

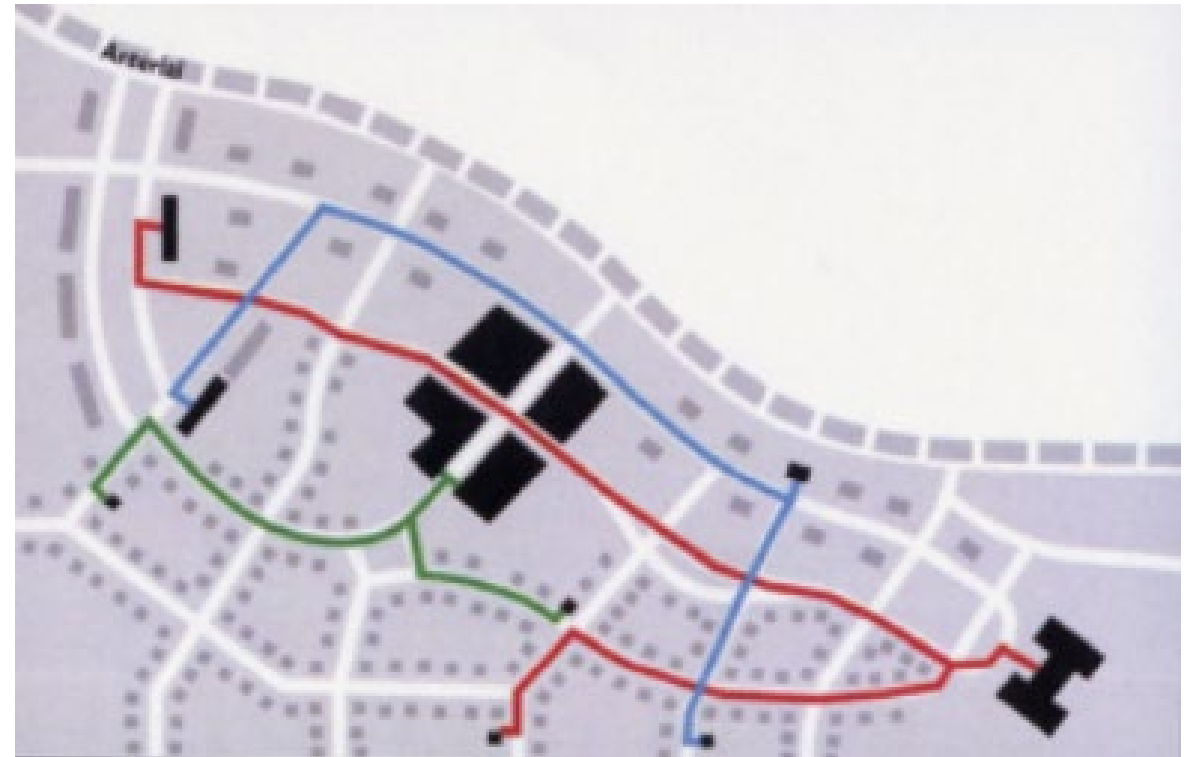
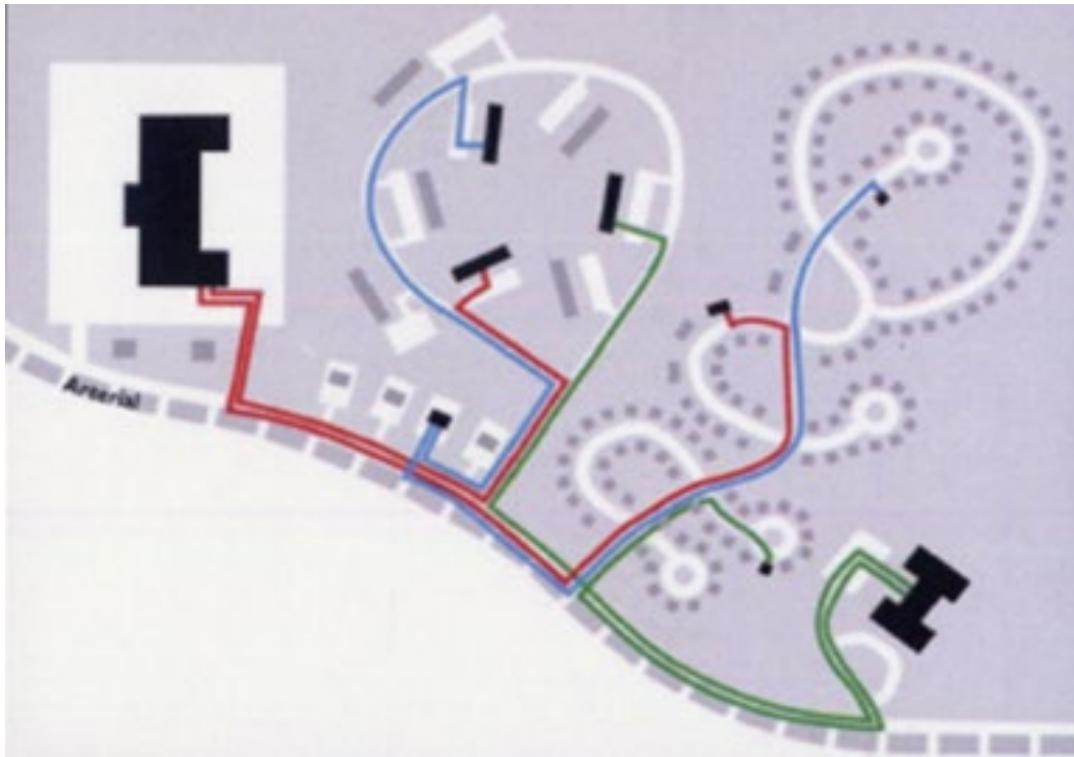
Planning Study -
Highway Criticality Measures

Statewide Transportation Planning Meeting

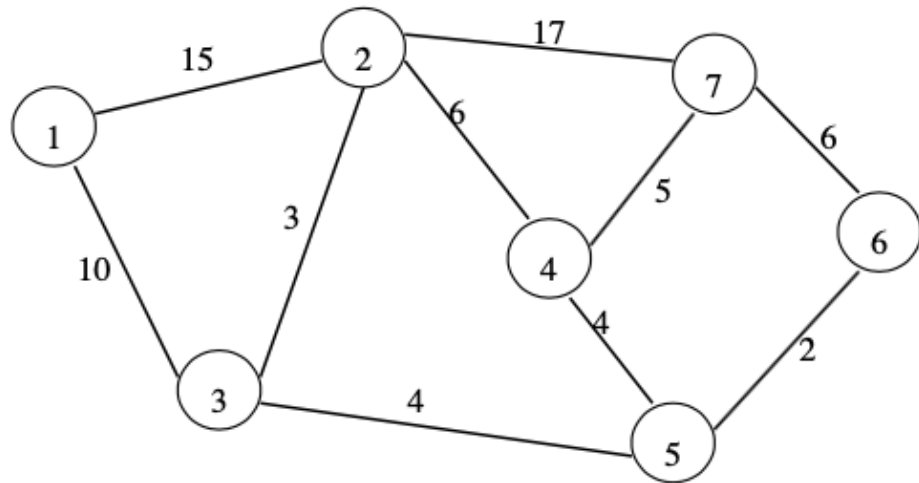
January 20, 2021



Network Connectivity



How to measure?



Betweenness Centrality (BC) is defined as the number of shortest paths that pass through the link.

$$BC(e) = \sum_{s,t \in V, s \neq t} \frac{\sigma(s,t|e)}{\sigma(s,t)}$$

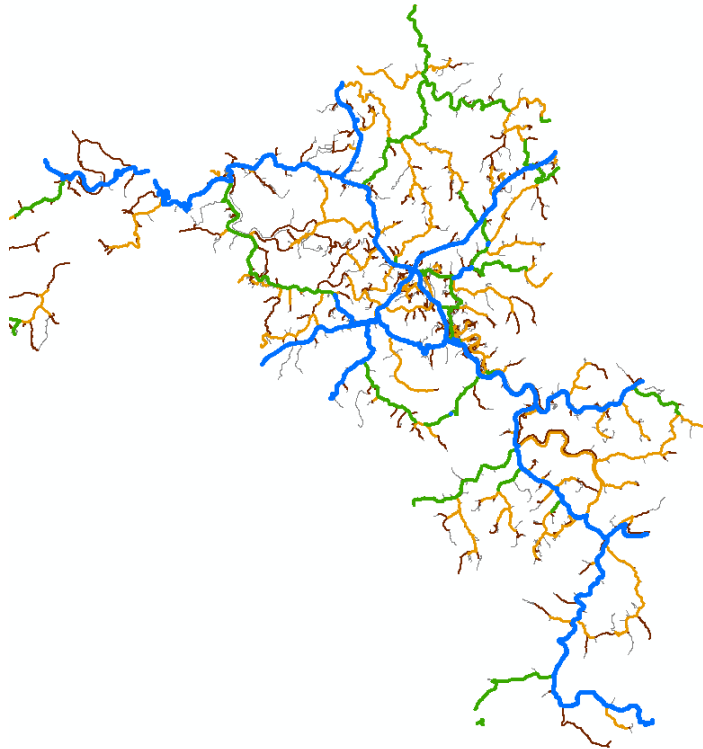
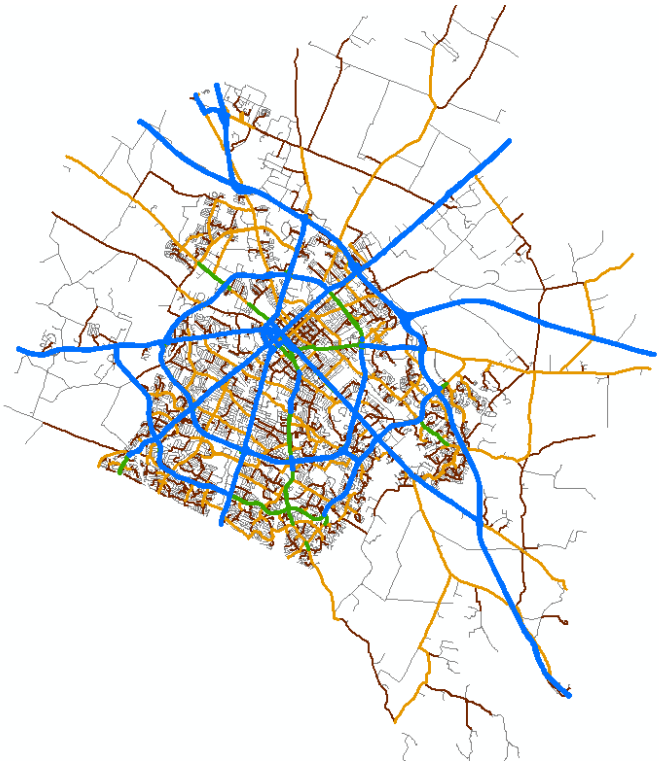
$BC(e)$ is the betweenness centrality for link e ;

V is the set of nodes (e.g., intersections, end nodes);

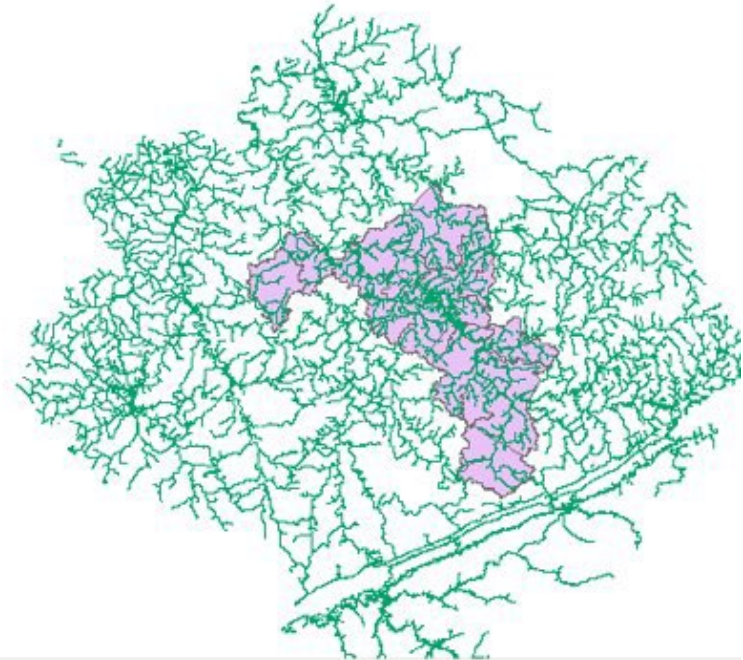
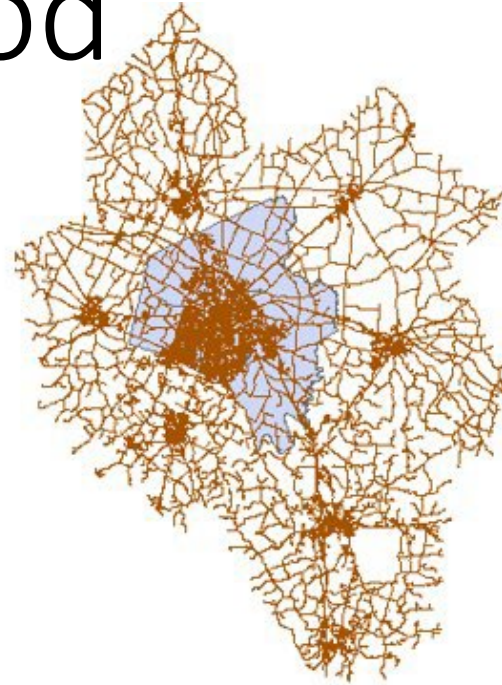
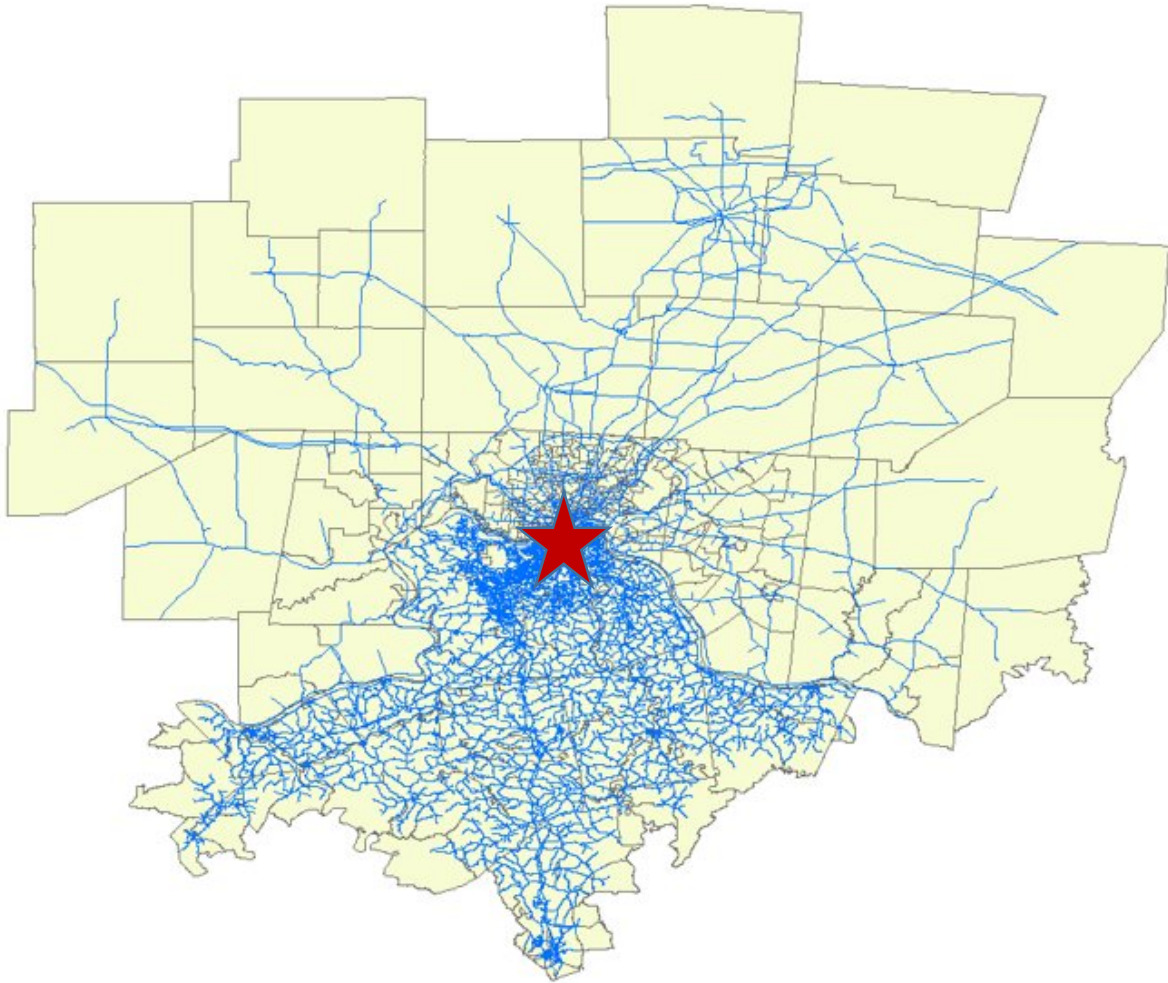
$\sigma(s,t)$ is the number of shortest paths from the origin node s to the destination node t ;

$\sigma(s,t|e)$ is the number of the shortest paths passing through link e .

Effect of network density

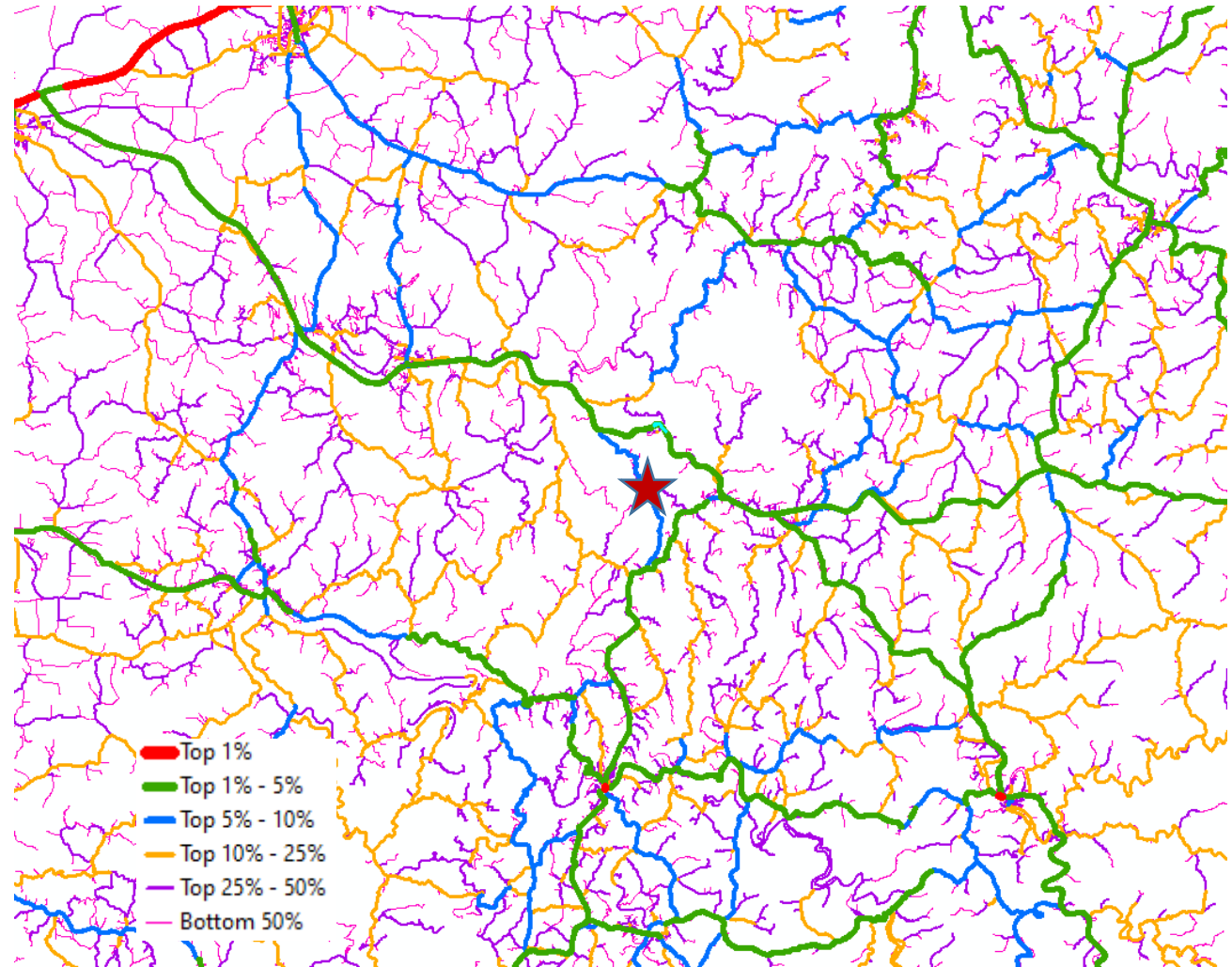


Size of neighborhood



Betweenness Centrality (normalized)

- Definition: % shortest paths a link belongs to between ODs within its 60min neighborhood
- Example:
Mountain Parkway MP35.8
 - Belong to 2.1% shortest paths in its neighborhood
 - In top 5% statewide



Data sources

- KYTC's Highway Information System network
 - AllRds
- KY Statewide Travel Demand Model
 - Traffic analysis zones
 - Out-of-state network

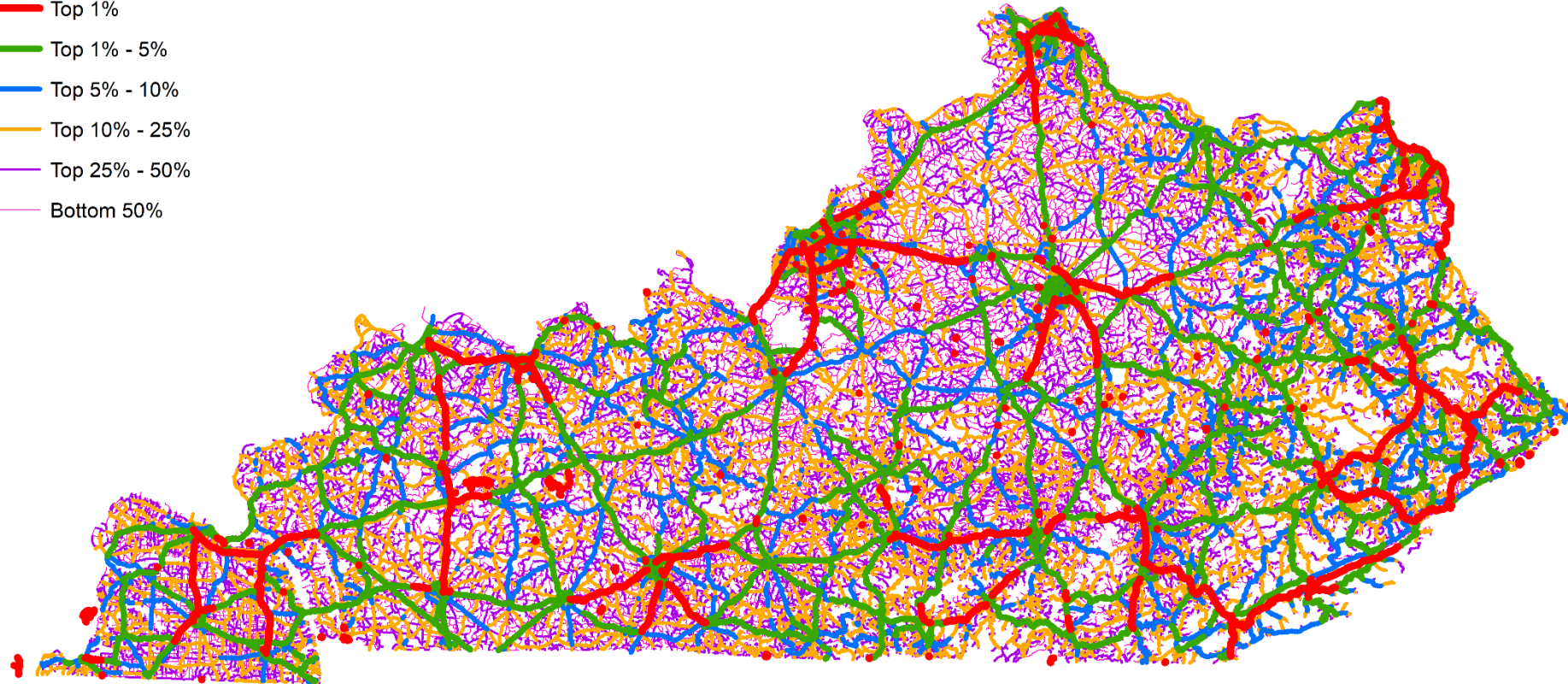
Betweenness Centrality

Legend

Statewide_Roads_Normalized_BC_Percentile_Rank

BC_Norm_PR

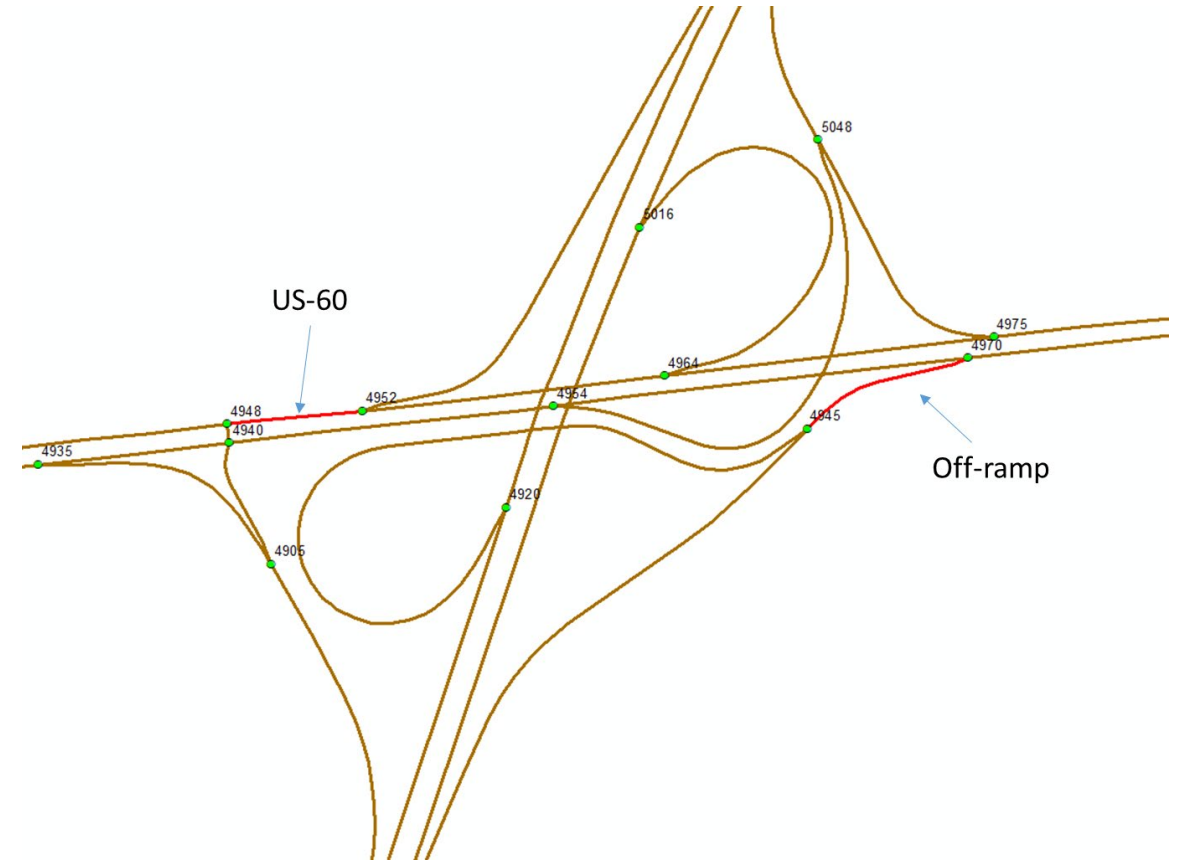
- Top 1%
- Top 1% - 5%
- Top 5% - 10%
- Top 10% - 25%
- Top 25% - 50%
- Bottom 50%



Node-to-node, 60 minute neighborhood

Road closure

- What if a link is broken?
- Zone-to-zone analysis
 - KYSTDM zones with centroid connectors linking to all nodes in the zone

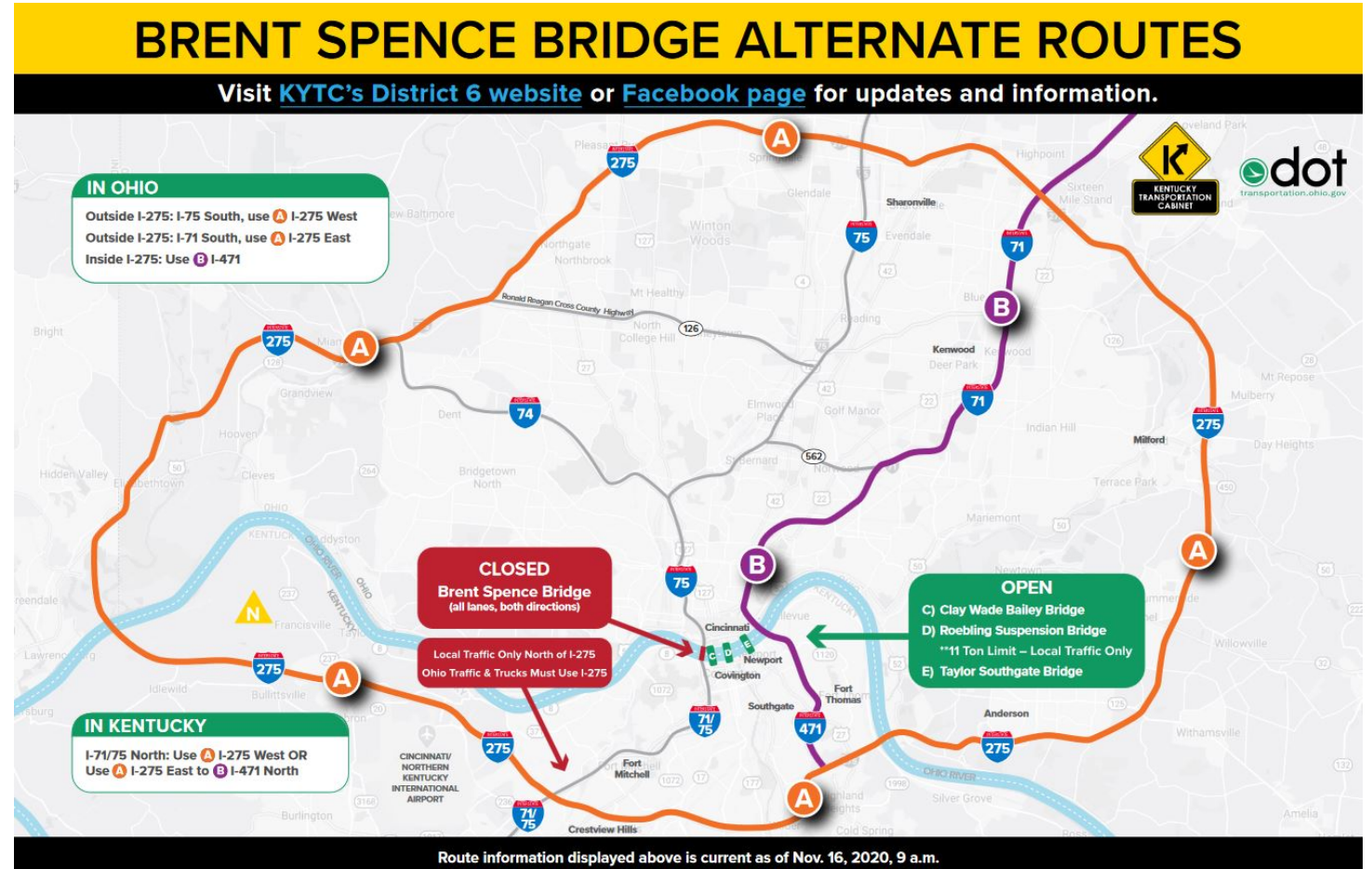


Detour scenarios

Scenarios	Description
1 – All roads	All roads (including local roads) can serve as detour.
2 – Collector +	Only consider roads that are collectors or above as detour.
3 – Equivalent roads	Only roads belong to the same or higher functional classes can be used as detour.

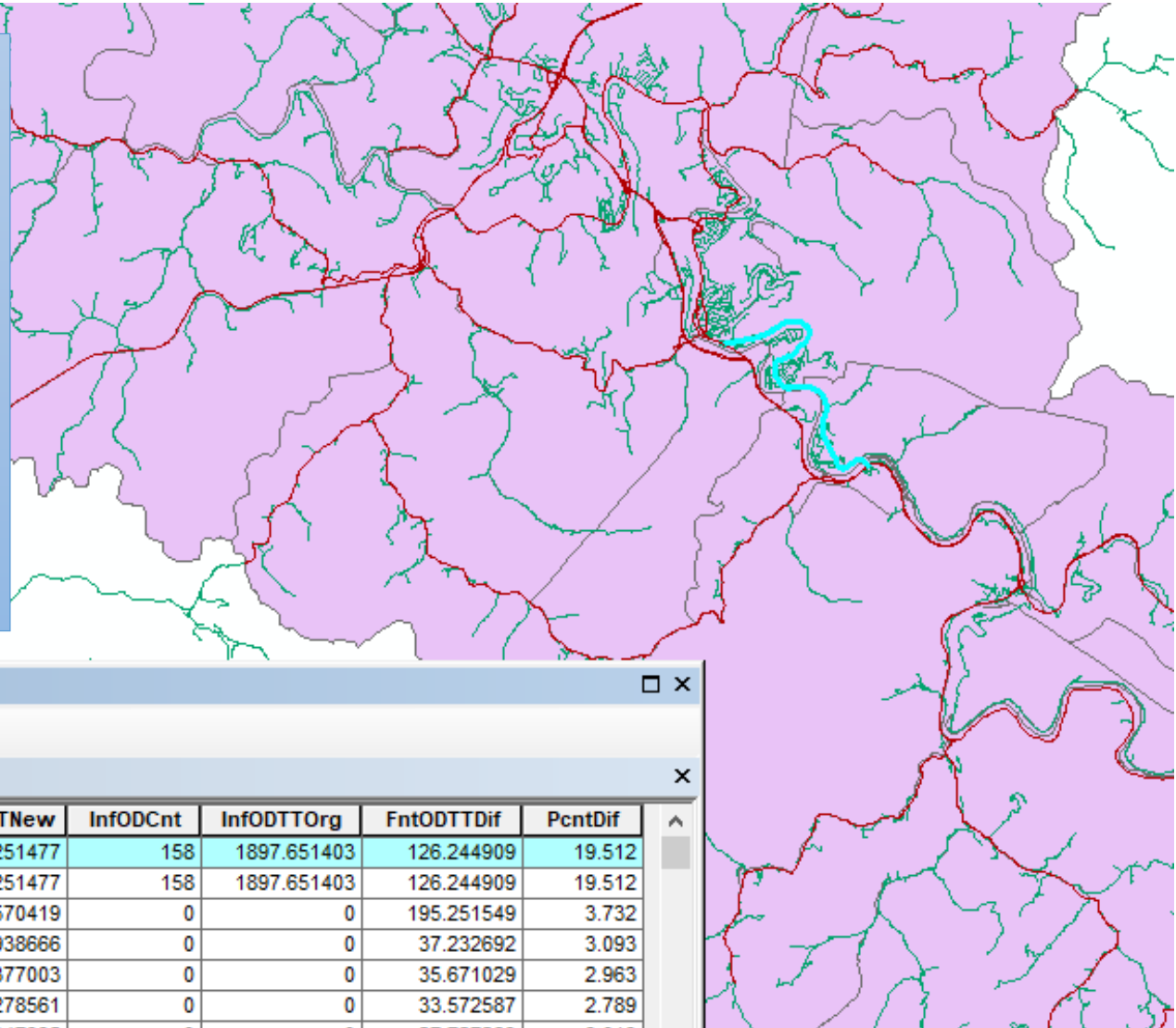
Impact of road closure

- Detour
- Change in travel time



What to track before and after closure?

- Trips can't be rerouted without going out of the neighborhood
 - How many and at what percentage of the total trips?
- Added travel time for all detoured trips.

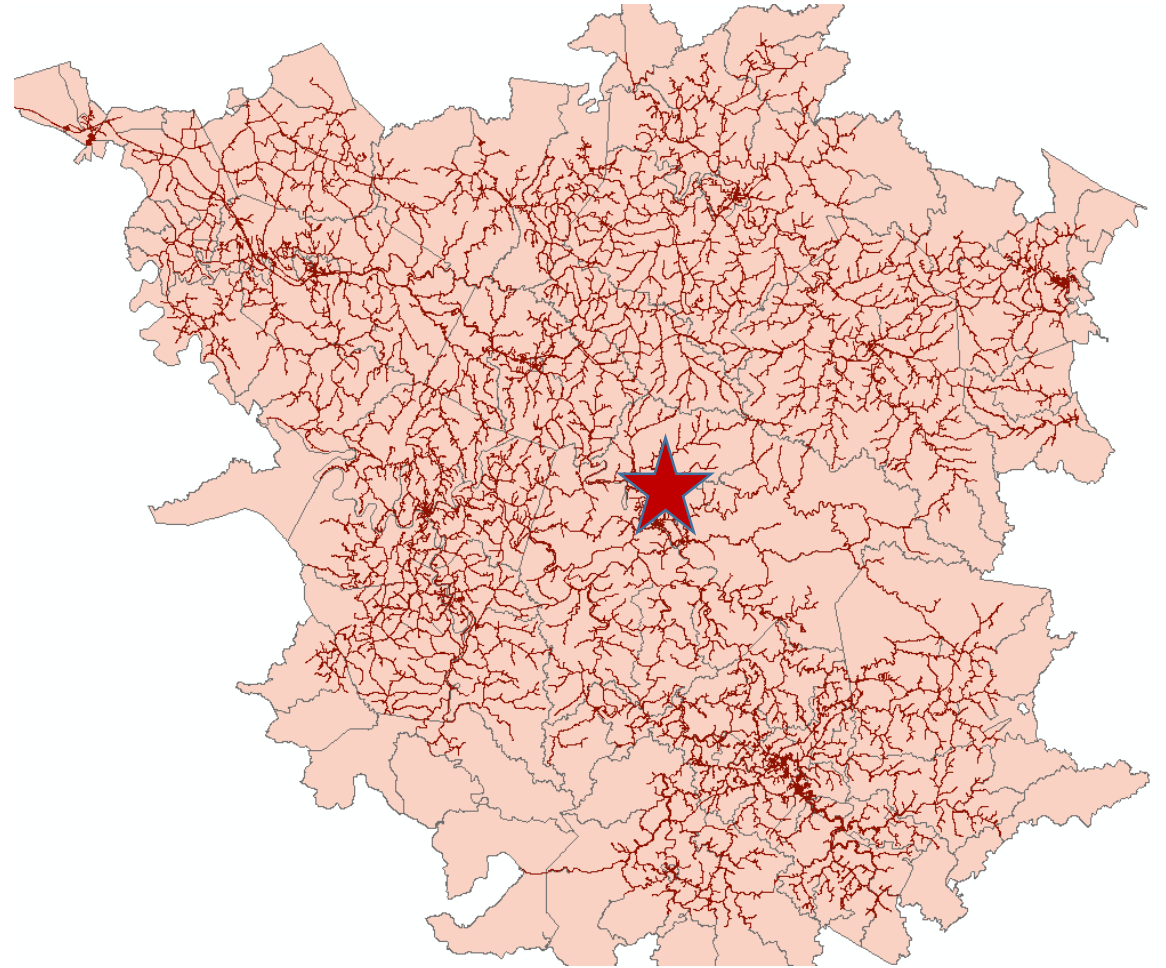


FID	Shape	SegID	TotalTTOrg	TotalODCnt	FntODCnt	FntODTTOrg	FntODTTNew	InfODCnt	InfODTTOrg	FntODTTDif	PcntDif
3055	Polyline	737	2544.65797	220	62	647.006568	773.251477	158	1897.651403	126.244909	19.512
3139	Polyline	1256	2544.65797	220	62	647.006568	773.251477	158	1897.651403	126.244909	19.512
0	Polyline	44	5232.318871	303	303	5232.318871	5427.570419	0	0	195.251549	3.732
1	Polyline	117	1203.705974	192	192	1203.705974	1240.938666	0	0	37.232692	3.093
2	Polyline	118	1203.705974	192	192	1203.705974	1239.377003	0	0	35.671029	2.963
3	Polyline	119	1203.705974	192	192	1203.705974	1237.278561	0	0	33.572587	2.789

013-KY-0015

MP20.2

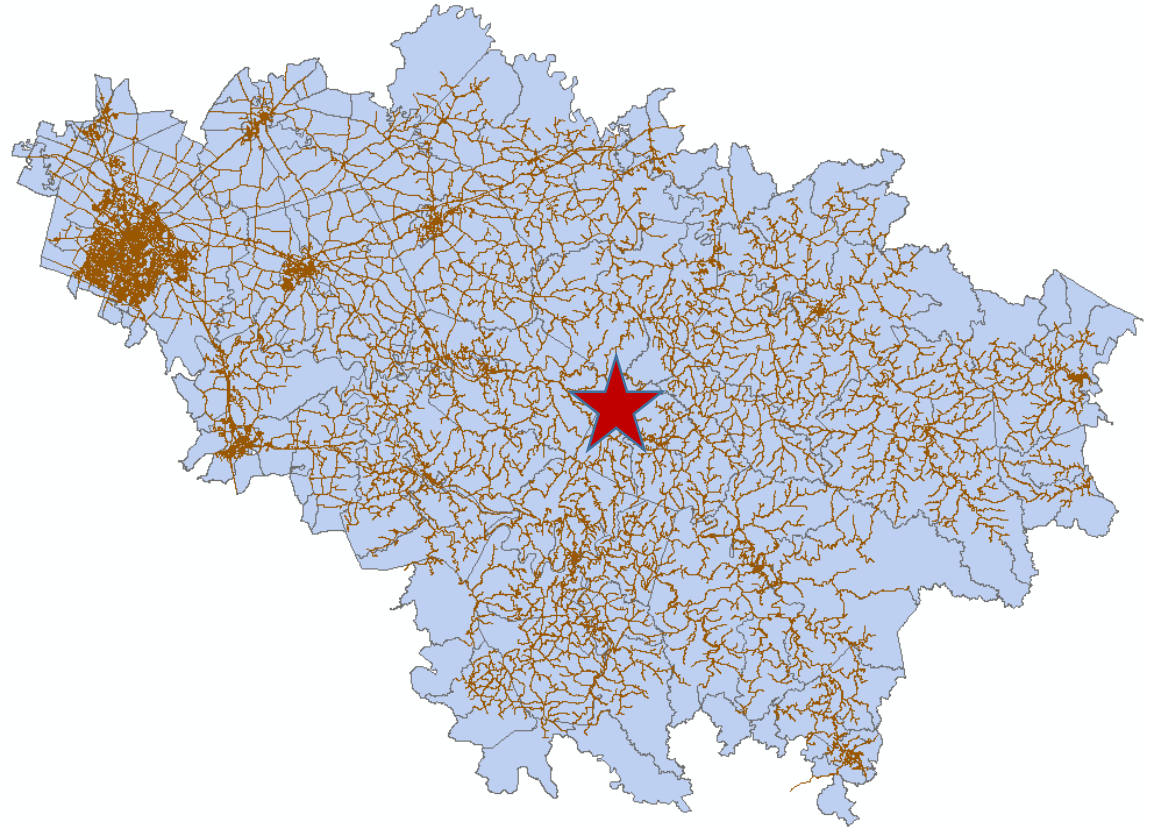
- Scenario 1 (AllRds)
 - The link carries 19,449 OD trips out of 50,596 total ODs (~ 38%).
 - All trips are reroutable after closure, but each will be 7 min longer.
- Scenario 3 (FC3 and above)
 - It carries 3,768 OD trips out of 7,671 total ODs (~ 49%) reachable with FC3 or above roads.
 - No detour available within the neighborhood.



099-KY-9000

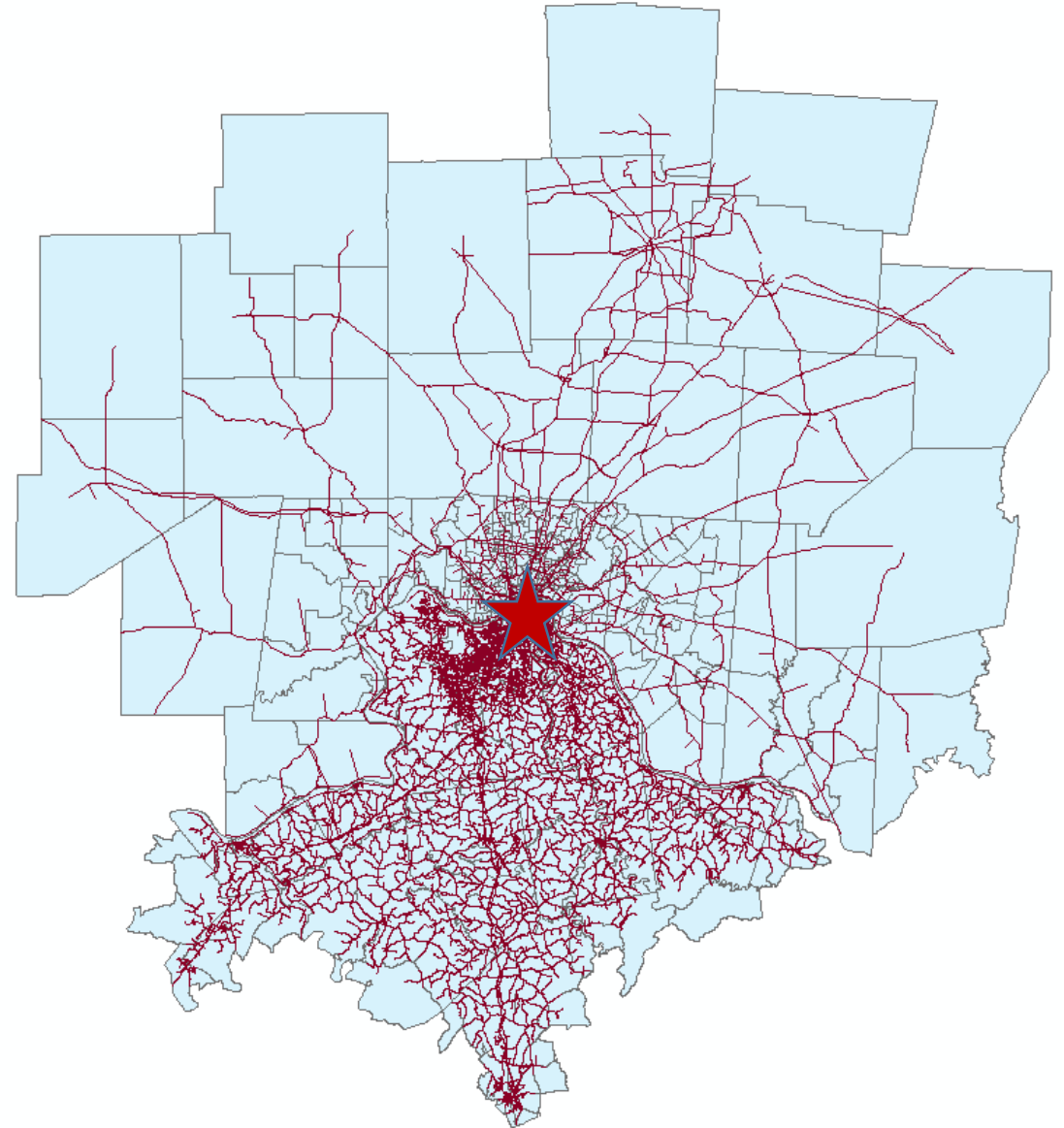
MP35.8

- Scenario 1 (AllRds)
 - The link carries 81,982 OD trips out of 365,213 total ODs (~22.4%).
 - All trips reroutable, but each on average is 5.3 min longer.
- Scenario 3 (FC2 and above)
 - It carries 910 OD trips out of 3387 total ODs (or 26.9%).
 - No reroutable trips within the neighborhood.



059-I -0075 MP191.5 Brent Spence Bridge

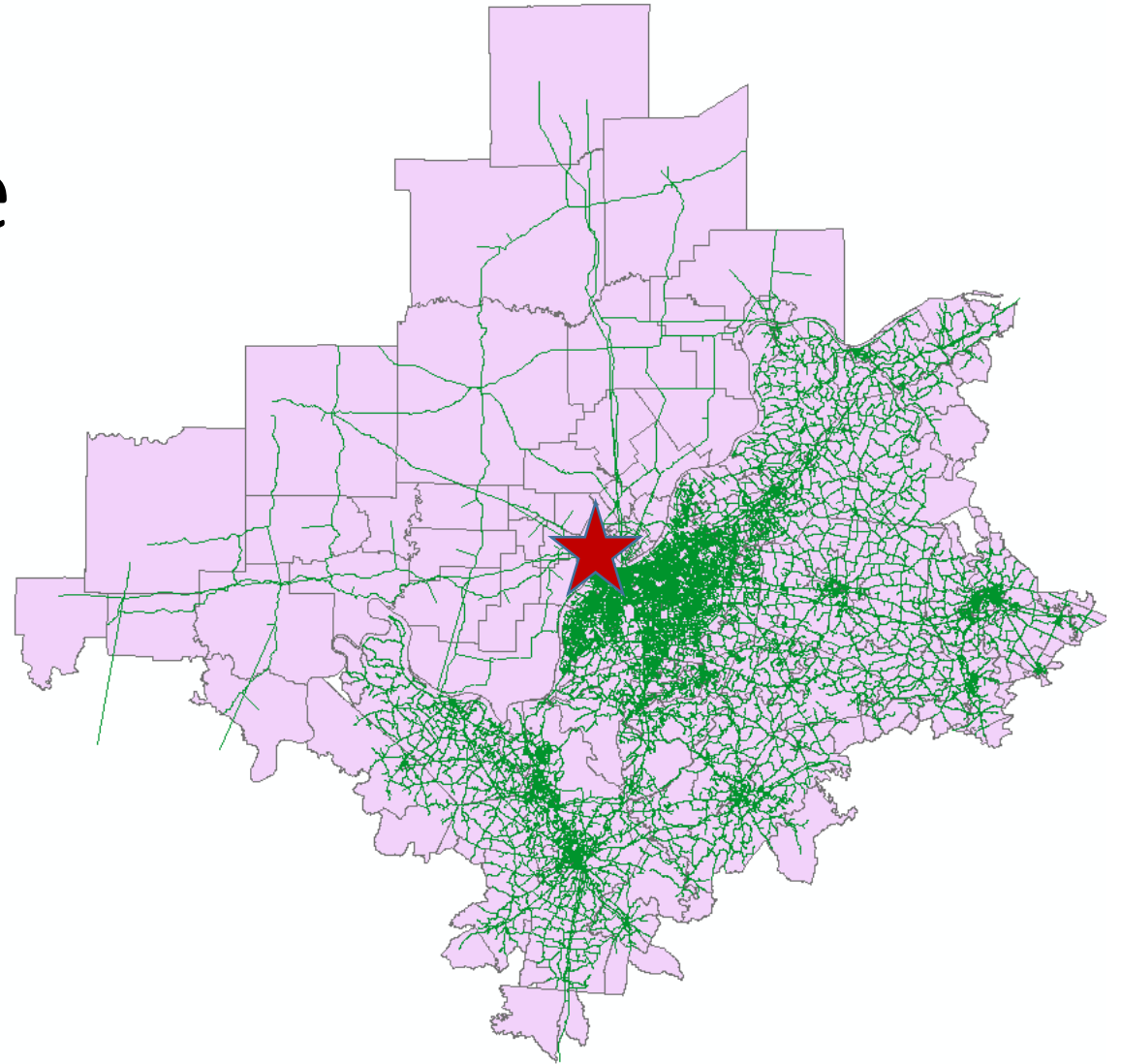
- Scenario 1 (AllRds)
 - The link carries 139,491 OD trips out of 526,937 total ODs (~ 26.5%).
 - Detours are possible
- Scenario 3 (FC1 and above)
 - It carries 19,180 OD trips out of 54,758 total ODs (~ 35%).
 - Each rerouted trip will be 12.6 min longer.



056-I -0064 MPO

Sherman Minton Bridge

- Scenario 1 (AllRds)
 - The link carries 70,856 OD trips out of 1,066,768 total ODs (~ 6.6%).
 - All trips reroutable; each will be 2.7 min longer.
- Scenario 3 (FC1 and above)
 - It carries 13,721 OD trips out of 71,221 total ODs (~ 19.3%).
 - About 40% of these trips are reroutable after its closure; each on average will be 5.5 min.



Several notes

- Tiered speed based on functional classification

FC	1	2	3	4	5	6	7
Speed (mph)	70	55	45	40	35	30	25

- Simplified routing, did not account for
 - Capacity constraint
 - Effect of congestion
- Egalitarian rule

Summary

- Normalized betweenness centrality (node or zone based) measures the relative importance of a link in its neighborhood based on existing network structure.
 - All roads
 - Allow statewide comparison
- Detour analysis
 - Requires intensive computing
- Potential expansion to include
 - OD volume (utilitarian rule)
 - Sociodemographic and land use data
 - Vulnerability

Questions?

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