

The influence of the road layout on the Network Fundamental Diagram

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Abstract

It is analyzed what the effect is of the exact network structure on the shape of the Network Fundamental Diagram (NFD). In order to do so, a tool is developed which can create random networks for which the aggregated properties are the same. Using this tool, different urban networks with the same properties are designed. They show different NFDs. Also, networks with extra arterial roads are designed. They do not increase the road capacity, but also increase the network inhomogeneity so the overall effect on network capacity is limited. Variations with the location of the extra arterials show that an asymmetrical arterial reduces network performance. Therefore, it is required that for each network an NFD is determined.

Introduction

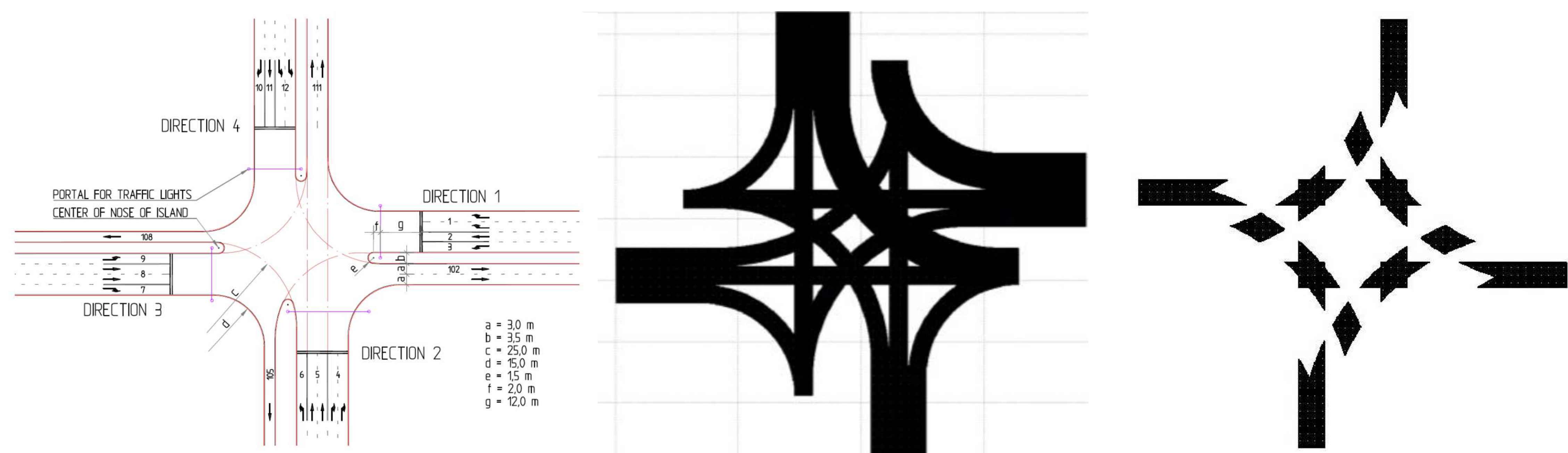
- Large scale traffic descriptions are needed in order to coordinate traffic measures over large areas
- NFD can be used for controlling traffic on large networks, for instance gating or perimeter control
- The NFD for an area needs to be known
- Can it be derived from the basic road characteristics?

Characteristics

The following properties are considered basic characteristics:

- Road length (per class)
- Number of intersections
- Signal setting

Network design tool



- Main network structure is put in
- For arterial roads and arterial-connectors intersections are designed
- Paths and overlaps are determined
- Extra red times are calculated based on overlap
- Traffic signals at intersections with arterials
- Standard Dutch signal setting design; vehicle actuated control

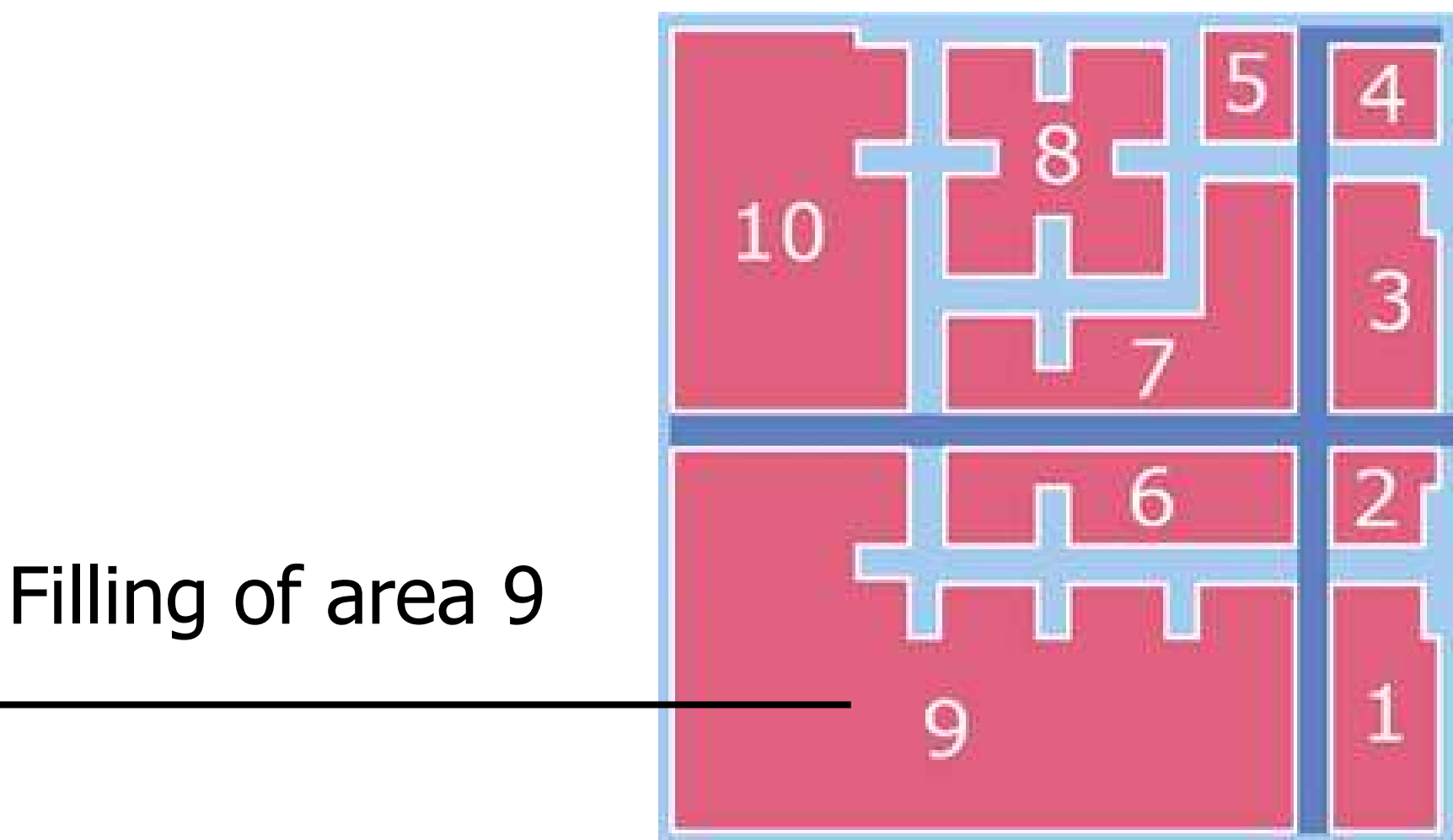
Type	Horizontal space		Vertical space		Land use
	min	max	min	max	
Houses	50	100	80	180	50
High rise buidings	60	90	120	200	25
Parks	50	400	50	400	10
Sport facitilies	150	400	200	500	15



Subnetwork creation

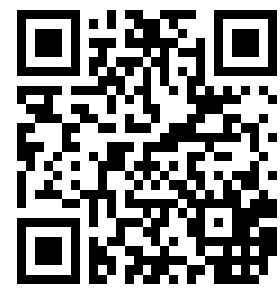
- Typical size for land use are analysed
- Typical surface percentage per land use is given
- Based on the land use percentage, "raw" land is allocated to a land use
- For this block, a size is drawn within the boundaries
- Each block has a surrounding road
- Remaining parts (to small) will be parks

The whole network is converted to be loaded in *Vissim*.

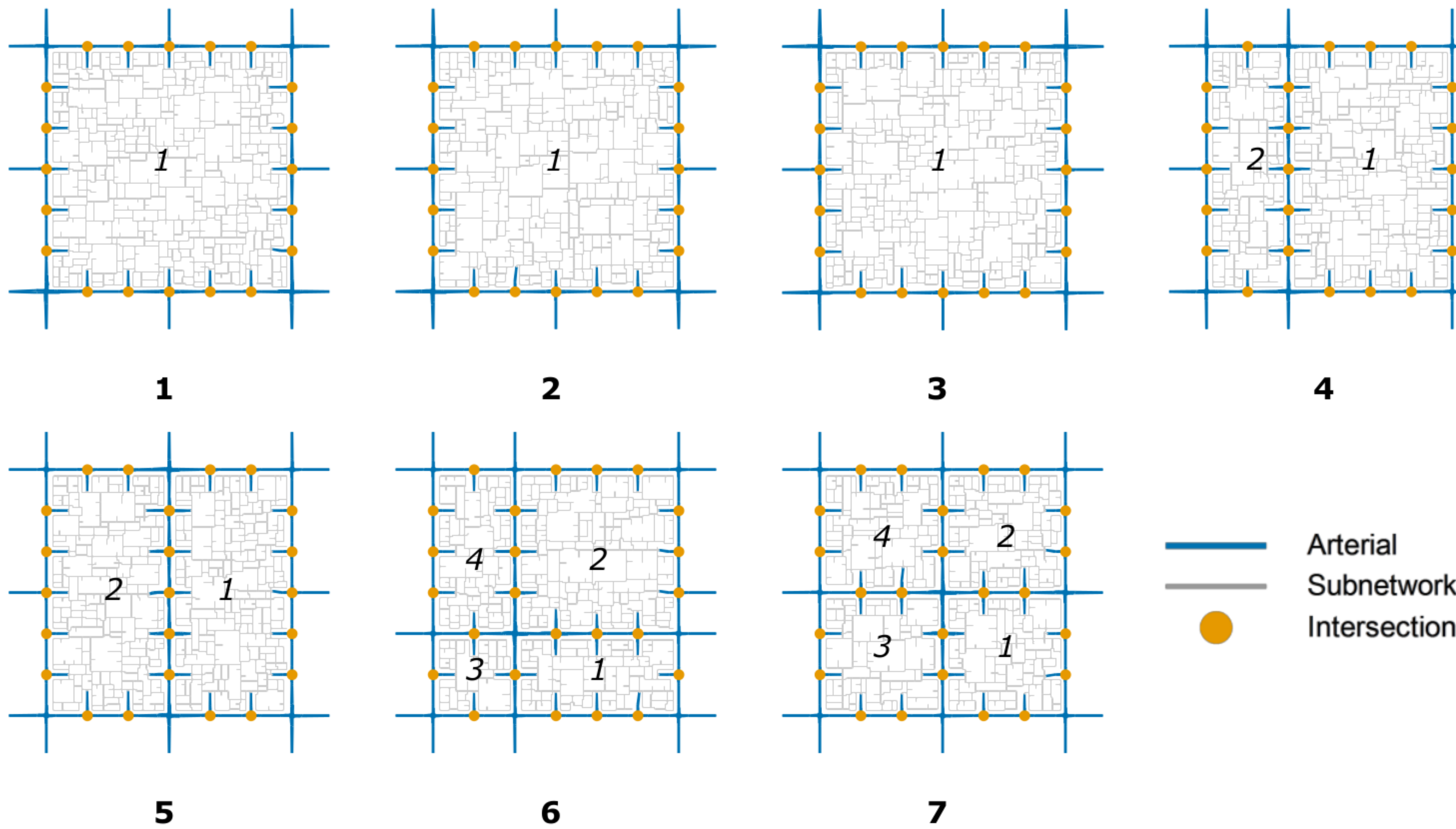


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Experimental design



Research question: Compare networks: what is the impact of...

Configuration of local roads: 1-2, 1-3, 2-3

Inhomogeneity in road type: 1-5, 2-5, 3-5, 1-7, 2-7, 3-7

Asymmetry: 4-5, 6-7

Simulations

- Networks loaded into *Vissim*
- Base demand exogenously set
- Different runs in *Vissim*; whole OD matrix scaled up and down to obtain full

Local roads

- NFD is almost triangular
 - Crisp NFD
 - Capacity for different layouts differs up to ~15%
 - With same demand no severe congestion in network 3
- => the exact roadway layout matters

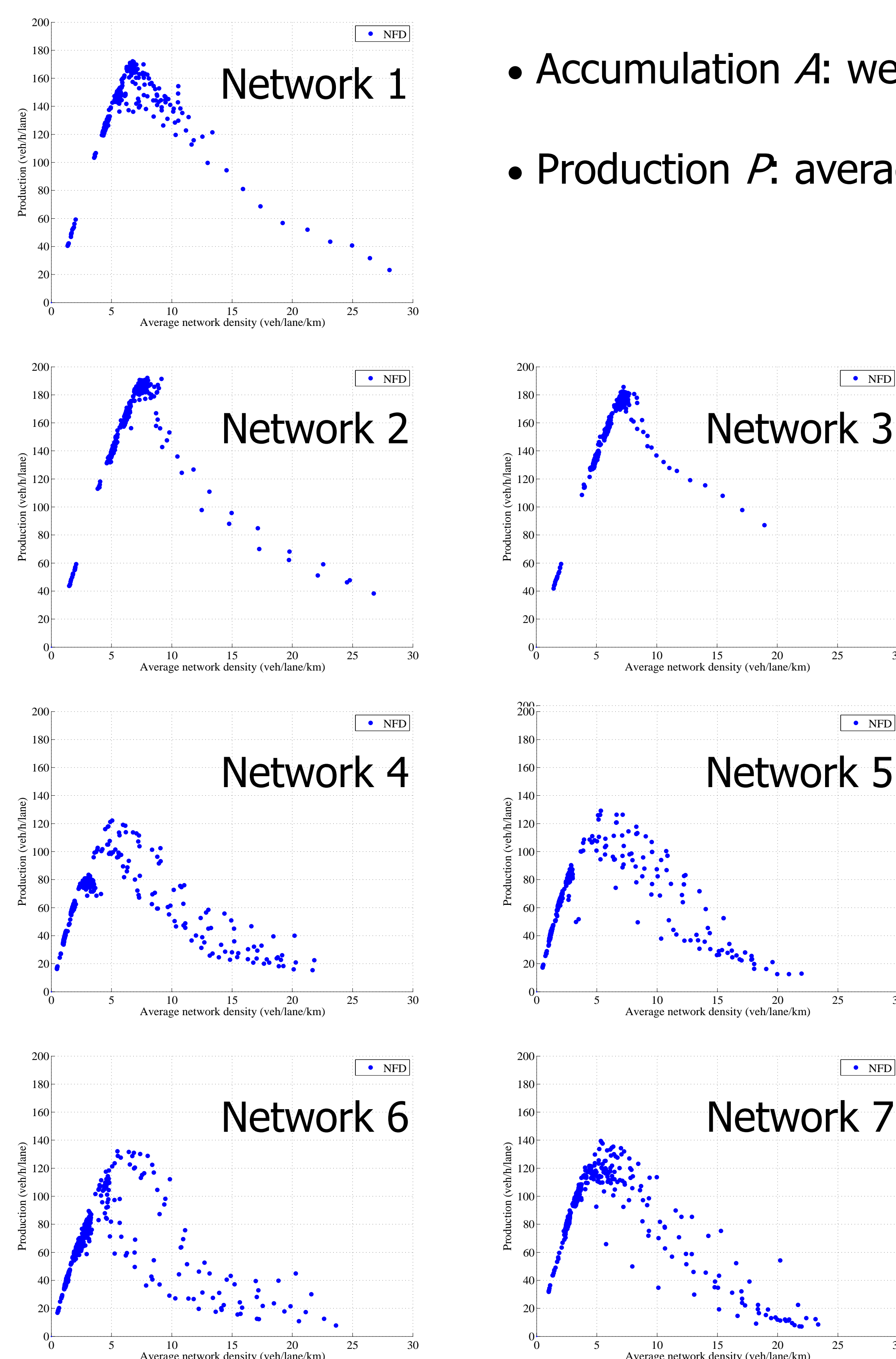
Adding arterial

- Increases variation in production (spread)
 - Lowers capacity (normalized to roadway length)
 - Two arterials (cross direction) similar effect, perhaps less spread
- => added inhomogeneity reduces capacity and increases spread

Asymmetric arterial

- One direction: increases spread compared to center arterial
- Two directions: reduces spread

Results



Compute NFDs

- Roadway length L_i per segment i (multiplied by nr of lanes)
- Accumulation A : weighted average density $k^A = \frac{\sum_i L_i k_i}{\sum_i L_i}$
- Production P : average flow q in a time step $P = \frac{\sum_i L_i q_i}{\sum_i L_i}$

Conclusions

We developed a tool which can automatically design networks. This tool is used to analyze the effects of random fluctuations on the NFD. It is shown that even if the roadway length, intersections and signals are the same, the capacity of the road differ. As a consequence, some networks might be more prone to jam than others. Also inhomogeneity plays a role. If an extra arterial is added, the inhomogeneity increases, and the spread increases and the capacity decreases. Moreover, a decentralized arterial causes more inhomogeneity and more spread. Concluding, key figures of the network do not suffice to find the NFD. Instead, it should be determined for each network separately.