
Digital Innovators
Séminaires d'innovation numérique
Semantic exploitation of underground geo-spatial data
09/06/2021
Ashley Caselli
ashley.caselli@unige.ch

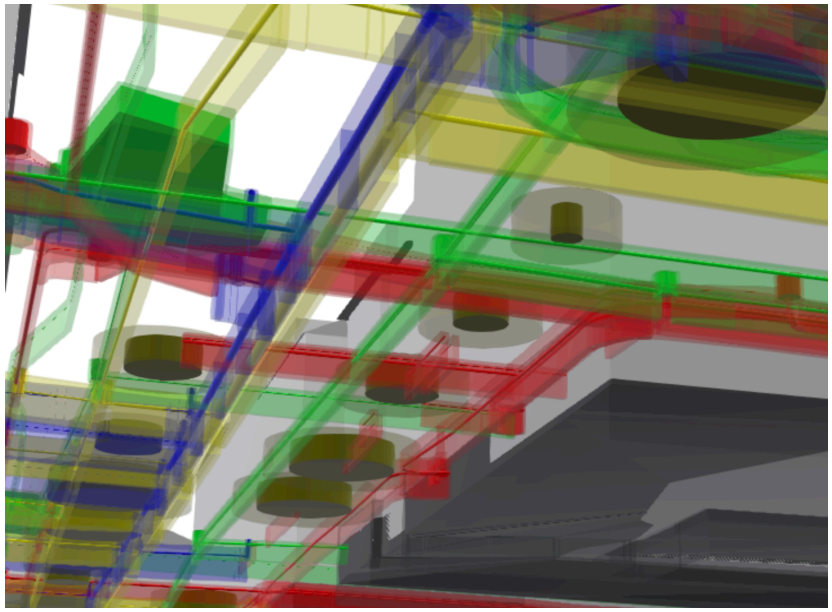
Outline

- Motivation
- The SUBSURFACE project
- The SUBSURFACE ontology
  - Subsurface objects
  - Geometry + WKT Geometry
- GIS data to RDF
- Generic rule representation model (GRRM)
- SHACL engine
  - Data completion / Secondary geometry generation
  - Regulation compliance checking
- DEMO

Motivation

Urban planning: should the underground objects be taken into account?

- Represent underground data
- Data integration
- Data completion: 3D-ify + infer missing information
- Dealing with uncertainty
- Regulation compliance checking



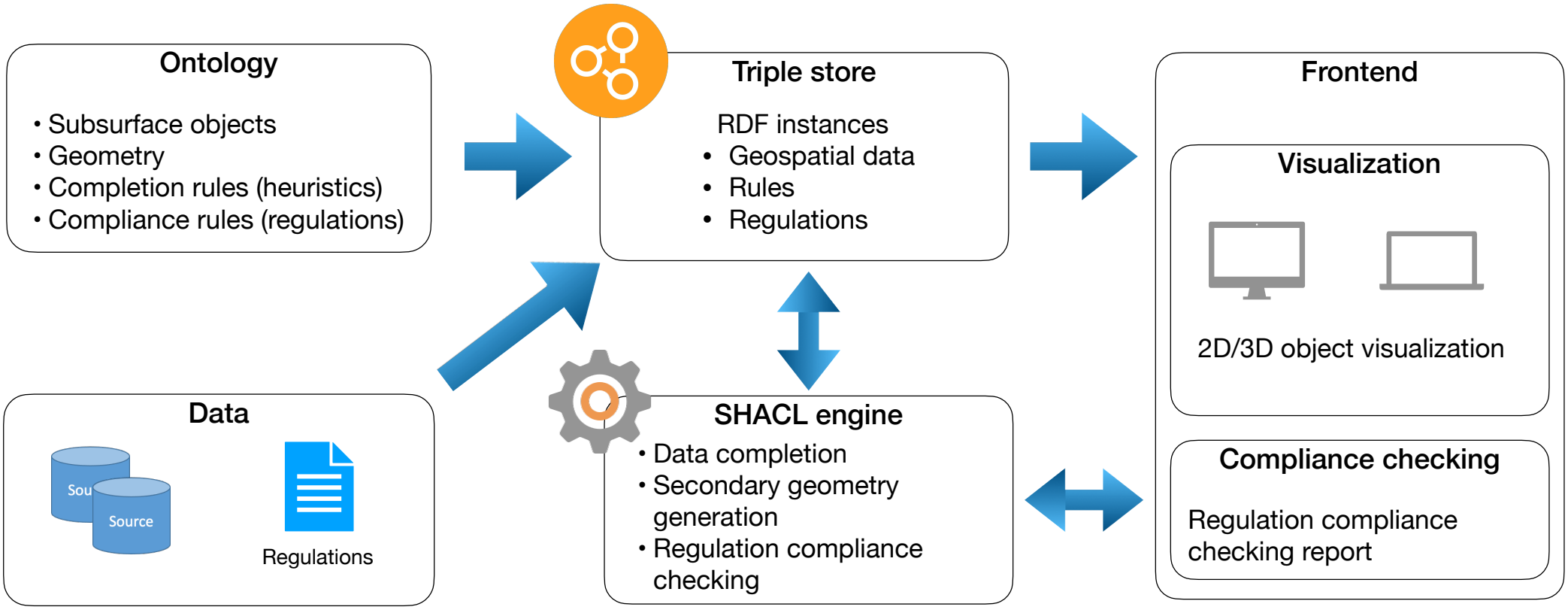
The SUBSURFACE project

SUBSURFACE: 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

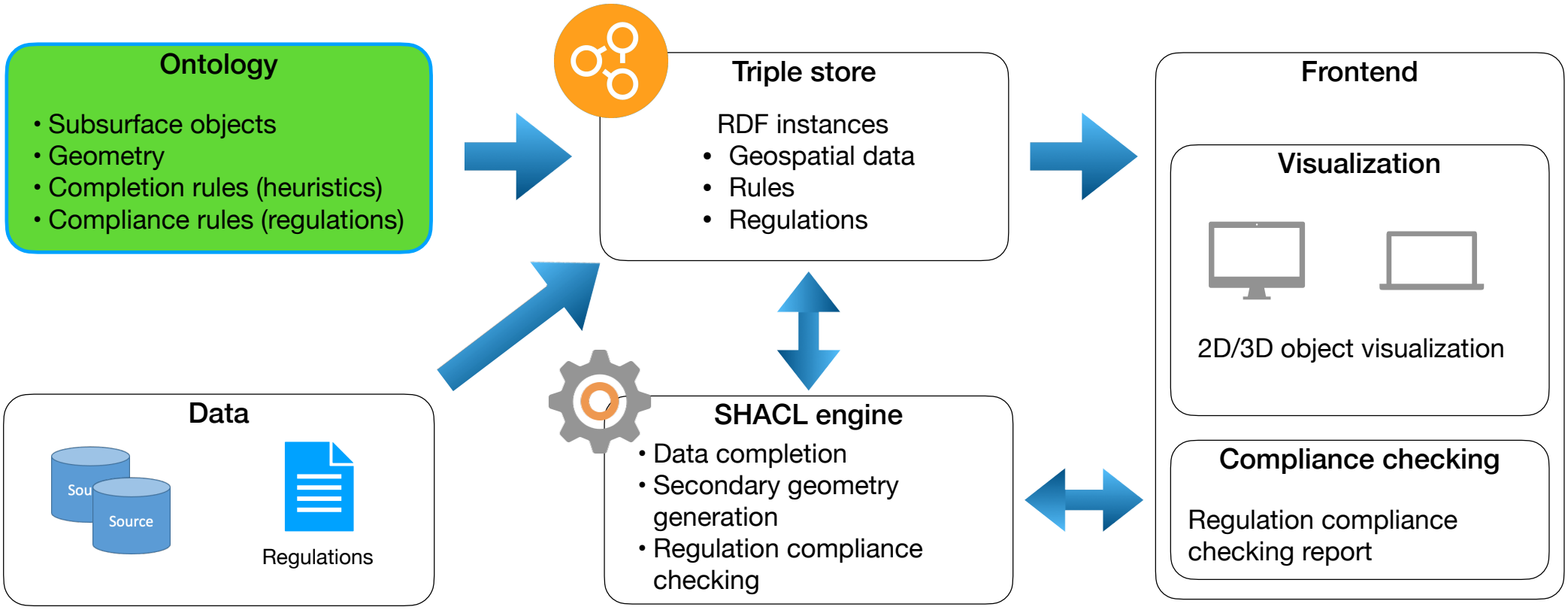
The SUBSURFACE project

Overview



The SUBSURFACE project

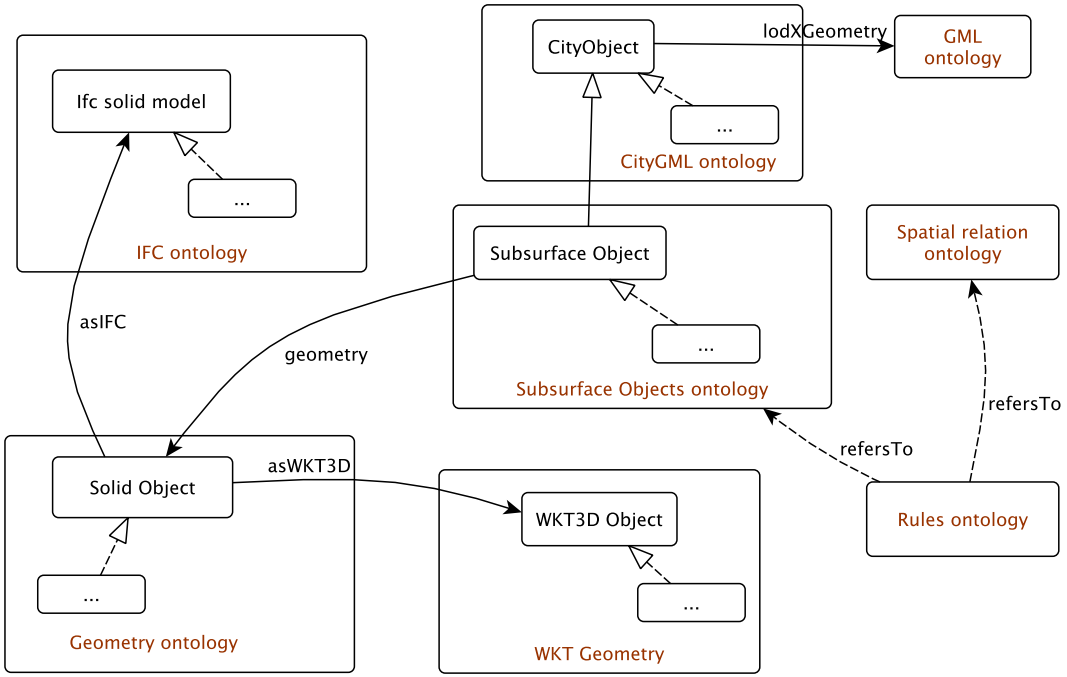
Overview



The SUBSURFACE ontology

We defined a set of interconnected ontologies to represent the subsurface objects as well as their spatial relationships and their geometry

- **Subsurface Objects**
- **Geometry**
- **WKT Geometry**
- **Rules ontology**
- **Spatial relation ontology**
- **CityGML Ontology**
- **IFC Ontology (ifcOWL)**



Métral, C., Daponte, V., Caselli, A., Di Marzo, G., and Falquet, G.: ONTOLOGY-BASED RULE COMPLIANCE CHECKING FOR SUBSURFACE OBJECTS, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLIV-4/W1-2020, 91–94, https://doi.org/10.5194/isprs-archives-XLIV-4-W1-2020-91-2020, 2020.

The SUBSURFACE ontology

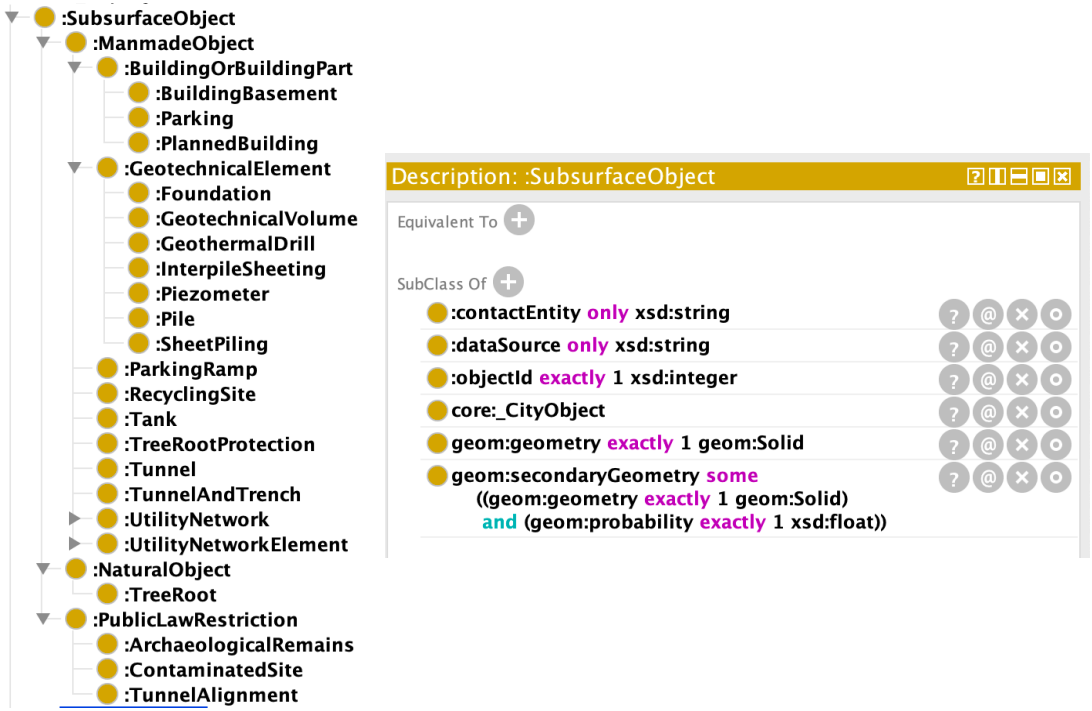
Subsurface Objects

Each subsurface object has:

- **one** solid primary geometry
- **one to many** secondary solid geometries

Each secondary geometry is represented as:

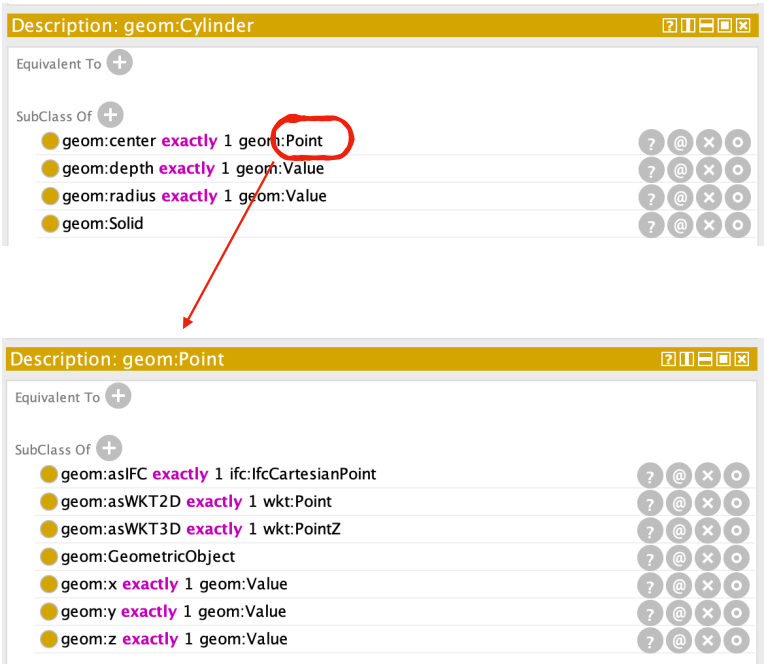
1. solid geometry
2. probability



The SUBSURFACE ontology

Geometry + WKT Geometry

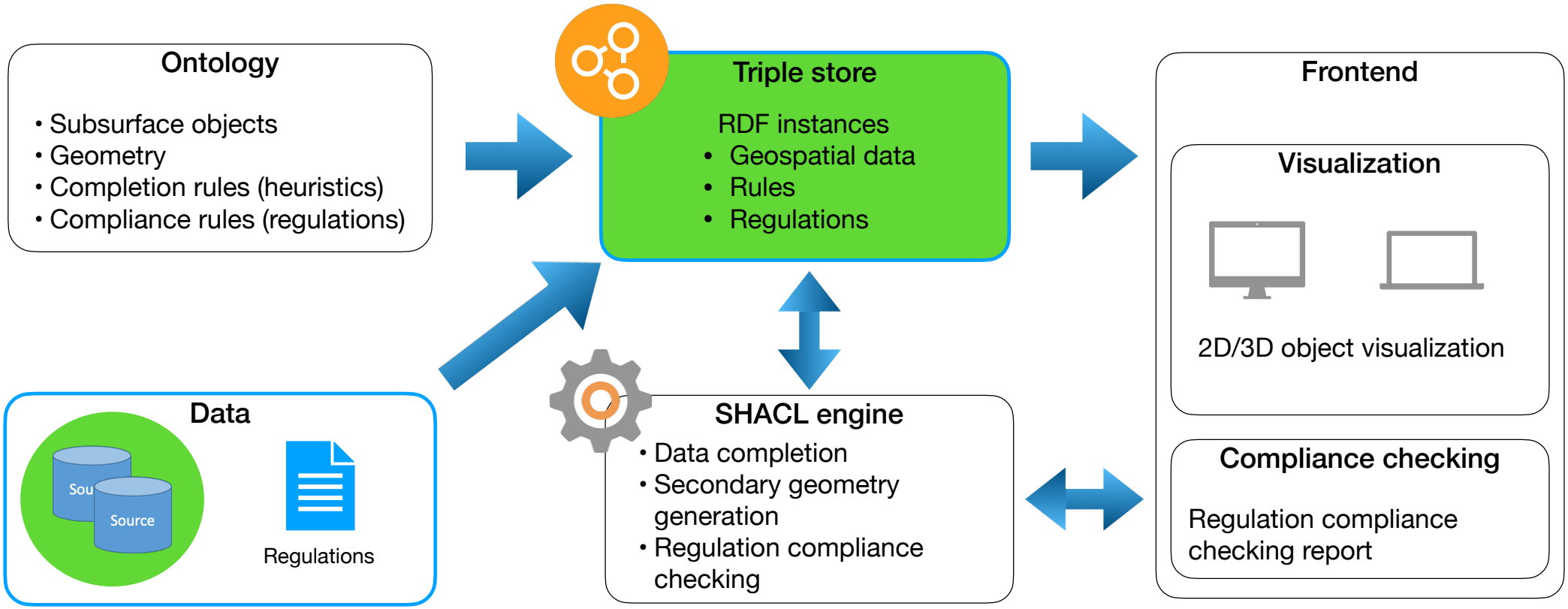
- Objects are associated to different types of geometry
  - A solid geometry
  - A 2D/3D WKT geometry
  - An IFC solid geometry
  - A GML geometry inherited from CityGML, since all the objects are city objects (according to CityGML)



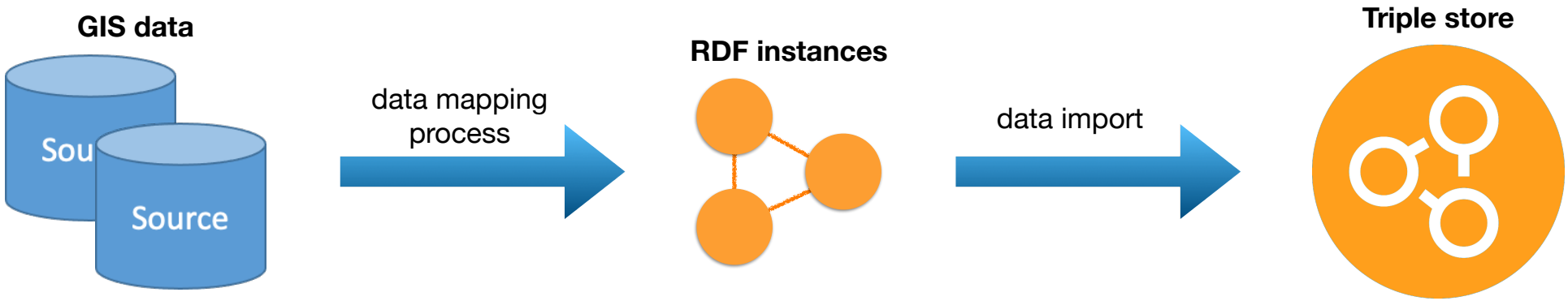
Example: Cylinder with the center represented as a Point.

The SUBSURFACE project

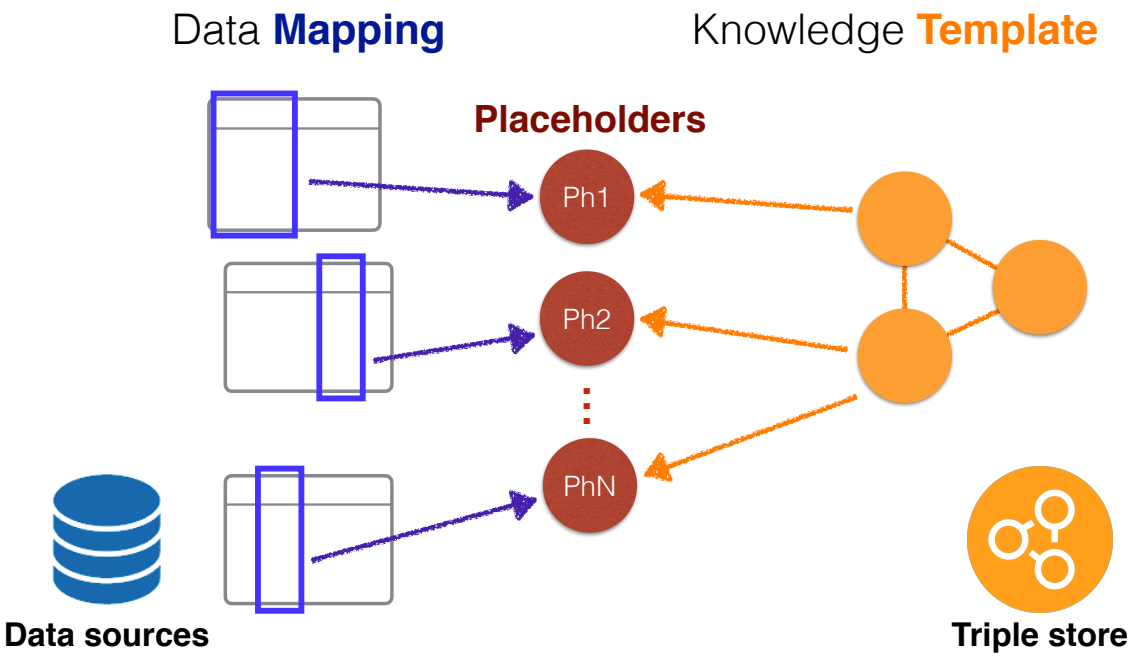
Overview



GIS data to RDF I



GIS data to RDF II



Data mapping: a JSON file that links each column with a placeholder

Knowledge Template: a graph that links each property with a placeholder

GIS data to RDF III

Data **Mapping**

L0
L1
L2
L3

```
{
  "domain": "GE_COR_SIPV_TR_",
  "mapping":
  {
      "L0":{
          "table":"cor_raw_sipv_ica_arbre_isole",
          "column": "id"
      },
      "L1":{
          "table":"cor_raw_sipv_ica_arbre_isole",
          "column": "geom"
      },
      "L2":{
          "table":"cor_raw_sipv_ica_arbre_isole",
          "column": "rayon_couronne"
      }
      "L3":{
          "table":"cor_raw_sipv_ica_arbre_isole",
          "column": "hauteur_totale"
      }
   }
}
```

Knowledge **Template**

L0

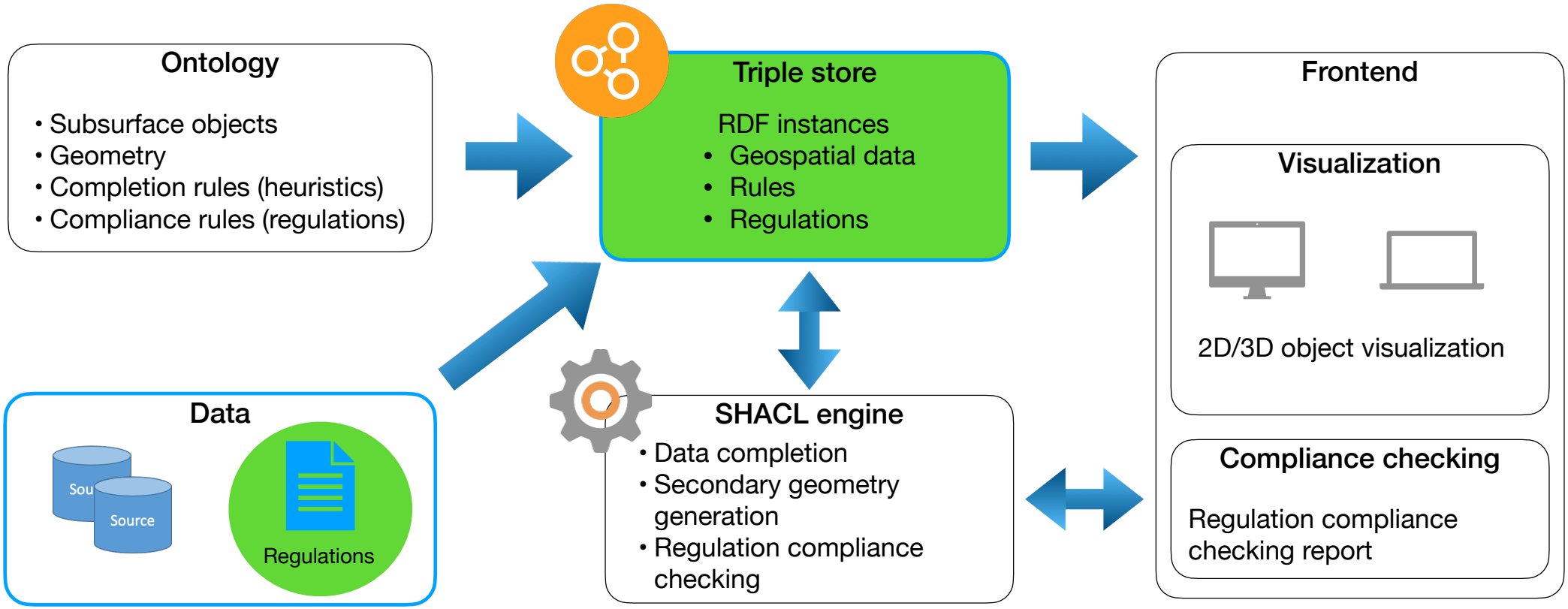
```
:L0
   a ktmap:PH_Subject ;
   a sub:TreeRoot ;
   sub:height [
      a geom:Value ;
      geom:uom "m" ;
      geom:value :L3 ;
   ] ;
   geom:geometry [
      a sub:Cylinder ;
      geom:radius [
         a geom:Value ;
         geom:uom "m" ;
         geom:value :L2
      ] ;
      geom:center [
         a geom:Point ;
         geom:asWKT2D [
            a wkt:Point ;
            geom:WKT2Dvalue :L1 ;
         ] ;
      ] ;
   ] ;
```

- syntax: ***Turtle***
- PH_Subject is a Class

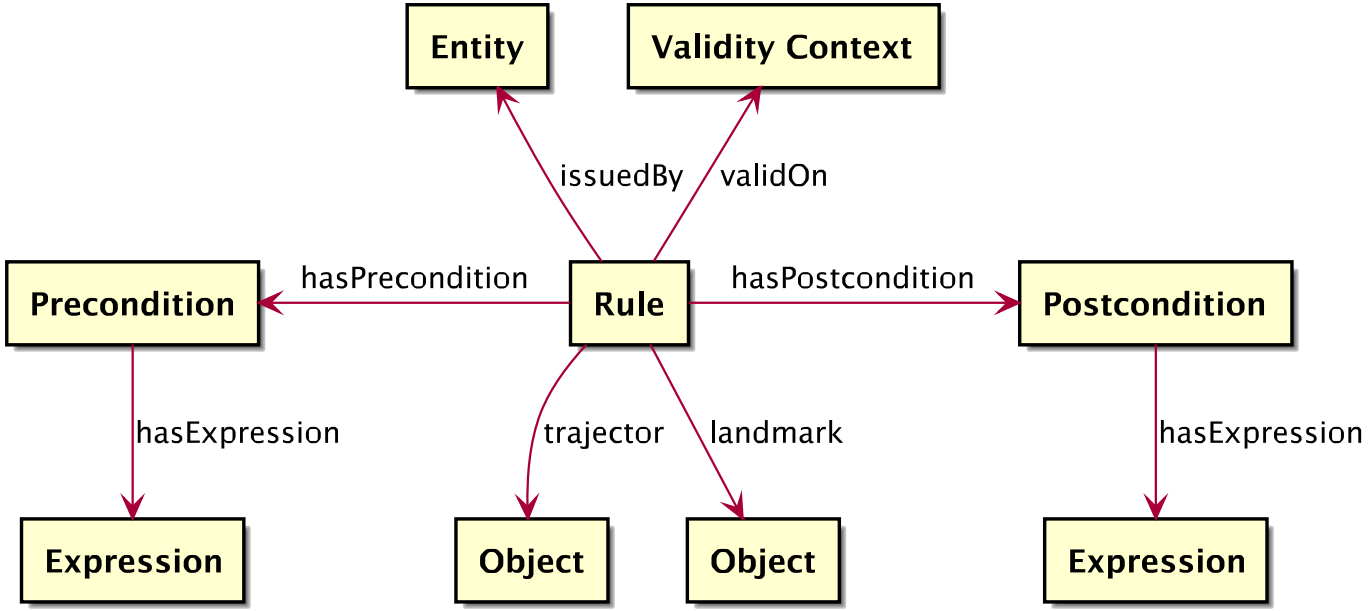
L3
L2
L1

The SUBSURFACE project

Overview

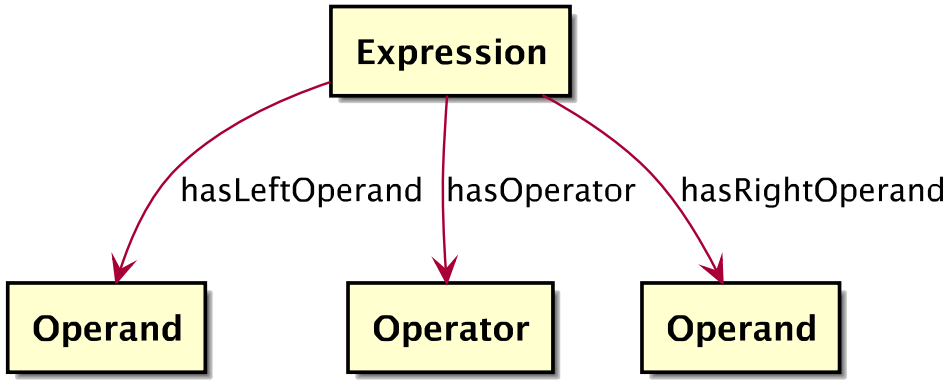


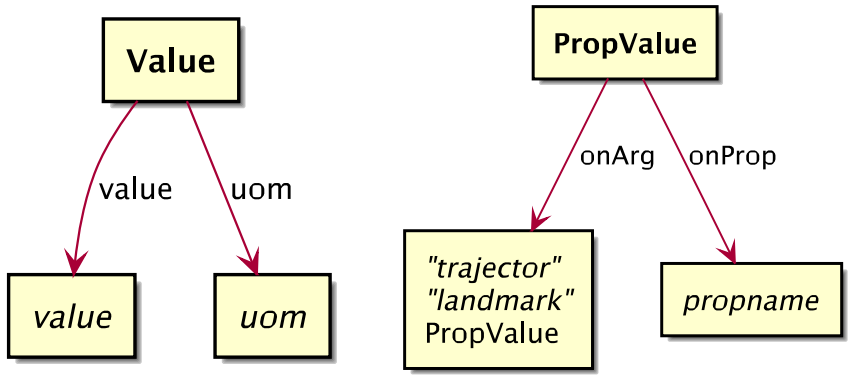
Generic rule representation model (GRRM) I



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 (GRRM) II





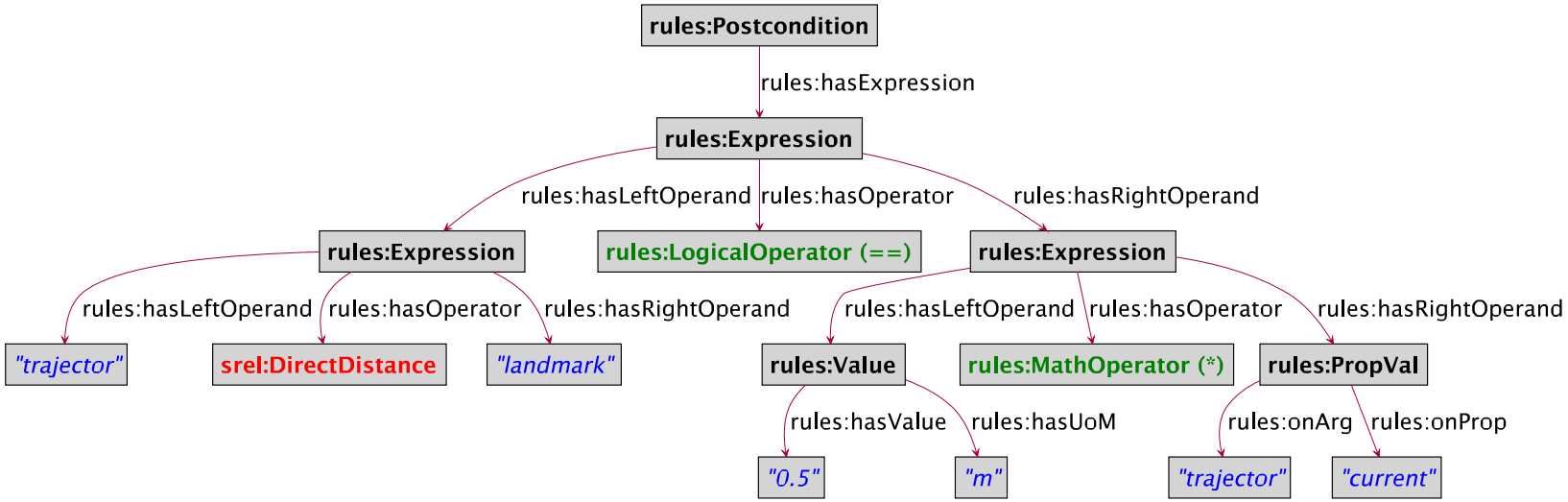
expression ::= operand operator operand ;
operand ::= “trajectory” | “landmark” |
value | propValue | expression ;
operator ::= mathematical | logical | spatial ;

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

Generic rule representation model (GRRM) III

Example - Ordonnance sur les lignes électriques, article 134.4 (EN translation)

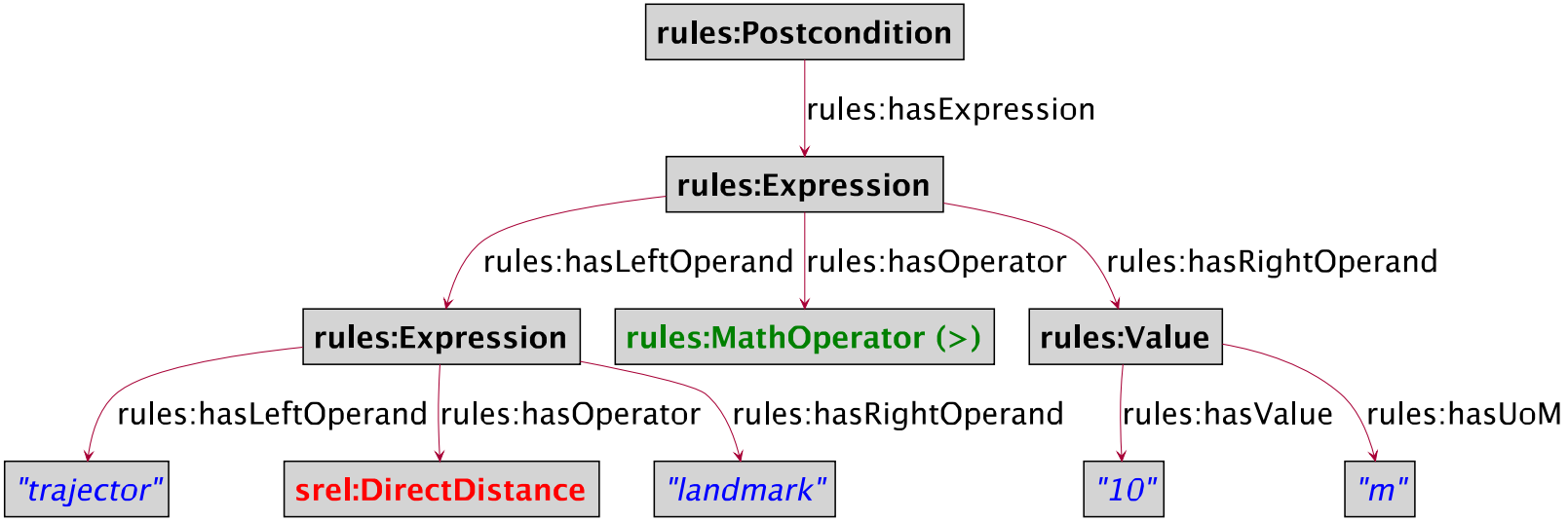
…the *direct distance* between **Object — trajector** and **Object — landmark must be 0.5 m per kA of short-circuit current to ground**, but never less than 10 m.



Generic rule representation model (GRRM) III

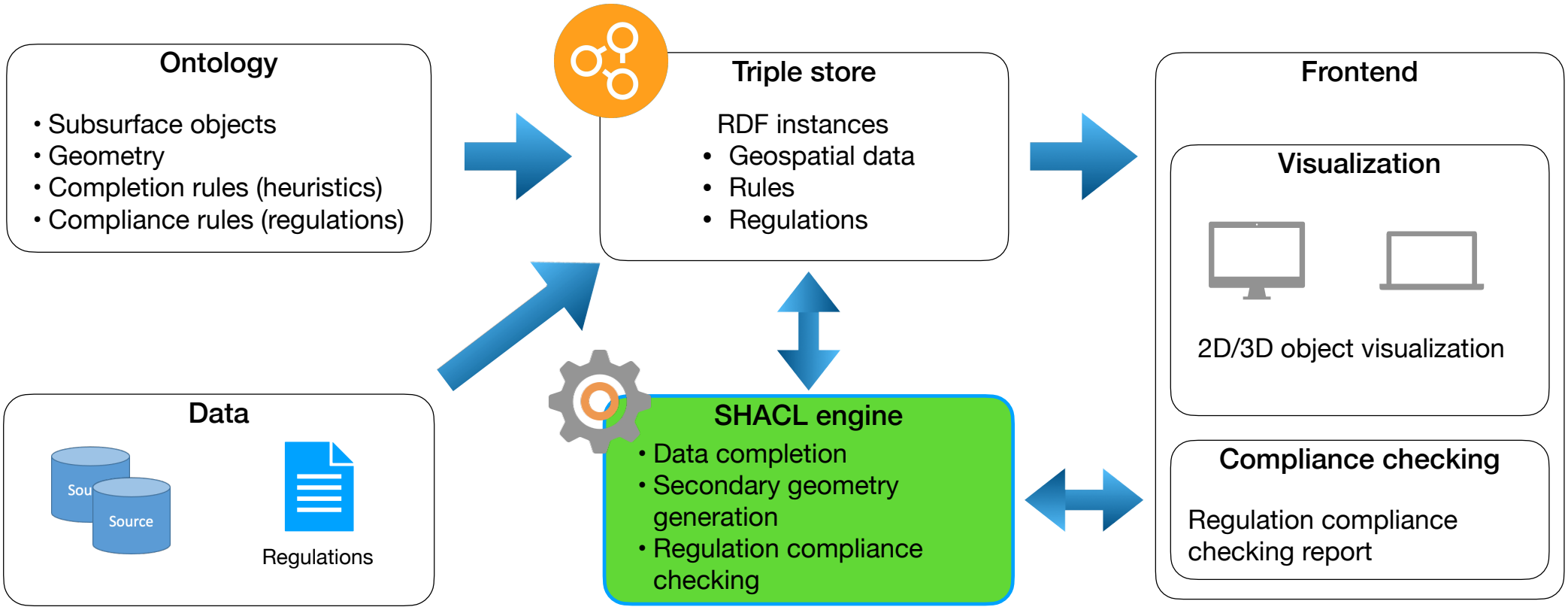
Example - Ordonnance sur les lignes électriques, article 134.4 (EN translation)

…the *direct distance* between **Object — trajector** and **Object — landmark** must be 0.5 m per kA of short-circuit current to ground, but **never less than 10 m**.



The SUBSURFACE project

Overview



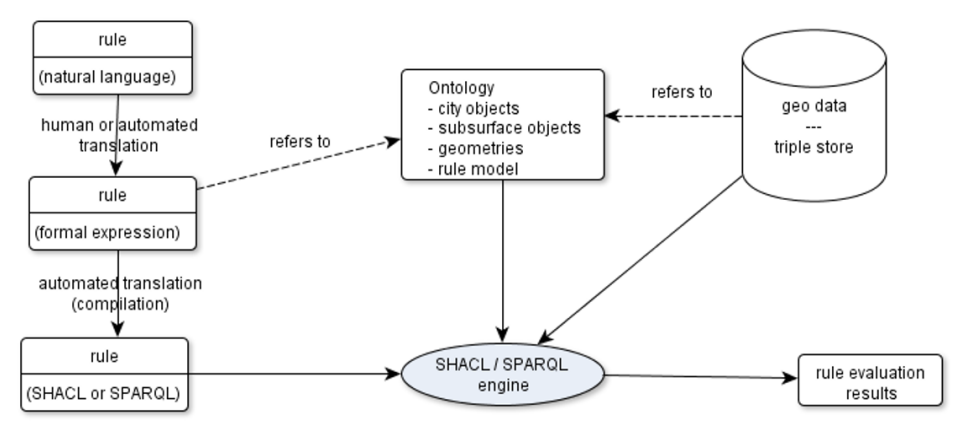
SHACL engine

SHACL = Shapes Constraint Language

Language for validating RDF graphs against conditions

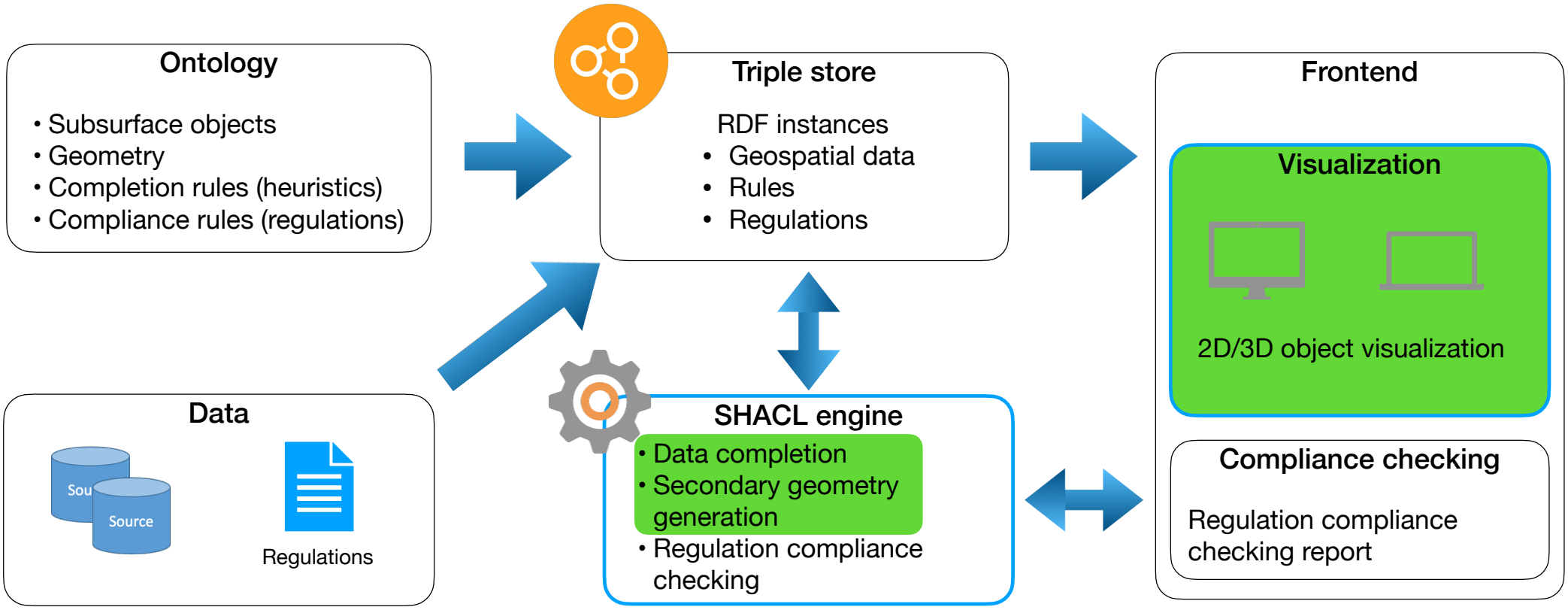
SHACL validation engine: takes as input a data graph and a shapes graph and produces a validation report

SHACL rules engine: takes as input a data graph and a shapes graph and adds triples to the data graph.



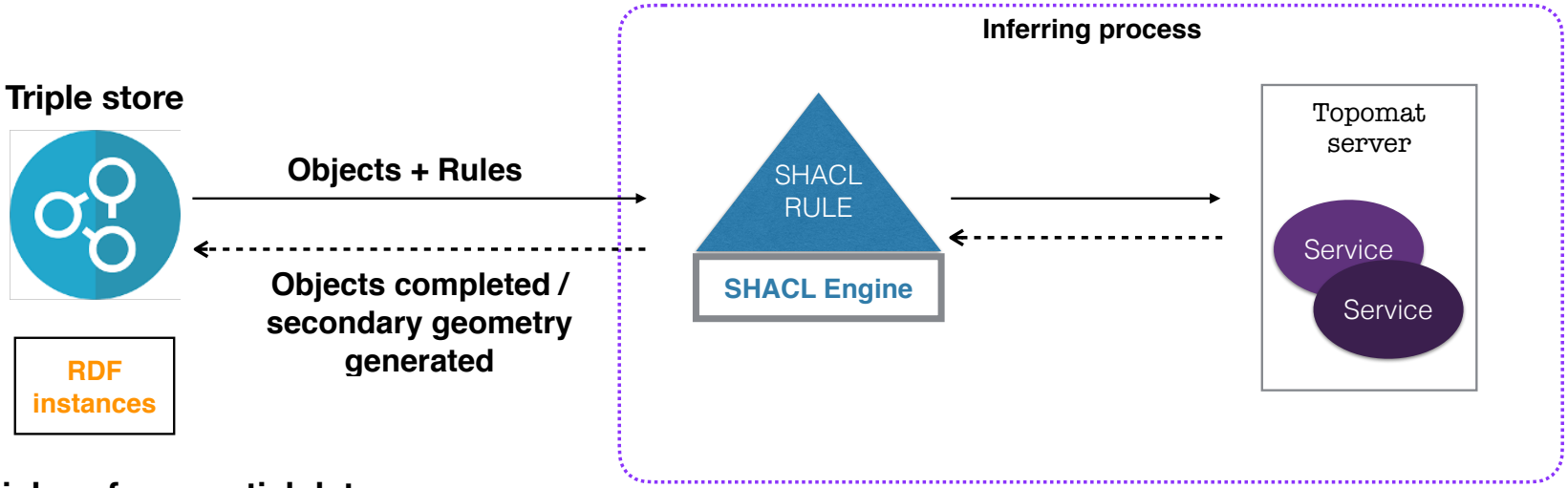
The SUBSURFACE project

Overview



Data completion / Secondary geometry generation

Workflow



~ 1.4 million triples of geospatial data
~ 50 data completion rules (3D, missing information inferring) + secondary geometry derivation rules (uncertainty)

Data completion / Secondary geometry generation

Examples

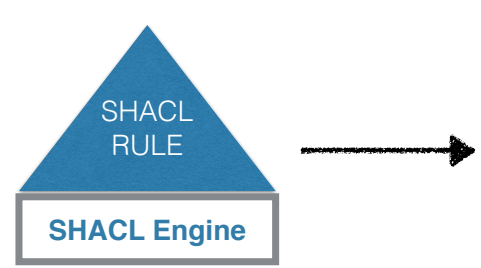
TreeRoot: Infer missing information

depth = height * 0.2

TreeRoot: Secondary geometry generation

Secondary geometry: Cylinder

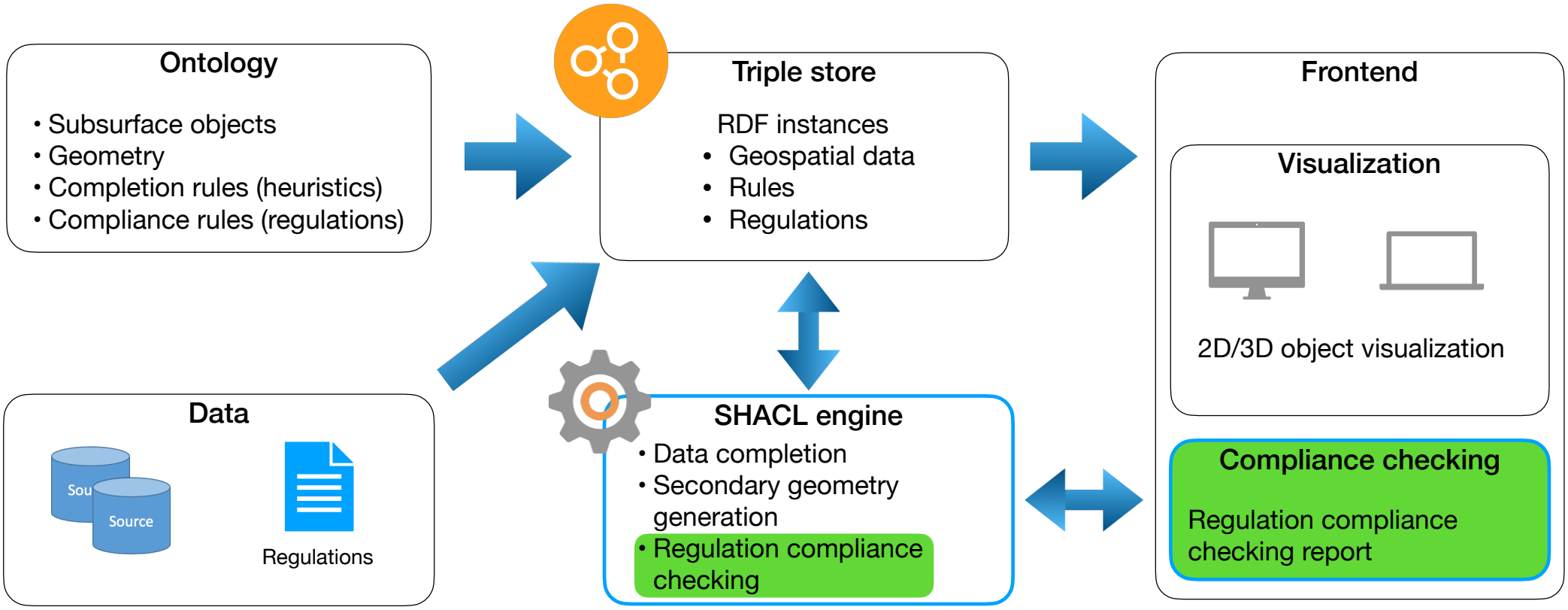
center = center
radius = 0.1 + 0.90 * 0.128801
depth = 1.05 + 0.90 * 0.128801



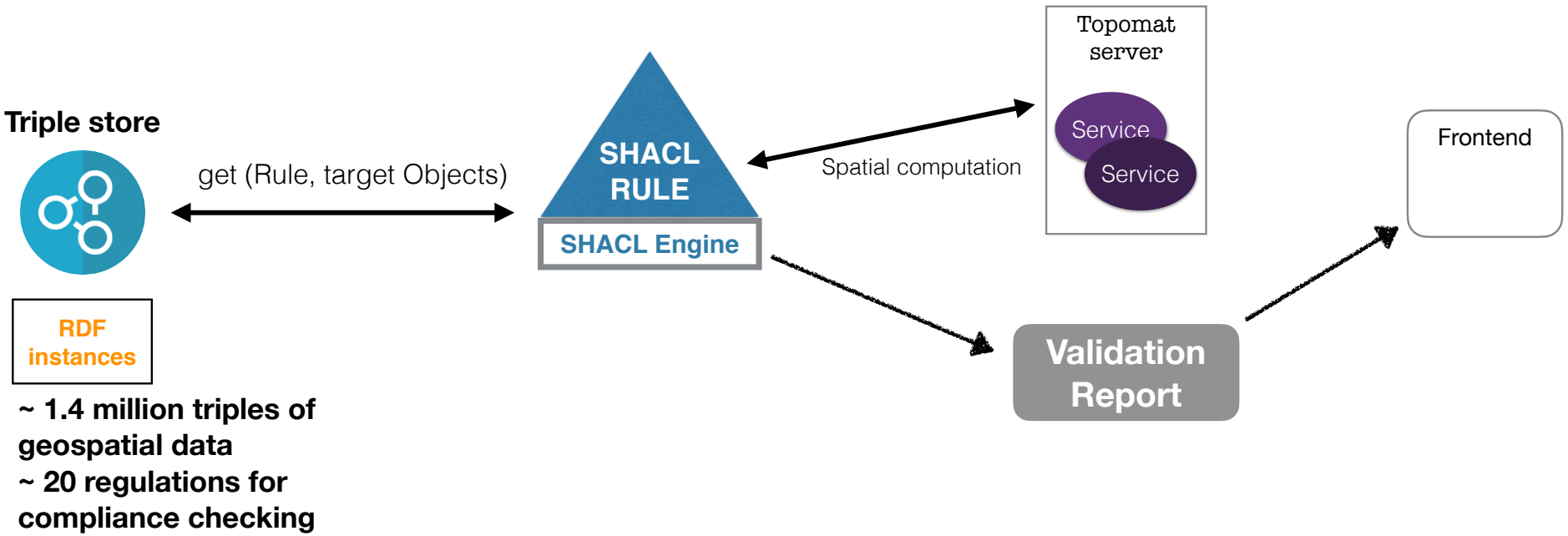
Triple store

The SUBSURFACE project

Overview



Regulation compliance checking



Summary

- Ontology to represent unifying data management of subsurface space (connecting standards…)
- Data completion: 3D-ified and inferred missing information
- Dealing with geometry uncertainties
- Automated regulation compliance checking
- Provide underground data as a key asset for efficient exploitation, visualization and decision making tools
- Provide a solid (unified) knowledge graph on which future tools for urban planning may rely

PROTOTYPE VIDEO

DEMO TopoSubSurface

Thanks for listening

Any question?