SHACL
Shapes Constraint Language

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slides from Olivier Corby

Semantic Web Languages

1. RDF: Resource Description Framework
2. RDFS: RDF Schema
3. SPARQL: RDF Query Language
4. OWL: Web Ontology Language
5. SKOS: Simple Knowledge Organization System (Thesaurus)

Semantic Web Languages

1. RDF: Resource Description Framework
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4. OWL: Web Ontology Language
5. SKOS: Simple Knowledge Organization System (Thesaurus)
6. SHACL: Shapes Constraint Language

SHACL

- Language for **validating** RDF graphs against « constraints »
- W3C Recommendation, 2017
- SHACL syntax is RDF

SHACL vs RDFS

- RDFS enables engine to perform entailments
- SCHACL enables engine to perform validation

Example

instances of class Person must have

one property name

with datatype string

Example

```
prefix sh: <http://www.w3.org/ns/shacl#>

ex:test a  sh:NodeShape ;
```

Example

```
prefix sh: <http://www.w3.org/ns/shacl#>

ex:test a  sh:NodeShape ;
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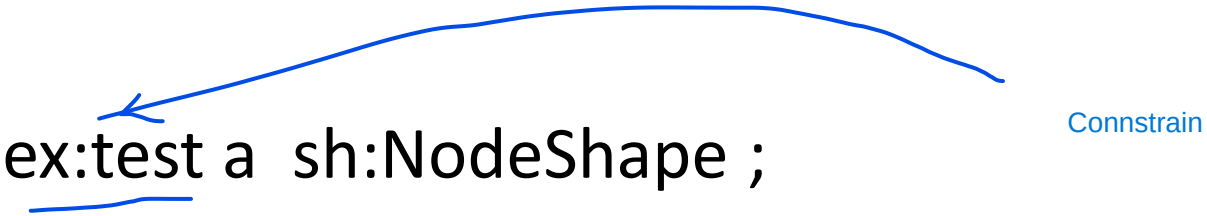
```



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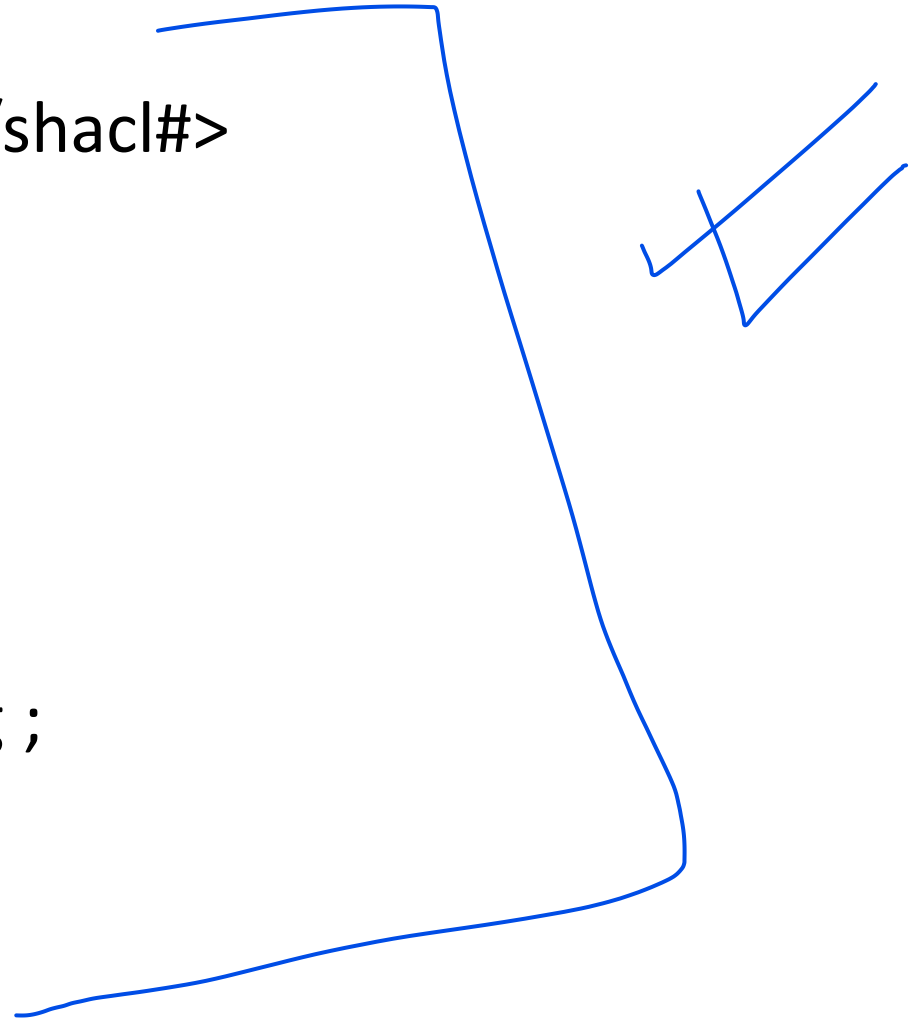
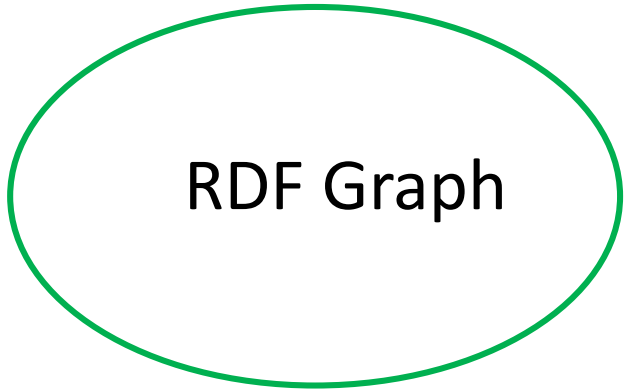


Example

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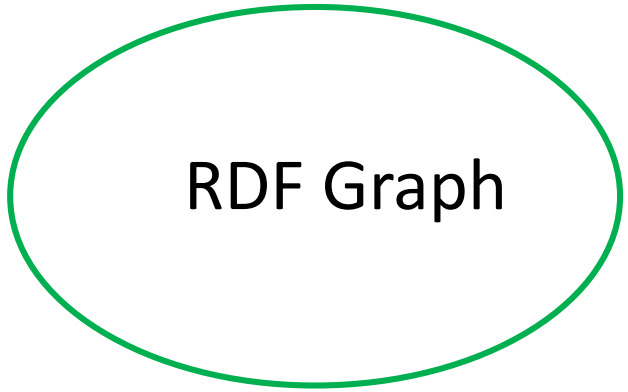


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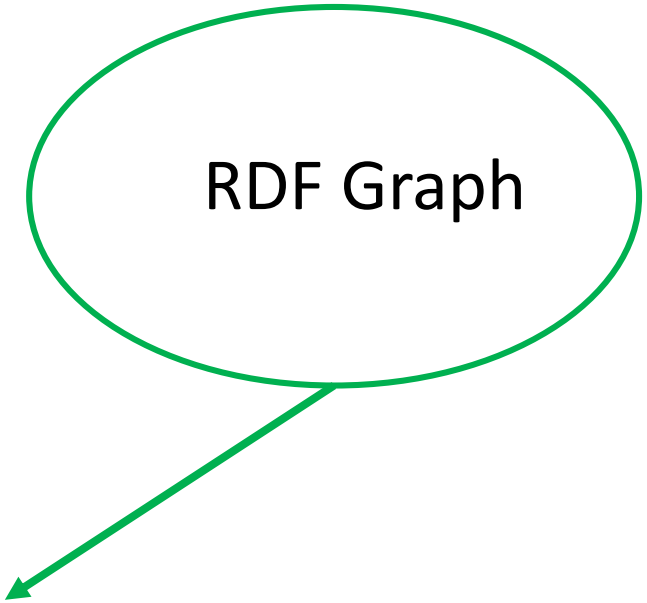
Example

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O_1 .. O_n

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        ] .
```

O_1 .. O_n

ex:John a foaf:Person ;
foaf:name ”John” .

Example

```
prefix sh: <http://www.w3.org/ns/shacl#>

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        sh:targetClass foaf:Person ;
        sh:property [
                sh:path  foaf:name ;
                sh:datatype xsd:string ;
                sh:minCount 1
        ] .
```

O_1 .. O_n


```
ex:Jack a foaf:Person ;
        foaf:name "Jack"@en .
```

Example

```
prefix sh: <http://www.w3.org/ns/shacl#>

ex:test a  sh:NodeShape ;
        sh:targetClass foaf:Person ;
        sh:property [
                sh:path  foaf:name ;
                sh:datatype xsd:string ;
                sh:minCount 1
        ] .
```

O_1 .. O_n


```
ex:James a foaf:Person ;
        rdfs:label "James" .
```

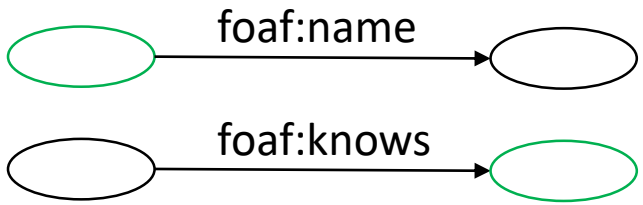
Target

Determine the set of nodes relevant for a shape

1. sh:targetClass foaf:Person
2. sh:targetNode us:John, us:Jack

for specific resourses

3. sh:targetSubjectsOf foaf:name
4. sh:targetObjectsOf foaf:knows



Target

Determine the set of nodes relevant for a shape

sh:targetClass foaf:Person, foaf:Organization

->

foaf:Person U foaf:Organization

SHACL Shapes

1. Property shape

   sh:property [sh:path foaf:name ; sh:minLength 10]

2. Node shape

   sh:minLength 10

Property Path

sh:property [sh:path foaf:name ; sh:minLength 10]

sh:property [sh:path EXP ; sh:minLength 10]

SPARQL Property Path

Property Path Expression

SPARQL: rdf:type/rdfs:subClassOf*

SHACL: (rdf:type [sh:zeroOrMorePath rdfs:subClassOf])

```
sh:property [
        sh:path (rdf:type [sh:zeroOrMorePath rdfs:subClassOf]) ;
        …
]
```

Property Path

SHACL	SPARQL
URI	URI
(EXP_1 EXP_2 …)	EXP_1/EXP_2/…
[sh:alternativePath (EXP_1 EXP_2 …)]	EXP_1|EXP_2|…
[sh:inversePath EXP]	^EXP
[sh:zeroOrMorePath EXP]	EXP*
[sh:oneOrMorePath EXP]	EXP+
[sh:zeroOrOnePath EXP]	EXP?

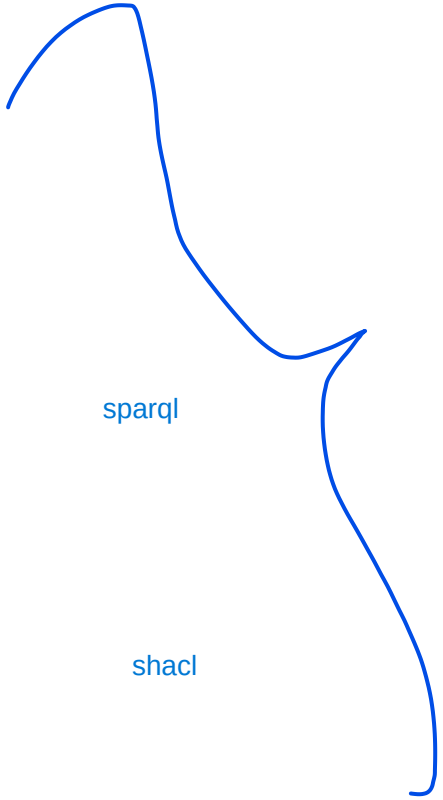
Property Path

foaf:knows / foaf:name

sparql

(foaf:knows foaf:name)

shacl



Property Path

(h:hasFriend | h:hasChild)+

[sh:oneOrMorePath
[sh:alternativePath (h:hasFriend h:hasChild)]]

Type Constraint

- sh:class
- sh:datatype
- sh:nodeKind
  - URI, Blank Node, Literal

Class

```
sh:property [
        sh:path foaf:knows ;
        sh:class foaf:Person
]
```

Semantics: rdf:type/rdfs:subClassOf* foaf:Person

Class

```
sh:property [
        sh:path foaf:knows ;
        sh:class ex:Professor, ex:Researcher
]
```

intersection

->

ex:Professor ⊓ ex:Researcher

Datatype

```
sh:property [
        sh:path foaf:name ;
        sh:datatype xsd:string
]
```

XSD datatypes: xsd:integer, xsd:boolean, xsd:date, etc.

RDF datatypes: rdf:langString, rdf:XMLLiteral, etc.

@en @fr

Node Kind

sh:nodeKind

- sh:BlankNode, sh:IRI, sh:Literal
- sh:BlankNodeOrIRI, sh:BlankNodeOrLiteral, sh:IRIOrLiteral

Cardinality Constraint

```
sh:property [
        sh:path  foaf:age ;
        sh:minCount 1 ;
        sh:maxCount 1
]
```

Value Range Constraint

- sh:minExclusive 0
- sh:maxExclusive 10

- sh:minInclusive “a”
- sh:maxInclusive “z”

String Value Range Constraint

- sh:minLength 1 -- string length
- sh:maxLength 10

- sh:pattern “uca” -- regex

- sh:languageIn (“fr” “it” “en”) -- @en @ru “test” ex:value
- sh:uniqueLang true -- (@fr @it) (@en @fr @en)

Exercise

Write a shape:

target class Person

property name

datatype string

string length > 0

cardinality > 0

```
ex:test a sh:NodeShape ;
sh:targetClass foaf:Person
sh:property [
sh:path ex:name ;
sh:datatype xsd:string ;
sh:minLength 1;
sh:minCount 1.
] .
```

Exercise

```
ex:test a sh:NodeShape ;
sh:targetClass ex:Person ;
sh:property [
        sh:path ex:name ;
        sh:datatype xsd:string ;
        sh:minLength 1 ;
        sh:minCount 1
] .
```

Exercise

Write SHACL Property Path for:

rdf:rest*/rdf:first

Exercise

Write SHACL Property Path for:

rdf:rest*/rdf:first

([sh:zeroOrMorePath rdf:rest] rdf:first)

Exercise

Write SHACL Property Path for:

foaf:knows | ^foaf:knows

Exercise

Write SHACL Property Path for:

foaf:knows | ^foaf:knows

[sh:alternativePath (foaf:knows [sh:inversePath foaf:knows])]

Property Pair Constraint

Compare two sets of values

- sh:equals
- sh:disjoint
- sh:lessThan
- sh:lessThanOrEquals

Property Pair Constraint

```
sh:property [
        sh:path    ex:firstName ;
        sh:equals ex:givenName
]
```

Property Pair Constraint

```
sh:property [
        sh:path      ex:child ;
        sh:disjoint ex:parent
]
```

Property Pair Constraint

```
sh:property [
        sh:path       ex:startDate ;
        sh:lessThan ex:endDate
]
```

Boolean Constraint

- sh:not
- sh:and
- sh:or
- sh:xone – each node conforms to exactly one constraint

Boolean Constraint

```
sh:property [
        sh:path  rdfs:label ;
        sh:or ([sh:datatype xsd:string] [sh:datatype rdf:langString])
]
```

Boolean Constraint

```
sh:property [
        sh:path  foaf:knows ;
        sh:not [sh:path foaf:name ; sh:hasValue ex:JohnDoe]
]
```

Boolean Constraint Example

Every class in namespace http://example.org/ns must be declared by rdf:type

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(cardinality(rdf:type) = 0)

```
sh:property [
        sh:path rdf:type ;   # this is a class
        sh:not [ sh:and (
                [sh:pattern  'http://example.org/ns ']
                [sh:property [sh:path rdf:type ; sh:maxCount 0]])]
]
```

Qualified Value Shape

Instance of Person have exactly:

- one parent of type Man
- one parent of type Woman

Qualified Value Shape

```
sh:property [ sh:path ex:parent ;
        sh:qualifiedMinCount 1 ;
        sh:qualifiedMaxCount 1 ;
        sh:qualifiedValueShape [ sh:class  ex:Man ] ]
```

Qualified Value Shape

```
sh:property [ sh:path ex:parent ;
        sh:qualifiedMinCount 1 ;
        sh:qualifiedMaxCount 1 ;
        sh:qualifiedValueShape [ sh:class  ex:Man ] ] ;
sh:property [ sh:path ex:parent ;
        sh:qualifiedMinCount 1 ;
        sh:qualifiedMaxCount 1 ;
        sh:qualifiedValueShape [ sh:class  ex:Woman ] ]
```

Qualified Value Shapes Disjoint

```
sh:property [ sh:path ex:parent ;
        sh:qualifiedMinCount 1 ;
        sh:qualifiedMaxCount 1 ;
        sh:qualifiedValueShapesDisjoint true;
        sh:qualifiedValueShape [ sh:class  ex:Man ] ] ;
sh:property [ sh:path ex:parent ;
        sh:qualifiedMinCount 1 ;
        sh:qualifiedMaxCount 1 ;
        sh:qualifiedValueShapesDisjoint true;
        sh:qualifiedValueShape [ sh:class  ex:Woman ] ]
```

Has Value

```
sh:property [
        sh:path foaf:knows ;
        sh:hasValue ex:JohnDoe
]
```

- *At least one* node must be equal to the value

Value In

```
sh:property [
        sh:path  ex:value ;
        sh:in (ex:Good ex:Bad ex:Ugly)
]
```

- *Every* node must be member of the value list

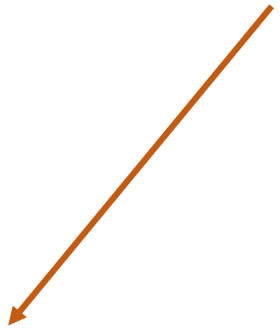
Other Constraints

```
ex:test a sh:NodeShape  ;
sh:targetClass  ex:Person ;
sh:closed true ;
sh:ignoredProperties (rdf:type rdfs:label …) ;
sh:property [ sh:path ex:name ; … ] ;
sh:property [ sh:path ex:address ; … ] ;
sh:property [ sh:path ex:phone ; … ]
.
```

Node Shape

```
ex:test1 a sh:NodeShape ;
sh:targetClass foaf:Person ;
sh:node ex:test2
.

ex:test2 a sh:NodeShape ;
...
```



Node Shape

```
ex:test a sh:NodeShape ;
sh:property [
        sh:path foaf:knows ;
        sh:node [
                sh:property [ sh:path foaf:name ; sh:datatype xsd:string ]
        ]
] .
```

Exercise

Check that the values (the objects) of property rdf:type are either of class rdfs:Class or class owl:Class

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Check that the values (the objects) of property rdf:type are either of class rdfs:Class or class owl:Class

sh:targetObjectsOf rdf:type ;

sh:or ([sh:class rdfs:Class] [sh:class owl:Class])

SHACL		
st:targetClass		
sh:targetNode		
sh:targetSubjectsOf		
sh:targetObjectsOf		
sh:property		
sh:path		
sh:node		

SHACL	OWL	RDFS
sh:class		rdfs:range
sh:dataype		rdfs:range
sh:minCount, sh:maxCount	owl:minCardinality, owl:maxCardinality	
sh:minInclusive, sh:maxInclusive		
sh:minExclusive, sh:maxExclusive,		
sh:minLength, sh:maxLength		
sh:pattern		
sh:languageIn		
sh:uniqueLang		

SHACL	OWL	RDFS
sh:equal		
sh:disjoint		
sh:lessThan, sh:lessThanOrEquals		
sh:or, sh:and, sh:not, sh:xone		
sh:hasValue		
sh:in		
sh:qualifiedValueShape		
sh:qualifiedMinCount, sh:qualifiedMaxCount		
sh:qualifiedValueShapesDisjoint		
sh:closed		
sh:ignoredProperties		

Import Shape

[] owl:imports <http://www.w3.org/ns/shacl-shacl> .

Shape Documentation

sh:message "This is a terrible mistake" ;

sh:severity sh:Info | sh:Warning | sh:Violation

+ user defined severity: ex:UltimateCriticalDamnedError

Validation Report

RDF graph with a list of errors, if any

```
[       a sh:ValidationReport ;
        sh:conforms true ;
] .
```

Validation Report

```
[       a sh:ValidationReport ;
        sh:conforms false ;
        sh:result
        [       a sh:ValidationResult ;
                sh:resultSeverity sh:Warning ;
                sh:focusNode ex:MyInstance ;
                sh:resultPath ex:myProperty ;
                sh:value "http://toomanycharacters"^^xsd:anyURI ;
                sh:sourceConstraintComponent sh:DatatypeConstraintComponent ;
                sh:sourceShape _:b1 ;
        ]
] .
```

SHACL SPARQL

SHACL SPARQL

Constraint defined by a SPARQL query

Query computes and returns nodes that fail, if any

SHACL SPARQL: select nodes that fail

```
ex:sparql a sh:NodeShape ;
sh:targetClass ex:Car ;
sh:sparql [
sh:select """
        select  $this (ex:carbon  as ?path) ?value
        where {
                $this ex:carbon ?value .
                filter (?value > 95)   # 95 g/km
        }
""" ;
] .
```

Usage

Download Corese last version (Java 11)

https://project.inria.fr/corese/download/

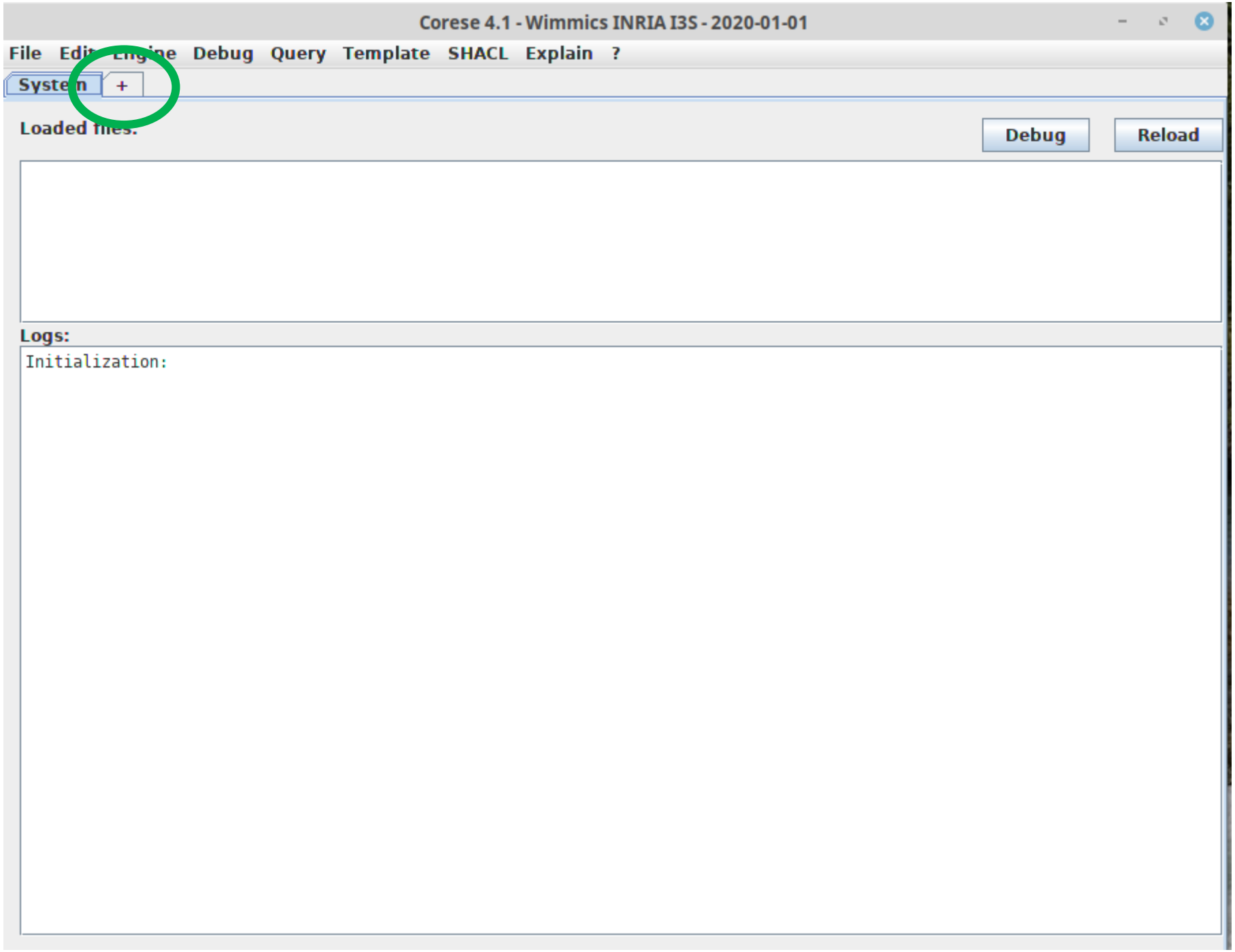
Usage

Load RDF graph

Load RDF schema

Load SHACL graph

Click + and click SHACL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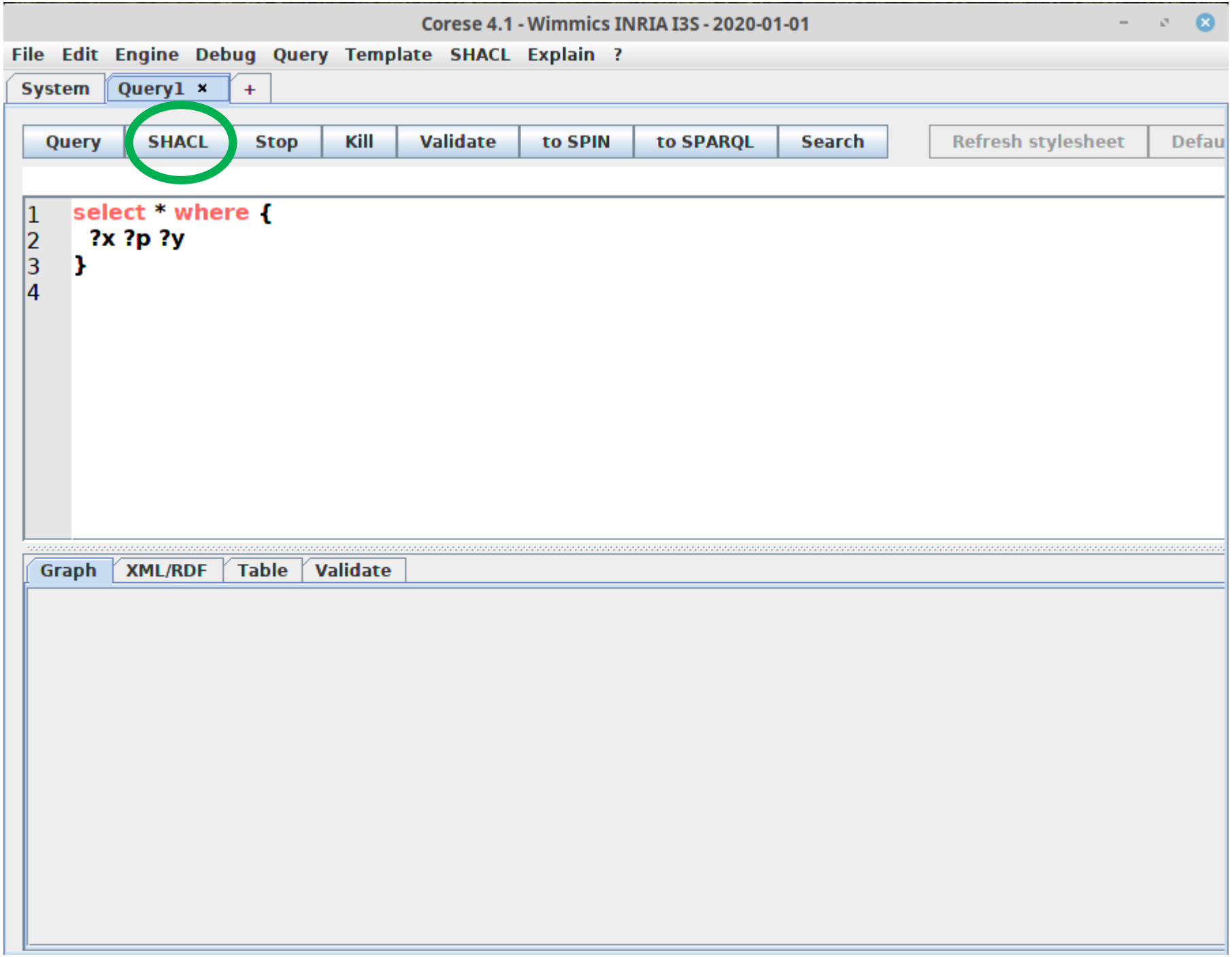
System
+
Loaded files:
Debug
Reload
Logs:
Initialization: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File Edit Engine Debug Query Template SHACL Explain ?
System
Query1 ×
+
Query
SHACL
Stop
Kill
Validate
to SPIN
to SPARQL
Search
Refresh stylesheet
Defau
1 select * where {
2 ?x ?p ?y
3 }
4
Graph
XML/RDF
Table
Validate

ShEx vs SHACL

- There is another shape language called ShEx !

https://shex.io/shex-primer/