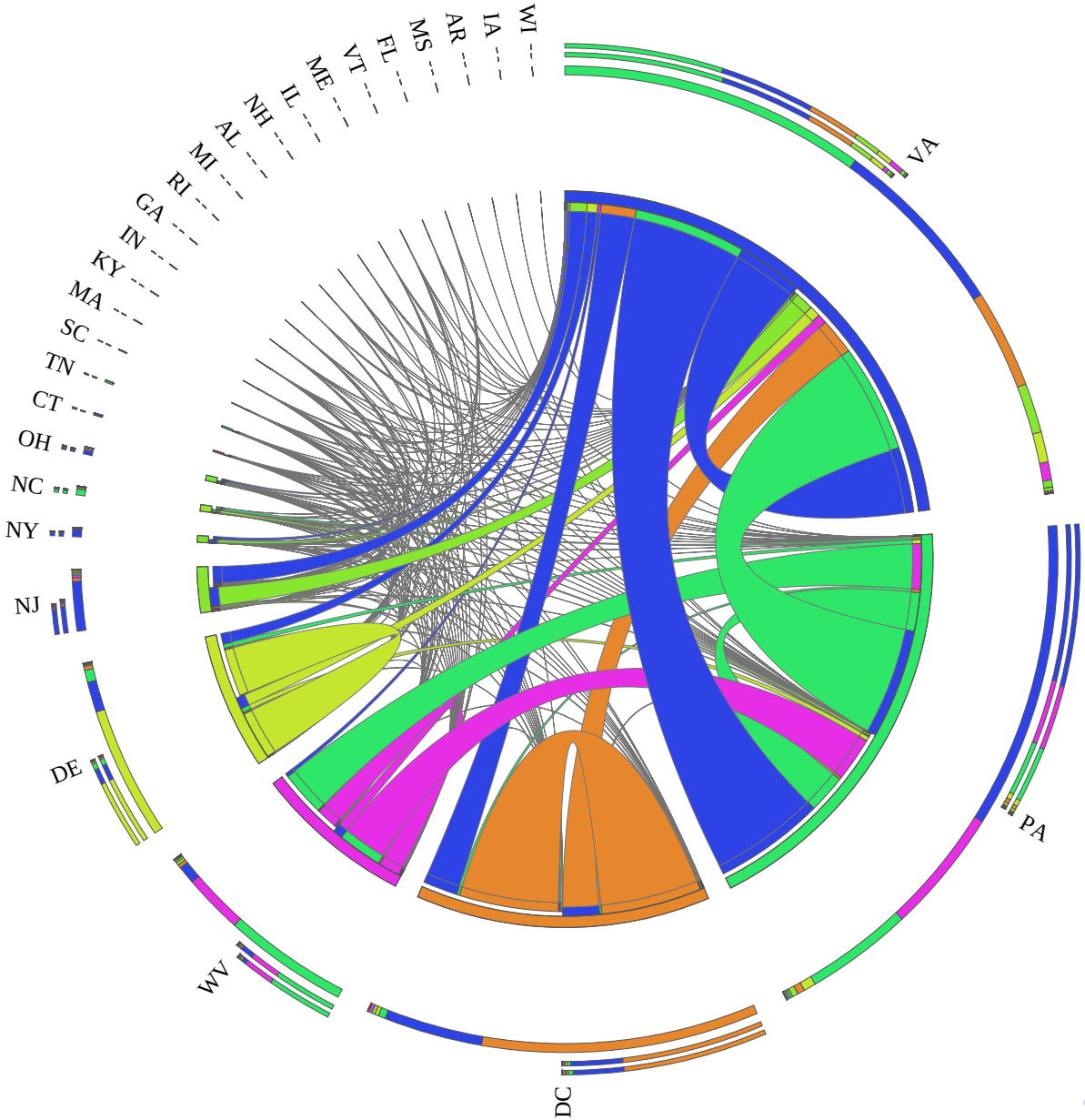
Chord Diagram

- Trips between MD and other states
- MD-MD trips are filtered out

Observations

- Balanced inflows/outflows
- Most trips to/from neighboring states

Trips traversing MD



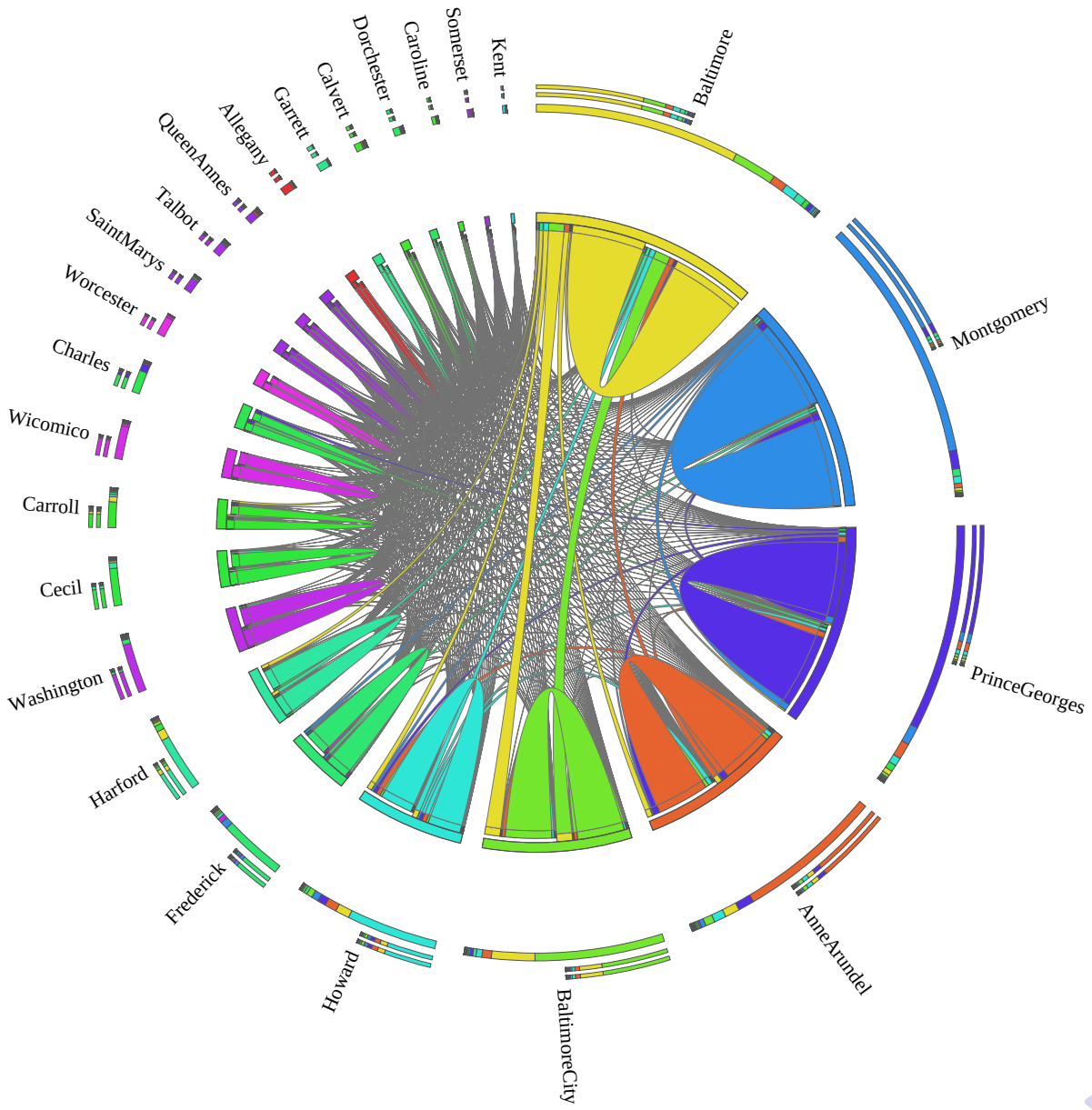
Chord Diagram

- Trips traversing MD without stopping
- Trips with O/D in MD are filtered out

Observations

- DE/DC trips show interesting patterns

Trips within MD



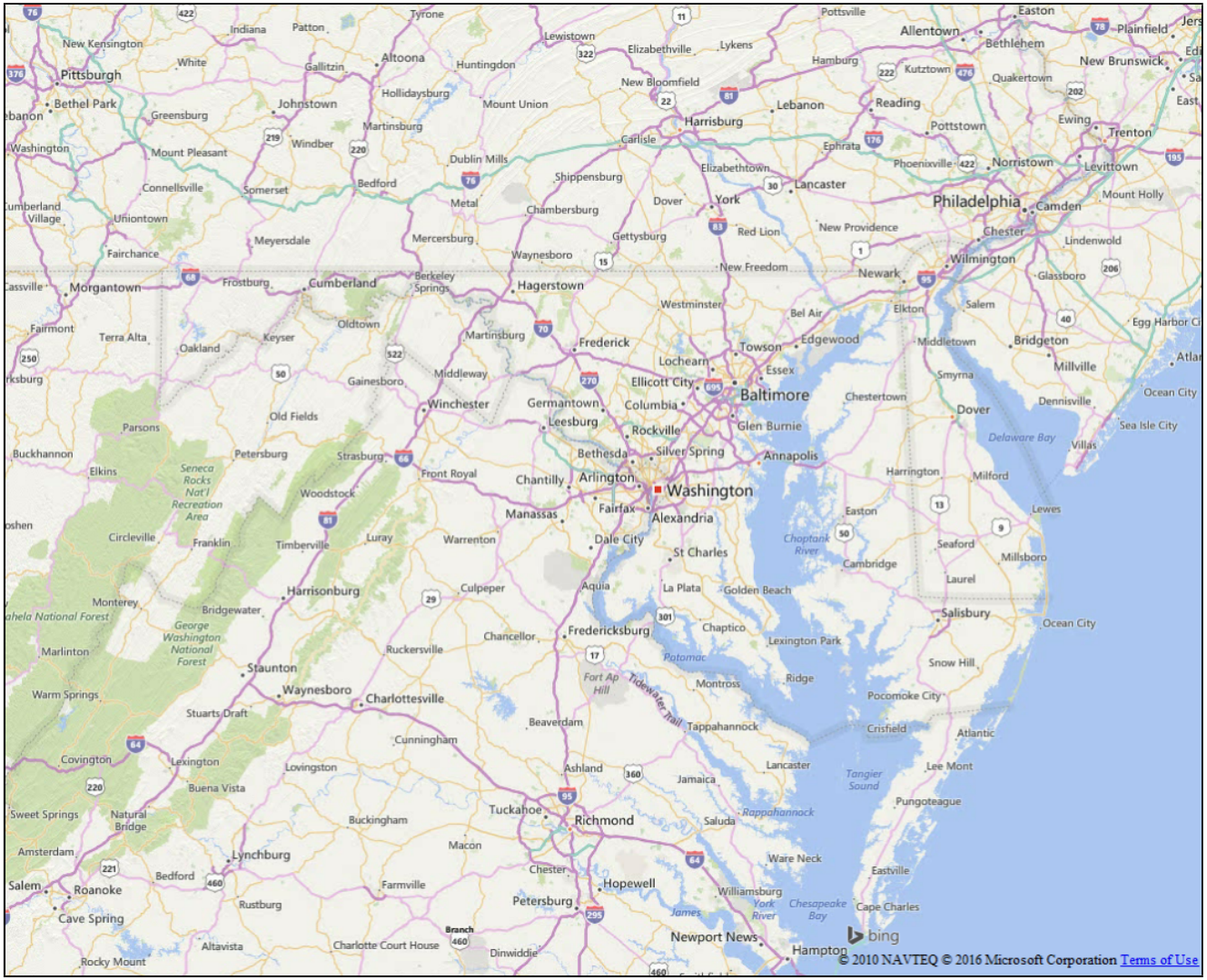
Chord Diagram

- Trips with O/D in MD
- Trips with a waypoint outside MD are filtered out

Observations

- Most trips are within the same county

Origins in MD



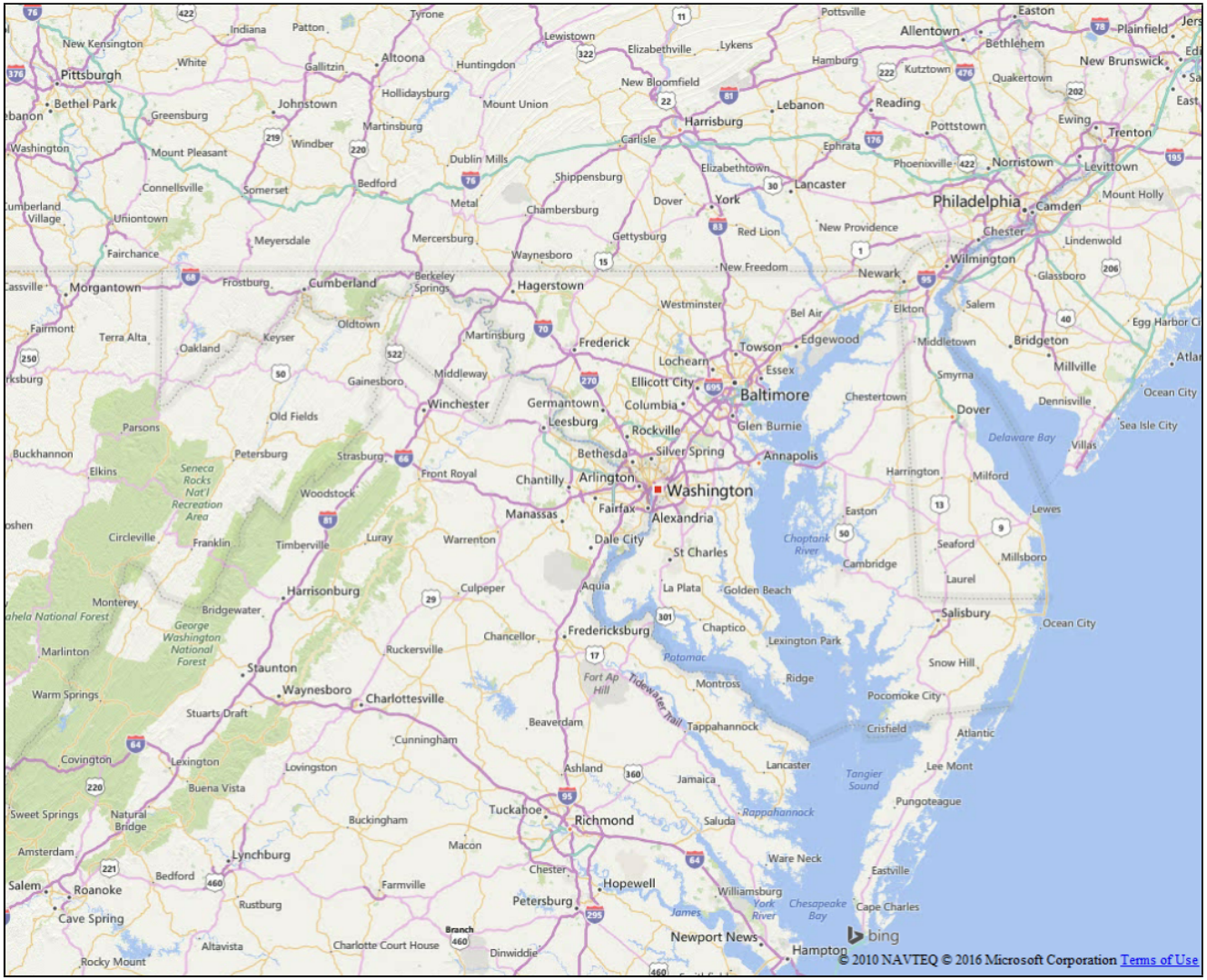
Heat Map

- Origins in MD

Trip generators

- Baltimore
- BWI - Ft. Mead
- Bethesda - Gr. Town

Destinations in MD



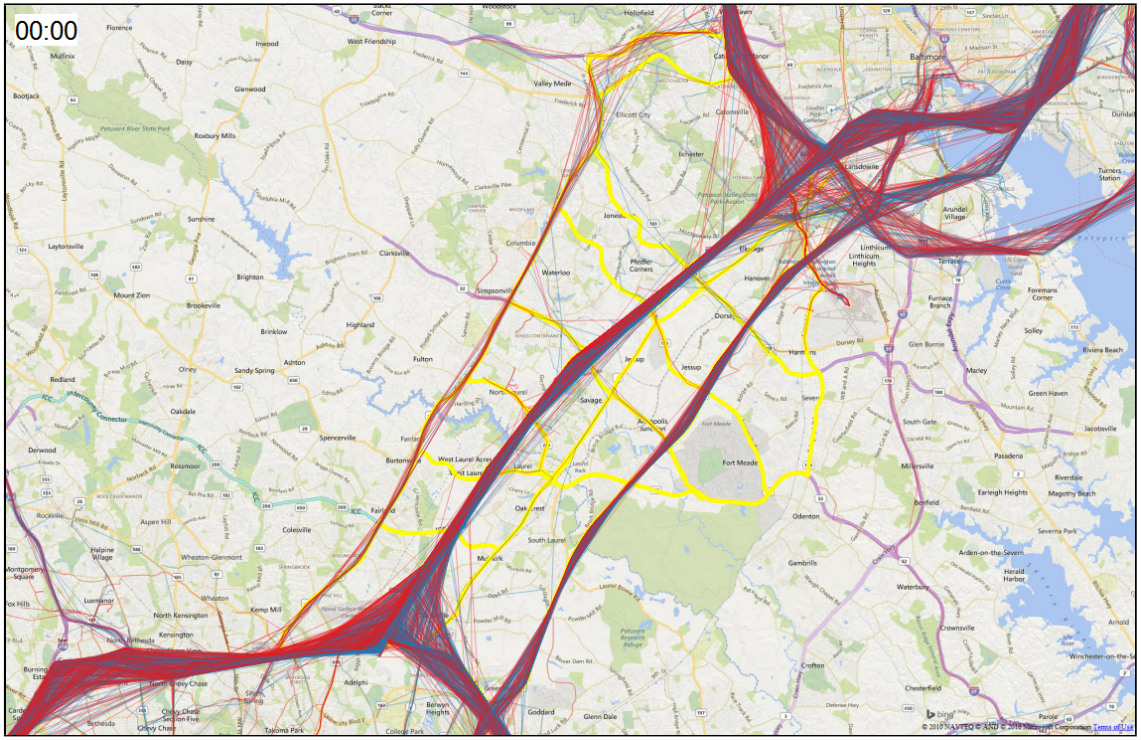
Heat Map

- Destinations in MD

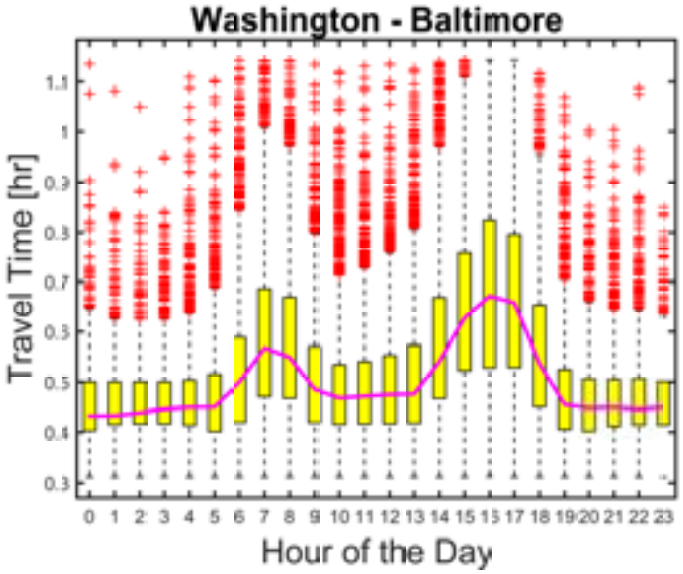
Trip attractors

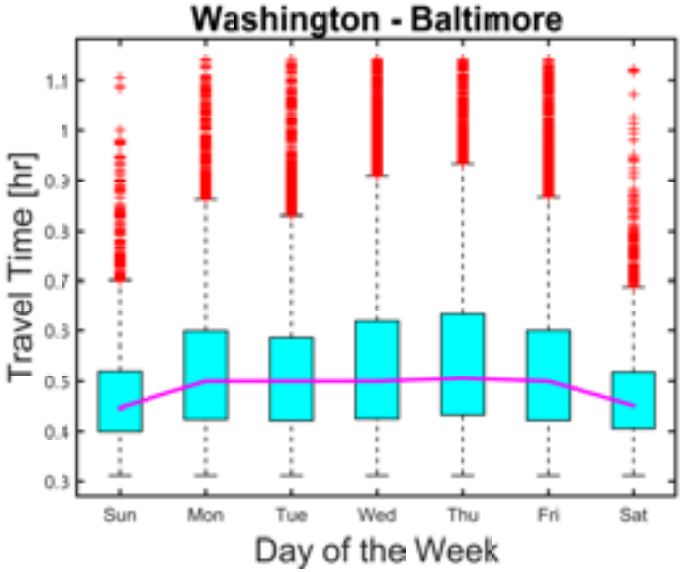
- Baltimore
- BWI - Ft. Mead
- Bethesda - Gr. Town

Trips along I-95

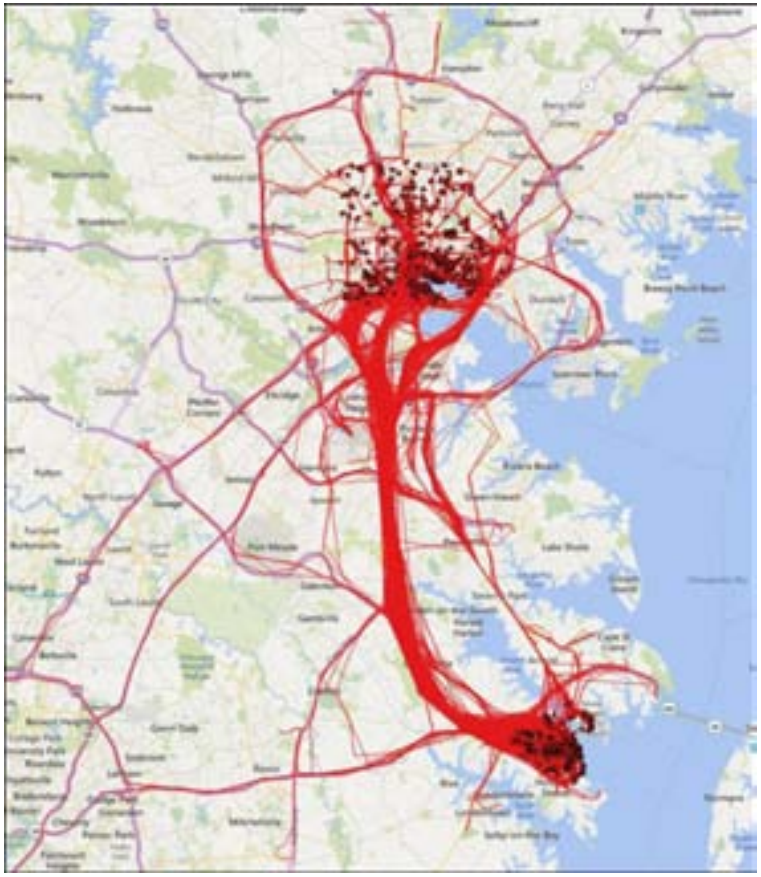


Blue/Red trajectories are North/South bound (70k trips during July)

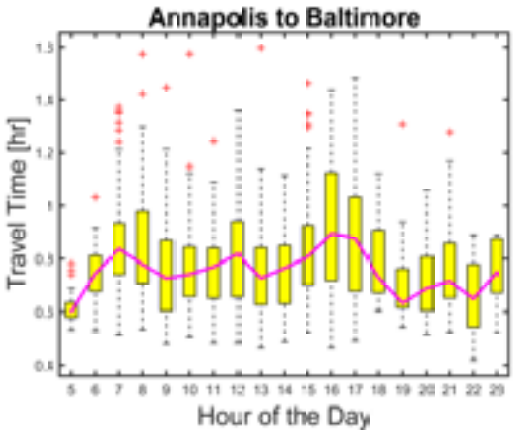


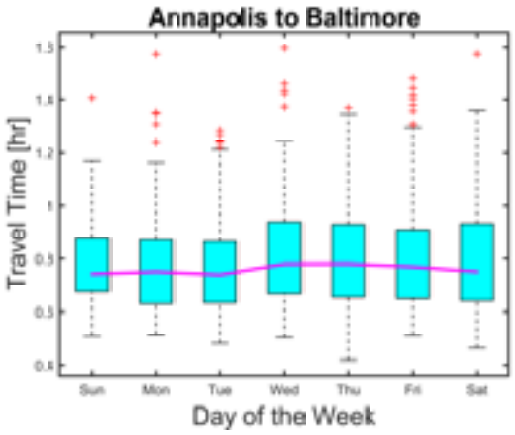


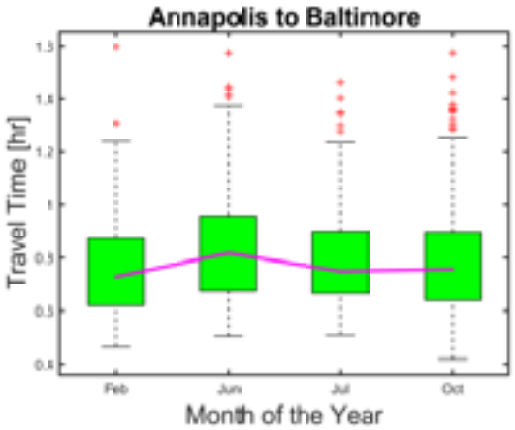
Trips from Annapolis to Baltimore

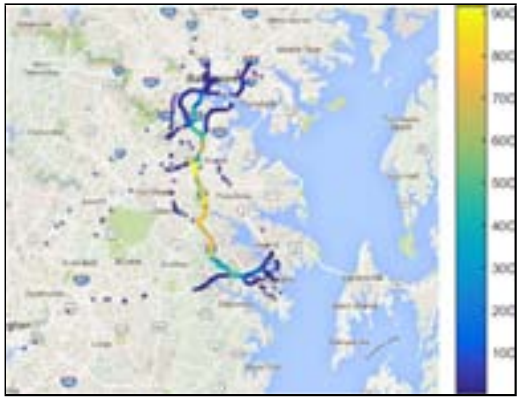


1,050 trips during 4 months

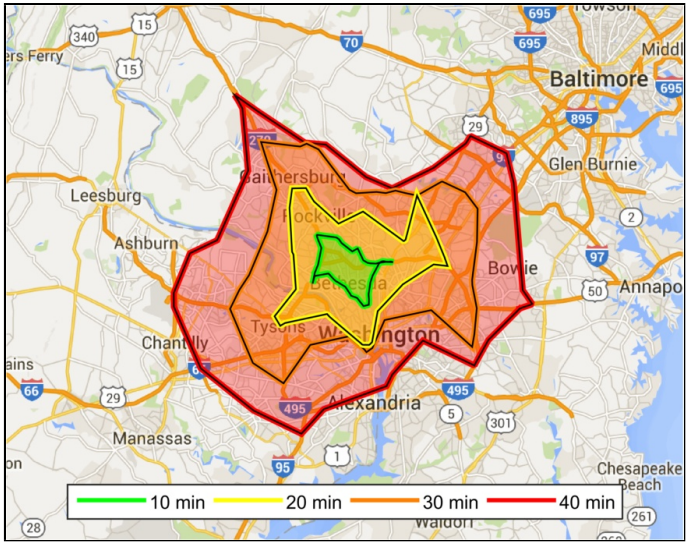




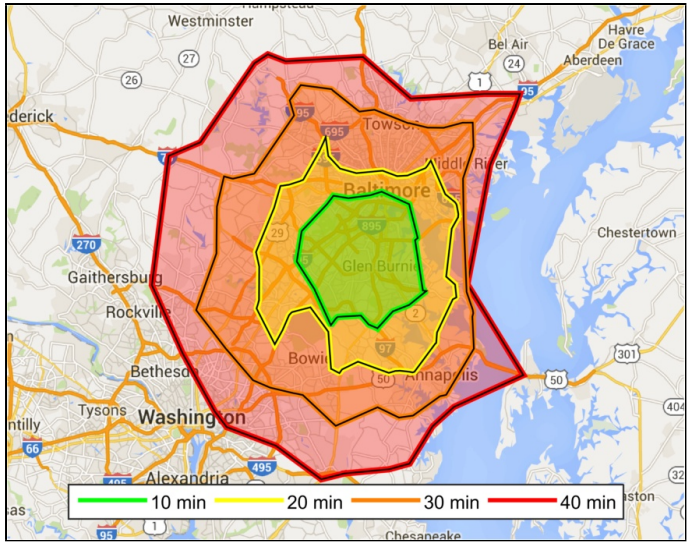




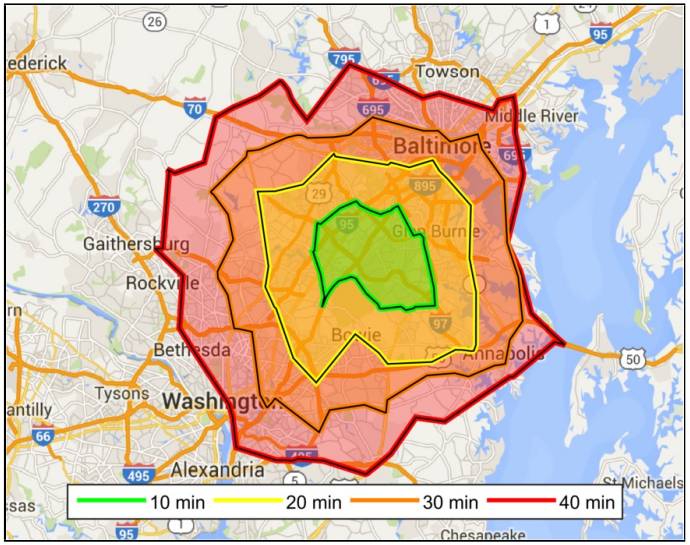
Trips from Activity Zones



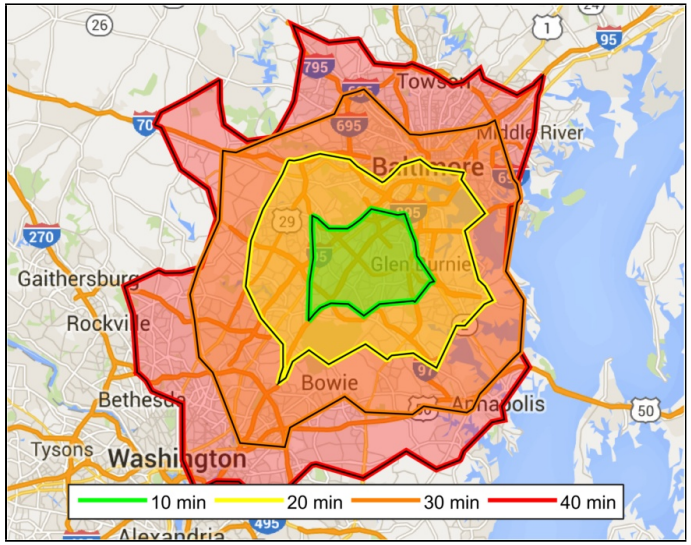
Walter Reed Medical Center



BWI



Fort Meade



Arundel Mills

Comparison

- Peak
  7:00 am - 9:00 am
  4:00 pm - 6:00 pm
- Offpeak

Clustering Annapolis Trips

Goal

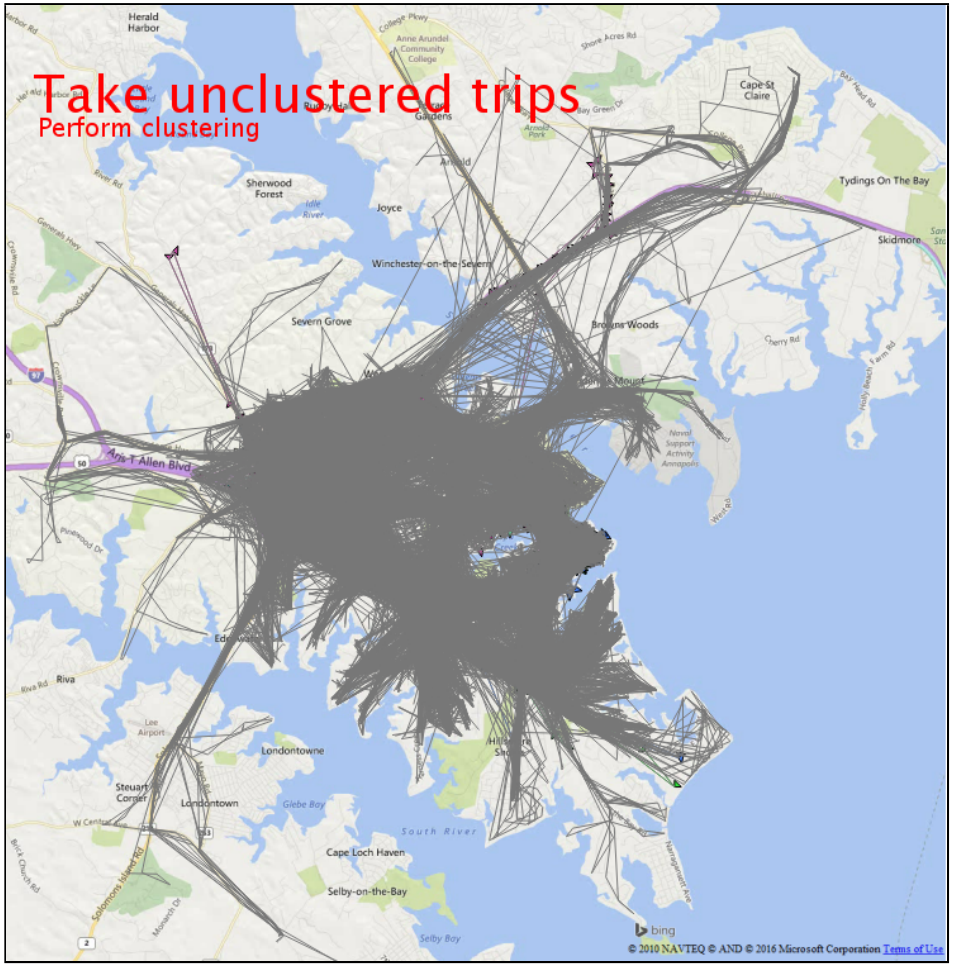
- Evaluate, redesign, or build from scratch routes for public transit

Intuition

- If many people travel between the same origin and destination, transit should connect these locations

Approach

- Find clusters of trips with similar origins and destinations
- Consider modifying existing transit routes based on these clusters



Similar idea for carpool programs

Clustering I-95 Trips

Goal

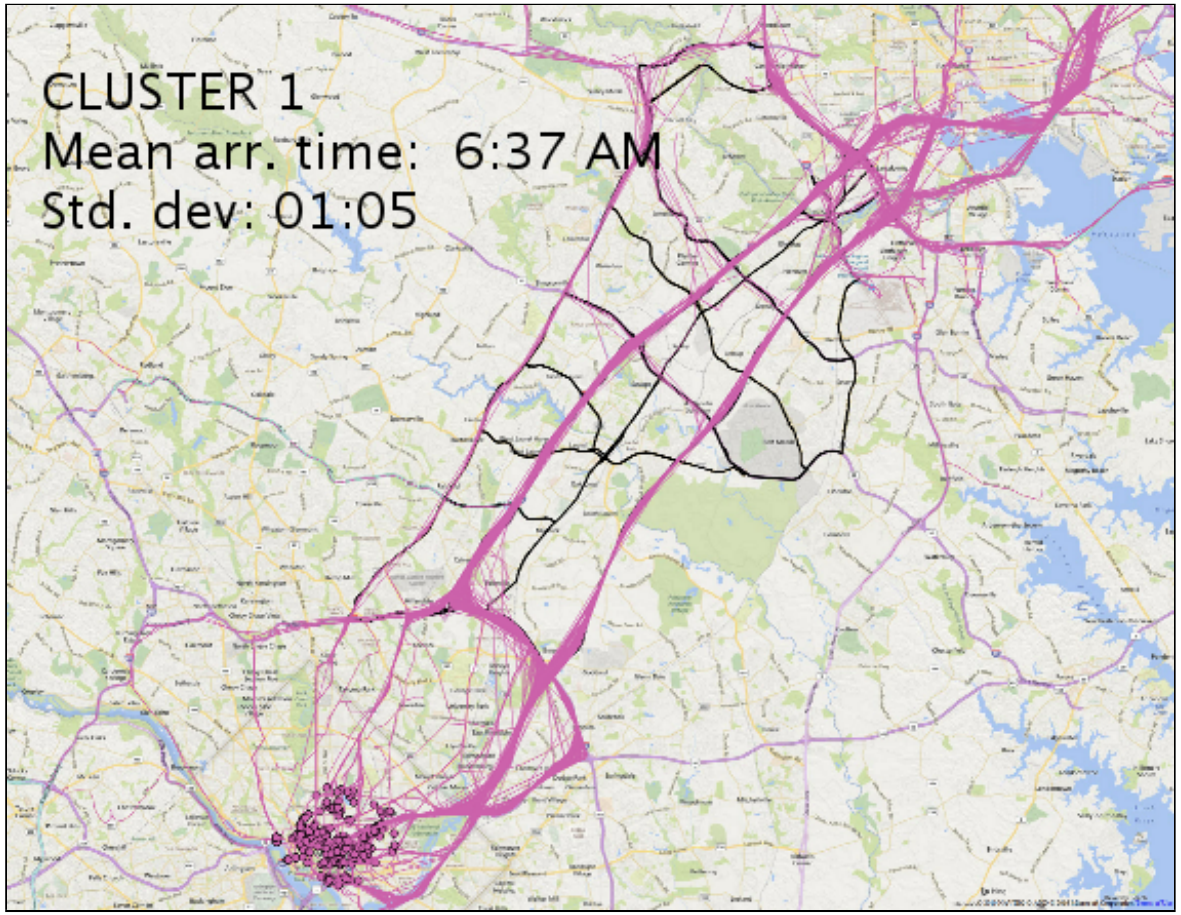
- Determine causes of congestion and mitigate it

Intuition

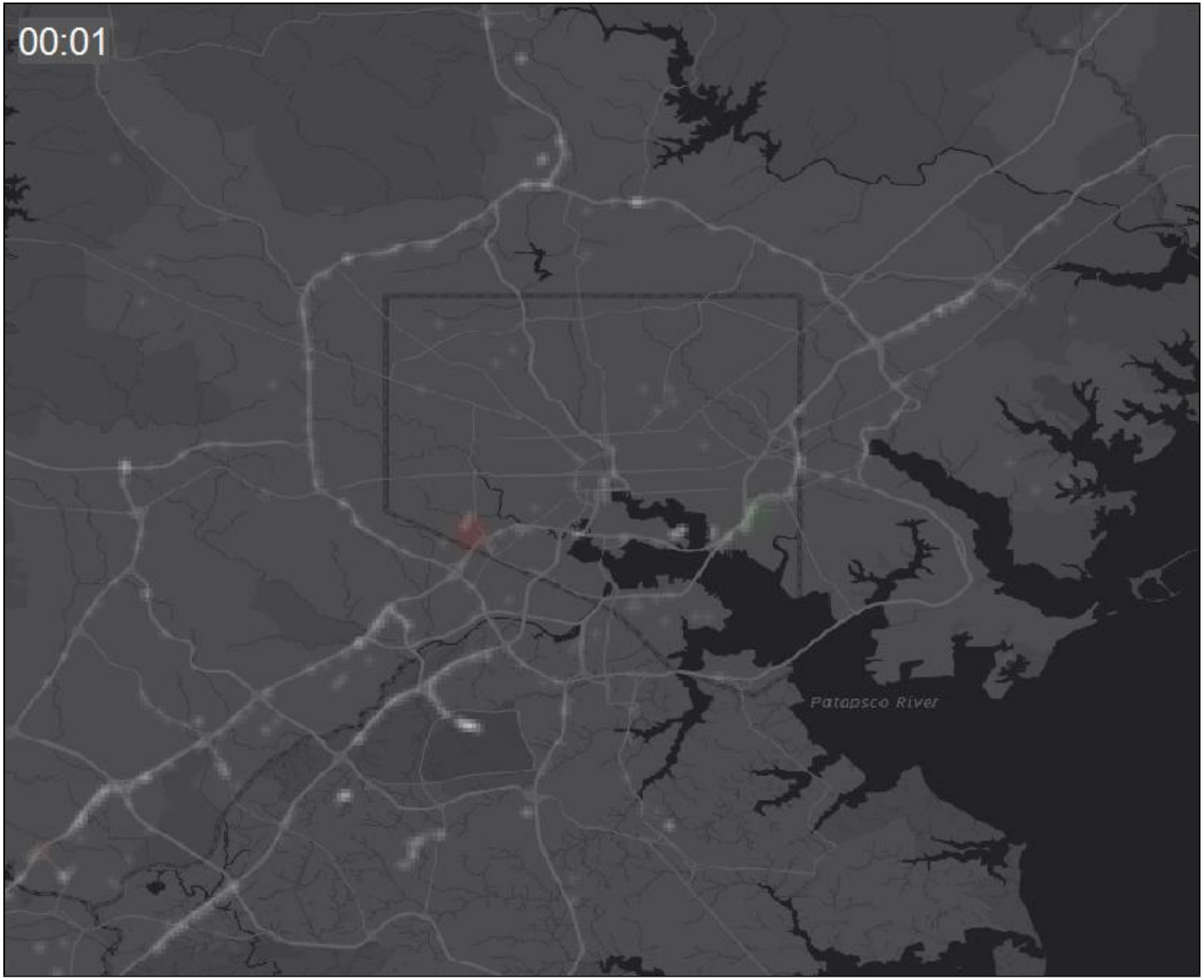
- Congestion occurs when many people travel to the same place at the same time

Approach

- Find trips with similar destinations and arrival times
- Analyze trip attractors and try to spread arrivals



A Day in Baltimore

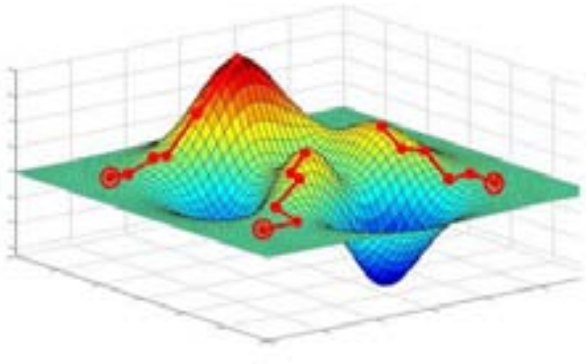


Animation

- July 7, 2015
- O/D: green/red

Conclusions

- GPS data can be used for various planning purposes, just like the cell phone data (which is much less accurate)
- It provides necessary inputs to many optimization models aimed to improve efficiency of transportation systems



- Improving transportation systems yields significant savings in money and time, but it also reduces emissions
- GPS data could become an invaluable resource to transportation agencies

Thank You

Q&A

Contact Information

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