# How networks are shaping Tshwane Tools for urban network analysis – Part III

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# The evolution urban form in Tshwane



#### Evolution of modernistic planning In Tshwane



## The evolution of the suburban tree



Evolution of modernistic planning In Tshwane

How to quantify the divergence of urban forms in Tshwane ?

# Presentation of tools

- Simple metrics
  - Nb of intersections per km<sup>2</sup>
  - Cyclomatic number
  - Gamma index
- Network analysis (based on Marshall)
  - Nodegram
  - Routegram, Netgram, Hetgram
- Space syntax
- Dual approach from Porta et al.

## Space syntax

- A tool designed by Hillier et al. to help architects simulate the likely social effects of their designs.
- A route in space syntax is one axial line



Space Syntax Routes are axial lines

# Space syntax – depth maps

- The depth maps enable you to specify a line number and then the program plots the increasing distance of other lines from that line. It plots these using the space syntax integration colors. For example, if we take line 1 which has depth 1 to itself, then all lines of depth 2 take on the next values, and so on until all the lines in the map are plotted at increasing depth from the original line.
- Depth maps can be implemented for lines and for junctions and help understanding the depth of a network

#### Space Syntax - Newlands



3 entrance points1 main road to access

### Space Syntax - Newlands



The top access route is of depth one, in red

Depth increases when moving inside the network, from yellow, to green, to blue

## Space Syntax - Newlands



From North entrance

From middle entrance

From South entrance

From all entrances, the very left hand side of the network is very deep and isolated from the outside

### Space Syntax – Silver Lakes



### Space Syntax – Silver Lakes



Two entrance points in Silver Lakes

# Space Syntax – Silver Lakes Depth map, from North entrance



# Space Syntax – Silver Lakes Depth map, from South entrance



There is no real axial line that structures the network within the district

# Space Syntax – Silver Lakes Depth map, from North entrance



# Space Syntax – Silver Lakes Depth map, from South entrance



# Dual approach Space syntax versus Porta

Porta et al. propose another dual approach, where routes have a real urban meaning (based on *Intersection Continuity Negotiation algorithm*)

Space Syntax Routes are axial lines



Porta – dual approach Routes are chosen according to the « urban understanting » of the network







# Dual approach – Brooklyn



Routes are chosen according to ICN algorithm (or by hand for small samples)

### Dual approach - Brooklyn



Then routes are numbered

## Dual approach - Brooklyn



Route 1 is connected to routes 2, 3, 4, 5, 6, 7, 8, 10, 15, 16, 18, 19, 20 Route 2 is connected to routes 4, 17...

# Dual approach – Brooklyn

This method generates a dual graph for Brooklyn



### Dual approach – Irene



# Dual approach – Irene



## Dual approach – Silver Lakes



## Dual approach – Silver Lakes



### Dual approach – Newlands



#### Dual approach – Newlands



Created with NodeXL (http://nodexl.codeplex.com)

#### Dual approach - Tshwane



These graphs show visually the impoverishment of networks in Tshwane

# Metrics of the dual graph

- 1. Geodesic distance and diameter
- 2. Clustering coefficient
- 3. Betweenness centrality

(Newland is a too poor network to do any math...)

# Metrics of the dual graph Geodesic distance and diameter

- Take two nodes (i,j), and measure the shortest path between them. Call the length of this path L<sub>ij</sub>. Lij is called the geodesic distance between node i and node j.
- Two parameters of interest:
  - The diameter of the graph is the highest value of Lij
  - The average geodesic distance, is the average of Lij



Diameter of the graph d

#### Average geodesic distance in Tshwane



The shortest topological path increases by 22% from Brooklyn to Silver Lakes

This reveals the switch from a spatial segregation to a topological segregation, with topological distances increasing in the networks.

Note: diameters (maximal geodesic distances) are identical for the three networks

# Metrics of the dual graph Clustering coefficient

- The clustering coefficient of a vertex indicates how concentrated the neighborhood of that vertex is.
- The clustering coefficient is the ratio of the number of actual edges there are between neighbors to the number of potential edges there are between neighbors (all possible edges between the vertices including blue edges).

#### Example

*Here the actual number of edges is 5 and the potential number of edges is 6 (add the blue line)* 

The clustering coefficient of node v is 5/6



# Metrics of the dual graph Clustering coefficient

- Clustering coefficients for all nodes in the network can be averaged.
- High average clustering coefficients indicate that networks have Small World properties (geodesic distance growths logarithmically with the size of the network).





# Metrics of the dual graph Clustering coefficient

- To compare clustering in networks, the easiest is to calculate the clustering of the network relatively to the clustering in a random network of the same size.
- The clustering in a random network is equal to the ratio of the average degree of routes in the network to the number of routes

 $relative \ clustering \ = \ \frac{clustering \ coeff}{clustering \ coeff \ of \ a \ random \ graph} = \frac{clustering \ coeff}{\frac{average \ degree}{nb \ of \ routes}}$ 

# Metrics of the dual graph Relative clustering in Tshwane



Networks become more and more clustered in Tshwane.

# Metrics of the dual graph Relative clustering in Tshwane

3								
San	Francisco		Barcelona		Waln	Walnut Creek		
	0.28	0.92	1.03	1.53		2.38	2.9	
	E	Brookly	n	Irene		S	ilver Lake	es

An increase of clustering from below 1 to 2 or 3 is typical for a move towards suburban urban forms.

# Metrics of the dual graph Betweenness centrality

- Betweenness centrality quantifies the number of times a node acts as a bridge along the shortest path between two other nodes. It was introduced as a measure for quantifying the control of a human on the communication between other humans in a social network
- High betweenness centrality allows strong access control
- Again, two parameters are of interest:
  - Maximum betweenness centrality: the maximal number of path passing by a node
  - Average betweenness centrality, which provides a more global insight on the network

#### Metrics of the dual graph Maximum betweenness centrality in Tshwane



The maximum betweenness centrality increases dramatically !

This reveals the collapse of the number of entry points in the communities, which makes control easier.

#### Metrics of the dual graph Average betweenness centrality in Tshwane



Same holds for the average betweenness centrality...



# **Relevance of Analysis**

Implications for planning and policy

- Stories told through urban morphology
  - White Urbanisation
    - From innercity to suburbs
  - "Black" Urbanisation (less understood)
    - Township (formal and informally planned)
    - Informal African Compound and social networks?
- Multi-scale Mapping of Boundaries and Barriers



The Urban Form the manifestation of a collection of "stories" of different people and groups



# **Taxonomy of Separation**





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#### Google earth

Google earth

### Separation between



# Separation/Isolation within



#### Policy recommendations and future research

- More research needed on the different "stories" form the urban fabric of Tshwane (South Africa)
- Link between urban form and social network important (Policy perspective)
- Research on Boundaries and Barriers is needed through mapping and understanding underlining rationale (Apartheid vs. Present Day Topological Separation)
- Using theory and application to inform urban management and planning strategies and policies (eg. Impacts of the eradication of informal areas)

Only when we understand the underlying factors influencing urban morphology/fragmentation can we put our city back together not just physically but also socially





#### Thank you for your attention !

