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A new Evolutionary Algorithm for Transport Network Generation and Shape Grammars Development in Urban Systems

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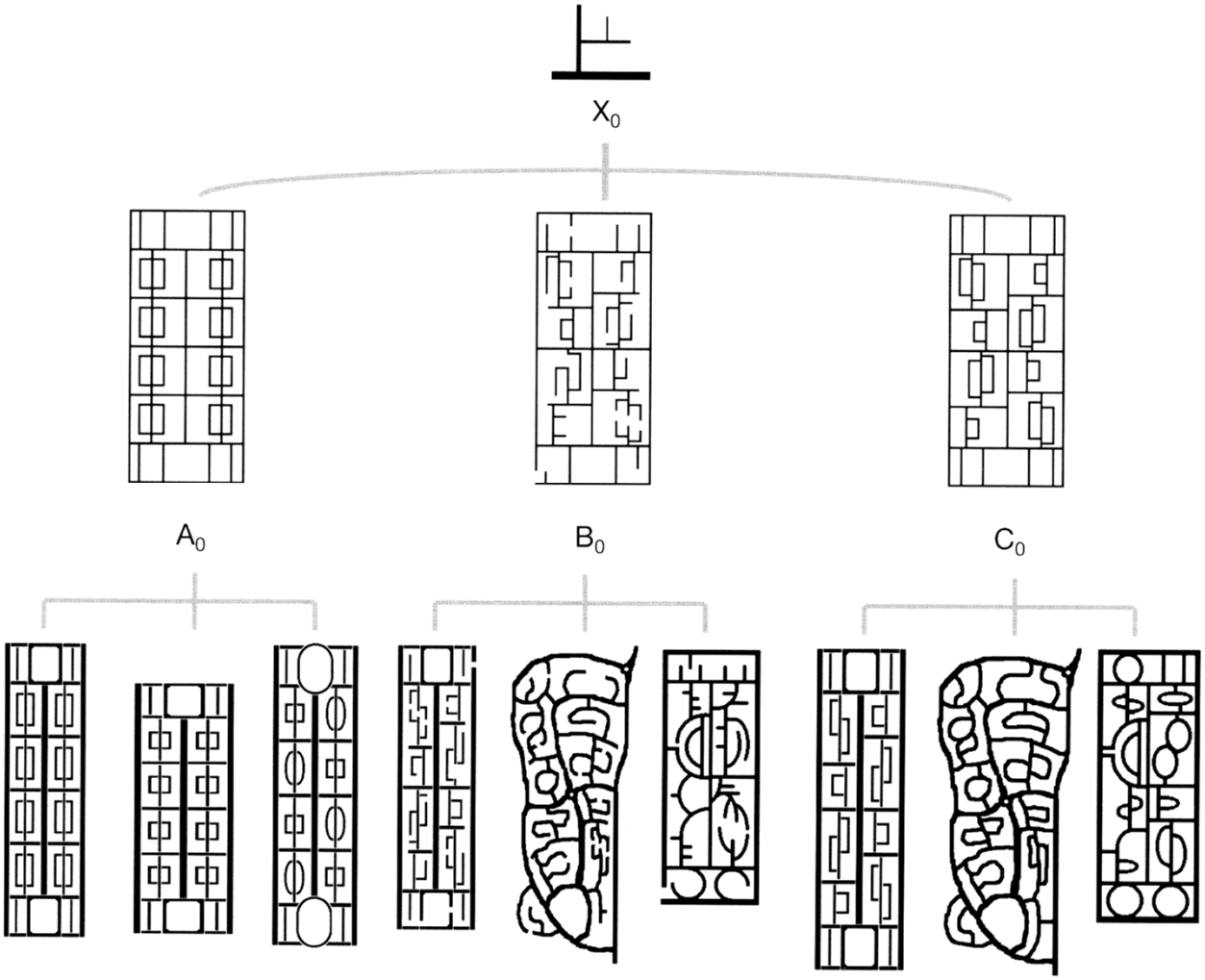
Application



Source: Marshall (2005) p. 227

Shape grammars

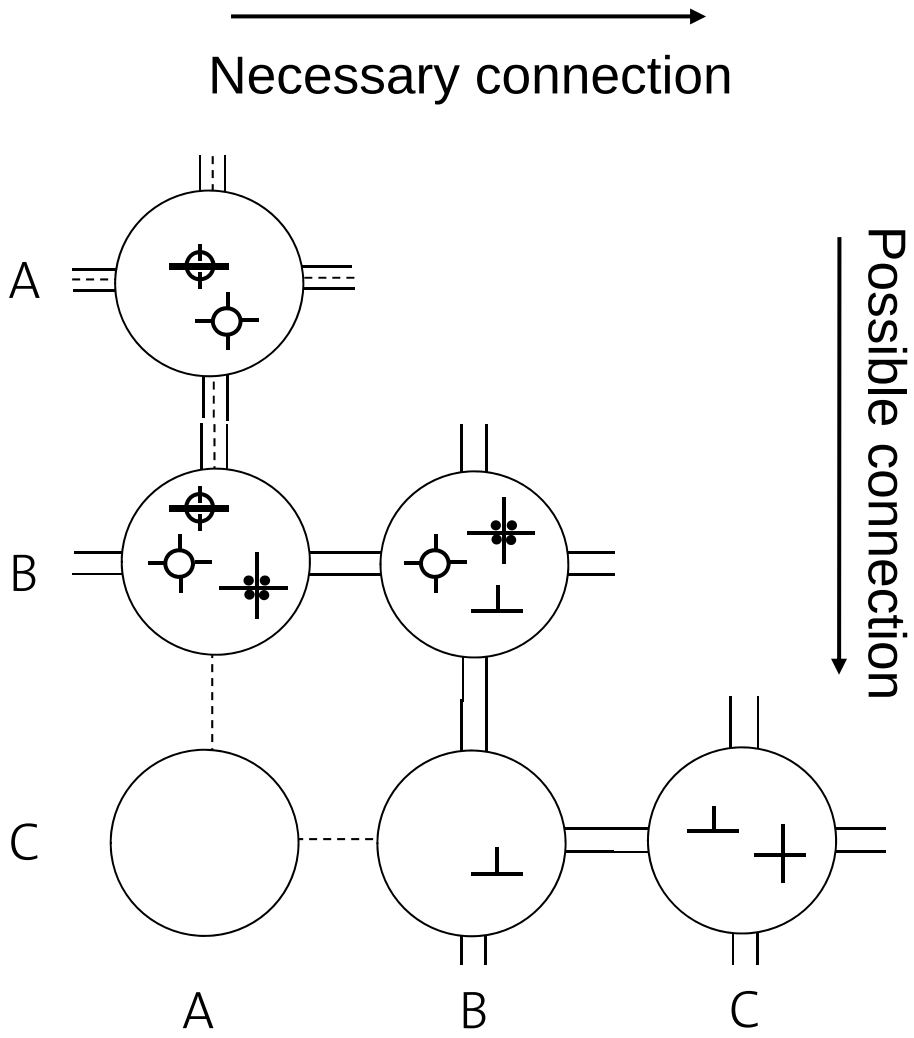
for practitioners of urban planning

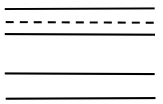
for standards in handbooks

for modeling urban systems

for building up and restructuring entire urban systems

Possible shape grammars





Link types

Possible additional rule

Multiple level node

Roundabout

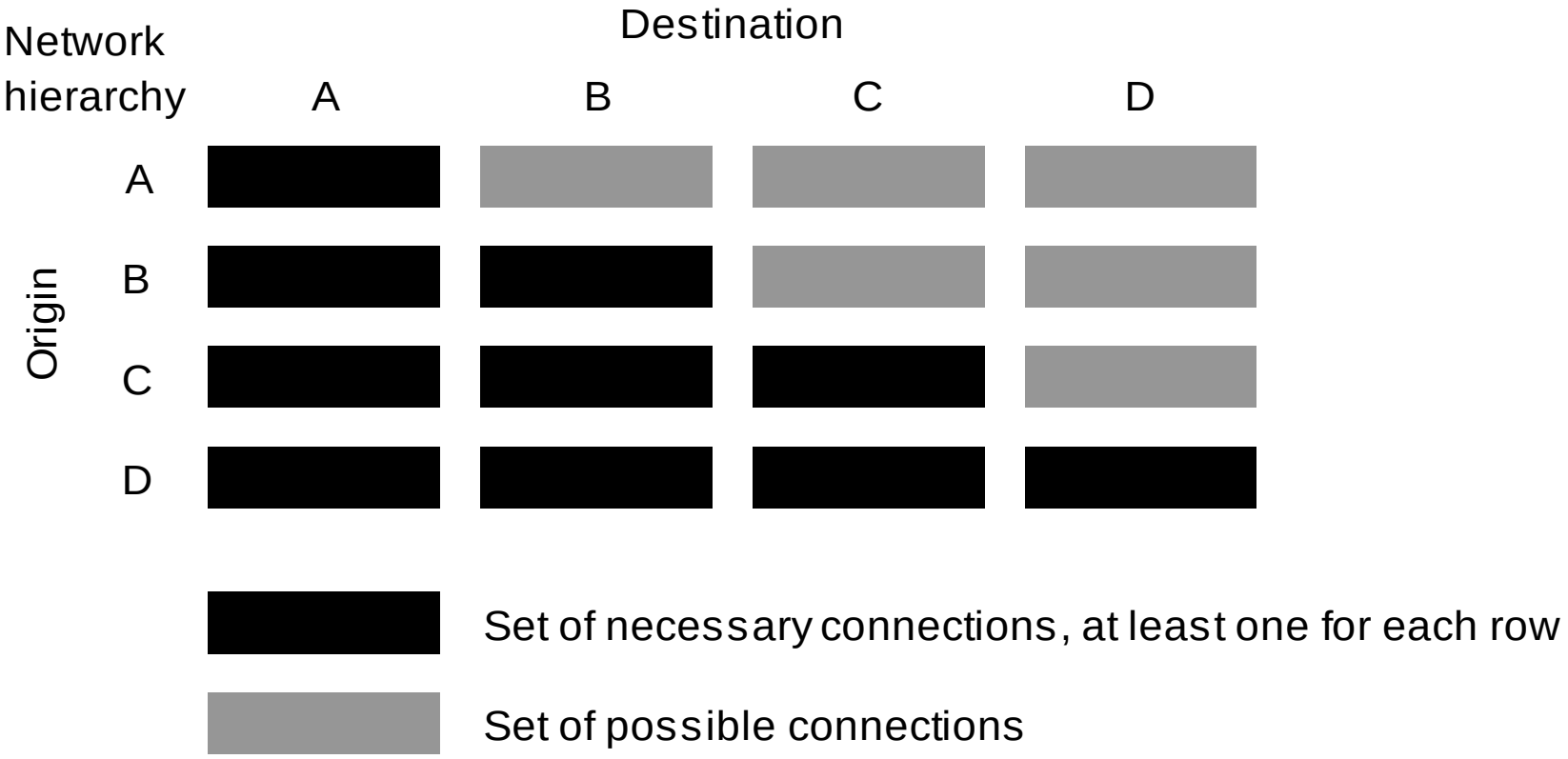
Light-signal system

T-junction

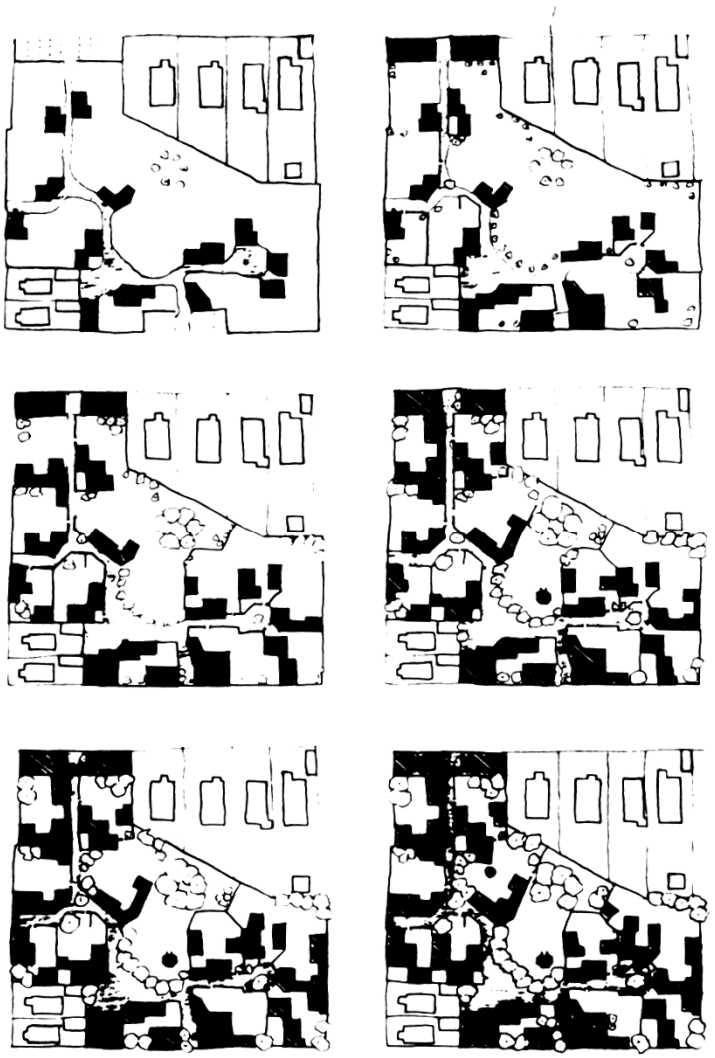
Crossing

Source: after Marshall (2005)

Abstract shape grammars

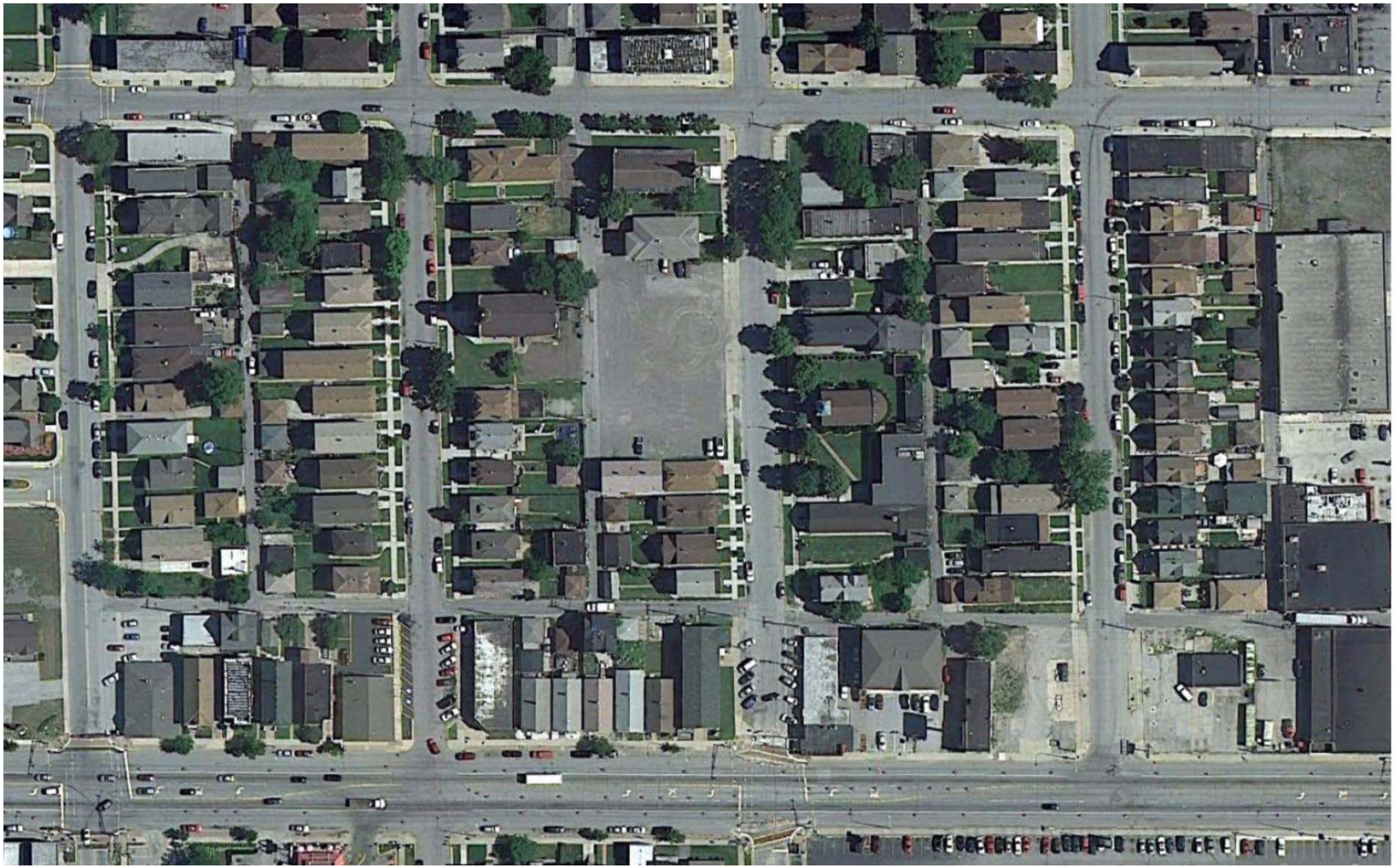


Pattern language



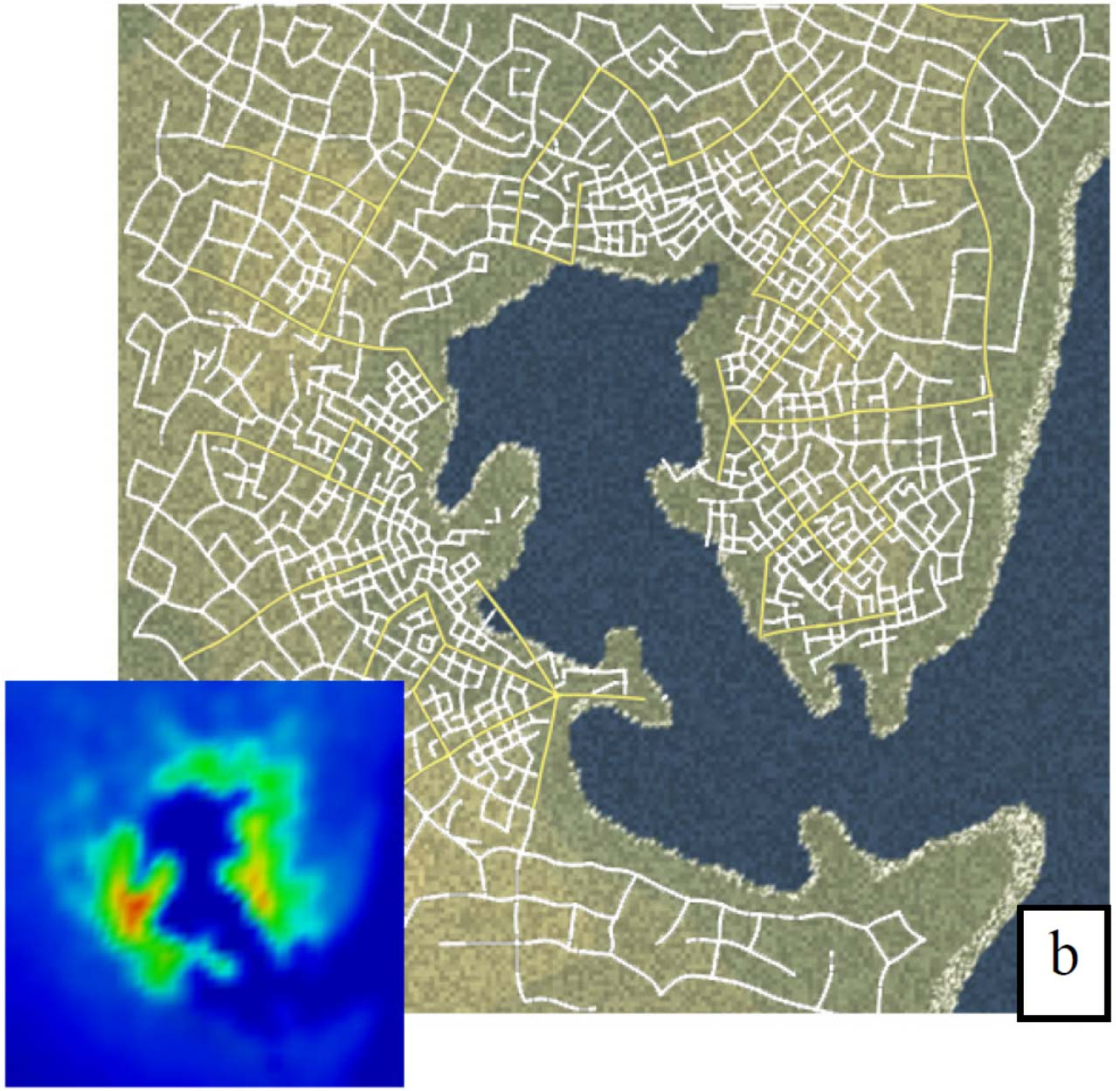
Source: Alexander (1977) p.190, p.489

Example network of East Chicago



Source: Google Earth (2010)

Example: City Engine



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

Objective functions

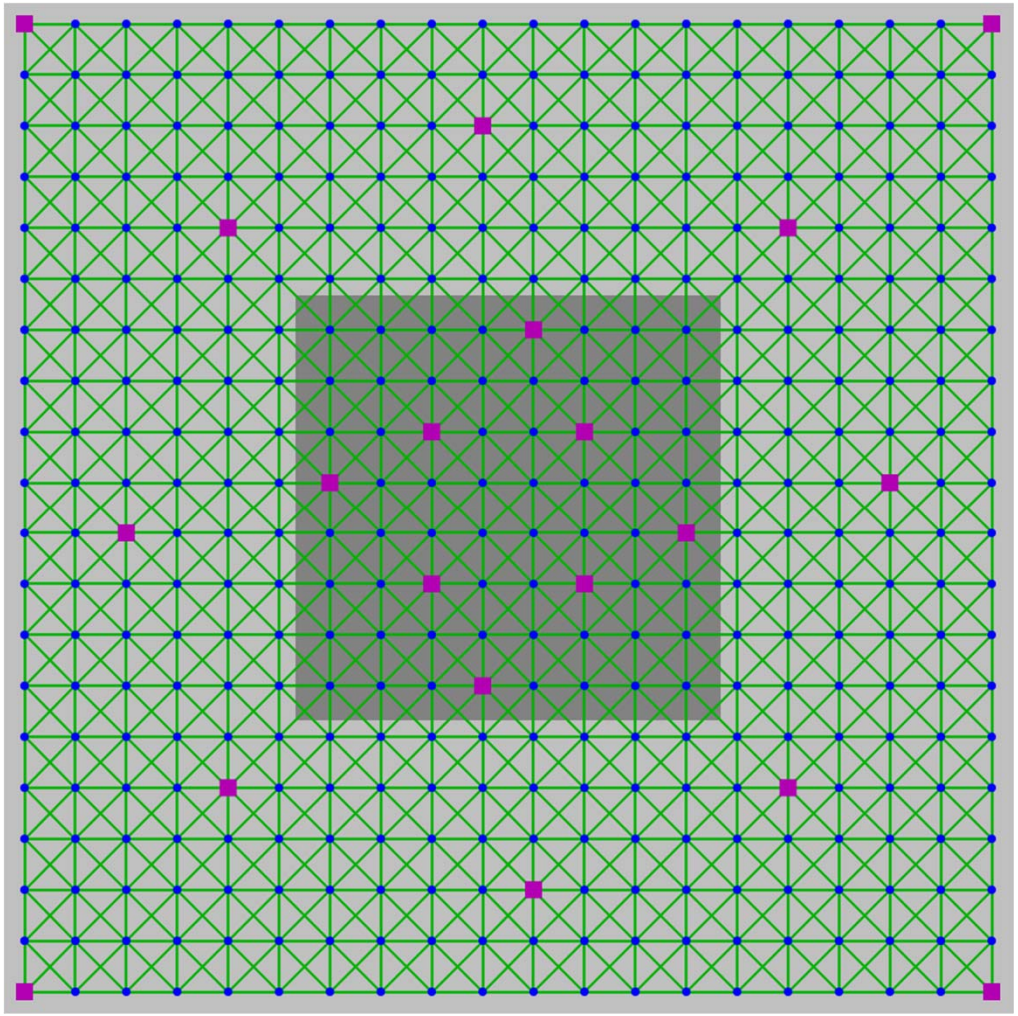
Costs:

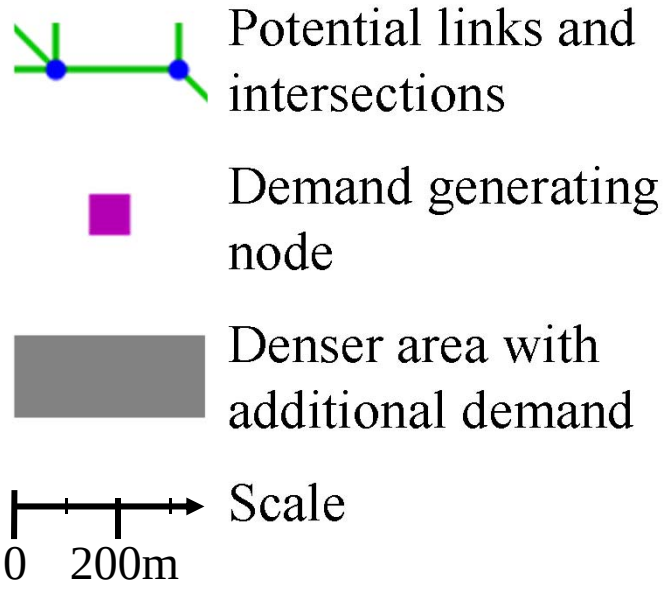
$$f = \left(Generalized\ Costs, External\ Costs, ..., Infrastructure\ Budget\right)$$

Accessibility:

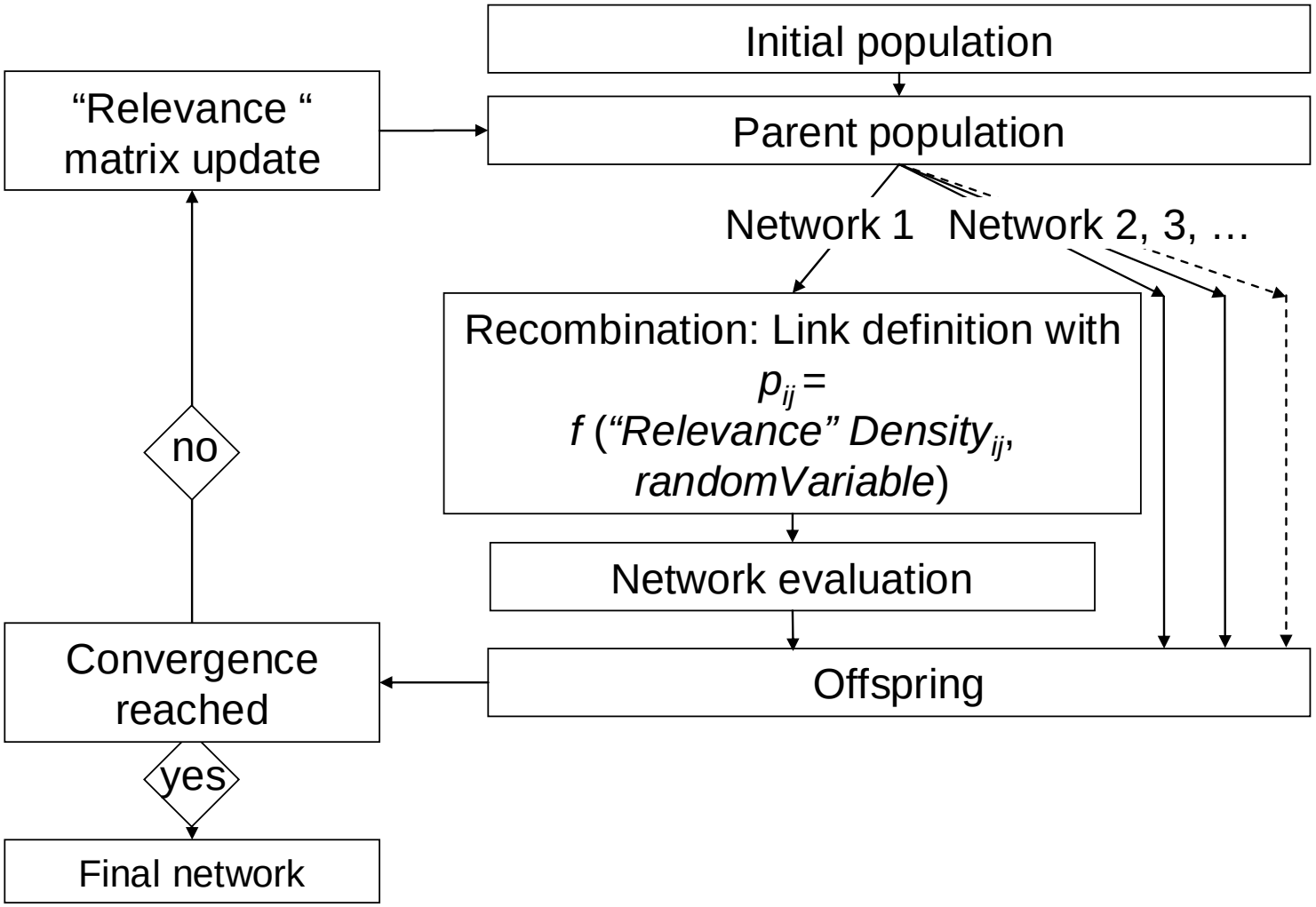
$$f = \sum_{o=1}^{O} I_o \cdot \ln\left(\sum_{d=1}^{D} A_d \cdot \exp(-\beta \cdot t_{od})\right) - Infrastructure\ Budget$$

Initial network setting

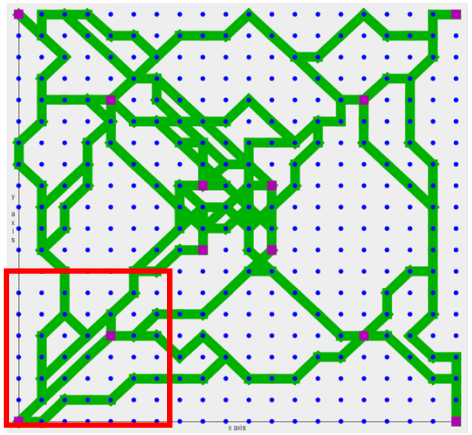


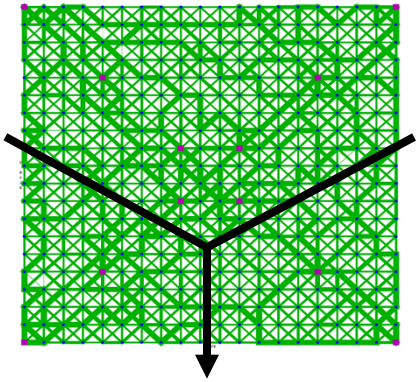


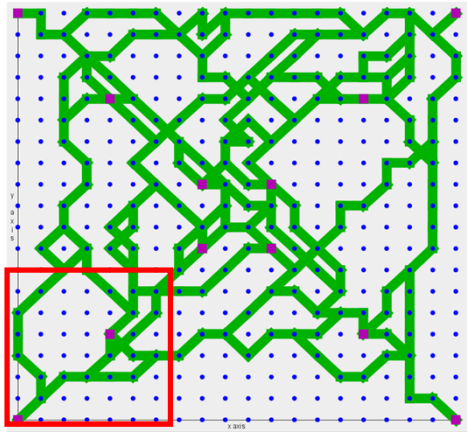
Overview Integrated Ant Colony Genetic Algorithm IACGA



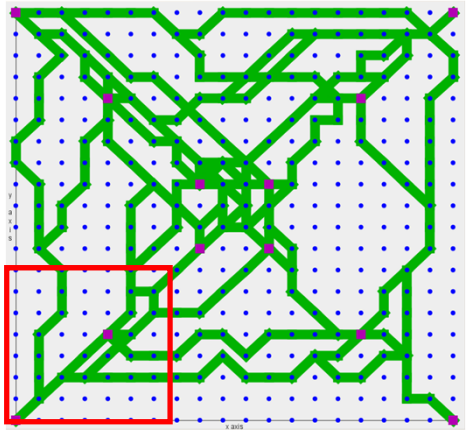
Merging procedure





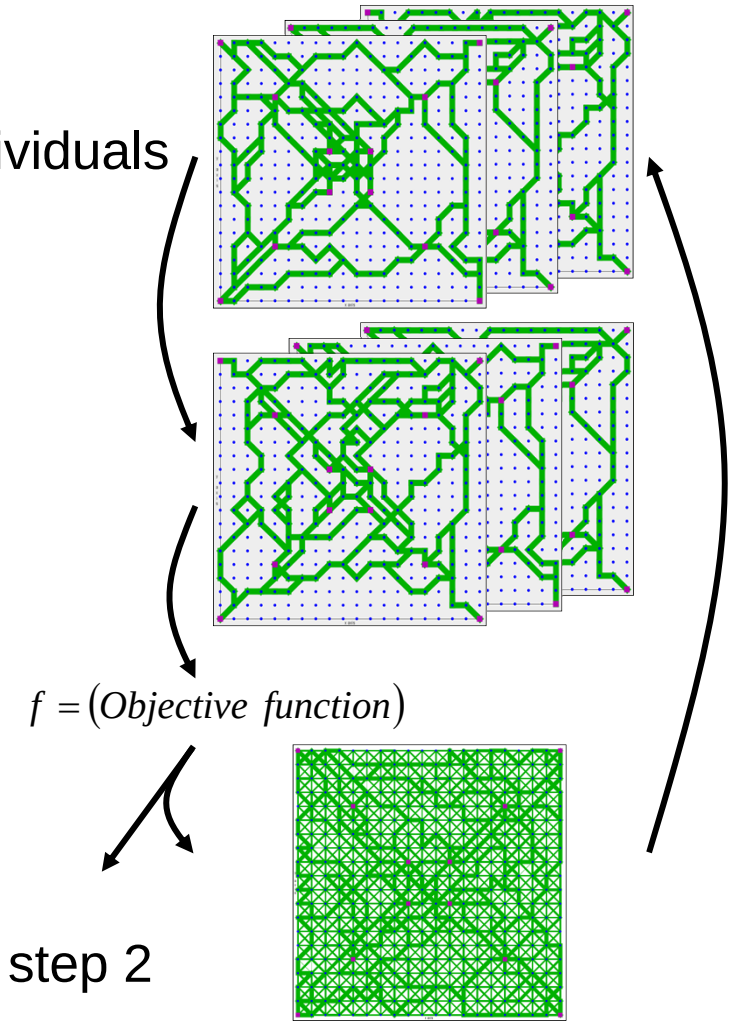


$$p = f\left("relevance\ matrix", random\ term\right)$$



Overview Integrated Ant Colony Genetic Algorithm IACGA

1. Initialize population with random individuals
2. Generate breed out of ancestors, using “relevance” matrix
3. Assess individuals in the breed
4. Update “relevance” matrix
5. Ancestors = breed
6. If convergence is not reached, go to step 2



“Relevance” matrix and intermediate networks

[Movie without shape grammars]

“Relevance” development and intermediate networks

[Movie with shape grammars]

Comparison of IACGA and GA – first estimation

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	~$1.1 \cdot 10^9$	700’000	-99.94%	33’000	124	-99.62%

Source: Vitins and Axhausen (2010)

Next steps

Implement link type optimization (capacity, speed, …)

Include land use and variable demand

Visualization

References

Alexander, C. (1977) *The Timeless Way of Building*, Oxford University Press, New York.

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Vanegas, C.A., D.G. Aliaga, B. Benes, P.A. Waddell (2009) Interactive design of urban spaces using geometrical and behavioral modeling, *ACM Transactions on Graphics*, **28** (5) 1-10.

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