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Investigations on Cartographic Constraint Formalisation

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Outline

- Introduction – EuroSDR-project “state-of-the-art” of commercially available generalisation software
- Typology of cartographic constraints
- Comparison of different NMA specifications
- Constraint formalisation
- Evaluation of generalisation solutions

Introduction

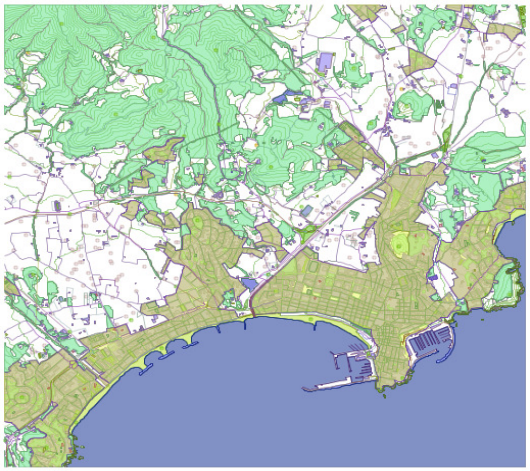
- EuroSDR-project objectives:
  - studying the state-of-the-art of commercially available generalisation software

    "to establish by a small set of controlled tests
    the state-of-the-art in generalisation,
    particularly with reference to … map production,
    … to inform both potential users and ongoing research"

    + software suppliers
  - focus is set on the generalisation of a complete topographic data sets at scales larger than 1:50k
- Timetable (start of the project Oct 2006)
  - testing from 1st of June till1st of Nov 2007

Introduction

- Definition of case studies covering areas in different countries
- Preparation of test data based on simplified data models
- Specification of cartographic requirements (*constraints*) for the target maps

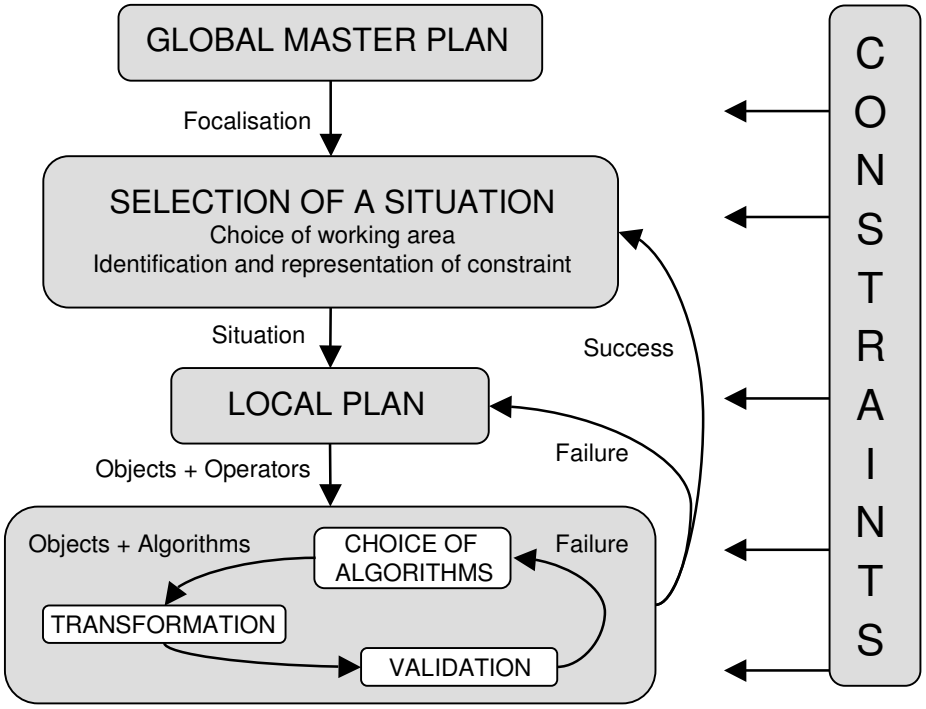


ICC data set (costal area)

TDK data set (rural area)

OSUK data set (urban area)

The usage of cartographic constraints in automated generalisation



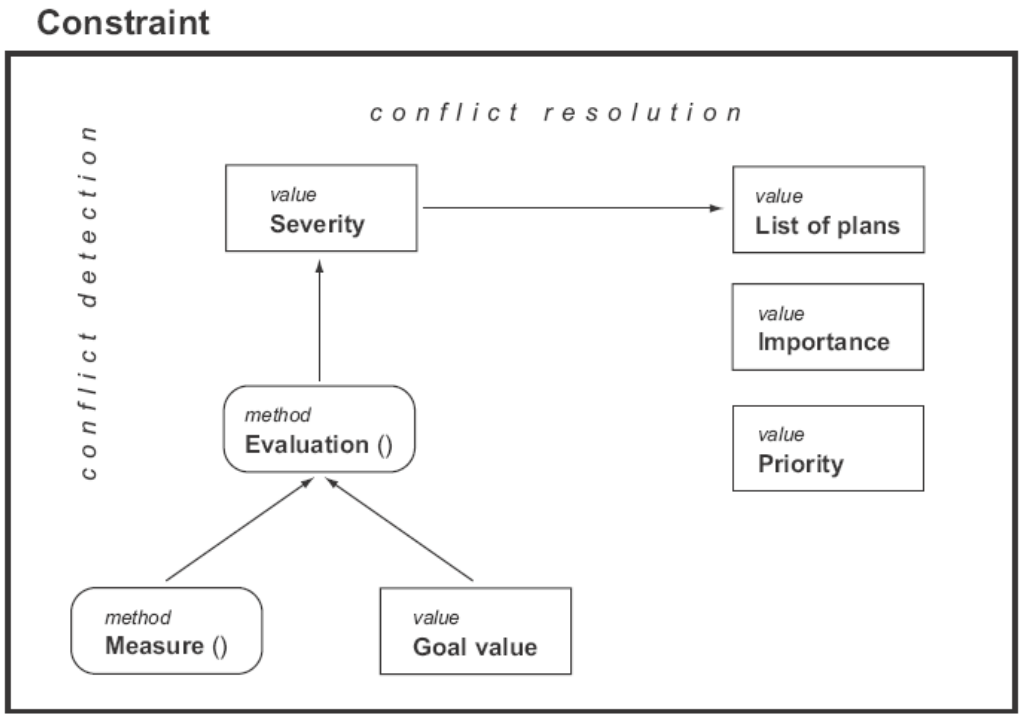
Generalisation process model with the utilisation of constraints (Ruas and Plazanet, 1996)

Cartographic constraints

Constraint definition from AGENT

The effect of constraints is to reduce the number of possible results of a process, while at the same time increasing the proportion of acceptable ones.

- *Cartographic constraints* (arising from characteristics of data and map specifications)
- *Process constraints* (arising from resource limitations and workflows)



Galanda, M. (2003) Automated Polygon Generalization in Multi Agent System. Dissertation

Cartographic constraints

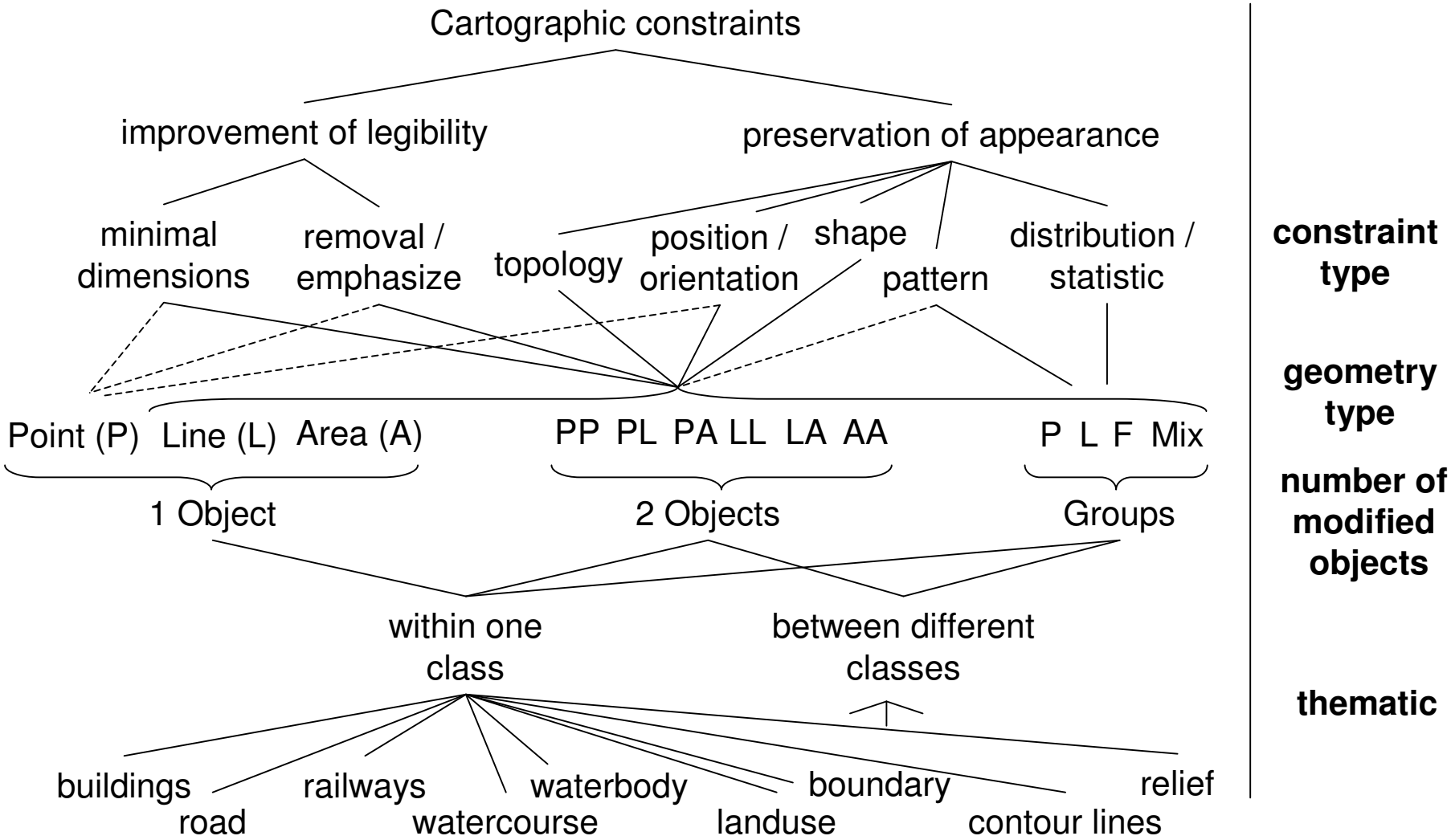
Constraint template

	A	B	C	D	E	F	G	H	I	J	K	L
1	Constraint ID	Class 1	Condition for object being concerned with this constraint	Class 2	Condition (in the initial data) for object being concerned with this constraint	Condition on the both objects (in the initial data) for them to be concerned with this constraint	Constrained property	Condition to be respected in the final data (do not forget the units)	Importance of constraint	Exceptions	Schema to illustrate if needed or comment	Comments if needed
2	IGN-2-1	Building		Building		Buildings are not topologically adjacent (sharing an edge)	Minimal distance between their symbols	> 0.1 map mm	3			
	IGN-2-2	Building		Building		Buildings are topologically adjacent (sharing	Adjacency	Buildings must remain adjacent	1			

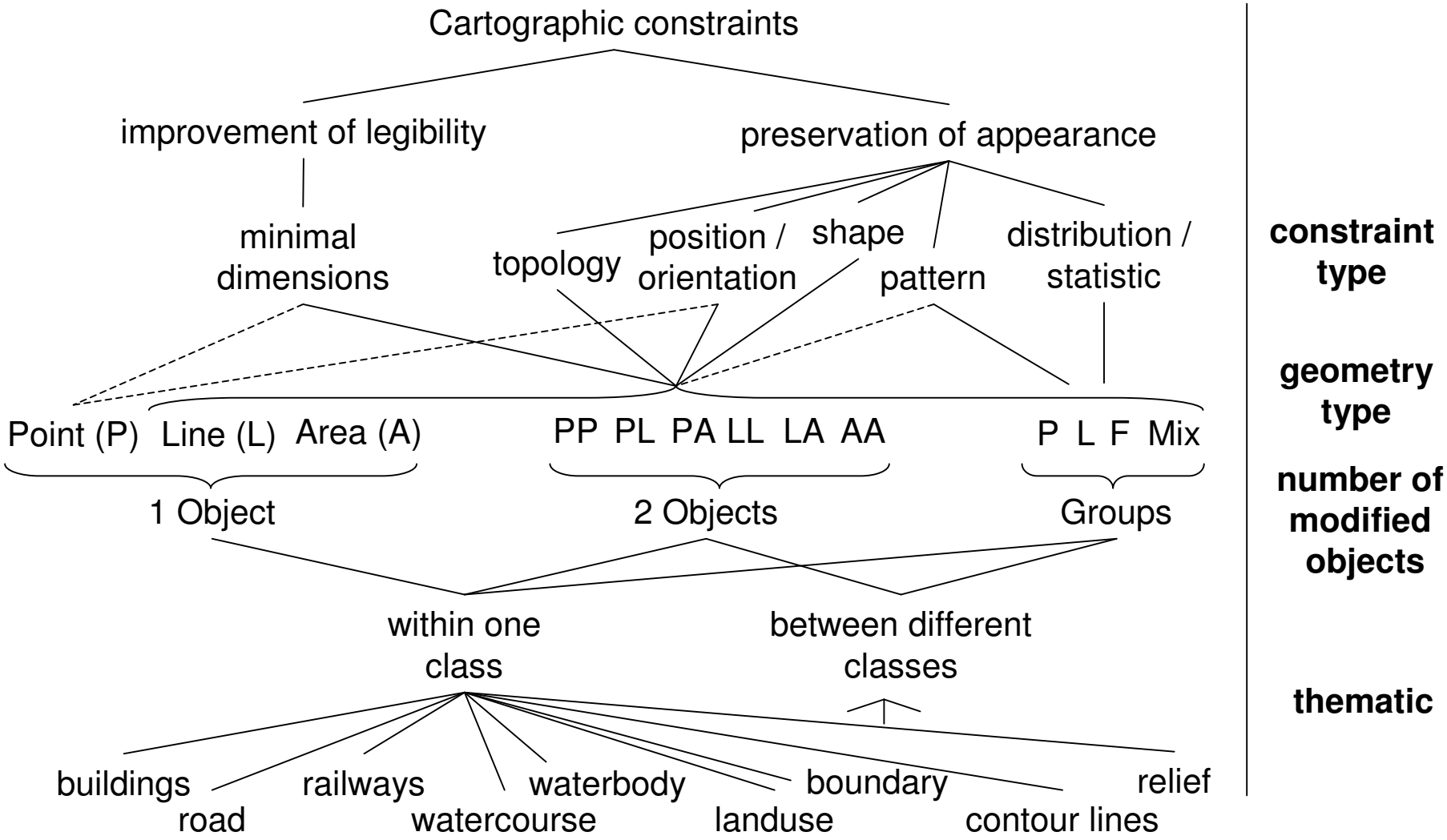
Constraints on one object | **Constraints between two objects** | Constraints on a group of ob

the constraints template were filled out by the four NMA specifically for the test cases of the EuroSDR project, i.e. the constraints that were generated are not meant to offer a complete description of cartographic generalisation output

Constraint typology



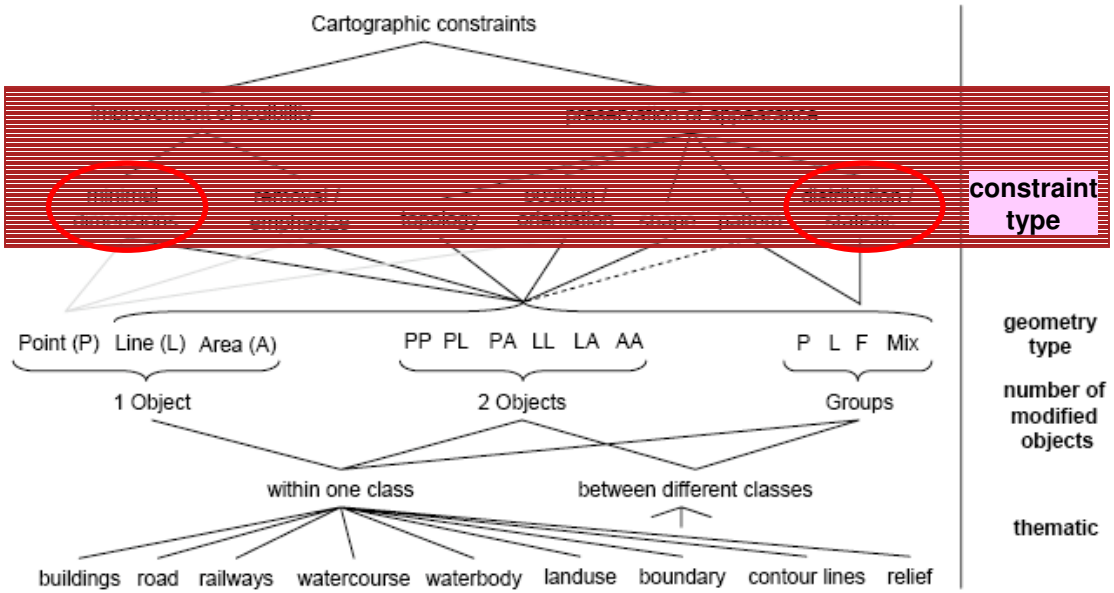
Constraint typology



Comparison of NMA specifications

Frequency distribution according to the constraint type:

- Constraint type of **preserving minimal dimensions** plays the most important role in all specifications.
- Statistic and distribution constraints are rare.
- Number of constraints differs strongly between the different specifications.



	ICC		IGN		TDK	
Minimal dimensions	79	54%	18	33%	26	43%
Removal / emphasize	26	18%	3	6%	29	48%
Topology	14	10%	9	17%	4	7%
Position / orientation	6	4%	6	11%	1	2%
Shape	6	4%	7	13%	0	0%
Pattern	10	7%	6	11%	0	0%
Distribution / statistics	5	4%	5	9%	0	0%

Comparison of NMA specifications

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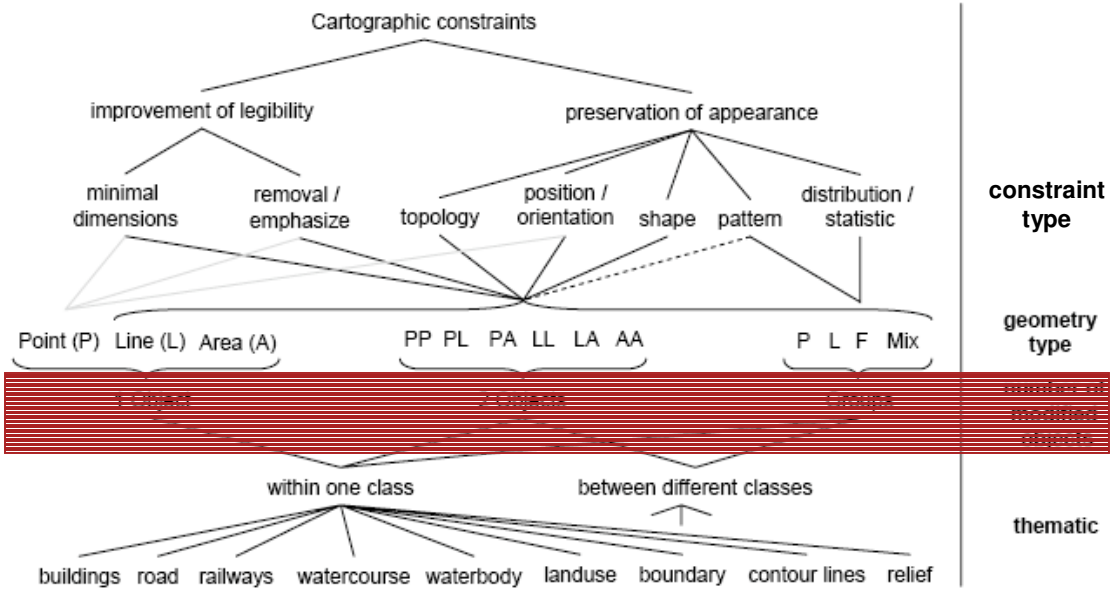
Frequency distribution according to the number of modified objects:

- Most of the constraints refer to one object whereas fewer constraints are defined for two or more objects.
- Constraints for group objects often refers to building themes.



	ICC	IGN	TDK
Constraints on one object	98	32	23
Constraints on two objects	27	13	17
Constraints on a group of objects	30	12	2

Comparison of NMA specifications

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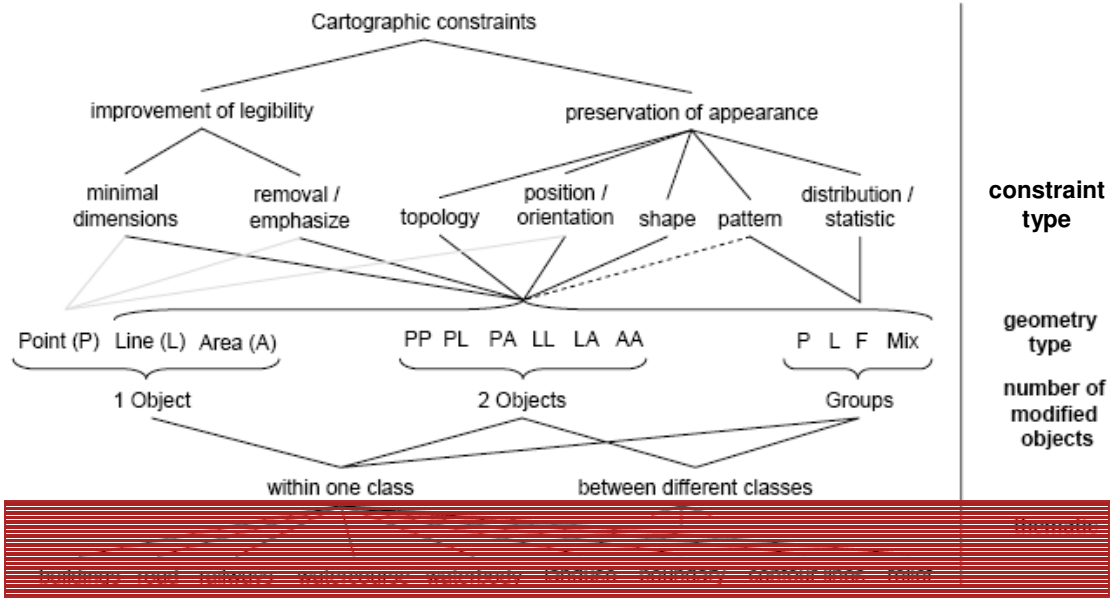
Frequency distribution according to the thematic scope:

- The large amount of constraints on building themes as well as on road themes is noticeable
- Boundary themes doesn't exist in the compared constraint specifications (exception: OSUK constraint specifications)



	ICC	IGN	TDK	Total
Building	49	36	12	97
Road	35	15	21	71
Railways	Doesn't exist	Doesn't exist	4	4
Watercourse	29	6	5	40
Waterbody	26	6	2	34
Landuse/Landcover	32	6	12	50
Contour lines	16	2	Doesn't exist	18
Boundary	Doesn't exist	Doesn't exist	Doesn't exist	0
Relief	2	2	Doesn't exist	4

Comparison of NMA specifications

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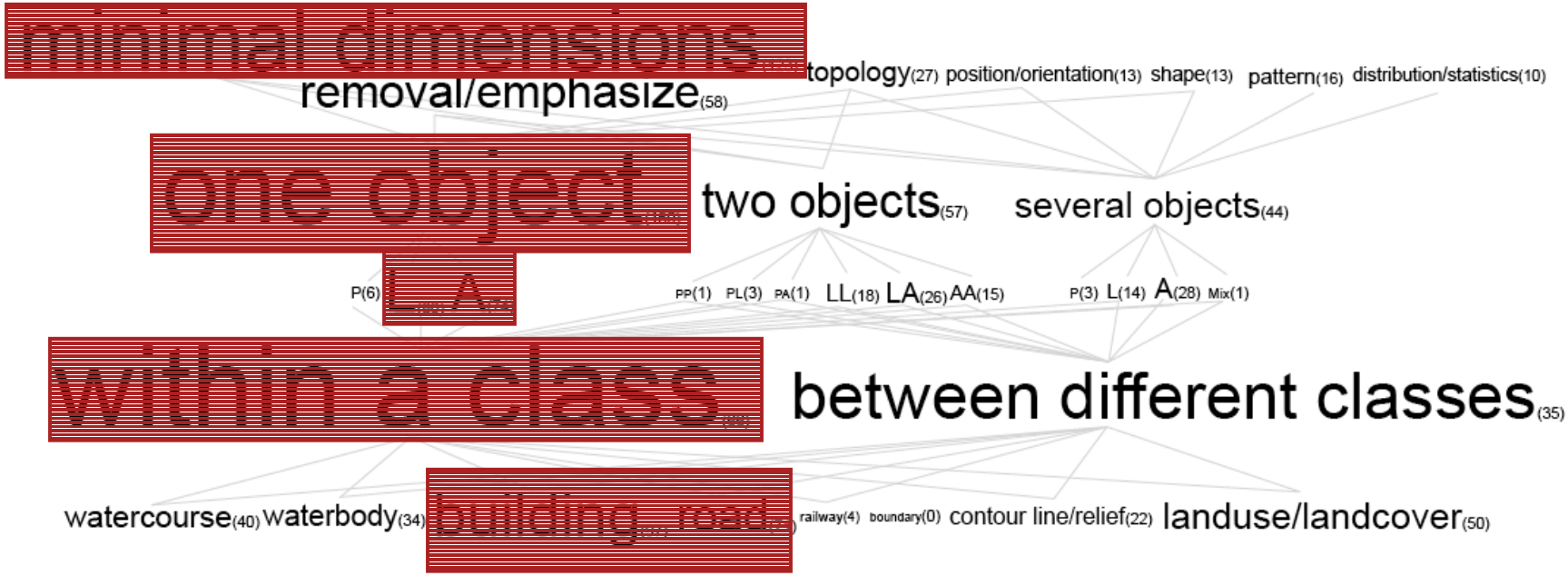
Illustration of frequency distribution based on the number of defined constraints:



Comparison of NMA specifications

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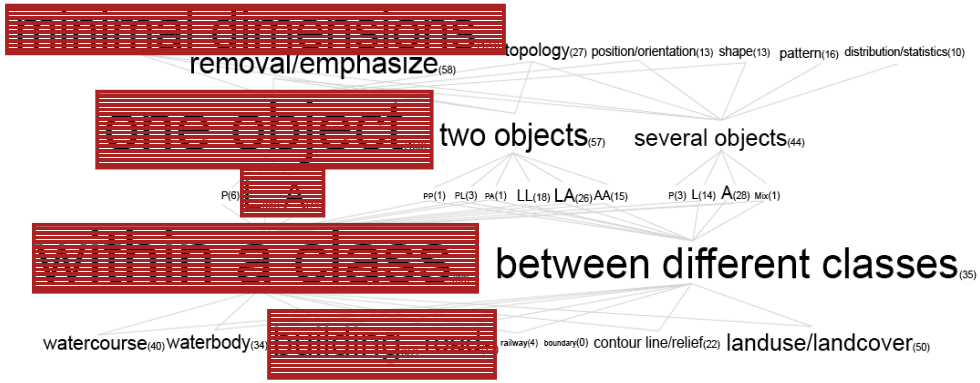
What are the reasons for the irregular frequency distribution of constraints?



Possible reasons:

- Number of constraints defined is proportional to number and complexity of map objects (effort needed on manual generalisation)
- Extend of scientific research (e.g. generalisation of building features is frequently object of interest)
- Incomplete handling, because focus was set only on specific data sets

Comparison of NMA specifications

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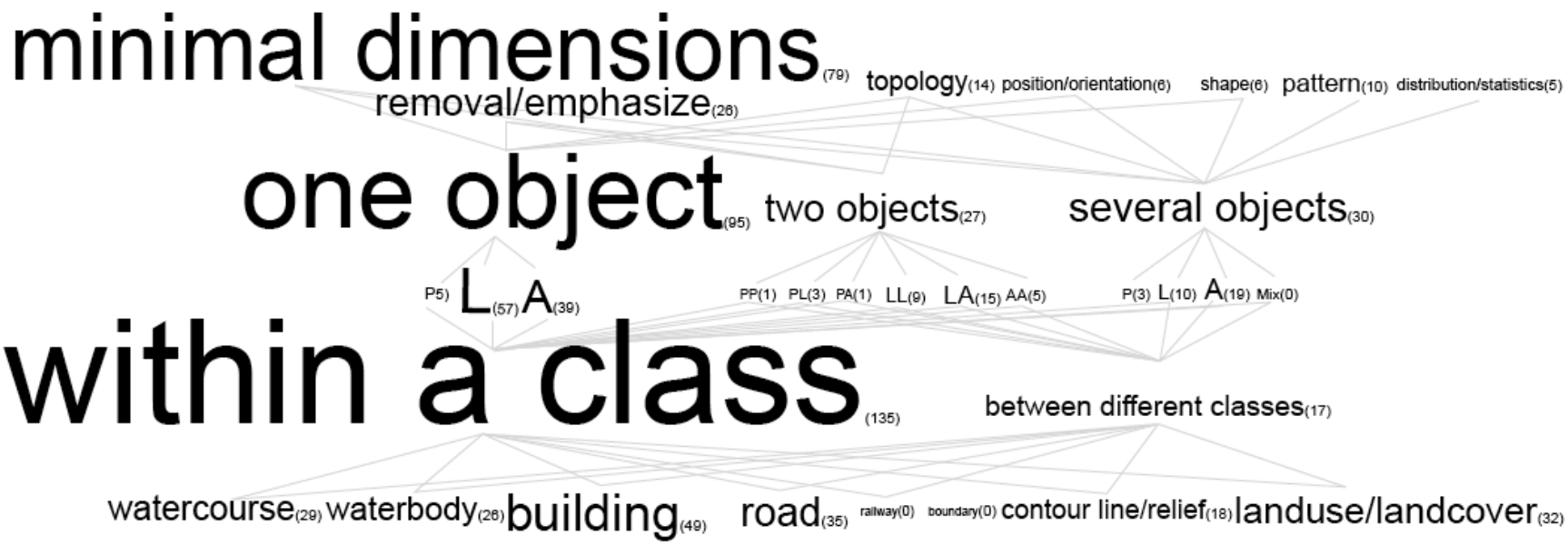
Illustration of frequency distribution based on the number of defined objects provided by **ICC**:



Comparison of NMA specifications

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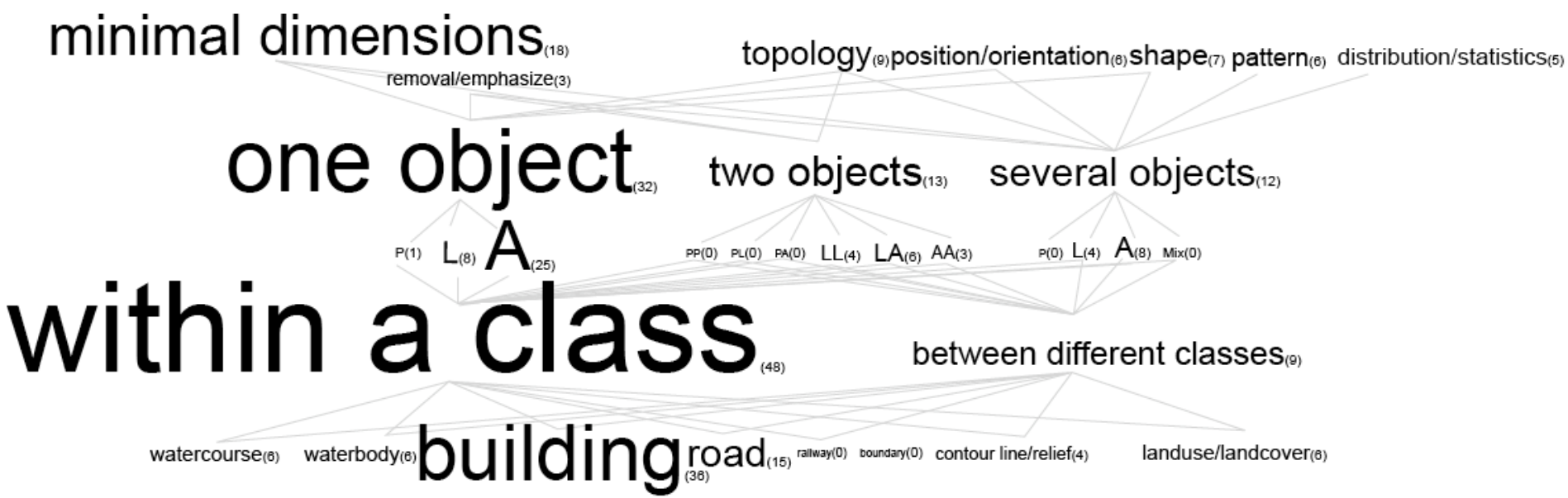
Illustration of frequency distribution based on the number of defined objects provided by **IGN**:



Comparison of NMA specifications

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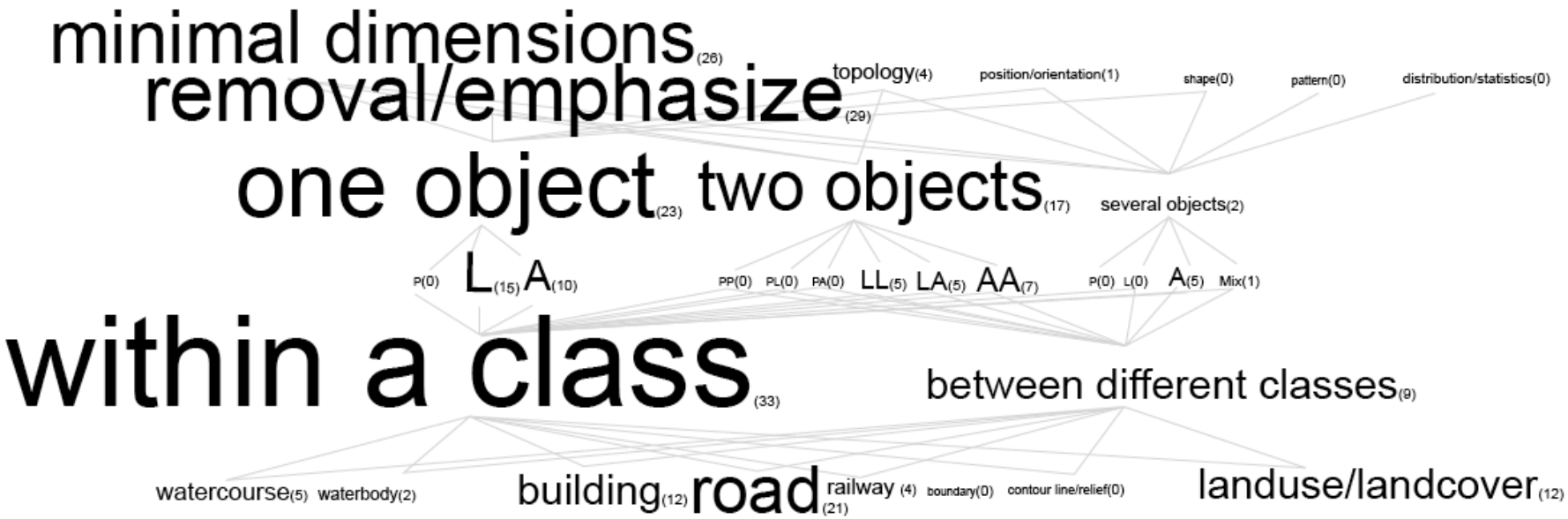
Illustration of frequency distribution based on the number of defined objects provided by **TDK**:



Harmonisation

Reason for harmonisation:

simplify **test** and **evaluation** procedures with the four different test data sets and the corresponding constraint specifications

harmonisation

data models

- Number and granularity of specified thematic classes varied, e.g.
  ICC had a more detailed data model at the beginning → more constraints
- Different handlings of unimportant objects (model generalisation)
  → more "removal" constraints

constraint specifications

- Constraint template itself
- Classification of constraints into two categories: specific / generic
- **Generic** constraints (within the project!) could be derived by comparing the different NMA constraint specifications

Formalisation

NMA	Class	Condition for object being concerned with constraint	Constraint property	Condition depends on initial value?	Condition to be respected
IGN	Building	Symbolisation ≠ 'Town hall' and initial_area < 30.0 terrain m_			Building should not appear in DCM
OSUK	Building	Size inferior to 0.16mm2	Size	No	Not displayed
ICC	Building	Isolated	Minimum area including holes	No	Maintain and area > 400 m2
TDK	Building	type_of_building ≠ “list 1” (see Comments column)	Length (edge or diameter)		Instance should not appear in DCM if length (edge or diameter) < 20 m

Generic Constraint ID	Geometry type	Condition for object being concerned with constraint	Constraint property	Condition depends on initial value?	Condition to be respected
EuroSDR 1-1	Polygon		Area	No	target area > x map mm^2

Degree of Formalisation

Concrete formalisation

Generic Constraint ID	Geometry type	Condition for object being concerned with constraint	Constraint property	Condition depends on initial value?	Condition to be respected
EuroSDR 1-16	Line and Polygon	Initially, no self-intersection	Intersection	Yes	No self-intersection must be created
EuroSDR 1-10	Polygon		Area of protrusion	No	target area > x map mm^2

Imprecise formalisation

Generic Constraint ID	Geometry type	Condition for object being concerned with constraint	Constraint property	Condition depends on initial value?	Condition to be respected
EuroSDR 1-1	Polygon	1:n relation (amalgamation)	General shape	Yes	target shape should be similar to initial shape

Process active vs. restrictive (condition-action vs. constrained based)

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condition (constraint) + generalisation action } rule

pure constraint

process active → ← **process restrictive**

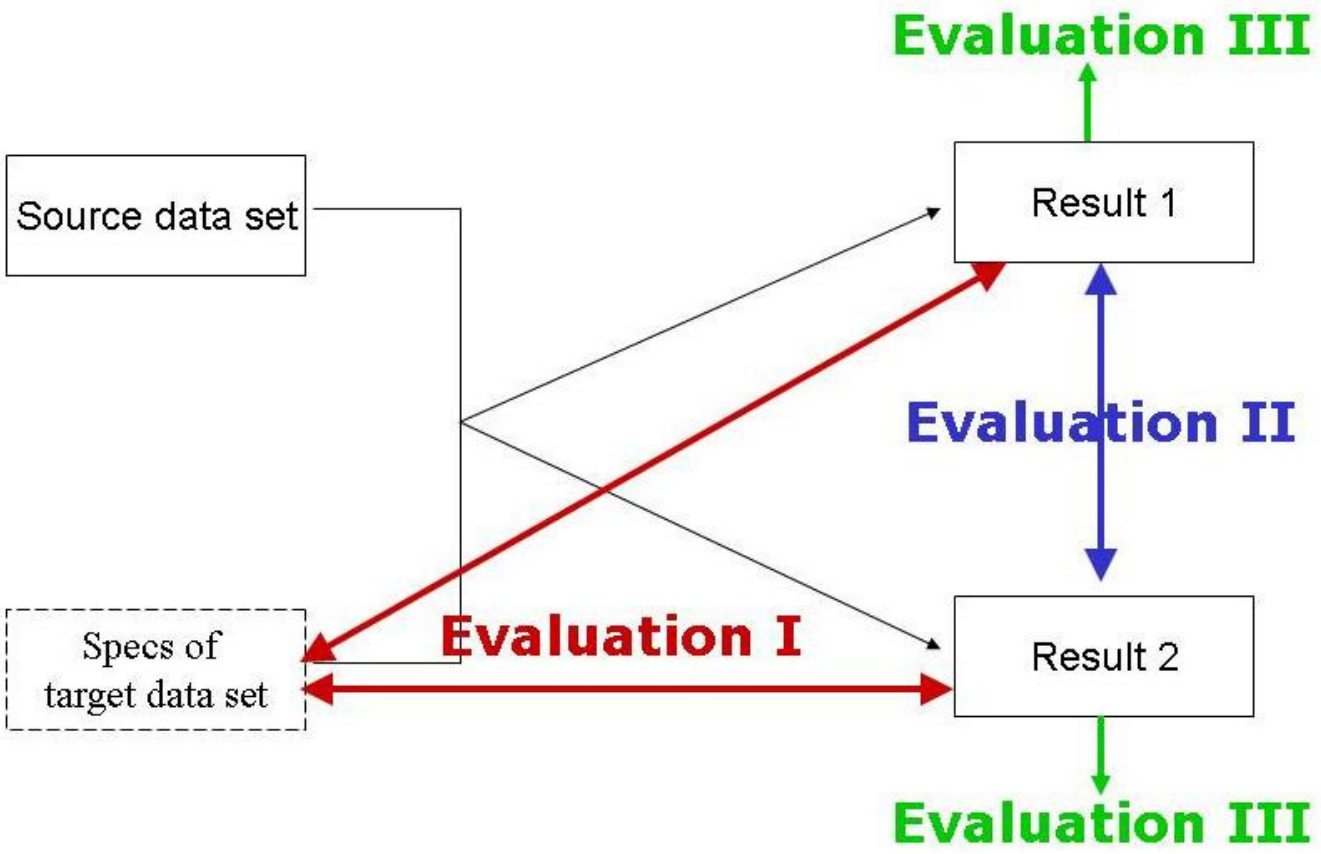
Advantages
- guidance
- close to manual generalisation

Disadvantages
- partially contradictory
- sequence of rules are important
- restrict the number of possible solutions (often different generalisation operations can solve the same problem)
- focus on legibility constraints

Advantages
- flexible
- separation of conflict analysis and conflict solution

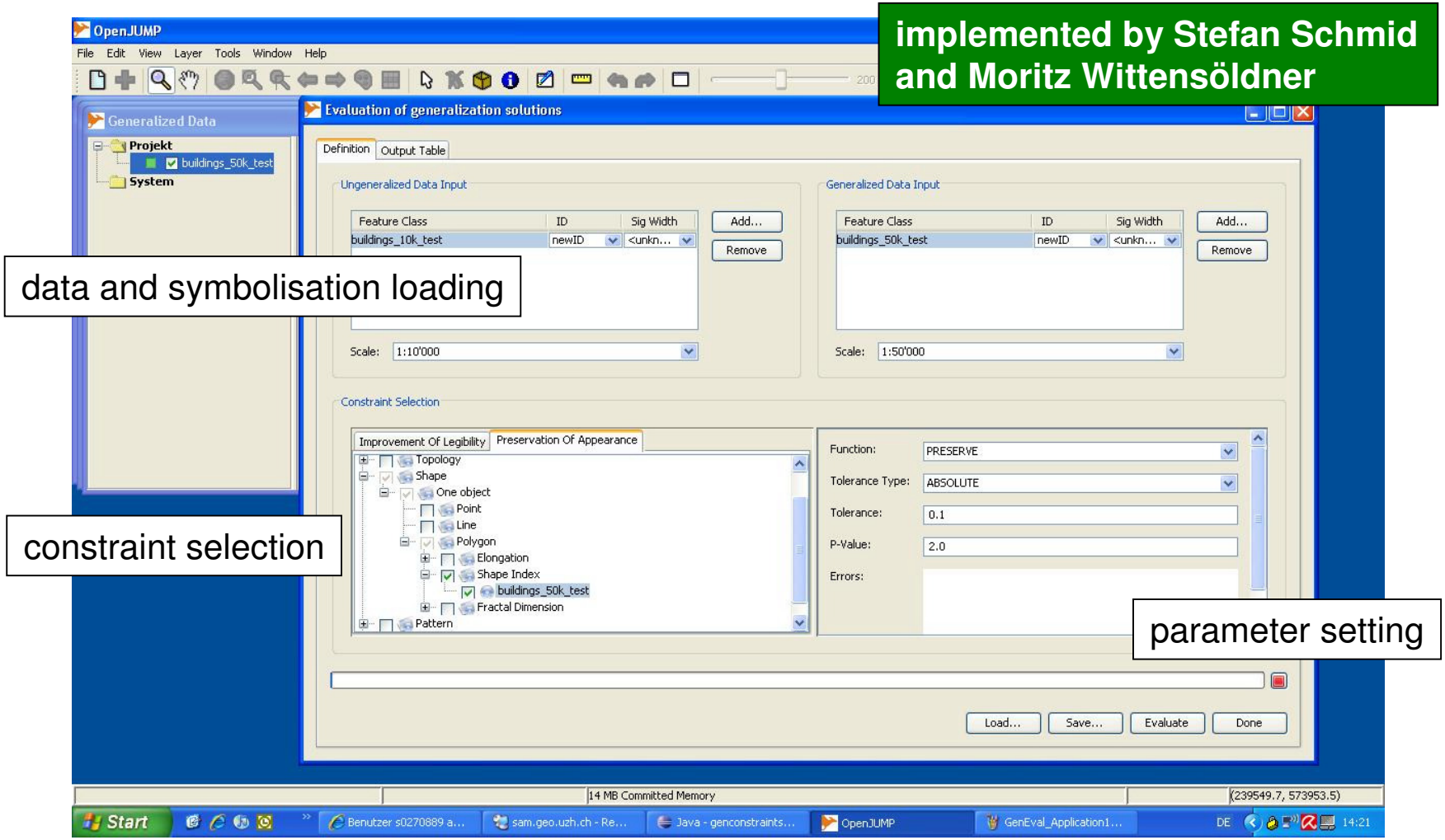
Disadvantages
- a large number of constraints has to be specified
- specification of preservation constraints is difficult (if there is the expectation that the generalisation will not effect a particular area or feature class)

Evaluation


Evaluation III
Source data set
Result 1
Evaluation II
Specs of
target data set
Evaluation I
Result 2
Evaluation III

Evaluation I (first prototype)

implemented by Stefan Schmid and Moritz Wittensöldner



data and symbolisation loading

constraint selection

parameter setting

Evaluation I (first prototype)

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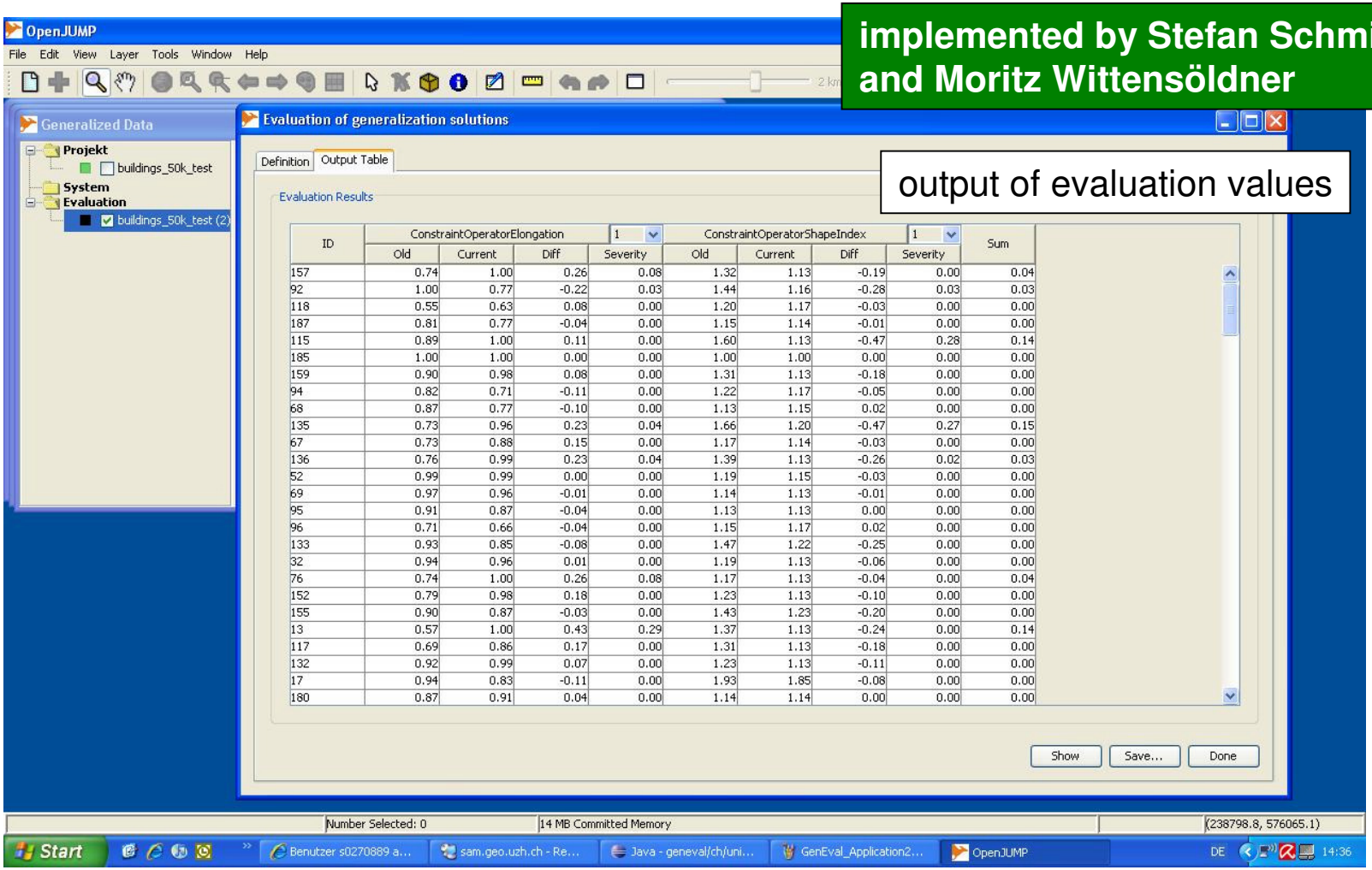
implemented by Stefan Schmid and Moritz Wittensöldner

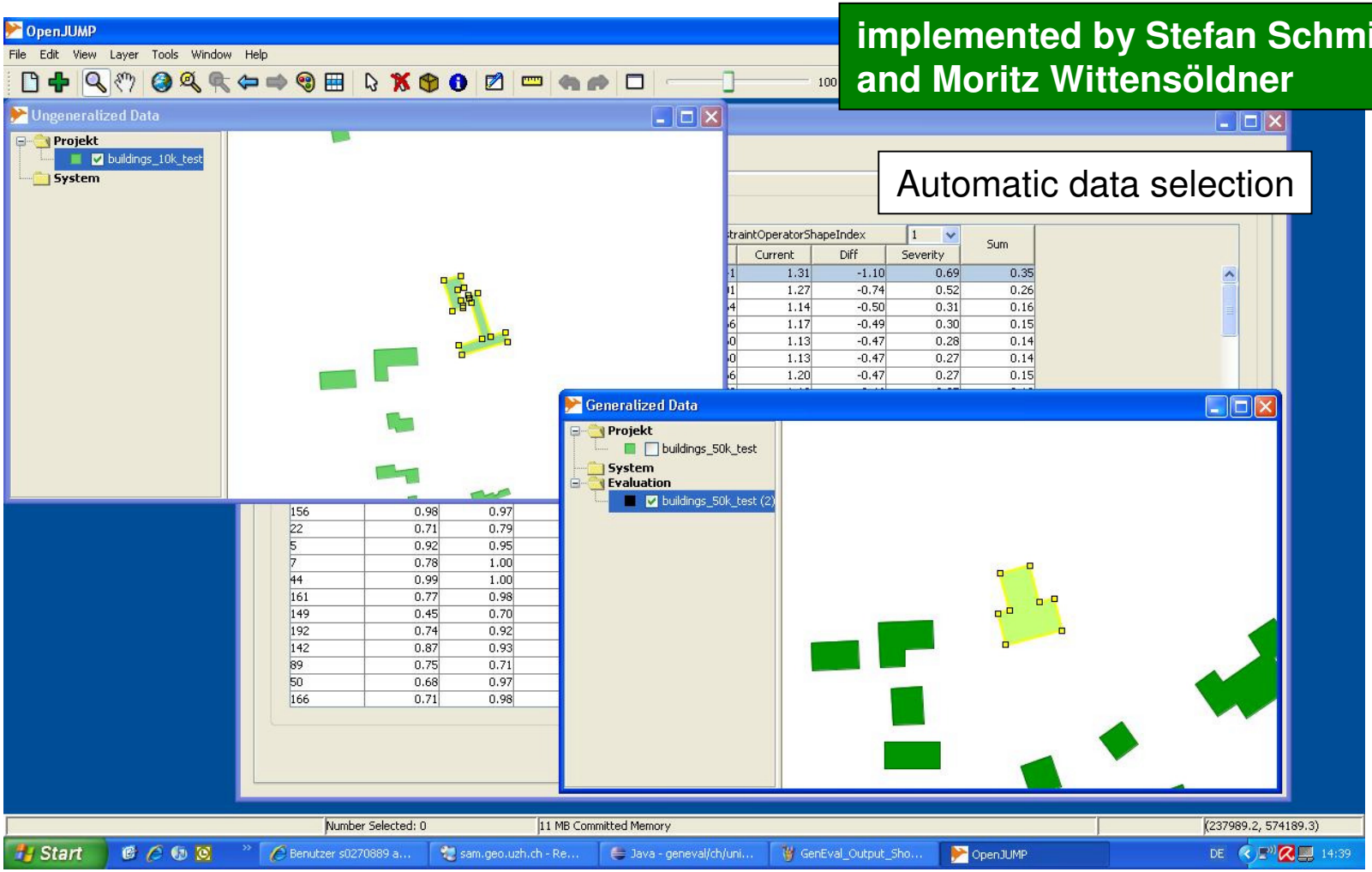


output of evaluation values

ID	ConstraintOperatorElongation			1	ConstraintOperatorShapeIndex			1	Sum
	Old	Current	Diff	Severity	Old	Current	Diff	Severity	
157	0.74	1.00	0.26	0.08	1.32	1.13	-0.19	0.00	0.04
92	1.00	0.77	-0.22	0.03	1.44	1.16	-0.28	0.03	0.03
118	0.55	0.63	0.08	0.00	1.20	1.17	-0.03	0.00	0.00
187	0.81	0.77	-0.04	0.00	1.15	1.14	-0.01	0.00	0.00
115	0.89	1.00	0.11	0.00	1.60	1.13	-0.47	0.28	0.14
185	1.00	1.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00
159	0.90	0.98	0.08	0.00	1.31	1.13	-0.18	0.00	0.00
94	0.82	0.71	-0.11	0.00	1.22	1.17	-0.05	0.00	0.00
68	0.87	0.77	-0.10	0.00	1.13	1.15	0.02	0.00	0.00
135	0.73	0.96	0.23	0.04	1.66	1.20	-0.47	0.27	0.15
67	0.73	0.88	0.15	0.00	1.17	1.14	-0.03	0.00	0.00
136	0.76	0.99	0.23	0.04	1.39	1.13	-0.26	0.02	0.03
52	0.99	0.99	0.00	0.00	1.19	1.15	-0.03	0.00	0.00
69	0.97	0.96	-0.01	0.00	1.14	1.13	-0.01	0.00	0.00
95	0.91	0.87	-0.04	0.00	1.13	1.13	0.00	0.00	0.00
96	0.71	0.66	-0.04	0.00	1.15	1.17	0.02	0.00	0.00
133	0.93	0.85	-0.08	0.00	1.47	1.22	-0.25	0.00	0.00
32	0.94	0.96	0.01	0.00	1.19	1.13	-0.06	0.00	0.00
76	0.74	1.00	0.26	0.08	1.17	1.13	-0.04	0.00	0.04
152	0.79	0.98	0.18	0.00	1.23	1.13	-0.10	0.00	0.00
155	0.90	0.87	-0.03	0.00	1.43	1.23	-0.20	0.00	0.00
13	0.57	1.00	0.43	0.29	1.37	1.13	-0.24	0.00	0.14
117	0.69	0.86	0.17	0.00	1.31	1.13	-0.18	0.00	0.00
132	0.92	0.99	0.07	0.00	1.23	1.13	-0.11	0.00	0.00
17	0.94	0.83	-0.11	0.00	1.93	1.85	-0.08	0.00	0.00
180	0.87	0.91	0.04	0.00	1.14	1.14	0.00	0.00	0.00

Evaluation I (first prototype)

implemented by Stefan Schmid and Moritz Wittensöldner



Automatic data selection

Conclusion

- Comparison of constraint formalisation carried out by four NMA within the EuroSDR project
- Constraint typology was used to categorise and visualise the frequency distribution of specified constraint
  - most of the defined constraints refer to *minimal dimensions* of *one object* of type *line (L) or area (A)* within *one class* of type *building or road*
  - Question: Is this a typical distribution or only valid for the test data?
- Formalisation:
  - constraint template was specified, but the degree of formalisation varies
  - a common syntax for constraint specifications would be useful
  - two direction of constraint specification: process active (legibility constraints) vs. process restrictive (preservation constraints)
- Evaluation
  - three types of evaluation will be carried out
  - a prototype for evaluation (I) of generalised data sets against constraint specification will be available

Successful testing
for the EuroSDR team !

Constraint-based approaches and condition-action modelling

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- separation of situation description (conflict analysis) and generalisation action (conflict solution) are more flexible
- often different generalisation operation can solve the same generalisation task
  → constraints enable the application of more than one action
- in manual generalisation nobody ask about the applied generalisation, only the final state is evaluated
- rule-based systems can become complex and non-configurable
- rules cause problems if contradictory

Constraint constraints

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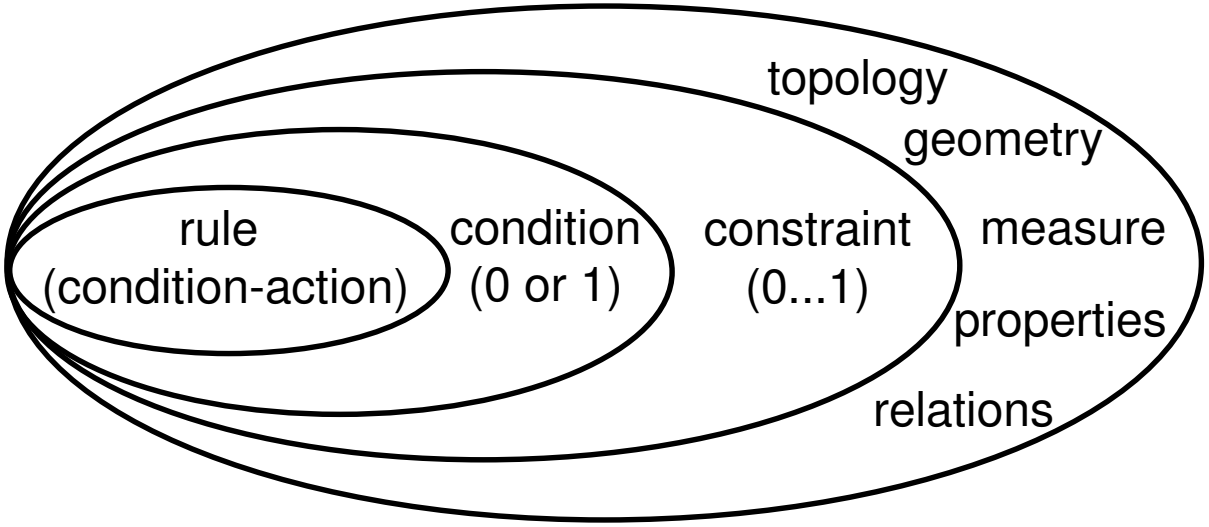
What is a constraint?



constraint categories:

- position/ orientation
- shape
- pattern
- distribution
- statistic

```
If ( condition() )    {
      … // action
}
```

} rule