Shapes Constraint Language Masterclass

By Veronika Heimsbakk

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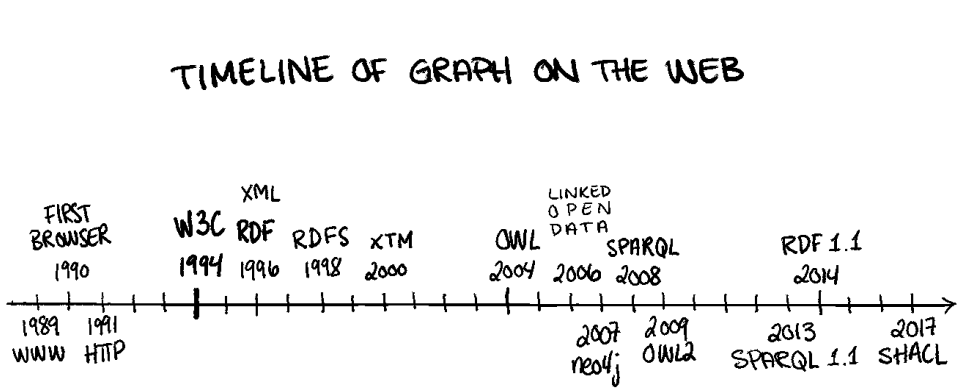
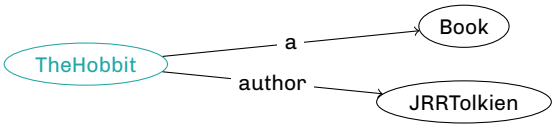
Once upon a time...



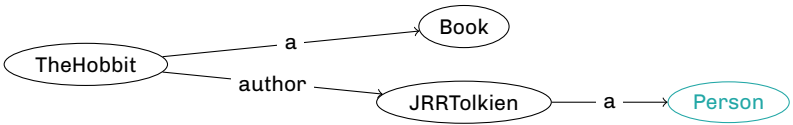
domain & range

domain




```
:author a rdf:Property ;
  rdfs:domain :Book .
```

range




```
:author a rdf:Property ;
  rdfs:domain :Book ;
  rdfs:range  :Person .
```

World assumptions

Open world assumption (OWA)

- Admits incomplete knowledge.
- Ontologies with Web Ontology Language (OWL).

The assumption that the truth value of a statement may be true irrespective of whether or not it is known to be true.

Example

Statement: In a hole in the ground there lived a hobbit.
Question: Do Gandalf live in a hole in the ground?
OWA: Unknown

Closed world assumption (CWA)

- Shape constraints with Shape Constraint Language (SHACL).

Any statement that is true is known to be true. What is not currently known to be true is false.

Example

Statement: In a hole in the ground there lived a hobbit.
Question: Do Gandalf live in a hole in the ground?
CWA: No

Shape Constraint Language

A language for describing and validating RDF graphs

Validation of RDF – a brief history

- Prior to SHACL; no W3C standard for validating RDF.
- SPARQL Inferencing Notation (SPIN), IBM Resource Shapes, Shape Expressions (ShEx)
- W3C recommendation in July 2017.

SPIN & ShEx

SPIN

- Both are backed by SPARQL.
- SHACL Constraint Components are more flexible than SPIN Templates due to the possibility of combining multiple constraint types into same shape definition.
- SPIN Templates require new instances and multiple `spin:constraint` triples.

ShEx

- Both have shapes on nodes and properties.
- ShEx intends to be a grammar or schema for RDF.
- SHACL aims to provide a constraint language for RDF.
- ShEx returns an annotated data graph.
- SHACL return a validation report as RDF.

SHACL & OWL

Common

- RDF & URIs
- Rely on RDF Schema (RDFS)

Difference

Inference Validation

When to use SHACL?

It depends on the use case!

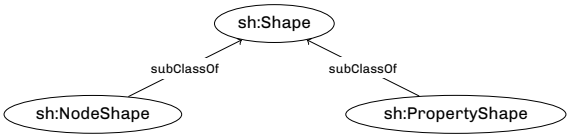
- Validation, before or after reasoning (or both).
- Automate certain parts of a data pipeline.
- Acceptance testing ontologies and/or shapes.
- Information modelling.

We'll get back to this!

SHACL Shape

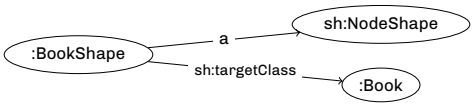
A collection of constraints for given RDF resource.

- Shapes about focus nodes (**sh:NodeShape**).
- Shapes about values of a property or path for the focus node (**sh:PropertyShape**).



sh:NodeShape

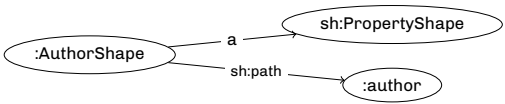
A *node shape* is a shape that is **not** the subject of a triple with *sh:path* as its predicate.




```
:BookShape
  a sh:NodeShape ;
  sh:targetClass :Book .
```

sh:PropertyShape

A *property shape* is a shape that is the subject of a triple that has *sh:path* as its predicate.




```
:AuthorShape
  a sh:PropertyShape ;
  sh:path :author .
```

BookShape

```
:BookShape
  a sh:NodeShape ;
  sh:targetClass :Book ;
  sh:property :AuthorShape .

:AuthorShape
  a sh:PropertyShape ;
  sh:path :author .
```

SHACL Core Constraint Components

SHACL Core Constraint Components

Value type

sh:class	Each value node is an instance of a given type.
sh:datatype	Datatype of each value node.
sh:nodeKind	Node kind (IRI, blank node etc.) of each value node.

```
:BookShape
  a sh:NodeShape ;
  sh:targetClass :Book ;
  sh:property [
    sh:path :author ;
    sh:class :Person ;
  ] ;
  sh:property [
    sh:path :published ;
    sh:datatype xsd:date ;
  ] .
```

SHACL Core Constraint Components

Cardinality

sh:minCount	Minimum cardinality as xsd:integer.
sh:maxCount	Maximum cardinality as xsd:integer.

Value range

sh:minExclusive	$x <$ $value
sh:minInclusive	$x <=$ $value
sh:maxExclusive	$x >$ $value
sh:maxInclusive	$x >=$ $value

```
:BookShape
  a sh:NodeShape ;
  sh:targetClass :Book ;
  sh:property [
    sh:path :pages ;
    sh:minInclusive 10 ;
    sh:maxExclusive 5000 ;
  ] .
```

SHACL Core Constraint Components

String-based

sh:minLength	Minimum length as xsd:integer.
sh:maxLength	Maximum length as xsd:integer.
sh:pattern	Regular expression.
sh:languageIn	A list of languages as per RFC5646.
sh:uniqueLang	One unique tag per language.

```
:BookShape
  a sh:NodeShape ;
  sh:targetClass :Book ;
  sh:property [
    sh:path :ISBN ;
    sh:pattern "^(?=(?:\D*\d){10}(?:(?:\D*\d){3})?$)[\d-]+$" ;
  ] .
```

SHACL Core Constraint Components

Property pair	Compare two IRIs where,
sh:equals	$x \equiv y$
sh:disjoint	$x \cap y = \emptyset$
sh:lessThan	$x < y$
sh:lessThanOrEquals	$x <= y$

```
:PersonShape
  a sh:NodeShape ;
  sh:targetClass :Person ;
  sh:property [
    sh:path :birth ;
    sh:lessThanOrEquals :death ;
  ] .
```

SHACL Core Constraint Components

Logical	List of value nodes that,
sh:not	Cannot conform to given shape.
sh:and	Conforms to all provided shapes.
sh:or	Conforms to at least one of the provided shapes.
sh:xone	Conforms to exactly one of the provided shapes.

```
:PersonShape
  a sh:NodeShape ;
  sh:targetClass :Person ;
  sh:or (
    [ sh:path :firstName ; sh:minCount 1 ; ]
    [ sh:path :lastName ; sh:minCount 1 ; ]
  ) .
```

SHACL & OWL

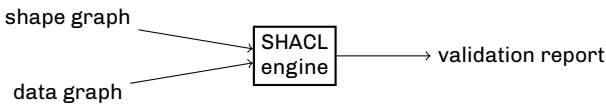
```
:BookShape
  a sh:NodeShape, owl:Class ;
  sh:targetClass :Book ;
  sh:property [
    sh:path :author ;
    sh:or (
      [ sh:class :Author ]
      [ sh:datatype xsd:string ]
    )
  ] .
```

SHACL Core Constraint Components

Shape-based	Each value node,
sh:node	Conforms to the given node shape.
sh:property	Has a given property shape.
Other	
sh:closed	Boolean signalising a complete shape.
sh:ignoredProperties	List of properties to ignore.
sh:hasValue	At least one value node is equal to the given term.
sh:in	Value node is member of given list.

```
:BookShape
  a sh:NodeShape ;
  sh:targetClass :Book ;
  sh:closed true ;
  sh:ignoredProperties (rdf:type) .
```

SHACL engine



Validation report

Each instance of *sh:ValidationReport* has exactly one value of *sh:conforms*.

sh:conforms is true iff the validation did not produce any **validation results**, and false otherwise.

Iff validation conforms false, the report will contain an instance of **sh:ValidationResult**.

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

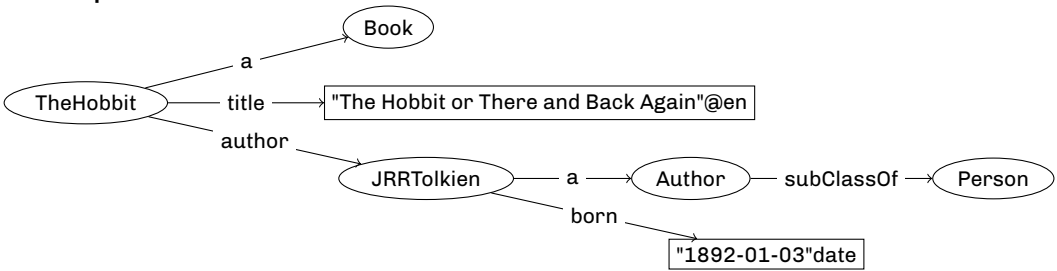
Validation result

All properties described can be specified in a validation result.

sh:focusNode	Node that caused the result.
sh:resultPath	Pointing to value of **sh:path**
sh:value	Value node that violated constraint.
sh:sourceShape	Shape that given focus node validated against.
sh:sourceConstraintComponent	Constraint component that caused the result.
sh:detail	Parent result containing more details about the violation.
sh:message	Annotation property with textual details.
sh:severity	Default **sh:Violation**.

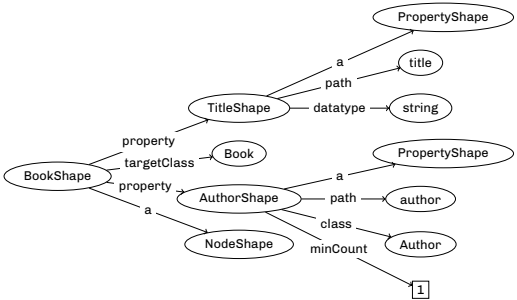
Validation example

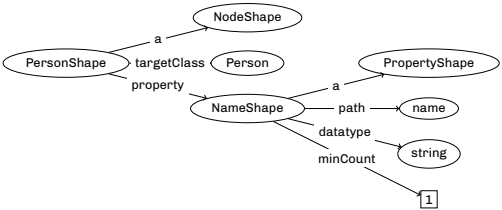
Data Graph



Validation example

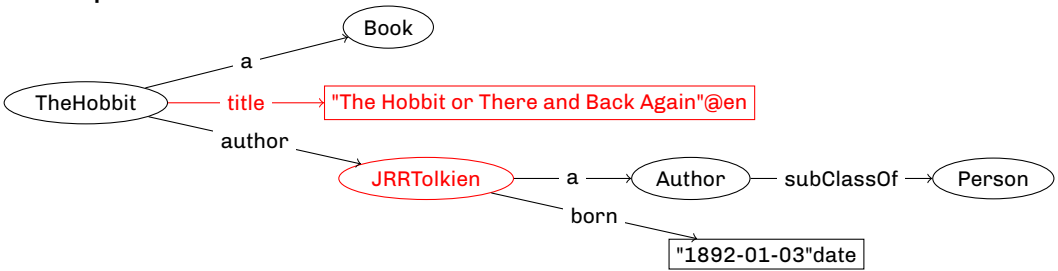
Shapes Graph





Validation example

Data Graph



Validation example

Validation Result (RDF4J)

Other nice to knows about SHACL

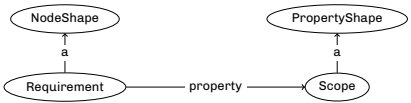
- Deactivating shapes
- Non-validating property shape characteristics
  - sh:name & sh:description
  - sh:order & sh:group
  - sh:defaultValue
- Syntax checking of shapes graph

SHACL Implementations

Framework	
ruby-rdf/shacl	`https://github.com/ruby-rdf/shacl`
dotNetRDF	`https://dotnetrdf.org/docs/stable/api/VDS.RDF.Shacl.html`
pySHACL	`https://github.com/RDFLib/pySHACL`
RDF4J	`https://rdf4j.org/`
Jena	`https://jena.apache.org/`
Vendors	
TopQuadrant	`https://www.topquadrant.com/`
Stardog	`https://www.stardog.com/`
Cambridge Semantics	`https://cambridgesemantics.com/anzograph/`
Franz	`https://allegrograph.com`
Web playground	
SHACL Playground	`https://shacl.org/playground/`

SHACL Stories

Regulatory Requirements



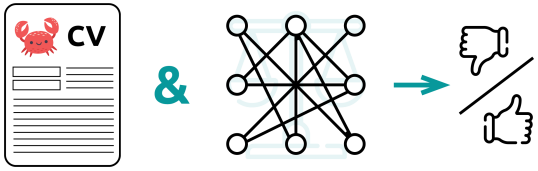

```
:REG2013112214O4S7P1 a :Requirement, sh:NodeShape ;
  :regulationTitle "A very fine title"@en ;
  :theme "Some very fine theme"@en ;
  rdfs:label "Paragraph title"@en ;
  sh:property :BuiltDate_after19980102 .

:BuiltDate_after19980102 a :Scope, sh:PropertyShape ;
  sh:path :builtDate ;
  sh:minInclusive "1998-01-02" ;
  sh:datatype xsd:date .
```

- Intuitive way of modelling Requirements and Scopes.
- Verbose vocabulary for describing scope characteristics.
- Closed World Assumption in the domain of law.

More details on a specific project: `http://www.lotico.com/index.php/Data_Shapes_in_Action`

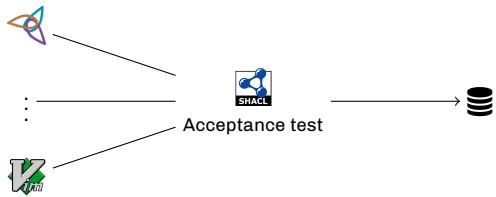
Issue Certificates




```
...
sh:or (
  [ sh:and ( # first alternative
    [ sh:or ( cert:D2A0 cert:D2B0 cert:D3A0
              cert:D3B0 cert:D4B0 cert:D4F0 ) ]
    [ sh:path nma:hasSeagoingServiceRequirement ;
      sh:hasValue nma:SGS_500_1080_DO ; ]
  )]

  [ sh:and ( # second alternative
    [ sh:or ( cert:D2A0 cert:D2B0
              cert:D3A0 cert:D3B0 ) ]
    [ sh:path nma:hasSeagoingServiceRequirement ;
      sh:hasValue nma:SGS_500_720_DO ; ]
    [ sh:path nma:hasSeagoingServiceRequirement ;
      sh:hasValue nma:SGS_500_360_CO ; ]
  )]
) ;
...
```

Acceptance Testing

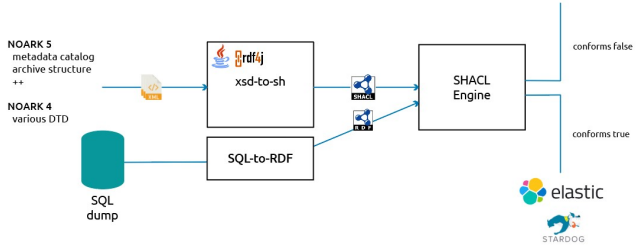



```
:RDFSClassShape a sh:NodeShape ;
  sh:targetClass rdfs:Class ;
  sh:property :RDFSLabelShape .

:RDFSLabelShape a sh:PropertyShape ;
  sh:path rdfs:label ;
  sh:minCount 1 ; sh:maxCount 1 ;
  sh:datatype rdf:langString .
```

- Shapes to validate the *structure* of the TBox.
- Included in the commit-pipeline, or outside if git is not used.
- Does not validate the *content* of the graph.

Schema



Journal post snippet

```
<jp/123> a :JournalPost ;
  :numAttachements 1 ;
  :documentMedium :ElectronicArchive ;
  :journalPostNumber "12/123-4"^^xsd:string ;
  ... .
```

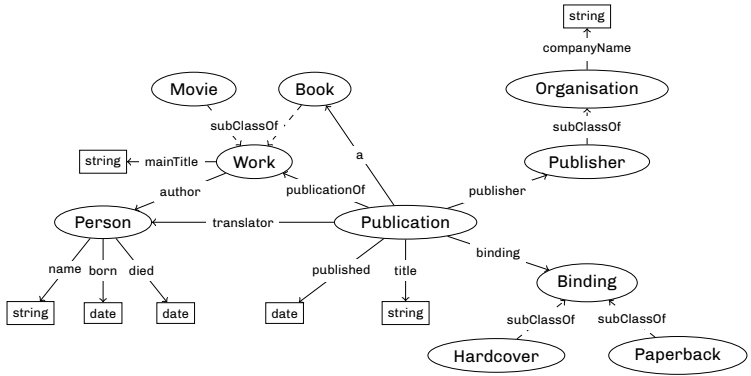
SHACL snippet

```
:JP_numAttachemets a sh:PropertyShape ;
  sh:datatype xsd:integer ;
  sh:maxCount 1 ;
  sh:path :numAttachements .
```

Get to work!

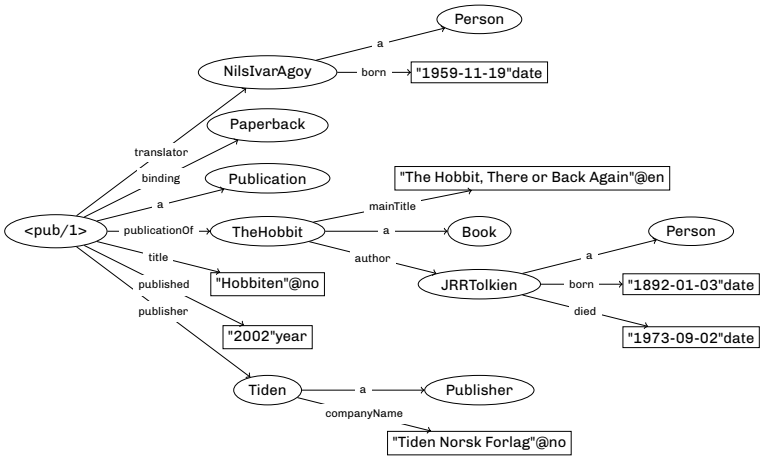
- Publications of books
- Persons and affiliations

Example Publication Ontology



https://tinyurl.com/2mfn4epk

Example data graph



Announcements!

SHACL Wiki
by Ivo Velitchkov and Veronika Heimsbakk
`https://kvistgaard.github.io/shacl/`

SHACL for the Practitioner (book)
`https://forms.gle/CpvsHFyHWqfwJ9fy9`

References & resources

Images

My toy box & bookshelf	freepik.com

Around the web

W3C Recommendation	*Shape Constraint Language*	`https://www.w3.org/TR/shacl/`
Holger Knublauch	*SHACL and OWL Compared*	`https://spinrdf.org/shacl-and-owl.html`
W3C Working Group Note	*SHACL Advanced Features*	`https://w3c.github.io/shacl/shacl-af/`
TopQuadrant	*DASH Data Shapes*	`http://datashapes.org/`

Book

Jose Emilio labra Gayo, Eric Prud'hommeaux, Iovka Boneva, Dimitris Kontokostas, *Validating RDF Data*, 2018.