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XXXXX<sup>1</sup> and XXXXX<sup>2</sup>

<sup>1</sup> XXXXX  
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<sup>2</sup> XXXXX  
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**Abstract. Keywords:** ..

## 1 Introduction

## 2 Ideas

- sind alle constraints abgedeckt?
- kann man alle constraints in SPARQL definieren?
- sind alle constraints mit Logik ausdrückbar?
- vollständig mit Reasoning — OW
- vollständig ohne Reasoning — CW
- es gibt keinen query rewriting mechanismus für OWL 2, nur für OWL-QL
- constraints in einer anderen constraint language definieren wenn constraints nicht in OWL beschrieben werden können
- durch reasoning entstehen Probleme, auf die man nicht gekommen wäre –i sofort nachvollziehbar
- zeigen, dass OWL-QL und constraint language einer konkreten Domäne zusammen vollständig sind
- System entwickeln, das effizient ist / Experimente

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Nehmen wir nun an, dass dein Framework welches entsprechende SPARQL Queries generiert diese auf einem SPARQL Endpoint evaluiert der zu der vorliegenden Ontologie bzw. des darin verwendeten OWL 2 Profils das entsprechende Entailment Regime realisiert, wären die zurückgegebenen Resultsets vollständig. Wie das Entailment Regime im Endpoint realisiert ist, also durch Query Rewriting oder durch Vervollständigung der ABox, ist dabei irrelevant.

Wie allerdings bspw. in [https://www.uni-ulm.de/fileadmin/website\\_uni-ulm/iui.inst.090/Lehre/WS\\_2011-2012/SemWebGrundlagen/LectureNotes.pdf](https://www.uni-ulm.de/fileadmin/website_uni-ulm/iui.inst.090/Lehre/WS_2011-2012/SemWebGrundlagen/LectureNotes.pdf) auf Seite 51 veranschaulicht, ist die Komplexität des Reasoning abhängig von der zugrunde gelegten Sprache und kann daher nur in bestimmten Fällen effizient durchgeführt werden. Wie in unserem letzten Paper beschrieben zielt unter anderem die Definition von DL-Lite gerade darauf ab Reasoning Aufgaben und Query Answering effizient zu ermöglichen und ist Grundlage des OWL 2 QL

Profils. Nun ist allgemein bekannt, dass die logische Konsistenz für diese Art von Sprachen effizient geprüft werden kann.

Allerdings wäre wie bspw. in [http://www.aifb.kit.edu/images/d/d2/2005\\_925\\_Haase.Consistent.Evol.1.pdf](http://www.aifb.kit.edu/images/d/d2/2005_925_Haase.Consistent.Evol.1.pdf) beschrieben auch eine sogenannte 'User-defined Consistency' denkbar. Genau an dieser Stelle könnten wir ansetzen.

### 3 research questions

- for which RDF validation requirement the expressivity of DL-LiteA respectively OWL 2 QL is sufficient?
- for which RDF validation requirement additional constraint languages are needed?
- which constraint languages are suitable to express remaining requirements?
- what are the effects of these constraints regarding complexity?

### 4 OWL 2 QL

OWL 2 profiles specification: [1]

- OWL 2 QL constructs
- Difference between OWL 2 DL and OWL 2 QL

**Logical Underpinning for OWL 2 QL.** OWL 2 QL is based on the DL-Lite family of description logics. Several variants of DL-Lite have been described in the literature, and DL-Lite<sub>R</sub> provides the logical underpinning for OWL 2 QL. DL-Lite<sub>R</sub> does not require the unique name assumption (UNA), since making this assumption would have no impact on the semantic consequences of a DL-Lite<sub>R</sub> ontology. More expressive variants of DL-Lite, such as DL-Lite<sub>A</sub>, extend DL-Lite<sub>R</sub> with functional properties, and these can also be extended with keys; however, for query answering to remain in LOGSPACE, these extensions require UNA and need to impose certain global restrictions on the interaction between properties used in different types of axiom. Basing OWL 2 QL on DL-Lite<sub>R</sub> avoids practical problems involved in the explicit axiomatization of UNA [1].

### 5 RDF Validation Requirements Not Covered By OWL 2 QL

#### 5.1 Class-Specific Disjointness of Properties

requirements:

- R-11-DISJOINT-DATA-PROPERTIES-CLASS-SPECIFIC
- R-12-DISJOINT-OBJECT-PROPERTIES-CLASS-SPECIFIC
- R-13-DISJOINT-GROUP-OF-PROPERTIES-CLASS-SPECIFIC

### 5.1.1 Class-Specific Disjoint Data Properties R-11-DISJOINT-DATA-PROPERTIES-CLASS-SPECIFIC

- exclusive OR of data properties
- with OWL 2, inclusive OR of properties would be possible to express, but not exclusive OR of data properties

constraint (ShEx):

```
1 (foaf:name xsd:string | foaf:givenName xsd:string+, foaf:familyName xsd:string)
```

valid data (ShEx):

```
1 <Anakin>
2   foaf:name "Anakin Skywalker" ;
3   foaf:familyName "Skywalker" .
```

```
1 <Anakin>
2   foaf:givenName "Anakin" ;
3       foaf:givenName "Darth" ;
4   foaf:familyName "Skywalker" .
```

invalid data (ShEx):

```
1 <Anakin>
2   foaf:name "Anakin Skywalker" ;
3   foaf:givenName "Anakin" ;
4   foaf:familyName "Skywalker" .
```

### 5.1.2 Class-Specific Disjoint Object Properties R-12-DISJOINT-OBJECT-PROPERTIES-CLASS-SPECIFIC

### 5.1.3 Class-Specific Disjoint Group of Properties R-13-DISJOINT-GROUP-OF-PROPERTIES-CLASS-SPECIFIC

- exclusive OR of property groups
- with OWL 2, inclusive OR of property groups would be possible to express, but not exclusive OR of property groups

A <Human> has either a name or at least 1 given name and 1 family name.  
constraint (ShEx):

```
1 <Human> {
2   (
3     foaf:name xsd:string
4     |
5     foaf:givenName xsd:string+,
6     foaf:familyName xsd:string
7   )
8 }
```

valid data (ShEx):

```
1 <Anakin>
2   foaf:givenName "Anakin" ;
3   foaf:familyName "Skywalker" .
```

```
1 <Anakin>
2   foaf:name "Anakin Skywalker" .
```

invalid data (ShEx):

```
1 <Anakin>
2   foaf:givenName "Anakin" ;
3   foaf:familyName "Skywalker" ;
4   foaf:name "Anakin Skywalker" .
```

## 5.2 Default Values

requirements:

- R-31-DEFAULT-VALUES-OF-RDF-OBJECTS
- R-38-DEFAULT-VALUES-OF-RDF-LITERALS

## 5.3 Membership in Controlled Vocabularies

requirements:

- R-32-MEMBERSHIP-OF-RDF-OBJECTS-IN-CONTROLLED-VOCABULARIES
- R-39-MEMBERSHIP-OF-RDF-LITERALS-IN-CONTROLLED-VOCABULARIES

constraint (DSP):

```
1 :bookDescriptionTemplate
2   a dsp:DescriptionTemplate ;
3   dsp:resourceClass swrc:Book ;
4   dsp:statementTemplate [
5     a dsp:NonLiteralStatementTemplate ;
6     dsp:property dcterms:subject ;
7     dsp:nonLiteralConstraint [
8       a dsp:NonLiteralConstraint ;
9       dsp:valueClass skos:Concept ;
10      dsp:vocabularyEncodingScheme :BookSubjects, :BookTopics, :BookCategories ] ] .
```

A DSP consists of `dsp:DescriptionTemplates` that put constraints on instances of a certain class (`dsp:resourceClass`). `:bookDescriptionTemplate` describes resources of the type `swrc:Book`. The constraints can either be constraints on the description itself, e.g. a minimum occurrence of instances of this class. Additionally, constraints on single properties can be defined within a `dsp:StatementTemplate`. The `dsp:NonLiteralStatementTemplate` restricts books to have `dcterms:subject` (`dsp:property`) relationships to RDF objects

which are further described by the `dsp:NonLiteralConstraint`. These RDF objects have to be of the class `skos:Concept` (`dsp:ValueClass`). Controlled vocabularies (like `:BookSubjects`) are represented as `skos:ConceptSchemes` in RDF and as `dsp:VocabularyEncodingSchemes` in DSP. `dsp:VocabularyEncodingScheme` points to a list of controlled vocabularies the `skos:Concept` resources must be members of. The controlled vocabulary members (`skos:Concepts`) are related to the controlled vocabulary (`skos:ConceptScheme`) via the object properties `skos:inScheme` and `dcam:memberOf`.

valid data (DSP):

```

1 :ArtificialIntelligence
2   a swrc:Book ;
3   dcterms:subject :ComputerScience .
4 :ComputerScience
5   a skos:Concept ;
6   dcam:memberOf :BookSubjects ;
7   skos:inScheme :BookSubjects .
8 :BookSubjects
9   a skos:ConceptScheme .

```

invalid data (DSP):

```

1 :ArtificialIntelligence
2   a swrc:Book ;
3   dcterms:subject :ComputerScience .
4 :ComputerScience
5   a skos:Concept ;
6   dcam:memberOf :BooksAboutBirds ;
7   skos:inScheme :BooksAboutBirds ;
8   dcam:memberOf :BookSubjects ;
9   skos:inScheme :BookSubjects .
10 :BookSubjects
11   a skos:ConceptScheme .

```

The related subject (`:ComputerScience`) is a member of a controlled vocabulary (`:BooksAboutBirds`) which is not part of the list of allowed controlled vocabularies.

## 5.4 Pattern Matching

requirements:

- R-21-IRI-PATTERN-MATCHING-ON-RDF-SUBJECTS
- R-22-IRI-PATTERN-MATCHING-ON-RDF-OBJECTS
- R-23-IRI-PATTERN-MATCHING-ON-RDF-PROPERTIES
- R-44-PATTERN-MATCHING-ON-RDF-LITERALS
- R-141-NEGATIVE-PATTERN-MATCHING-ON-RDF-LITERALS

## 5.5 Calculations on and Comparisons of RDF Literals

requirements:

- R-41-STATISTICAL-COMPUTATIONS
- R-42-COMPUTATIONS-BASED-ON-DATATYPE
- R-43-COMPARISONS-BASED-ON-DATATYPE
- R-194-PROVIDE-STRING-FUNCTIONS-FOR-RDF-LITERALS

## **5.6 Constraining Facets on RDF Literals**

requirements:

- R-45-RANGES-OF-RDF-LITERAL-VALUES
- R-142-NEGATIVE-RANGES-OF-RDF-LITERAL-VALUES
- R-46-CONSTRAINING-FACETS
- R-50-WHITESPACE-HANDLING-OF-RDF-LITERALS

## **5.7 Language of RDF Literals**

requirements:

- R-47-LANGUAGE-TAG-MATCHING
- R-48-MISSING-LANGUAGE-TAGS
- R-49-RDF-LITERALS-HAVING-AT-MOST-ONE-LANGUAGE-TAG

## **5.8 Property Occurrences**

requirements:

- R-52-NEGATIVE-OBJECT-PROPERTY-CONSTRAINTS
- R-53-NEGATIVE-DATA-PROPERTY-CONSTRAINTS
- R-67-CLASSIFY-PROPERTIES-ACCORDING-TO-OCCURRENCE

## **5.9 Property Groups**

requirements:

- R-13-DISJOINT-GROUP-OF-PROPERTIES-CLASS-SPECIFIC
- R-66-PROPERTY-GROUPS

## **5.10 RDF-Specific Validation**

requirements:

- R-120-HANDLE-RDF-COLLECTIONS

## **5.11 RDF Shapes**

requirements:

- R-125-RDF-SHAPE-CHECKING

## 5.12 RDF Validation Results

requirements:

- R-150-RDF-REPRESENTATION-OF-VALIDATION-RESULTS
- R-151-USEFUL-MESSAGE-VALIDATION-RESULTS
- R-152-FIND-NOT-VALIDATED-TRIPLES
- R-153-RDF-REPRESENTATION-OF-CONSTRAINT-VIOLATIONS
- R-154-HANDLE-CONSTRAINT-VIOLATIONS
- R-155-GUIDANCE-HOW-TO-BECOME-VALID-DATA
- R-156-REFERENCES-TO-TRIPLES-CAUSING-THE-CONSTRAINT-VIOLATIONS
- R-157-REFERENCES-TO-VALIDATION-RULES-CAUSING-CONSTRAINT-VIOLATIONS
- R-158-SEVERITY-LEVELS-OF-CONSTRAINT-VIOLATIONS
- R-159-EXPLAIN-REASONS-OF-CONSTRAINT-VIOLATIONS

## 5.13 Requirements Covered by OWL 2 DL But Not by OWL 2 QL

## 6 Related Work

## 7 Evaluation

### 7.1 Evaluation Using Practical Data Set

### 7.2 RDF Validation Requirements Covered by OWL 2 QL

Table 2

### 7.3 RDF Validation Requirements Not Covered by OWL 2 QL

Table 3 Table 4 Table 5

## 8 Conclusion and Future Work

## 9 Appendix

### 9.1 Allowed Usage of Constructs in Class Expressions in OWL 2 QL

#### Subclass Expressions

```
1 subclassExpression :=  
2   Class |  
3   subObjectSomeValuesFrom | DataSomeValuesFrom  
4 subObjectSomeValuesFrom := 'ObjectSomeValuesFrom' '(' ObjectPropertyExpression owl:Thing ')'
```

#### Superclass Expressions

```
1 superClassExpression :=  
2   Class |  
3   superObjectIntersectionOf | superObjectComplementOf |  
4   superObjectSomeValuesFrom | DataSomeValuesFrom
```

**Table 1.** RDF Validation Requirements Covered by OWL 2 QL

Requirements	Classification	Requirements
		R-1-UNIQUENESS-OF-URIS
		R-2-UNIQUE-INSTANCES
		R-3-EQUIVALENT-CLASSES (EquivalentClasses)
		R-4-EQUIVALENT-OBJECT-PROPERTIES (EquivalentObjectProperties)
		R-5-EQUIVALENT-DATA-PROPERTIES (EquivalentDataProperties)
		R-7-DISJOINT-CLASSES (DisjointClasses)
		R-9-DISJOINT-OBJECT-PROPERTIES (DisjointObjectProperties)
		R-10-DISJOINT-DATA-PROPERTIES (DisjointDataProperties)
		R-14-DISJOINT-INDIVIDUALS (DifferentIndividuals)
		R-25-OBJECT-PROPERTY-DOMAIN (ObjectPropertyDomain)
		R-26-DATA-PROPERTY-DOMAIN (DataPropertyDomain)
		R-27-CLASS-SPECIFIC-VALIDATION
		R-28-OBJECT-PROPERTY-RANGE (ObjectPropertyRange)
		R-35-DATA-PROPERTY-RANGE (DataPropertyRange)
		R-54-SUB-OBJECT-PROPERTIES (SubObjectPropertyOf)
		R-56-INVERSE-OBJECT-PROPERTIES (ObjectInverseOf)
		R-59-REFLEXIVE-OBJECT-PROPERTIES (ReflexiveObjectProperty)
		R-60-IRREFLEXIVE-OBJECT-PROPERTIES (IrreflexiveObjectProperty)
		R-61-SYMMETRIC-OBJECT-PROPERTIES (SymmetricObjectProperty)
		R-62-ASYMMETRIC-OBJECT-PROPERTIES (AsymmetricObjectProperty)
		R-64-SUB-DATA-PROPERTIES (SubDataPropertyOf)
		R-93-DIFFERENCE-BETWEEN-CONSTRAINTS-ON-OBJECT-AND-DATA-PROPERTIES
		R-94-POSITIVE-OBJECT-PROPERTY-ASSERTIONS (ObjectPropertyAssertion)
		R-95-POSITIVE-DATA-PROPERTY-ASSERTIONS (DataPropertyAssertion)
		R-99-STABLE-IDENTIFICATION-OF-CONSTRAINTS
		R-100-SUBSUMPTION (SubClassOf)
		R-101-DECLARATIVE-CONSTRAINT-LANGUAGE
		R-102-INTUITIVE-CONSTRAINT-LANGUAGE
		R-103-HIGH-LEVEL-CONSTRAINT-LANGUAGE
		R-104-CONSTRAINT-LANGUAGE-HAVING-IMPLEMENTATION-LANGUAGE
		R-105-CONSTRAINT-LANGUAGE-TRANSLATABLE-TO-IMPLEMENTATION-LANGUAGE
		R-107-TRANSFORMATIONS-BETWEEN-CONSTRAINT-LANGUAGE-AND-UML
		R-108-TRANSFORMATIONS-BETWEEN-CONSTRAINT-LANGUAGE-AND-XML-Schema
		R-109-TRANSFORMATIONS-BETWEEN-CONSTRAINT-LANGUAGE-AND-OCL
		R-110-TRANSFORMATIONS-BETWEEN-CONSTRAINT-LANGUAGE-AND-SPARQL



**Table 2.** RDF Validation Requirements Covered by OWL 2 QL

Requirements Classification	Requirements
	R-111-BASIC-USE-CASES-COVERED-BY-CONSTRAINT-LANGUAGE
	R-113-INTERACTION-OF-VALIDATION-WITH-REASONING
	R-115-CLOSED-WORLD-ASSUMPTION-CWA
	R-116-UNIQUE-NAME-ASSUMPTION-UNA
	R-117-CONTEXT-SENSITIVE-CONSTRAINTS
	R-118-NAMESPACE-SENSITIVE-CONSTRAINTS
	R-122-TRADE-OFF-BETWEEN-DIMENSIONS-EXPRESSIVITY-COMPLEXITY-PRE
	R-124-DESCRIBE-DATA
	R-126-CUSTOMIZABLE-VALIDATION-PROCESS
	R-128-HUMAN-UNDERSTANDABLE-CONCRETE-SYNTAXES-FORMULATING-CON
	R-129-MACHINE-UNDERSTANDABLE-CONCRETE-SYNTAXES-FORMULATION-CO
	R-130-CONCISE-CONCRETE-SYNTAXES-FORMULATING-CONSTRAINTS
	R-131-OWL-AS-CONCRETE-SYNTAX-FORMULATING-CONSTRAINTS
	R-132-MULTIPLE-CONCRETE-SYNTAXES-FORMULATING-CONSTRAINTS
	R-133-MULTIPLE-CONCRETE-SYNTAXES-FORMULATING-DATA
	R-136-MODULARITY-OF-CONSTRAINT-DEFINITIONS
	R-137-LEVERAGE-ON-EXISTING-TECHNOLOGIES
	R-138-CONSTRAINT-LANGUAGE-COMPATIBLE-WITH-SPARQL
	R-139-CONSTRAINT-LANGUAGE-DRIVES-USER-INTERFACE-FORM-GENERATIO
	R-140-SEPARATE-ONTOLOGIES-FROM-VALIDATION-SCHEMAS
	R-143-CONDITIONAL-TYPED-VALIDATION
	R-147-DISTRIBUTION-OF-CONSTRAINT-SCHEMAS
	R-148-DISTRIBUTED-VALIDATION-IN-COLLABORATIVE-ENVIRONMENTS
	R-149-MANAGEMENT-OF-CONSTRAINT-SCHEMA-EVOLUTION
	R-160-OPEN-SOURCE-CONSTRAINT-VALIDATION
	R-161-ACCEPTABLE-PERFORMANCE-OF-VALIDATION-ALGORITHM
	R-162-SPECIFICATION-PUBLICLY-AVAILABLE
	R-163-IMPLEMENTATION-EXISTS
	R-164-IMPLEMENTATION-PUBLICLY-AVAILABLE
	R-165-EXECUTABLE-DEMOS-EXAMPLES-USE-CASES
	R-168-PERFORM-BIG-DATASETS
	R-169-RDF-REPRESENTATION-OF-CONSTRAINT-LANGUAGE
	R-173-SEPARATE-CONSTRAINTS-FROM-VOCABULARIES-AND-ONTOLOGIES
	R-174-REUSE-CONSTRAINTS
	R-175-DISCOVER-CONSTRAINTS
	R-177-DEFINE-SEMANTICS-FOR-CONSTRAINTS
	R-178-ASSOCIATE-CONSTRAINTS-WITH-VOCABULARIES
	R-182-USE-KNOWN-CONCRETE-SYNTAX
	R-184-COMPACT-CONCRETE-SYNTAX
	R-187-DEFINE-SEMANTICS-OF-CONSTRAINTS-IN-TERMS-OF-SPARQL
	R-190-SPECIFY-EXPECTED-BEHAVIOR-UNDER-ALL-POSSIBLE-ENTAILMENT-RI
	R-192-DEFINE-ANNOTATIONS-FOR-CONSTRAINTS
	R-195-CONSTRAINT-LANGUAGE-EASY-TO-CONSUME-BY-TOOLS
	R-197-ATTACH-CONSTRAINTS-TO-CLASSES
	R-198-RDF-VALIDATION-AFTER-INFERENCING
	R-199-RDF-VALIDATION-MUST-COMPILE-DOWN-TO-SPARQL

**Table 3.** RDF Validation Requirements Not Covered by OWL 2 QL

Requirements	Covering Constraint La
R-6-EQUIVALENT-INDIVIDUALS (SameIndividual)	OWL 2 DL
R-8-DISJOINT-UNION-OF-CLASS-EXPRESSIONS (DisjointUnion)	OWL 2 DL
R-11-DISJOINT-DATA-PROPERTIES-CLASS-SPECIFIC	ShEx
R-12-DISJOINT-OBJECT-PROPERTIES-CLASS-SPECIFIC	ShEx
R-13-DISJOINT-GROUP-OF-PROPERTIES-CLASS-SPECIFIC	ShEx
R-15-CONJUNCTION-OF-CLASS-EXPRESSIONS (ObjectIntersectionOf)	OWL 2 DL
R-16-CONJUNCTION-OF-DATA-RANGES (DataIntersectionOf)	OWL 2 DL
R-17-DISJUNCTION-OF-CLASS-EXPRESSIONS (DisjointUnionOf)	OWL 2 DL
R-18-DISJUNCTION-OF-DATA-RANGES (DataUnionOf)	OWL 2 DL
R-19-NEGATION-OF-CLASS-EXPRESSIONS (ObjectComplementOf)	OWL 2 DL
R-20-NEGATION-OF-DATA-RANGES (DataComplementOf)	OWL 2 DL
R-21-IRI-PATTERN-MATCHING-ON-RDF-SUBJECTS	SPIN
R-22-IRI-PATTERN-MATCHING-ON-RDF-OBJECTS	SPIN, ShEx
R-23-IRI-PATTERN-MATCHING-ON-RDF-PROPERTIES	SPIN, ShEx
R-24-PROVENANCE-CONSTRAINTS	
R-29-CLASS-SPECIFIC-RANGE-OF-RDF-OBJECTS	SPIN, RS
R-30-ALLOWED-VALUES-FOR-RDF-OBJECTS (ObjectOneOf)	OWL 2 DL
R-31-DEFAULT-VALUES-OF-RDF-OBJECTS	SPIN, BF, RS
R-32-MEMBERSHIP-OF-RDF-OBJECTS-IN-CONTROLLED-VOCABULARIES	DSP, SPIN
R-33-NEGATIVE-OBJECT-CONSTRAINTS	
R-34-AVAILABLE-CLASS-DEFINITION	ShEx, SPIN
R-36-CLASS-SPECIFIC-RANGE-OF-RDF-LITERALS	ShEx, BF, SPIN
R-37-ALLOWED-VALUES-FOR-RDF-LITERALS (DataOneOf)	OWL 2 DL
R-38-DEFAULT-VALUES-OF-RDF-LITERALS	SPIN, BF, RS
R-39-MEMBERSHIP-OF-RDF-LITERALS-IN-CONTROLLED-VOCABULARIES	DSP, SPIN
R-44-PATTERN-MATCHING-ON-RDF-LITERALS	ShEx, RS, SPIN
R-41-STATISTICAL-COMPUTATIONS	SPIN
R-42-COMPUTATIONS-BASED-ON-DATATYPE	
R-43-COMPARISONS-BASED-ON-DATATYPE	DQTP, ShEx, SPIN
R-45-RANGES-OF-RDF-LITERAL-VALUES	DQTP, SPIN
R-46-CONSTRAINING-FACETS	Stardog, SPIN
R-47-LANGUAGE-TAG-MATCHING	SPIN
R-48-MISSING-LANGUAGE-TAGS	SPIN
R-49-RDF-LITERALS-HAVING-AT-MOST-ONE-LANGUAGE-TAG	DQTP, SPIN
R-50-WHITESPACE-HANDLING-OF-RDF-LITERALS	SPIN
R-51-HTML-HANDLING-OF-RDF-LITERALS	SPIN
R-52-NEGATIVE-OBJECT-PROPERTY-CONSTRAINTS	ShEx, SPIN
R-53-NEGATIVE-DATA-PROPERTY-CONSTRAINTS	ShEx, SPIN
R-55-OBJECT-PROPERTY-PATHS (SubObjectPropertyOf)	OWL 2 DL
R-57-FUNCTIONAL-OBJECT-PROPERTIES (FunctionalObjectProperty)	OWL 2 DL
R-58-INVERSE-FUNCTIONAL-OBJECT-PROPERTIES (InverseFunctionalObjectProperty)	OWL 2 DL
R-63-TRANSITIVE-OBJECT-PROPERTIES (TransitiveObjectProperty)	OWL 2 DL
R-65-FUNCTIONAL-DATA-PROPERTIES (FunctionalDataProperty)	OWL 2 DL
R-66-PROPERTY-GROUPS	ShEx, SPIN
R-67-CLASSIFY-PROPERTIES-ACCORDING-TO-OCCURRENCE	
R-68-REQUIRED-PROPERTIES (ObjectMinCardinality, DataMinCardinality)	OWL 2 DL
R-69-OPTIONAL-PROPERTIES (ObjectMinCardinality, DataMinCardinality)	OWL 2 DL
R-70-REPEATABLE-PROPERTIES (ObjectMinCardinality, DataMinCardinality)	OWL 2 DL
R-71-CONDITIONAL-PROPERTIES	
R-72-RECOMMENDED-PROPERTIES	

**Table 4.** RDF Validation Requirements Not Covered by OWL 2 QL

Requirements
R-74-EXACT-QUALIFIED-CARDINALITY-RESTRICTIONS-ON-OBJECT-PROPERTIES (ObjectExactCardinality)
R-75-MINIMUM-QUALIFIED-CARDINALITY-RESTRICTIONS-ON-OBJECT-PROPERTIES (ObjectMinCardinality)
R-76-MAXIMUM-QUALIFIED-CARDINALITY-RESTRICTIONS-ON-OBJECT-PROPERTIES (ObjectMaxCardinality)
R-77-EXACT-QUALIFIED-CARDINALITY-RESTRICTIONS-ON-DATA-PROPERTIES (DataExactCardinality)
R-78-MINIMUM-QUALIFIED-CARDINALITY-RESTRICTIONS-ON-DATA-PROPERTIES (DataMinCardinality)
R-79-MAXIMUM-QUALIFIED-CARDINALITY-RESTRICTIONS-ON-DATA-PROPERTIES (DataMaxCardinality)
R-80-EXACT-UNQUALIFIED-CARDINALITY-RESTRICTIONS-ON-OBJECT-PROPERTIES (ObjectExactCardinality)
R-81-MINIMUM-UNQUALIFIED-CARDINALITY-RESTRICTIONS-ON-OBJECT-PROPERTIES (ObjectMinCardinality)
R-82-MAXIMUM-UNQUALIFIED-CARDINALITY-RESTRICTIONS-ON-OBJECT-PROPERTIES (ObjectMaxCardinality)
R-83-EXACT-UNQUALIFIED-CARDINALITY-RESTRICTIONS-ON-DATA-PROPERTIES (DataExactCardinality)
R-84-MINIMUM-UNQUALIFIED-CARDINALITY-RESTRICTIONS-ON-DATA-PROPERTIES (DataMinCardinality)
R-85-MAXIMUM-UNQUALIFIED-CARDINALITY-RESTRICTIONS-ON-DATA-PROPERTIES (DataMaxCardinality)

## 9.2 Supported Constructs in OWL 2 QL

- subclass axioms (SubClassOf)
- class expression equivalence (EquivalentClasses)
- class expression disjointness (DisjointClasses)
- inverse object properties (InverseObjectProperties)
- property inclusion (SubObjectPropertyOf not involving property chains and SubDataPropertyOf)
- property equivalence (EquivalentObjectProperties and EquivalentDataProperties)
- property domain (ObjectPropertyDomain and DataPropertyDomain)
- property range (ObjectPropertyRange and DataPropertyRange)
- disjoint properties (DisjointObjectProperties and DisjointDataProperties)
- symmetric properties (SymmetricObjectProperty)
- reflexive properties (ReflexiveObjectProperty)
- irreflexive properties (IrreflexiveObjectProperty)
- asymmetric properties (AsymmetricObjectProperty)
- assertions: DifferentIndividuals, ClassAssertion, ObjectPropertyAssertion, and DataPropertyAssertion

## 9.3 Not Supported Constructs in OWL 2 QL

- existential quantification to a class expression or a data range (ObjectSomeValuesFrom and DataSomeValuesFrom) in the subclass position
- self-restriction (ObjectHasSelf)
- existential quantification to an individual or a literal (ObjectHasValue, DataHasValue)
- enumeration of individuals and literals (ObjectOneOf, DataOneOf)
- universal quantification to a class expression or a data range (ObjectAllValuesFrom, DataAllValuesFrom)

**Table 5.** RDF Validation Requirements Not Covered by OWL 2 QL

Requirements	Coveri
R-86-EXISTENTIAL-QUANTIFICATION-ON-OBJECT-PROPERTIES (ObjectSomeValuesFrom)	OWL 2
R-87-UNIVERSAL-QUANTIFICATION-ON-OBJECT-PROPERTIES (ObjectAllValuesFrom)	OWL 2
R-88-INDIVIDUAL-VALUE-RESTRICTION-ON-OBJECT-PROPERTIES (ObjectHasValue)	OWL 2
R-89-SELF-RESTRICTION (ObjectHasSelf)	OWL 2
R-90-EXISTENTIAL-QUANTIFICATION-ON-DATA-PROPERTIES (DataSomeValuesFrom)	OWL 2
R-91-UNIVERSAL-QUANTIFICATION-ON-DATA-PROPERTIES (DataAllValuesFrom)	OWL 2
R-92-LITERAL-VALUE-RESTRICTION (DataHasValue)	OWL 2
R-96-NEGATIVE-OBJECT-PROPERTY-ASSERTIONS (NegativeObjectPropertyAssertion)	OWL 2
R-97-NEGATIVE-DATA-PROPERTY-ASSERTIONS (NegativeDataPropertyAssertion)	OWL 2
R-98-CHECK-VALIDITY-OF-URIS	
R-106-EXTENSIBLE-CONSTRAINT-LANGUAGE	
R-112-EXTENSIBLE-CONSTRAINTS	
R-114-PROVIDE-RDF-REST-SERVICES-FOR-RDF-VALIDATION	
R-119-VALIDATION-ON-NAMED-GRAPHS	
R-120-HANDLE-RDF-COLLECTIONS	ShEx,
R-121-SPECIFY-ORDER-OF-RDF-RESOURCES	
R-123-STATE	
R-125-RDF-SHAPE-CHECKING	ShEx
R-126-CUSTOMIZABLE-VALIDATION-PROCESS	
R-134-SPECIFY-USAGE-OF-TERMS	
R-135-CONSTRAINT-LEVELS	
R-141-NEGATIVE-PATTERN-MATCHING-ON-RDF-LITERALS	DQTP
R-142-NEGATIVE-RANGES-OF-RDF-LITERAL-VALUES	DQTP
R-146-CONSTRAINT-VALIDATION-OF-RDF-INPUT-WITH-RESPECT-TO-EXISTING-RDF	
R-150-RDF-REPRESENTATION-OF-VALIDATION-RESULTS	SPIN,
R-151-USEFUL-MESSAGE-VALIDATION-RESULTS	SPIN,
R-152-FIND-NOT-VALIDATED-TRIPLES	ShEx
R-153-RDF-REPRESENTATION-OF-CONSTRAINT-VIOLATIONS	SPIN
R-154-HANDLE-CONSTRAINT-VIOLATIONS	ShEx,
R-155-GUIDANCE-HOW-TO-BECOME-VALID-DATA	ShEx,
R-156-REFERENCES-TO-TRIPLES-CAUSING-THE-CONSTRAINT-VIOLATIONS	SPIN
R-157-REFERENCES-TO-VALIDATION-RULES-CAUSING-CONSTRAINT-VIOLATIONS	ShEx,
R-158-SEVERITY-LEVELS-OF-CONSTRAINT-VIOLATIONS	SPIN
R-159-EXPLAIN-REASONS-OF-CONSTRAINT-VIOLATIONS	SPIN,
R-166-RDF-STREAMING-VALIDATION	
R-167-VALIDATE-RDF-IN-AN-HTML-DOCUMENT-CONSTAINING-RDFA-MARKUP	
R-170-VALIDATION-OF-SPARQL-ENDPOINTS	
R-171-VALIDATION-OF-URIS-BY-DEREFERENCING	
R-172-GENERATE-HUMAN-READABLE-DOCUMENTATION	
R-176-PROVIDE-HIGH-LEVEL-VOCABULARY-FOR-THE-MOST-COMMON-TYPES-OF-CONSTRAINTS	
R-179-ASSOCIATE-CONSTRAINTS-WITH-RDF-DOCUMENTS	
R-180-ASSOCIATE-CONSTRAINTS-WITH-RDF-DATASETS	
R-181-ASSOCIATE-CONSTRAINTS-WITH-RDF-REST-APIS	
R-183-CONSTRAINTS-ABOUT-CONSTRAINTS	
R-185-FEDERALIZED-RDF-VALIDATION	
R-186-EXTEND-EXPRESSIVITY-WITH-SPARQL	
R-188-EXPRESSIVITY-OF-CONSTRAINT-LANGUAGE-EQUIVALENT-TO-SPARQL	
R-189-ADD-ANNOTATIONS-TO-CONSTRAINT-VIOLATION-OBJECTS	
R-191-SHAPES-RELATED-TO-TYPES	
R-193-MULTIPLE-CONSTRAINT-VALIDATION-EXECUTION-LEVELS	
R-194-PROVIDE-STRING-FUNCTIONS-FOR-RDF-LITERALS	SPIN

- cardinality restrictions (ObjectMaxCardinality, ObjectMinCardinality, ObjectExactCardinality, DataMaxCardinality, DataMinCardinality, DataExactCardinality)
- disjunction (ObjectUnionOf, DisjointUnion, and DataUnionOf)
- property inclusions (SubObjectPropertyOf) involving property chains
- functional and inverse-functional properties (FunctionalObjectProperty, InverseFunctionalObjectProperty, and FunctionalDataProperty)
- transitive properties (TransitiveObjectProperty)
- keys (HasKey)
- individual equality assertions and negative property assertions (SameIndividual, NegativeObjectPropertyAssertion, NegativeDataPropertyAssertion)

## References

1. Boris Motik, Bernardo Cuenca Grau, Ian Horrocks, Zhe Wu, Achille Fokoue, and Carsten Lutz. Owl 2 web ontology language: Profiles. Technical report, December 2008.