

# Summer School on Topological and Scaling Analyses of Transport and Social Media Data (June 13–17, 2016, Gävle, Sweden)

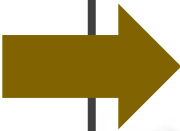
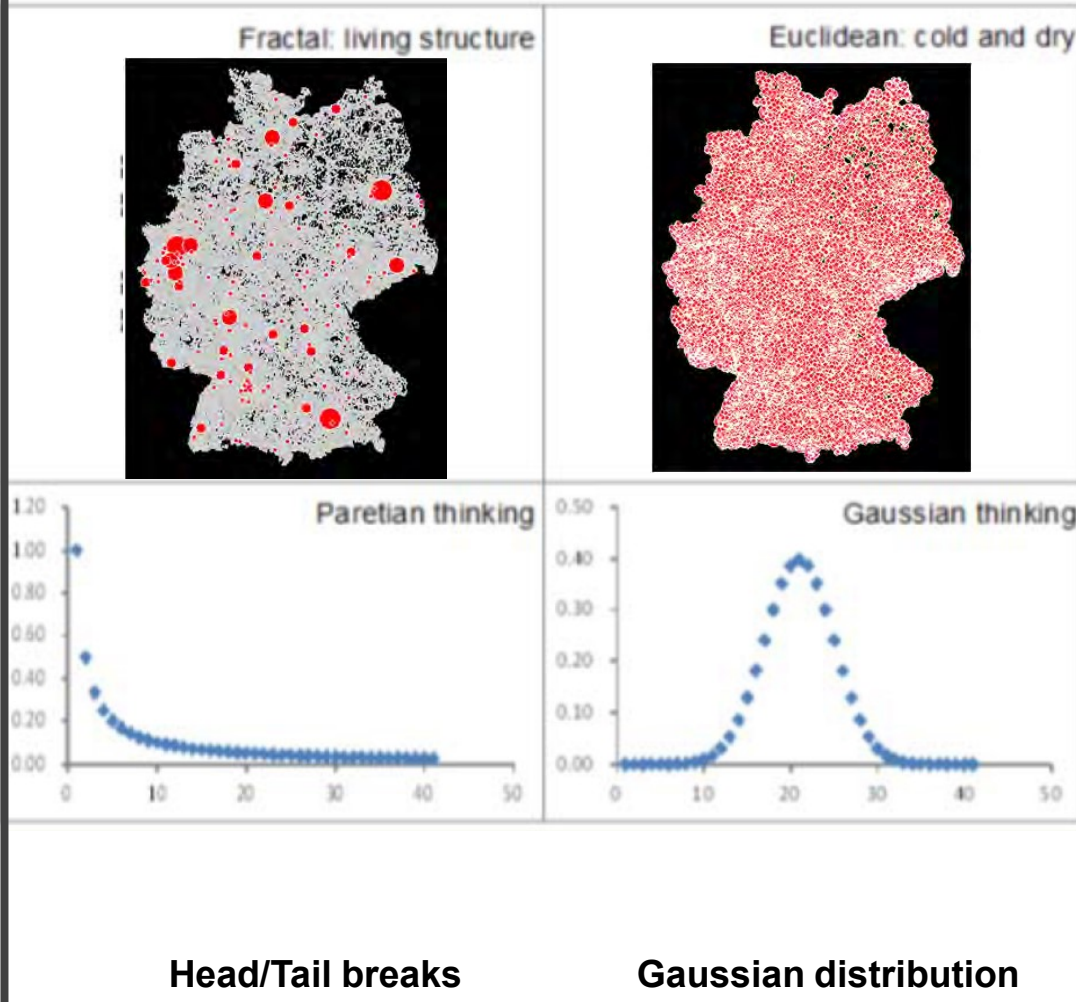


From Euclidean geometry  $\longrightarrow$  to Topology and Fractal geometry  
From Gaussian statistics  $\longrightarrow$  to Power Law statistics

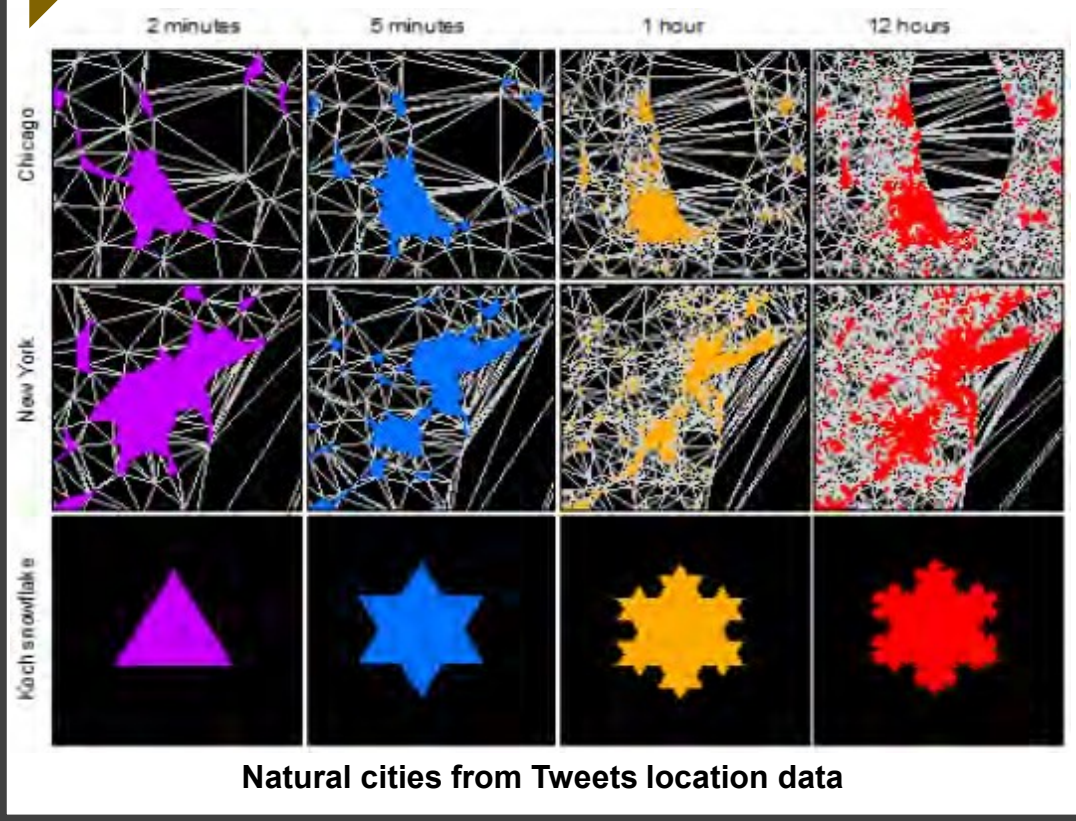




Introduction to “Head-Tail breaks”

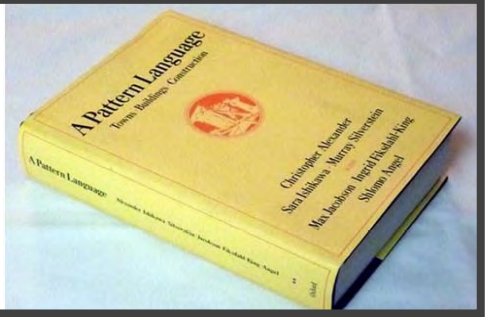


Implications



Theory

Christopher Alexander



# Week Schedule



	Morning Lecture		Afternoon Lecture / Lab	
Monday	Bin Jiang Lecture Zero: <b>Introduction to the lectures</b> (topology, scaling and beauty + Tobler’s law)		Bin Jiang <b>Fractal geometry as a new paradigm for urban structure and dynamics:</b> natural cities as an example	
Tuesday	Bin Jiang Two ways of thinking: <b>Topology and scaling</b> Paradigms   Fractal Theory	Bin Jiang Head-Tail Breaks: Theory / Practice <b>A Mathematical Model of Beauty for Sustainable Urban Design</b>	Bin Jiang and Ding Ma Lab: <b>Natural Cities animation</b> (ArcGIS)	Bin Jiang <b>Space Syntax Modeling and Urban Morphology</b>
Wednesday	Yoav Lerman: <b>An application of Space Syntax Modeling</b>	Bin Jiang <b>Scaling law + Tobler’s law</b>	Thoshihiro Osaragi: <b>Choice Behavior Model; Spatial Correlation Analysis</b>	Thoshihiro Osaragi: <b>Applications of Spatiotemporal Distribution of People for Disaster Mitigation Planning</b>
Thursday	Marija Mitrovic Dankulov: <b>Complex networks theory:</b> an introduction		Bin Jiang and Ding Ma Lab: <b>Axwoman 6.0</b>	Bin Jiang <b>Topology &gt; Scaling &gt; Beauty</b>
Friday	Group Discussion	Bin Jiang <b>Writing &amp; Publishing for</b>		

## Introduction to the Head-Tail Theory

**Zipf's Law - far more small things than large one.**

**From Euclidean geometry → to Topology and Fractal geometry**

**From Gaussian statistics → to Power Law statistics**

**Types of ‘Big Data’**

## Far more small things than large one; Zipf's Law



# Two types of data

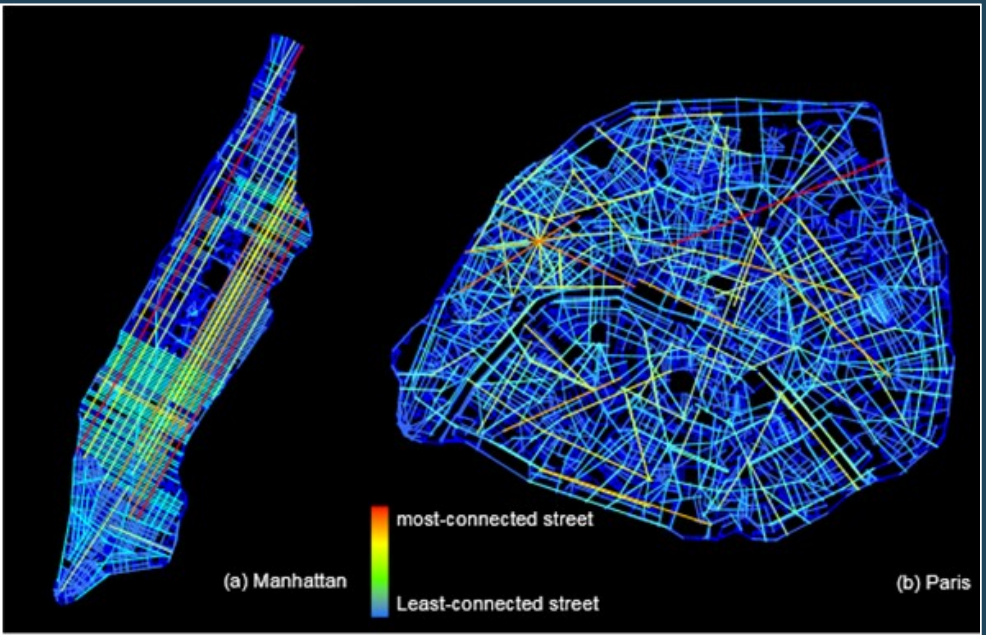
## Transport

Street networks (cycling, pedestrian);  
Public transport routes; Points of interest;  
Source: OpenStreetMap

## Social media

Social media = social networks, e.g.;  
Geolocations from Brightkite and Twitter;  
Derived geolocation data

Small Data	Big Data
Sampled Data	All Data
Estimated Location	Measured Location (x,y,z,t)
Individual Data	Aggregated Data



Gaussian Thinking

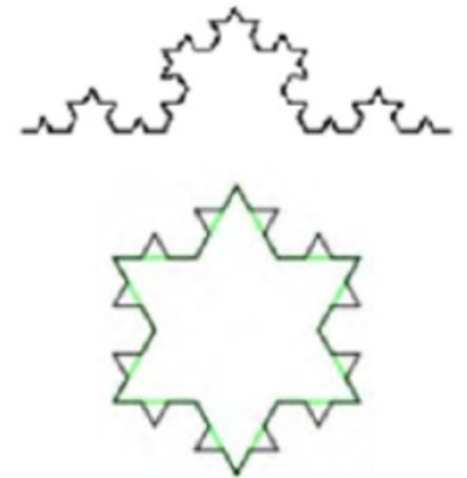
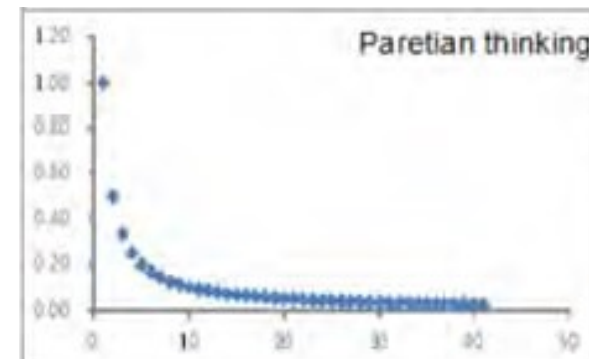
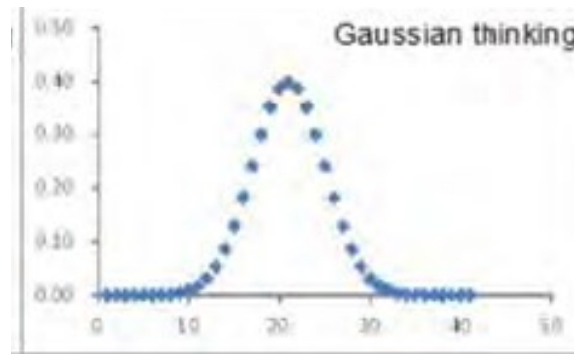
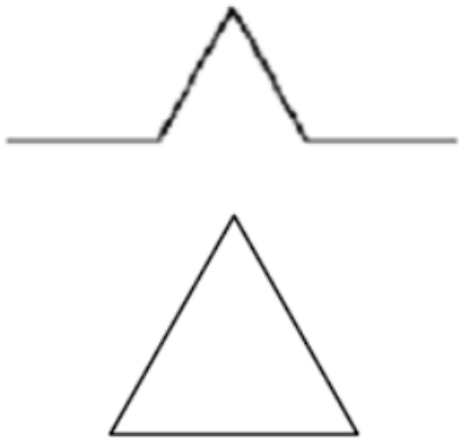
Paretian Thinking

Euclidean

Fractal

Cold & dry

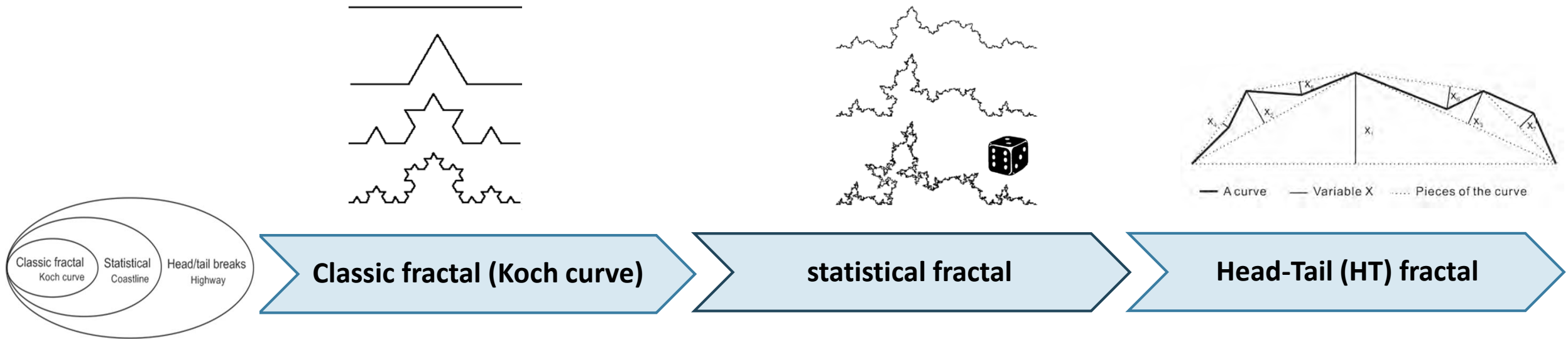
Living Structure



**Euclidean Geometry & Thinking**

**Fractal Geometry & Thinking**

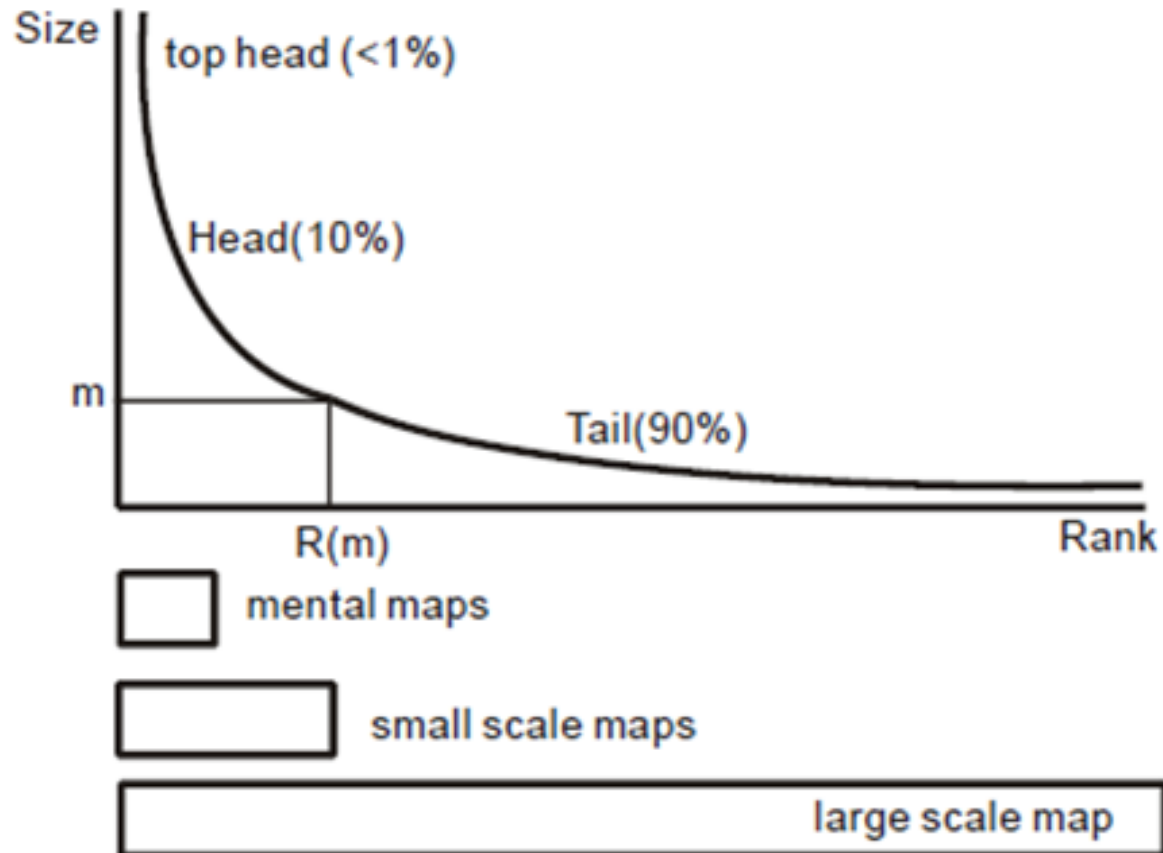
A new definition of fractals: a set or pattern is fractal if the scaling pattern of far more small things than large ones recurs at least twice, or with ht-index at least greater than three.





## Head/tail division rule

Given a variable  $X$ , if its values  $x$  follow a heavy tailed distribution, then the mean ( $m$ ) of the values can divide all the values into two parts: a high percentage in the tail, and a low percentage in the head.

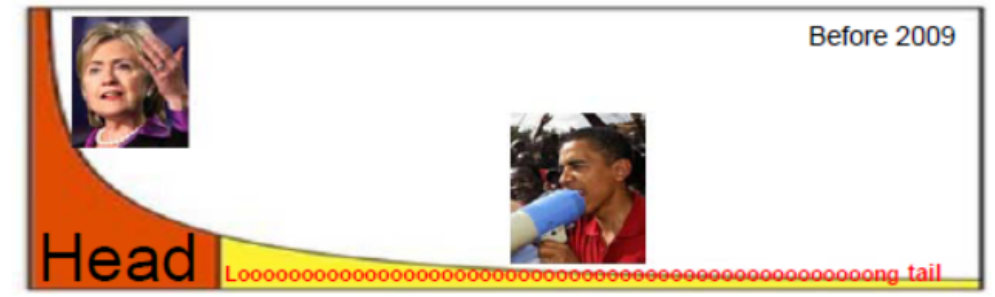


### Head/tail breaks thinking

- |                           |                        |
|---------------------------|------------------------|
| ■ AT&T                    | ■ Skype                |
| ■ Britinica               | ■ Wikipedia            |
| ■ National mapping agency | ■ OpenStreetMap        |
| ■ Governments/CNN         | ■ WikiLeaks(OpenLeaks) |

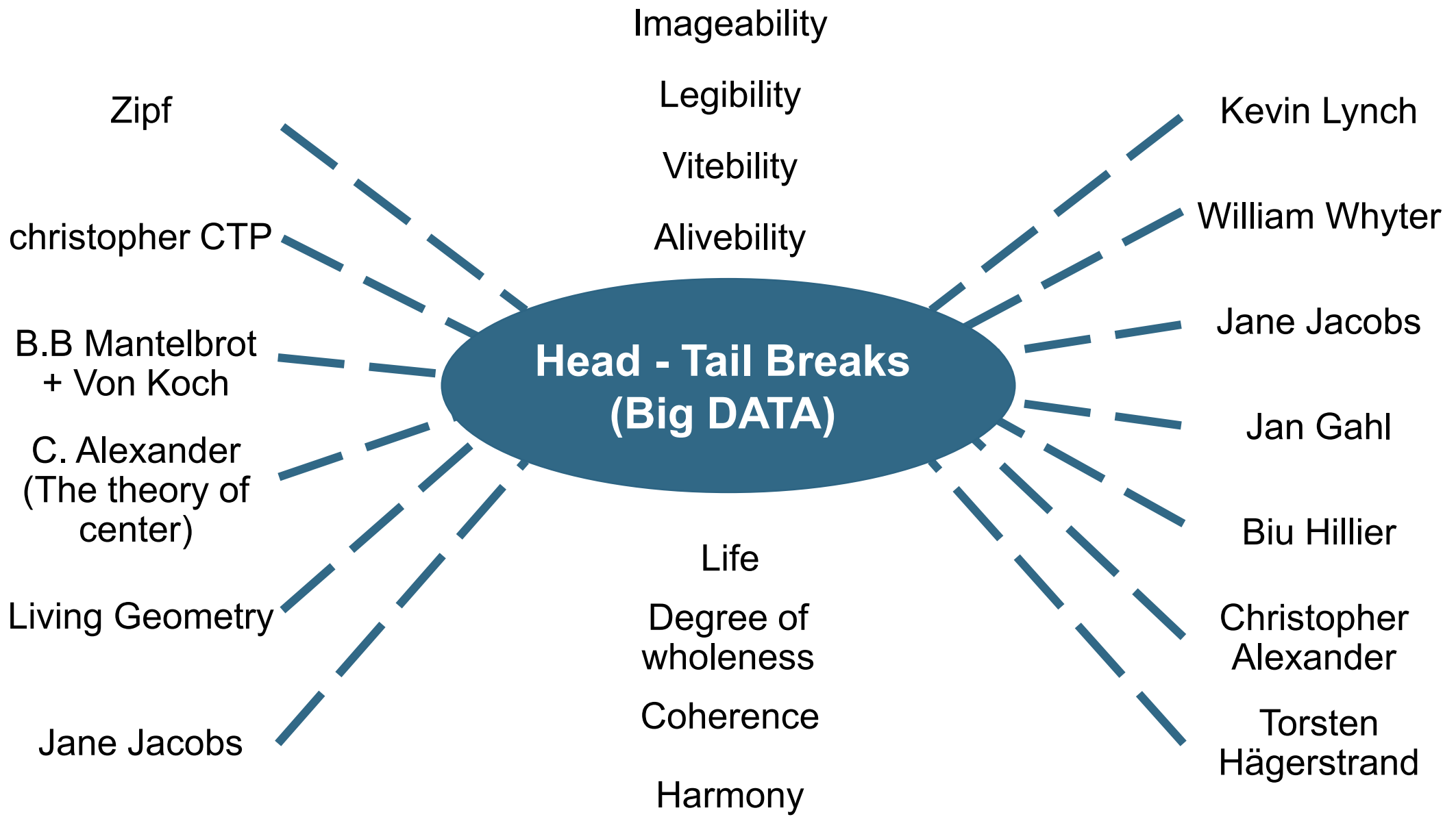
Centralized mindset, top-down

Decentralized mindset, bottom-up



Scale free; Average free; Differentiation;  
Adaptation: Geometric, Topological, Semantic

Theory



Practice

### Conclusion

- We need to shift our paradigm from geometric to topological, from the Gaussian thinking to something, which is “more normal than normal”.
- The paradigm shift is a de fact shift from Newton’s physics metaphor to a biological metaphor, focusing on the individual interactions from the bottom up.
- We need to shift our paradigm from computational science (since the invention of computers) to data-intensive computing (since the 21st century), in order to uncover the underlying forms and processes geographic space and society.

### Linked to the COST Action

The duality of social networks

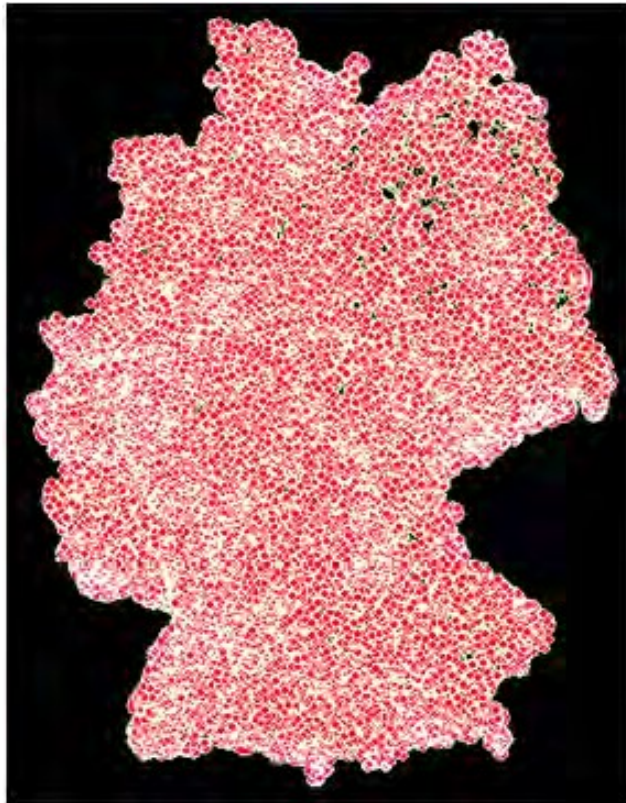
- A new method of analysis – a complex network approach to complexity of society, e.g., small world, scale free, community detection, hierarchy
- A new way of data collection – location based social media, e.g., Flickr, Twitter, and Brightkite

In terms of collective traffic flow, there is no much difference between human beings and random walkers.



## The notion of natural cities

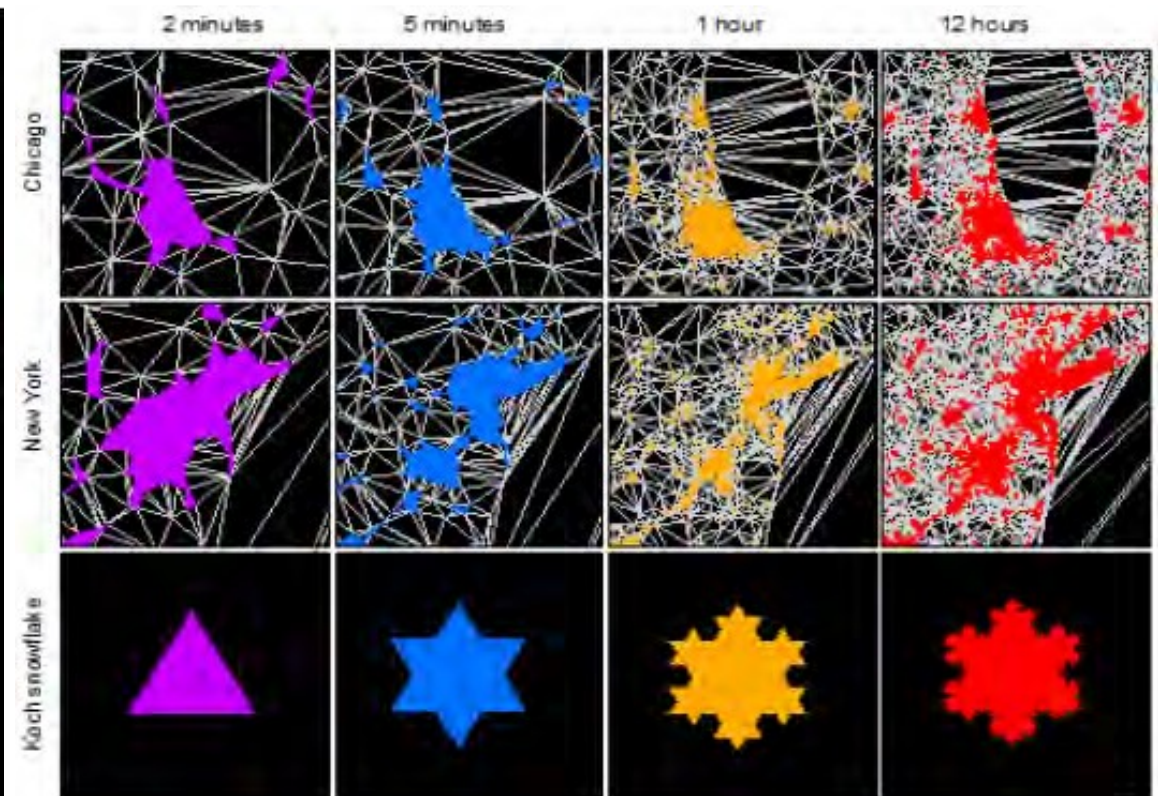
Natural cities refer to objectively or naturally defined and delineated human settlements, or surface, human activities in general on the Earth's using massive geographic information of various kinds, and based on head/tail breaks.



Gaussian distribution



Head/Tail breaks



Natural cities from Tweets location data

## Space syntax principles

- large-scale space is beyond human body perception, and cannot be perceived from a single viewpoint;
- small-scale space is presumably larger than the human body, but can be perceived from a single viewpoint.

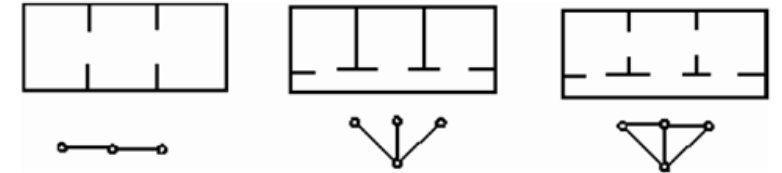


FIGURE 1 Closed building plans and their connectivity graphs

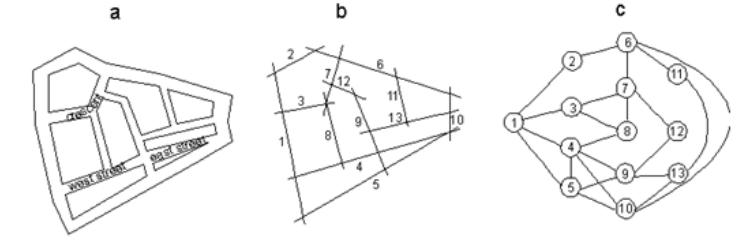
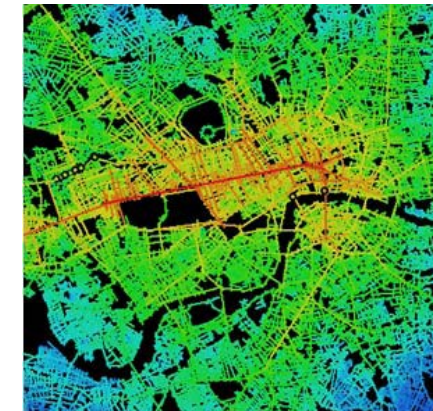
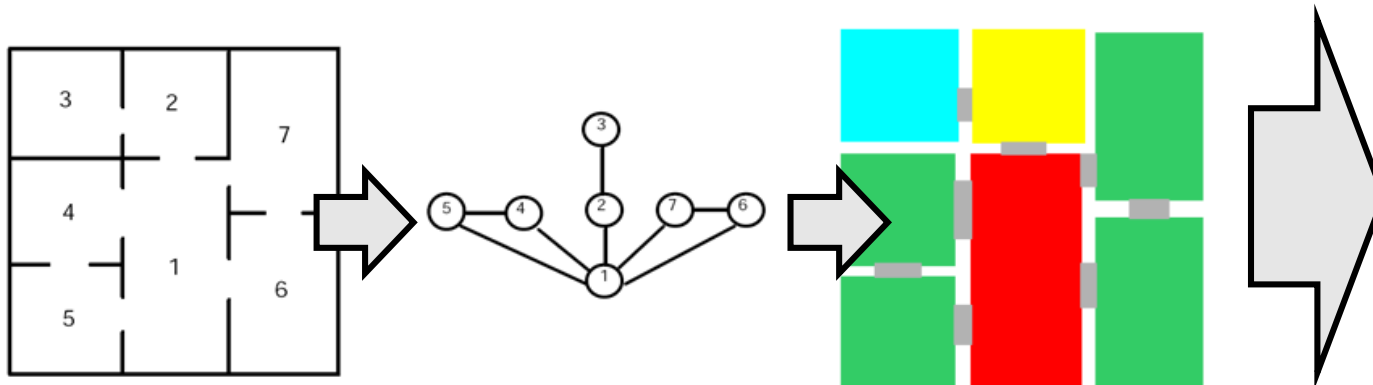
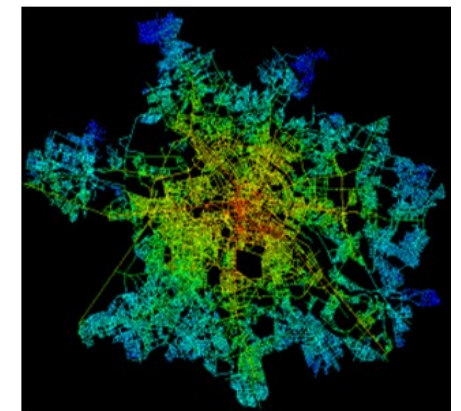


Figure 1: A fictive urban system (a), its axial map (b) and connectivity graph (c)



London



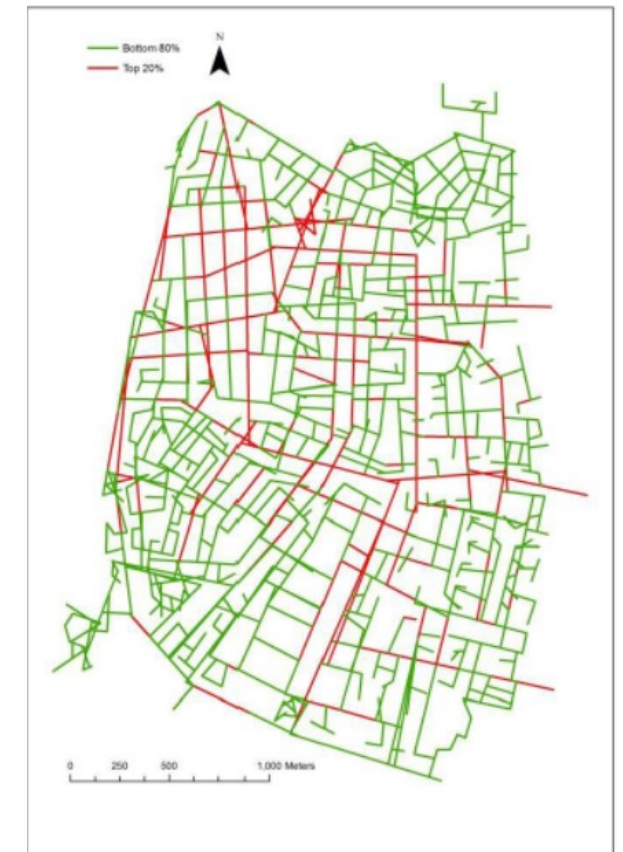
Berlin



## Using Space Syntax to Model Pedestrian Movement in Urban Transportation Planning

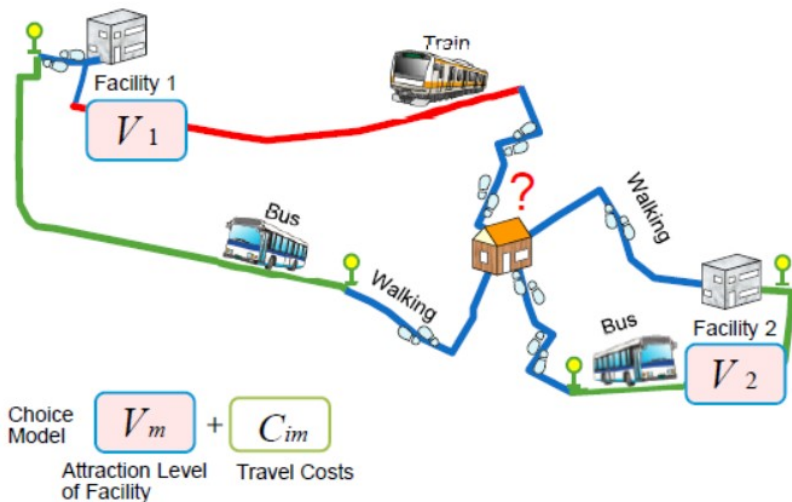
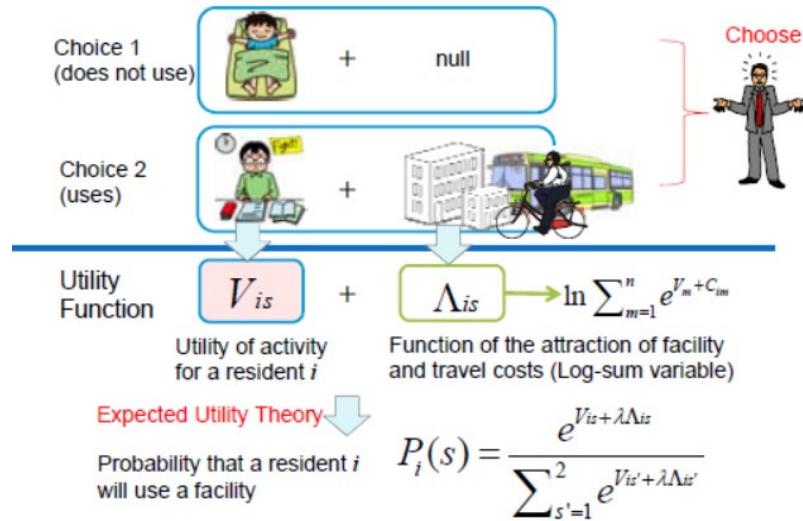
### Bat Yam, Israel

- Build a pedestrian traffic model for current and future state (year 2030) of the city of Bat Yam
- Identify conflicts and complements between pedestrian movement and other transportation means, especially motorized vehicles
- Prioritize streets for improvement of pedestrian realm



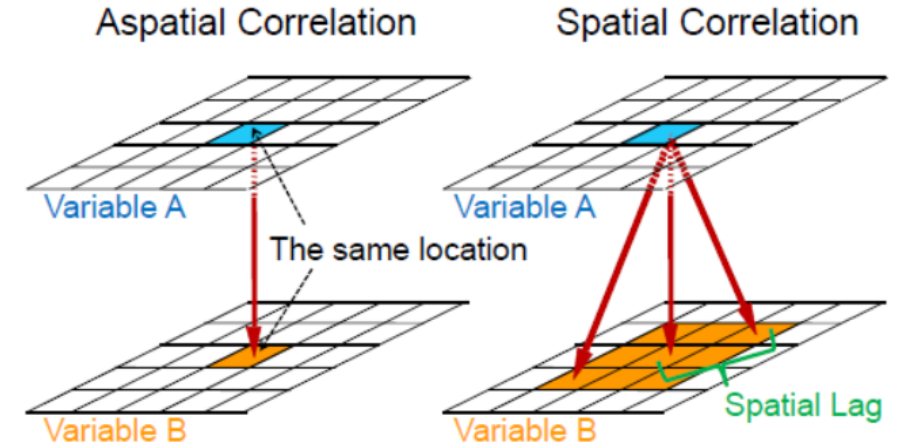
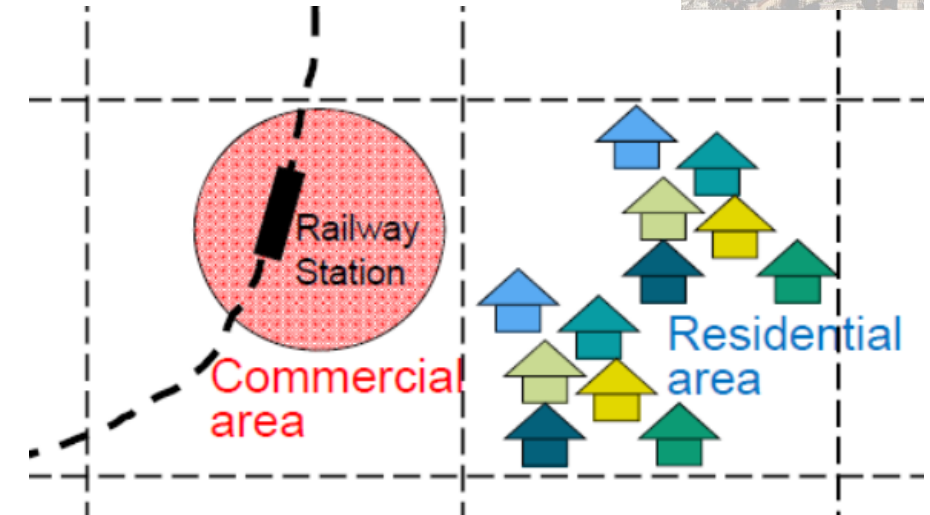


# Thoshihiro Osaragi: Choice Behavior Model; Spatial Correlation Analysis

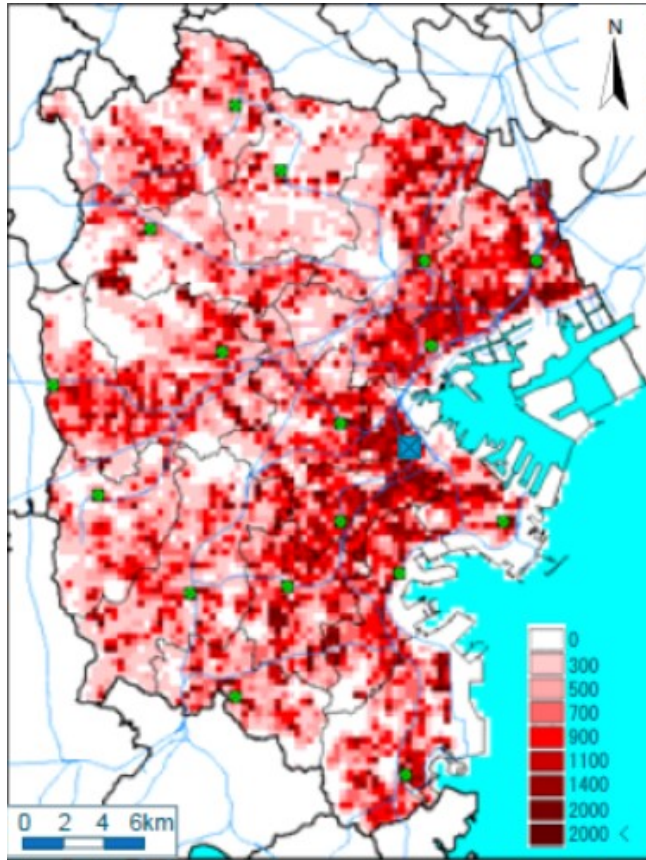


## Choice Behavior Model

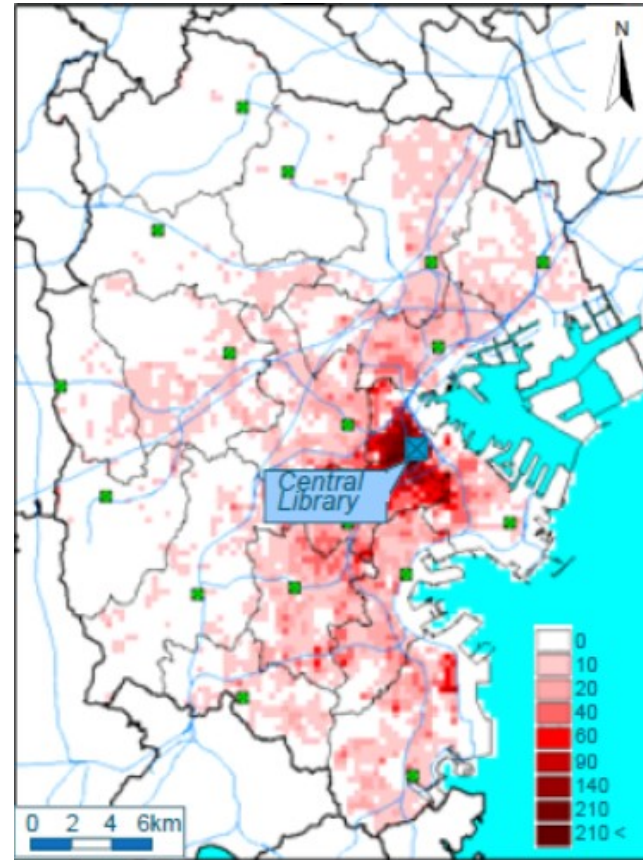
Choice model = Attractiveness of facility + travel cost



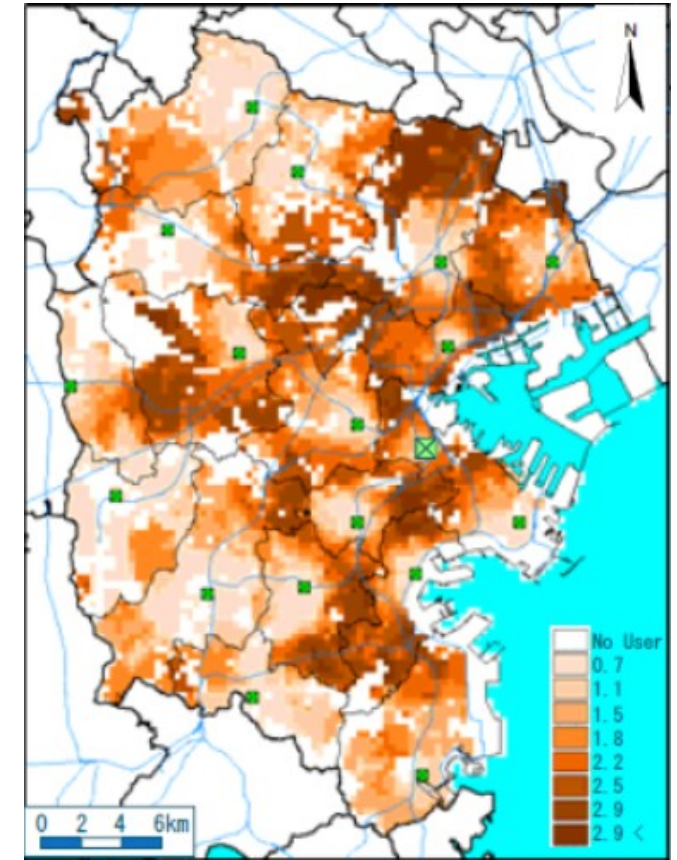
## Spatial Correlation Analysis and its Extension to Road Network Spaces



**Spatial Distribution of  
Population (250mX250m)**



**Spatial Distribution of Real number  
of users (the central Library)**



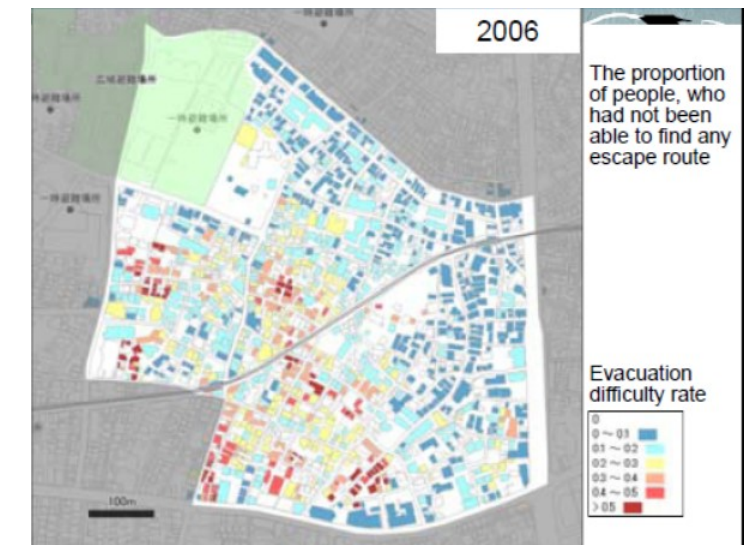
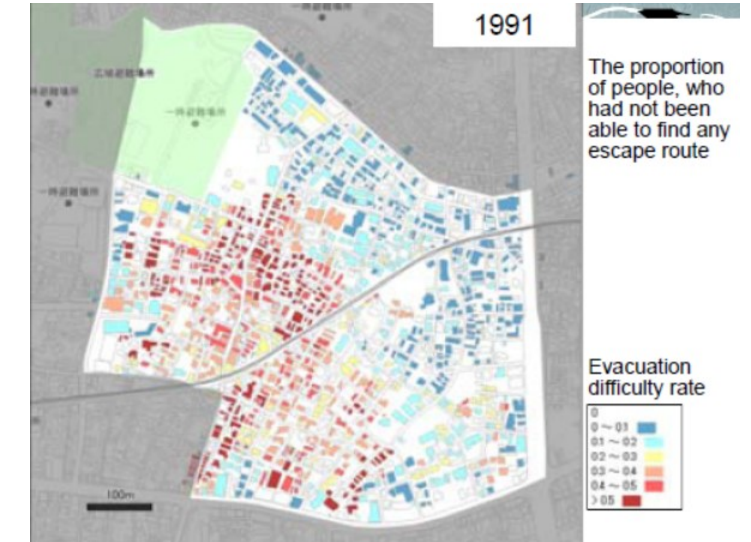
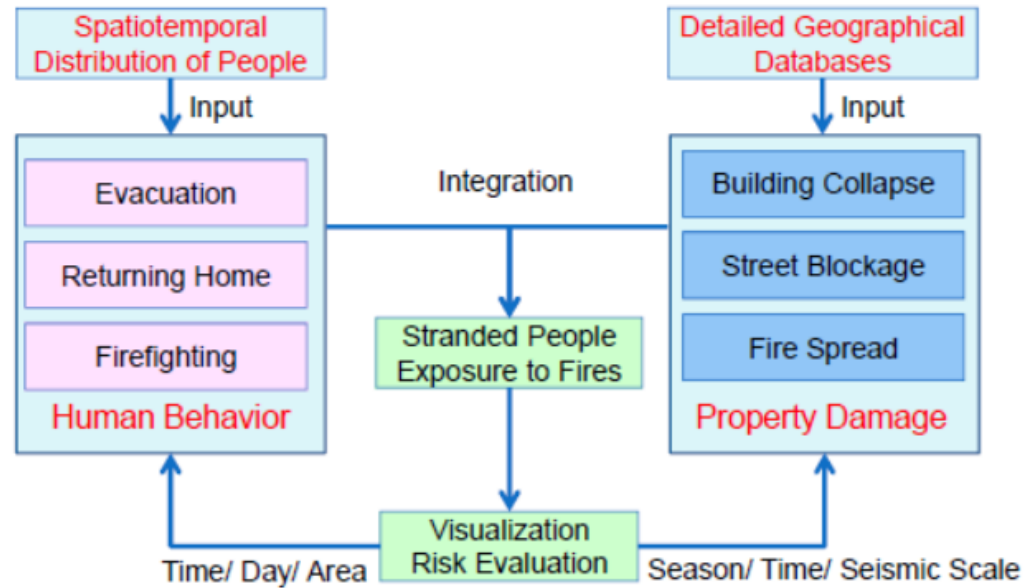
$$C_i = \sum_{j \in L_i} C_{ij} P_{ij}$$

**Spatial Distribution of Average  
travel costs**



Thoshihiro Osaragi:

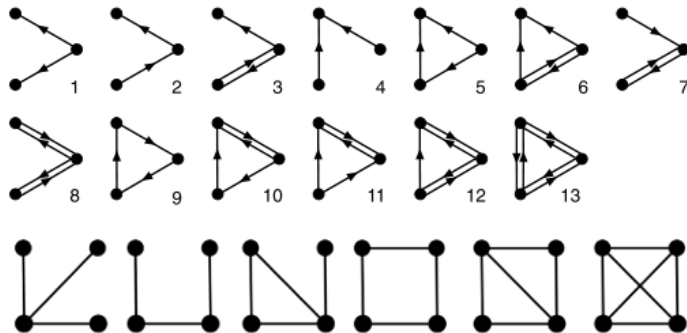
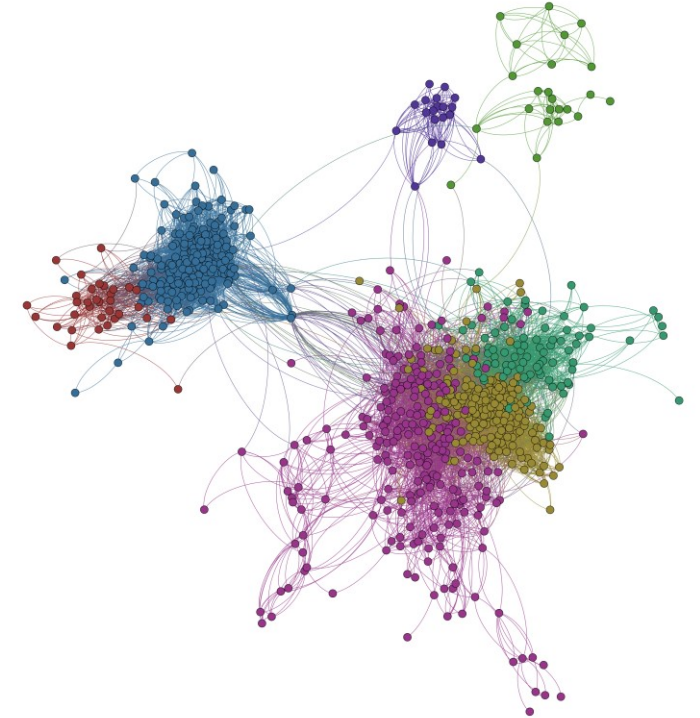
## Applications of Spatiotemporal Distribution of People for Disaster Mitigation Planning





## Complex systems

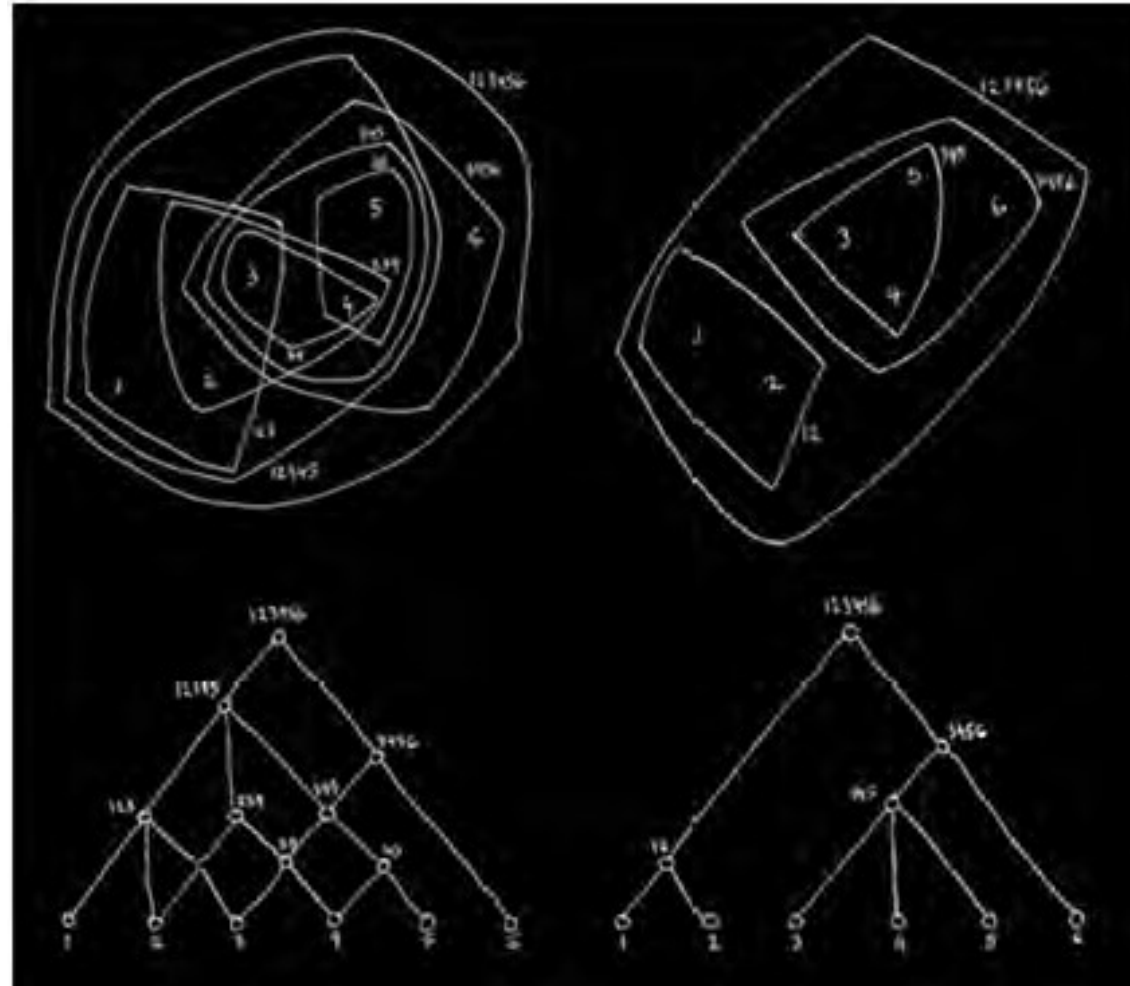
- Consists of large number of interacting components.
- Exhibits emergent, collective, behaviour which cannot be derived from behaviour of individual components.
- Self-organised behaviour.



## Structure and dynamics of complex networks

- Structure influence network dynamics
- Dynamic influences network structure
- Understanding network structure => understanding dynamic of network/system

## A CITY IS NOT A TREE



# 253 Patterns

Geometric scale

from

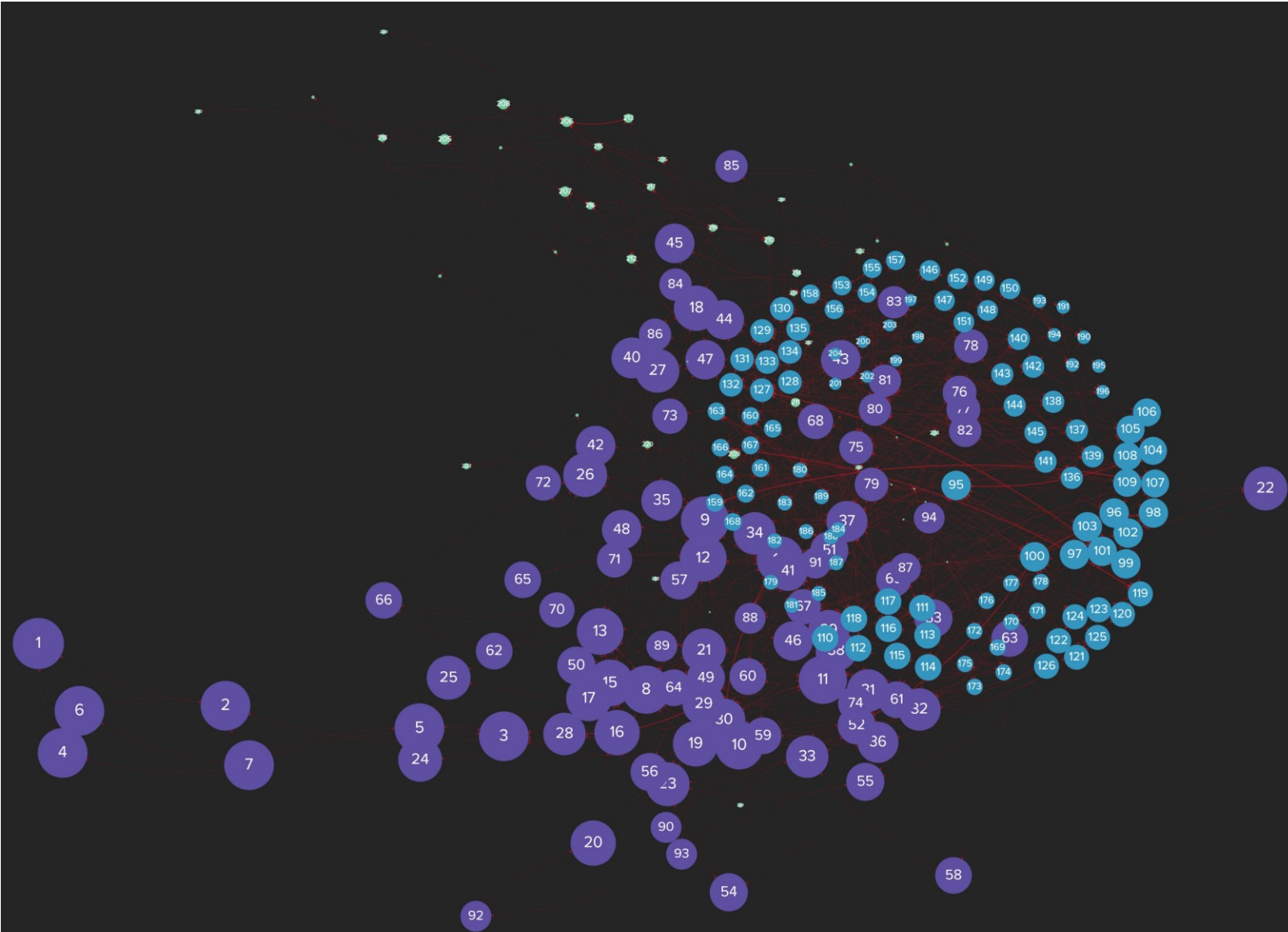
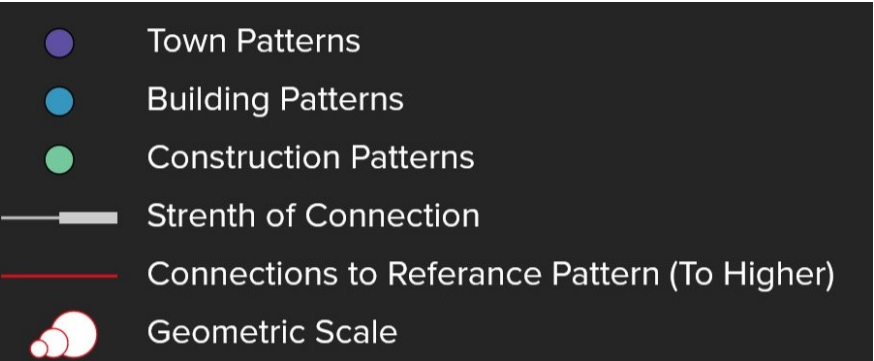
**‘INDEPENDENT REGIONS’**

to

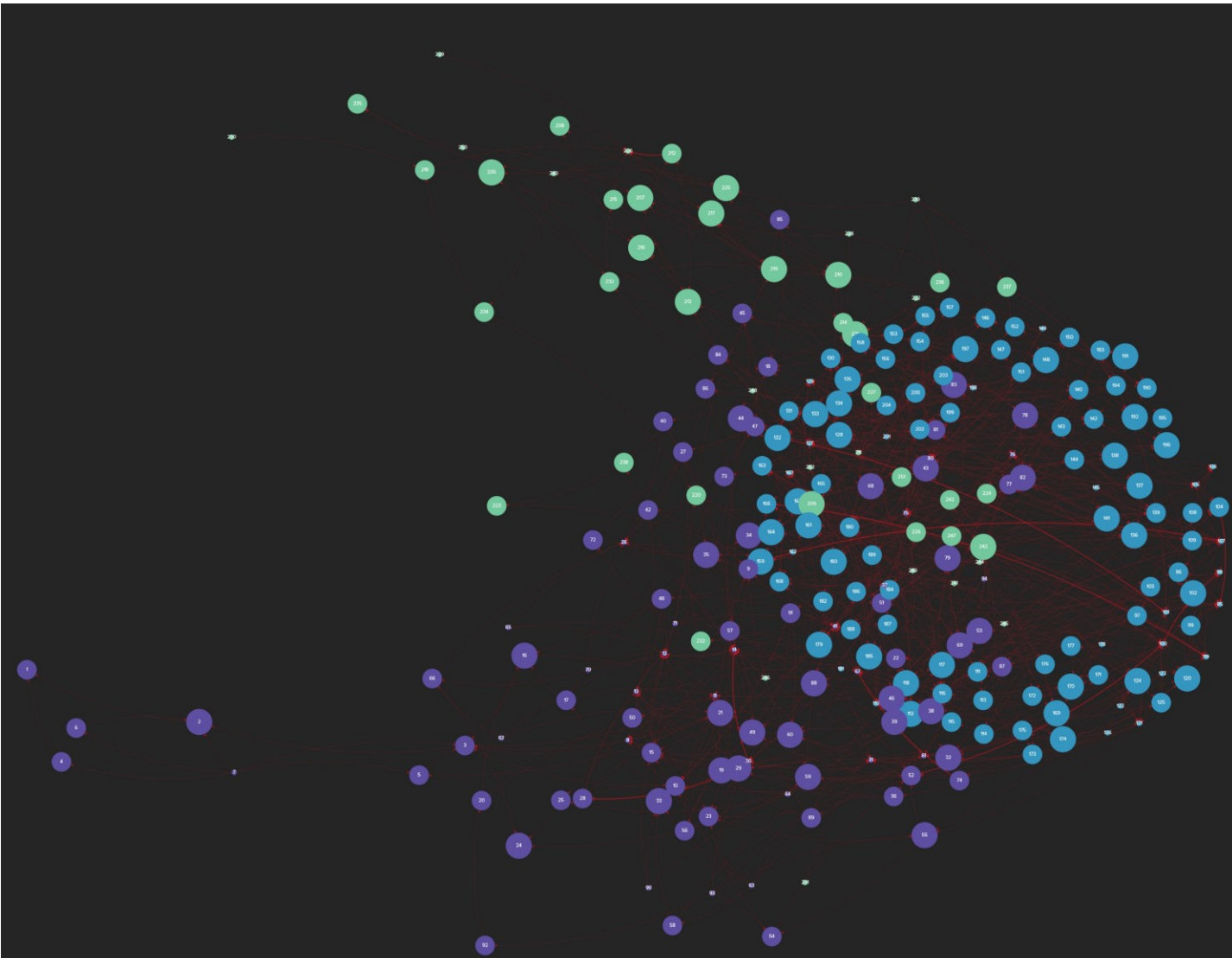
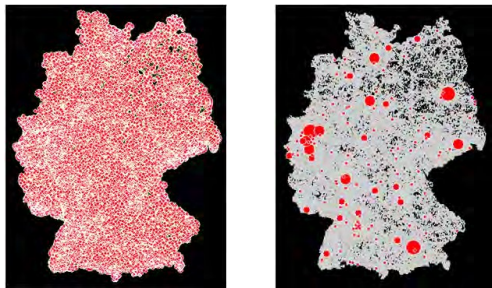
**‘THING FROM YOUR LIFE’**



# Geometric scale

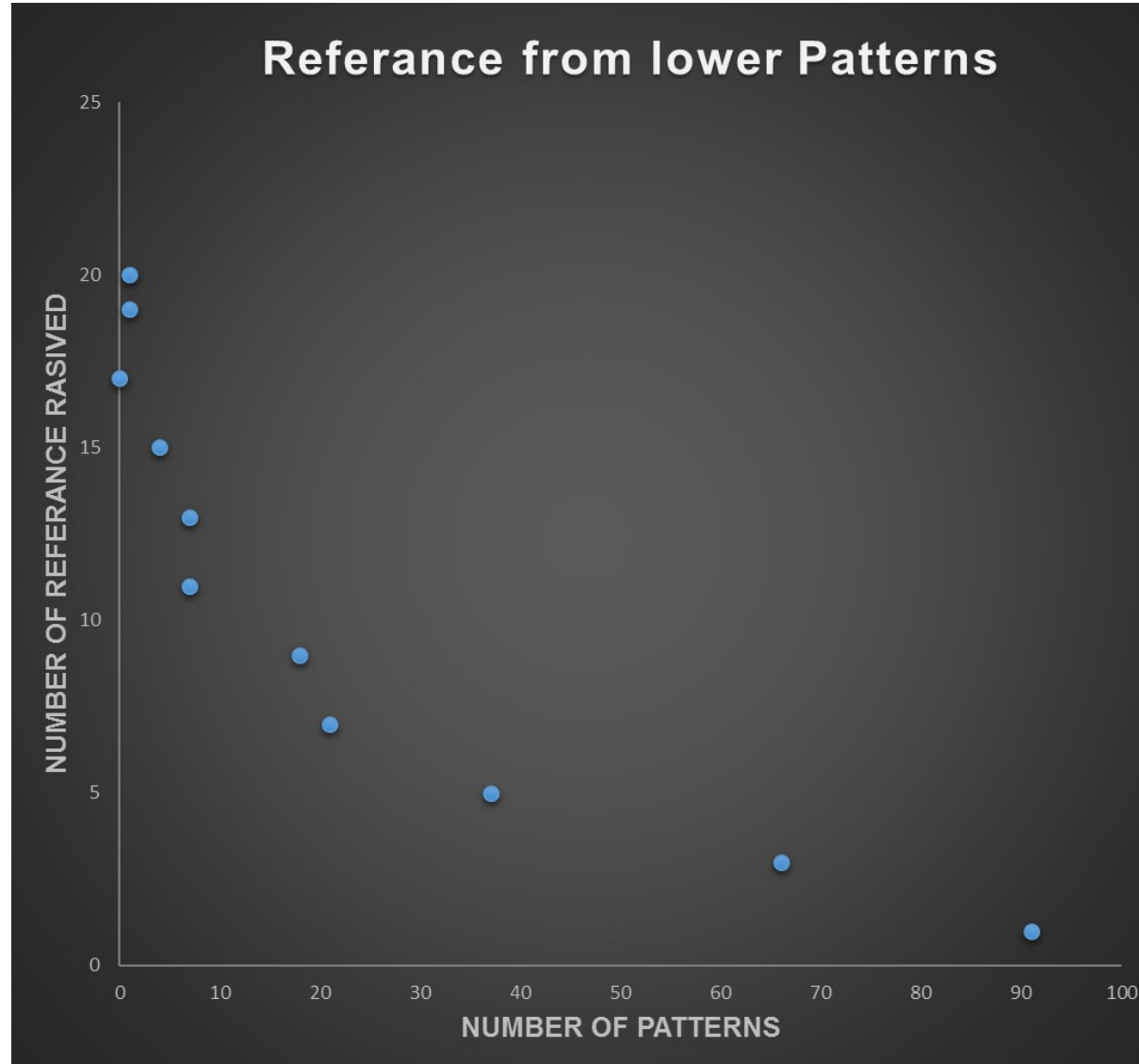


# Topological scale - Gaussian statistics

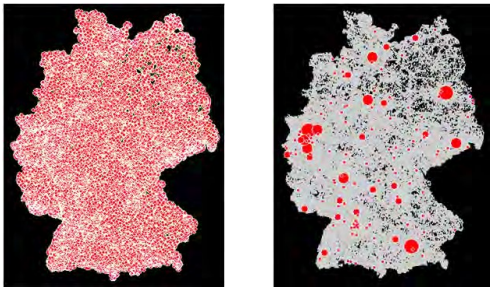


- Town Patterns
- Building Patterns
- Construction Patterns
- Strenth of Connection
- Connection to Complimentary Patterns (To Lower)
- Connections to Reference Pattern (To Higher)
- Avarge Conected Element 3-5 connections
- Avarge second degree









## From Geometric Scale to Topological scale

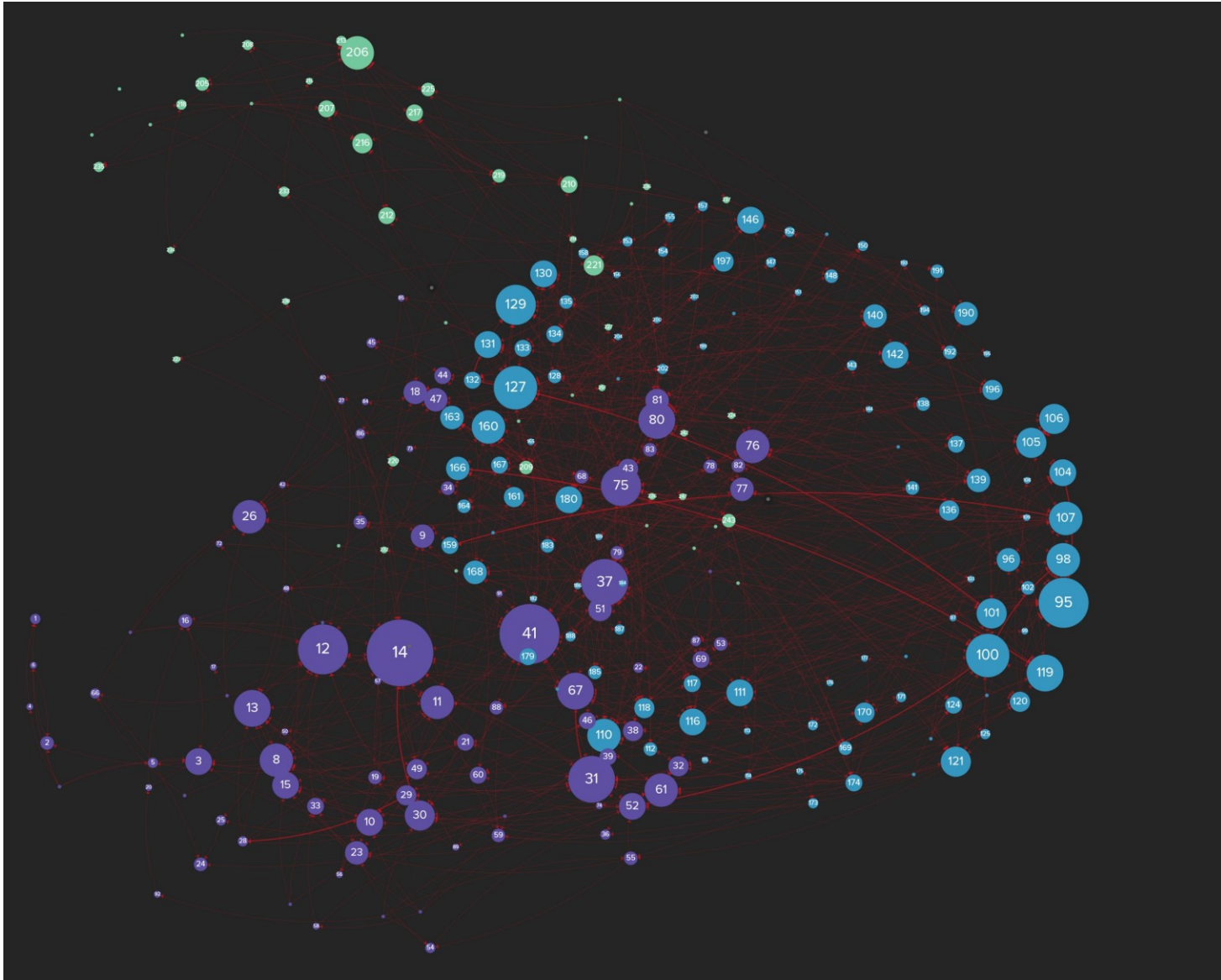






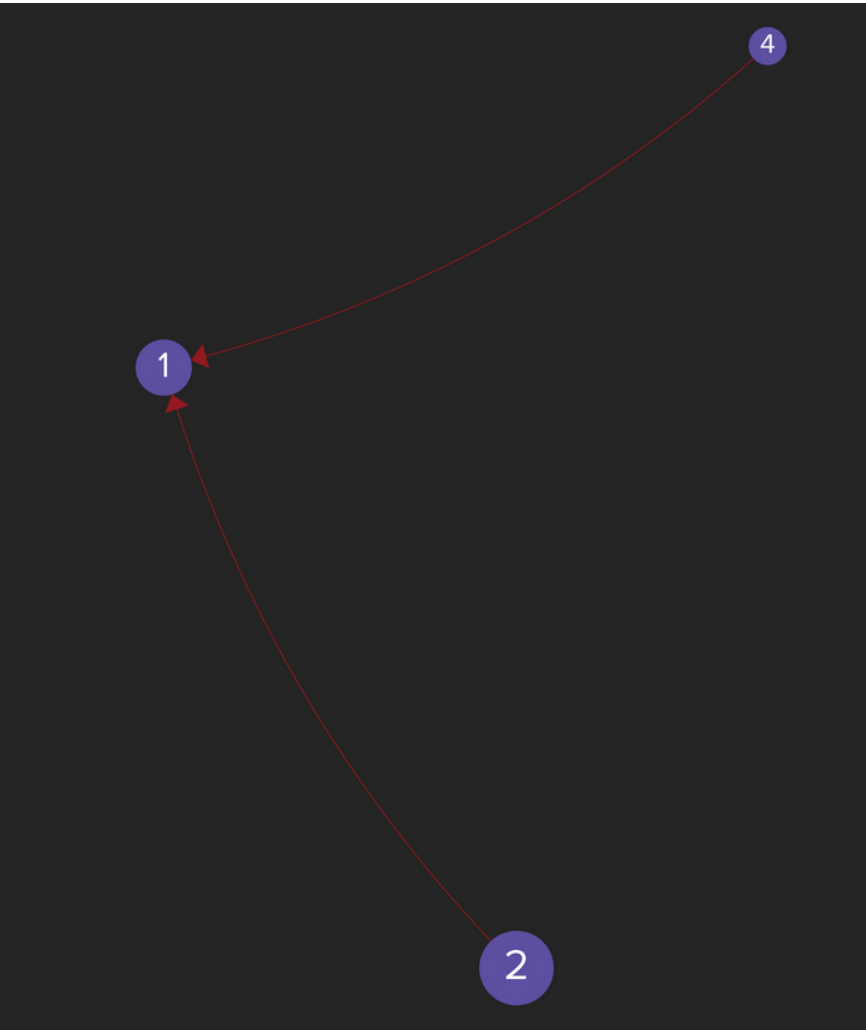
# Topological scale - Head / Tail

-  Town Patterns
-  Building Patterns
-  Construction Patterns
-  Strenth of Connection
-  No' of Indegree connections
-  Sub-Type
-  Connection to Complimentary Patterns (To Lower)
-  Connections to Refarence Pattern (To Higher)

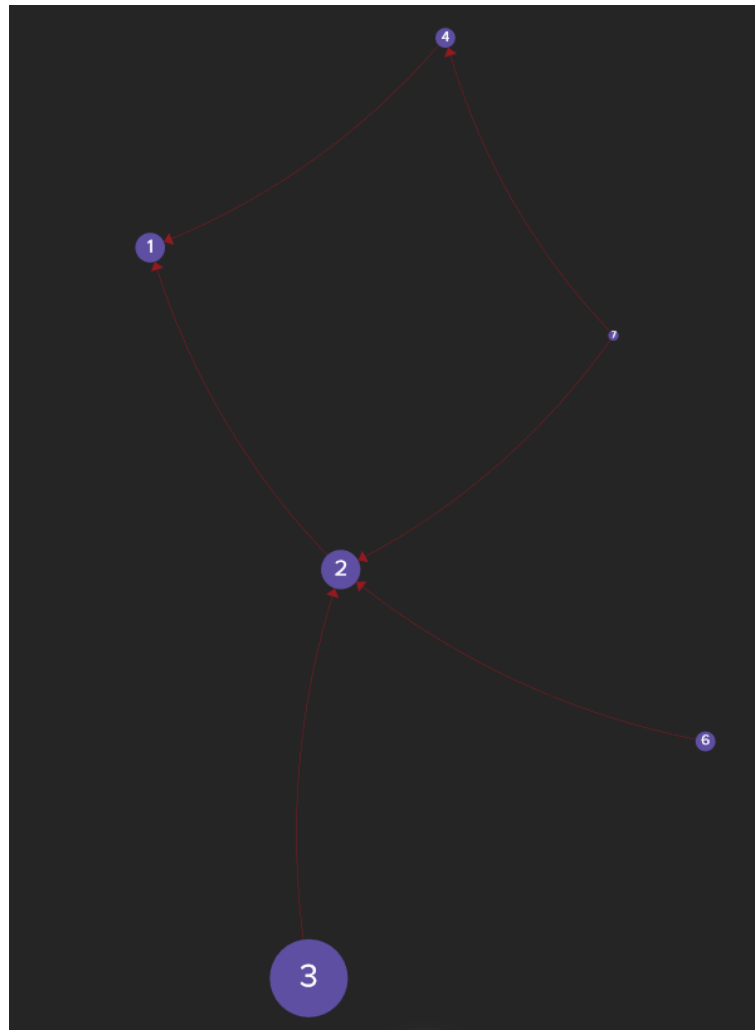




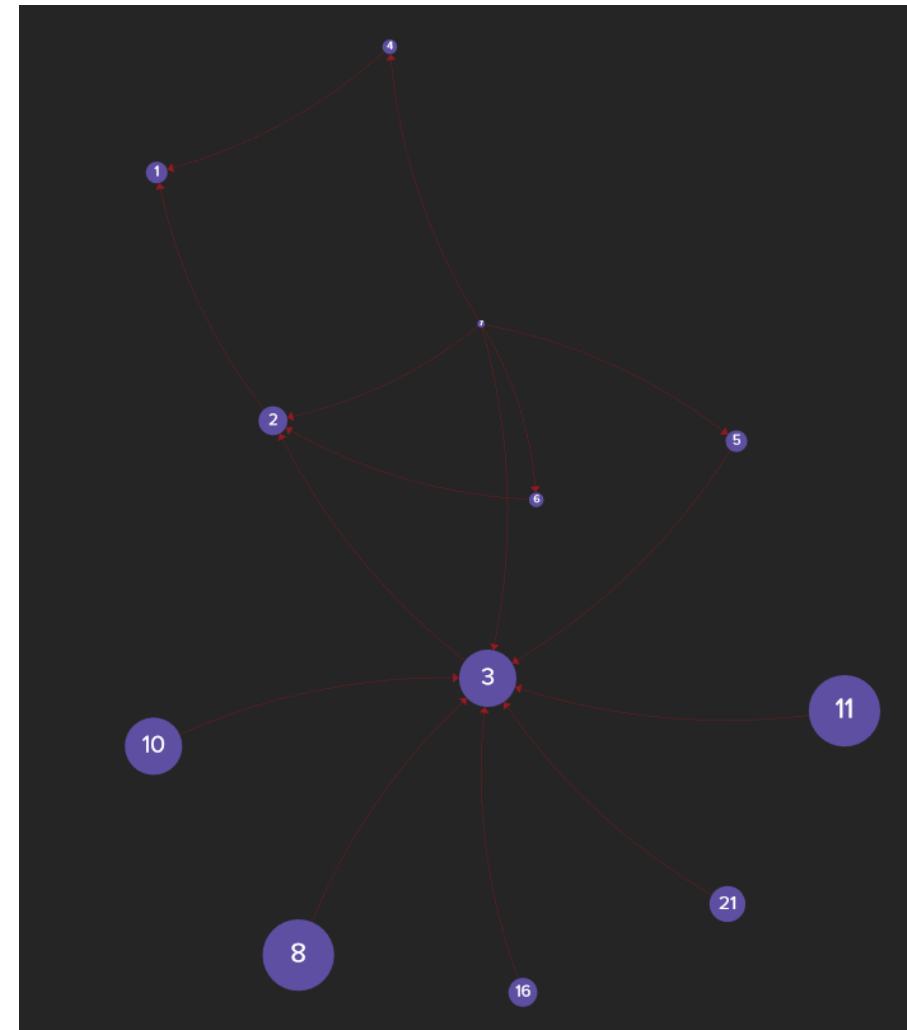
# Pattern no' 1 'INDEPENDENT REGIONS'



Direct (out 1)

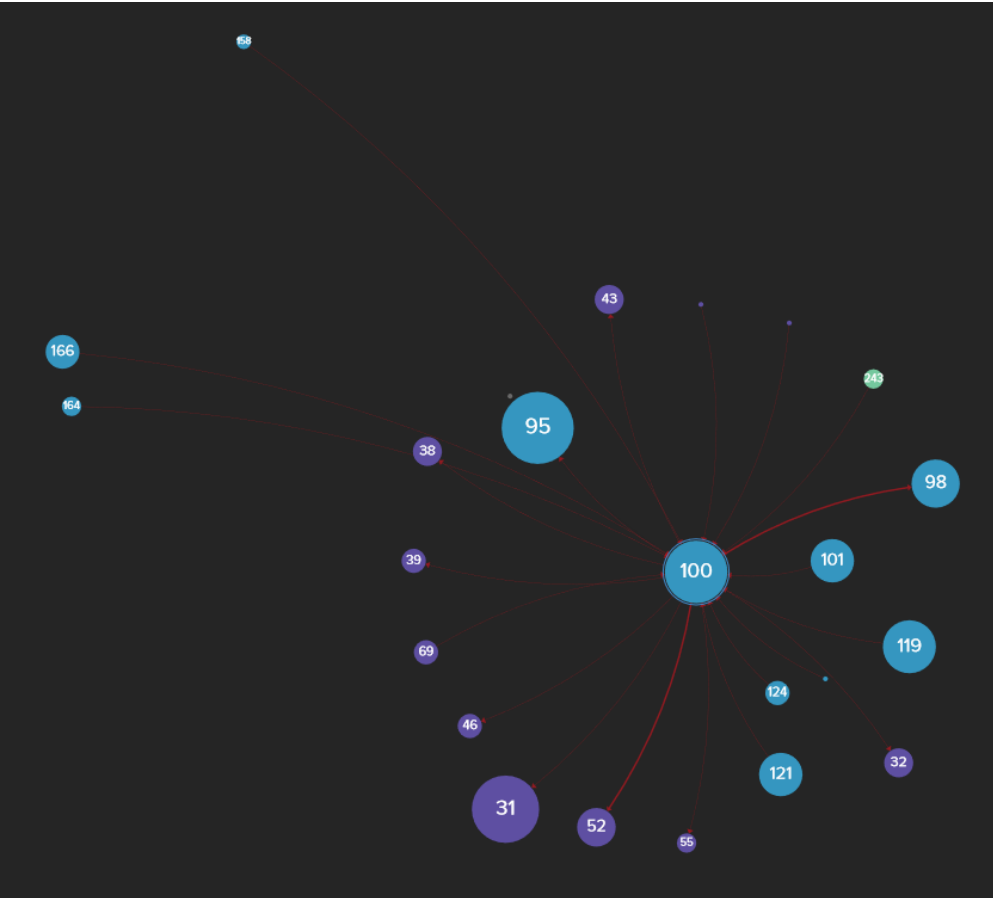


Indirect (out 2)

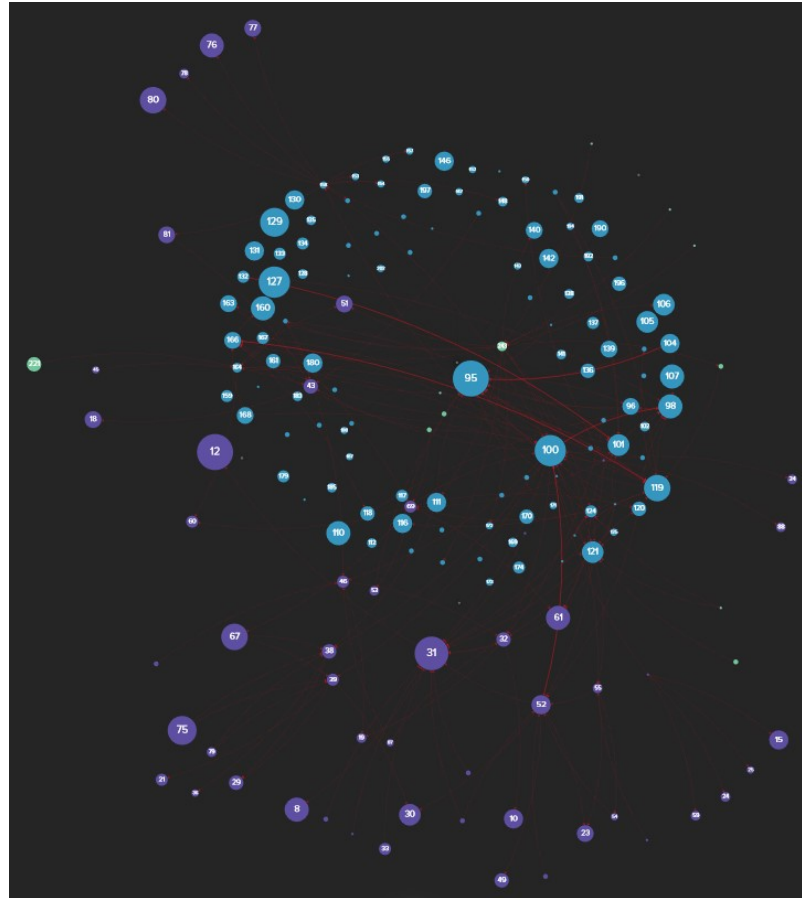


Extended (out 3)

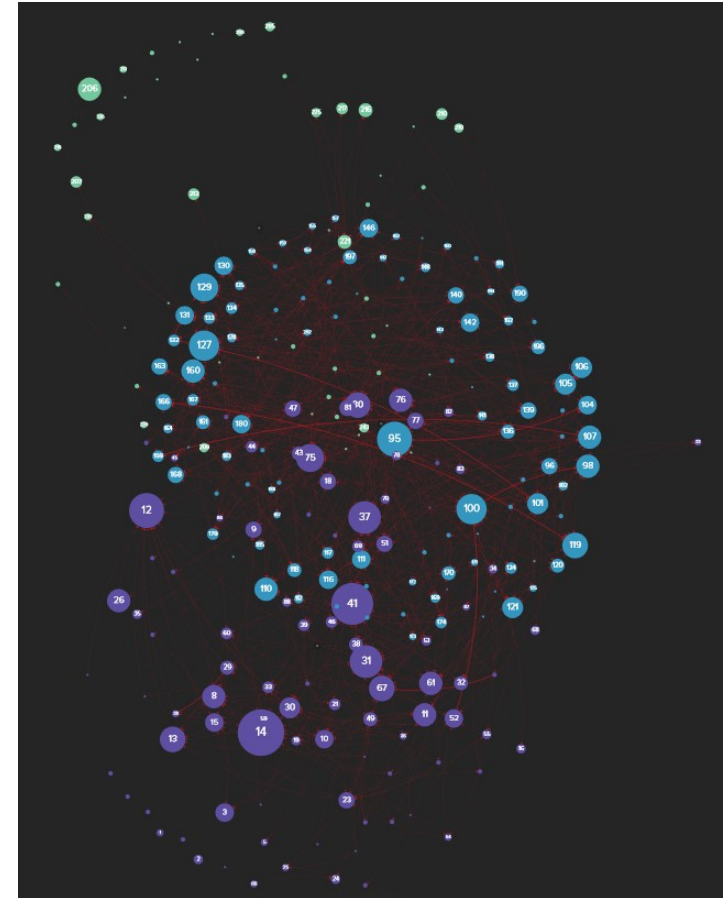
# Pattern no' 100 'PEDESTRIAN STREET'



## Direct (out 1)



### Indirect (out 2)



### Extended (out 3)

**Bin Jiang**, University of Gävle, Sweden

**Marija Mitrovic Dankulov**, University of Belgrade, Serbia

**Toshi Osaragi**, Tokyo Institute of Technology, Japan



This presentation was supported by COST Action TU1305  
“Social networks and travel behavior” [www.tu1305.eu](http://www.tu1305.eu)

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Maria del Mar Alonso

Anastasios Koutoulas

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Israel

Israel

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Italy

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Spain

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Sweden

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Switzerland





**COST Action TU1305**  
**Social Networks and**  
**Travel Behaviour**

