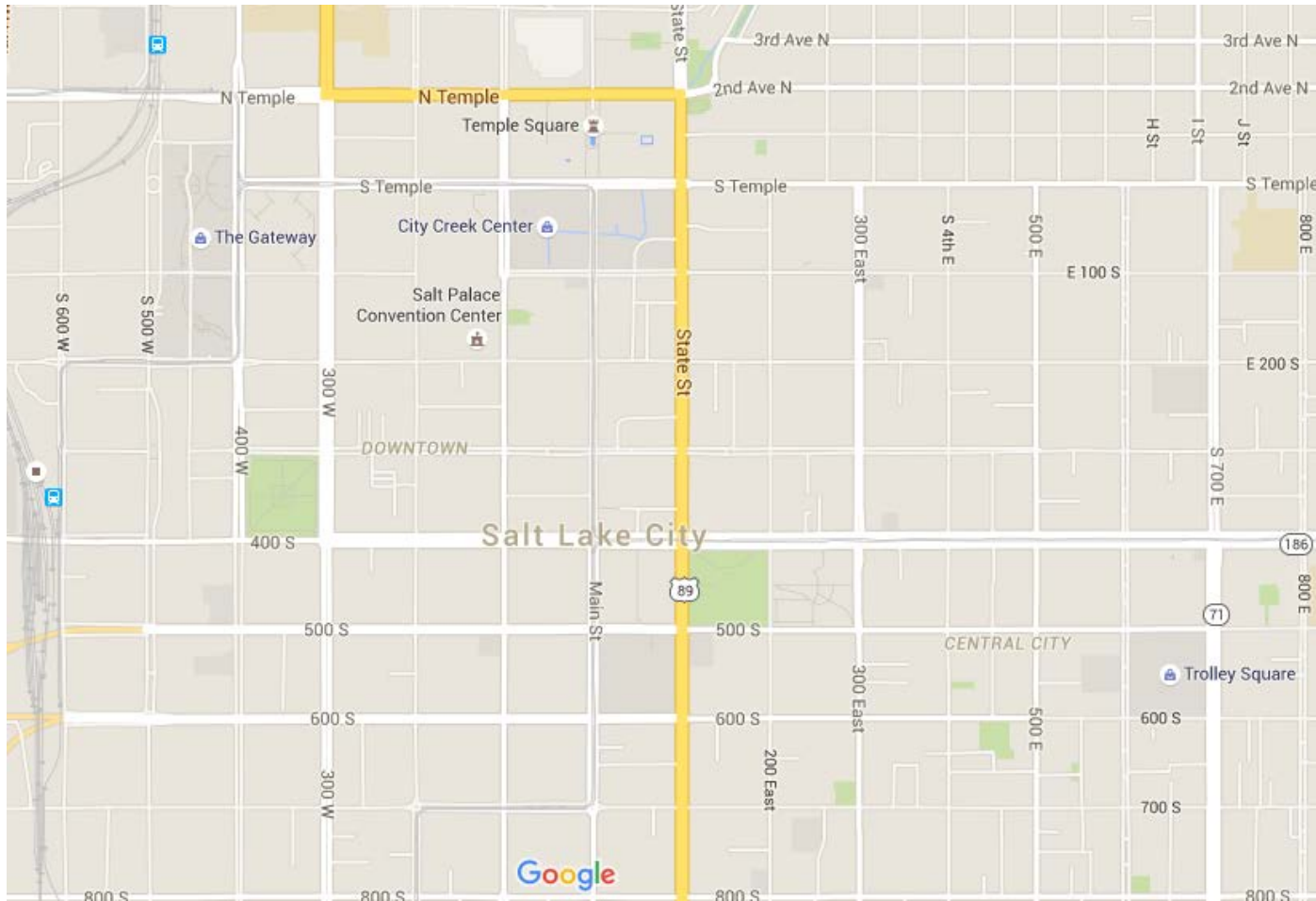


# Characterizing Bikeshare Usage with Network Modeling Techniques

Jeffrey Taylor and Cathy Liu

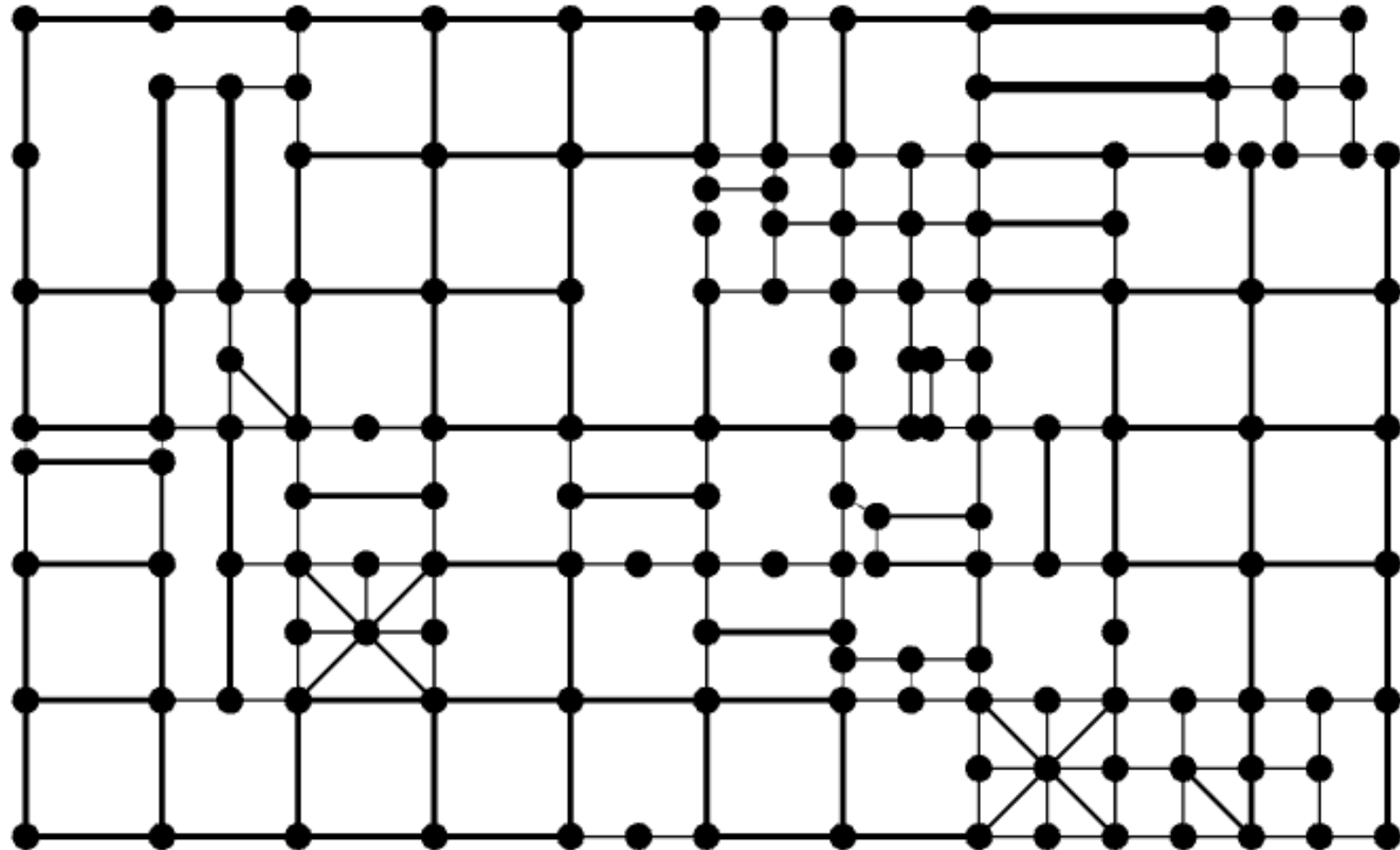
Presented April 13, 2016

# Transportation Networks



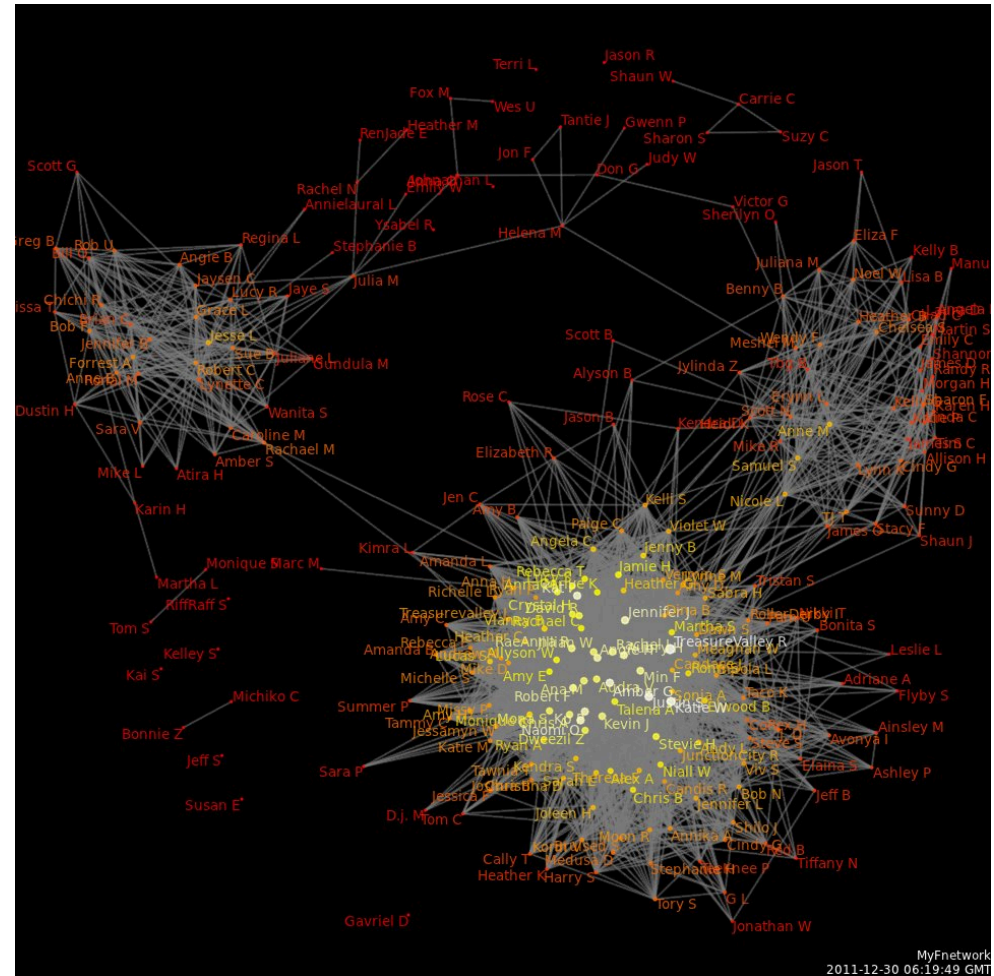
Source: Google Maps

# Simplified Representation



# Networks/Graphs

- Components:
  - Nodes/Vertices
  - Links/Edges
- Network Structure
  - Connectivity
  - Density
  - Distance
  - Centrality



MyNetwork  
2011-12-30 06:19:49 GMT

Source: Wikimedia Foundation

# Centrality Measures

- Centrality can indicate importance in graphs

Measure	Definition
Degree centrality	Number of incoming links to a node
Eigenvector centrality	Like degree centrality, but weights incoming links based on the centrality of neighboring nodes
Closeness centrality	Measures the average distance to other nodes from each node
Betweenness centrality	Measures how many paths between nodes use each network node

# Application to Bikeshare Usage

# Methodology

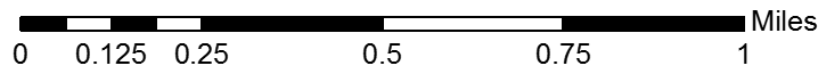
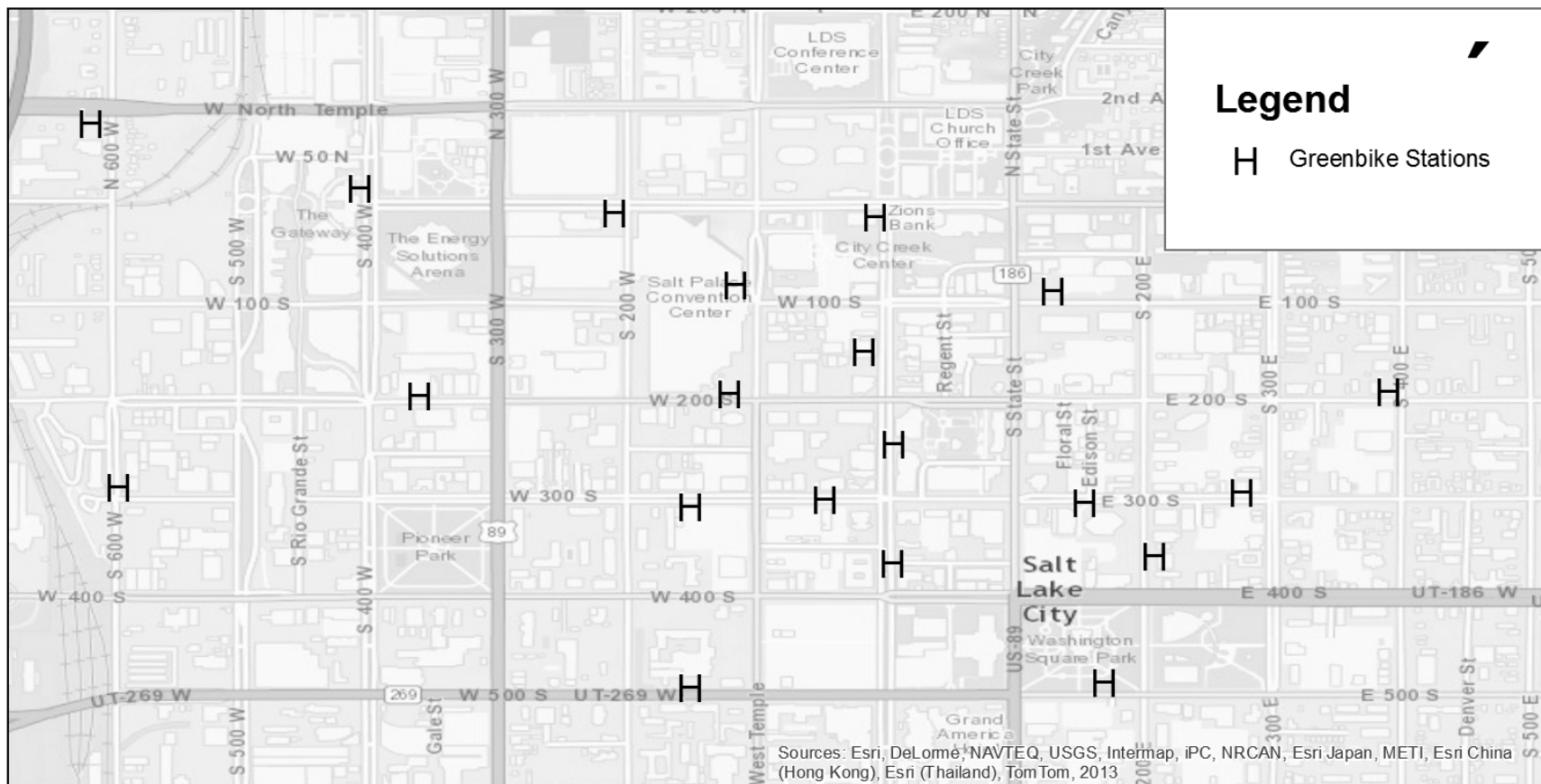
- Inspired by Wang et al. (2012) and Toole et al. (2015)
  - Analyze usage with graph of network flows
  - Metrics: Degree & Betweenness Centrality
- Goal: Identify attractive routes, and what makes them attractive

# Background

- GREENbike SLC opened in 2013
  - Automated rental kiosks located downtown
- Rapid system expansion
  - Open in 2013: 10 Stations, 55 Bikes
  - By Mid 2013: 12 Stations, 75 Bikes
    - Expanded capacity at 5 existing stations
  - 2014: 20 Stations, 150 Bikes
    - Expanded capacity at 4 existing stations



# GREENbike Bikeshare Program

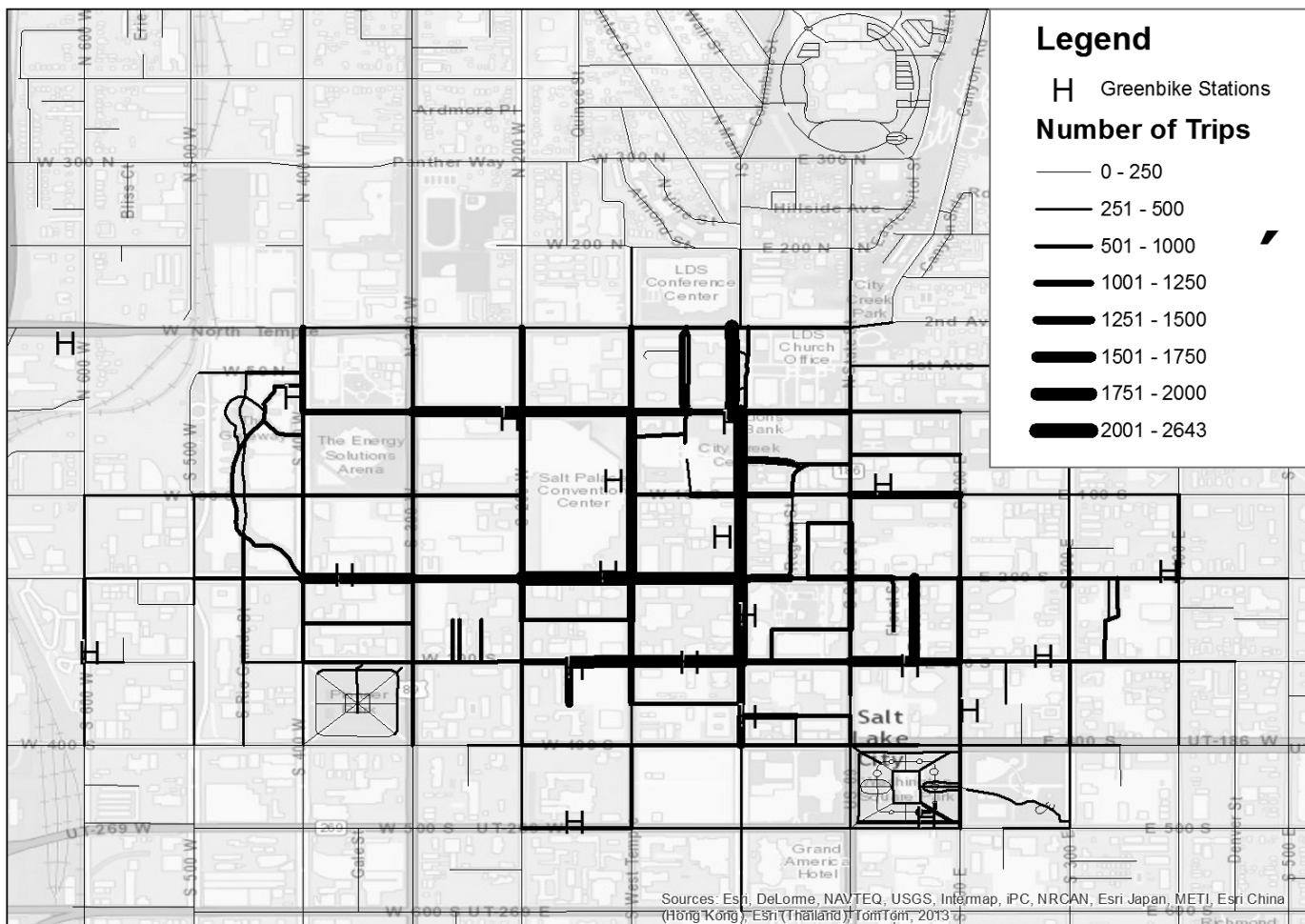


# GreenBike GPS Data

- Approx. 9500 trips, 3400 travelers
- Time Period: July 1, 2014 to Sept. 30, 2014
- Passive GPS Data
  - Locations along route, no time stamps
- Other Relevant Data:
  - Checkout/Return Kiosk, Checkout/Return Time
  - Trip Distance, Travel Time
  - User type (24-hour, Annual Memberships)

# GPS Map Matching

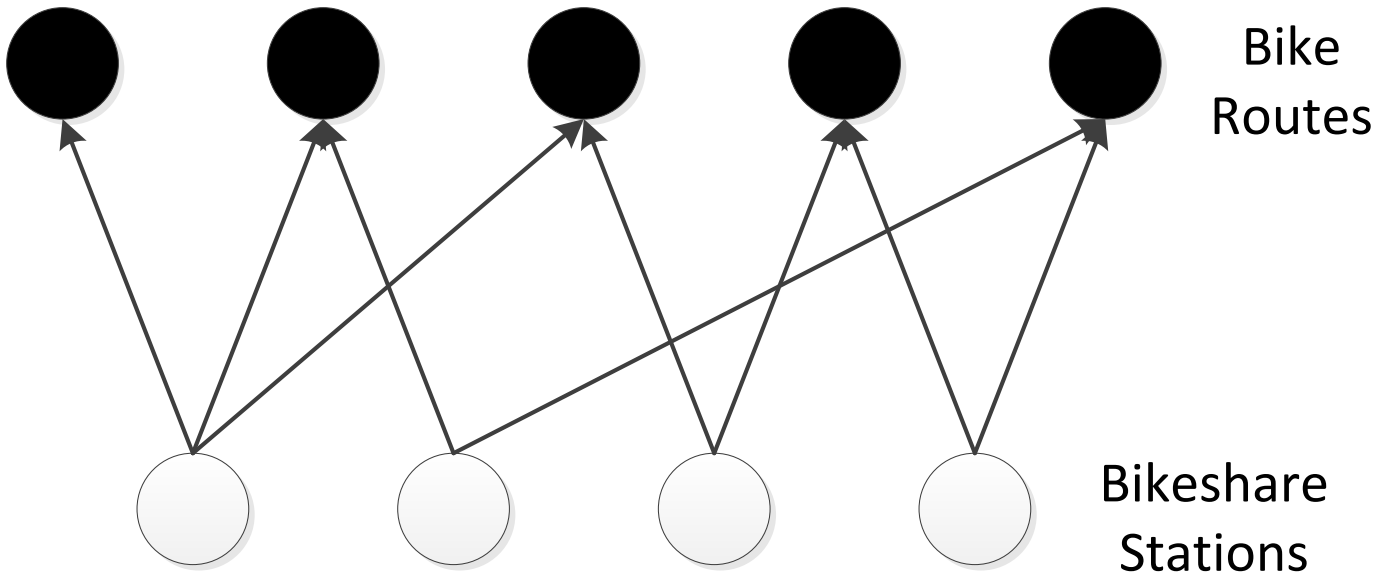
# Bikeshare Trip Densities



0 0.125 0.25 0.5 0.75 1 Miles

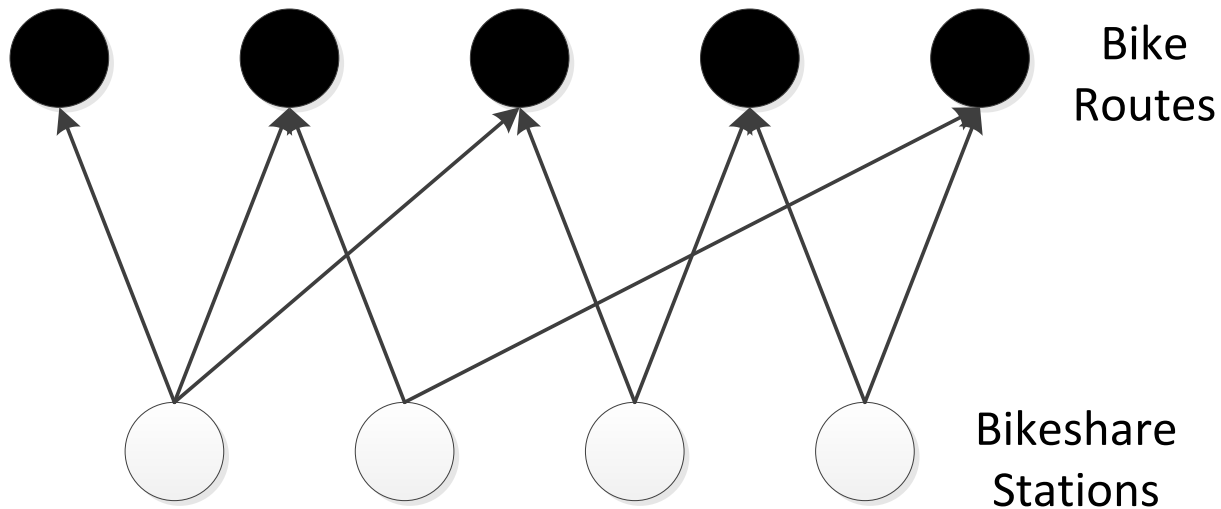
# Bipartite Usage Graph

- Bipartite: 2 sets of nodes
- Convert links to nodes

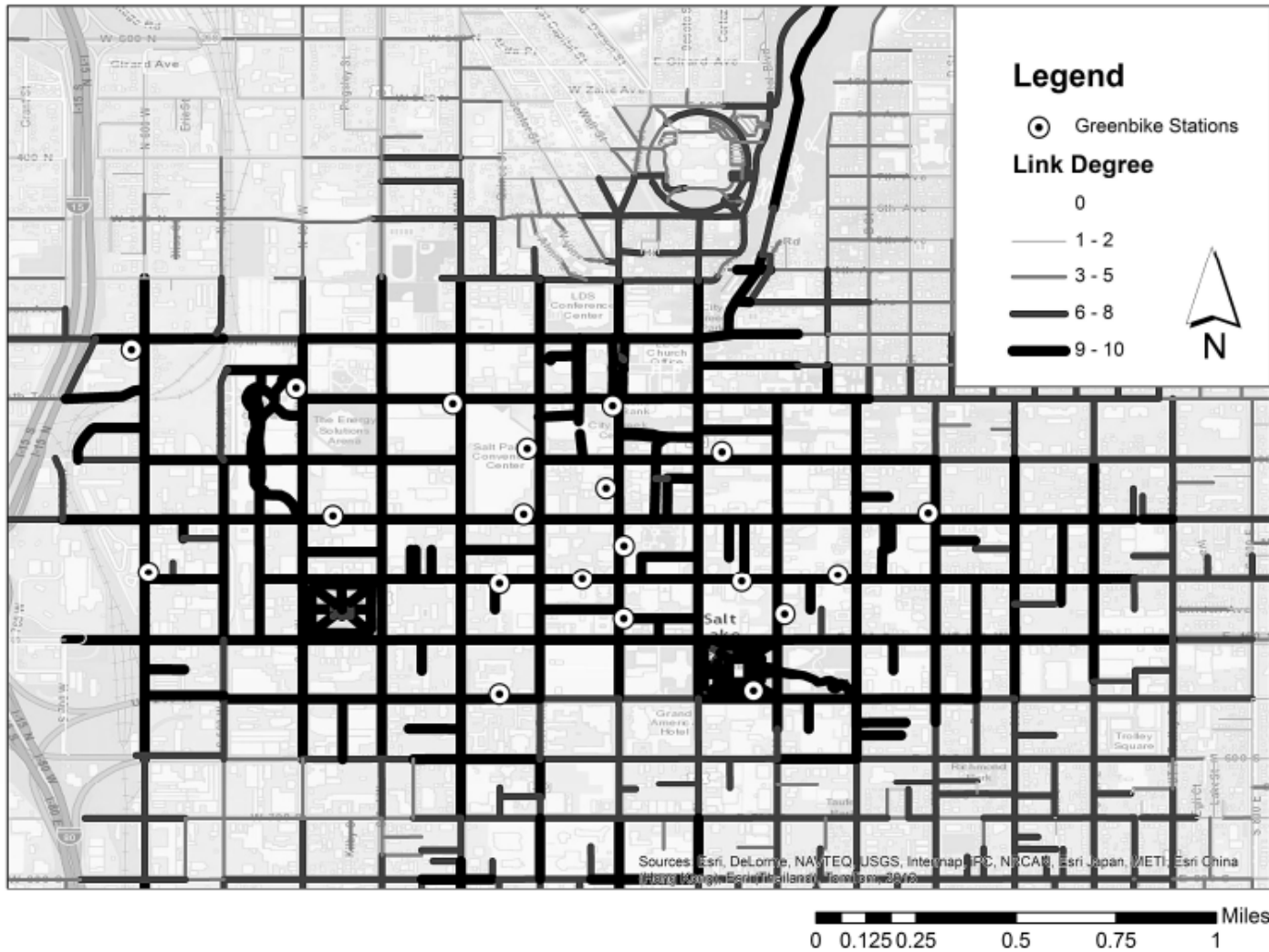


# Degree Centrality

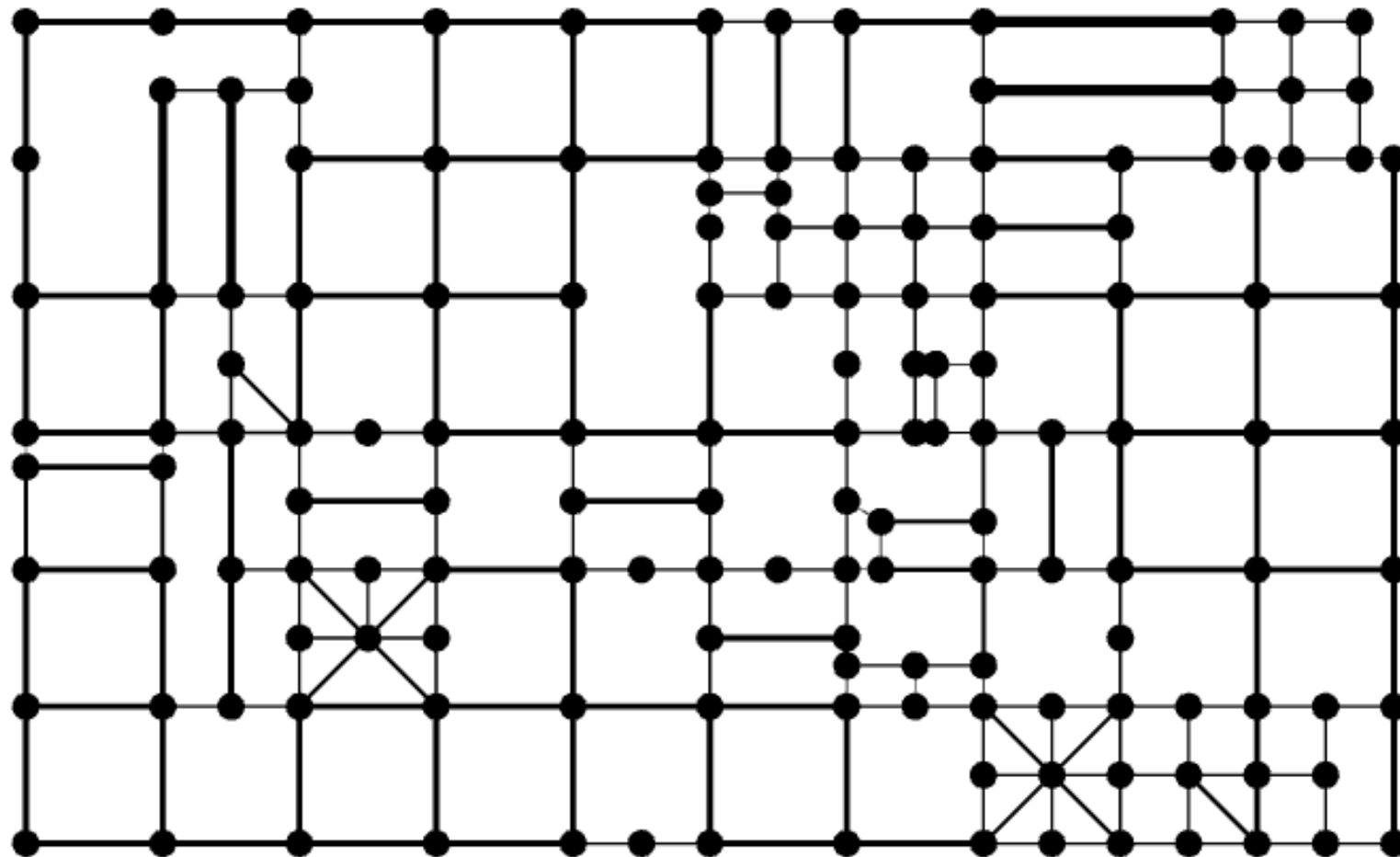
- Count the number of incoming links at a node
  - In the bipartite usage graph, this counts the number of trip sources using a link in the street network



# Degree Centrality

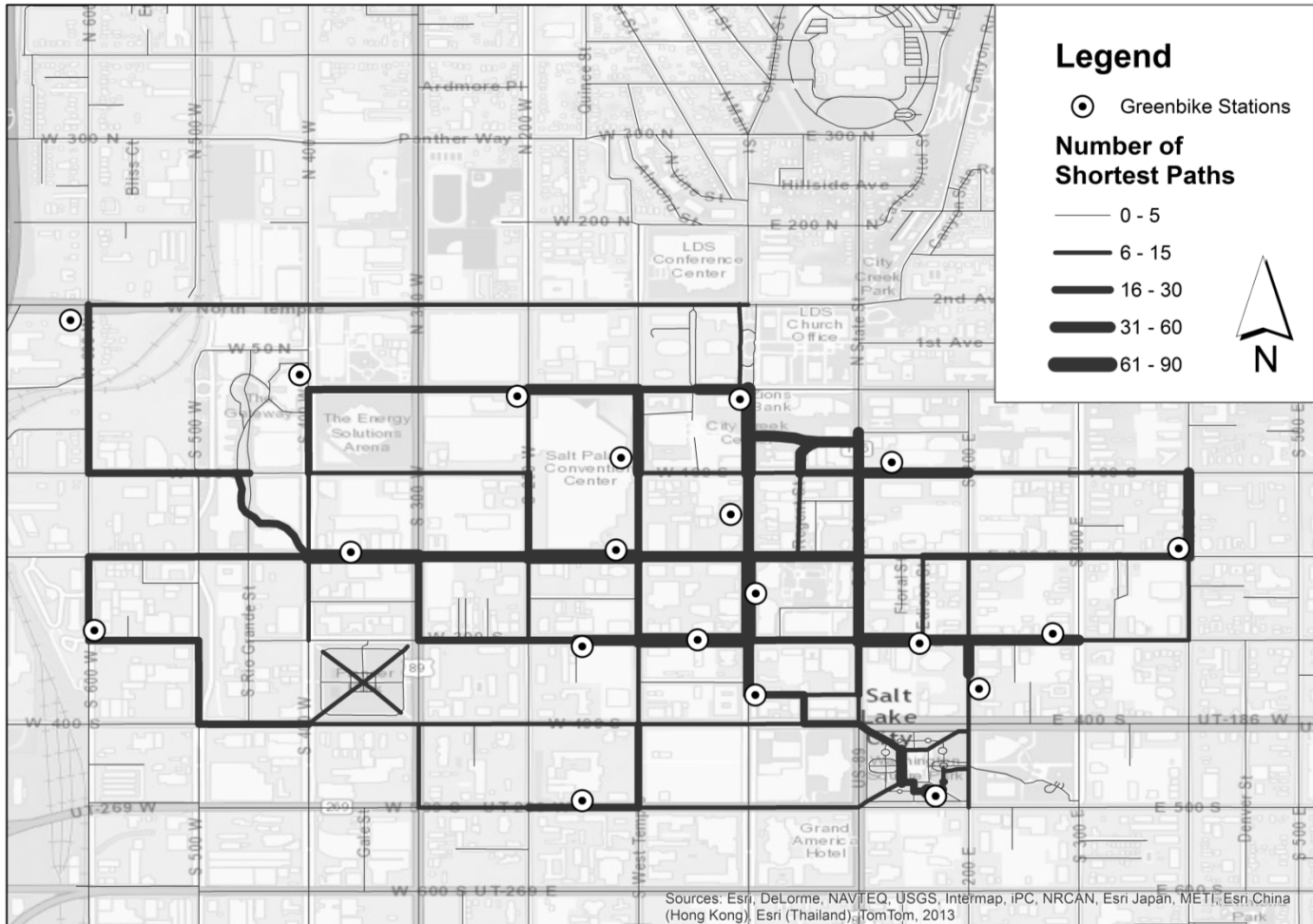


# Betweenness Centrality





# Betweenness Centrality



0 0.125 0.25 0.5 0.75 1 Miles

# Application: Conceptual Understanding

- Degree centrality indicates which routes are used by multiple trip sources
  - Higher values indicate wide-spread use
- Betweenness centrality indicates which routes we expect most trips to utilize
  - Where do we expect to see high traffic from multiple trip sources?

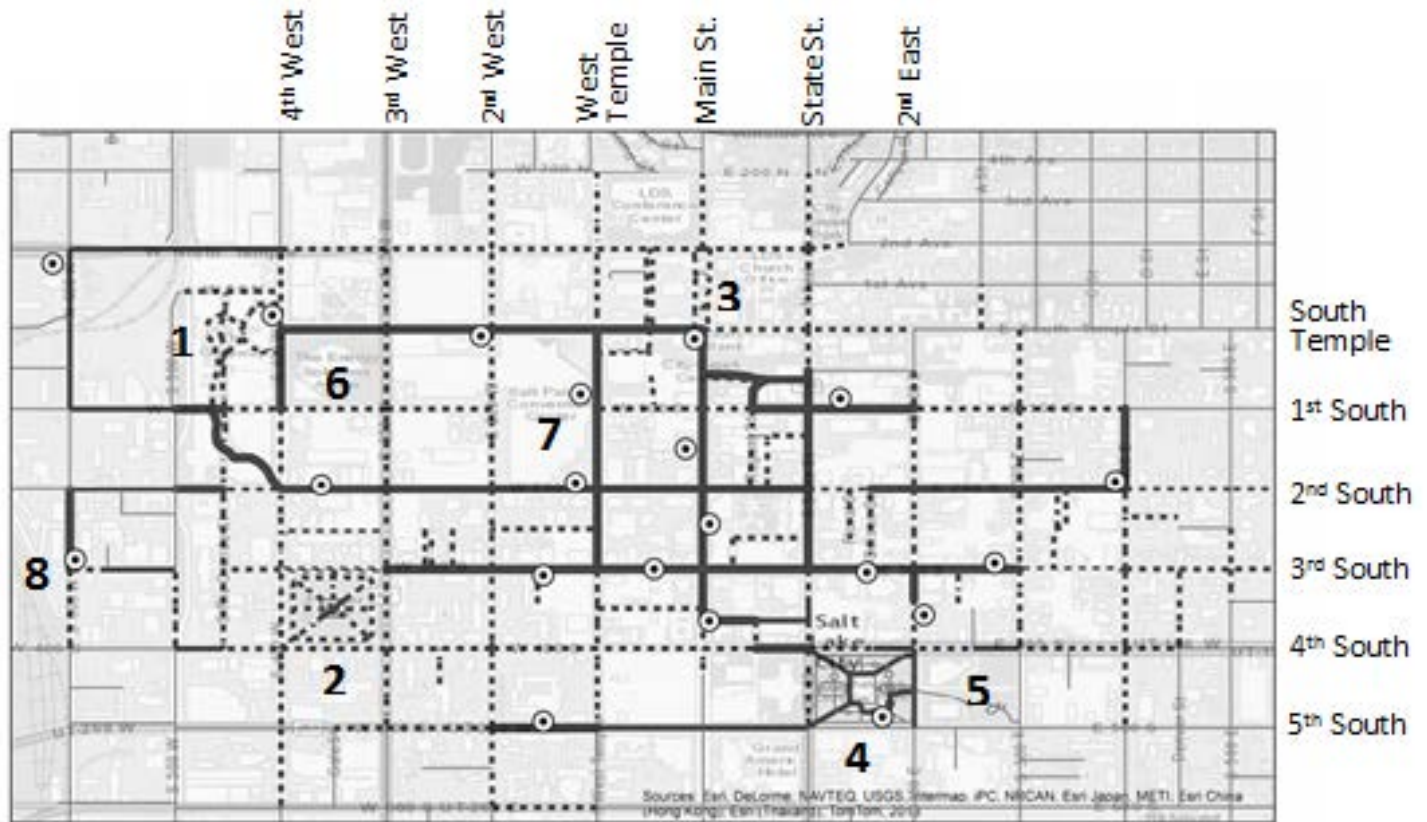
# Application: Conceptual Understanding

- Combine Degree & Betweenness
  - Compare links with many diverse traffic sources to areas expected to have many diverse traffic sources
- Outcomes:

Betweenness	Degree	Interpretation
High	High	Important links connecting many trip sources
Low	High	Higher utilization than expected – Attractive links
High	Low	Lower utilization than expected – important links, but utilized by more local travelers
Low	Low	Lower importance links mostly used by local travelers

# Route Classification Results

1. Gateway Mall
2. Pioneer Park
3. Temple Square
4. SLC Gov. Building
5. SLC Library
6. Energy Solutions Arena
7. Salt Palace Conv. Center
8. Salt Lake Central Station



## Route Classification

— Local

— Peripheral Connectors

⊙ Greenbike Stations

----- Attractors

— Connectors



0 0.1 0.2 0.4 0.6 0.8 Miles