Preferred citation style for this presentation

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An Integrated and Adaptive Ant Colony and Genetic Algorithm for Transport Network Design

BJ Vitins
KW Axhausen

IVT
ETH
Zürich

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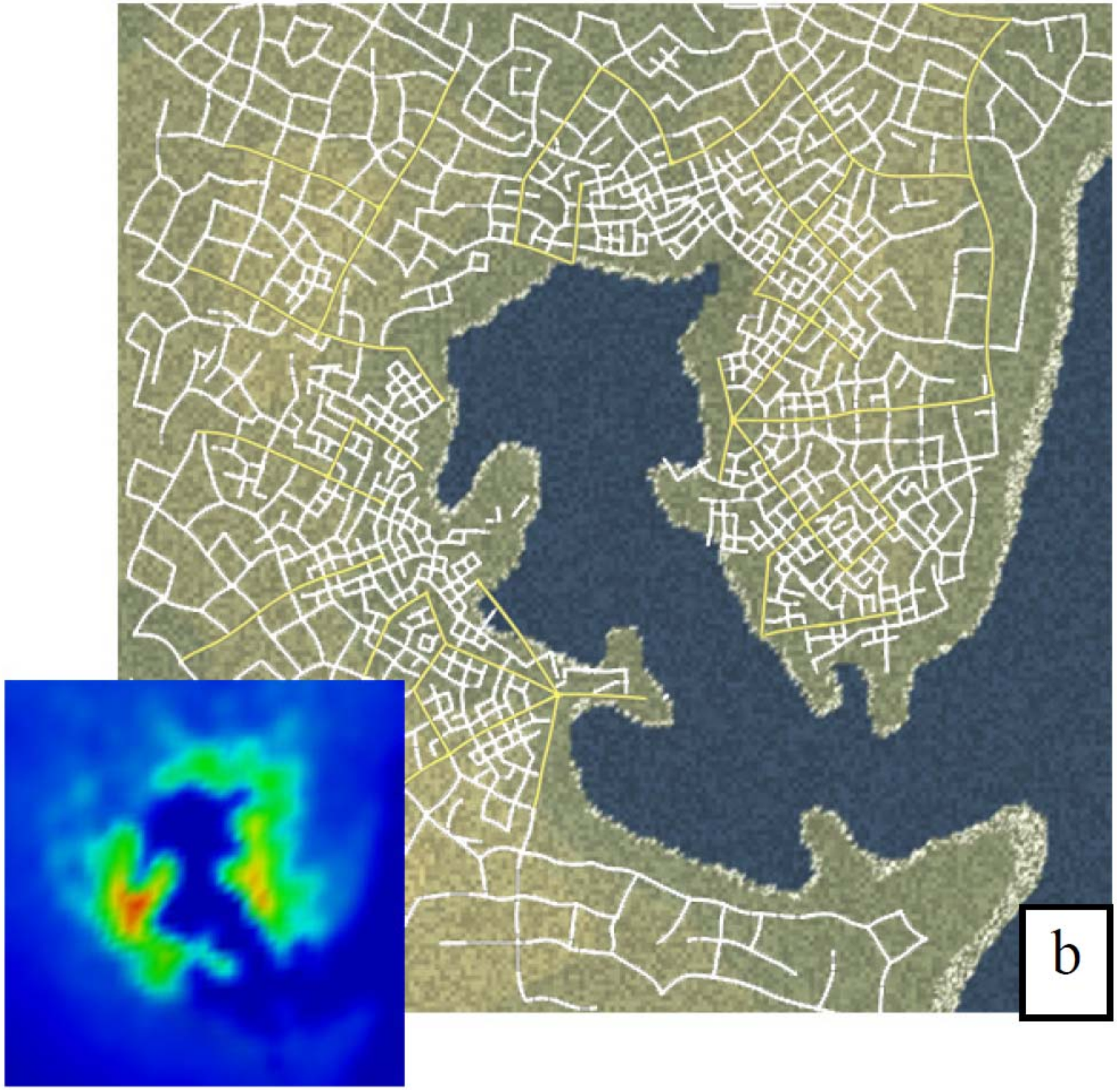
Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Background

Source: Vanegas, Aliaga, Benes, Waddell (2009, Procedural (2010)



Concern – network design

1. Order

- Volume delay function
- Wardrop Equilibrium

2. Order

- Determination of a subset of candidate links and nodes
- Determination of network element types

Preliminaries – objective functions

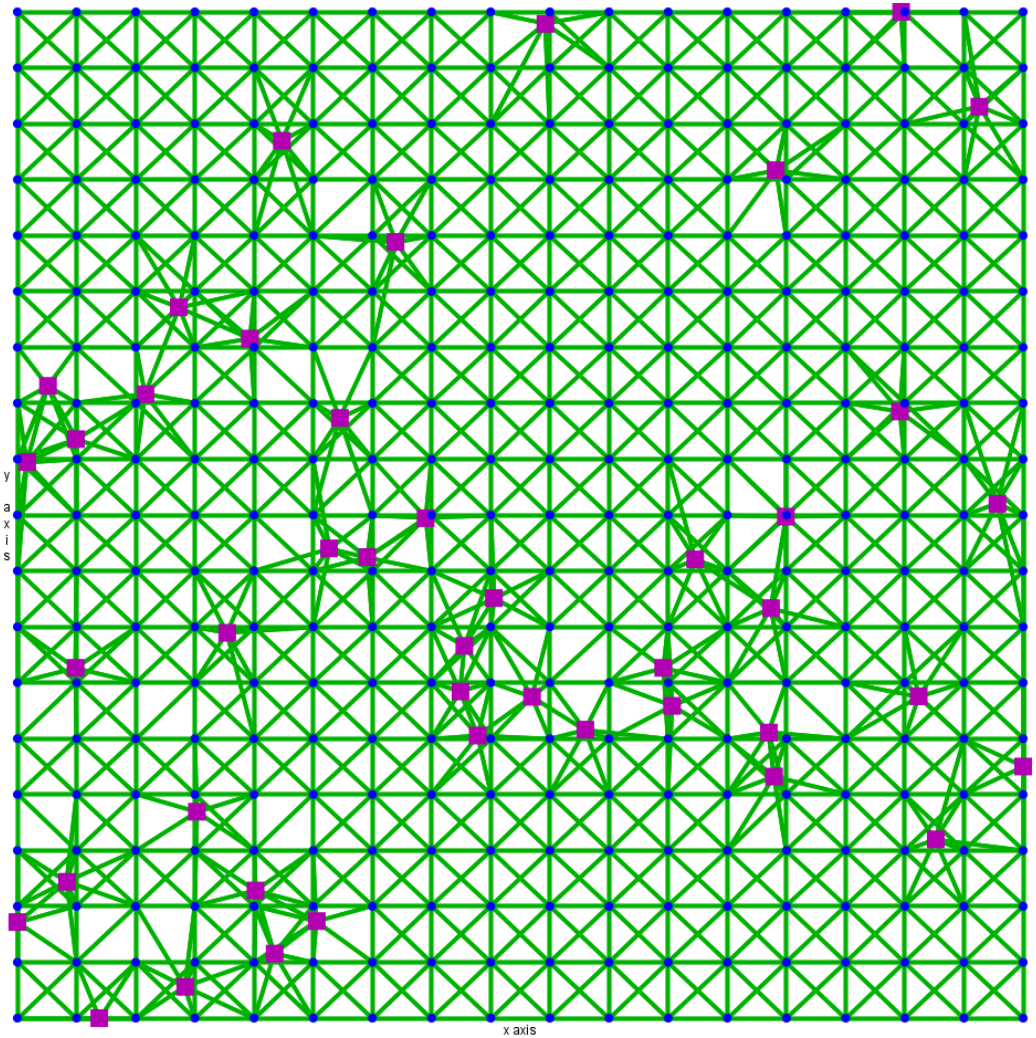
Costs:

$$f = \left(Generalized\ Costs,\ External\ Costs,\ ...,\ Infrastructure\ Budget\right)$$

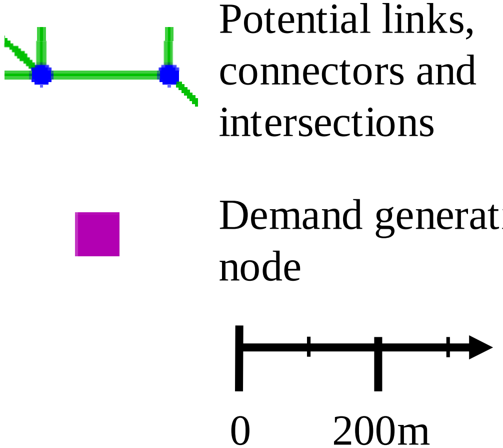
Accessibility:

$$f = \sum_{o=1}^{O} I_o \cdot \ln\left(\sum_{d=1}^{D} A_d \cdot \exp(-\beta \cdot t_{od})\right) - Infrastructure\ Budget$$

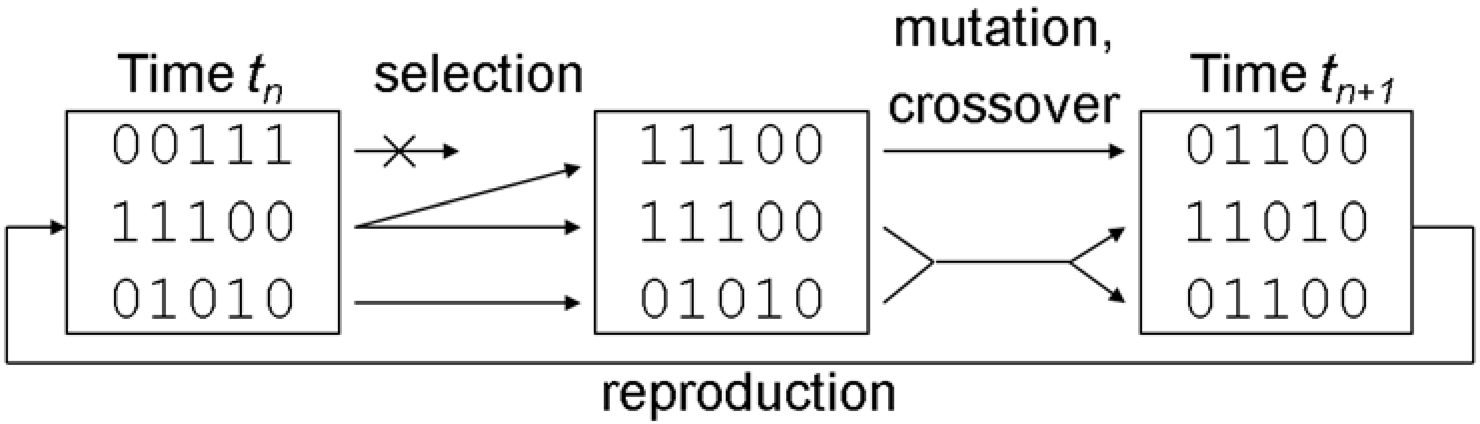
Preliminaries – search space

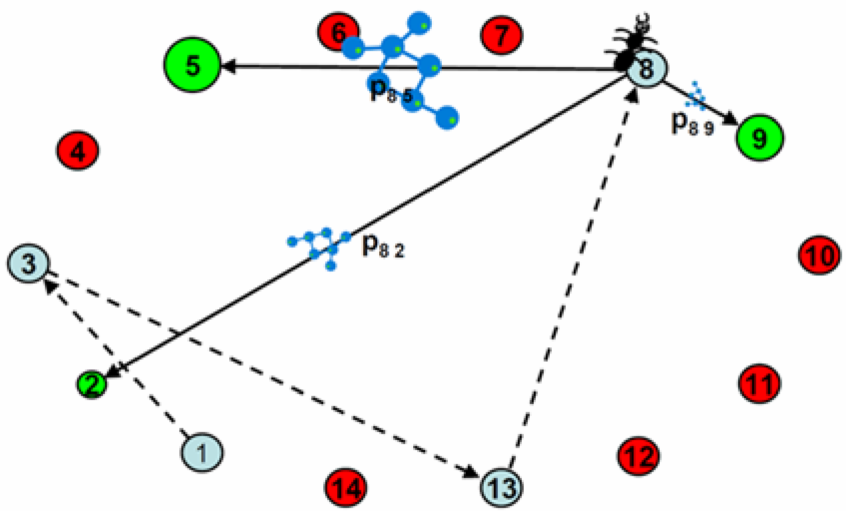


Potential solutions:
100 nodes -> 10^{103}
400 nodes -> 10^{446}
625 nodes -> 10^{708}

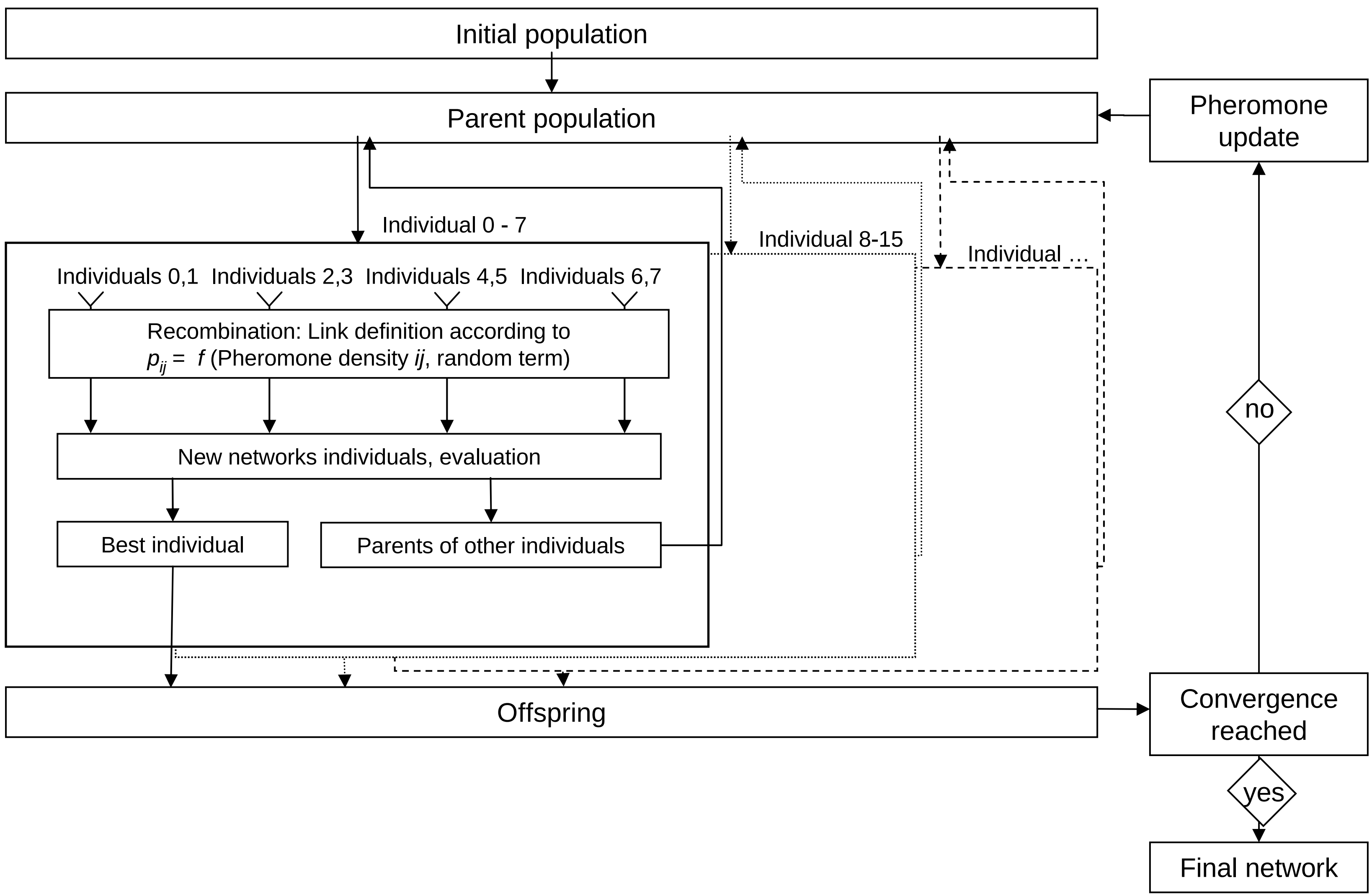


Design – Genetic Algorithm vs. Ant Colony Optimization

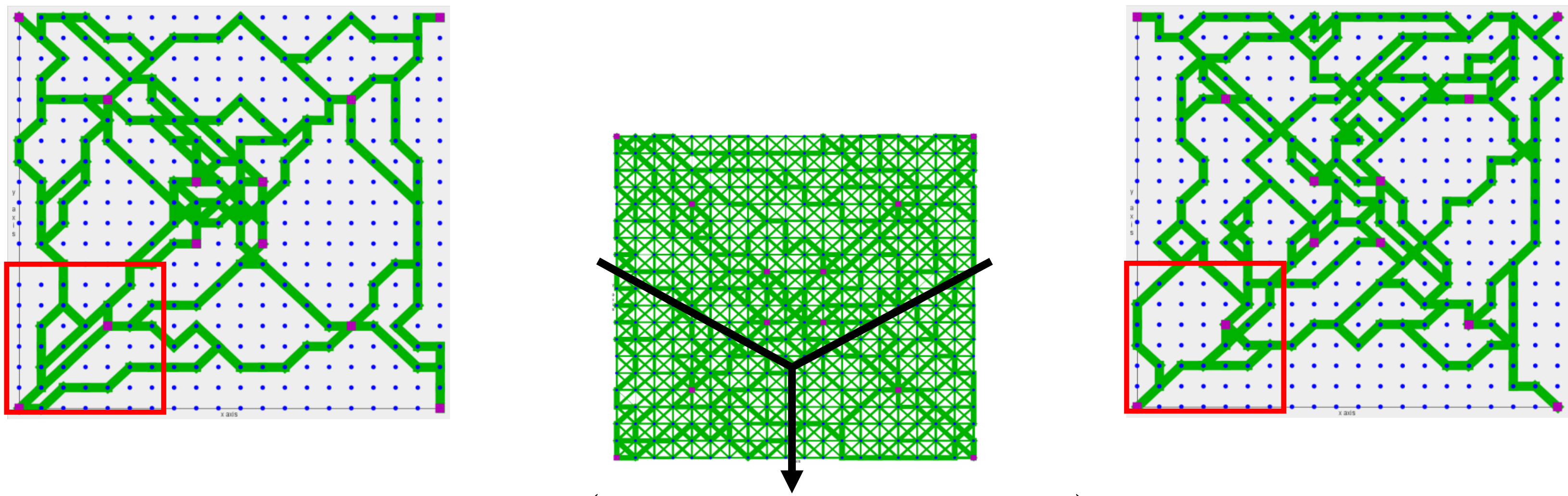




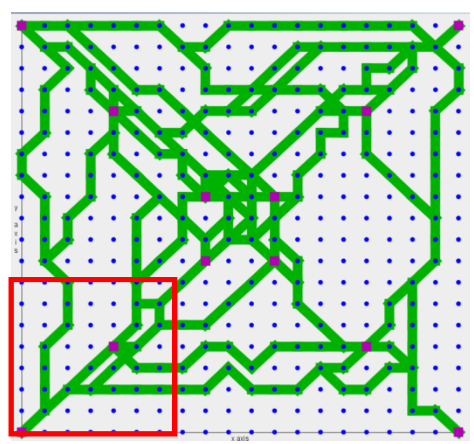
Design - Integrated Ant Colony Genetic Algorithm



Design – recombination procedure



$$p = f\left(\text{"}\,pheromone\text{"},\, random\ term \right)$$



Design – path picking and pheromones update

$$p_{ij}^{g}=\begin{cases}\dfrac{e^{\alpha\tau_{ij}^{g}}e^{\beta r}}{\displaystyle\sum_{l_{ij}\in L_{Parents}} e^{\alpha\tau_{ij}^{g}}e^{\beta r}}, & when\ l_{ij}\in L_{Parents}\\ 0, & otherwise\end{cases}$$

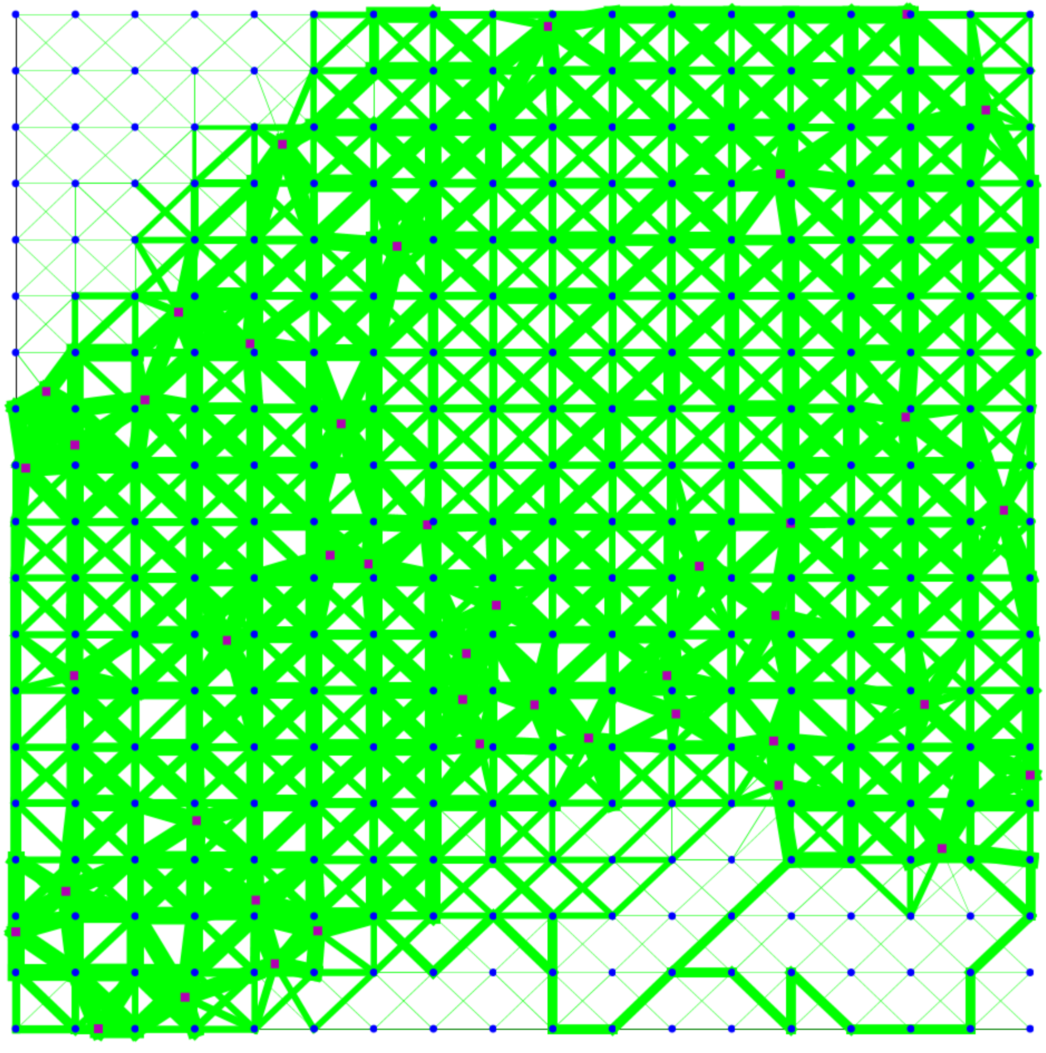
$$\tau_{ij}^{g}=(1-\delta)\cdot\tau_{ij}^{g-1}+\max\left(\Delta\tau_{ij}^{g}\right)$$

τ_{ij}^{g} : Pheromone density in iteration g on link $i-j$.

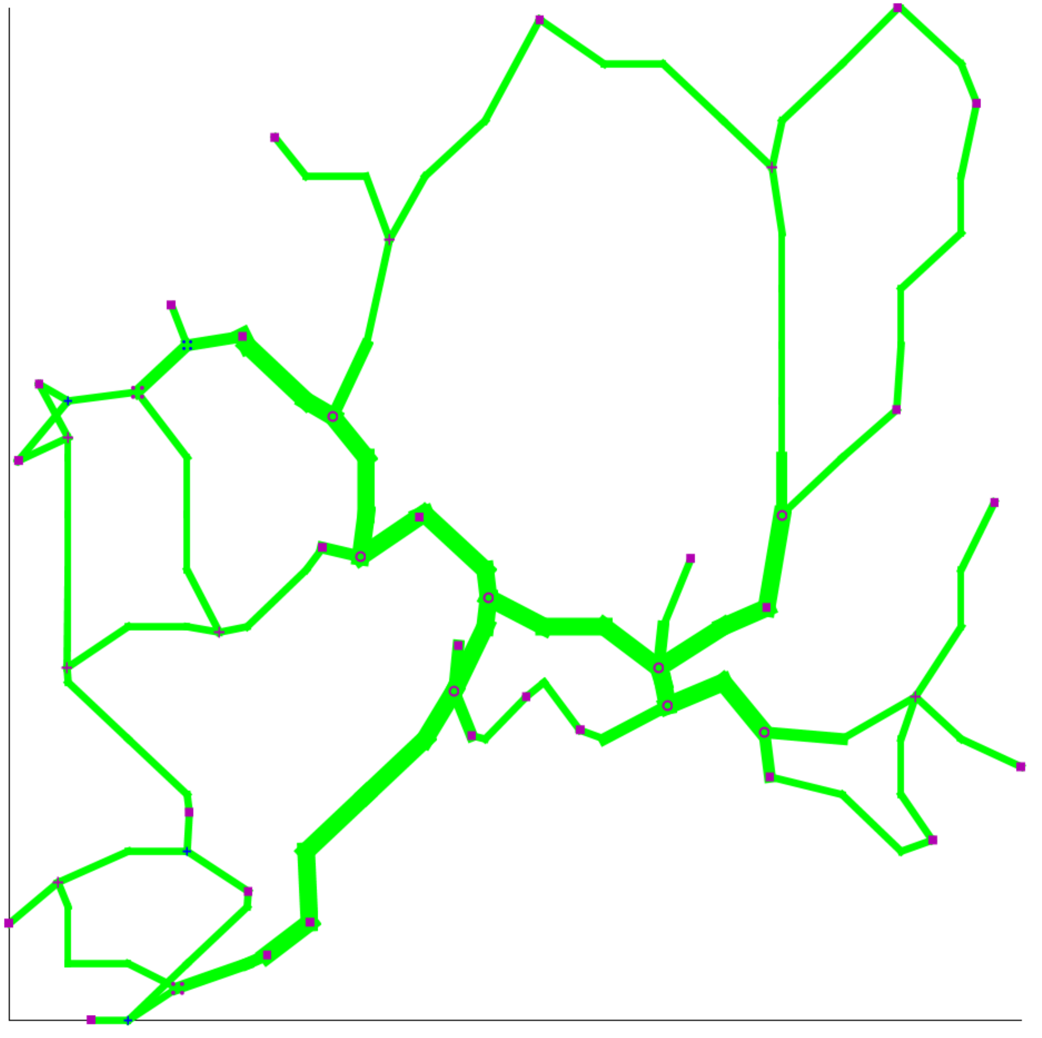
δ : Evaporation rate.

$\max\left(\Delta\tau_{ij}^{g}\right)$: Score of the best individual out of all processed network individual.

Results – pheromone development (generation 100)



Results – capacities (generation 100)



Results – comparison of IACGA and GA (approximation)

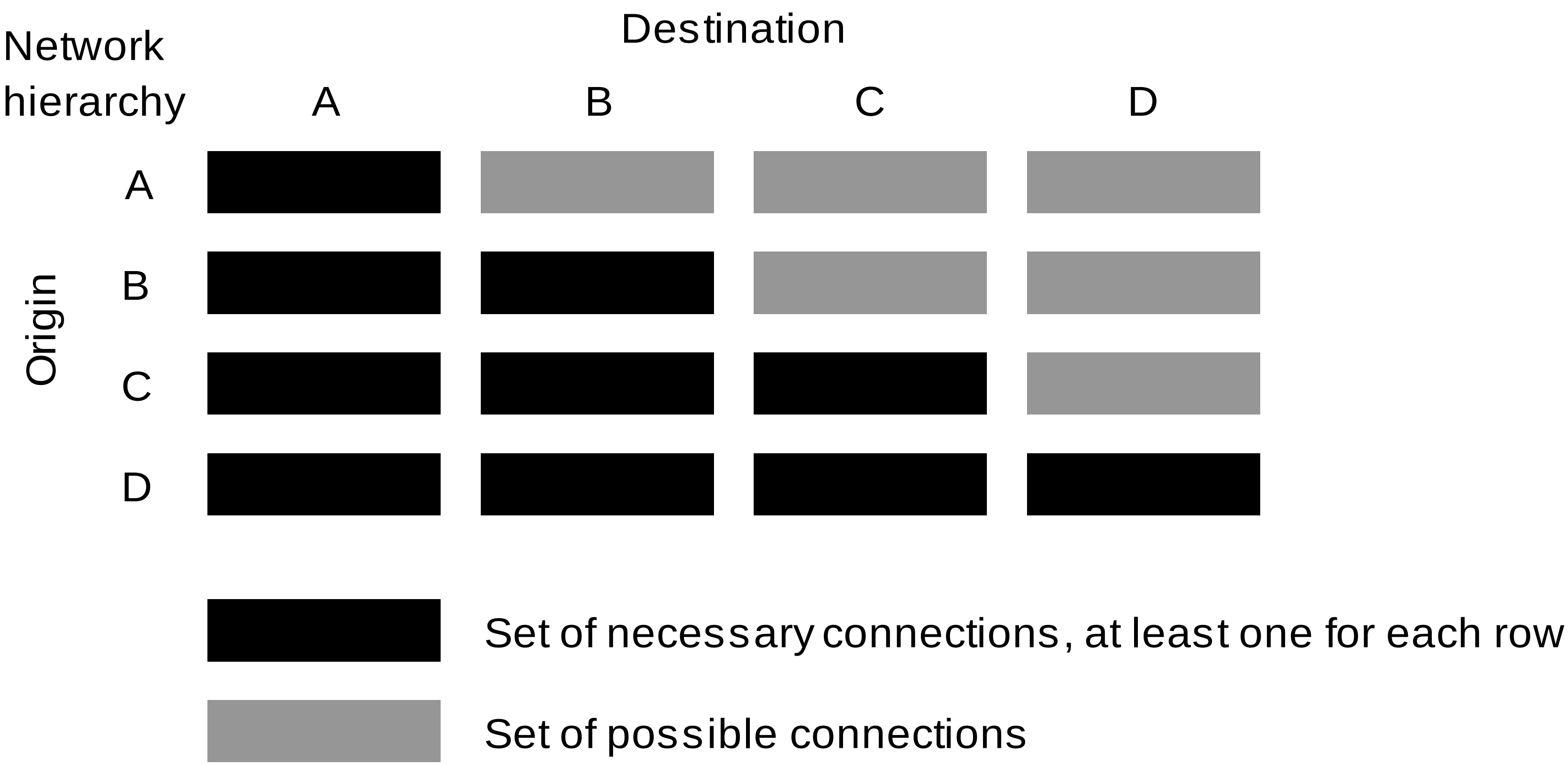
Network size [nodes]	Objective functions evaluated [numbers]			Total calculation time [h]		
	GA	IACGA	Difference	GA	IACGA	Difference
100	200’000	54’000	-73.00%	6	0.75	-88.5%
225	$1.7 \cdot 10^{8}$	140’000	-99.92%	5’100	2	-99.96%
400	$\sim 1.1 \cdot 10^{9}$	700’000	-99.94%	33’000	124	-99.62%

Source: Vitins and Axhausen (2010)

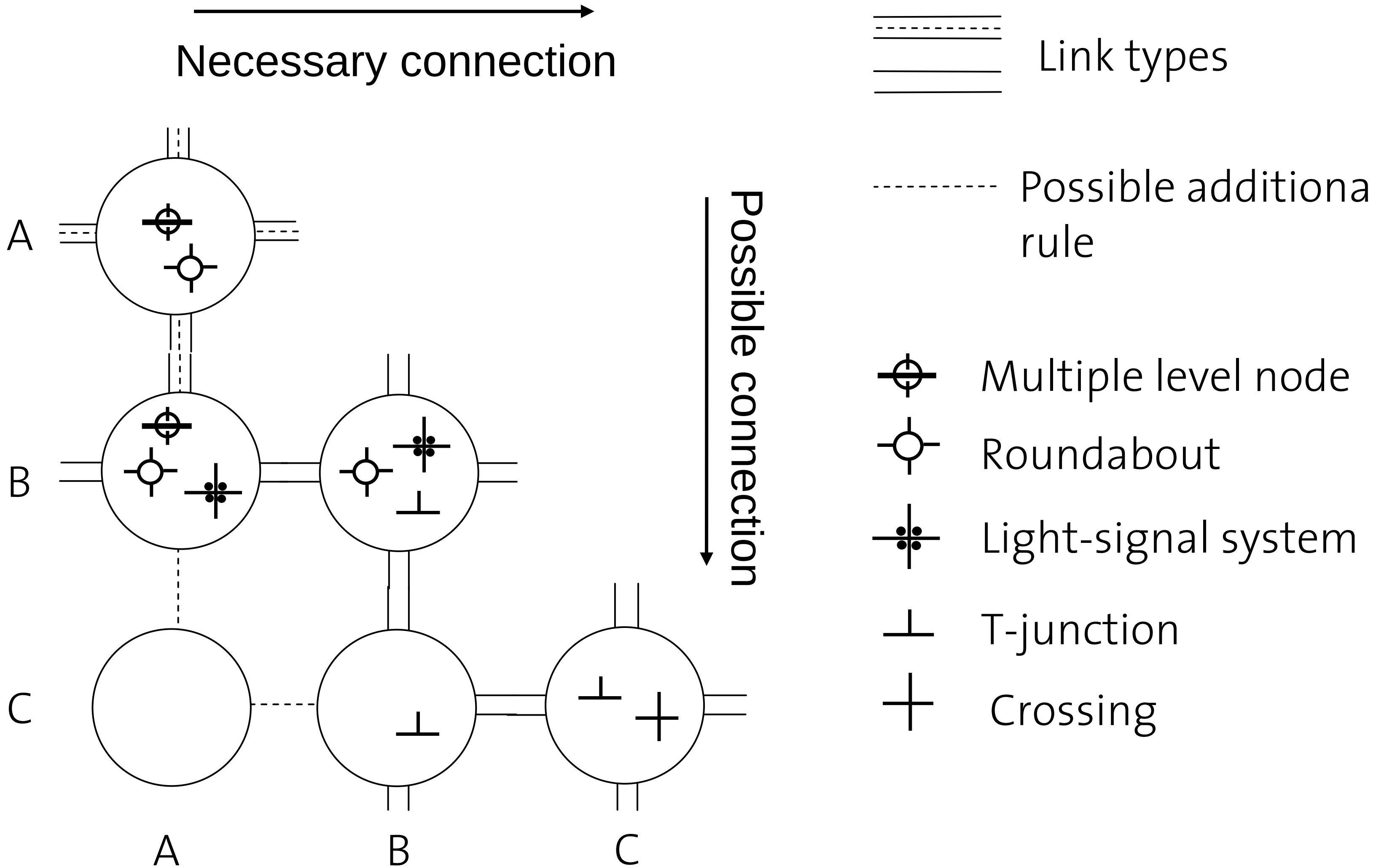
Results – quality (420 candidate links, n = 73)

Best possible score	Share of optimal networks	Standard deviation	Standard error
Without degraded initial population			
-2’432	51%	0.67%	3.37
With degraded initial population			
-2’432	55%	0.79%	3.90

Application – abstract shape grammars



Application – possible shape grammars



Source: after Marshall (2005)

Application – implemented shape grammars

	Initial setting 1			Initial setting 2 (n = 3)	
Shape grammar	Average score	Relative difference	Wilcoxon rank-sum	Average score	Relative difference
A	-143'200	-		-300'192	-
B	-147'132	2.75%	0.0087% (n=20)	-317'145	5.65%
C	-116'550	-		-250'895	-
D	-129'297	10.94%	0.15% (n=10)	-303'507	20.97%

Outlook

Faster and more precise…

Implement other network elements and land use parameters

Include land use and variable demand

Visualization

References

Google Earth (2010) http://earth.google.com/, September 2010.

Marshall, S. (2005) *Streets & Patterns*, Spon Press, London.

Procedural (2010) www.procedural.com, September 2010.

Vitins,B.J. and K.W. Axhausen (2010) Patterns and Grammars for Transport Network Generation, paper presented at the *10th Swiss Transport Research Conference*, Ascona, September 2010.