How networks are shaping Tshwane

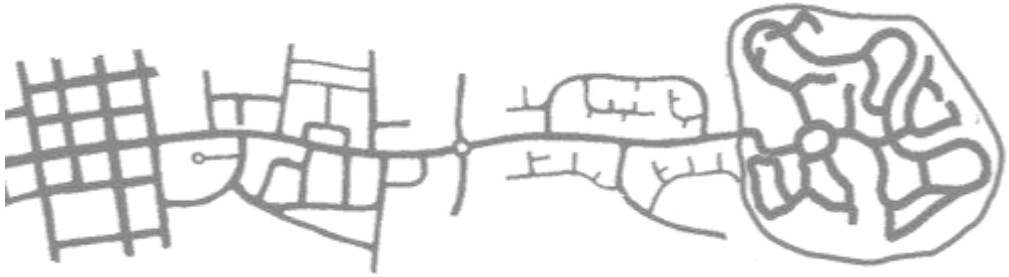
Tools for urban network analysis – Part II

Serge SALAT

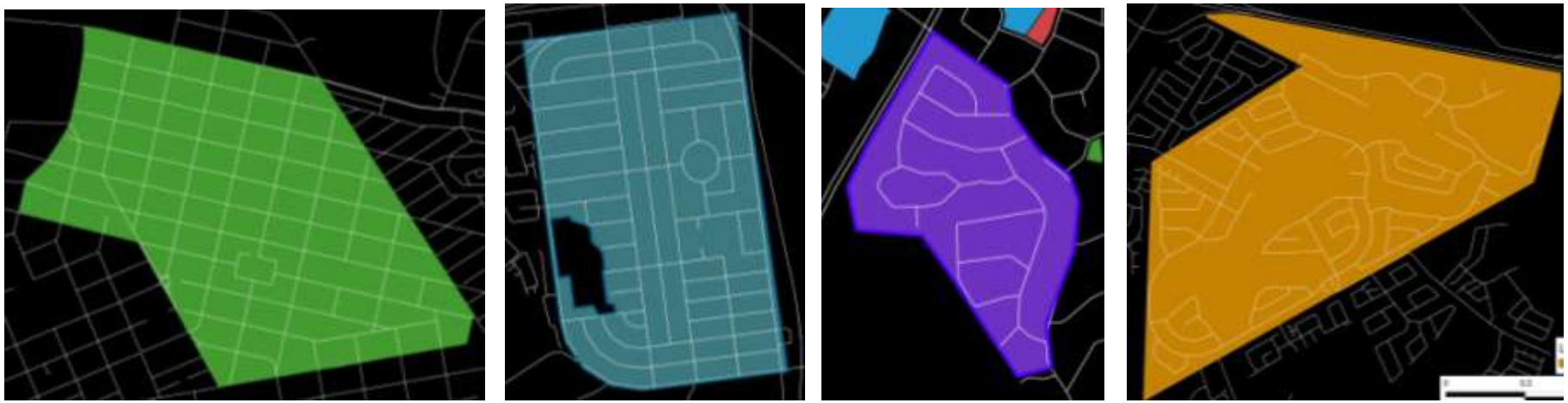
Data analysis by Loeiz BOURDIC

Urban analysis by Darren NEL

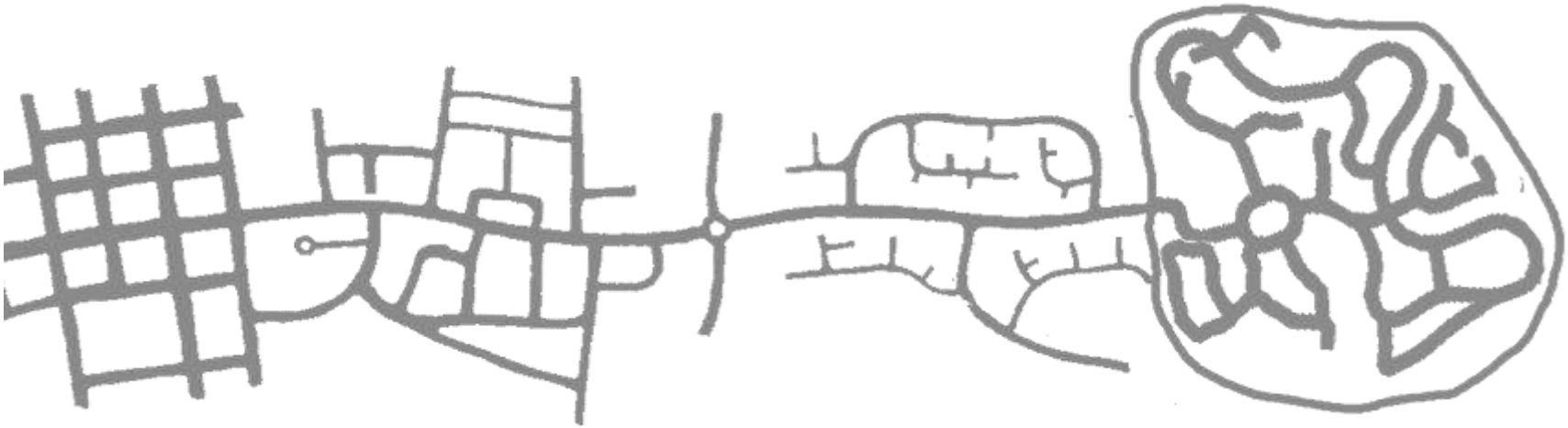
Urban Morphology Institute – University of Pretoria



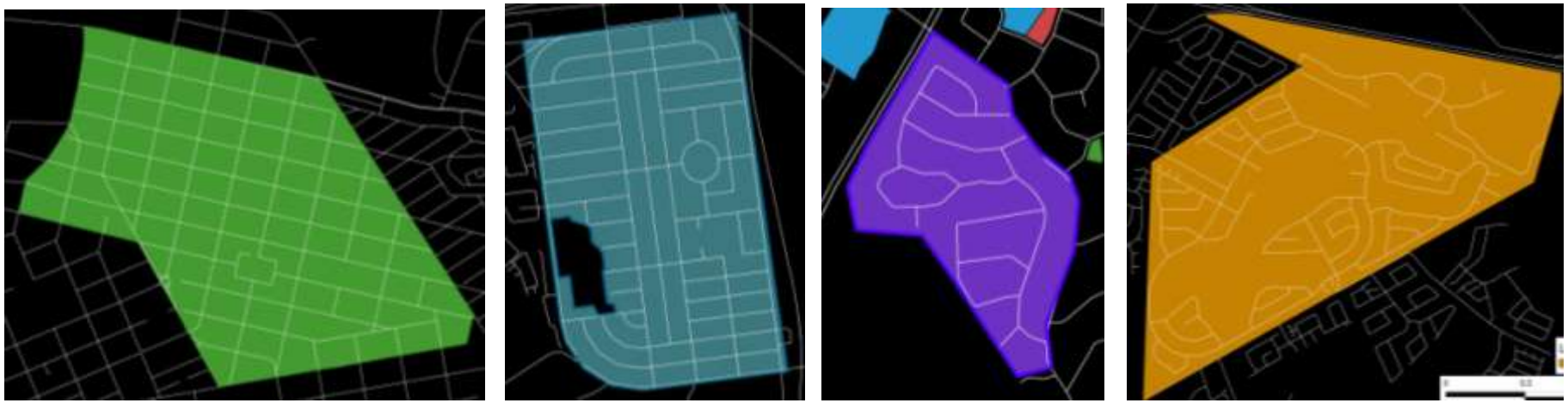
The evolution urban form in Tshwane



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 ?

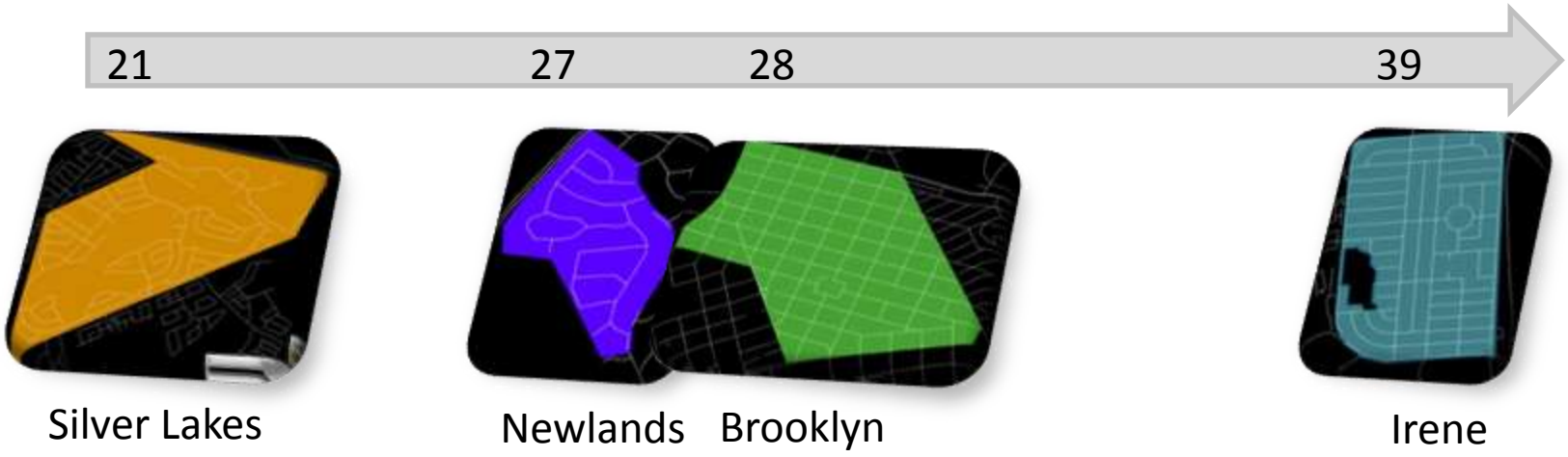
Presentation of tools

- Simple metrics
  - Nb of intersections per km²
  - Cyclomatic number
  - Gamma index
- Network analysis (based on Marshall)
  - Nodegram
  - Routegram, Netgram, Hetgram
- Space syntax (later today)
- Dual approach (later today)

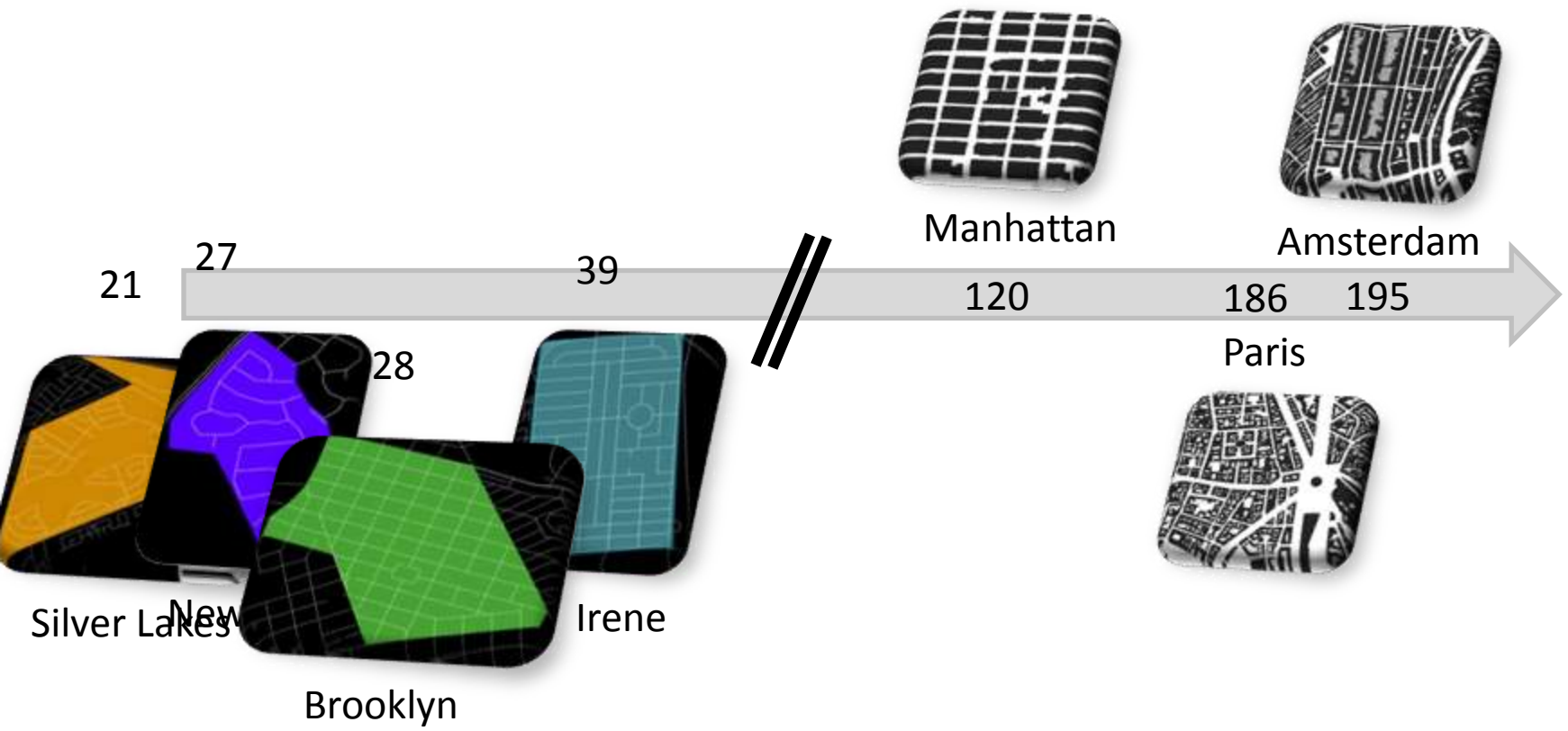
Part 1 – Simple metrics

1. Nb of intersections per km^2
2. Cyclomatic number
3. Gamma index

Number of intersections per km^2

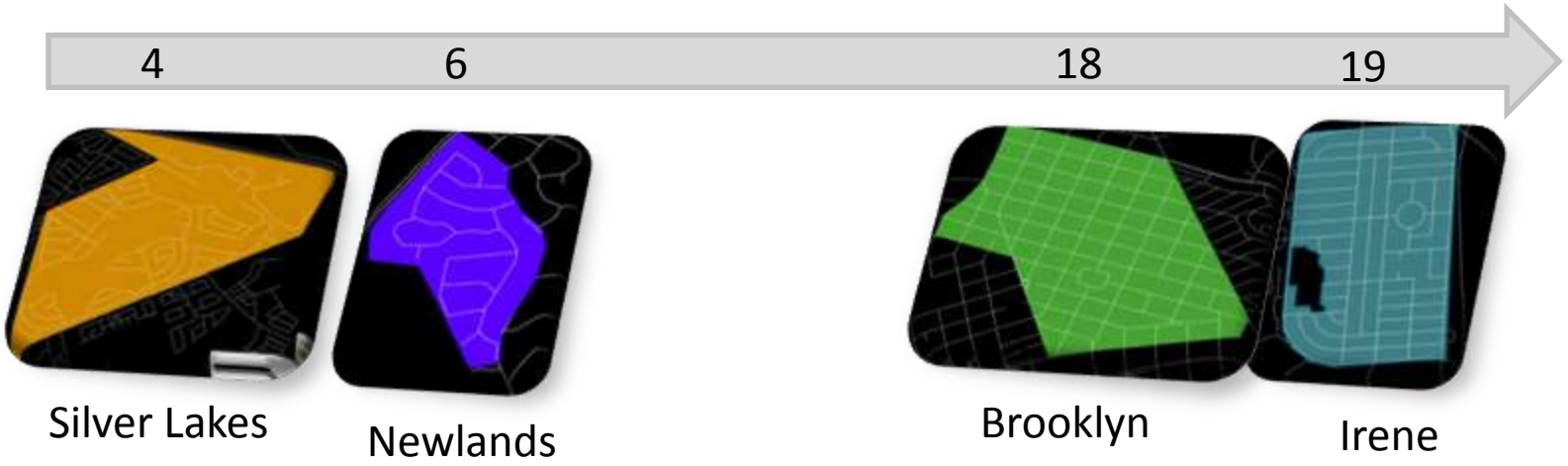


Number of intersections per km²

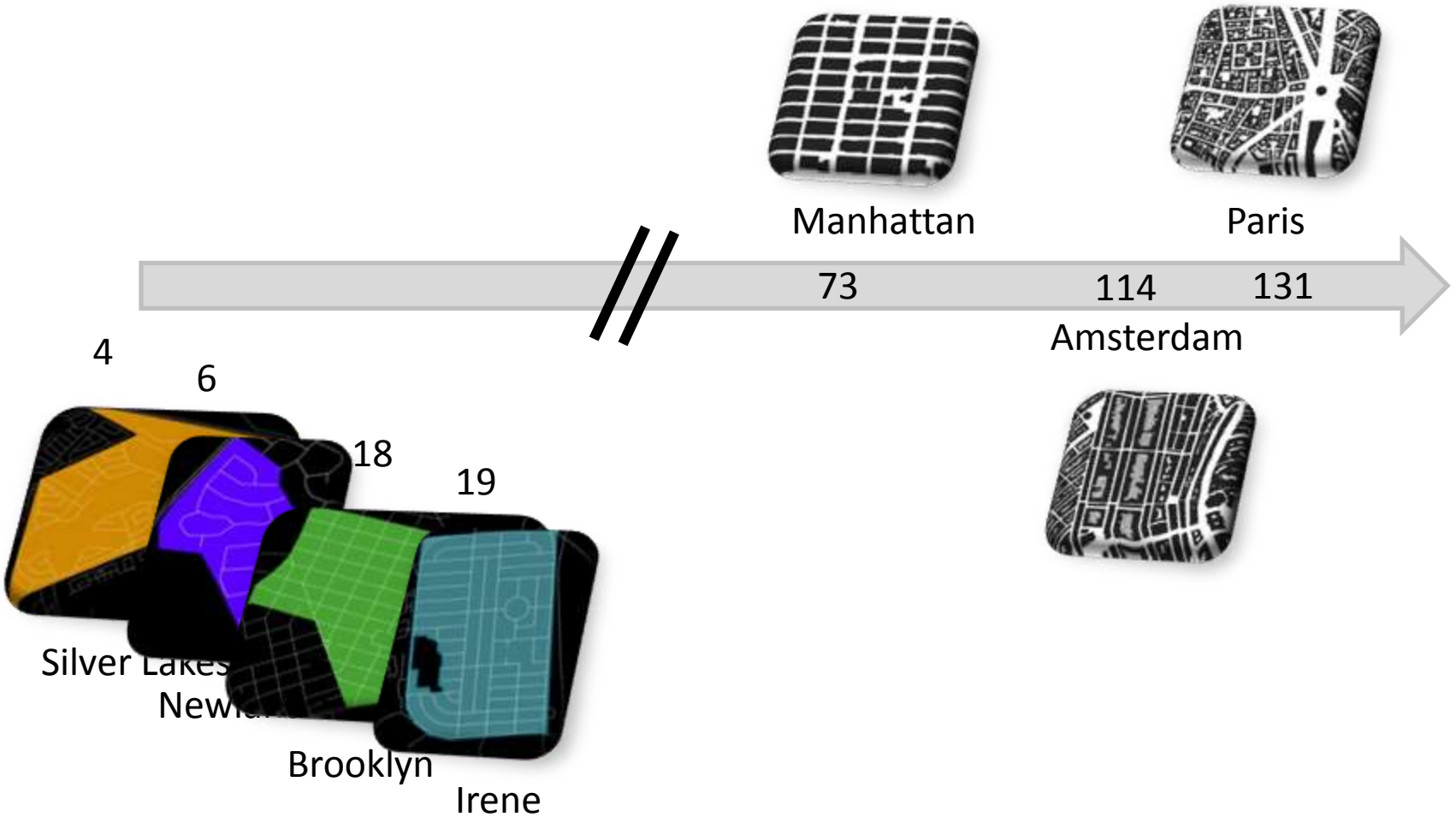


Cyclomatic number per km²

The cyclomatic number is the number of closed loops in the network. The higher the cyclomatic number, the more available paths in the network.



Cyclomatic number per km²

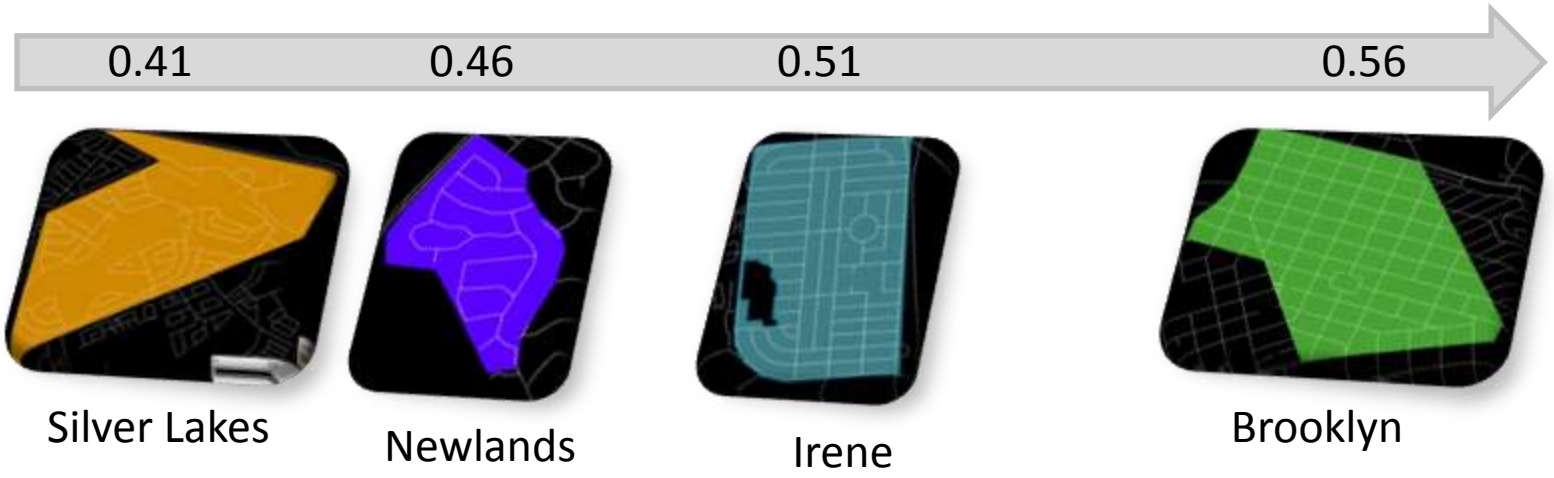


Gamma Index

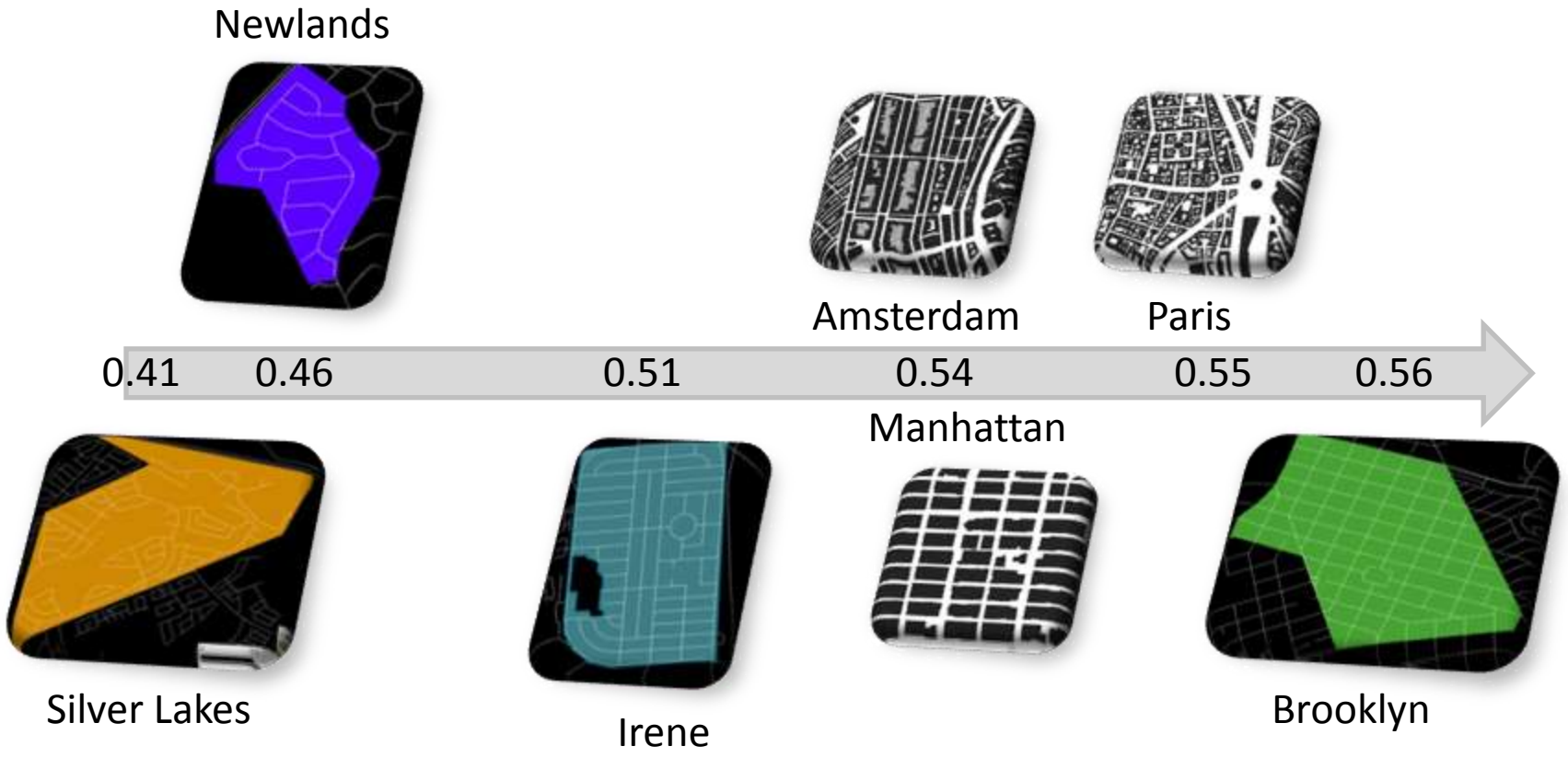
The gamma index measures the connectivity in a network.
It is a measure of the ratio of the number of edges in a network to the maximum number possible (that is 3(v-2)). It is calculated as follows:

$$\gamma = \frac{e}{3(v-2)}$$

The index ranges from 0 (no connections between nodes) to 1 (the maximum number of connections, with direct links between all the nodes).



Gamma Index

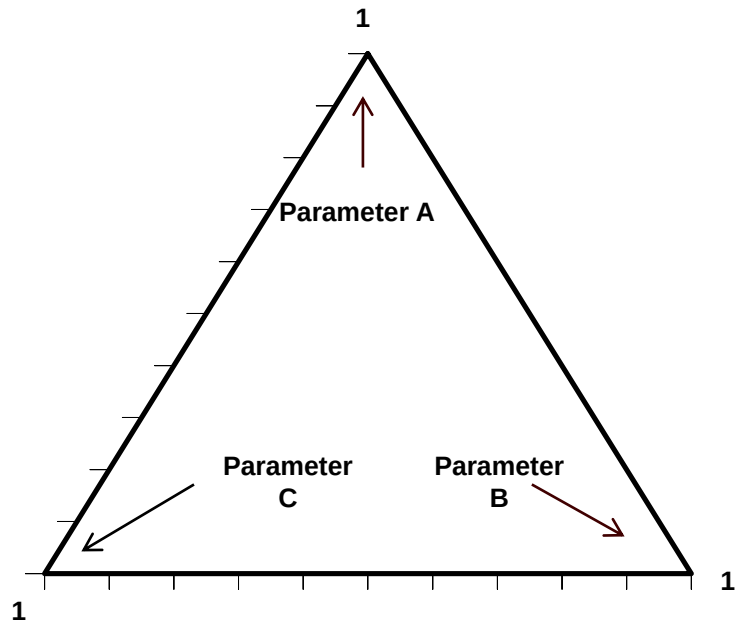

Newlands
Amsterdam
Paris
0.41
0.46
0.51
0.54
0.55
0.56
Manhattan
Silver Lakes
Irene
Brooklyn

Part 2 – Network analysis (based on S. Marshall)

1. Nodegrams
2. Routegrams
3. Netgrams
4. Hetgrams

Triangle diagrams

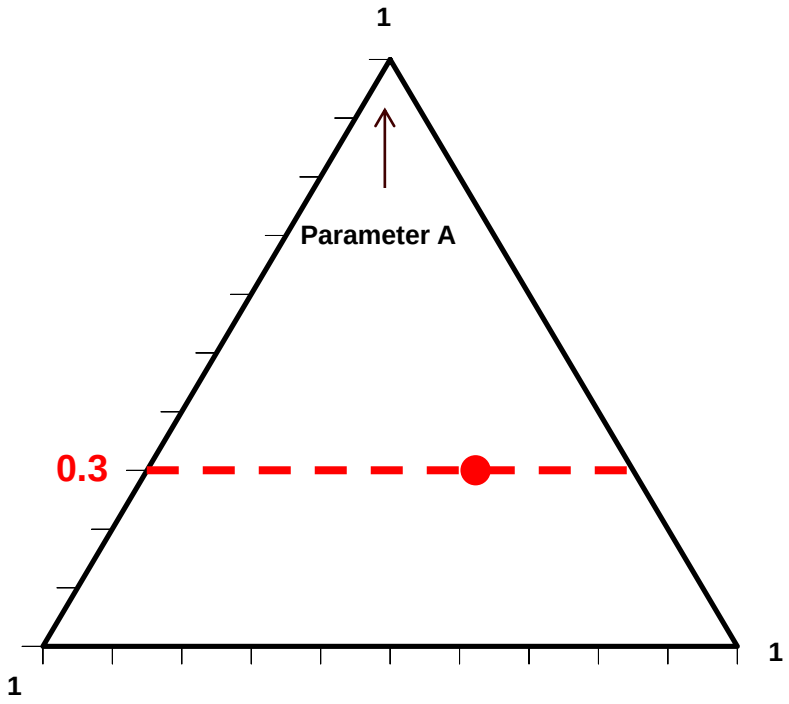
Triangle diagrams are a way to plot three parameters on a same chart, when these three parameters sum to one.



A+B+C=1

Triangle diagrams

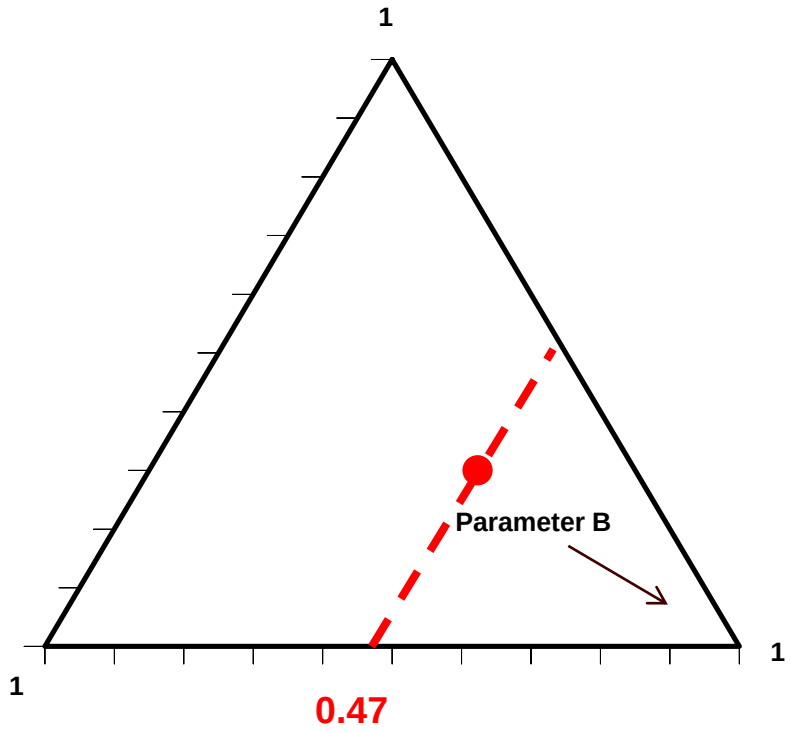
How to read a nodegram?



A=0.3

Triangle diagrams

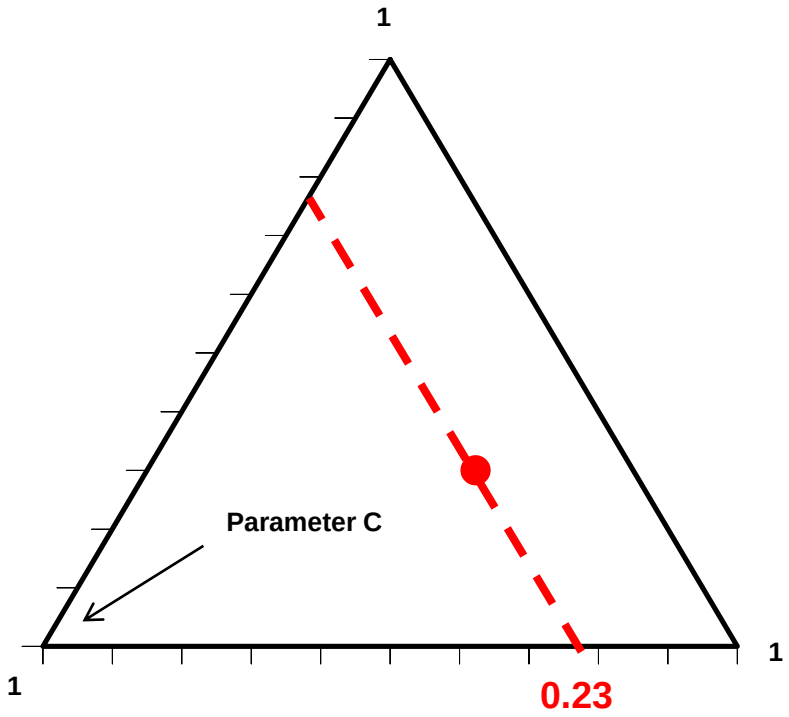
How to read a nodegram?



B=0.47

Triangle diagrams

How to read a nodegram?



C=0.23

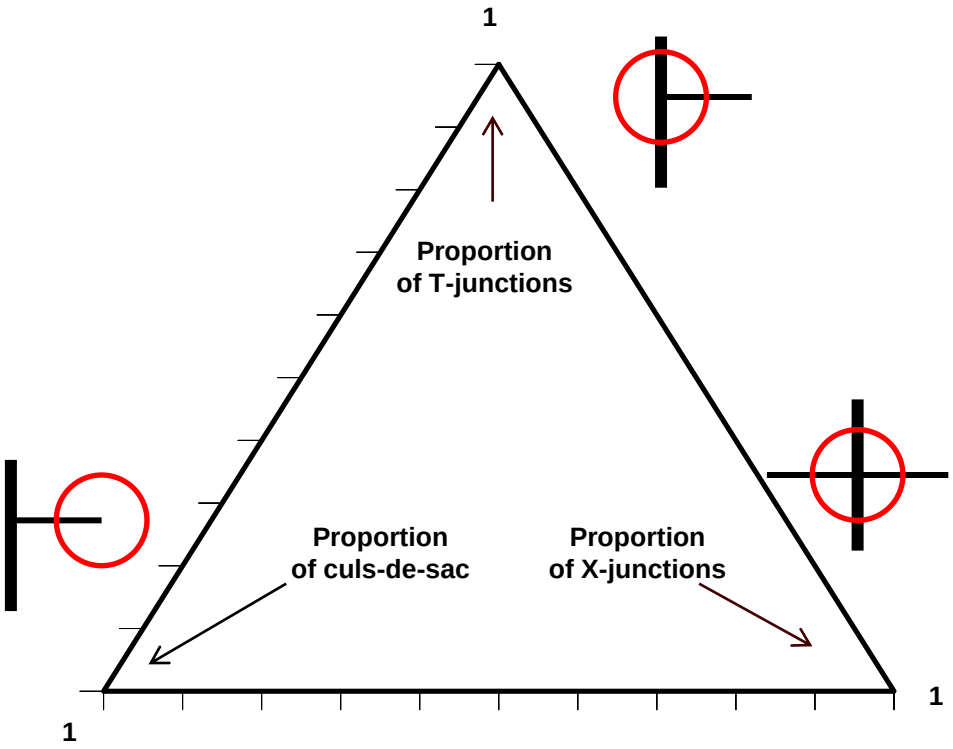
A+B+C

= 0.3+0.47+0.23

= 1

Nodegram

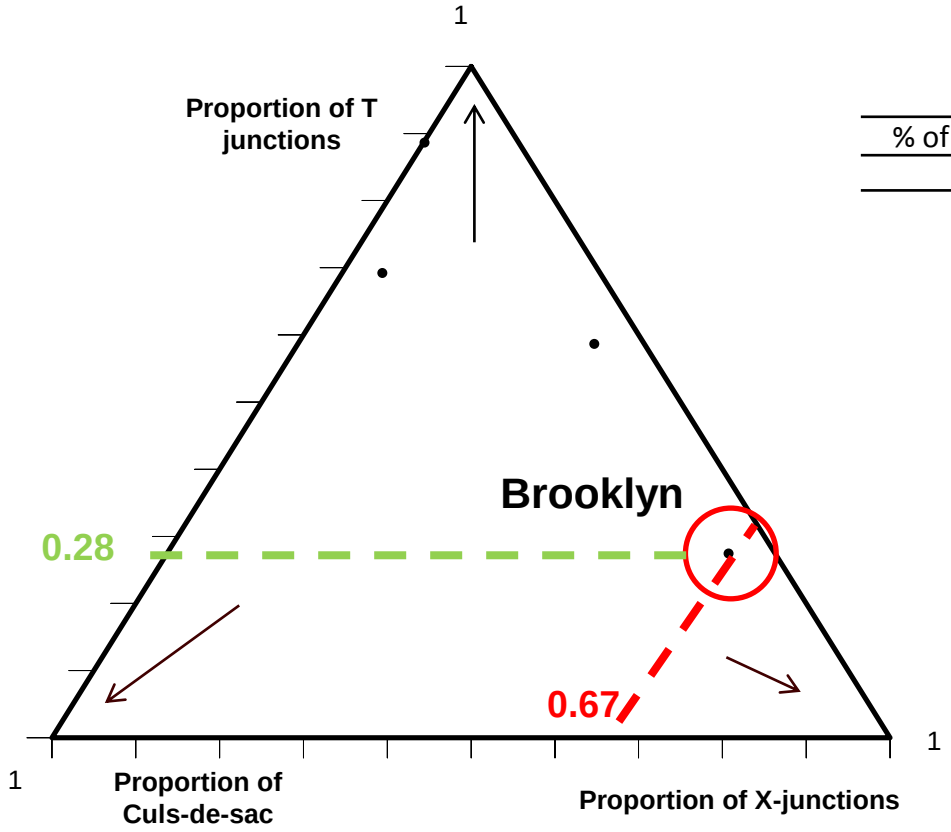
Nodegrams display the respective proportion of X-junctions, T-junctions and culs-de-sac.



Nodegram

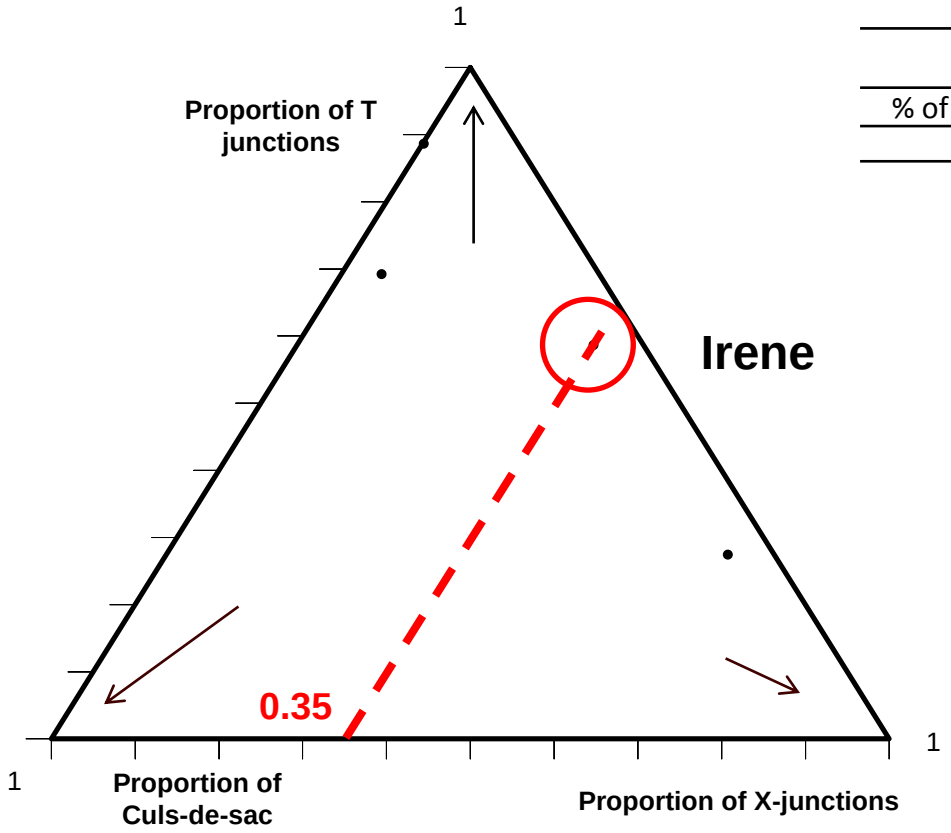
Nb of X junctions	Nb of T junctions	Nb of cul de sacs
73	30	6

% of X junctions	% of T junctions	% of cul de sac
67	28	6



Brooklyn

Nodegram



Nb of X junctions	Nb of T junctions	Nb of cul de sacs
30	50	5

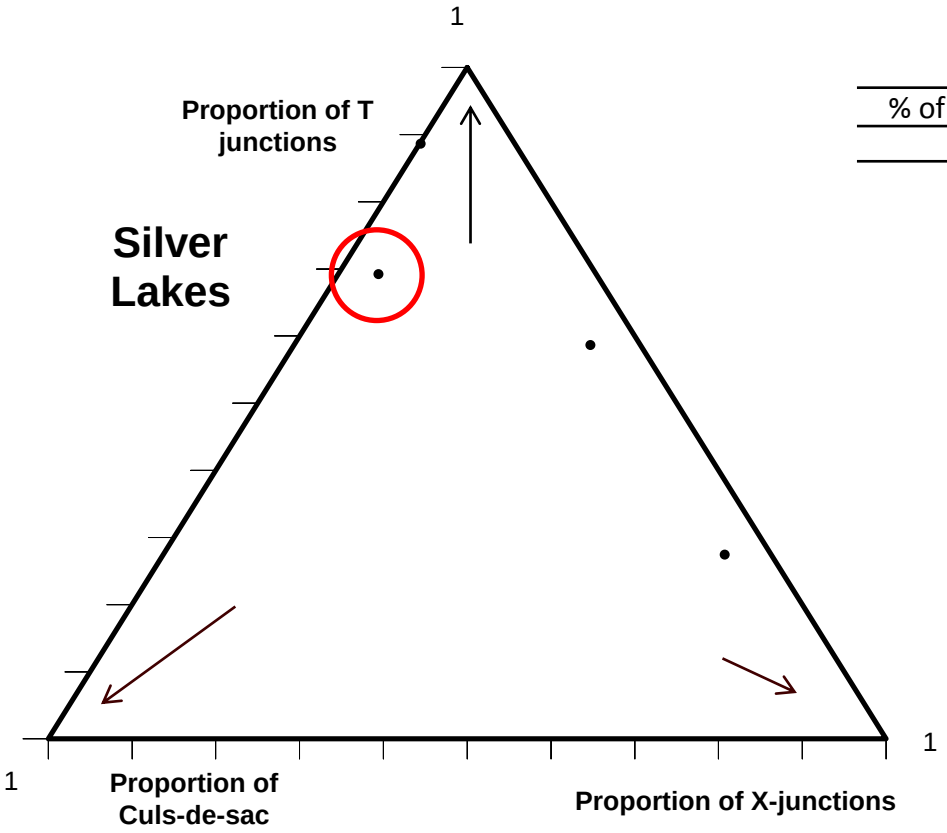
% of X junctions	% of T junctions	% of cul de sac
35	59	6

Irene

Nodegram

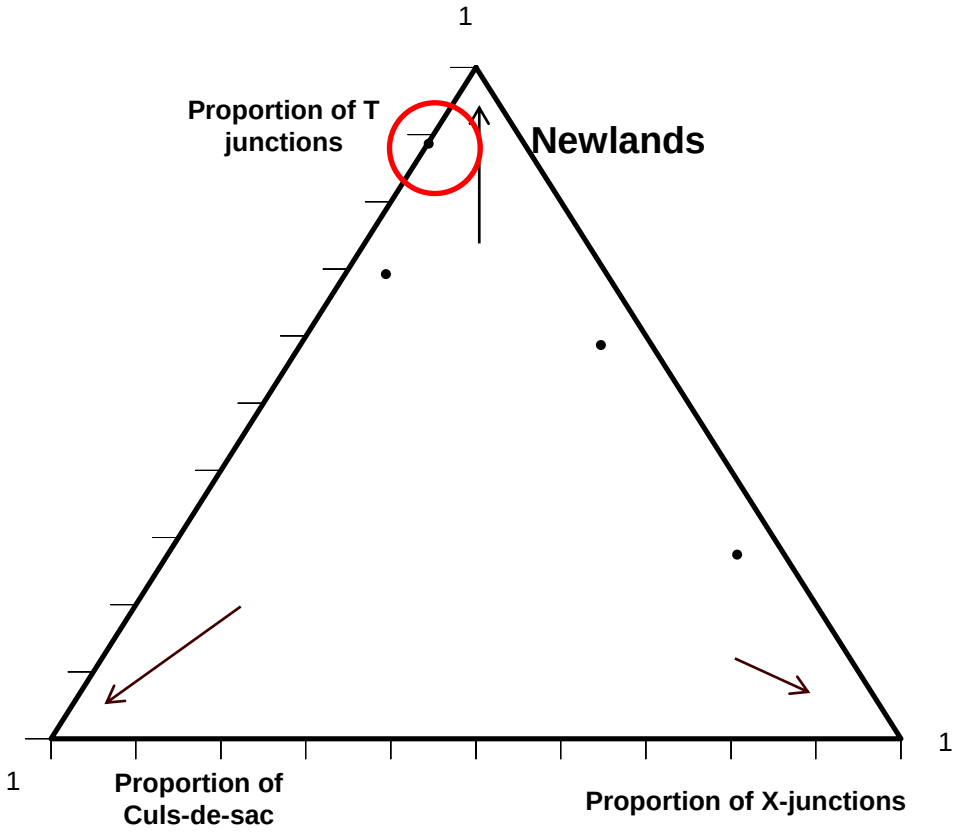
Nb of X junctions	Nb of T junctions	Nb of cul de sacs
4	59	22

% of X junctions	% of T junctions	% of cul de sac
5	69	26



Silver Lakes

Nodegram

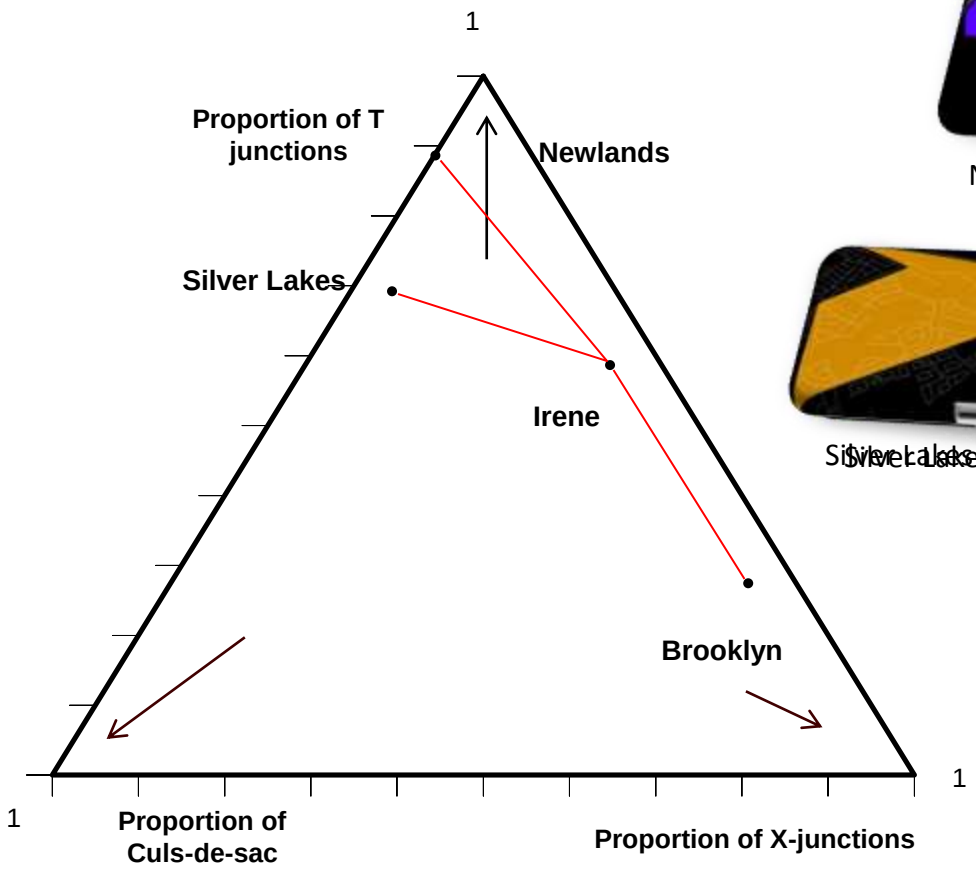


Nb of X junctions	Nb of T junctions	Nb of cul de sacs
0	16	2

% of X junctions	% of T junctions	% of cul de sac
0	89	11

Newlands

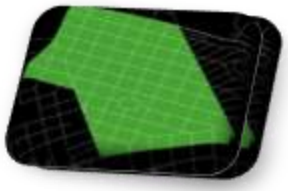
Nodegram



Newlands

Silver Lakes

Irene



Brooklyn

Workshop exercises

- Workshop held at the University of Pretoria
- Interactive and participatory workshop
  - Introduction of theories of urban morphological analysis and resilience
  - Application of theories on case studies in Tshwane

Case study areas

Savannah country estate

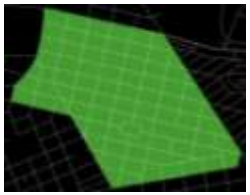
CBD

Equestria

Analysed by Loeiz Bordic

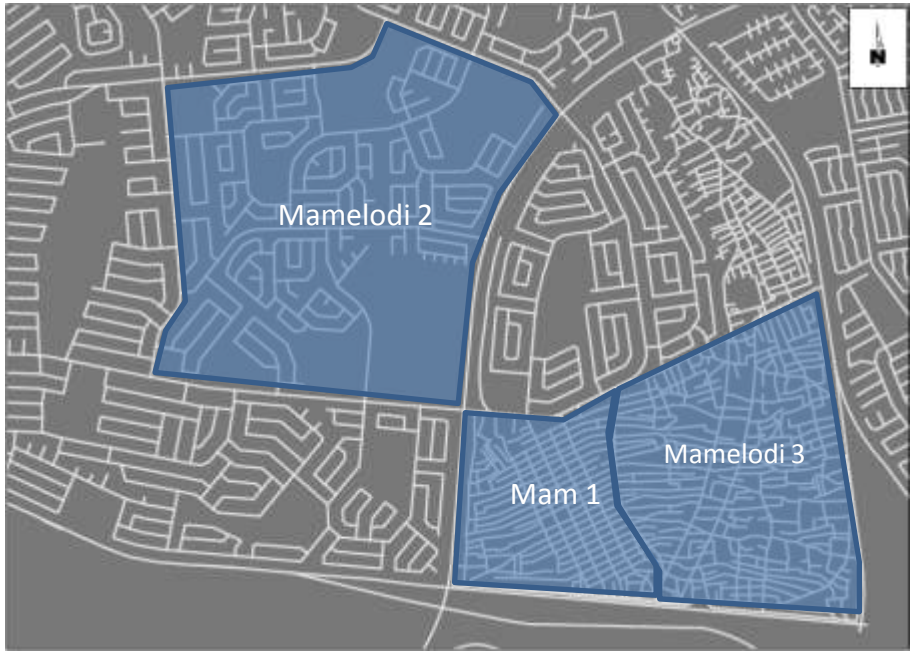
Irene

Newlands



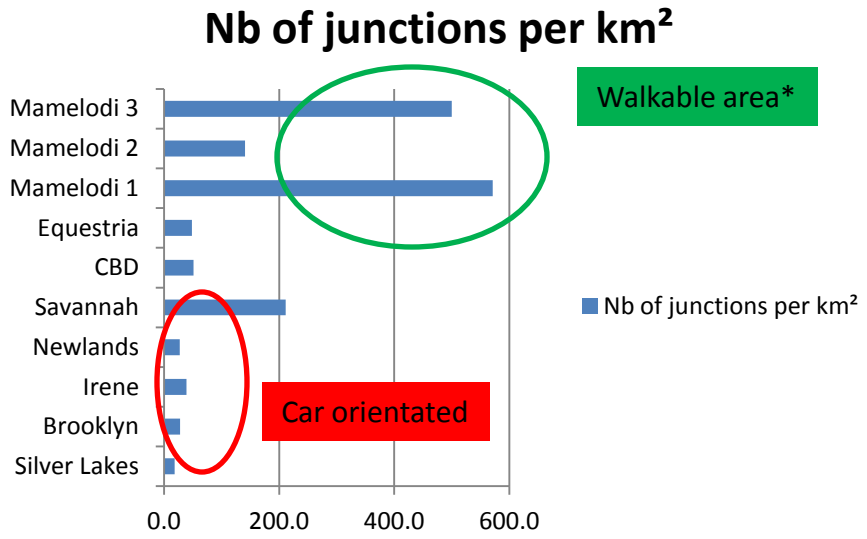
Brooklyn

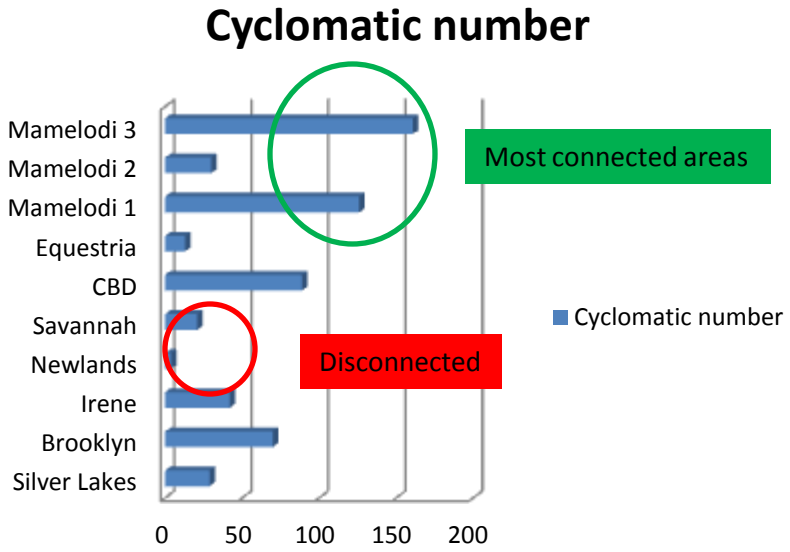
Silver Lakes

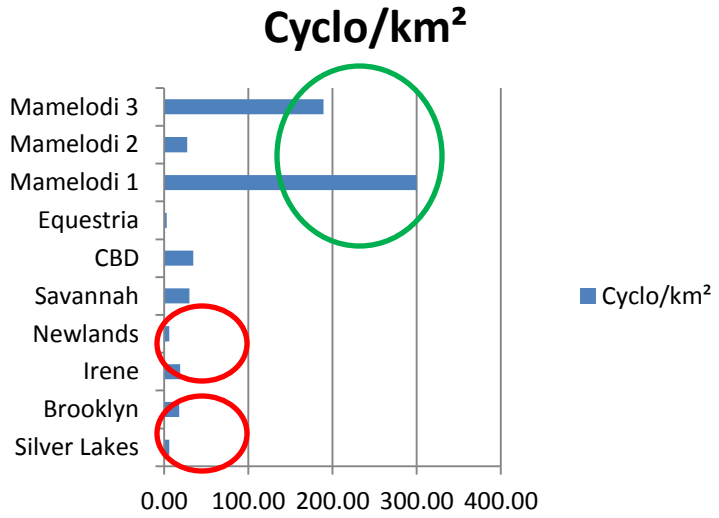


Mamelodi

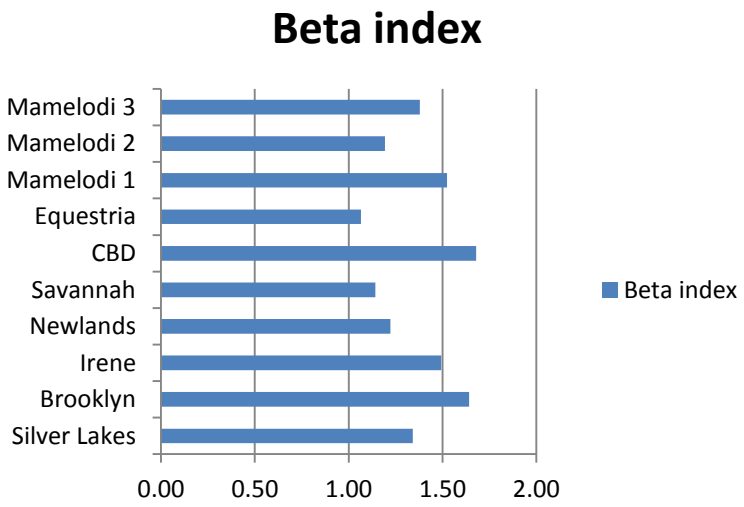
Simple Metrics

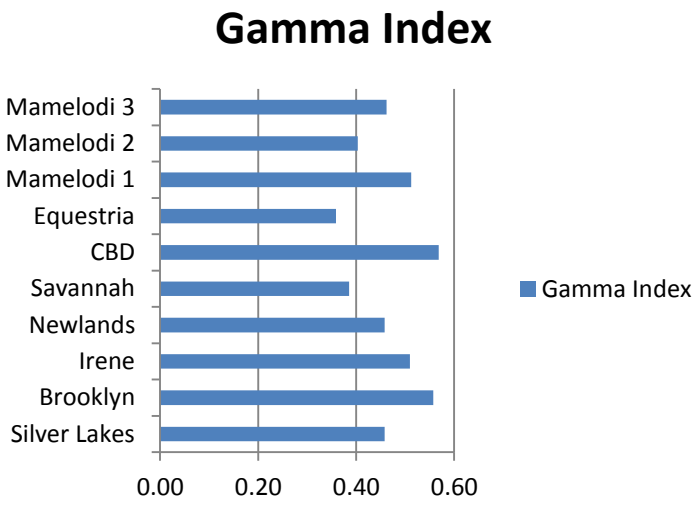




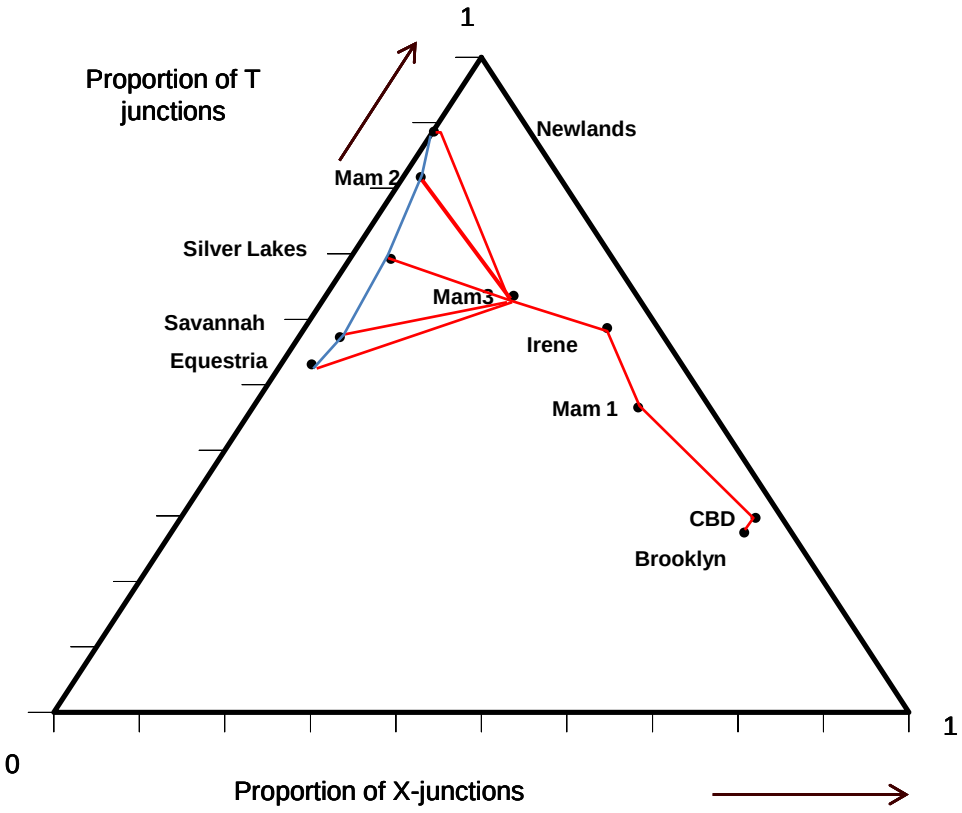


Gamma and Beta Index





Combined Nodegram

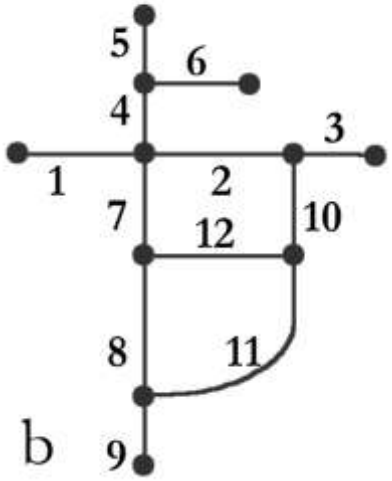


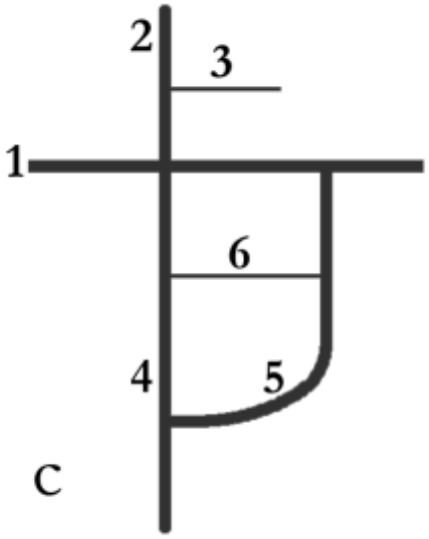
Routegram

A routegram allows locating a route on a triangle diagram according to:

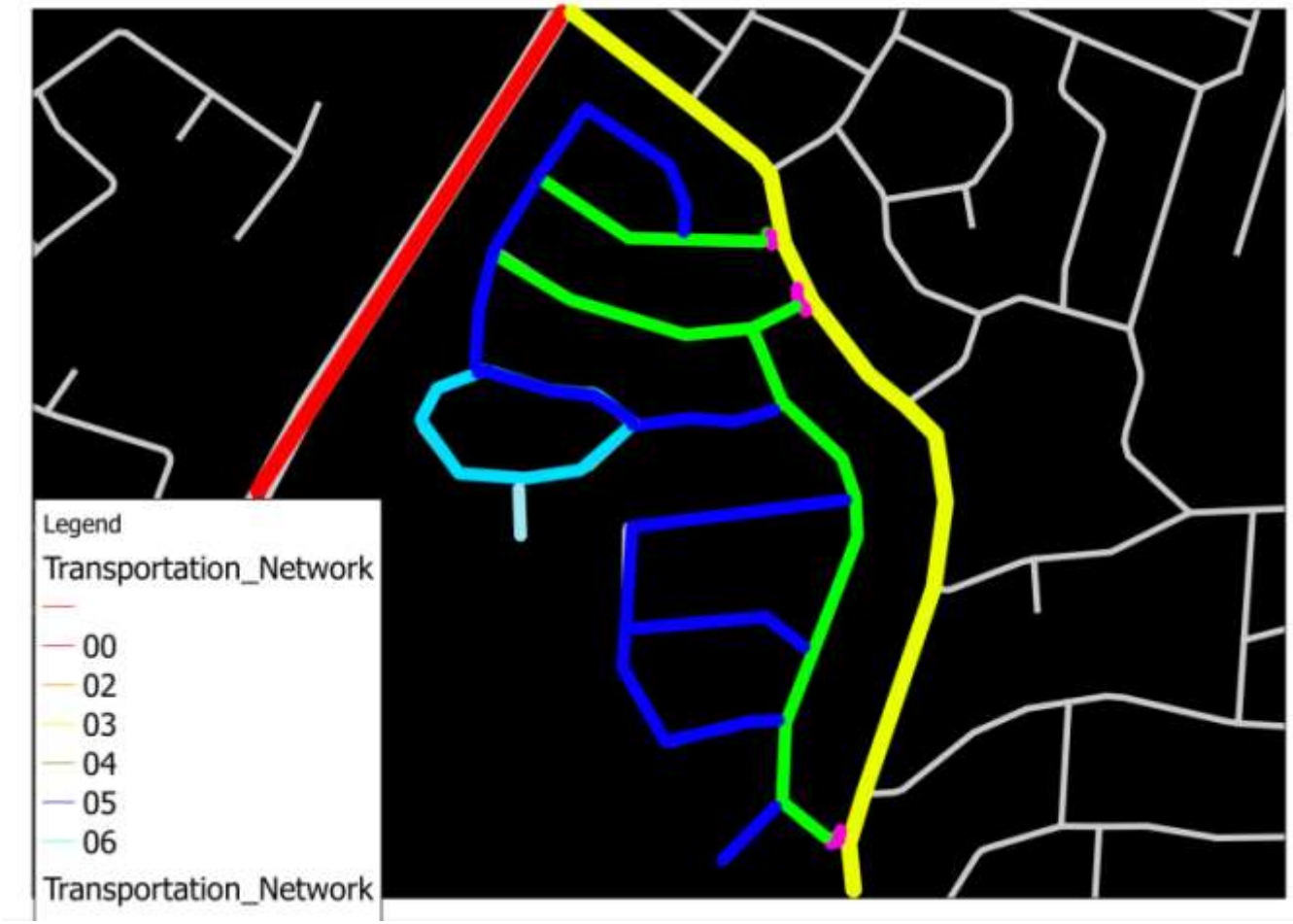
1. Depth
2. Connectivity
3. Continuity

What is a « route » ?





What is a route in a network?



Routegram

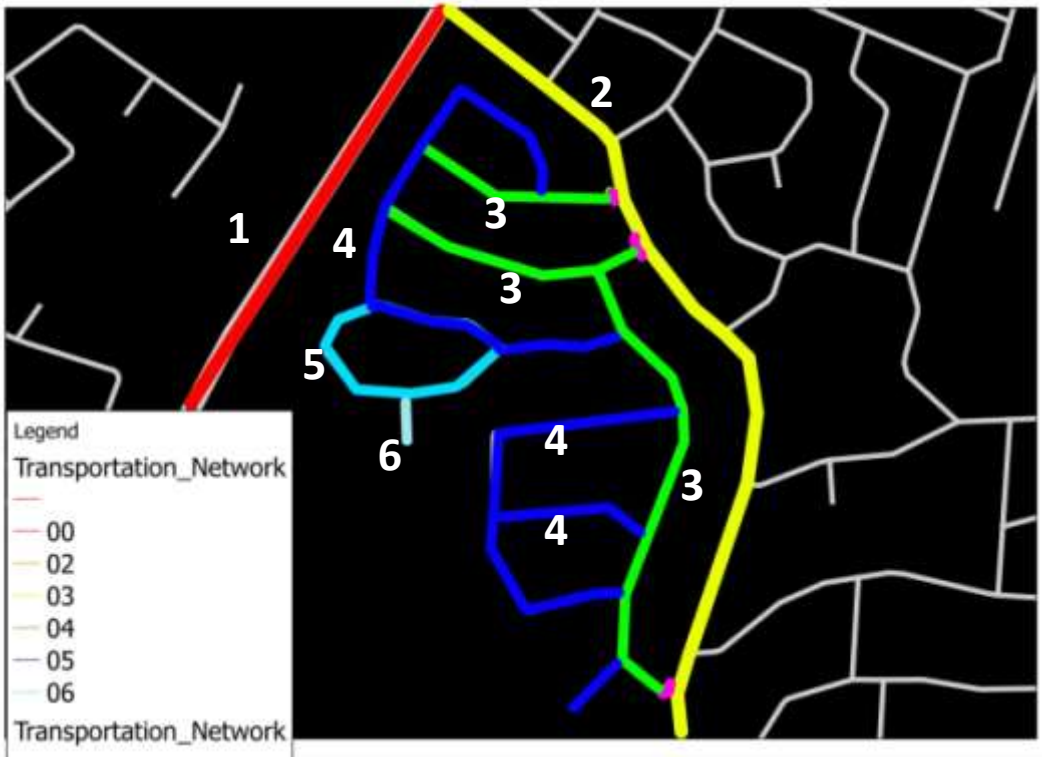
S. Marshall builds on three indicators for route analysis:

- **Continuity** is defined as the number of links that constitute a route. Thus, the more intersections the road runs through, the stronger its continuity. The continuity of a road indicates its power to continue without stopping or terminating at a more important road.
- **Connectivity** refers to the number of roads that are connected by a given road. Connectivity indicates the structuring power of the route, its power to bring together other routes and make them converge.
- **Depth** necessitates choosing a datum route (for example a ring road, a national route or any important road), and then counting the number of steps, that is of routes, to take to join up with the analyzed road. A route is more or less deep depending on whether it is directly connected to a main road or hidden in the depth of the city's street network. The depth reveals the relative orientation of the road to long-range traffic or short-range access to residences. Hierarchically higher-level roads are arterials that connect the city on the big scale.

Routegram

1. Depth

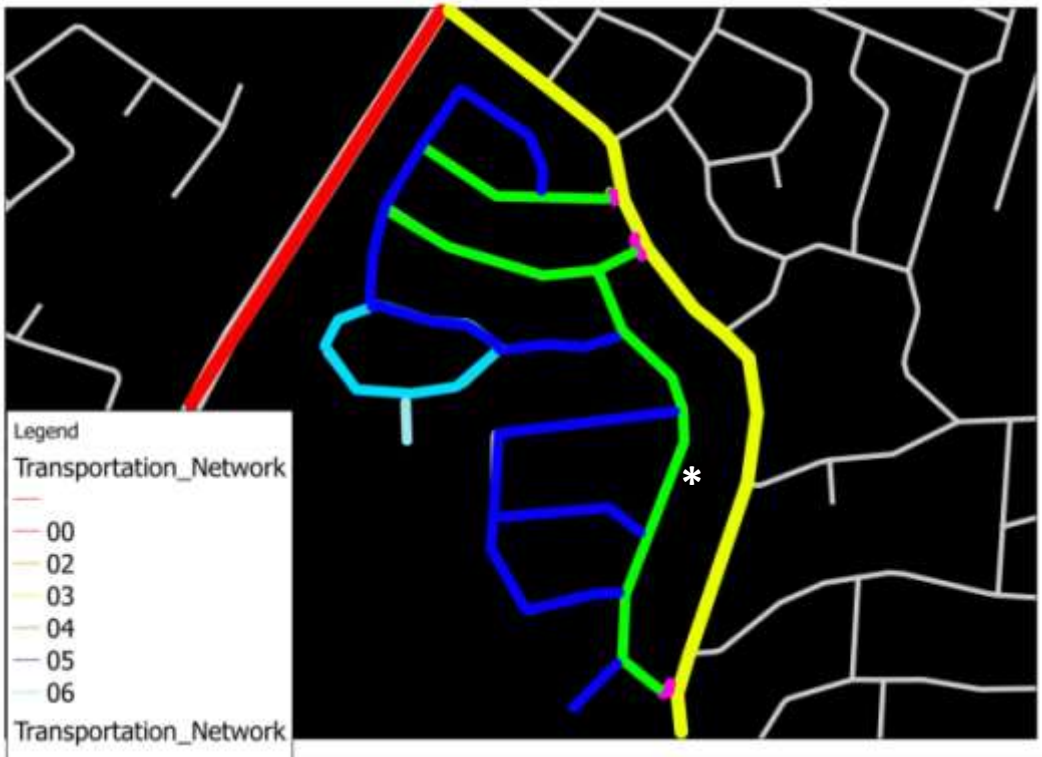
   The depth of a route is a measure of the distance to a *datum* (reference route)



Routegram

2. Continuity is the number of links a route is made up of

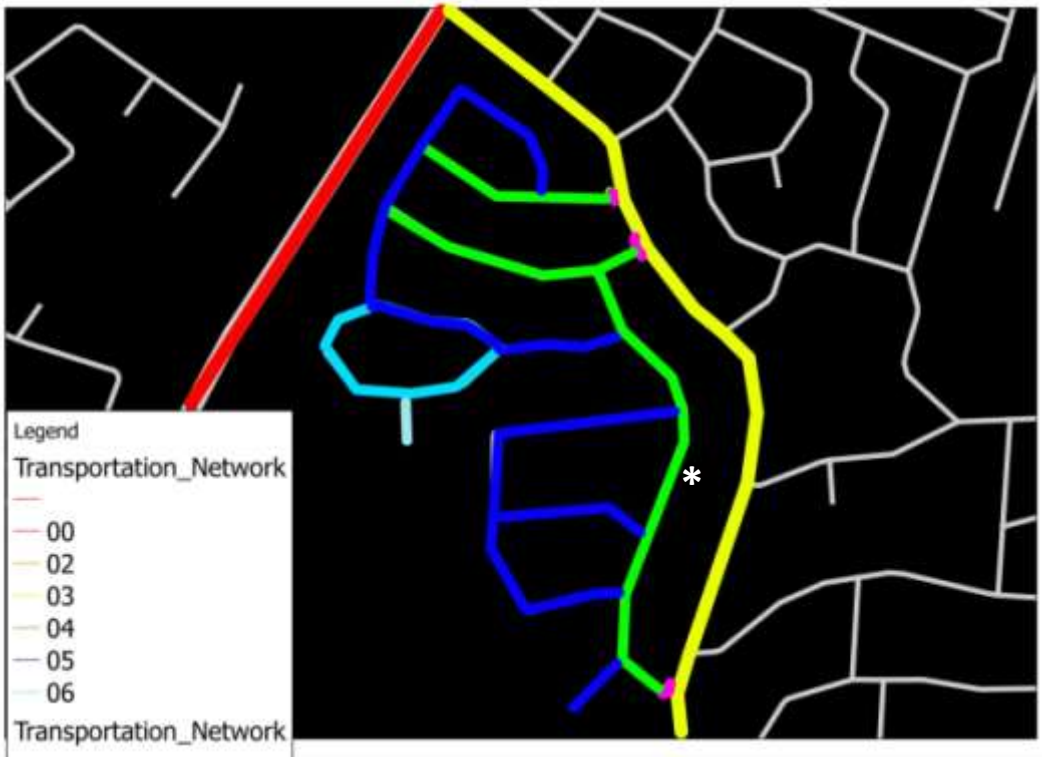
The green road (*) is made up of 6 links



Routegram

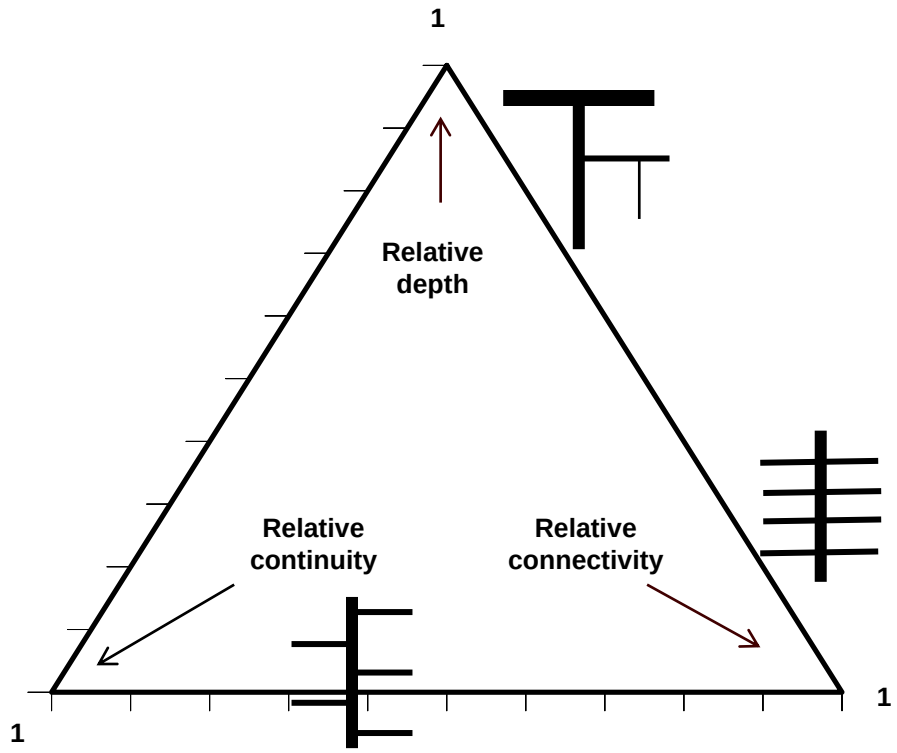
3. Connectivity is the number of routes a given route connects

   The green road (*) connects 7 routes.



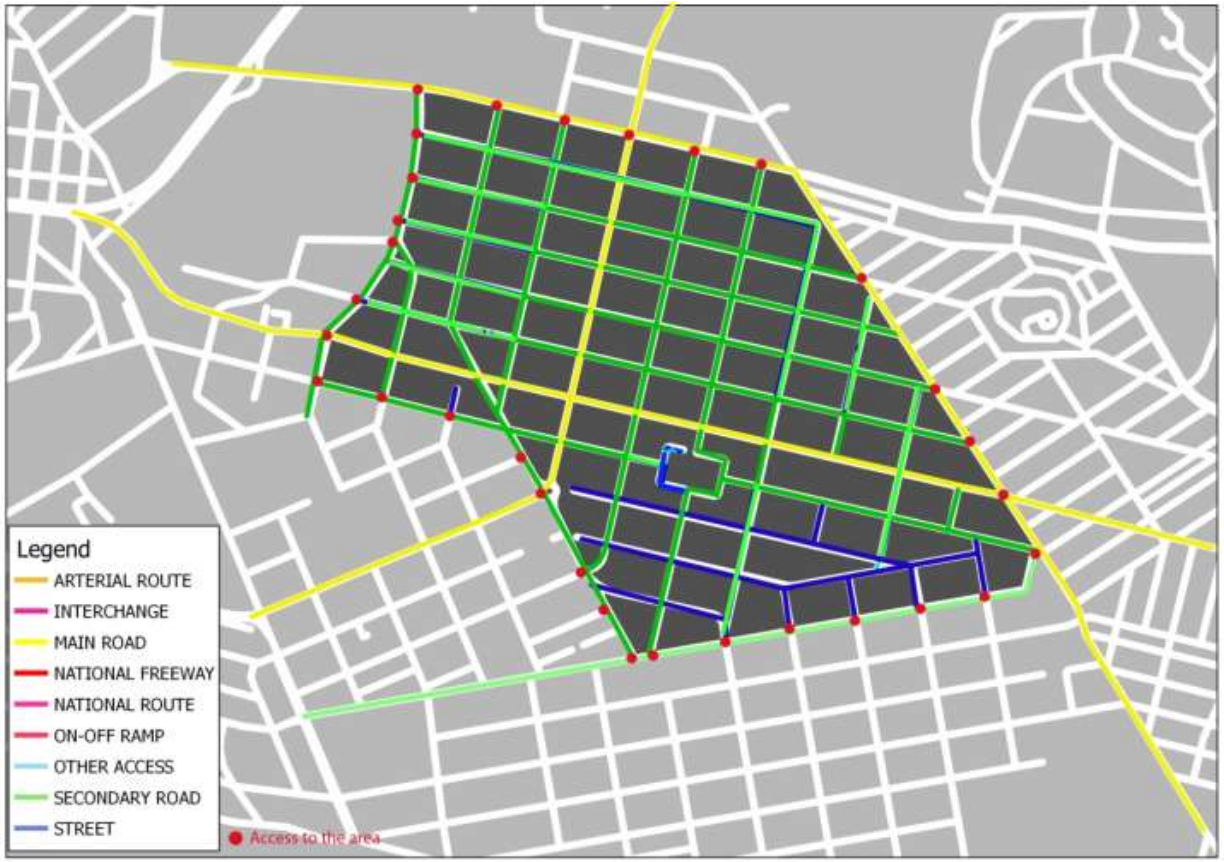
Routegram

A routegram displays relative depth, connectivity and continuity

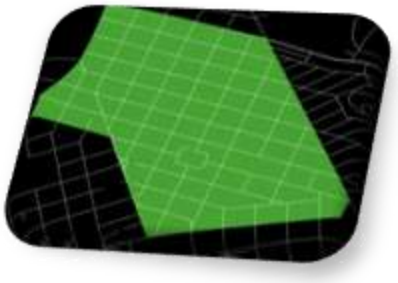


Relative depth is the ratio of depth by the sum of the three parameters. Same for other parameters.

Routegram - Brooklyn



Routegram - Brooklyn



Example

Depth = 2

It connects 8 routes
Connectivity = 8

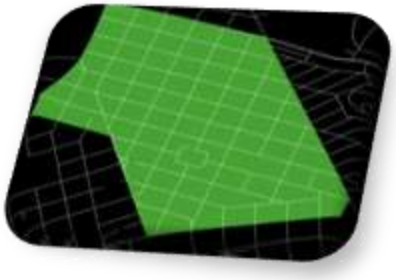
It is made up of 7 links
Continuity = 7

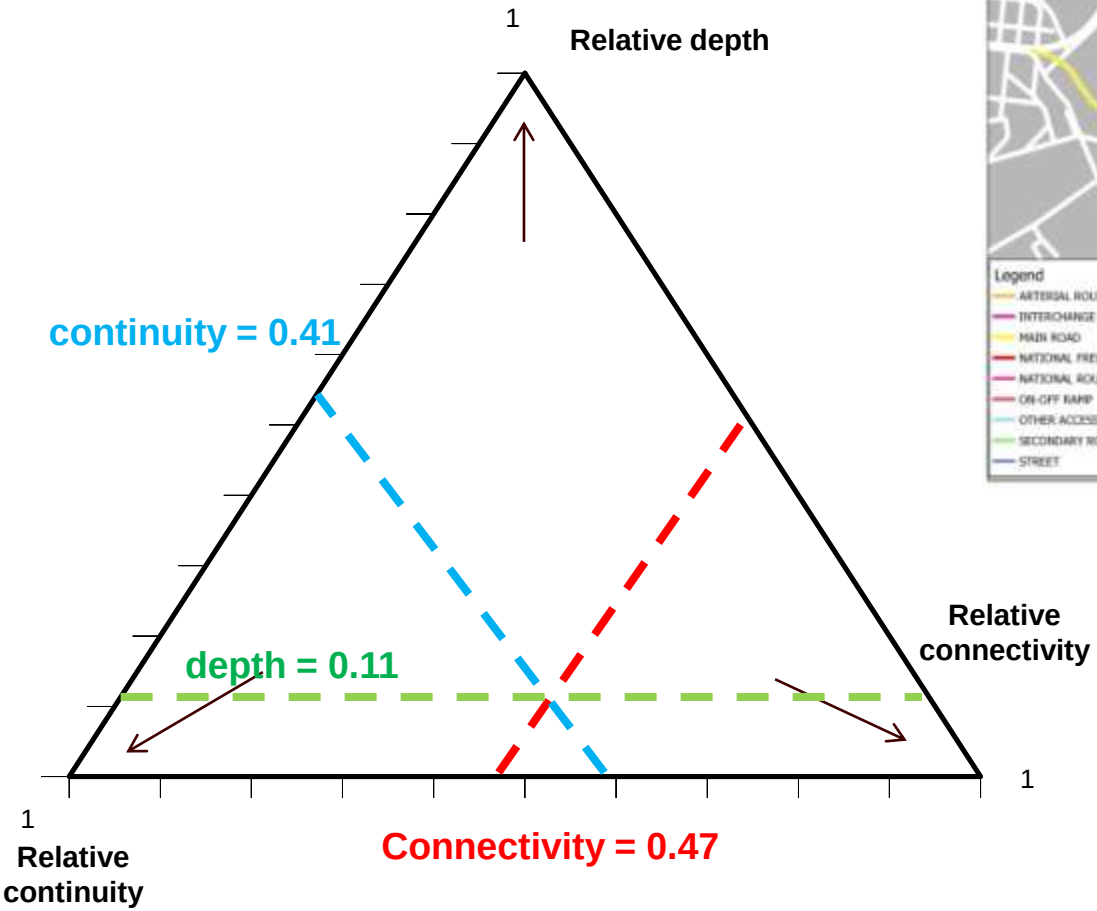
Relative depth =
2/(8+7+2) = 0.11

Relative connectivity =
8/17 = 0.47

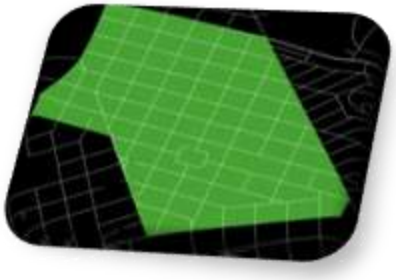
Relative continuity =
7/17 = 0.41

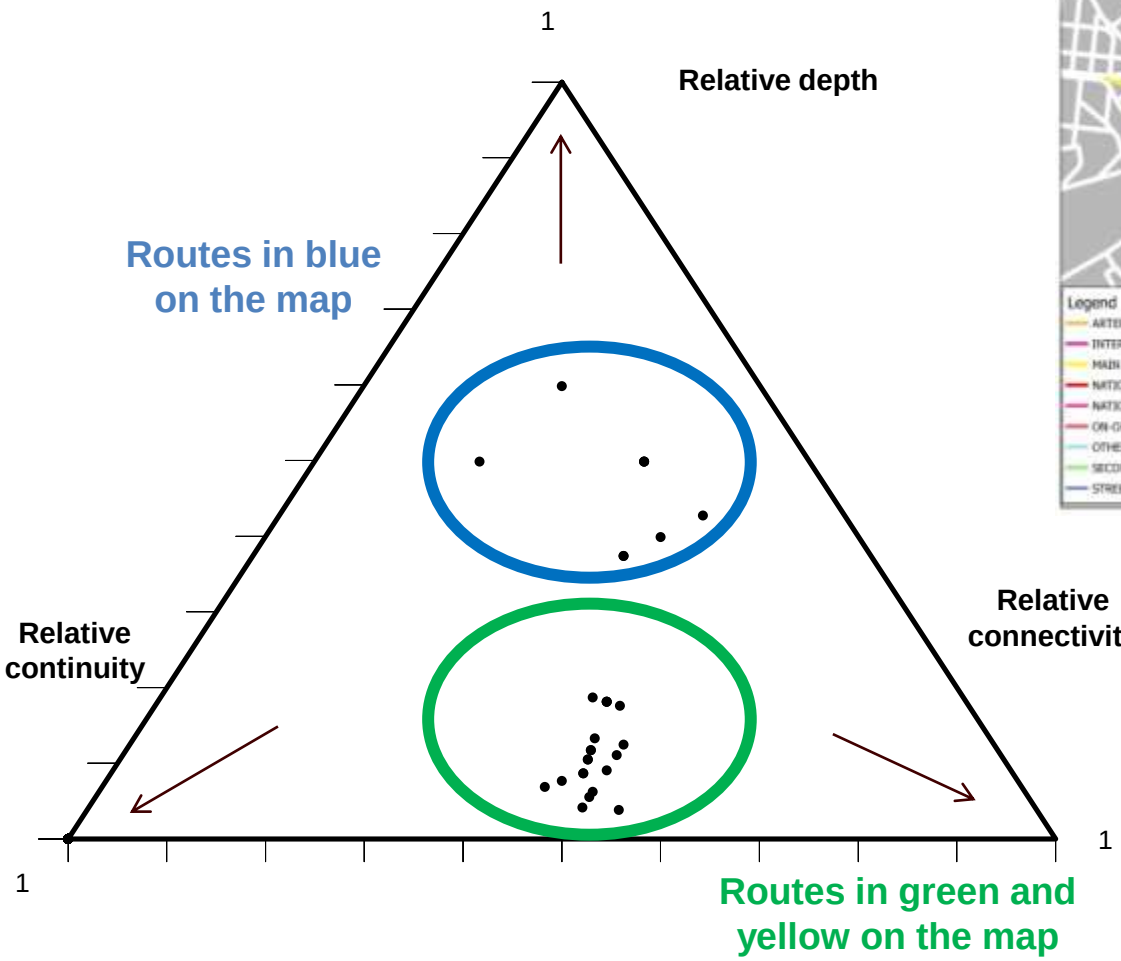
Routegram - Brooklyn





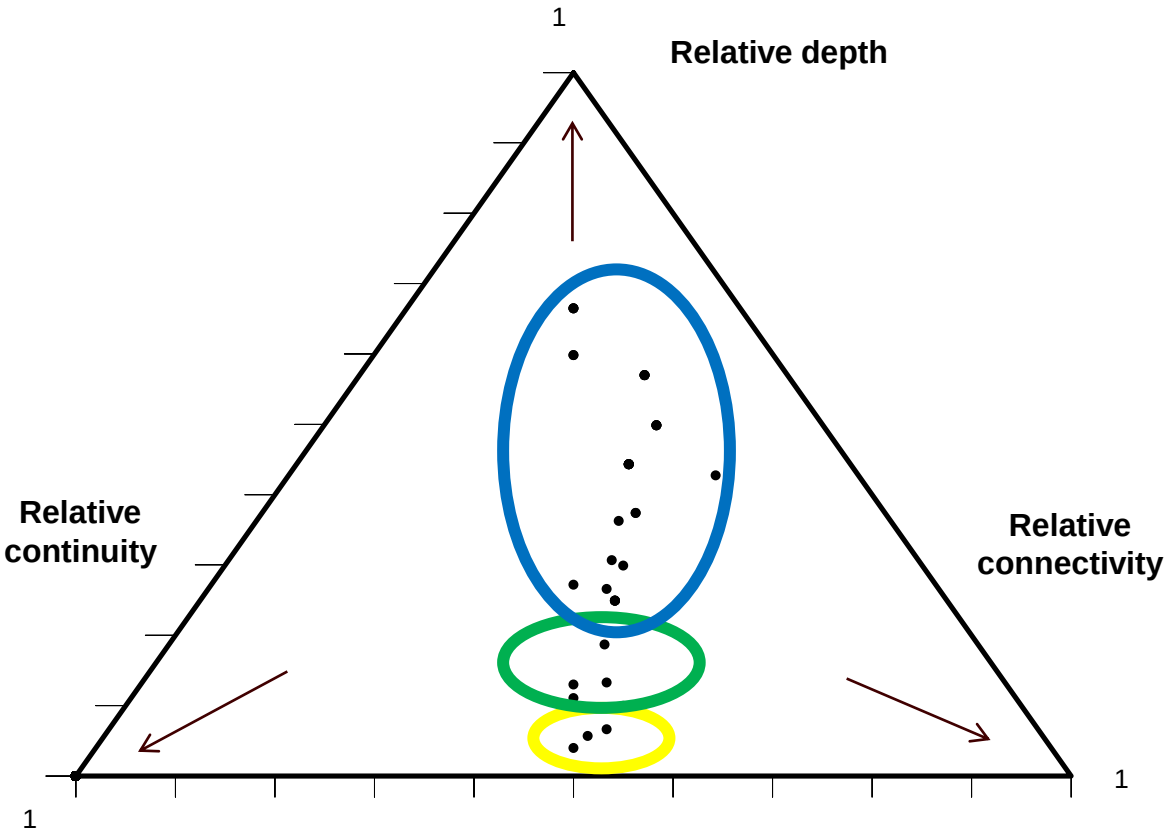
Routegram - Brooklyn

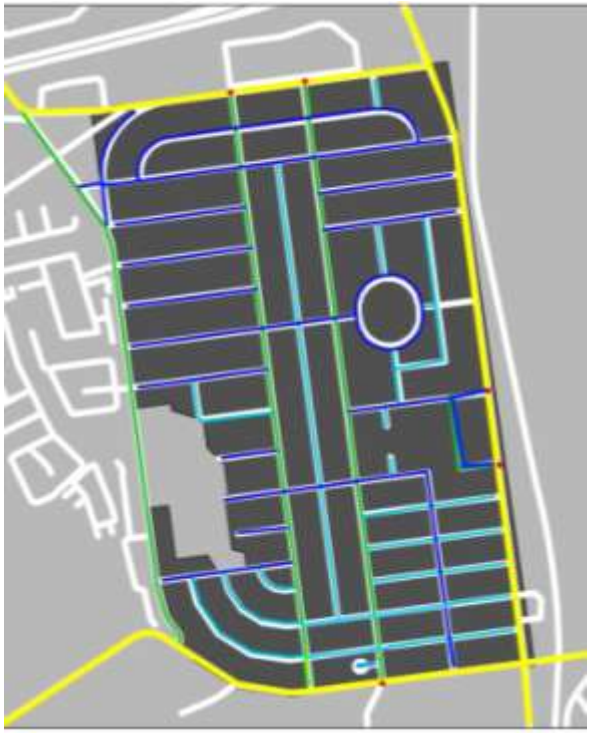




Routegram - Irene

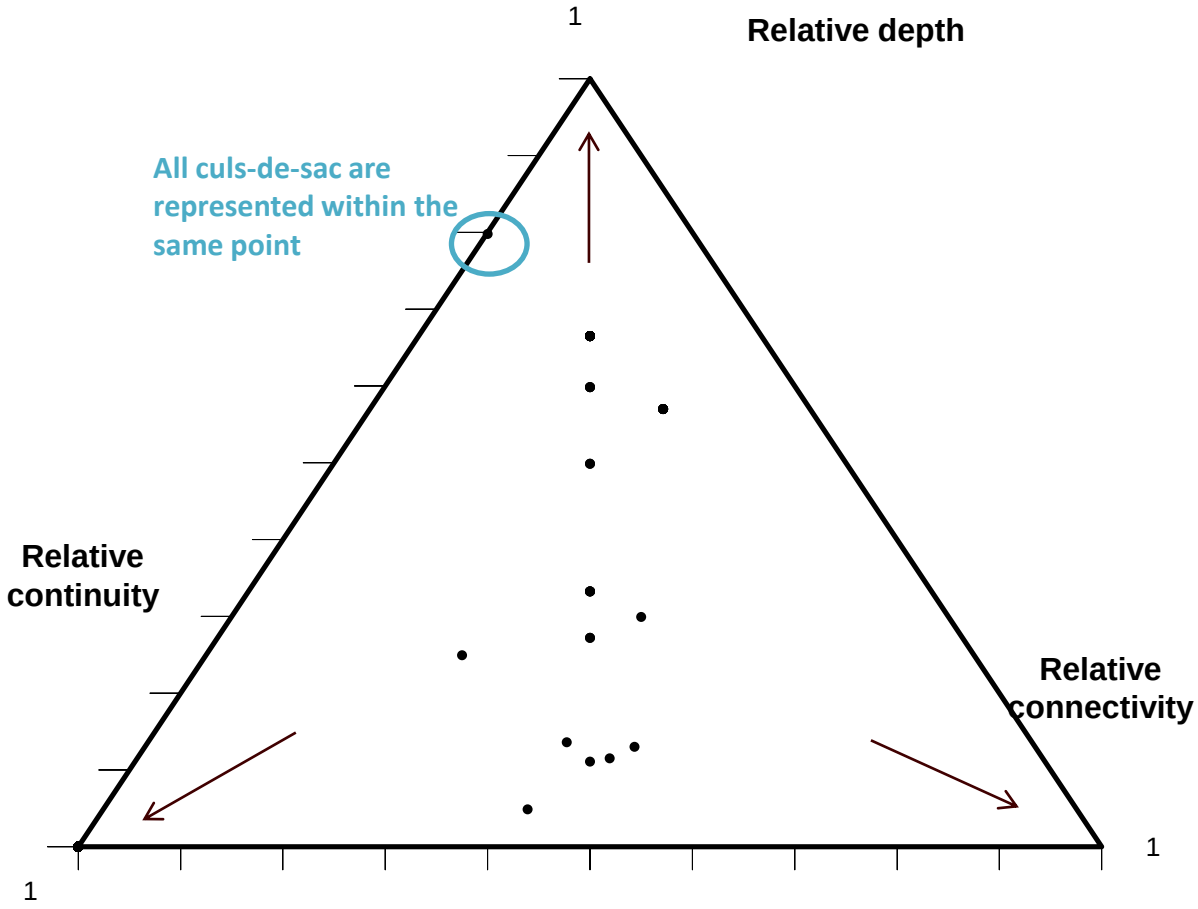
Routegram - Irene





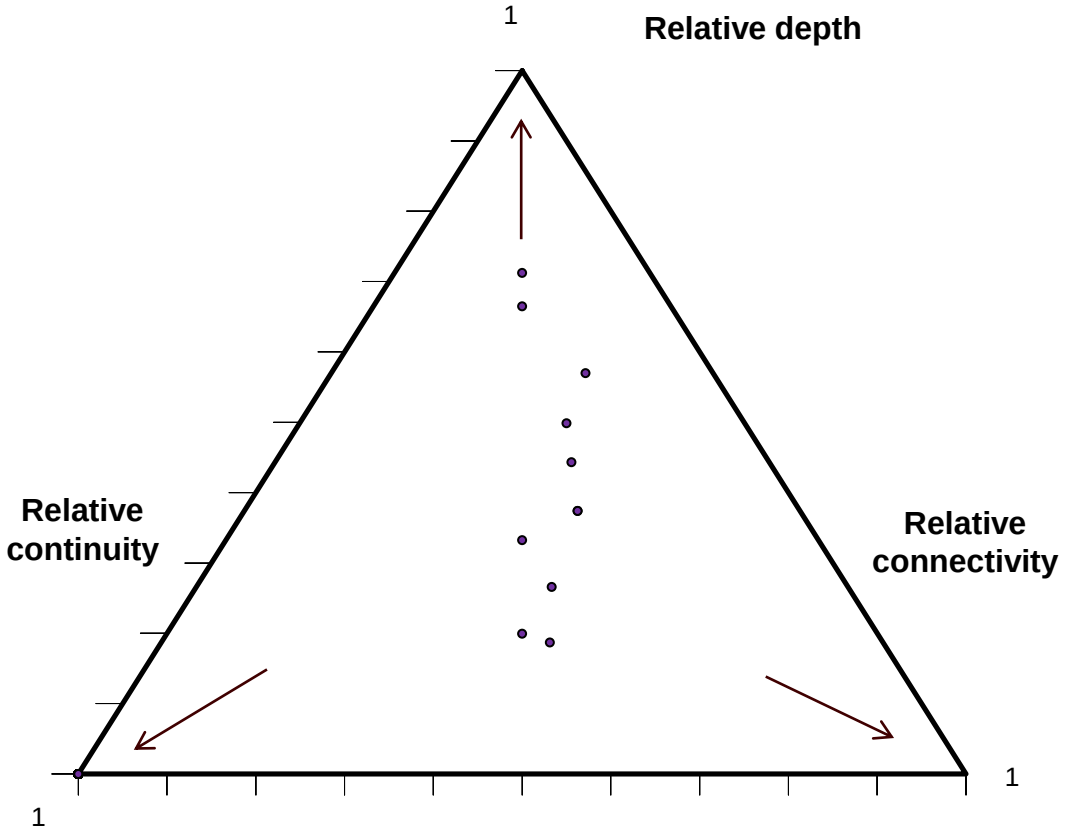
Routegram – Silver Lakes

Routegram – Silver Lakes

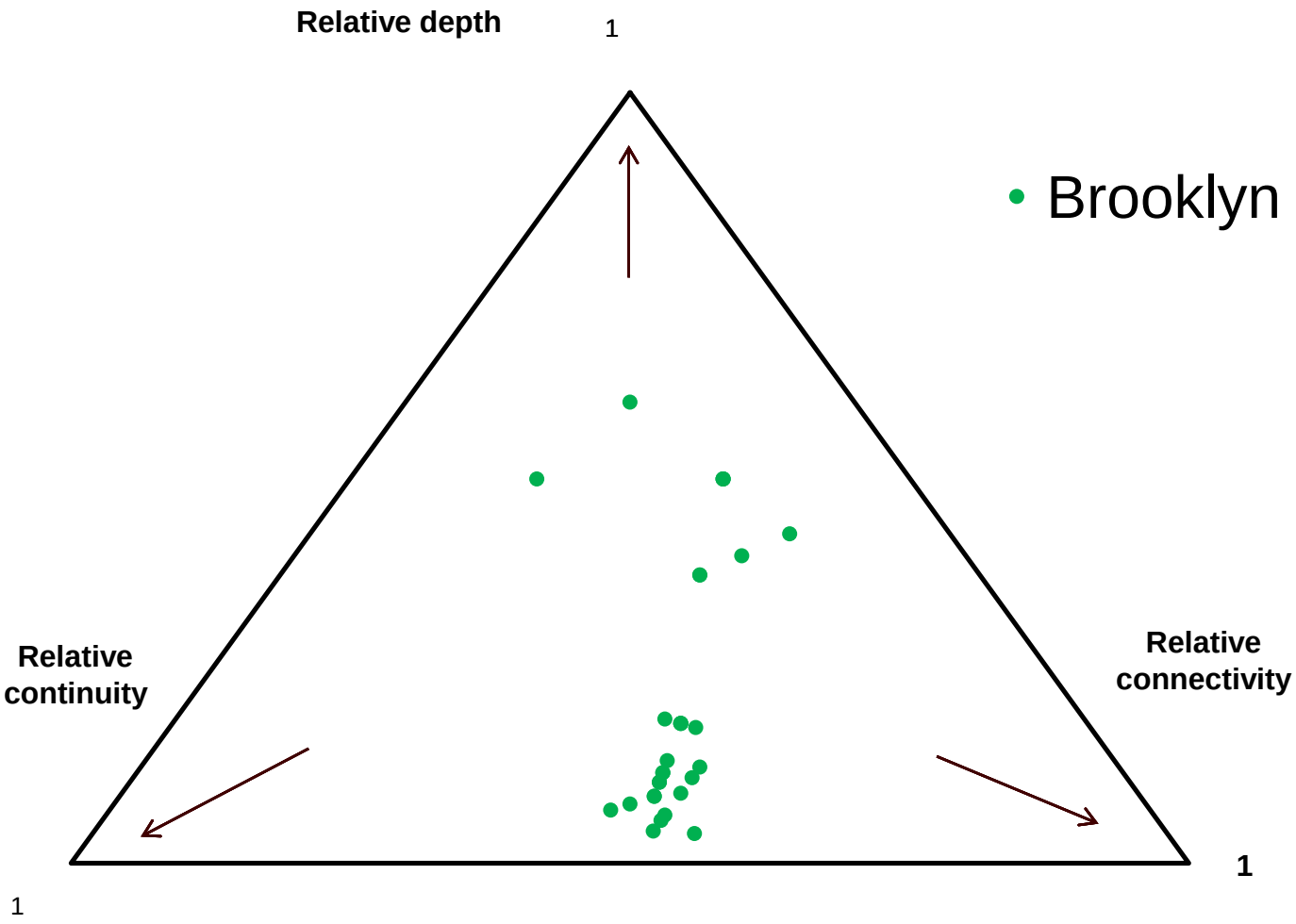


Routegram – Newlands

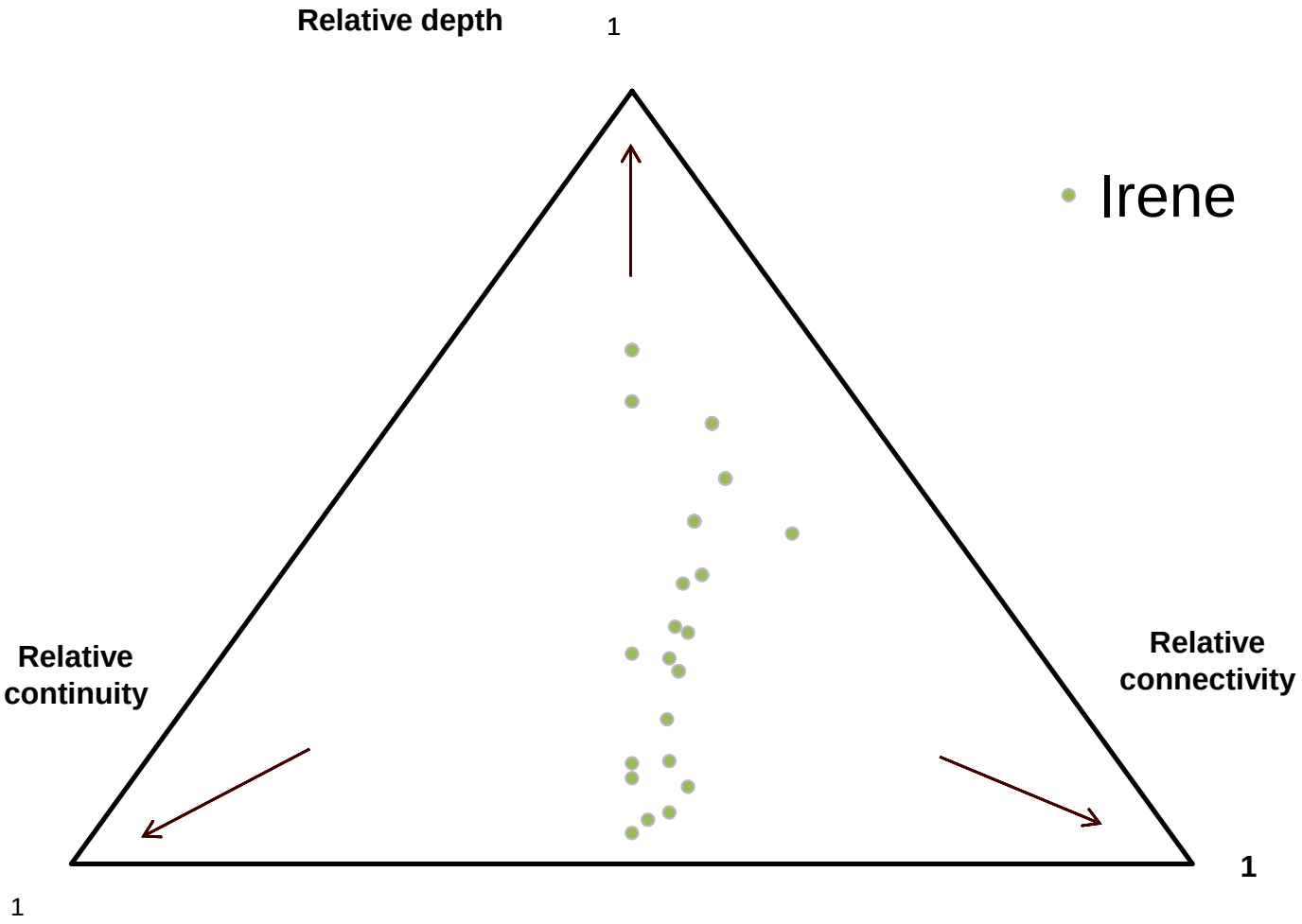
Routegram – Newlands



Evolution in the routegram

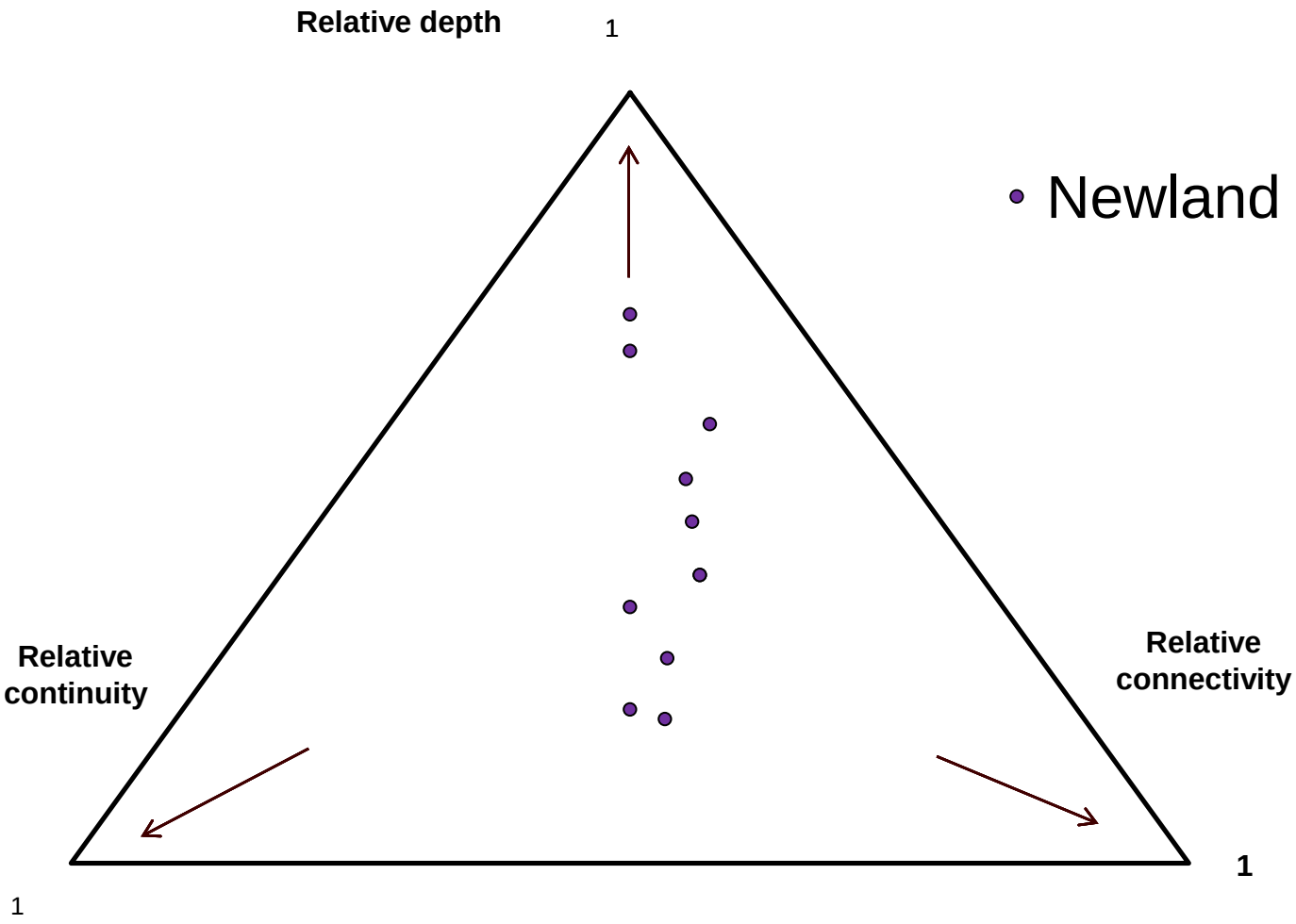


Evolution in the routegram

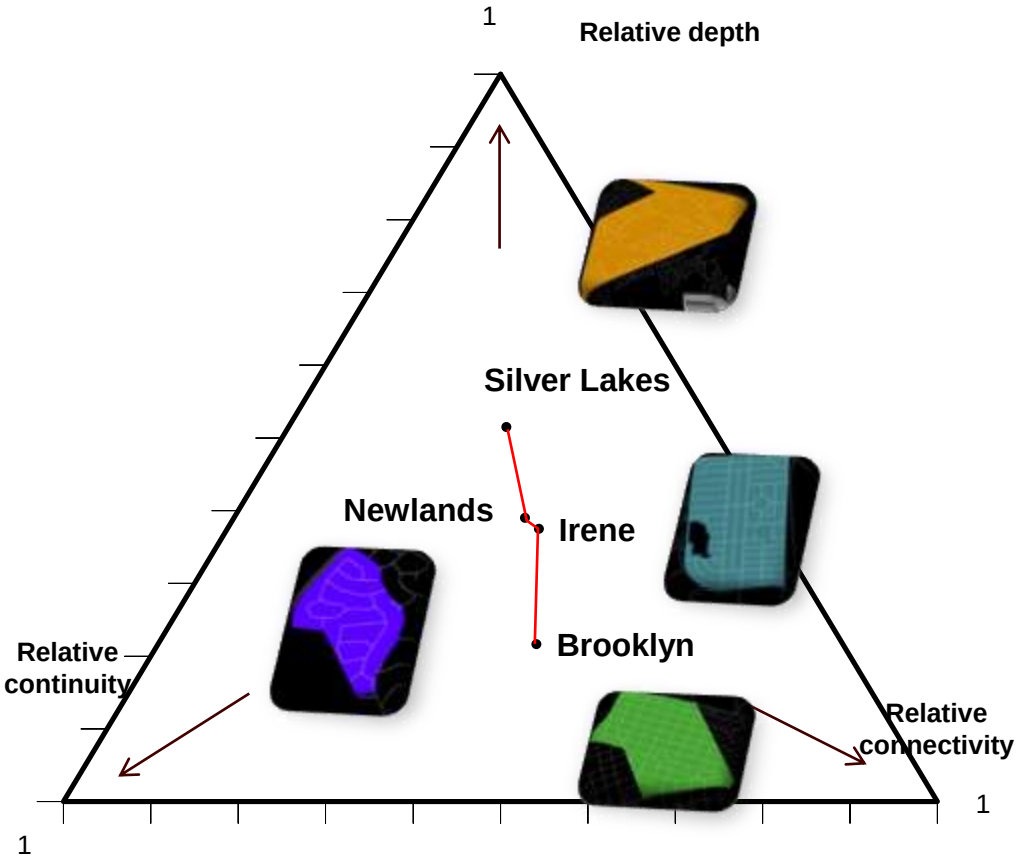


Evolution in the routegram

Evolution in the routegram



Netgram – averaged routegrams



Hetgrams

Hetgrams address the issue of heterogeneity and assist the recognition of networks according to the differentiation of route types.

It rests upon three parameters:

1. Regularity
2. Recursivity
3. Complexity

Hetgrams

1. Regularity

- A **route type** is a triplet (continuity,connectivity,depth)
- The **number of route types** is the number of different triplets

- **Irregularity** in a network can be calculated as the ratio of the number of route types by the total number of routes

- **Regularity** is the complement to irregularity:

  regularity=1-irregularity

Hetgrams

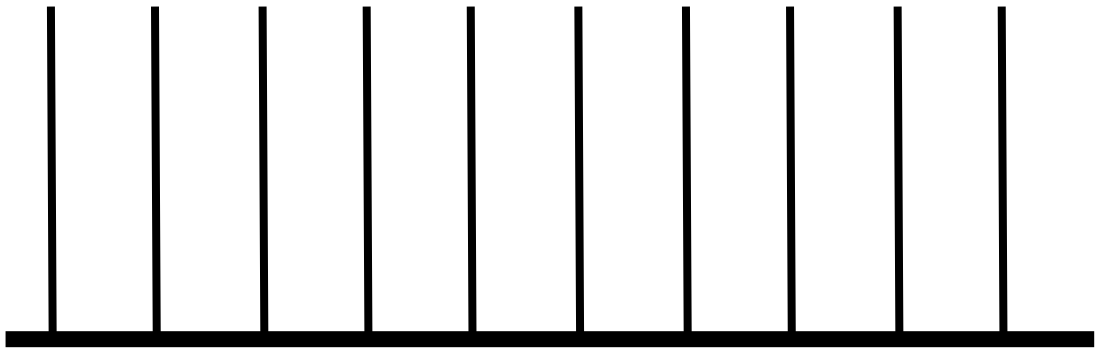
1. Regularity

   Example:

   2 route types, 11 routes

   irregularity = 2/11 = 0.18

   regularity = 1 – 0.18 = 0.82



Hetgrams

2. Recursivity

Recursivity is the number of depth (maximum depth) divided by the number of routes.

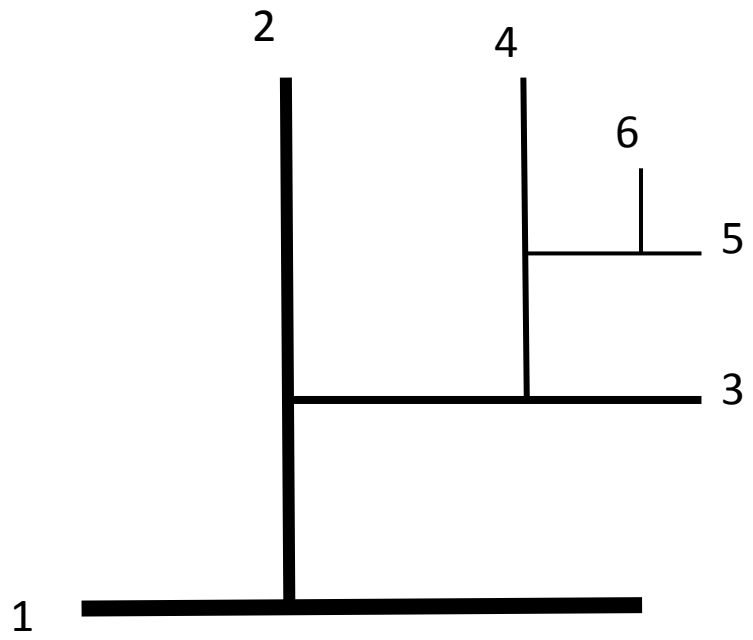
Example:

Max depth is 6

There are 6 routes

Recursivity = 6/6 = 1

Recursivity is maximum



Hetgrams

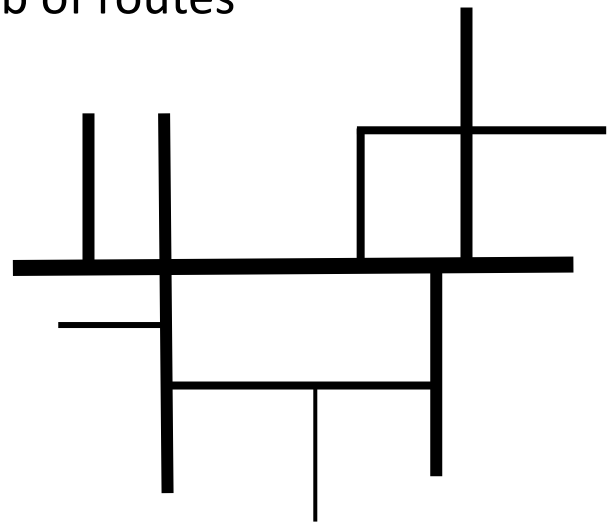
3. Complexity

- Complexity can be defined as the number of distinct route types present over and above the number of distinct route types generated by difference in depth alone…
- It is equal to: (nb of route types – depth)/total nb of routes

Example:

Max depth is 4, there are 11 routes and 11 route types

Complexity is (11-4)/6 = 0.64

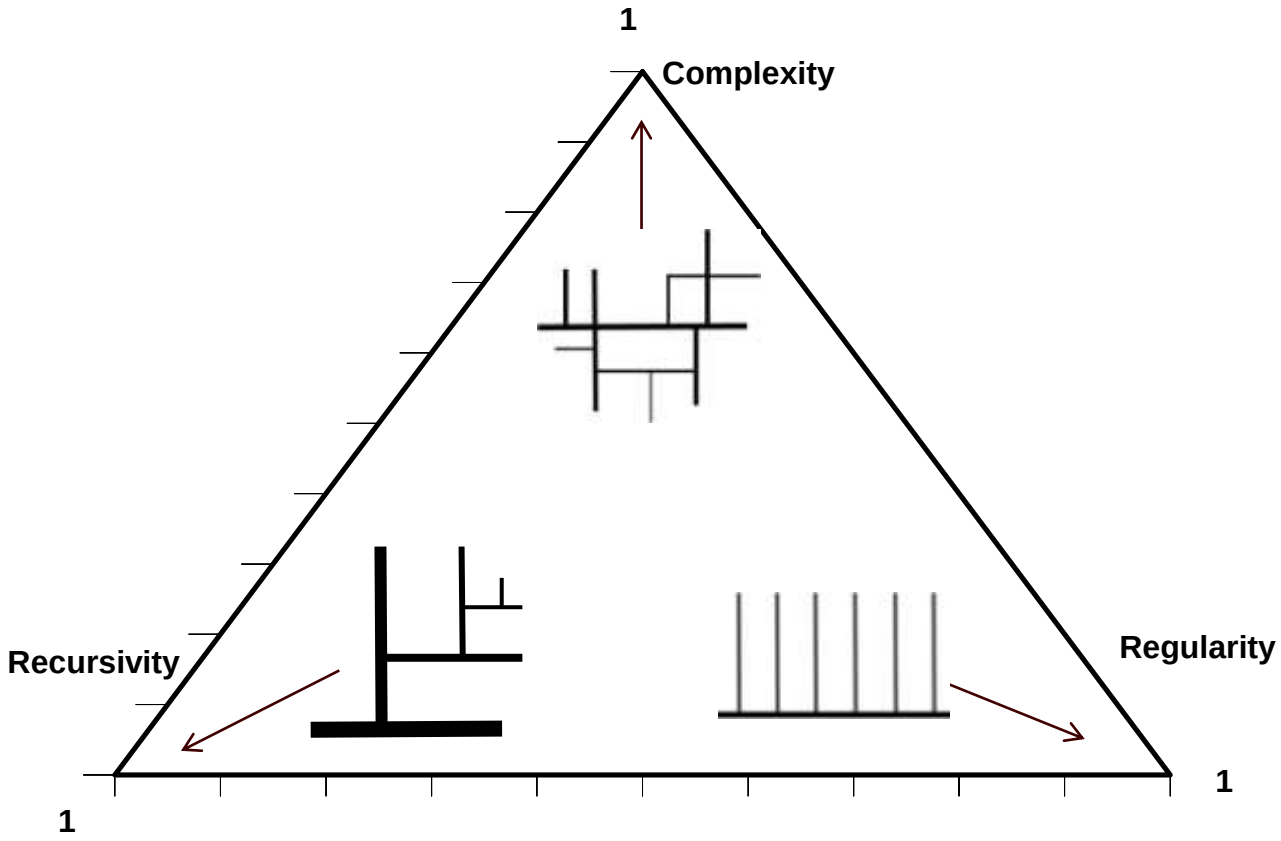


Remarks:

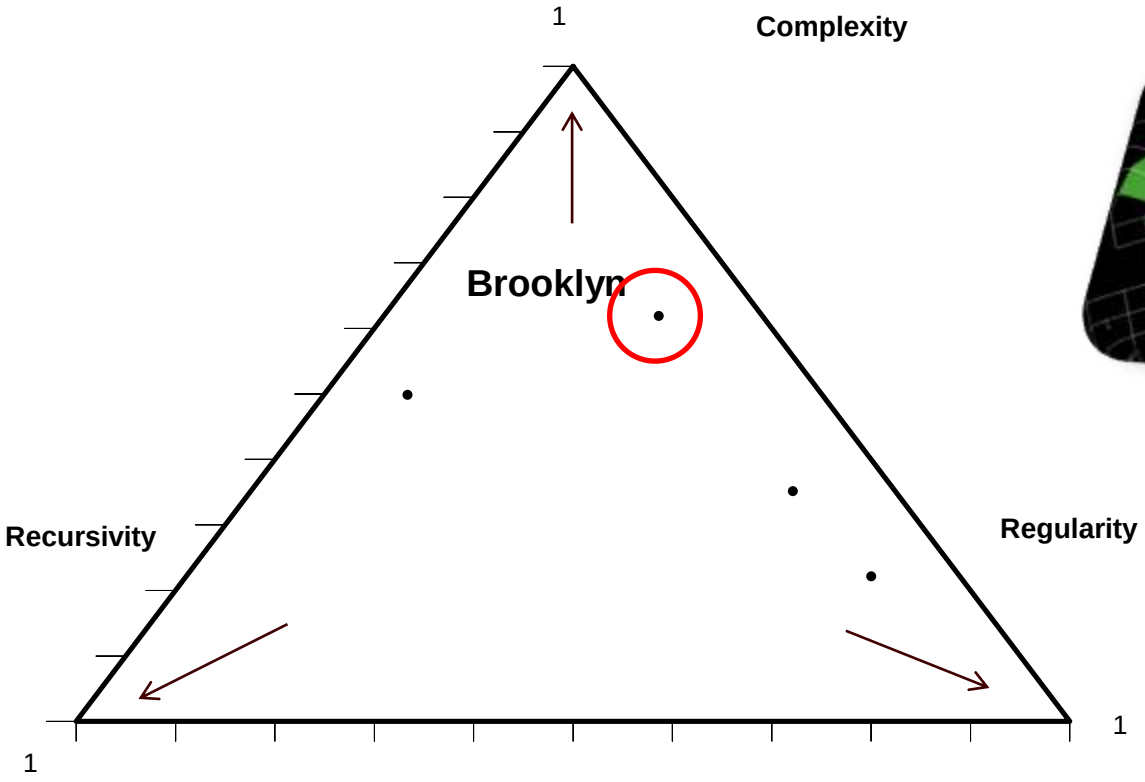
Complexity relates to the information quantity (bits necessary to describe the network)

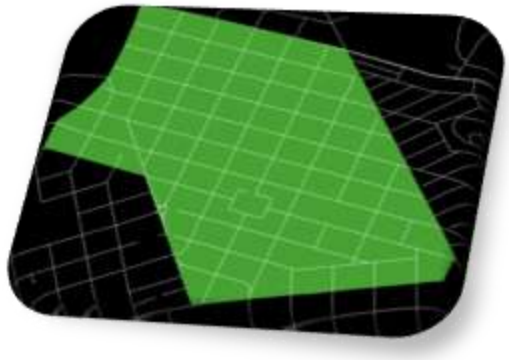
The complexity of the two precedent networks was zero

Hetgram - Examples



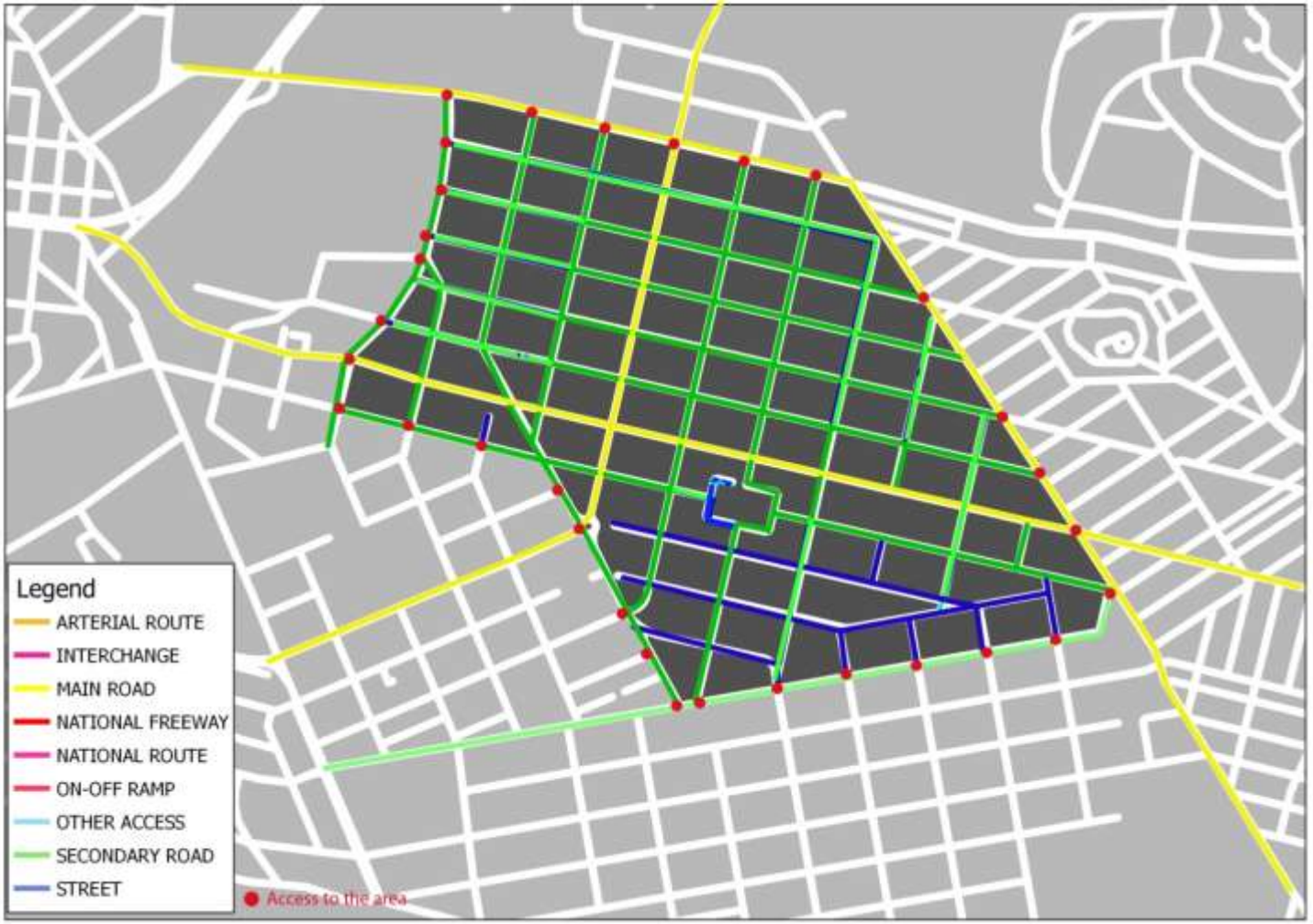
Hetgram



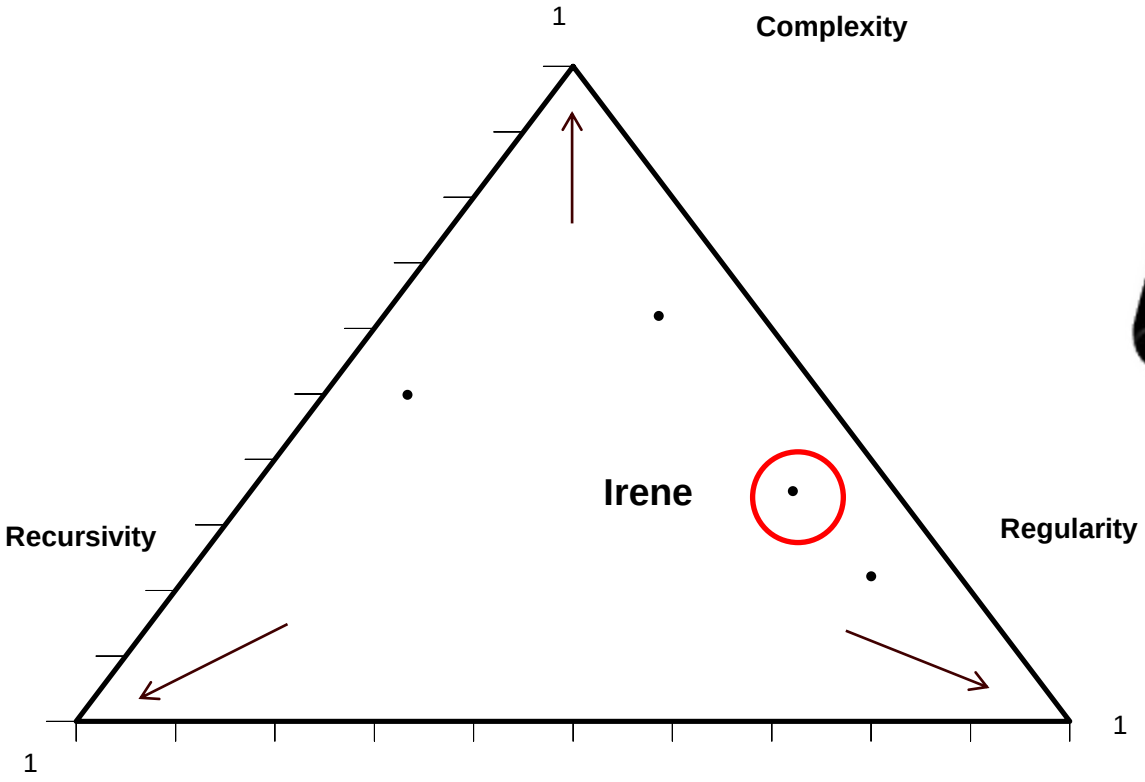


Hetgram

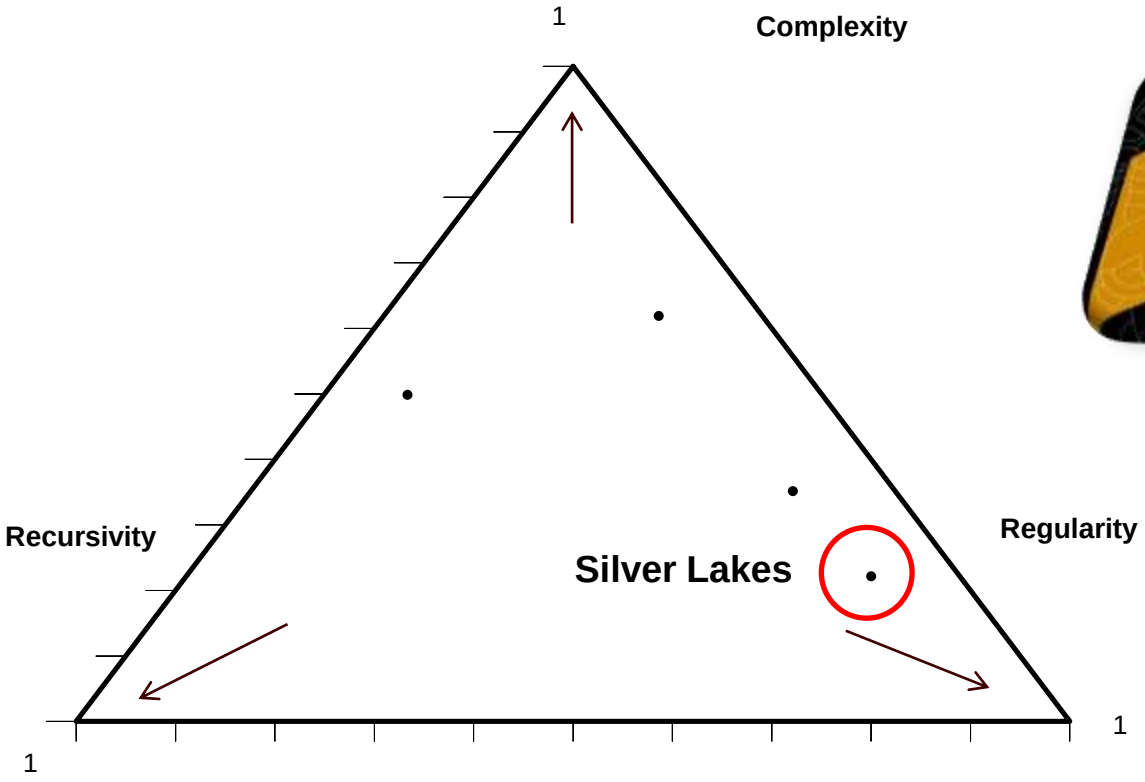
Complexity in Brooklyn – The role of diagonals



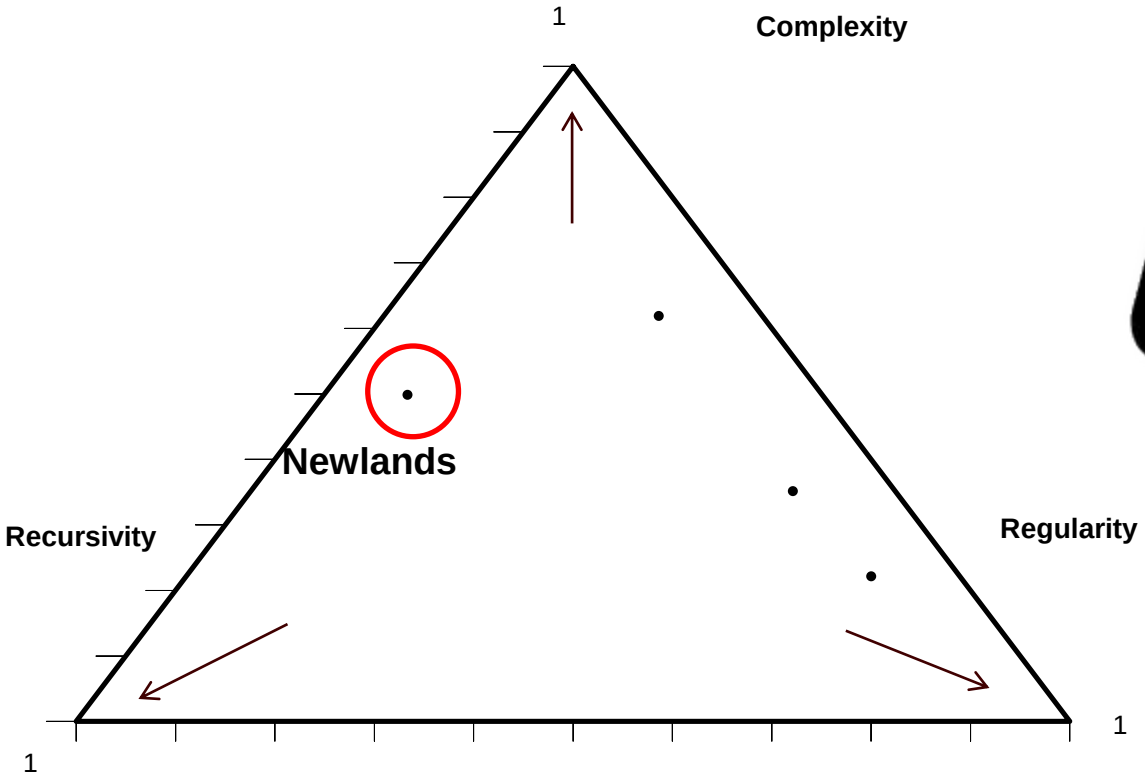
Hetgram



Hetgram

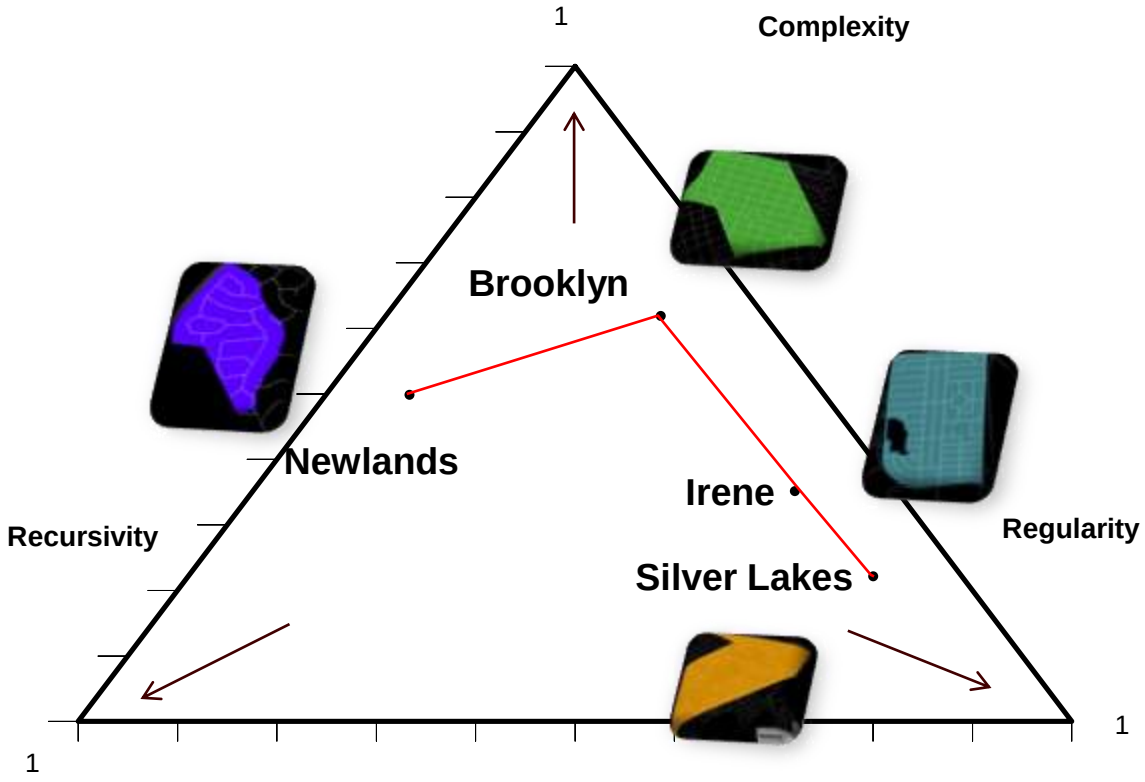


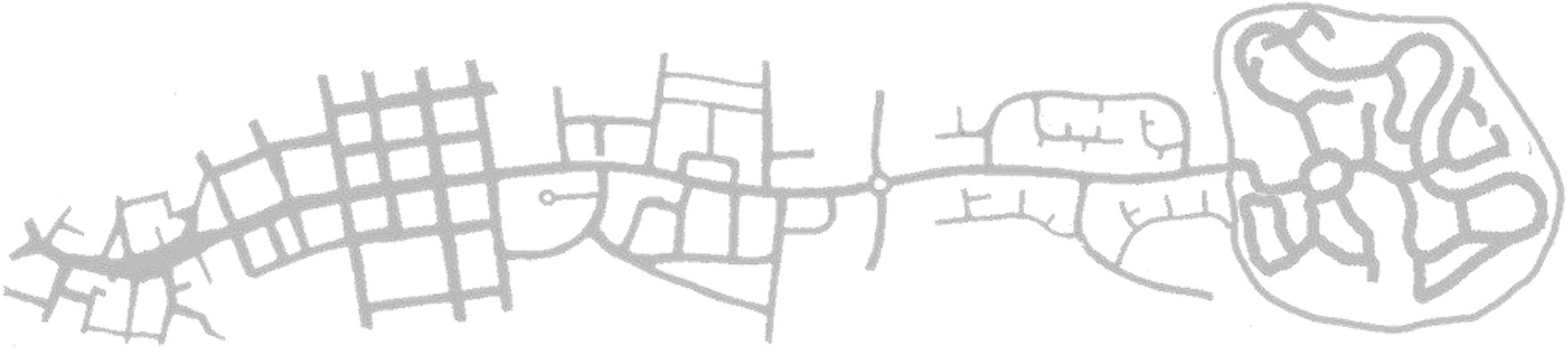
Hetgram



Hetgram
Recursivity in Newlands

Hetgram


1
Complexity
Brooklyn
Newlands
Irene
Silver Lakes
Recursivity
Regularity
1
1



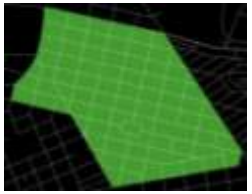
A

Mamelodi 3

B

CBD

Mamelodi 1



Brooklyn

C

Irene

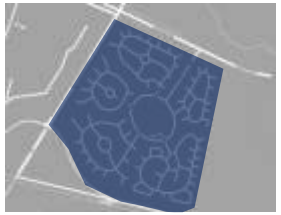
D

Mamelodi 2

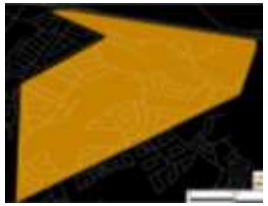
Newlands

E

Equestria



Savannah country estate



Silver Lakes

Thank you for your attention !