Rules for the Semantic Web

The WSML Approach

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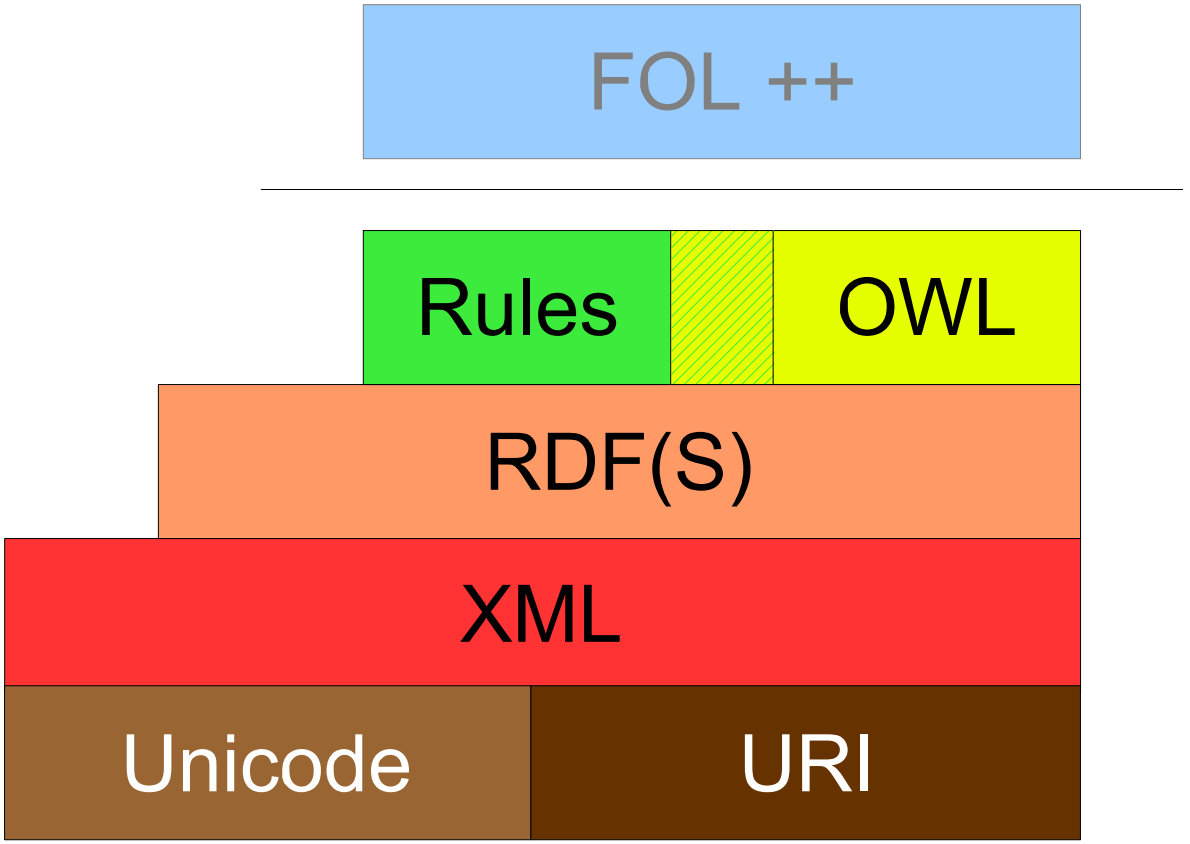
Web Rule Language in its Context



Outline

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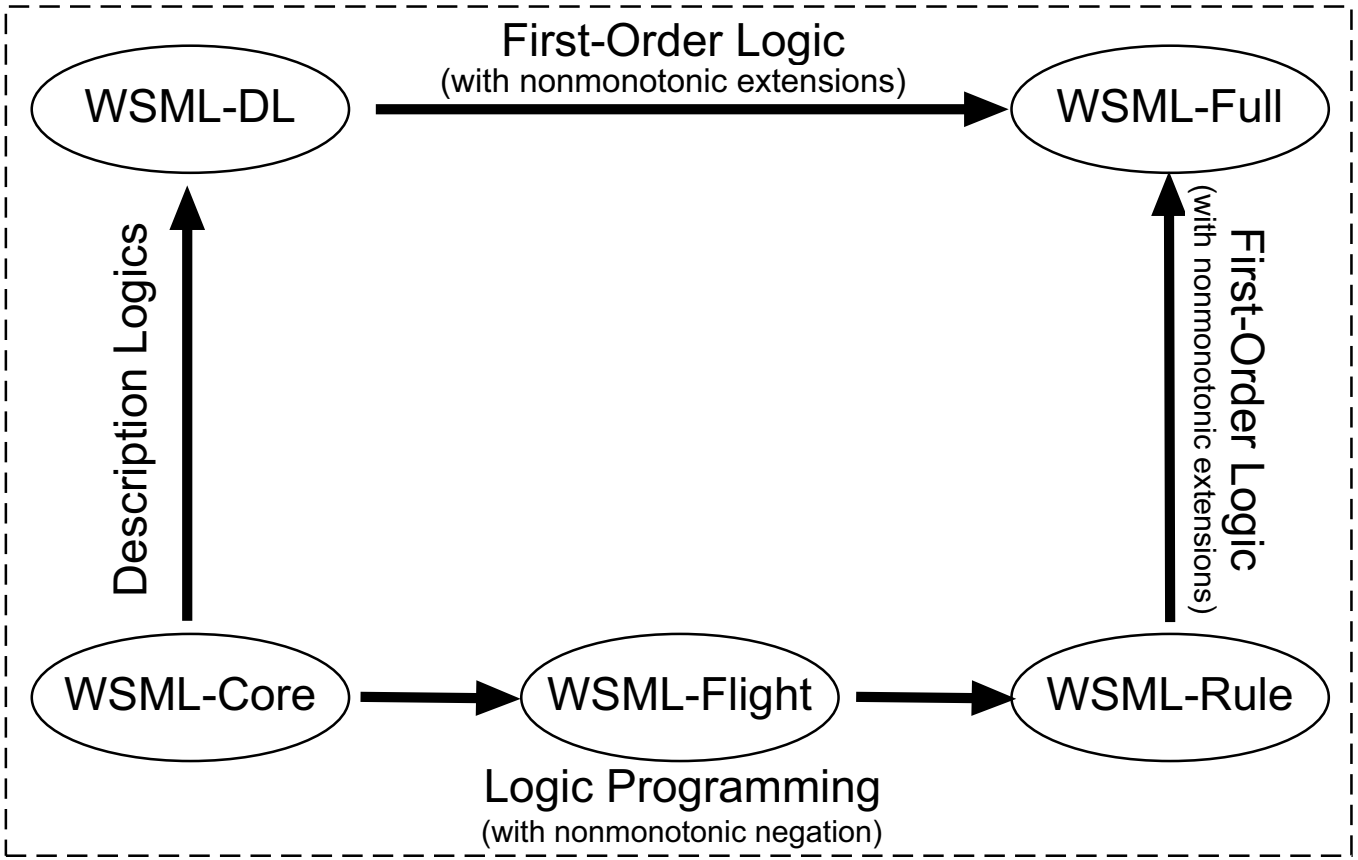
The Web Service Modeling Language WSML

- A language for the Semantic description of Web Services
- Based on the Web Service Modeling Ontology WSMO
  - Ontologies
  - Web Services
  - Goals
  - Mediators
- Disregard Web Service-related aspects in this presentation
- Semantics based on well-known logical language paradigms:
  - Description Logics
  - Logic Programming
  - Frame Logic
- WSML distinguishes between:
  - Conceptual modeling
  - Logical expressions

WSML Language Variants



Prologue

By Example

```
// Specification of the WSML variant
wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-flight"
// Namespace prefix declaration
namespace {_"http://www.example.org/example#",
  dc _"http://purl.org/dc/elements/1.1/"}
// WSML specifications
ontology _"http://www.example.org/exampleOntology"
 [...]
goal _"http://www.example.org/exampleGoal"
 [...]
```

etc...

WSML Specification

A WSML specification has the following structure:

- Type of specification (Ontology/Web Service/Goal/Mediator)
- Header
  - Non-Functional Properties
  - Imported Ontologies
  - Used Mediators
- Content of the specification

Ontologies

Header

[.. prologue ..]

ontology _"http://www.example.org/ontologies/example"

nonFunctionalProperties

dc#title **hasValue** "WSML example ontology"

endNonFunctionalProperties

importsOntology {_"http://www.wsmo.org/ontologies/location"}

usesMediator {_"http://www.wsmo.org/mediators/"}

Ontologies

Concepts

- Form the basic terminology of the domain of discourse
- May be organized in a hierarchy (using **subConceptOf**)
- Has a number of attributes:
  - Attributes have a type:
    - Type constraint (**ofType**)
    - Type inference (**impliesType**)
  - Attributes may have cardinality constraints
  - Attributes may have a number of features:
    - Transitive
    - Symmetric
    - Reflexive
    - Inverse of another attribute

Ontologies

Concepts - example

```
concept Person subConceptOf {Primate, LegalAgent}
  nfp
 // Related axiom
     dc#relation hasValue personUncle
   endnfp
 // A functional attribute (maximal cardinality=1)
    hasName ofType (0 1) _string
 // hasParent is the inverse of hasChild
    hasChild inverseOf(hasParent) ofType Person
    hasParent ofType Person
    hasBrother ofType Person
```

Ontologies
Relations

- Inspired by relations in mathematics
- Have arbitrary arity
- May have typing associated with its arguments
- May be organized in a hierarchy (using **subRelationOf**)

relation Marriage (ofType Person, ofType Person, ofType _date)
nfp
dc#description **hasValue** "Marriage is a relation between two persons, which are the participants in the marriage, and the date in the marriage."
endnfp

Ontologies
Instances

- Are the objects in the domain
- May be member of one or more concepts
- May have a number of attribute values associated with it

instance john **memberOf** Person
nfp
dc#description **hasValue** "The person John Smith"
endnfp
hasName **hasValue** "John Smith"

Ontologies
Relation Instances

- Are tuples in a relation

relationInstance Marriage(john,mary,_date(2005,03,03))
nfp
dc#description **hasValue** "John and Mary married on 2005-03-03."
endnfp

Ontologies
Axioms

- Refine concept and relation definitions in Ontologies using logical expressions
- Add arbitrary knowledge and constraints
- Entry point for logical expressions, rules in ontology
- Allowed logical expressions depend on WSML variant

```
axiom personUncle
nfp
  dc#description hasValue "The brother of a person's parent is that
    person's uncle."
endnfp
definedBy
  ?x[hasUncle hasValue ?z] impliedBy ?x[hasParent hasValue ?y] and
    ?y[hasBrother hasValue ?z].
```

Logical Expression syntax

- Used for refining Ontologies and specifying Web Service functionality
- Allow to use the full expressive power of the underlying logic
- Frame syntax (F-Logic)
- Logic Programming constructs
  - Negation-as-failure
  - LP implication
- Variables are implicitly universally quantified outside the formula
- Symbols resemble natural language and are unambiguous
- WSML variants restrict allowed logical expressions

Examples

Examples

// a simple rule ; the brother of someone's parent is that person's
// uncle
?x[hasUncle **hasValue** ?z] :− ?x[hasParent **hasValue** ?y] **and**
?y[hasBrother **hasValue** ?z].

Examples

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// the same person cannot be both a man and a woman (constraint)
!– ?x **memberOf** Man **and** ?x **memberOf** Woman.

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// every person has a father
?x **memberOf** Person **implies exists** ?y (?x[father **hasValue** ?y]) .

WSML XML Syntax

- Syntax for exchange over the Web
- Translation between human-readable and XML syntax
- XML Schema for WSML has been defined

WSML XML

Example

```
<!ENTITY ex "http://www.example.org/ontologies/example#">
<!ENTITY wsml "http://www.wsmo.org/wsml/wsml-syntax#">
<wsml xmlns="&wsml;"
 variant="http://www.wsmo.org/wsml/wsml-syntax/wsml-flight">
  <importsOntology>
    http://www.wsmo.org/ontologies/location
  </importsOntology>
  <concept name="&ex;Person">
    <nonFunctionalProperties>[..]</nonFunctionalProperties>
    <attribute name="&ex;hasName" type="constraining">
      <range>&wsml;string</range>
      <maxCardinality>1</maxCardinality>
    </attribute>
      [..]
  </concept>
    [..]
</wsml>
```

WSML RDF Syntax

- Interoperability with RDF applications
- Maximal reuse of RDF and RDFS vocabulary
- WSML RDF includes most of RDF
- Translation between human-readable and RDF syntax
- For logical expressions, XML literals are used

WSML RDF

Example

```
<http://www.example.org/ontology> rdf#type wsml#ontology
<http://www.example.org/ontology> wsml#variant
    <http://www.wsmo.org/wsml/wsml-syntax/wsml-flight>
<http://www.example.org/ontology> wsml#nfp _:nfp1
_:nfp1 dc#title "WSML example ontology"^^xsd#string
<http://www.example.org/ontology> wsml#importsOntology
    <http://www.wsmo.org/ontologies/location>
<http://www.example.org/ontology> wsml#hasConcept ex#Person
ex#Person wsml#hasAttribute _:att1
_:att1 wsml#attribute ex#hasName
_:att1 wsml#ofType xsd#string
_:att1 wsml#maxCardinality "1"^^xsd:integer
<http://www.example.org/ontology> wsml#hasAxiom
    ex#personUncle
ex#personUncle rdfs#isDefinedBy
    "<impliedByLP>..</impliedByLP>"^^rdf#XMLLiteral
```

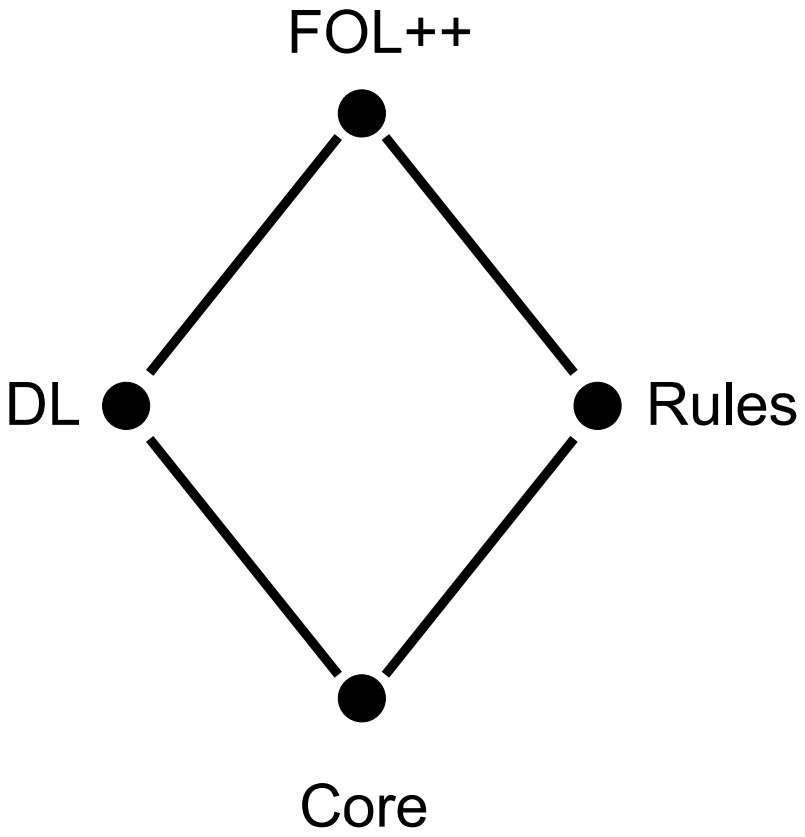
Outline

Key Features of WSML

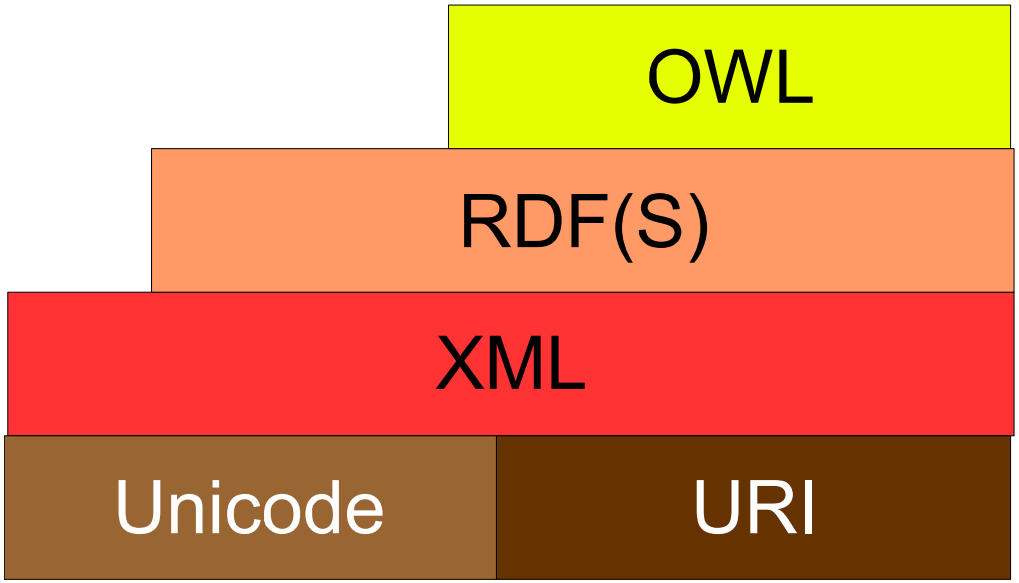
- One framework for a set of Layered Languages
- Normative, Human-readable Syntax
- Separation of conceptual modeling and logical expressions
- Semantics based on well-known formalisms
- Relation between DL and Rules through common subset
- Web Language
- Frame-based syntax

Outline

The WSML Approach to language layering



Current Languages on the Semantic Web



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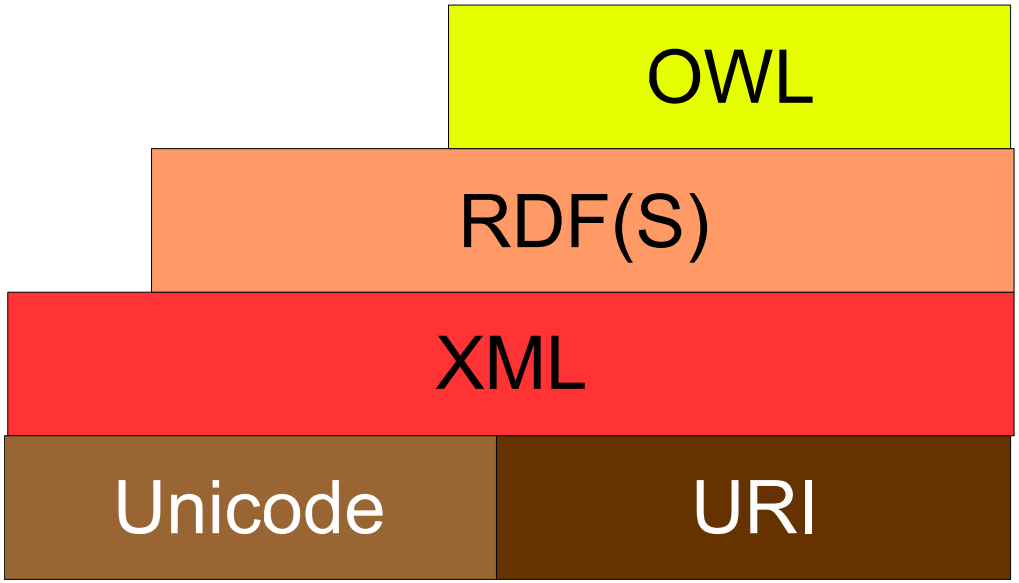
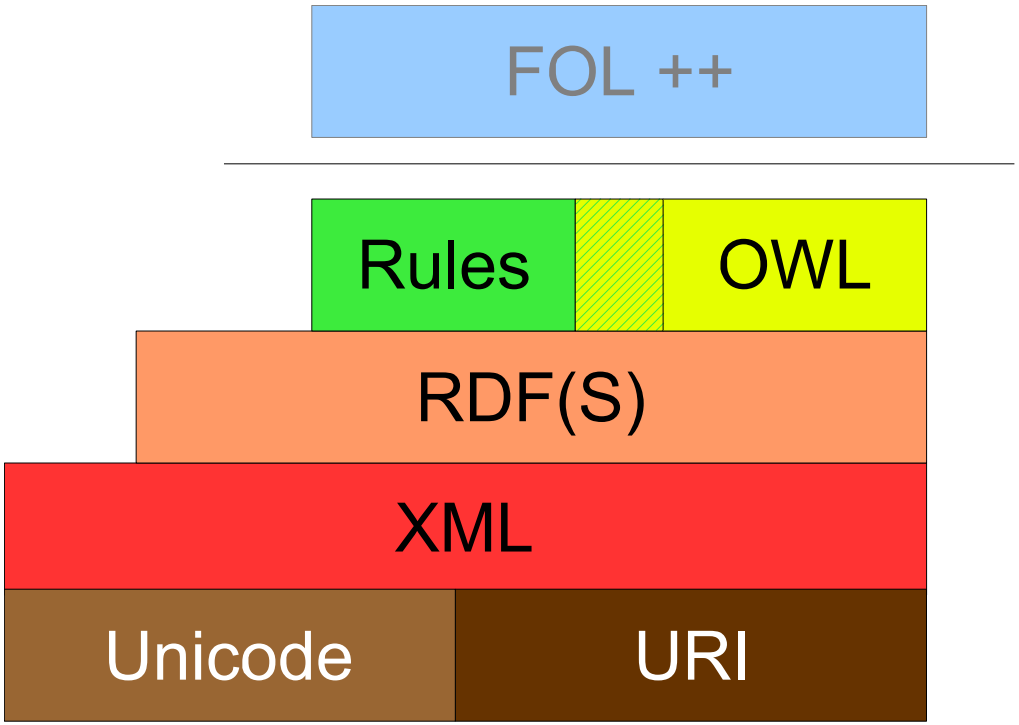


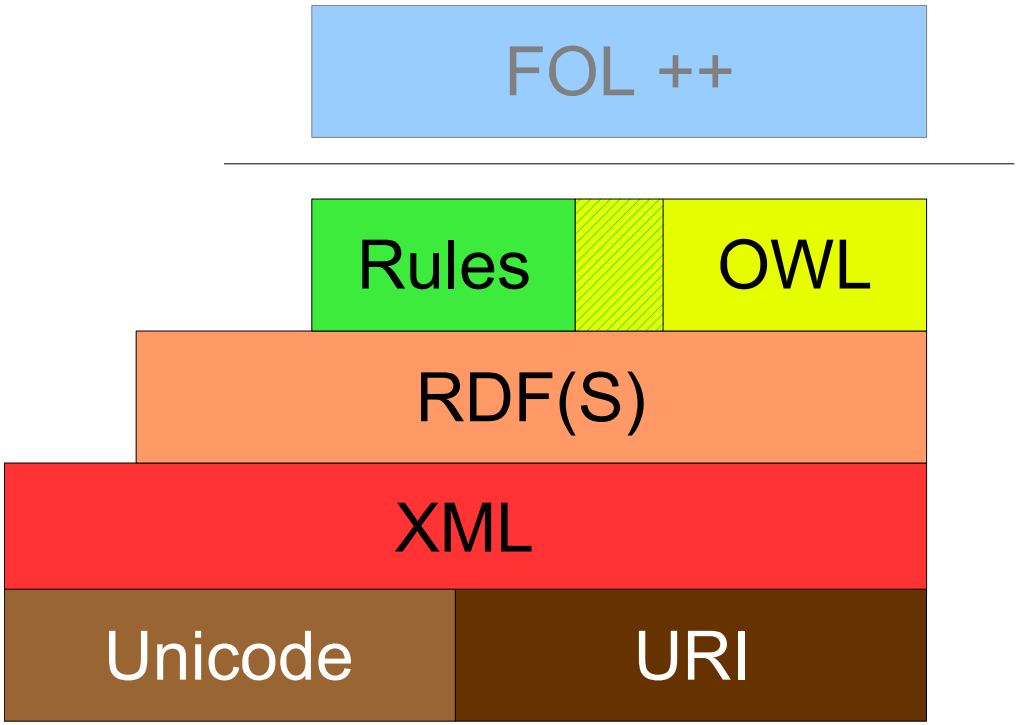
How to Incorporate rules?

- Layering Rules on top of OWL (e.g. SWRL)
- Hybrid approach (e.g. CARIN/AL-Log)
- Using a common subset for interoperation (e.g. DLP)

Common subset



Common subset



- Maintain nice properties of each of the underlying logics
- Reuse existing implementations of rules and description logic
- Allow straightforward extension in both directions

Outline

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WSML resources

http://www.wsmo.org/wsml/wsml-syntax#

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