

16th Urban Mobility India Conference cum Exhibition 2023

Using urban topology to identify critical links of the road network: a Centrality based approach



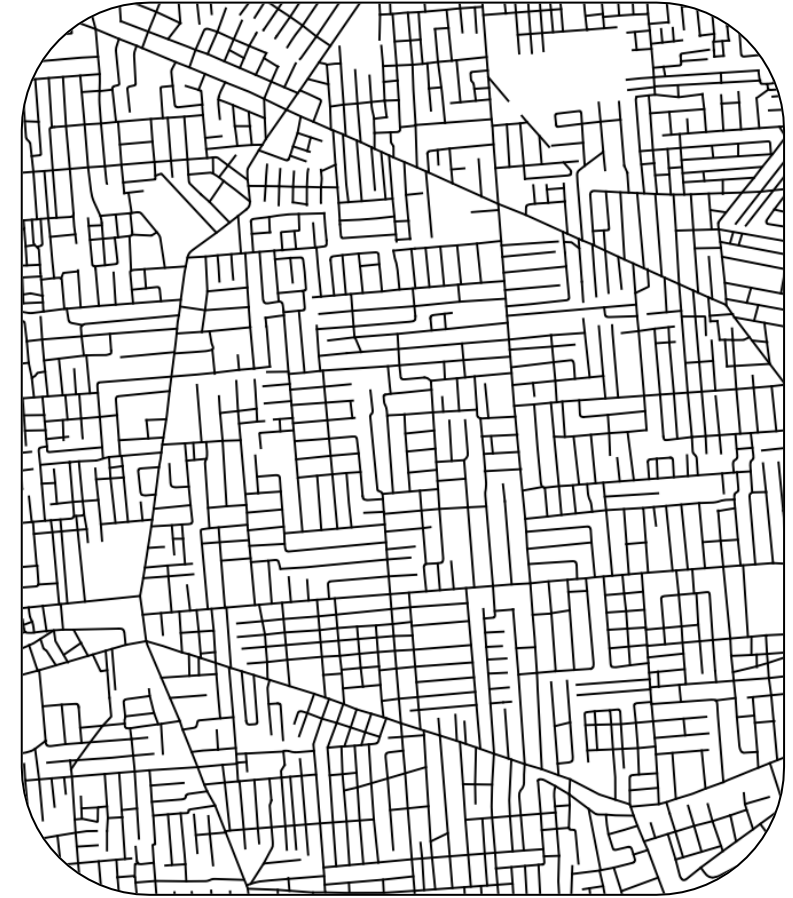
Aaditya Bhamidipati

Rahul TM

Navdeep Asija

Contents

- Planned vs unplanned networks
- Network analysis measures
- Centrality
- Analysis
- Results and Discussion



Vector data of road network

Planned vs unplanned urban networks



Source : Reddit

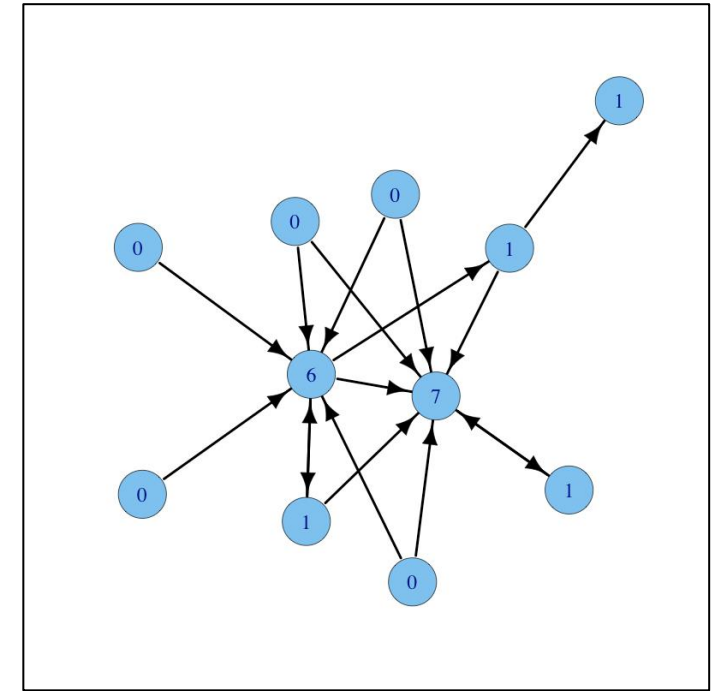
Network analysis measures

- Density based – Network density, Clustering coefficient
- Length based – Average link length, Length distribution analysis
- Accessibility based – Isochrone maps
- **Connectivity based - Centrality**



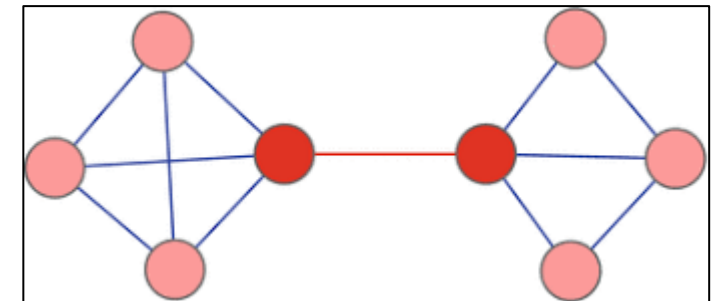
Centrality

- Centrality- measures the importance of node/edge within a network
- Used to identify key nodes/edges which aid in information transfer
- Urban road network – nodes and links
- Can be node based or edge based.
- **Betweenness centrality** – important to understand critical paths



Degree Centrality

Source : www.sci.unich.it



Edge based centrality

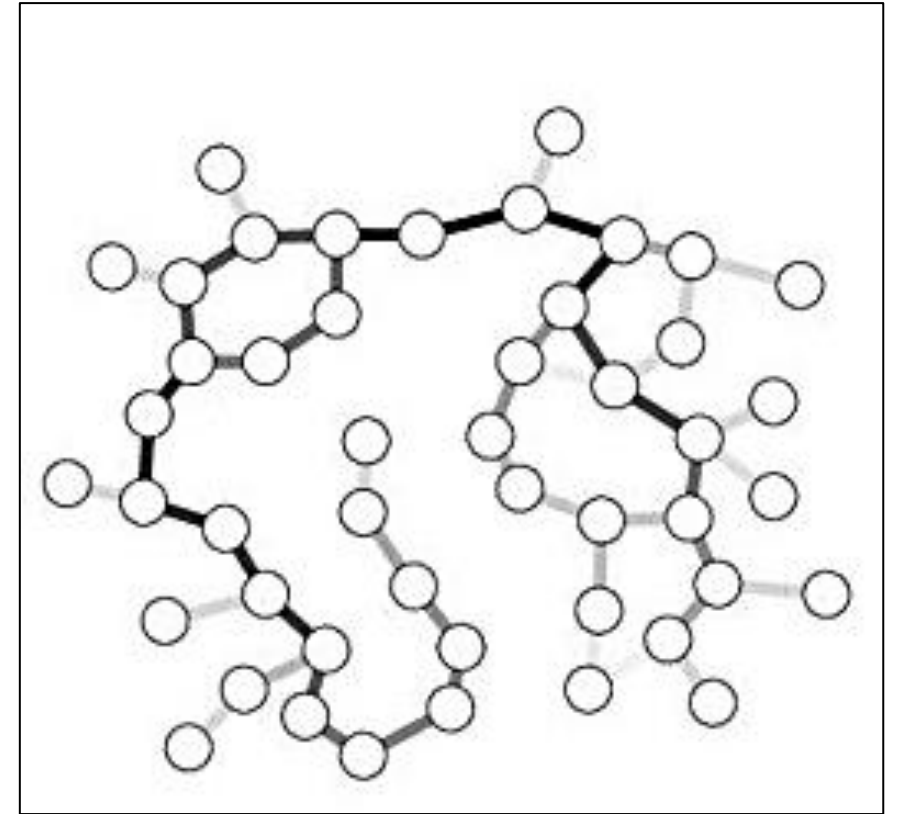
Source : (Lu & Zhang, 2013)

Betweenness centrality

- Quantifies the number of times a link acts as a bridge along the shortest path between two other links.

- $C_B(v) = \sum \frac{\sigma_{st}(v)}{\sigma_{st}}$

where σ_{st} is total number of shortest paths from node s to node t , and $\sigma_{st}(v)$ is the number of those paths passing through v



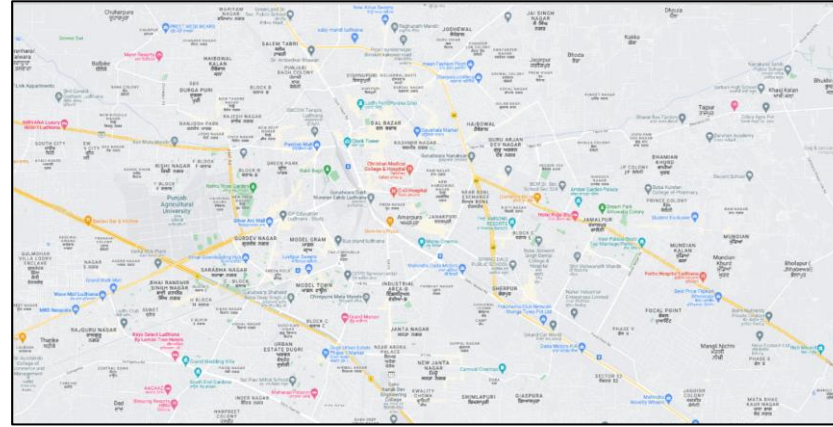
Edge based betweenness centrality
Source: Wang & Tang, 2013

Betweenness centrality and travel demand

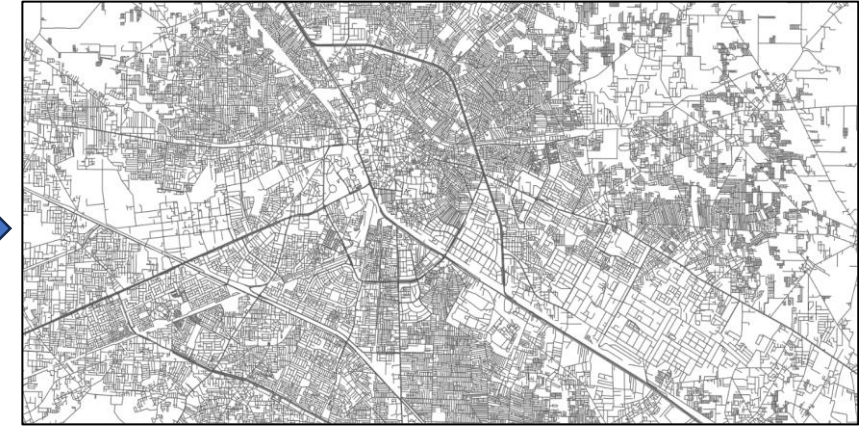
- Betweenness depicts the importance of the link in the network
- Higher the betweenness, critical is the link for the flow of information(traffic).
- More important the link is, higher is the traffic flow, and hence, wider should be the road to accommodate the traffic.
- In the absence of traffic flow data, the current study understands whether road width and the criticality of the links in the network are correlated

Analysis

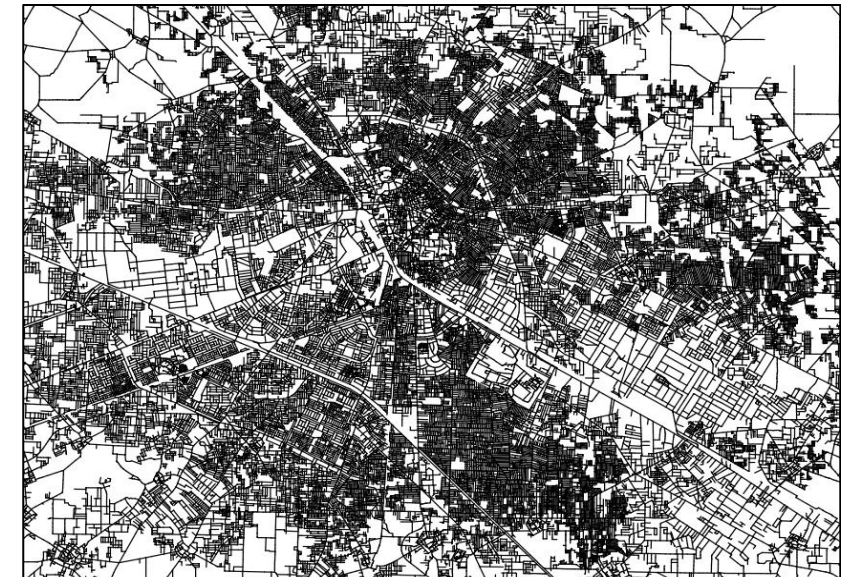
Open Street Maps



Vector data



- Ludhiana urban dwelling – study area
- Initial vector data extraction – Open Street Maps (OSM)
- Vector data of Trunk, Primary, Secondary, Tertiary and residential merged
- Network cleaned for road centre lines, disconnectivities and irregular segments
- Cleaned data used in DepthMapX



Centrality analysis

- The network is cleaned for stubs and irregularities manually
- Further stub removal performed using the DepthMapX plugin of QGIS
- This network data is used for the segment based Betweenness (choice) analysis using the DepthMapX software
- The values post analysis used for understanding correlation



A section of road network post analysis
(lighter the colour, lesser is the betweenness)

Correlation Analysis

- Network data calibrated with the width of road segments at link level
- Post analysis, all links defined by
 - Width of the road segment of all links &
 - Corresponding edge based betweenness centrality
- Correlation analysis performed to determine significance of relation between betweenness centrality and width of road network features

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

- Where x_i and y_i represent the values of variables x (width) and y (betweenness) in the sample and $\bar{x}$, $\bar{y}$ are the respective sample means

Results and discussion

- Correlation between road width and betweenness - 0.468
- p value <0.05 and t value 262 - statistically significant.
- Interpreted in two ways –
 - *High betweenness and low width of roads* - the segments are important for the network topologically but are not emphasized in practice for widening.
 - *Lower betweenness and higher width of roads*, the identified links in the network can be used for alternative routing decisions

Thank You