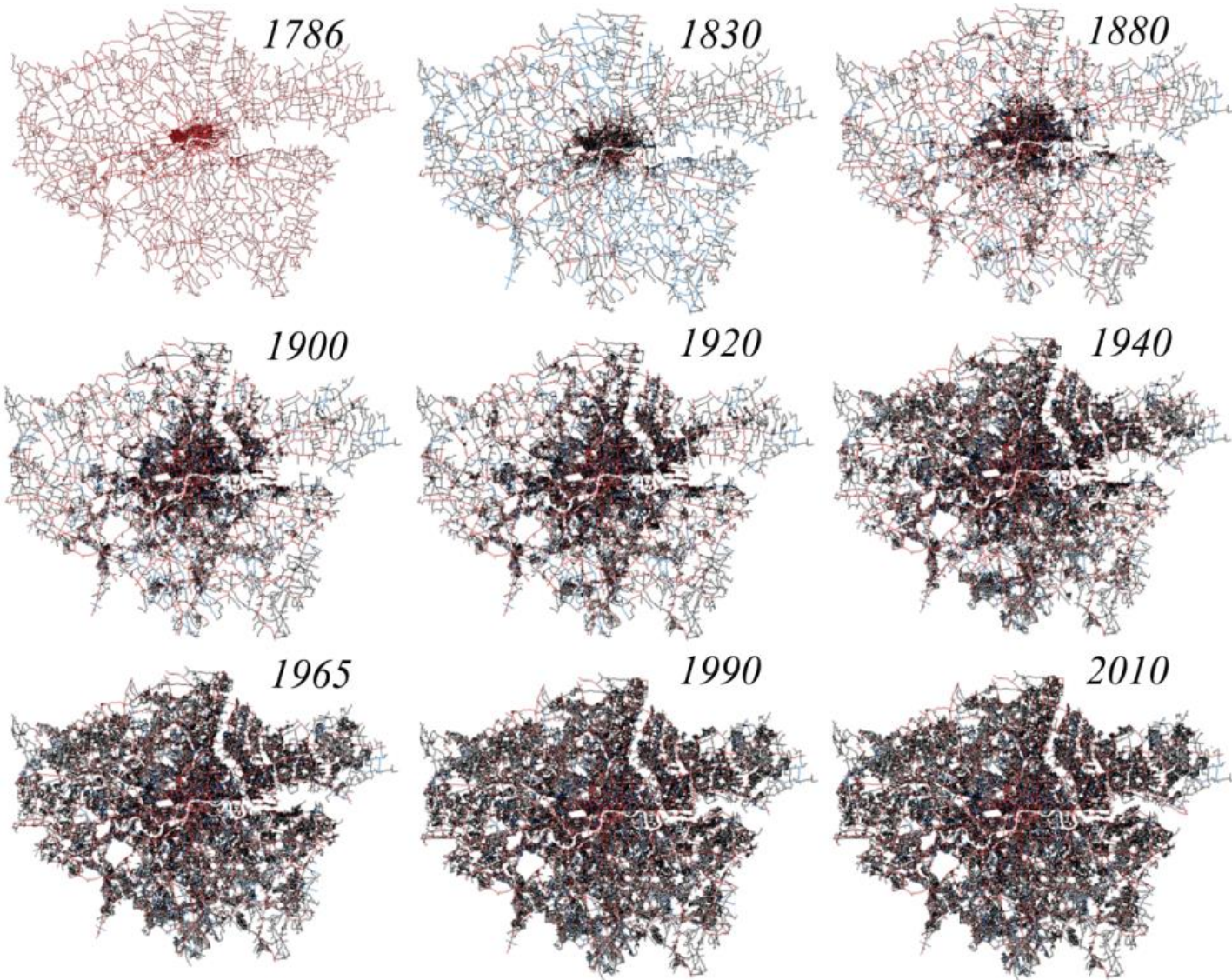# Modelling the Evolution of Road Networks

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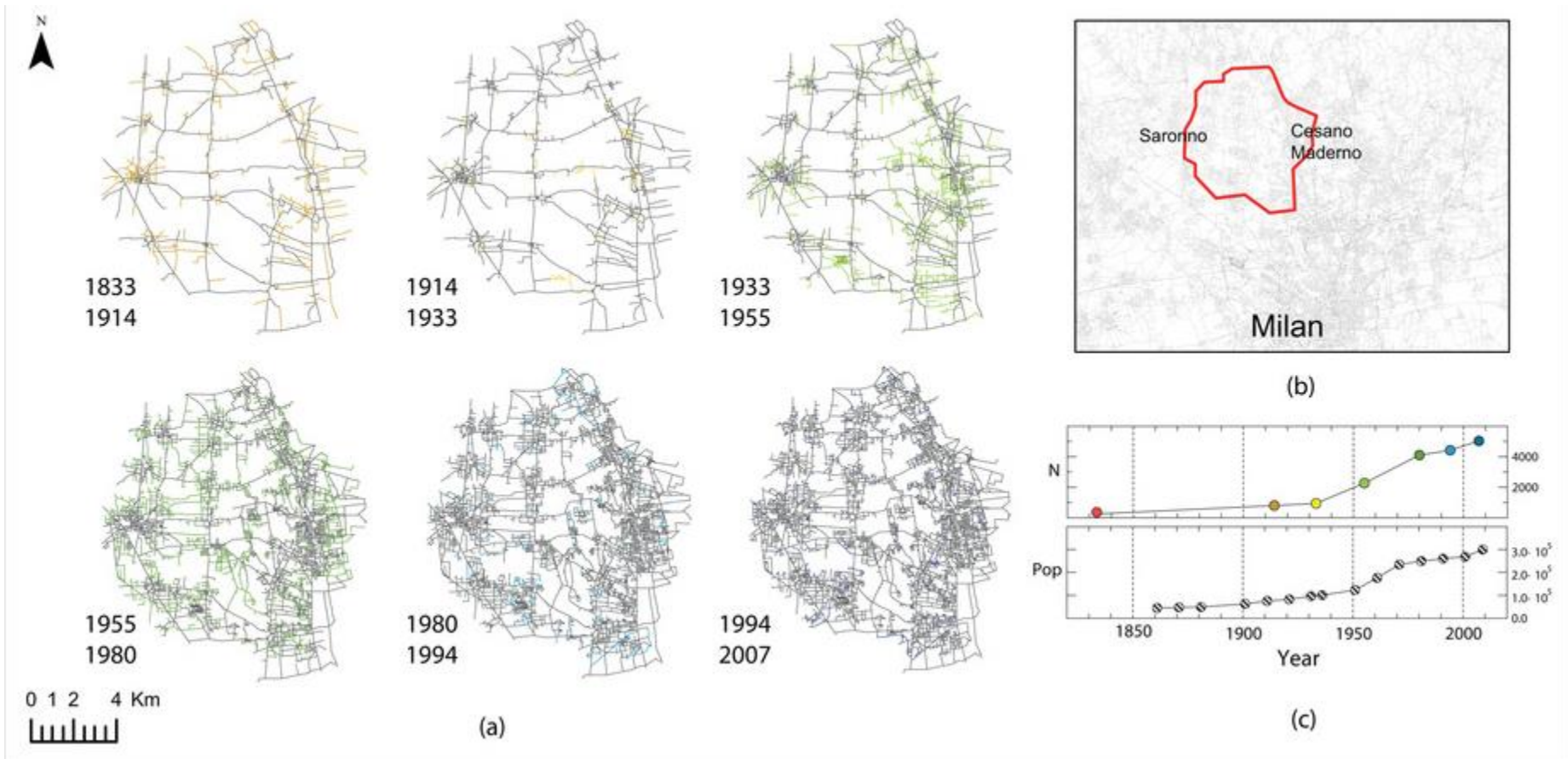
tsjy@leeds.ac.uk

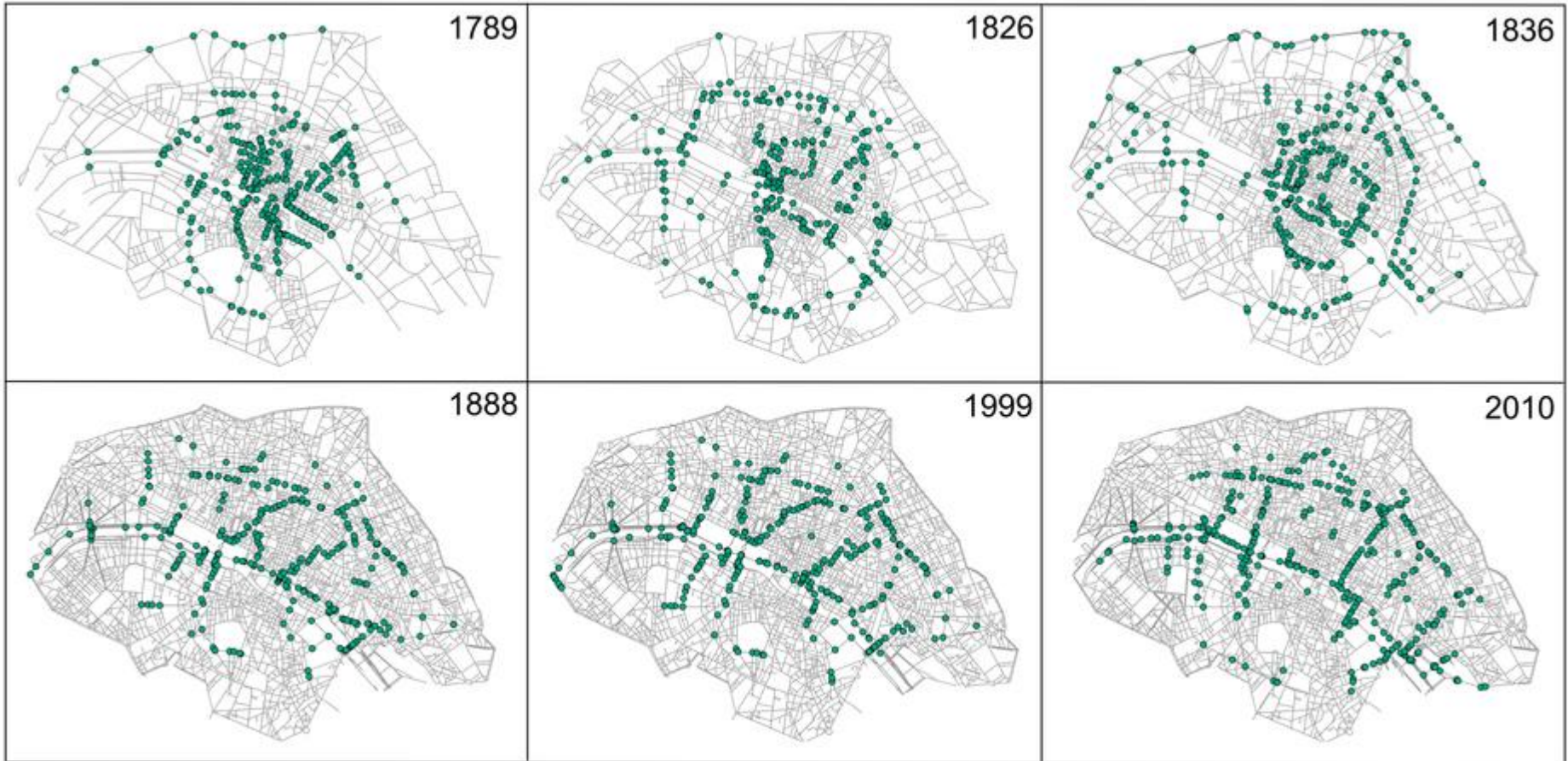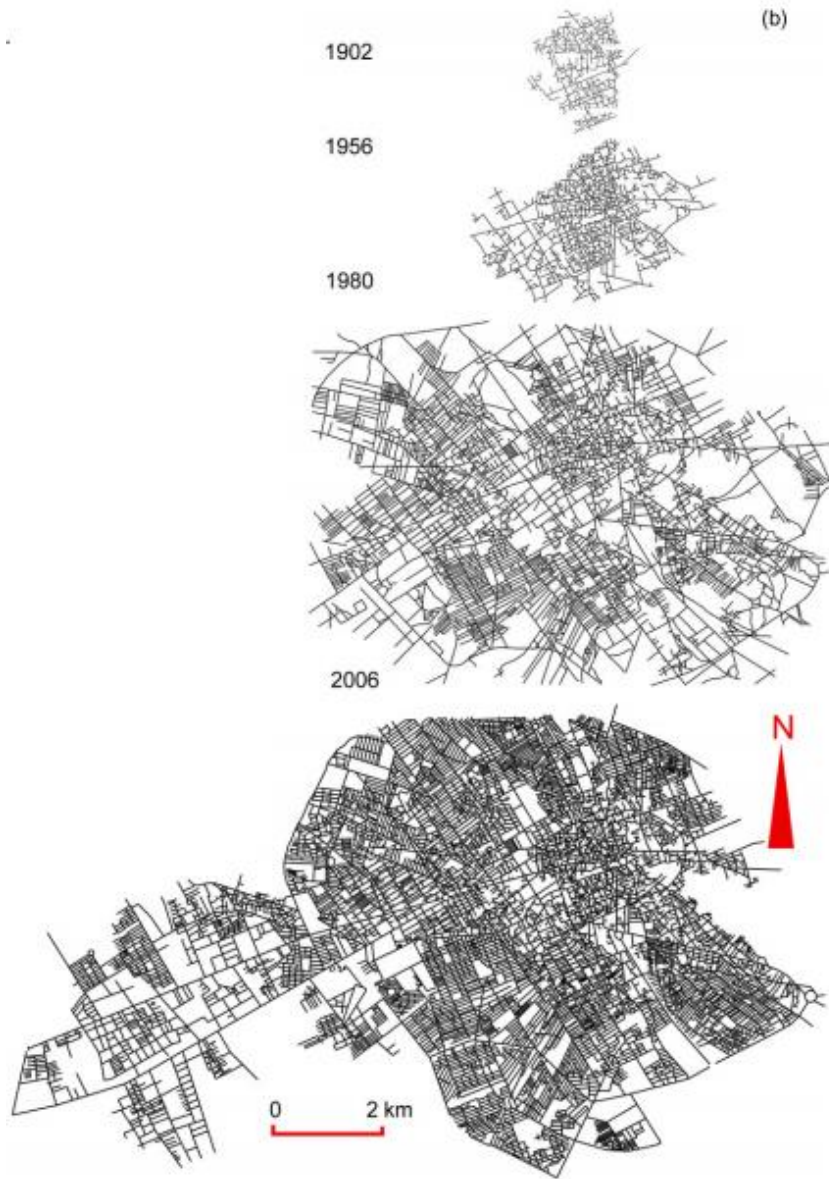Great London Area 1786-2010 (Masucci, Stanilov, & Batty, 2013)

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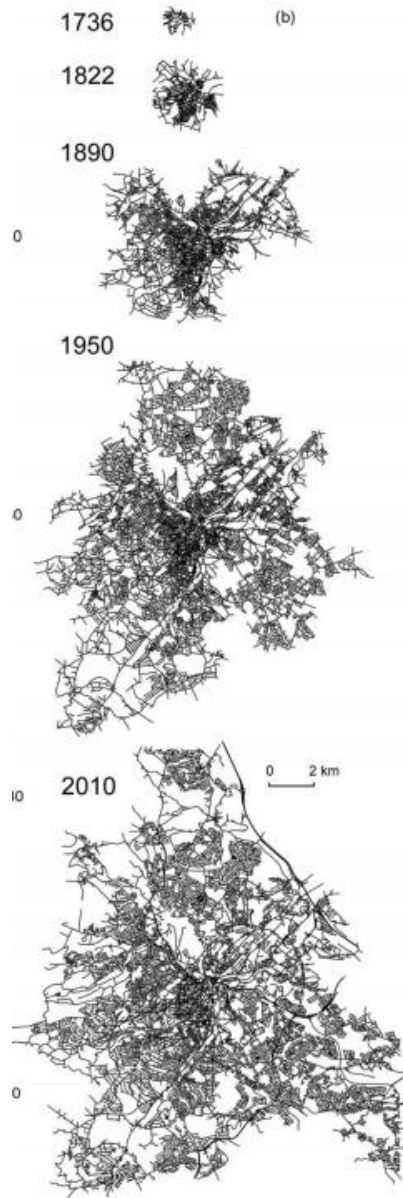
Groane, Italy 1833-2007 (Strano, Nicosia, Latora, Porta, & Barthélemy, 2012)

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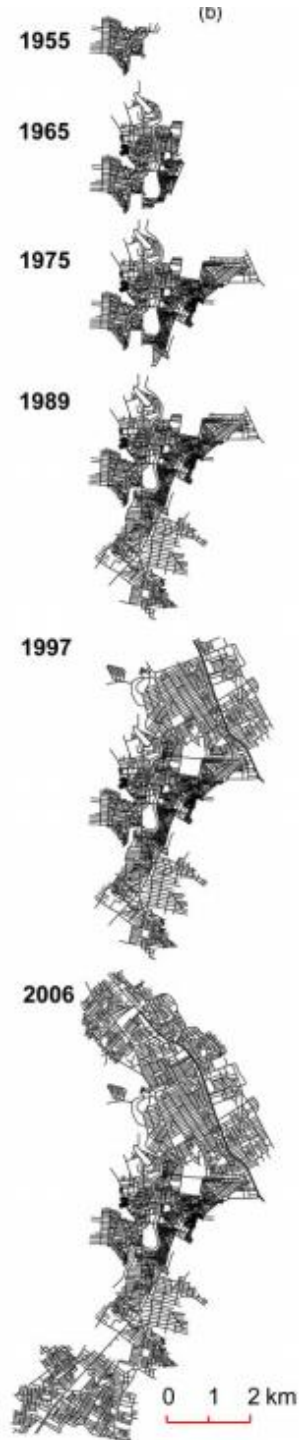Paris 1789-2010 (Barthelemy, Bordin, Berestycki, & Gribaudi, 2013)

1902

1956

1980

2006

N

0 2 km

Kerman Iran 1902-2006
(Mohajeri & Gudmundsson, 2014)

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Sheffield 1736 – 2010
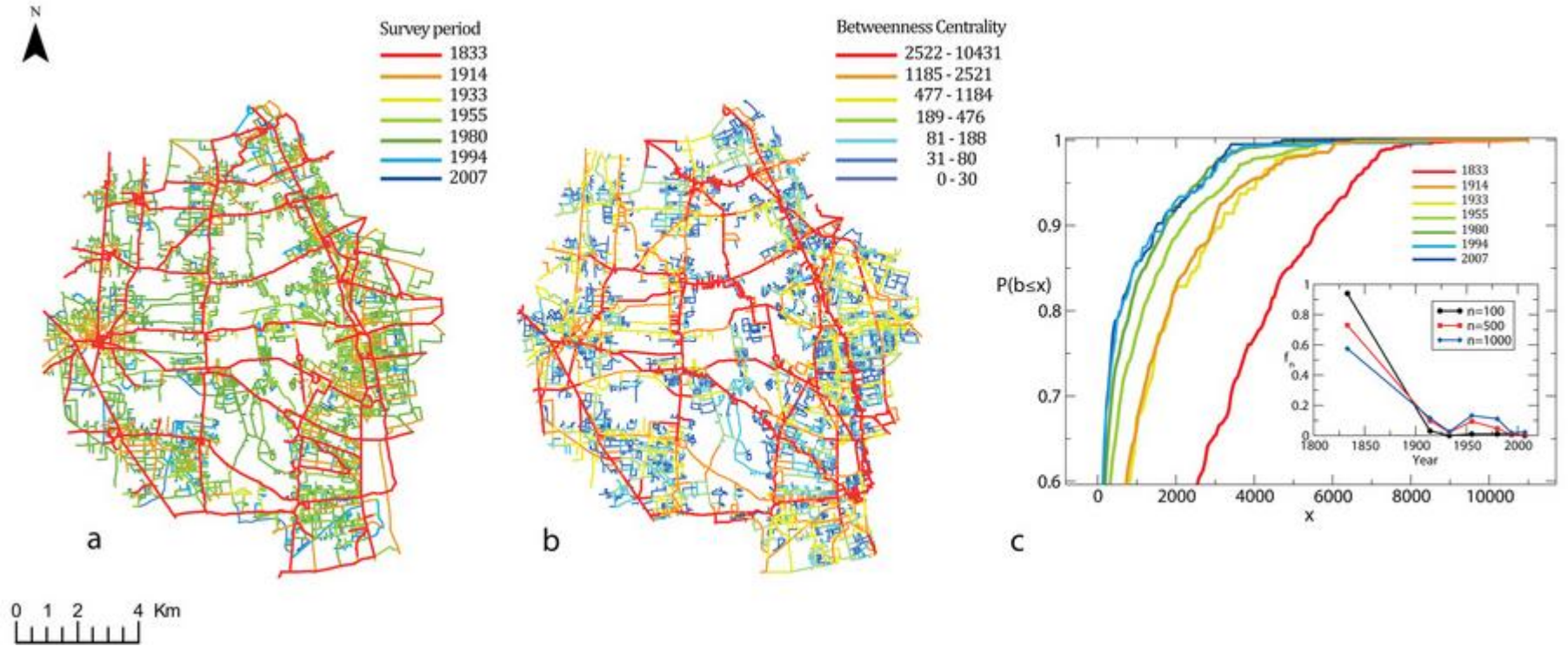(Mohajeri & Gudmundsson, 2014)

1955
1965
1975
1989
1997
2006

0 1 2 km

Khorramabad Iran 1955-2006
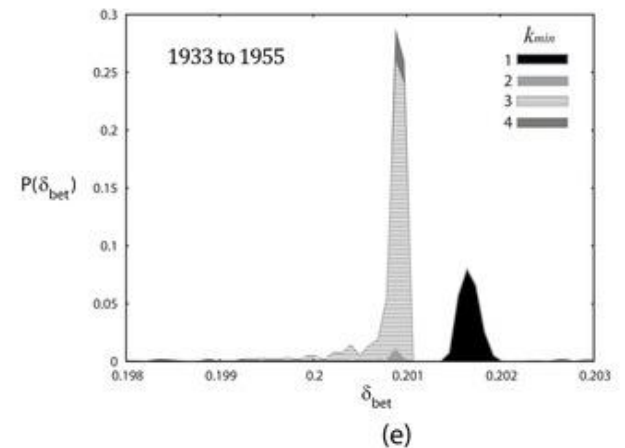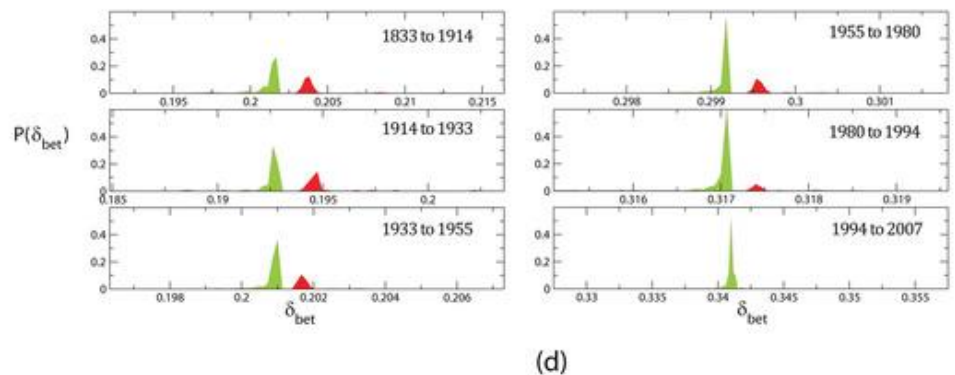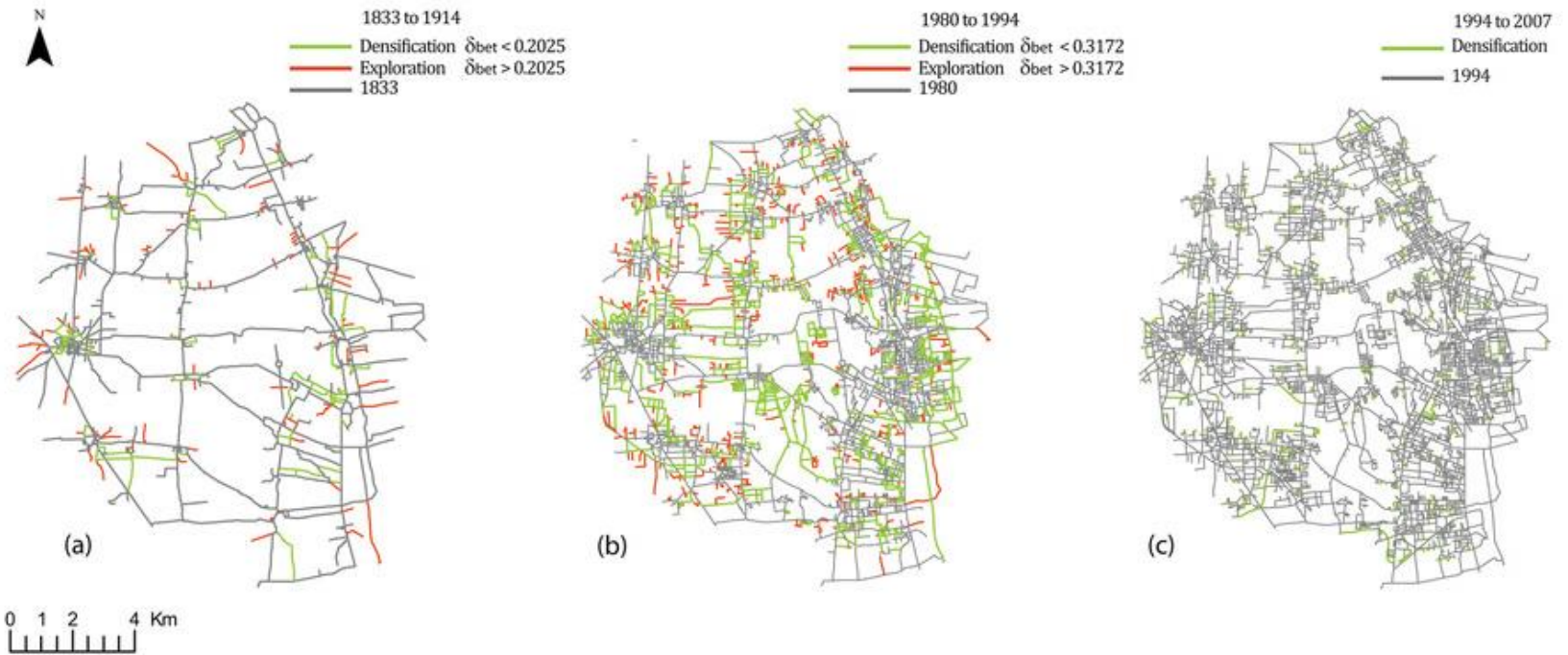(Mohajeri & Gudmundsson, 2014)

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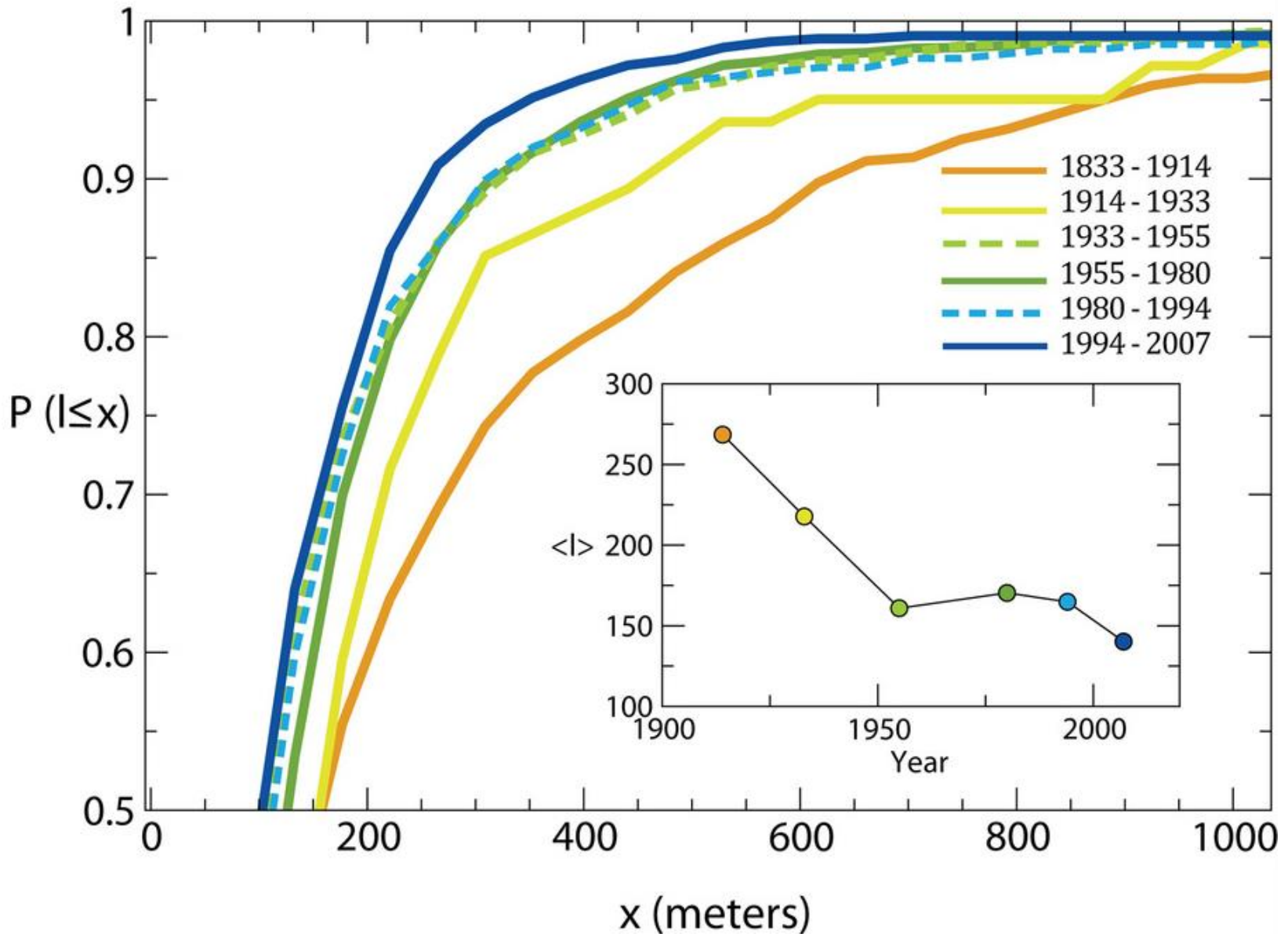
Cumulative link length distributions of link of different ages (Strano et al., 2012)

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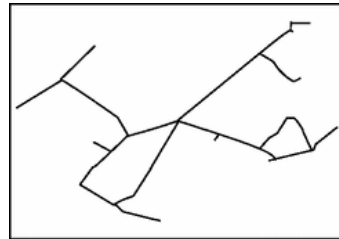**Correlation between links' age and their centrality (Strano et al., 2012)**

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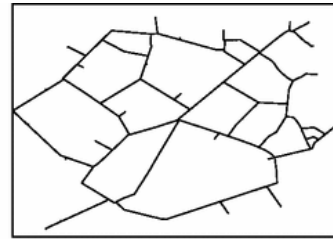
Densification and Exploration (Strano et al., 2012)

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Leaf venation pattern with cycles (Runions et al., 2005)
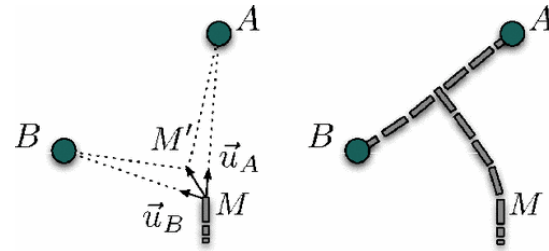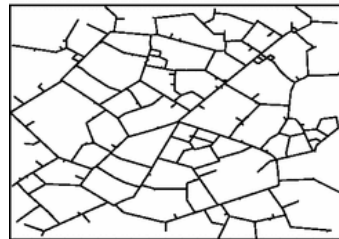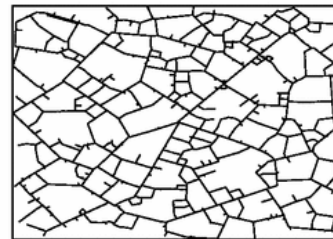
Local optimality(Barthélemy & Flammini, 2008)
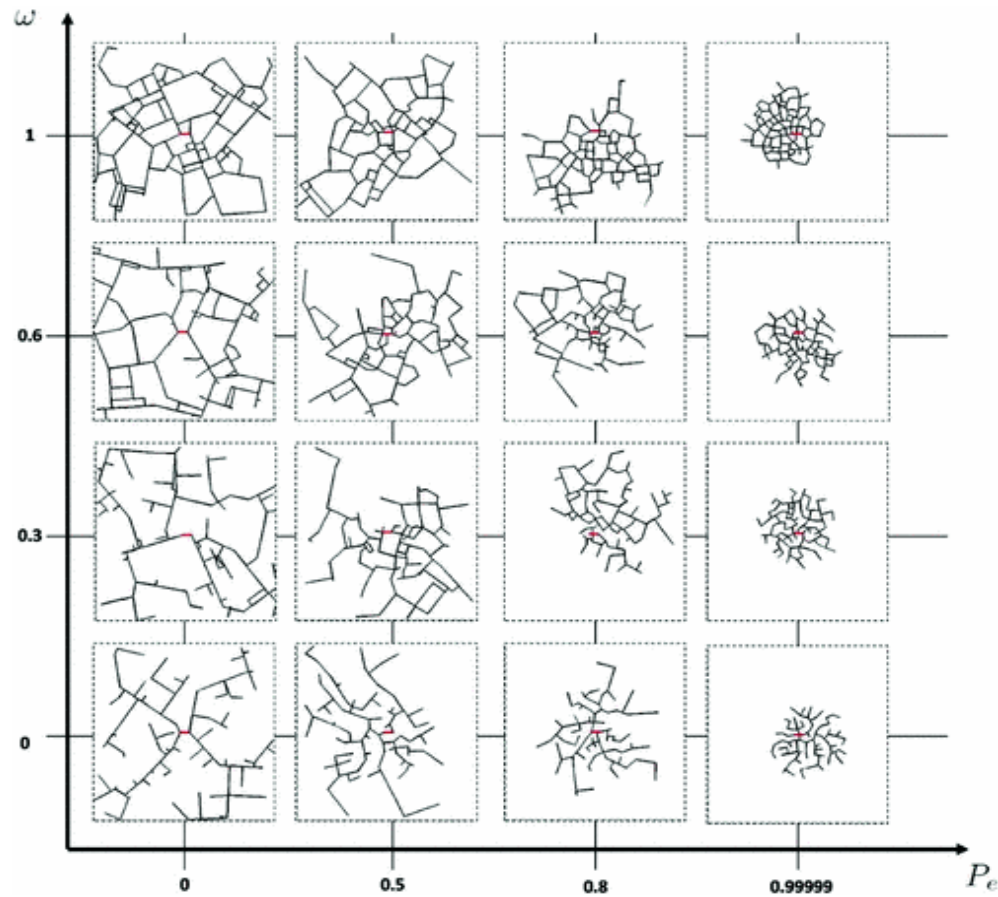
City graph(Courtat, Gloaguen, & Douady, 2011)

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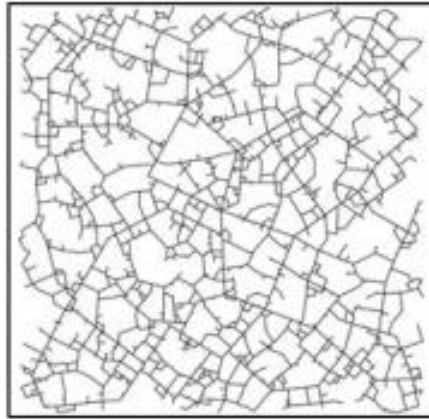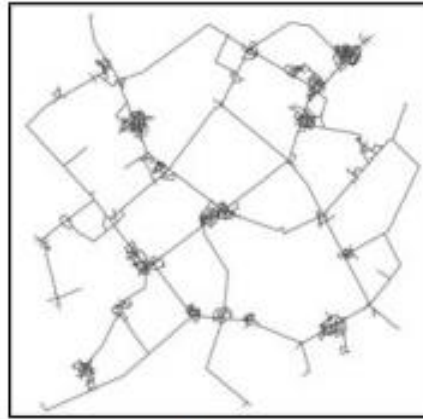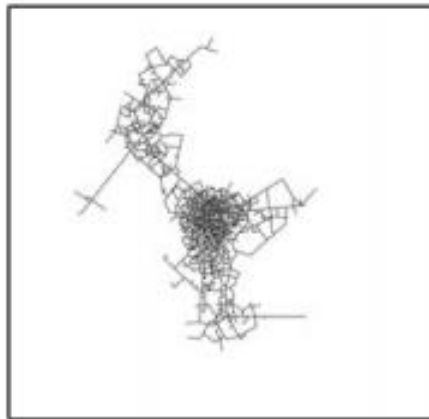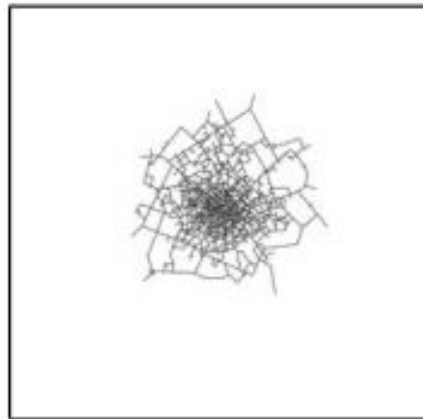
Local optimal with node competition (Rui, Ban, Wang, & Haas, 2013)

While time steps <= N:

Position new node;

Connect new node to the network.
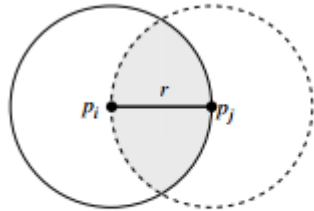
Fig. 2. Search region for RNG.

Relative Neighbours
in Relative Neighbourhood Graph
(Watanabe, 2008)

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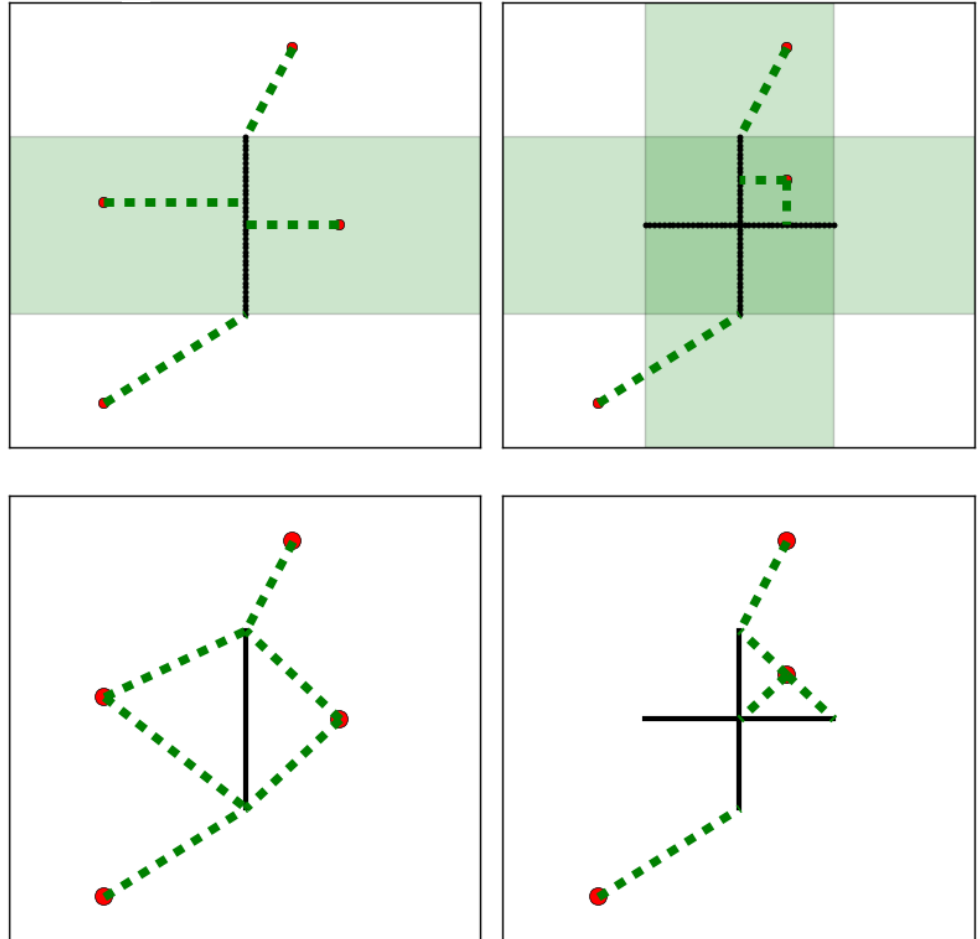
After 500 time steps, a network with 900 nodes and 1068 links
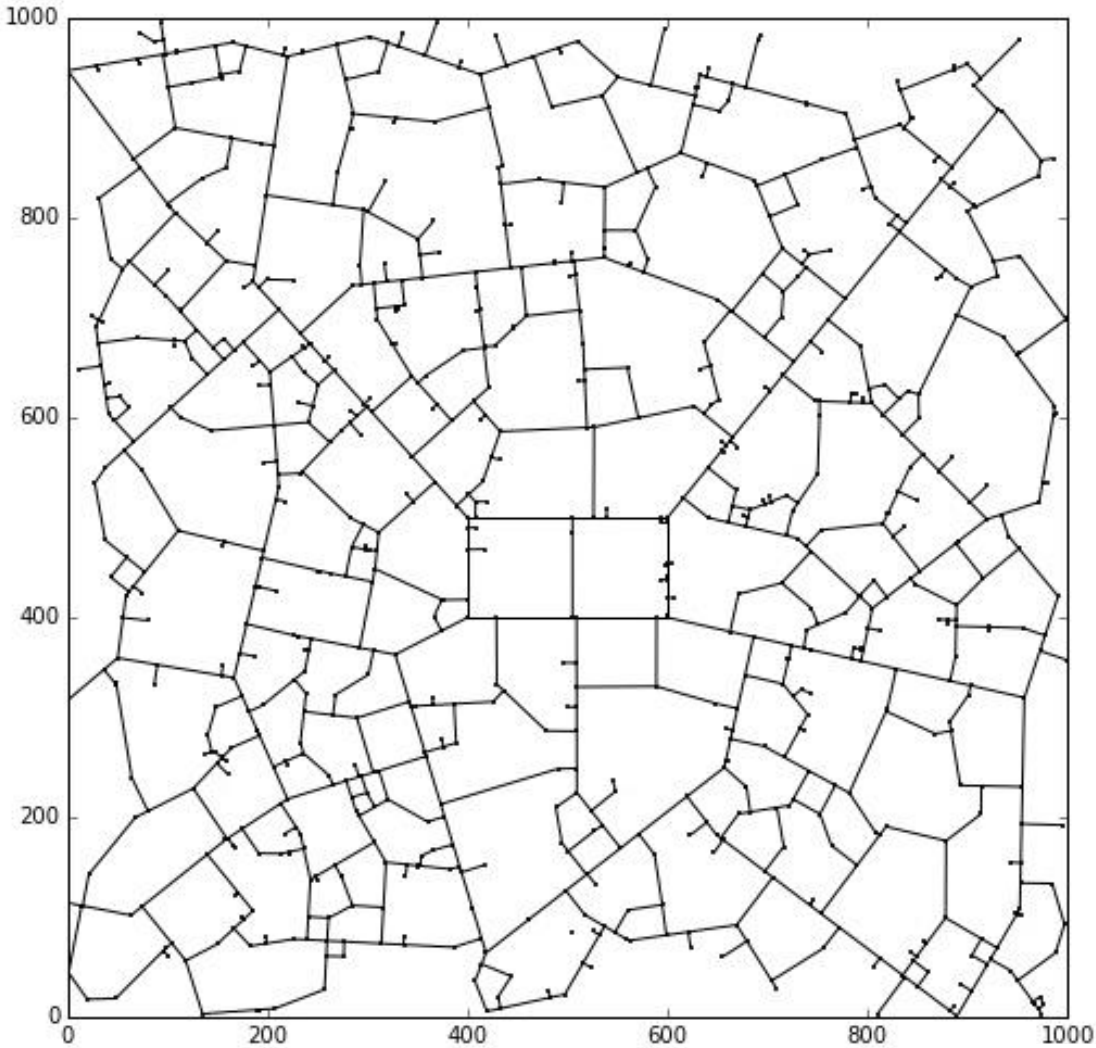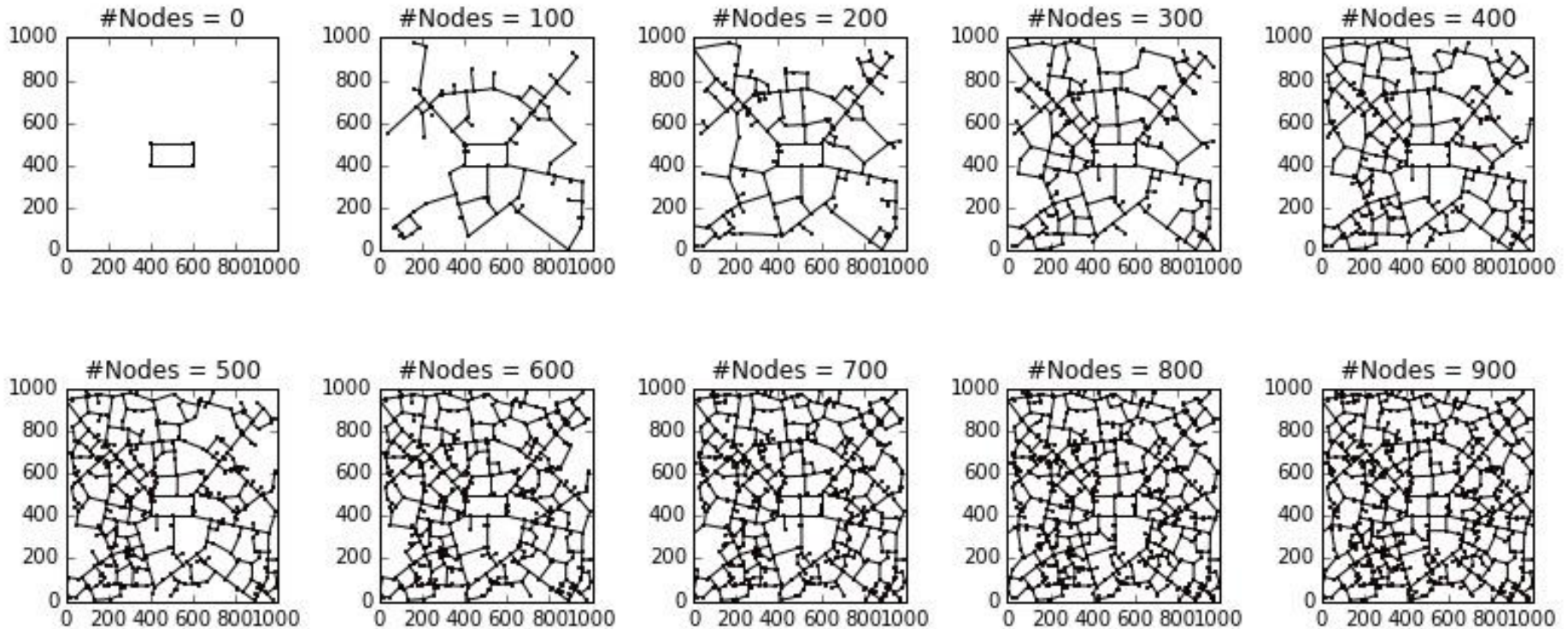
Process of road network evolution

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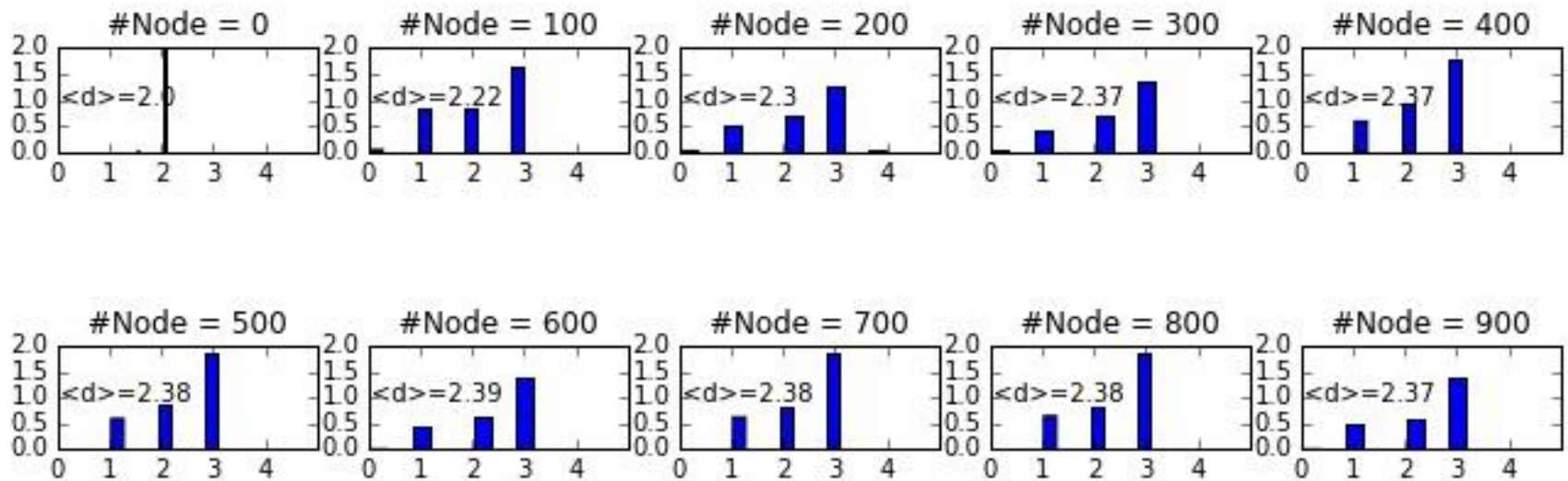
Node degree composition's change during the simulation process

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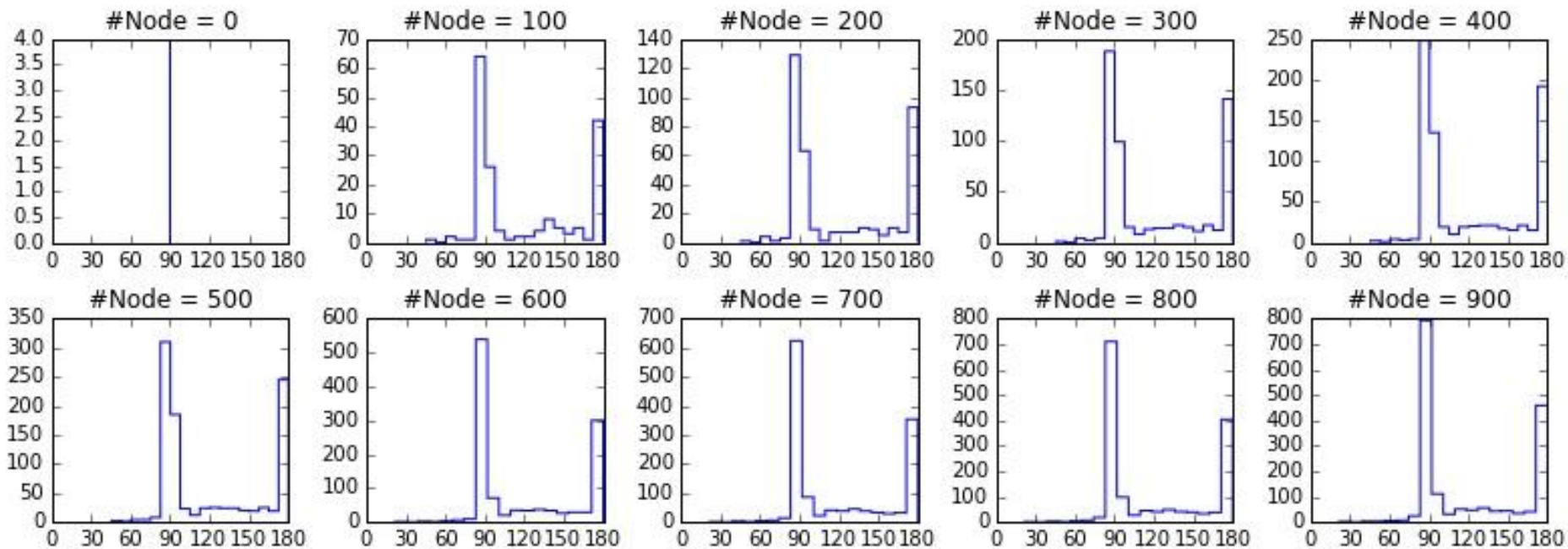
Link Intersection Angles Distribution during simulation process

UNIVERSITY OF LEEDS
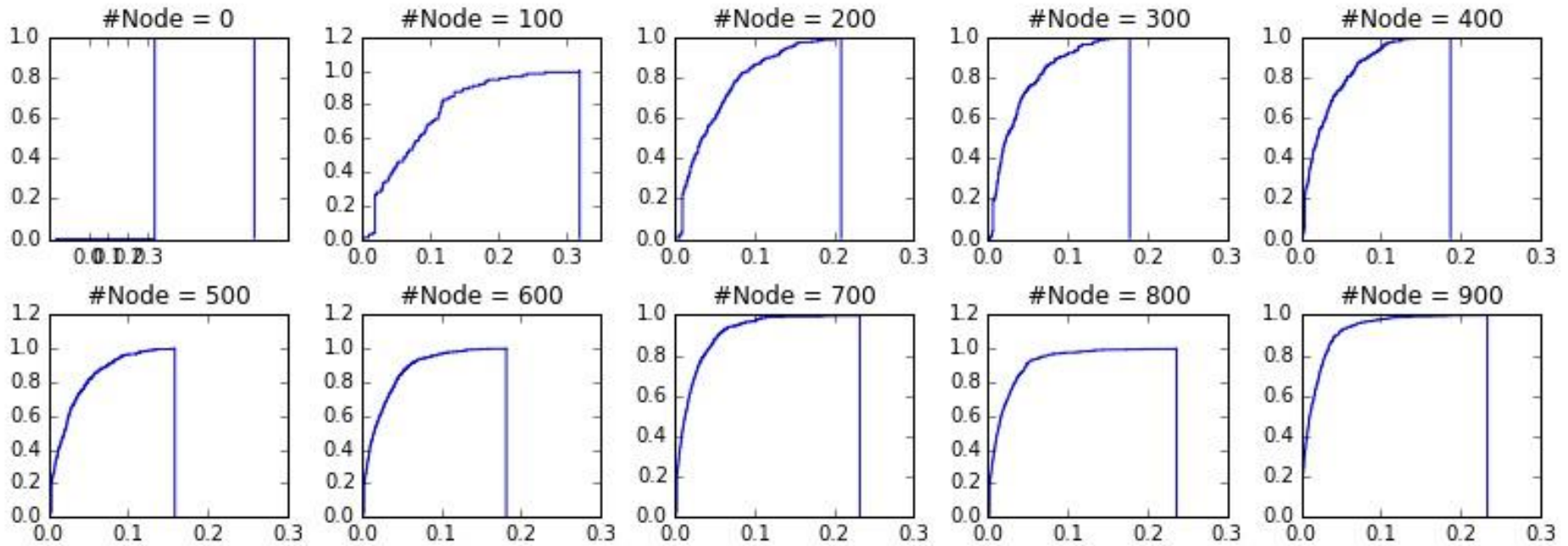
Link Betweenness Centrality Cumulative Distribution during simulation process
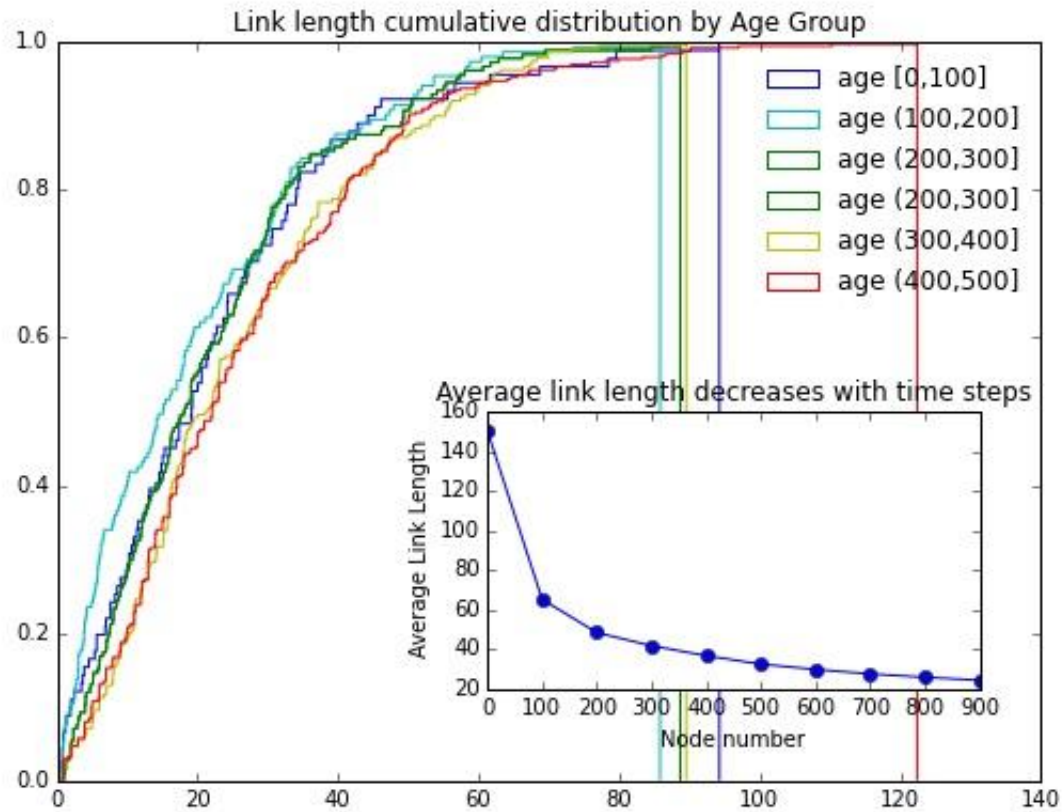
Cumulative link length distribution

Model ↑   v.s   Empirical results →

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Link age

Link Centrality

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Link age

Link Centrality

Link Betweenness Centrality Cumulative Distribution by Age

- age [0,100] iterations
- age (100,200] iterations
- age (200,300] iterations
- age (300,400] iterations
- age (400,500] iterations

Survey period
- 1833
- 1914
- 1933
- 1955
- 1980
- 1994
- 2007

Betweenness Centrality
- 2522 - 10431
- 1185 - 2521
- 477 - 1184
- 189 - 476
- 81 - 188
- 31 - 80
- 0 - 30

0 1 2   4 Km

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Fig. 2. Search region for RNG.

$$r = \frac{L}{2}$$

Relative neighbours
in Gabriel Graph
(Osaragi & Hiraga, 2010)

RP   NNG   MST

RNG   GG   DT

Fig. 1. Proximity graphs on same random points.

The family of Proximity Graphs
(Watanabe, 2008)

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#Node = 0   #Node = 100   #Node = 200

#Node = 300   #Node = 400   #Node = 450

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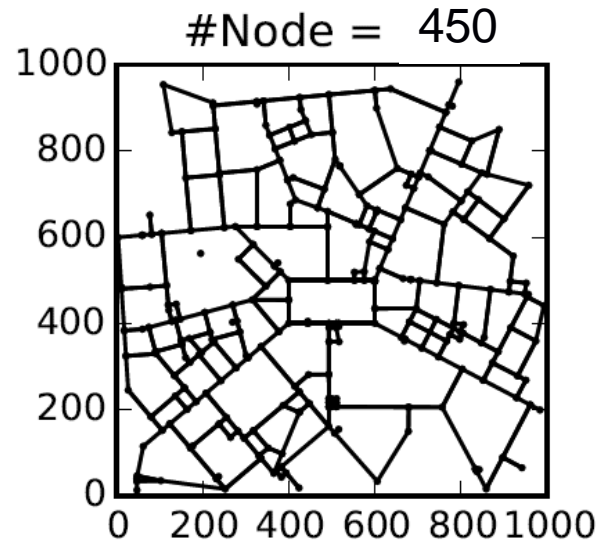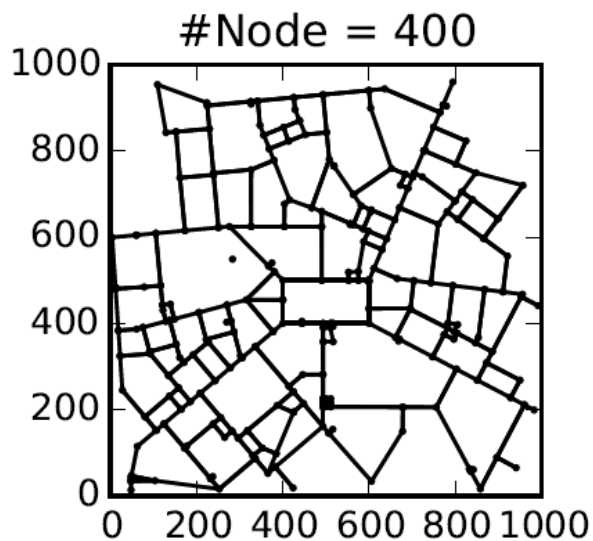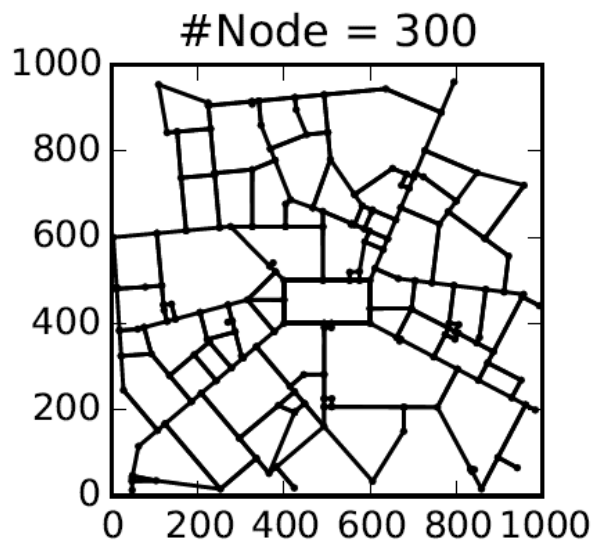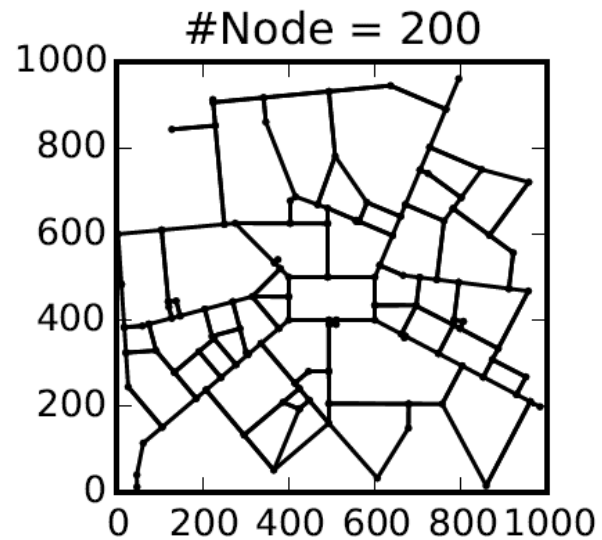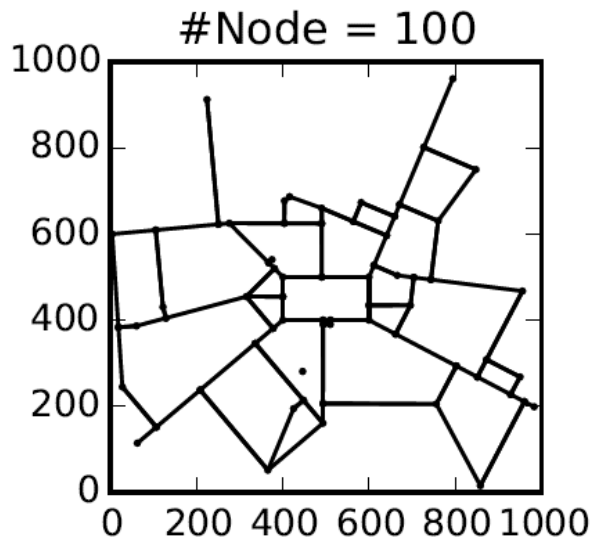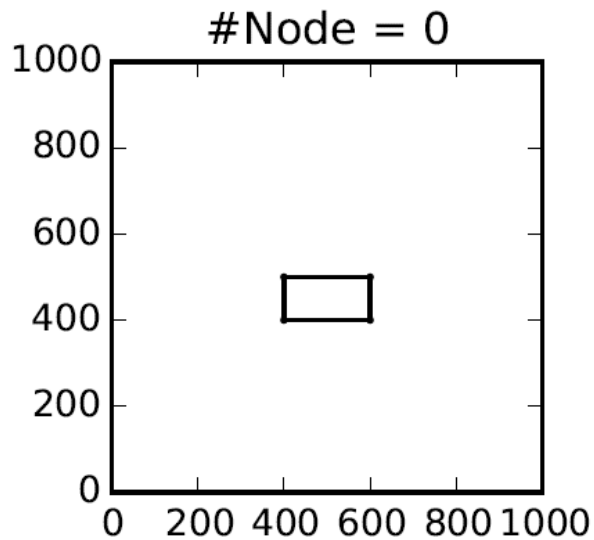
To wrap up:

- Goal: Understand the evolution of road networks
    - Importance of understanding changes in road networks
    - Necessity of models and simulation
    - Understand the result from simulation
    - Proximity's role in road network generation

- Future plan

Reference:

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8. Rui, Yikang, Ban, Yifang, Wang, Jiechen, & Haas, Jan. (2013). Exploring the patterns and evolution of self-organized urban street networks through modeling. The European Physical Journal B, 86(3), 1-8.
9. Watanabe, Daisuke. (2008). Evaluating the configuration and the travel efficiency on proximity graphs as transportation networks. Forma, 23(2), 81-87.
10. Osaragi, Toshihiro, & Hiraga, Yuko. Street Network created by Proximity Graphs: Its Topological Structure and Travel Efficiency.

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