UNIVERSITÉ DE GENÈVE

CENTRE UNIVERSITAIRE D'INFORMATIQUE

Semantic Regulation Compliance Checking

A real-world scenario involving urban underground data

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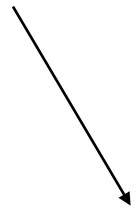
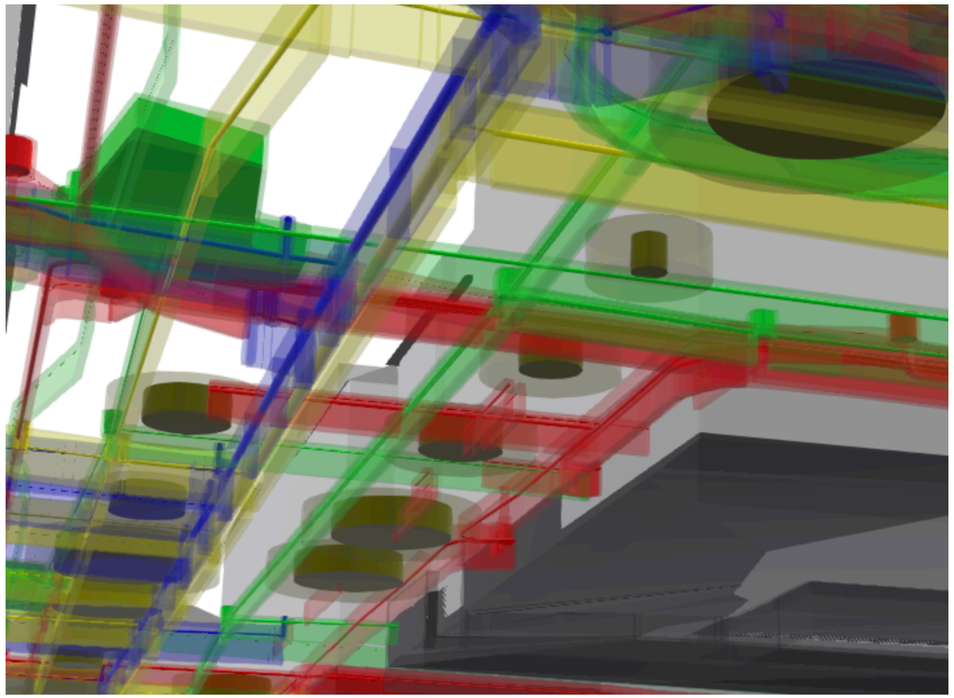
Motivation

Besides the challenges **urban planning** faces**:**

- How do we plan constructions that conform to standing regulations
- How do we take into account the underground objects spatial configuration



  - Represent (underground) objects
  - Represent regulations
  - Perform Compliance checking



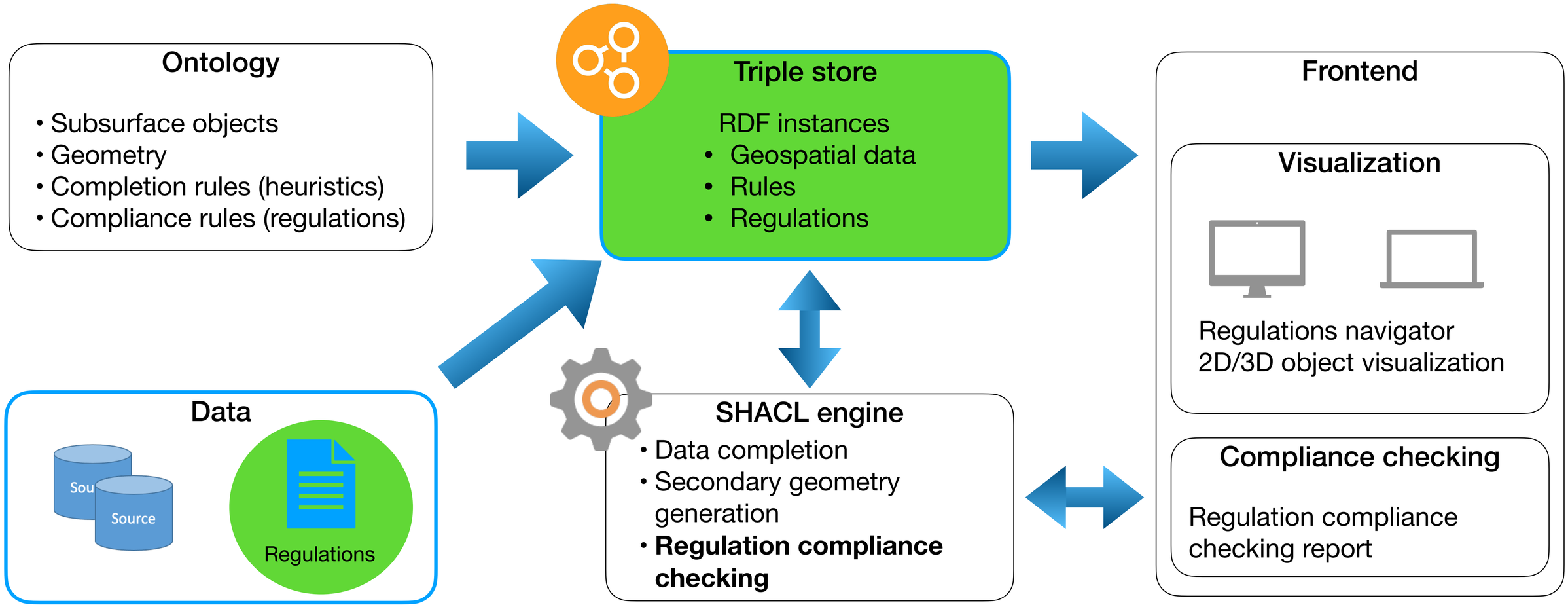
The SUBSURFACE project

Goal: Efficient data exploitation in urban subsurface planning

- Funded by Innosuisse, the Swiss Innovation Agency
- Research partners: HEPIA, Université de Genève
- Industrial partner: Topomat
- Application partners: Etat de Genève, SIG, Genève Aéroport

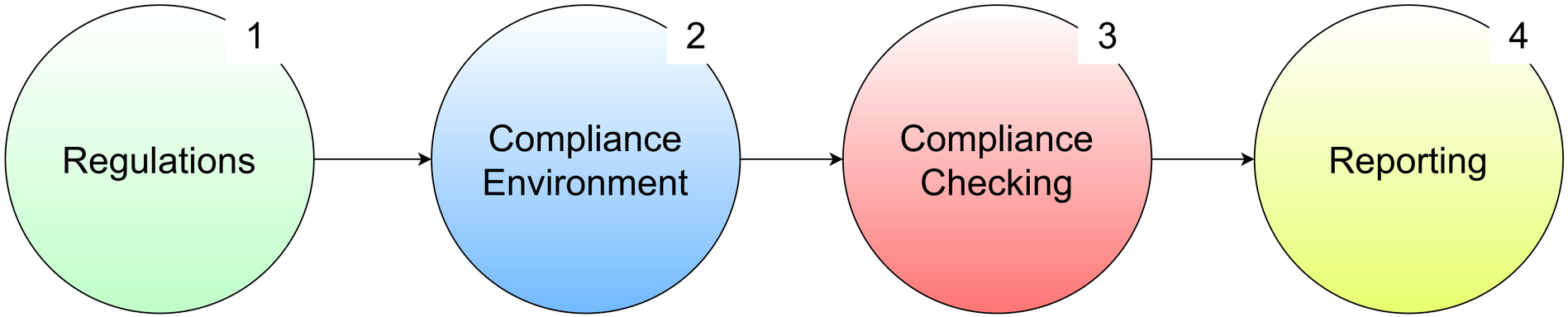
The SUBSURFACE project

Overview



Compliance Checking System (CCS)

- Tools for checking conformance with standing regulations
- Used in many domains (financial, AEC, hardware design)



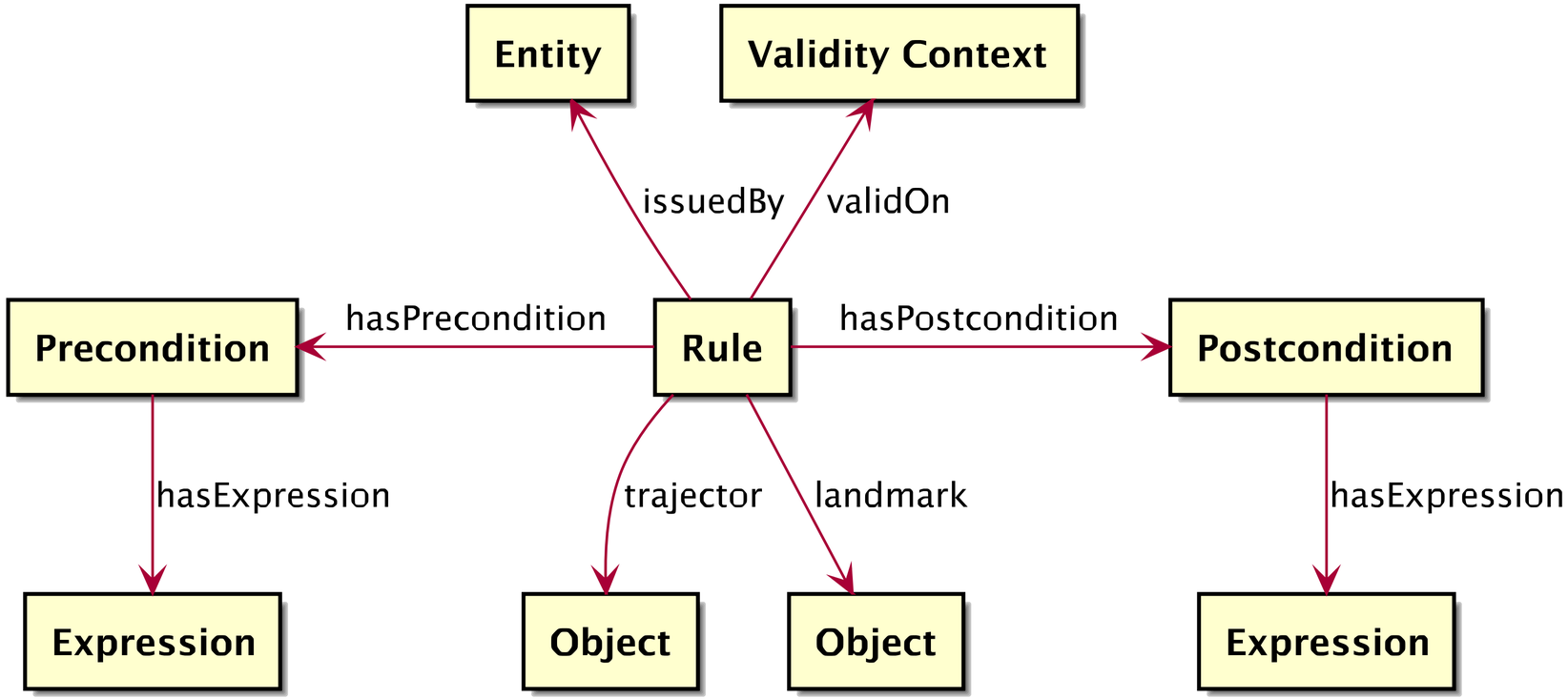
Formalize Regulations

Regulations are defined in natural language:

- no structure (made to be read by human)
- no formal language
- written by several entities (vocabulary issues)
- written in different languages
- …

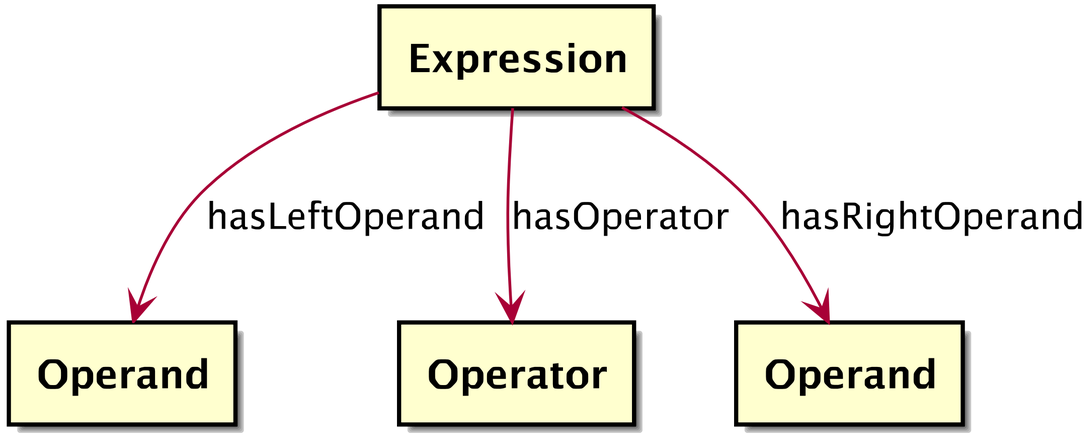
Ontology + Rule model + RDF

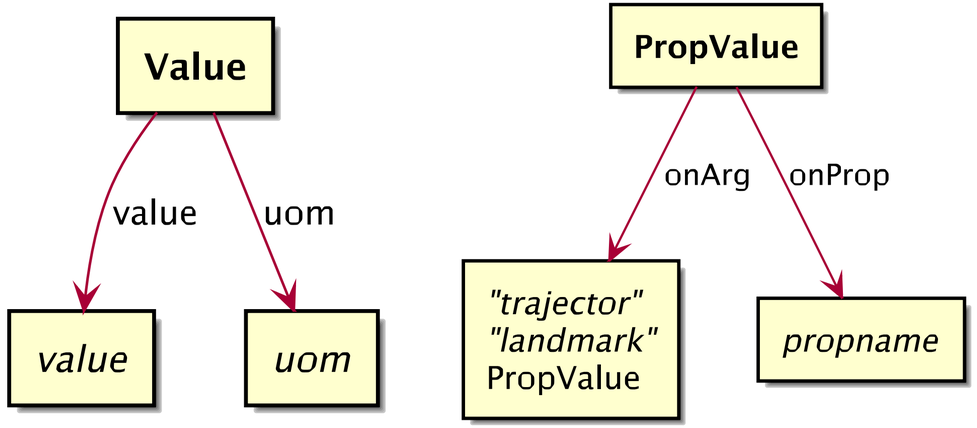
Generic Rule Representation Model I



Caselli A, Daponte V, Falquet G, Métral C. A Rule Language Model for Subsurface Data Refinement. In: EG-ICE 2020 Workshop on Intelligent Computing in Engineering. Berlin: Universitätsverlag der TU Berlin; 2020:443-452. doi:http://dx.doi.org/10.14279/depositonce-9977

Generic Rule Representation Model II





Expression ::= Operand Operator Operand ;
Operand ::= “trajector” | “landmark” |
Value | PropValue | Expression ;
Operator ::= Mathematical | Logical | Spatial ;

Spatial operator / spatial relation = above, below, parallel, close, lateral distance, vertical distance, etc…

Formalizing regulations

3.3.3. Distances et croisements

L'implantation de tubes et conduites à proximité d'un bâtiment et ou d'un ouvrage enterré (fondation, fosse, etc.) est réglementé en fonction du réseau considéré. Des contrôles sont impératifs, pour permettre la mise en place de protections adaptées (explosion, rayonnement ORNI, etc.).

Sous réserve d'une modification des normes techniques applicables, les distances latérales entre des canalisations sont recommandées par type de tuyau (SIA 190) :

- D <= 350mm 0.25m
- D <= 700mm 0.35m
- D <= 1200mm 0.425m
- D > 1200mm 0.5m

… the ***lateral distance*** between the **pipes (trajector, landmark)** is recommended according to the pipe's type:

- ø <= 350mm 0.25m
- ø <= 700mm 0.35m
- ø <= 1200mm 0.425m
- ø > 1200mm 0.5m

Unofficial translation adapted from: Original text (FR): SIG — GUIDE DE CONCEPTION ET DE COORDINATION DES TRAVAUX EN SOUS-SOL, https://media.sig-ge.ch/

Formalizing regulations

… the ***lateral distance*** between the **pipes (trajector, landmark)** is recommended according to the pipe's type:

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- ø <= 1200mm 0.425m
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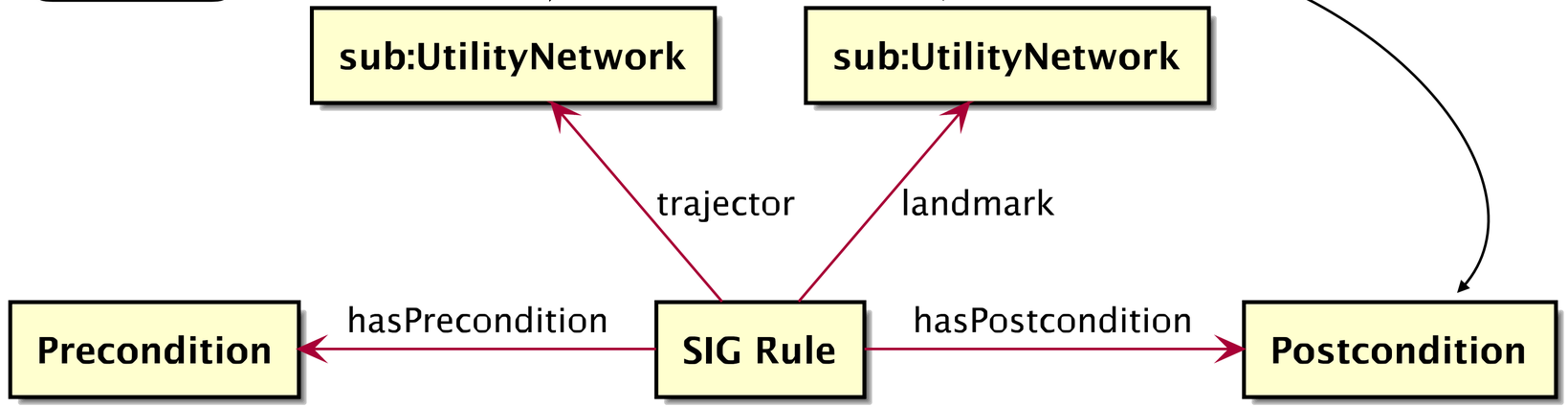
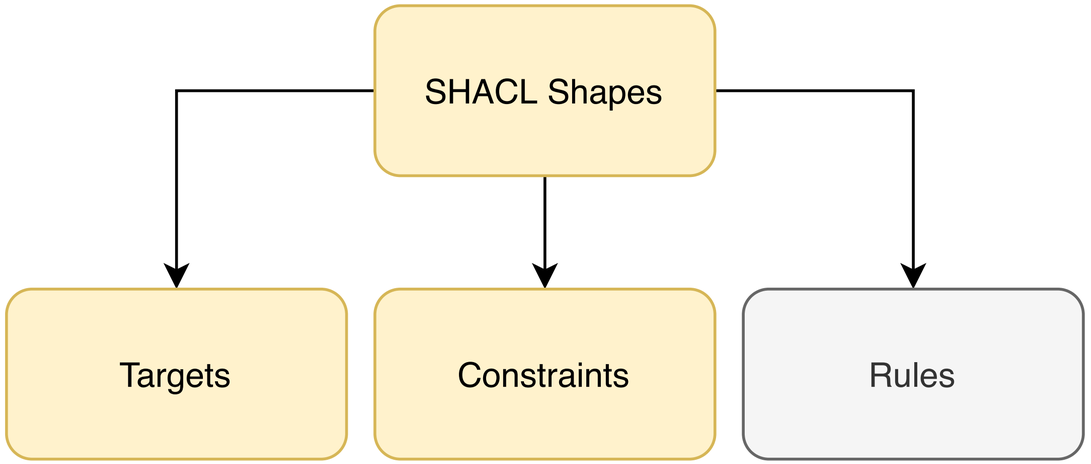


Regulations as SHACL validation constraints

Shapes Constraint Language (SHACL): validating RDF graphs against a set of conditions (shapes)



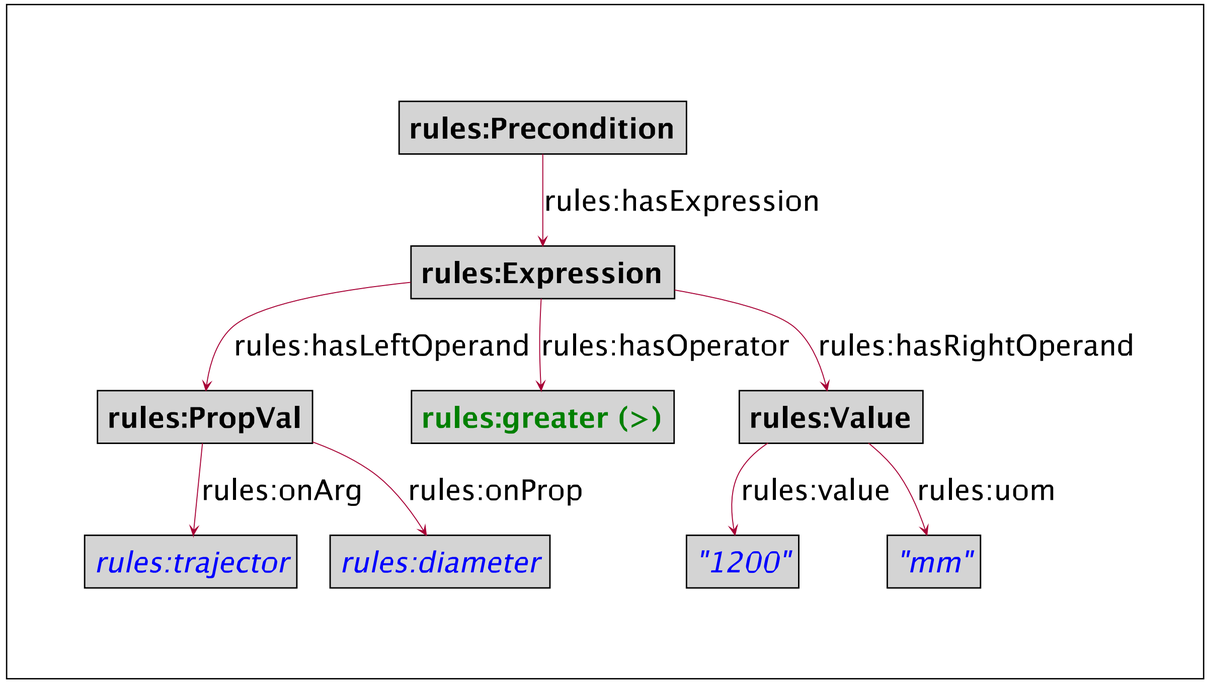
Rule **trajector** or **trajector + precondition**

Rule **postcondition**

Regulations as SHACL validation constraints

Precondition Example

ø > 1200mm

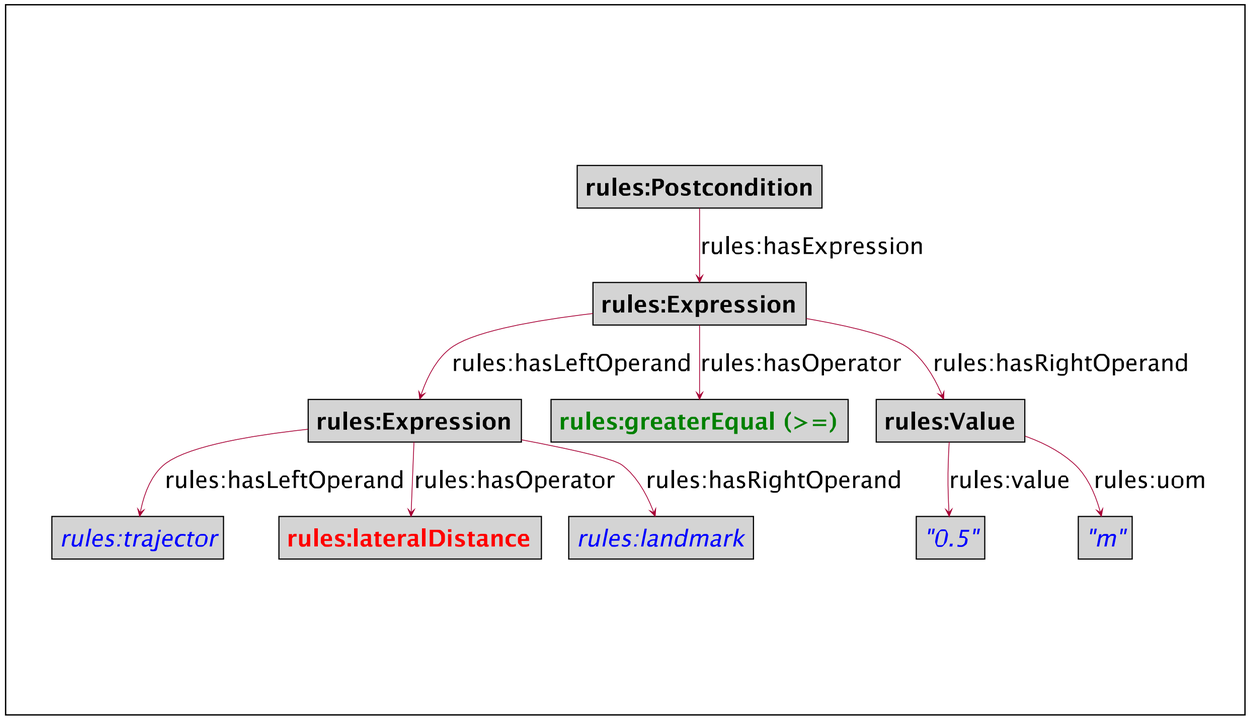



```
sh:target [
      rdf:type sh:SPARQLTarget ;
      sh:select """
          PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
          PREFIX sub: <http://cui.unige.ch/isi/onto/SubsurfaceObjects#>
          PREFIX rules: <http://cui.unige.ch/isi/onto/rules.ttl#>
          SELECT ?this
          WHERE {
              ?this a sub:UtilityNetwork .
              ?this rules:diameter ?diam .
              ?diam rules:val ?diamValue .
              FILTER(?diamValue > 1200) .
          }
          """ ;
   ] ;
```

Regulations as SHACL validation constraints

Postcondition Example

lateral distance => 0.5m




```
sh:sparql [
      rdf:type sh:SPARQLConstraint ;
      sh:message "Lateral distance between pipes. Diameter > 1200mm." ;
      sh:select """
          PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
          PREFIX sub: <http://cui.unige.ch/isi/onto/SubsurfaceObjects#>
          PREFIX rules: <http://cui.unige.ch/isi/onto/rules.ttl#>
          SELECT $this ?value
          WHERE {
              ?landmarkInst rdf:type sub:UtilityNetwork .
              FILTER(rules:lateral_distance($this, ?landmarkInst) < 0.5) .
          }
          """ ;
    ] ;
```

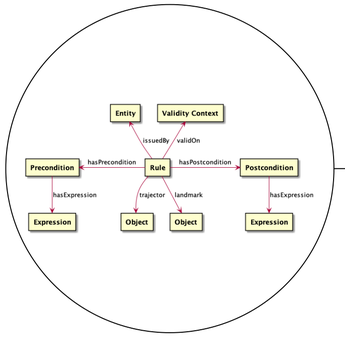
rules:lateral_distance is a sh:JSFunction

Compliance checking framework architecture

Regulations

formalize

Regulations RDF



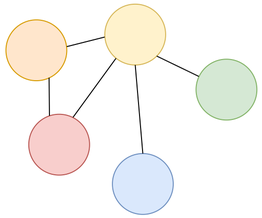
compile

Executable Regulations

SHACL Shapes +
SHACL-SPARQL +
SHACL-JS

SHACL

RDF Data



Rule engine

Frontend

Visualization

Regulations navigator
2D/3D object visualization

Compliance checking

Regulation compliance checking report

Summary

- Rule model for formalizing regulations
- Represent regulations using RDF
- Executable version of the regulations using SHACL + SHACL extensions
- Automated regulation compliance checking