Introduction to SHACL

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Takeaways

- How SHACL fits into the Semantic Web technology stack
- Basic understanding of the core features in SHACL
- Hands-on experience in using SHACL to validate RDF graphs

About RDF

- The standard language for describing data on the Semantic Web

- Data is represented as directed graphs

- Allows for integration of different data sources

- Many serialization formats
  - XML, JSON-LD, NT, N-Triples, Turtle, …

What about a schema language for RDF?

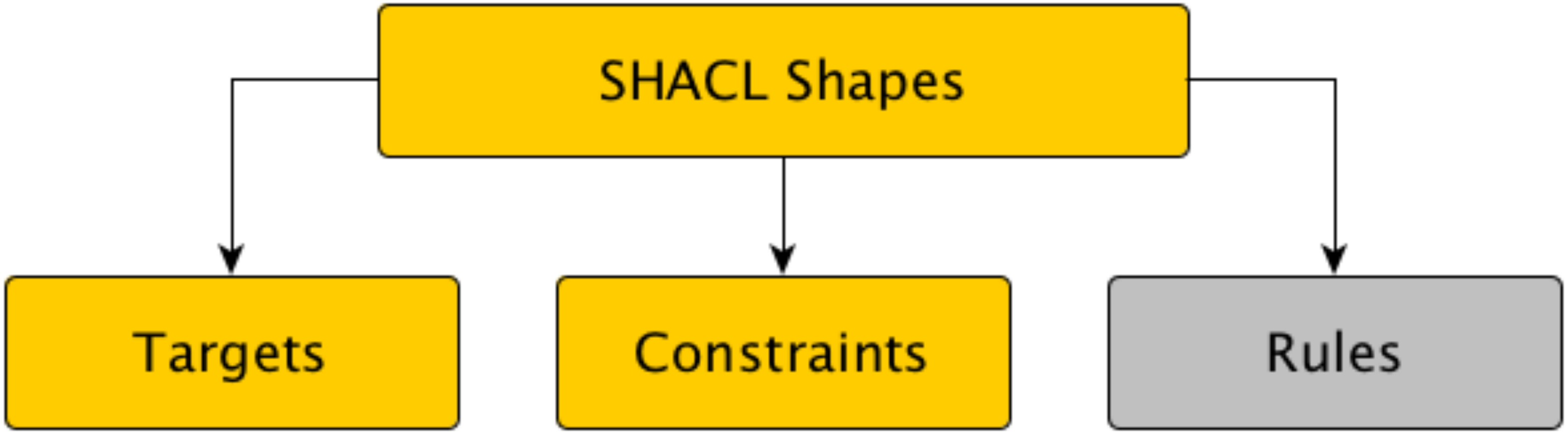
- RDF Schema
  - A bit of a misnomer
  - Should really be something like “RDF Vocabulary Definition Language”
  - Limited expressivity
- OWL
  - Targets logic modeling and inferencing, not validation
  - Open-world assumption
  - No unique name assumption
- Alternative approaches
  - OWL under the closed-world assumption
- Semi-official specifications (W3C submissions)
  - SPIN, Resource Shapes, ShEx, …

SHACL

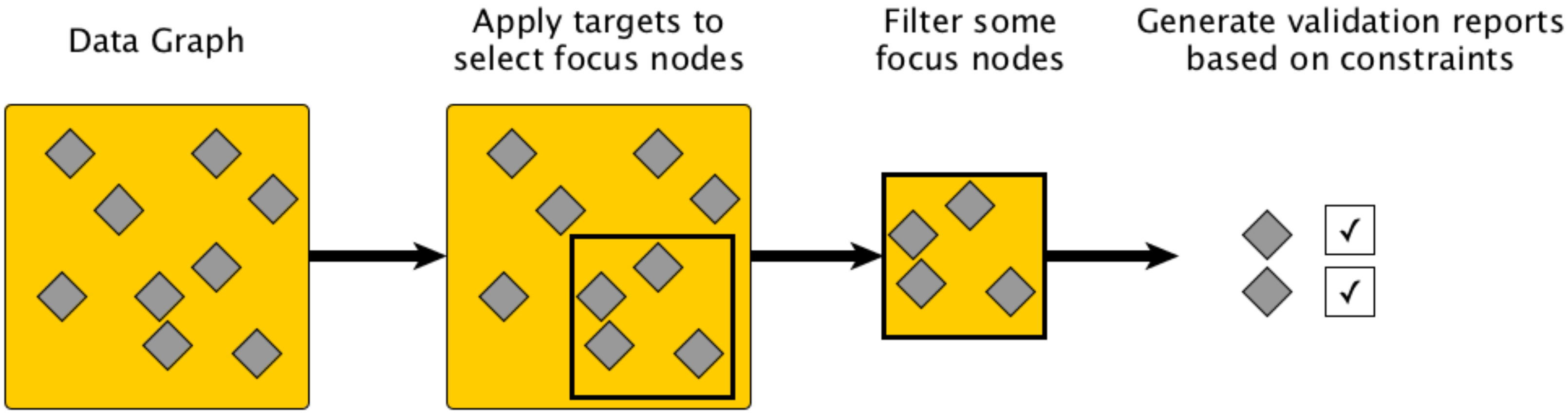
What is SHACL?

- **Sha**pes **C**onstraint **L**anguage
- W3C recommendation since July 2017
- Allows RDF data to be validated against *shapes*
  - Data graph
  - Shapes graph
- … and more (user-interface generation, inference, SPARQL extensions, etc.)

Overview



Validation process


Data Graph
Apply targets to select focus nodes
Filter some focus nodes
Generate validation reports based on constraints
✓
✓

Turtle

- Shorthand expressions
  - Semi-colon denotes repeated use of preceding subject
  - Comma denotes repeated use of the preceding subject and property
  - Parentheses denote lists or collections
  - Brackets denote blank nodes (anonymous resources)

SHACL Example

```
ex:PonyShape
    a sh:NodeShape ;
    sh:targetClass ex:RainbowPony ;
    sh:property ex:PonyPropertyShape .

ex:PonyPropertyShape
    a sh:PropertyShape ;
    sh:path ex:color ;
    sh:in ( ex:Pink ex:Purple ) .
```

SHACL Example

```
ex:PonyShape
    a sh:NodeShape ;
    sh:targetClass ex:RainbowPony ;
    sh:property [
       sh:path ex:color ;
       sh:in ( ex:Pink ex:Purple )
    ] .
```

Targets

- Targets are applied to Node Shapes and specify the nodes that are to be validated
- Targets can be specified in several ways
  - targetClass – All instances of a class
  - targetNode – Specific nodes
  - targetObjectsOf – All object of a specific property
  - targetSubjectsOf – All subjects of a specific property

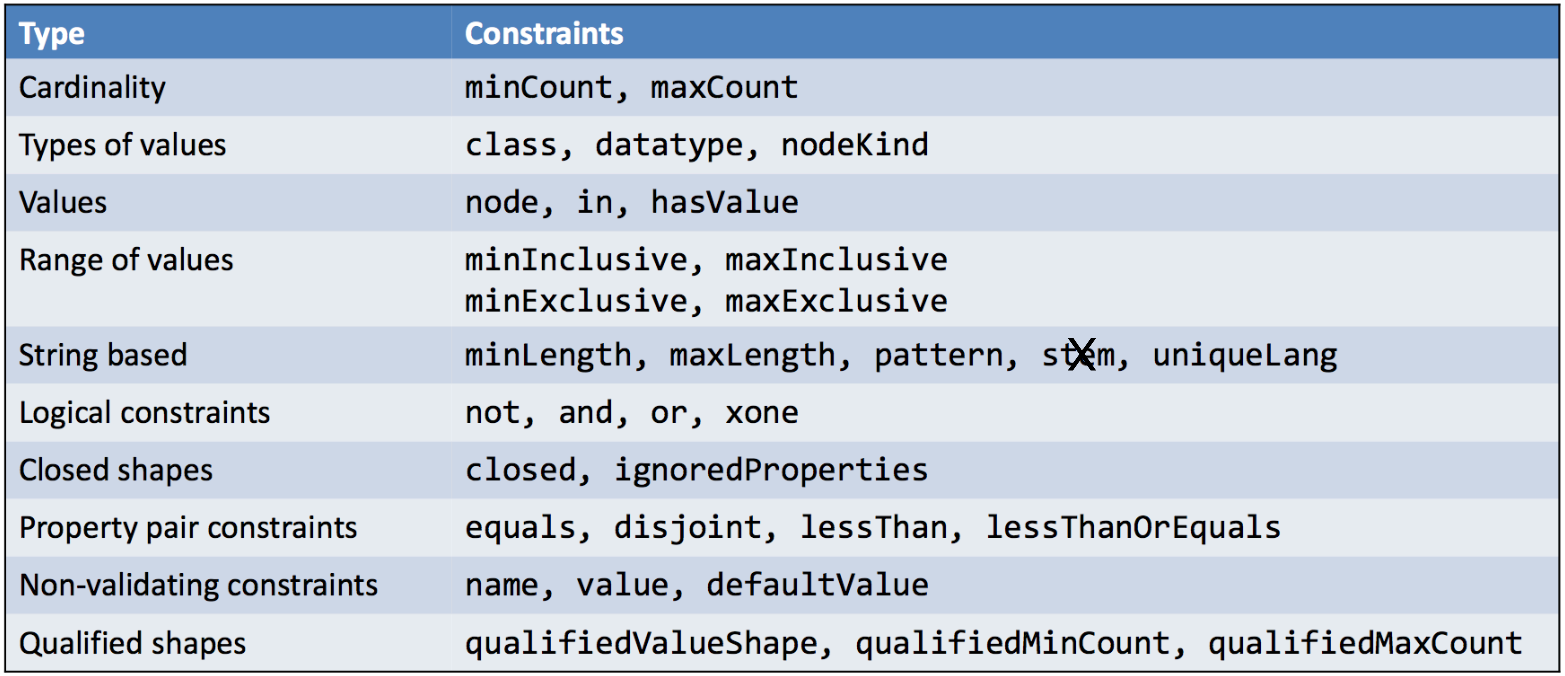
Targets

```
ex:PonyShape1
    a sh:NodeShape ;
    sh:targetClass ex:Pony .

ex:PonyShape2
    a sh:NodeShape ;
    sh:targetNode ex:Pinkie_Pie, ex:Rarity .

ex:PonyShape3
    a sh:NodeShape ;
    sh:targetSubjectsOf ex:hasFriend .
```

SHACL Core Constraints



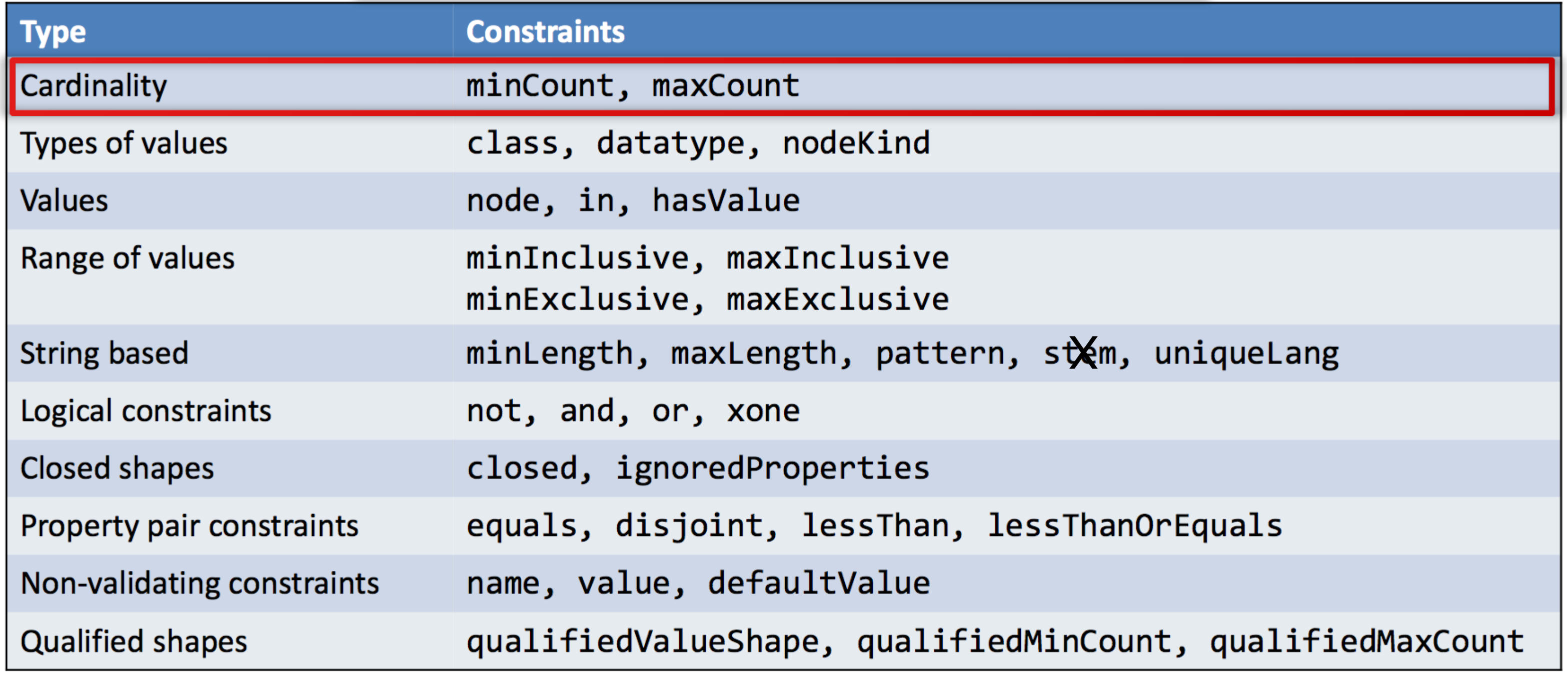
Type	Constraints
Cardinality	`minCount, maxCount`
Types of values	`class, datatype, nodeKind`
Values	`node, in, hasValue`

Range of values	`minInclusive, maxInclusive`
	`minExclusive, maxExclusive`

String based	`minLength, maxLength, pattern,` ~~`stem`~~`, uniqueLang`
Logical constraints	`not, and, or, xone`
Closed shapes	`closed, ignoredProperties`
Property pair constraints	`equals, disjoint, lessThan, lessThanOrEquals`
Non-validating constraints	`name, value, defaultValue`
Qualified shapes	`qualifiedValueShape, qualifiedMinCount, qualifiedMaxCount`

SHACL Core Constraints

Constraint on the number of value nodes (i.e., individual focus nodes) that satisfy the condition.



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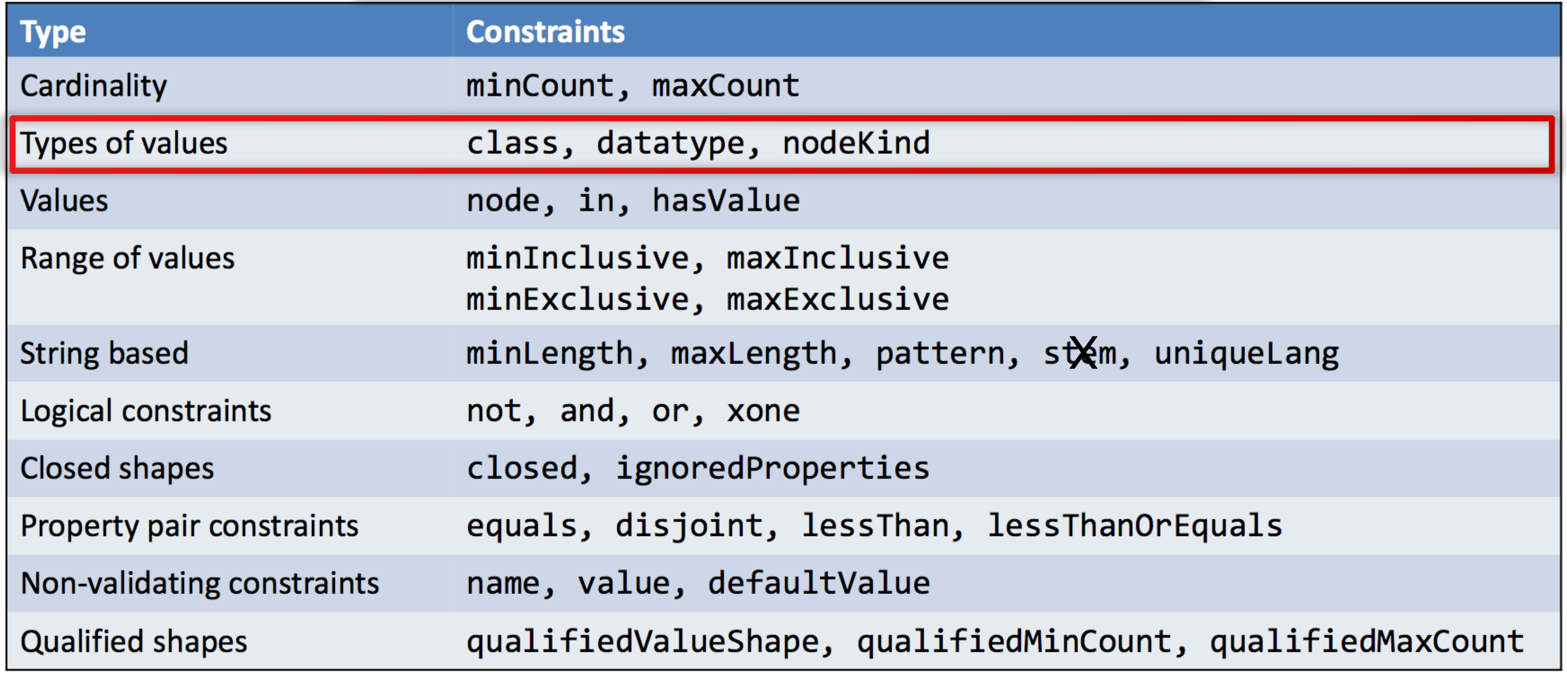
SHACL Core Constraints

Constraints that restrict the type of value nodes.



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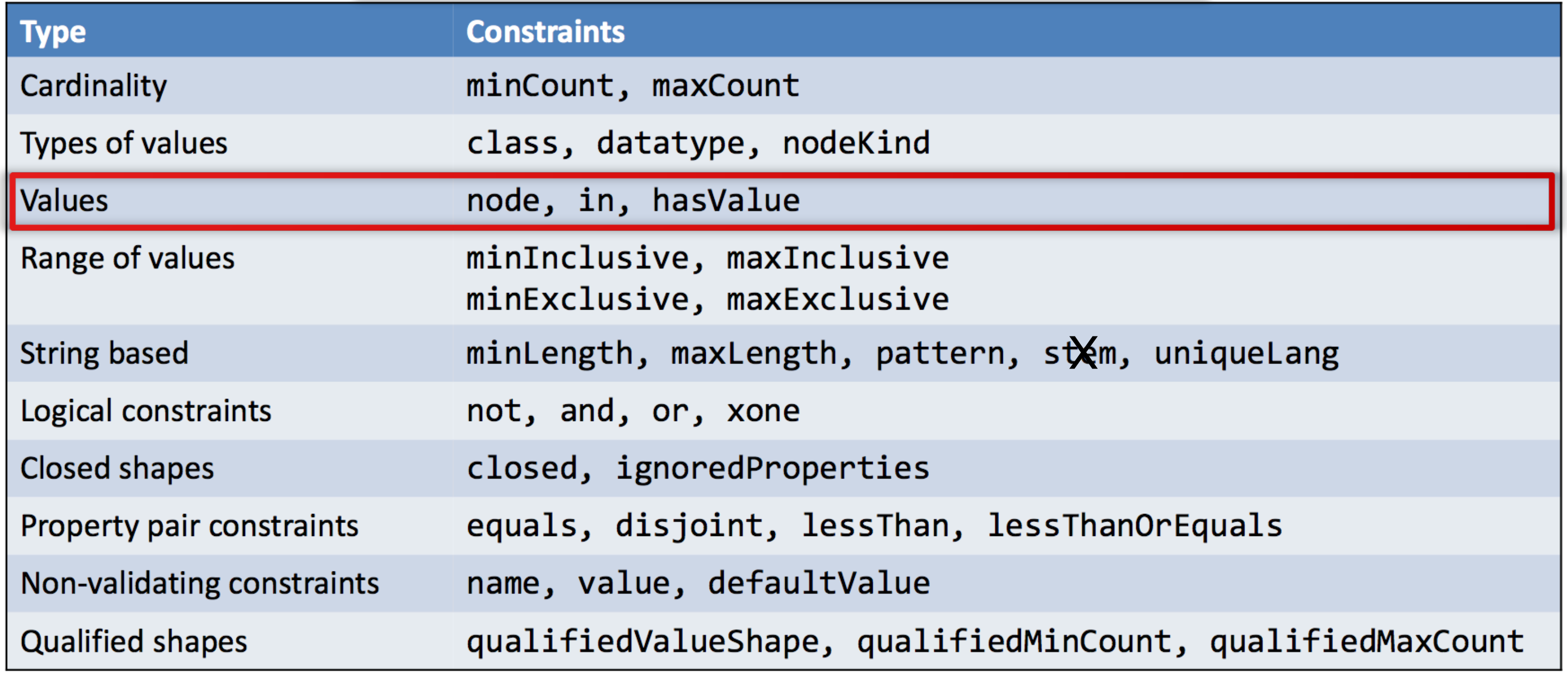
SHACL Core Constraints

Specifies a value to which a value node must conform.



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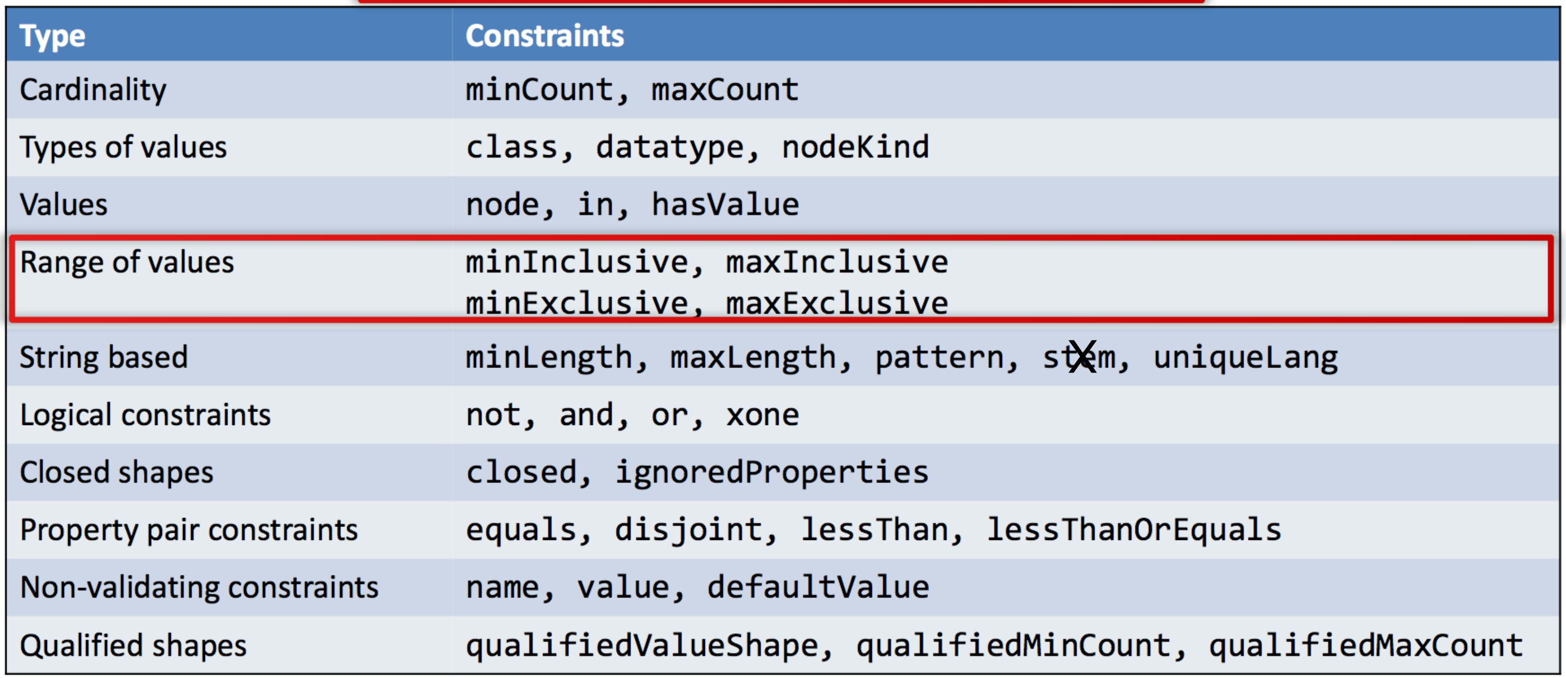
Warning: Not the same!

SHACL Core Constraints

Constraints on value nodes comparable using <, <=, > and >=.



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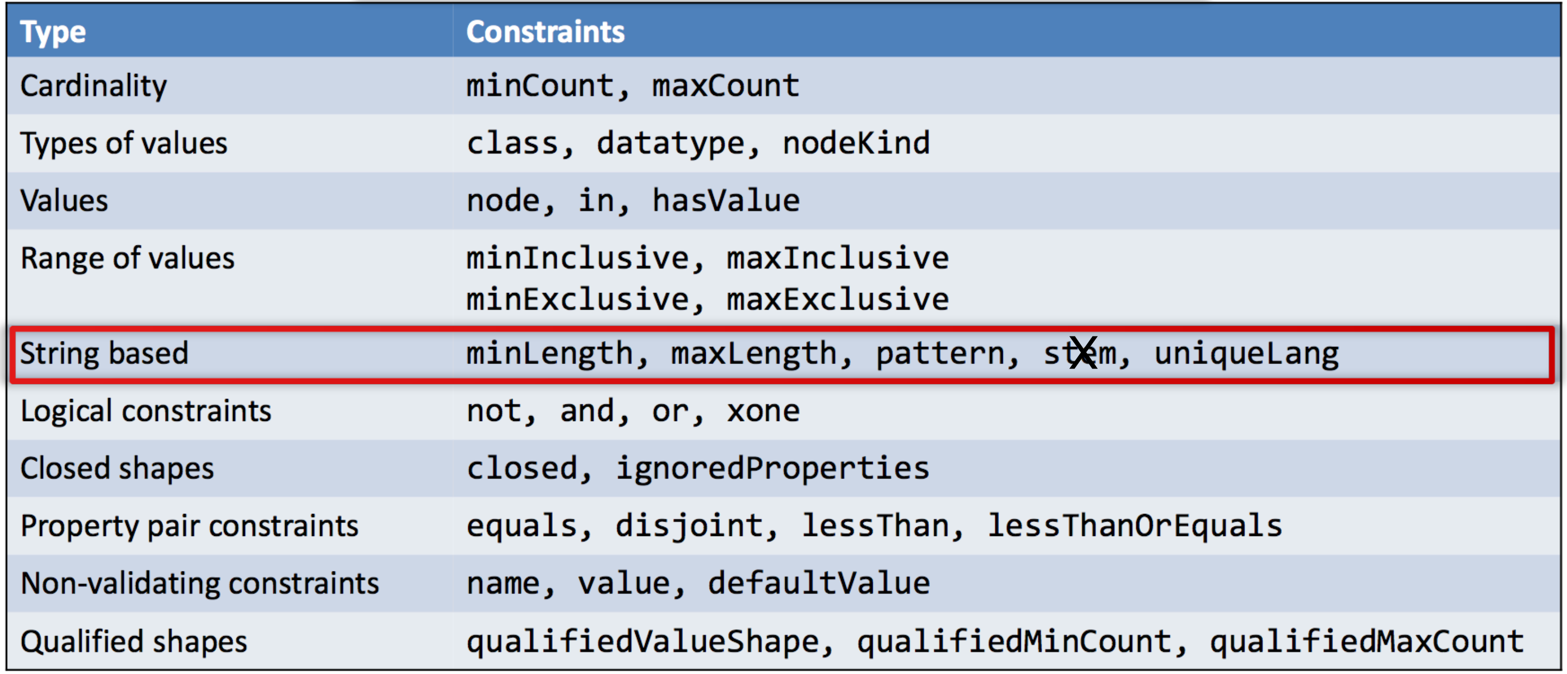
SHACL Core Constraints

Constraints on the string representation of value nodes.



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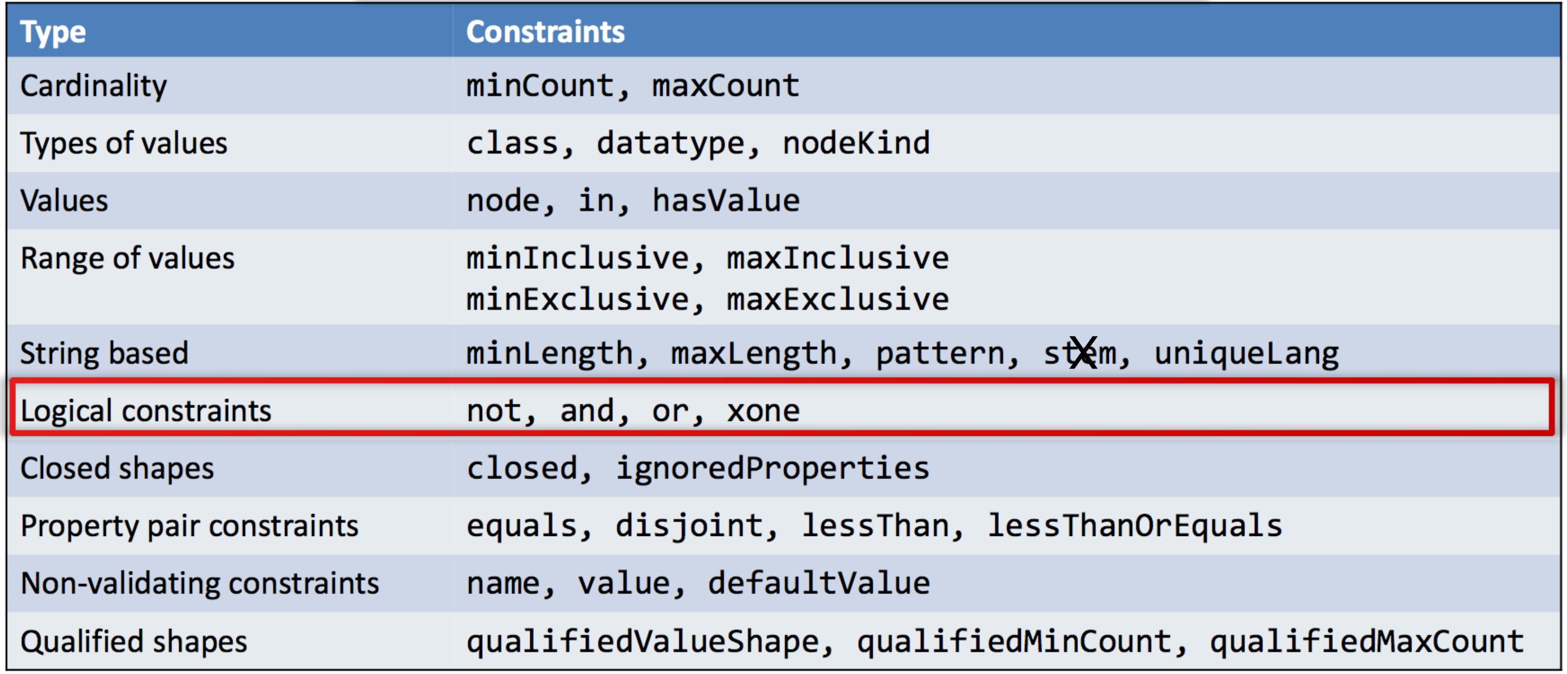
SHACL Core Constraints

Logical operators and, or, not, and exclusive or. These expect shape constraints.



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SHACL Core Constraints

```
ex:Twilight_Sparkle
    a ex:MagicPony ;
    ex:knows ex:Magic .

ex:Rarity
    a ex:MagicPony ;
    ex:hasHorn true .
```

```
ex:MagicPonyShape
    a sh:NodeShape ;
    sh:targetClass ex:MagicPony ;
    sh:or (
        [ sh:path ex:knows ;
          sh:hasValue ex:Magic ]
        [ sh:path ex:hasHorn ;
          sh:hasValue true ]
    ) .
```

SHACL Core Constraints

Limit the flexibility of RDF data model.
closed: Only properties listed in the shape are allowed.
ignoredProperties: Permitted in addition to listed ones.

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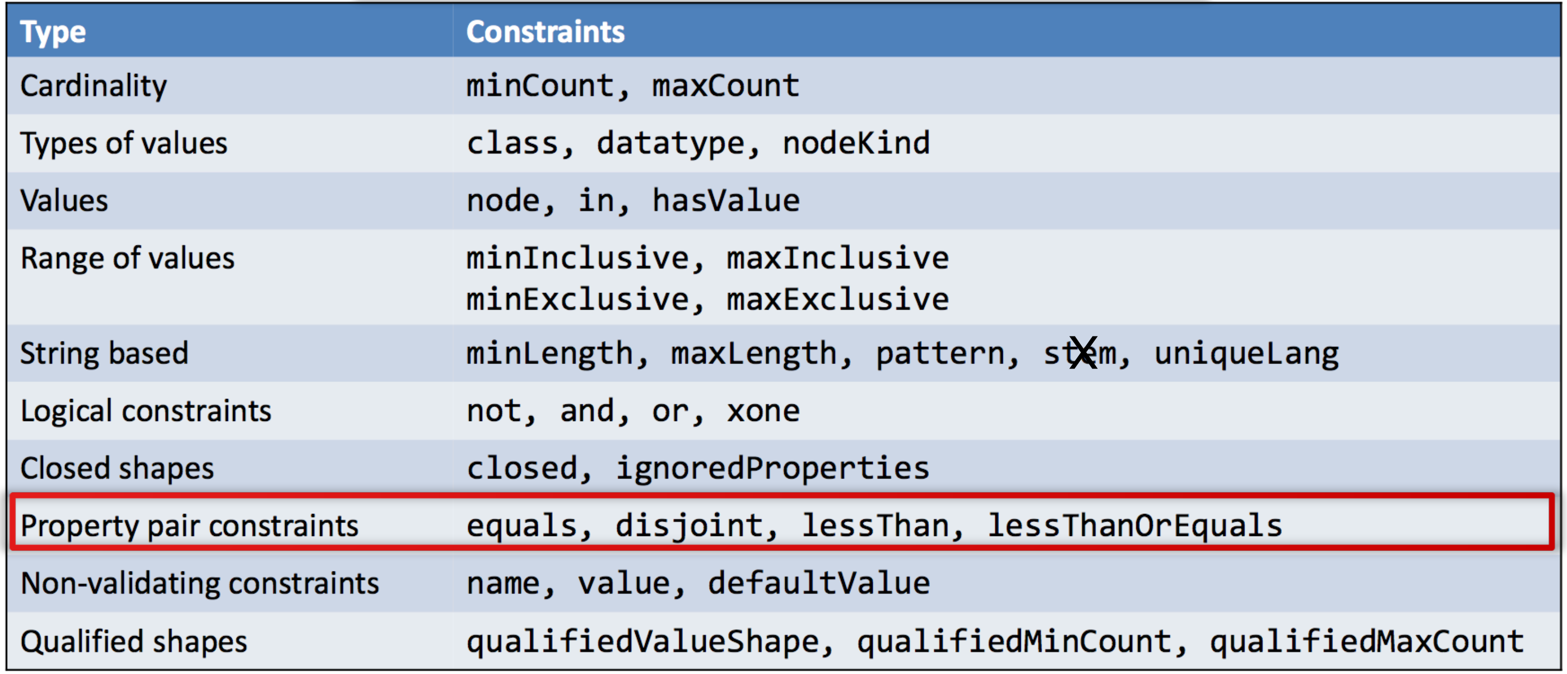
SHACL Core Constraints

Conditions on value nodes in relation to other properties. Can only be used by property shapes.



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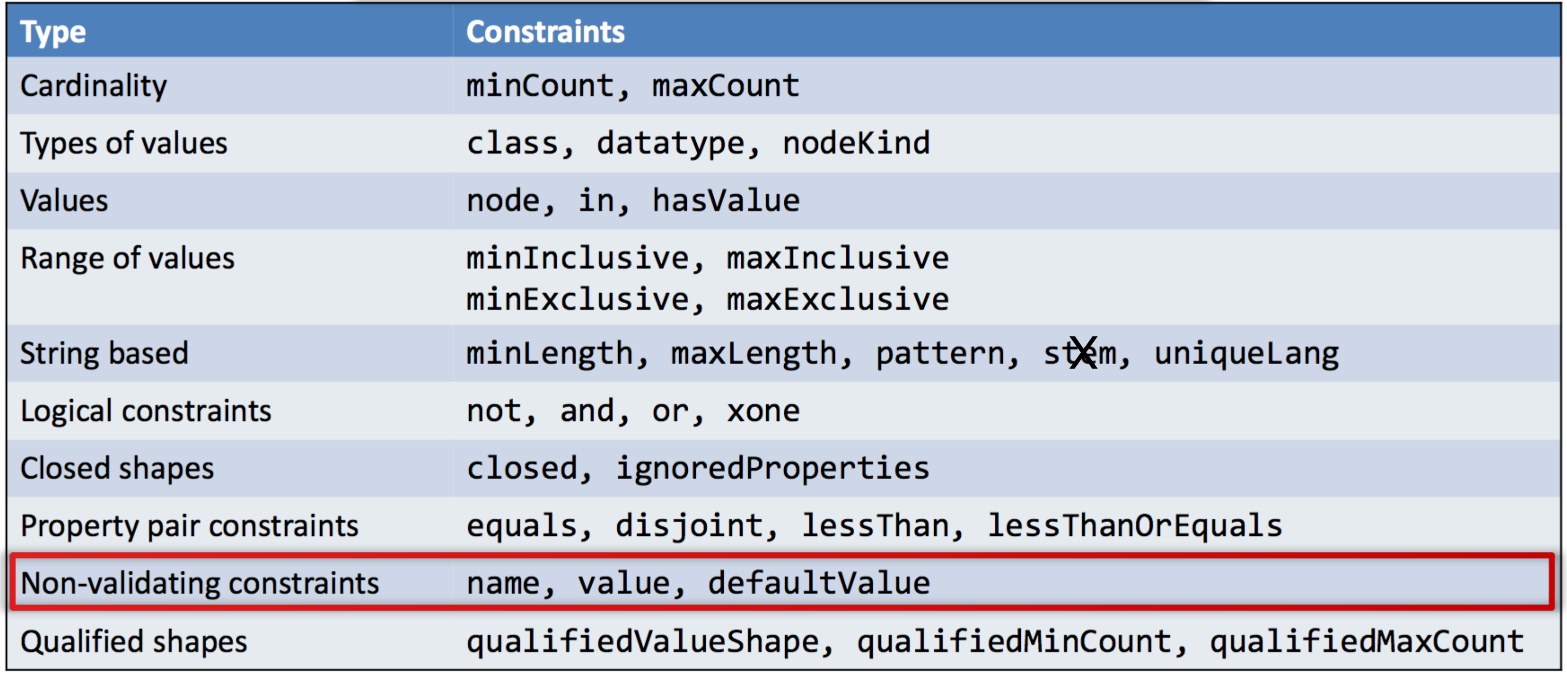
SHACL Core Constraints

Non-validating properties are optional and not validated by default.



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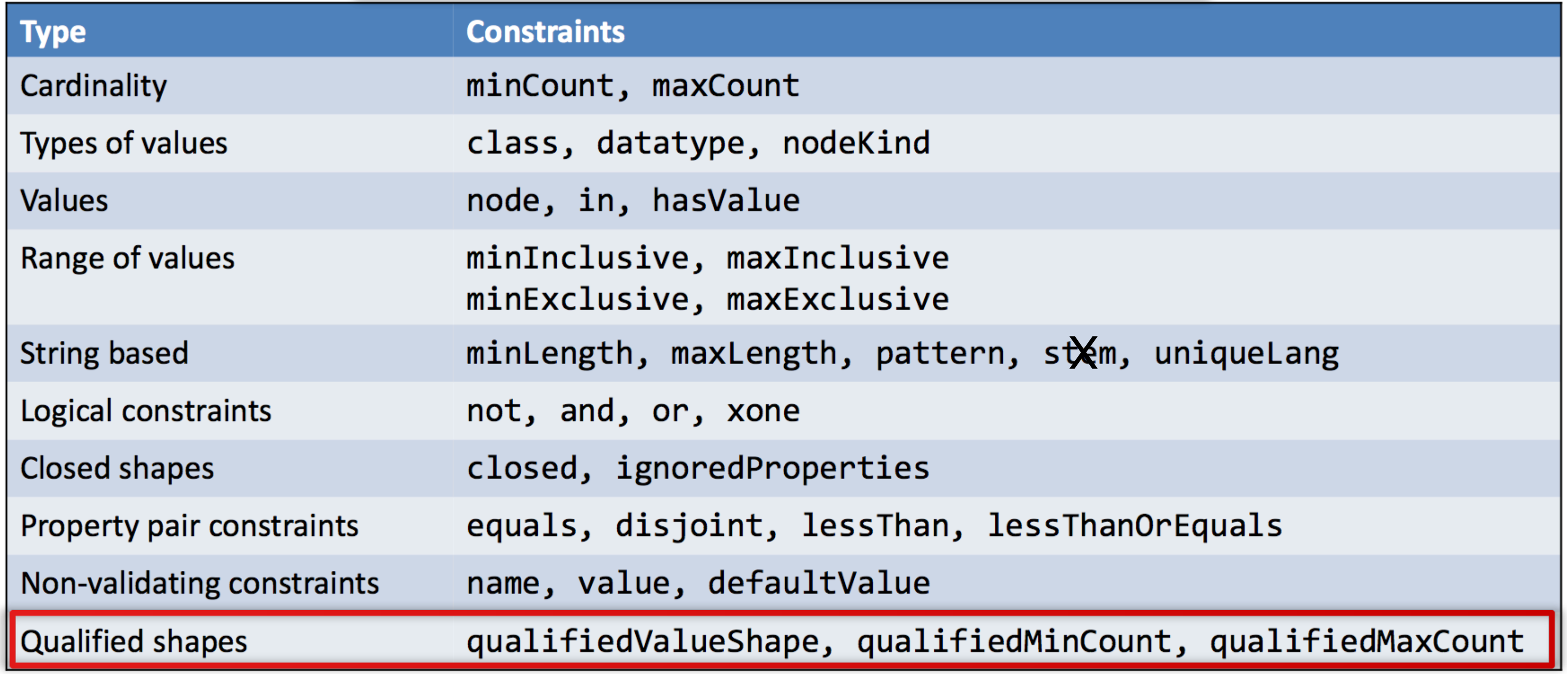
SHACL Core Constraints

Specifies conditions about the number of value nodes that conform to the given shape.



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Property paths

-
  ```
  SPARQL        ex:parent
  SHACL         ex:parent
  ```

-
  ```
  SPARQL        ^ex:parent
  SHACL         [ sh:inversePath ex:parent ]
  ```

-
  ```
  SPARQL        ex:parent/ex:firstName
  SHACL         ( ex:parent ex:firstName )
  ```

-
  ```
  SPARQL        rdf:type/rdfs:subClassOf*
  SHACL         ( rdf:type [ sh:zeroOrMorePath rdfs:subClassOf ] )
  ```

-
  ```
  SPARQL        ex:father|ex:mother
  SHACL         [ sh:alternativePath ( ex:father ex:mother ) ]
  ```

Useful resources

- This document (available from the course website)
- *SHACL by example*
  - https://www.slideshare.net/jelabra/shacl-by-example
  - Not based on the final version of SHACL, but very close and with many examples.
- SHACL specification
  - https://www.w3.org/TR/shacl/
  - Relatively heavy reading
  - Use the table of contents to read up on specifics
- Turtle specification
  - https://www.w3.org/TR/turtle/
- Regular expressions online
  - https://regex101.com/

Hands-on exercises

- Instructions on the course website
- SHACL Tutorial Playground
  - No installation required
  - https://www.ida.liu.se/~robke04/SHACLTutorial/
- Tasks of increasing in difficulty with more than a single correct solution
- *Keep a backup of the shapes graph you are working on!*