Rule Interchange on the Web

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Outline

Motivation

The rule-based programming paradigm offers a

- flexible and adaptive approach towards application development
- executable specification: declarative model $\longrightarrow$ rapid prototyping
- high level means for deploying applications in various domains

For exploiting further the potential of the rule-based approach

- both the **Business Rules** and **Semantic Web** communities started to develop solutions to reuse and integrate knowledge
  - distributed over the Web
  - specified in different rule languages

(Some) rule-based systems and languages

... tailored (more or less) to the Web

- Rendering rules: CSS
- Prolog with XML support: Ciao Prolog, SWI Prolog
- Rules for XML: Xcerpt, XChange, ...
- Rules for RDF: TRIPLE, JenaRules, N3, F-Logic OntoBroker/OntoStudio (F-Logic), Fair Isaac Blaze Advisor (SRL),
  Oracle Business Rules, Prova (Prolog and Java), IRIS (WSML/WRL),
  FLORA-2 (F-Logic) ...

... and many more!

Application Examples

- Negotiating e-business contracts across rule platforms
  - reuse business documents made available online
- Access to business rules of supply chain partners
  - ease the integration of business processes
- Collaborative policy development for dynamic spectrum access
  - reuse protocols of wireless communication devices/services
- Ruleset integration for medical decision support
  - complex decision making systems using diff. data sources
- Vocabulary mapping for data integration
  - reuse rules implementing mappings between data models

(More) Application Examples

- Negotiating e-commerce transactions
  - by exchanging policies and credentials
  - an example rule

    ```
    Disclose Alice's credit card information only to
    online shops belonging to the Better Business Bureau.
    ```
  - such rules can elegantly be specified in Protune (recall Daniel's talk!)
- Publishing rules for interlinked metadata
  - specify and publish implicit data in form of rules
  - an example rule

    ```
    If a movie is listed at http://amdb.example.org but
    not listed at http://imd.example.org
    then it is an independent movie.
    ```

The multitude of such use cases drives the strong interest in rules and rule interchange technology!

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Current Efforts

Efforts such as ...

- Rule Markup Initiative - RuleML
- OMG - PRR and SBVR
- REWERSE - Xcerpt, XChange, ..., R2ML
- W3C Member Submissions - SWRL, WRL, SWSL Rules

...led to the W3C Rule Interchange Format Working Group (RIF WG)

- 78 participants from industry and academia
- chaired by representatives of IBM and ILOG
- chartered to standardize a common format for interchanging rules
  - which is not a trivial task!

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Rule Types

PR vendors, database systems vendors, and Semantic Web researchers have different views on the notion of *rules*:

- *deduction rules* (derivation or constructive rules)
  - derive knowledge by means of logical inference
- *normative rules* (structural rules)
  - pose constraints on the data and the logic of applications
- *reactive rules* (dynamic rules)
  - automatically execute actions when events occur and/or conditions become true
  - for example
    - Production rules (PR)
    - Event-Condition-Action (ECA) rules

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Rule Types

Example (deductive) rule

IF movie ?M was produced before 1930
THEN ?M is a black and white movie

- IF-part
  - specifies a **condition** for retrieving data on movies
  - binds the variable ?M to data items
- THEN-part
  - constructs/derives new data by using the retrieved bindings
  - using relational database terminology you can say it creates a 'view' over movie data

Rule Types

Example (normative) rule

Each movie must have a single production year.

- specifies a **condition** which must not be violated by the data
- two different production years for the same movie is an indication of corrupted data

- derivation and dynamic rules can be used to implement normative rules
- implementation decision depends on the application and the available support for rules

Rule Types

Example (reactive) rule

`ON` request from customer ?C to book movie ?M
`IF` customer ?C is blacklisted
`DO` deny ?C's request for ?M

- ON-part waits for a request for a movie to come in (an **event**)
- IF-part checks a **condition** on the customer's data
- DO-part
  - specifies the **action** to be executed
  - on a request from a blacklisted customer

Rule Types

Condition part is common to all possible rule “dialects”, so

- let’s start with developing a format for interchanging rule conditions
- and then extend it!

Rule Types

Example rule variant implemented using XChange (recall Paula's talk!):

```
ON
  xchange:event {{
    xchange:sender { var S },
    order {{
      customer { var C }
    }}
  }}
FROM
  in { resource { "http://MoviShop.org/blacklisted.xml", XML },
    desc var C
  }
DO
  xchange:event {
    xchange:recipient { var S },
    message { "Your request can not be processed,
               since you are blacklisted" }
  }
END
```

Rule Types

Example rule variant implemented using ILOG JRules (recall Philippe's talk!):

```
rule denyBlacklistedCustomers {
     when {
       c: Customer (blacklisted == yes);
       m: MoviesCart (owner == c; value > 0);
     } then {
        out.println ("Customer " + c.name + " is blacklisted!");
        retract m;
     }
 }
```

Rule Types

The proposed classification of rules

- basis for discovering commonalities between rule languages
- however, they reveal also considerable differences regarding
  - *syntax*,
  - *supported features*, and
  - *semantics*

. . . a standard interchange format should be able to interchange rules

- not only with different structure
- but also intertranslatable constructs and semantics!

W3C RIF WG Charter

... i.e., what the W3C RIF WG should do[1]:

Phase I

- simple, but extensible interchange format for Horn-like rules (RIF Core)
- Dec 2005 - Nov 2007

Phase II

- extensions in form of RIF Dialects (e.g. FOL, PR)
- until June 2008

Emphasizes compatibility with

- Web technologies - XML
- Semantic Web technologies - RDF, OWL, SPARQL

[1] http://www.w3.org/2005/rules/wg/charter.html

The Web as Framework for Rule Interchange

- The Web is a success story in terms of **linking** data (HTML)
- Web formats, such as XML have made it to nowadays standard formats for also non-Web **data exchange**
- The next generation of the Web will allow to link and exchange data (RDF) and its **structure** (models/vocabularies, ontologies in RDF Schema, OWL) even more flexible
  $\longrightarrow$ this is often called the **Semantic** Web
- As an important facilitator for this flexibility, the Semantic Web will also allow to **exchange rules**!

ie.: The Semantic Web is about exchange of Data, Data/Domain Models and Rules (e.g., by RIF)!

Let us talk about these foundations a bit, since they have some implications for RIF!

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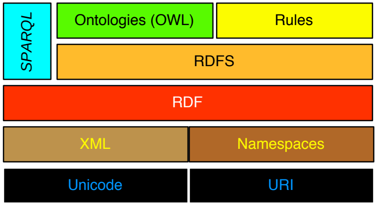

The (Semantic) Web architecture stack

Semantic Web architecture 1/5: XML

```
<?xml version="1.0"  encoding="UTF-8"?>
<moviedb xmlns="http://imd.example.org/ns/">
  <movie ID="m1">
    <title>Plan 9 from Outer Space</title>
    <directedBy ID="p1">
      <name>Edward D. Wood Jr.</name>
      <dateOfBirth>1924-10-10</dateOfBirth>
    </directedBy>
    ...
    <year>1959</year>
  </movie>

  ...
</moviedb>
```

- Tree to handle semi-structured data
- Unique identifiers to disambiguate formats (namespaces)
- Facilitates data exchange on a syntactical level
- Take-up in many applications which need common formats (ebXML, Web Services,. . .)

⇒ RIF will also have an XML syntax!

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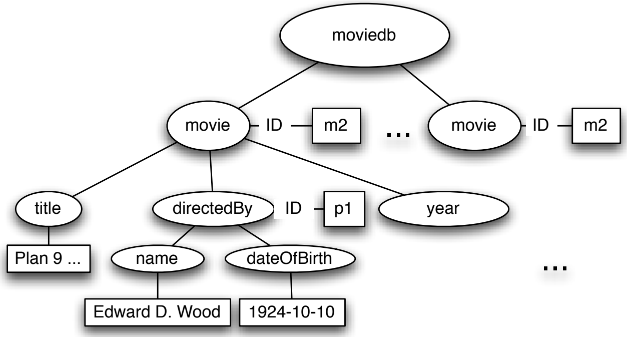

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Semantic Web architecture 2/5: RDF

- Integrating **different** XML formats is still sometimes tricky (XSLT), due to the tree format of XML.
- The data model of the Semantic Web is **graphs** instead of trees.

An RDF graph is made up by a set of “**statements**” (i.e.simple triples) about **resources**:

```
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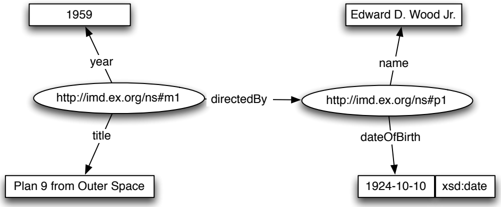
Sets of RDF statements may be viewed as directed, labelled Graphs:



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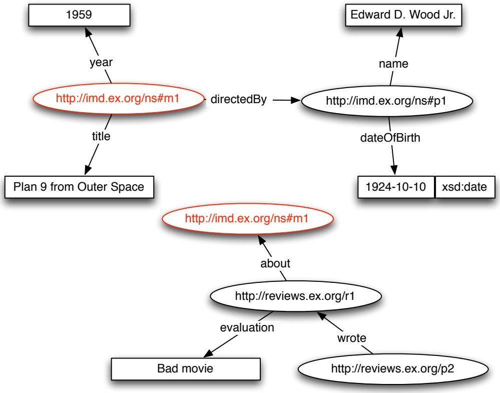

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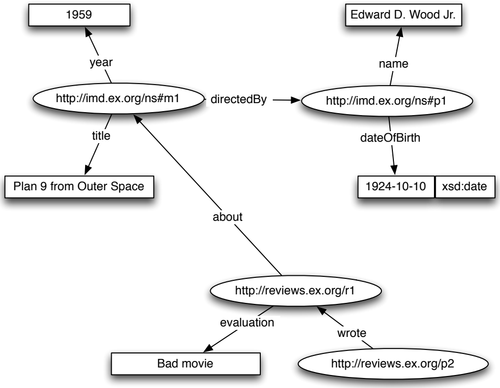
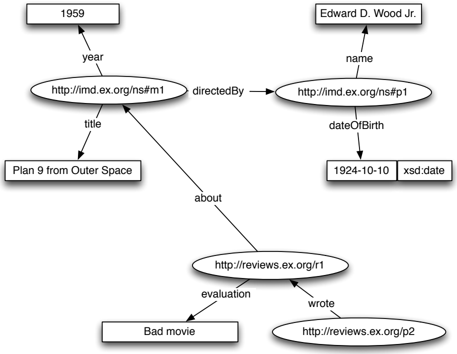


The flat data model of RDF is **easier to integrate** than XML!

Semantic Web architecture 3/5: RDFS/OWL

The Semantic Web architecture has defined more flexible ways to **exchange and integrate** not only data, but also **data/domain models**:

- RDFS (= RDF Schema) and OWL (= Web Ontology Language)
- allow to add classes and types to RDF
- allow to express subclass hierarchies, subproperty hierarchies, etc.



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OWL and RDFS can express additional relations among types and properties, e.g.:

- *each Director is a Person (subclass)*
- *each Reviewer is a Person (subclass)*
- *somebody who directed a Movie is a Director (range restriction)*
- *somebody who wrote a Review is a Reviewer (domain restriction)*
- etc.

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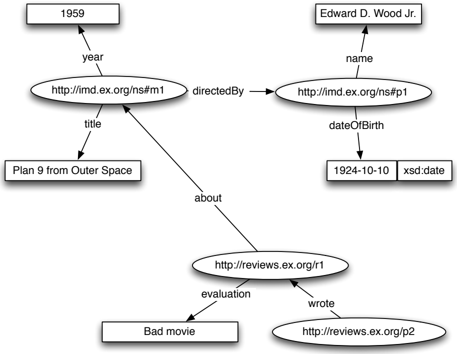

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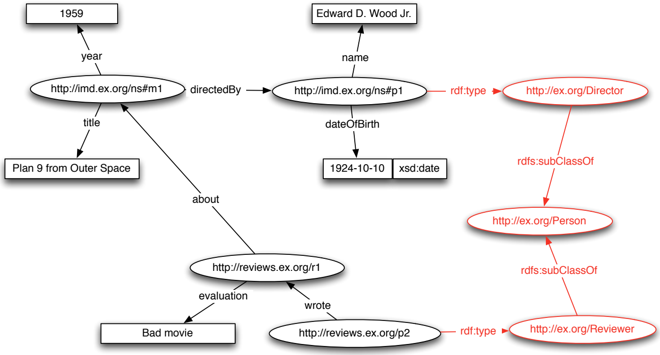

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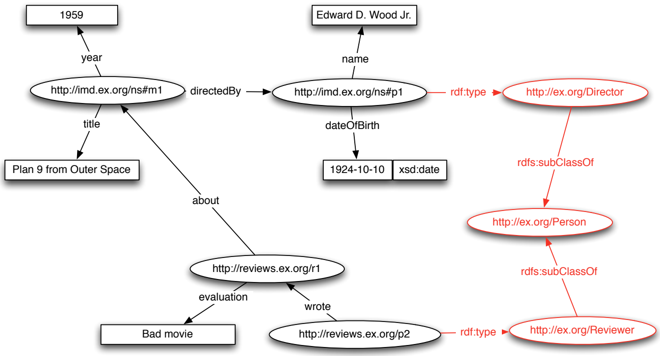

Real power of common domain models reveals in **sharing**, **exchanging** and **reusing** them!

Semantic Web architecture 4/5: XML vs. RDF(S)+OWL

	XML	RDF
Data Model:	Tree	Graph
Identifiers:	element, attribute names	everything identified by URIs
Data:	in the leaves	in the nodes
Relations	in the nodes	in the edges
Data structure :	XML Schema (syntax)	RDFS/OWL (semantics)

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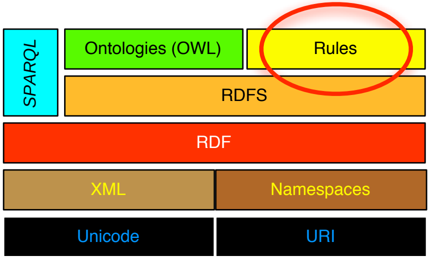

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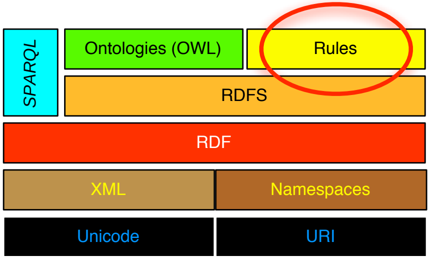

Support for lower layers of the SW Arch in RIF:

Implications:

- RIF will use URIs as identifiers (for predicates, constants, etc.)
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This is not a trivial goal to achieve:

- Vertical Compatibility/exchange not even solved on the lower layers of the SW stack:
  - How to get from XML to RDF? W3C is working on it: GRDDL, RDFa, etc.
  - How to get from XML Schema to RDFS
  - Tricky issues around mixing OWL DL with arbitrary RDF
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Some example Rules on top of RDF data 1/2

Given the RDF Data from above. . .

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unary/binary predicate style:

```
∀ ?M "moviShop:BWMovie"( ?M ) ←
  ( ∃ ?Y
    "imd:Movie"( ?M ) ∧ "imd:Year"( ?M, ?Y ) ∧
    ?Y < "1930" )
```

We assume that we can use IRIs (QNames) as predicate/constant names here, variables are denoted by question marks.

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one designated predicate `triple` for RDF triples:

```
∀ ?M triple( ?M,"rdf:type","moviShop:BWMovie")←
  ( ∃ ?Y
    triple( ?M,"rdf:type","imd:Movie" ) ∧ triple( ?M,"imd:Year",?Y )
    ?Y < "1930" )
```

This notion is more verbose, but has advantages as we will see. . .

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slotted notation, i.e. FRAMES for RDF triples:

```
∀ ?M ?M#moviShop:BWMovie←
  ( ∃ ?Y
    ?M#imd:Movie[ imd:Year → ?Y ] ∧
    ?Y < "1930" )
```

Logic languages like F-Logic (Kifer et al. 1995) support this while still staying in a first-order semantics. '#' (class membership), '##' (is-A), and '[ ]' are basically syntactic sugar for the verbose notation that we used in the last slide.

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    "op:date-less-than"( ?Y , "1930-01-01T00:00:00Z"^^dateTime ) )
```

Alternative: How about built-in functions like '<'?
We could/should reuse XPath/XQuery standard functions here, we could/should allow typed literals (primitive datatypes) as present in RDF.

Some example Rules on top of RDF data 2/2

. . . So, we see that some design decisions need to be made on how to embed different data models such as for instance RDF.

Let's consider another prominent example rule: the RDFS entailment rule (rdfs3) from semantics (Hayes 1999):

`IF` an RDF graph contains triples `(P rdfs:range C)` and `(S P O)`
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Let's consider another prominent example rule: the RDFS entailment rule (rdfs3) from semantics (Hayes 1999):

> `IF` an RDF graph contains triples `(P rdfs:range C)` and `(S P O)`
> `THEN` the triple `O rdf:type C` is entailed

Can be written as a Horn rule as follows (using the triple predicate notation):

```
∀ ?S,?P,?O,?C triple(?O,"rdf:type",?C) ←
              ( triple(?P,"rdf:range",?C) ∧ triple(?S,?P,?O) )
```

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Note: The unary/binary predicate version would go outside first-order:

```
∀ ?S,?P,?O,?C "rdf:type"(?O,?C) ←
              ( "rdf:range"(?P,?C) ∧ ?P(?S,?O) )
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Slotted/F-Logic version works as well:

```
∀ ?S,?P,?O,?C ?O#?C ←
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Let's see how this looks in several existing rules systems for RDF!

Some SW Rules Language Systems: TRIPLE

TRIPLE:

- M.Sintek, S.Decker, A.Harth, 2002
- Frame syntax, similar to F-Logic
- Special syntax to import RDF, define namespaces, etc.

```
rdf:= 'http://www.w3.org/1999/02/22-rdf-syntax-ns#'.
rdfs:= 'http://www.w3.org/2000/01/rdf-schema#'.
type := rdf:type.
range := rdfs:range.

FORALL O,C O[type->C] <- EXISTS  S,P (S[P->O] AND P[range->C]).
```

Some SW Rules Systems: JENA

JENA:

- HP Labs Bristol
- proprietary syntax
- natively dealing with RDF, rules as add-on part of Jena API.

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>.

[rdfs3: (?s ?p ?o) (?p rdfs:range ?c) -> (?o rdf:type ?c)]
```

Some SW Rules Systems: N3

N3:

- W3C people, Dan Connolly, TimBL
- syntax extends N-Triples RDF syntax by rules
- natively extension of RDF, implemented in a prototype system (cwm).

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix log: <http://www.w3.org/2000/10/swap/log#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .

{ <#p> rdfs:range <#c>. <#s> <#p> <#o> . }
               log:implies { <#o> rdf:type <#c> }.
```

Some SW Rules Systems: FLORA-2

FLORA-2:

- M. Kifer et al.
- A reference implementation for F-Logic with RDF support
- Additional support for higher-order modeling via HiLog

```
:- iriprefix rdf = 'http://www.w3.org/2000/01/rdf-schema#'.

?O[rdf#type->?C] :- ?S[?P->?O], ?P[rdf#range->?C].
```

Some SW Rules Systems: `dlvhex`

dlvhex:

- R. Schindlauer et al., developed within REWERSE
- SW rules engine on top of the `dlv` system, stable model semantics
- Prolog-style syntax, special predicates for RDF import, namespaces, etc.

```
#namespace("rdf","http://www.w3.org/1999/02/22-rdf-syntax-ns#")
#namespace("rdfs","http://www.w3.org/2000/01/rdf-schema#")

triple(O,rdf:type,C) :-  triple(P,rdfs:range,C), triple(S,P,O).
triple(S,P,O) :-
       &rdf["http://UrlWithRdfData.example.org/data.rdf"](S,P,O).
```

Some SW “Rules” Systems: SPARQL engines! 1/2

SPARQL:

- upcoming W3C query language standard
- Actually, SPARQL’s `CONSTRUCT` queries may be viewed as rules as well
- Syntax a bit like merging SQL with N-Triples/Turtle.

```
CONSTRUCT { ?M rdf:type moviShop:BWMovie }
WHERE { ?M rdf:type imd:Movie . ?M imd:year ?Y .
        FILTER (?Y < 1930) }

CONSTRUCT { ?O rdf:type ?C }
WHERE { ?P rdf:range ?C . ?S ?P ?O . }

CONSTRUCT { ?P foaf:knows _:a }
WHERE { ?P rdf:type ex:socialPerson . }
```

Issues:

- No recursive/fixpoint evaluation in standard engines
- No combination of several CONSTRUCTs in standard engines
- BTW: Blank nodes in rule heads (last rule) would make things non-Horn.

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Rule Exchange on top of RDF - Syntactical/Semantic Issues

Summary: Now what issues arise for Web Rule exchange?

- Different options for embedding RDF
- Different Syntax (slotted, unary/binary) in different existing systems
- How to embed RDF(S) semantics?
- (Even worse: How to refer to more complicated semantics such as OWL, how to combine/integrate different data/domain models (XML, UML))

But this is not all, also signatures are important...

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Rule Exchange - Signatures/Namespaces

Recall: When hearing about first-order semantics on Monday, you learned about signatures, that is:
Every ruleset or first-order theory uses a particular signature: $\Sigma = (P, F, C, V)$

- P . . . predicate symbols
- F . . . function symbols
- C . . . constant symbols
- V . . . variables

Important for defining a semantics for rules and also for combination/exchange of rulesets!

Ruleset r1:

```
∀ ?X,?Y q(p(?X,?Y),?X) ← q(?Y,?X)
```

Ruleset r2:

```
p("1") ←
```

Could still exchange rules on first-order level, if we know that p in ruleset 1 is something else than p in ruleset 2.

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```

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r2:p("1") ←
```

Could still exchange rules on first-order level, if we know that p in ruleset 1 is something else than p in ruleset 2, IRIs/namespaces partially solve that problem.

Current Status of RIF

Now you got an idea of issues which need to be solved for Web rule exchange

. . . Let's finally talk about RIF's current state . . .

2 working drafts produced so far:

- Use Cases and Requirements
- RIF Core Design (now being renamed to "RIF Basic Logic Dialect")

Use Cases and Requirements

- almost 50 use cases for a rule interchange format submitted
- 2 Public Working Drafts of *'RIF Use Cases and Requirements'*
  - use cases from various application domains
  - requirements mainly for Phase I
- a refined Working Draft underway
- we gather Phase II requirements at the moment

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RIF Core Design

RIF Core shall cover the minimal overlap of different Rule dialects, that is

- an extensible formalism to express “basic” conditions
- a simple framework for “basic” rules

⇒ “basic” = **positive Horn** rules

- allow to define rulesets
- provide formal underpinning for
  - interoperation with the remaining Semantic Web architecture
  - extensible semantics for Horn rules and extending dialects

⇒ an extensible **architecture** to build RIF “dialects” around a common Core: This Core Horn dialect will be called RIF Basic Logic Dialect (BLD)

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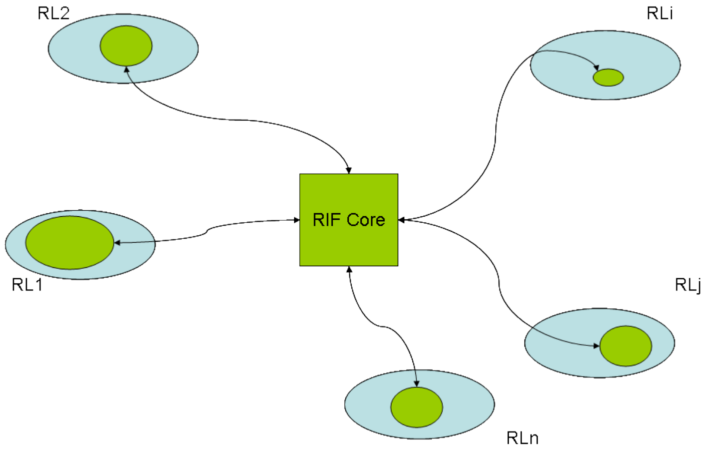
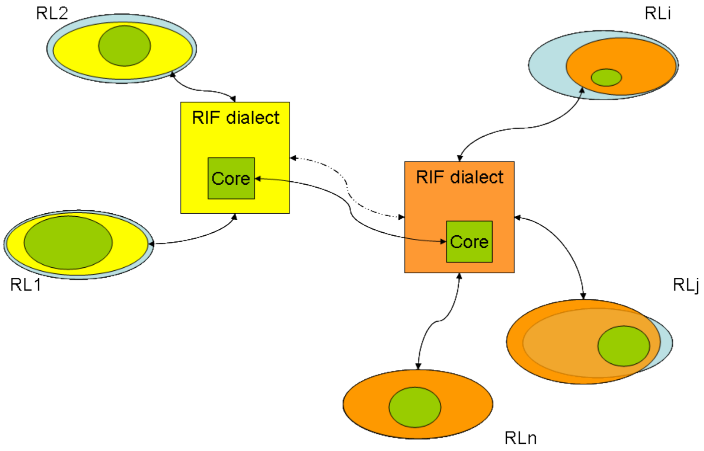


RIF Architecture 1/2



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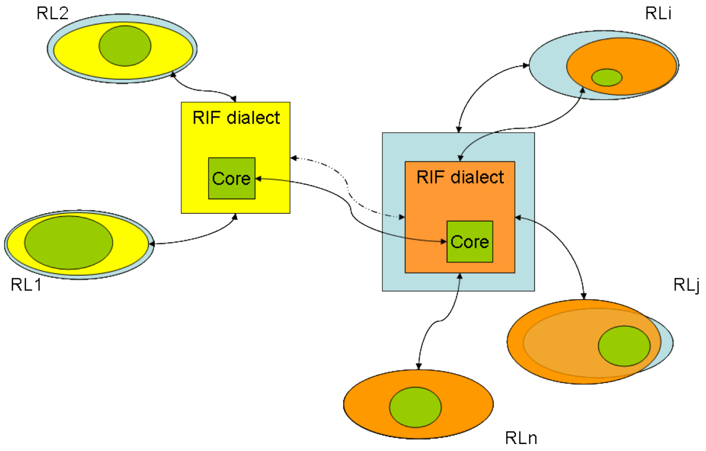

RIF Architecture 2/2

Required:

- Ruleset
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- Rule
  - Annotation: Name, Description, . . .
  - Event (`ON`)
  - Condition (`IF`)
  - Conclusion/Derivation (`THEN`)
  - Action (`DO`)
  - . . .

Start with positive Horn:

`IF`: conjunctions (and disjunctions) of atomic conditions

`THEN`: atomic formulae

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$$\text{IF } C_1 \text{ AND } C_2 \text{ AND } \ldots \text{AND } C_n \text{ THEN } A$$

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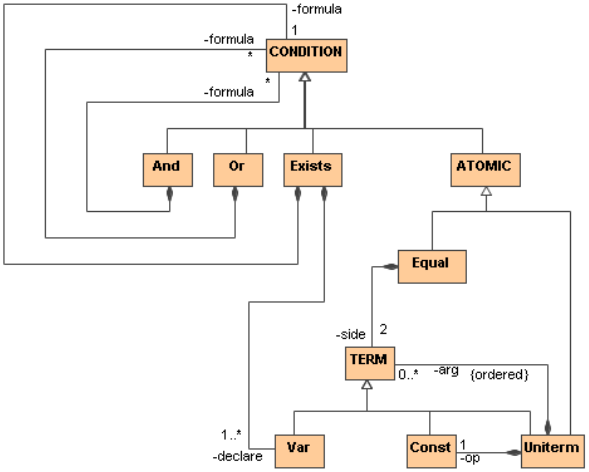
RIF Core Conditions

An extensible model to express basic conditions:



RIF Core Conditions

An extensible model to express basic conditions:

EBNF Syntax (in progress/under discussion):

```
CONDITION       ::= CONJUNCTION | DISJUNCTION | EXISTENTIAL | ATOMIC
CONJUNCTION     ::= 'And' '(' CONDITION* ')'
DISJUNCTION     ::= 'Or' '(' CONDITION* ')'
EXISTENTIAL     ::= 'Exists' Var+ '(' CONDITION ')'
ATOMIC          ::= Uniterm | Equal | CLASSIFICATION | Frame
Uniterm         ::= Const '(' TERM* ')' | Const '(' (Const '->' TERM)* ')'
Equal           ::= TERM '=' TERM
TERM            ::= Const | Var | Uniterm
Const           ::= CONSTNAME | '"'CONSTNAME'""^^'TYPENAME
Var             ::= '?'VARNAME
```

For instance under discussion: language labels for literals as in RDF (e.g. `"lecture"@en`, `"vorlesung"@de`)

RIF Core Conditions – Example 1/2

Example: `IF` movie ?M was produced before 1930

RIF “readable” version of this condition:

```
Exists ?Y (
    And ( "imd:Movie"( ?M ) "imd:Year"( ?M ?Y )
          "op:date-less-than"( ?Y "1930-01-01T00:00:00Z"^^dateTime )
```

- Names of predicates are “webized” (using URIs and namespaces like in XML and RDF)
- Builtin predicates, like `op:date-less-than` around XPath and XQuery functions and operators will be also standardized (in an extensible way)

RIF Core Conditions – Example 2/2

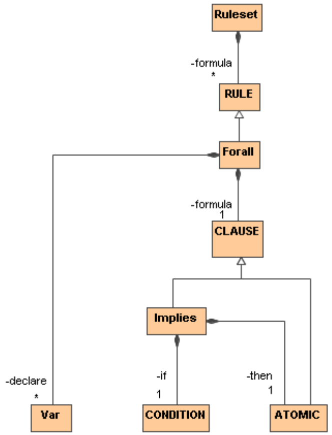
Mock-up XML serialization (currently under discussion):

```
    <Exists>
      <declare><Var>Y</Var></declare>
      <formula>
       <And>
        <formula>
          <Uniterm>
            <Const>Movie</Const>
            <Var>M</Var>
          </Uniterm>
        </formula>
        <formula>
          <Uniterm>
            <Const>Year</Const>
            <Var>M</Var>
            <Var>Y</Var>
          </Uniterm>
        </formula>
        <formula>
          <Uniterm type="builtin">
            <Const>date-less-than</Const>
           <Var>M</Var>
           <Const type="&xsd;dateTime">"1930-01-01T00:00:00</Const>
          </Uniterm>
        </formula>
    </Exists>
  </And>
```

Discussed issues: How to markup typed constants, builtin functions, etc.

RIF Core Horn Rules

A basic model for Horn rules:



Current focus:

- only cover simple `IF-THEN` rules
- provide a clean formal underpinning (model theory)

RIF Core Horn Rule – Example

A rule “local” to a certain DVD shop:

IF dvd ?D shows movie ?M and ?M was produced before 1930

THEN ?M is a black and white movie

```
"moviShop:BWMovie" ( ?M ) :-
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- XML syntax similarly discussed
- Keep door open for later extensibility
- Discussions how to integrate with RDF/OWL data and also other data models!

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Semantics of RIF Core

General picture

- model-theoretical semantics
- starts with defining the semantics of RIF conditions
- and extends it to RIF (Horn) rules

- RIF dialects are to further extend this semantics
- however, some dialects might not have a model theory (e.g. PR dialect)

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General picture

- model-theoretical semantics
- starts with defining the semantics of RIF conditions
- and extends it to RIF (Horn) rules = RIF Basic Logic Dialect

- RIF dialects are to further extend this semantics
- however, some dialects might not have a model theory (e.g. PR dialect)

Semantics - RIF Positive Conditions

From the first lecture of this summer school, we know about the notion of interpretation (or semantic structure).

We define a **basic semantic structure** I

- a tuple $<D, I_C, I_V, I_F, I_R>$ that determines the truth value of a formula (`CONDITION` or `CLAUSE` production of EBNF
- D - a non-empty set of elements called the domain of I
- $Const$ - the set of individuals, predicate names, and function symbols
- Var - the set of variables

We denote by TV the set of truth values

- for the RIF BLD it includes only t (true) and f (false)
- TV has a *truth order* $f <_t t$

Semantics - Positive Conditions

... and the mappings are as follows:

- I_C from $Const$ to elements of D
- I_V from Var to elements of D
- I_F from $Const$ to functions from D^* into D
- I_R from $Const$ to truth-valued mappings $D^* \rightarrow TV$

A more general mapping is defined as follows

- $I(k) = I_C(k)$ if k is a symbol in $Const$
- $I(?v) = I_V(?v)$ if $?v$ is a variable in Var
- $I(f(t1...tn)) = I_F(f)(I(t1),...,I(tn))$

Note that signatures do not appear in the definition of semantic structure!
...But they are important for keeping typical first-order restrictions of RIF's Basic Logic Dialect! more on that later ...

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Semantics - Positive Conditions

Truth valuation for formulas determined using I_{Truth}

- atomic formulas: $I_{Truth}(r(t1...tn)) = I_R(r)(I(t1),...,I(tn))$
- equality: $I_{Truth}(t1 = t2) = t$ iff $I(t1) = I(t2)$; $I_{Truth}(t1 = t2) = f$ otherwise
- conjunction: $I_{Truth}(And(c1...cn)) = min_t(I_{Truth}(c1),...,I_{Truth}(cn))$, where min_t is minimum with respect to the truth order
- disjunction: $I_{Truth}(Or(c1...cn)) = max_t(I_{Truth}(c1),...,I_{Truth}(cn))$, where max_t is maximum with respect to the truth order
- quantification: $I_{Truth}(Exists?v1...?vn(c)) = max_t(I^*_{Truth}(c))$, where max_t is taken over all interpretations I^* of the form $<D, I_C, I^*_V, I_F, I_R>$, and the mapping I^*_V has the same value as I_V on all variables except, possibly, on the variables $?v1,...,?vn$.

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Semantics - RIF Horn Rules

General form of a RIF rule

$Q\ then\ :\!-\ if$, where Q is the quantification prefix (universal here)

- We first define rule satisfaction without Q

$$I \models then\ :\!-\ if \text{ iff } I_{Truth}(then) >_t I_{Truth}(if)$$

- We define

$$I \models Q\ then\ :\!-\ if \text{ iff } I^* \models then\ :\!-\ if \text{ for every } I^*$$

  where I^* agrees with I everywhere except possibly on some variables mentioned in Q. In this case I is a **model of the given rule.**

- I is a **model of a rule set** R

$$I \models R \text{ if } I \text{ is a semantic structure such that}$$
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Entailment of RIF conditions by rule sets

- let S be a RIF rule set and
- ϕ a closed RIF condition (i.e. no free variables)

S **entails** ϕ written as $S \models \phi$

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. . . This sign indicates issues which are being currently discussed and reflect partially personal opinions of WG members!

Slots + Frames

- As we've seen, several rule languages support slots and frames (e.g. F-Logic)
- Considered to model RDF or ontological data, relations with named attributes; often more intuitively than predicates
- Meta-modeling no problem (recall (rdfs3) rule from before!)
- Proposal in the WG from Michael Kifer, Harold Boley

EBNF Syntax:

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CONDITION      ::= CONJUNCTION | DISJUNCTION | EXISTENTIAL | ATOMIC
CONJUNCTION    ::= 'And' '(' CONDITION* ')'
DISJUNCTION    ::= 'Or' '(' CONDITION* ')'
EXISTENTIAL    ::= 'Exists' Var+ '(' CONDITION ')'
ATOMIC         ::= Uniterm | Equal | CLASSIFICATION | Frame
Uniterm        ::= Const '(' TERM* ')' | Const '(' (Const '->' TERM)* ')'
CLASSIFICATION ::= TERM '#' TERM | TERM '##' TERM
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    ?C1##?C3 :- Exists ?C2 (And ( ?C1##?C2 ?C2##?C3 ) )
    ```
- I_{isa}: gives meaning to class membership
  - $I_{Truth}(o\#cl) = I_{isa}(I(o), I(cl))$
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    ```

Slots + Frames – Semantics

A **semantic structure**, I, is a tuple of the form

- a tuple $<D, I_C, I_V, I_F, I_R, I_{slot}, I_{SF}, I_{SR}, I_{sub}, I_{isa}>$
- I_{slot}: from D to truth-valued functions of the form $D \times D \rightarrow TV$
  - Truth valuation: $I_{Truth}(T[p\text{->}V]) = I_{slot}(I(p))(I(T), I(V))$
- I_{SF}: interprets terms with named arguments
  - $I(f(p_1\text{->}t_1 \ldots p_n\text{->}t_n)) = I_{SF}(f)(\{\langle I(p_1), I(t_1)\rangle, \ldots\ldots, \langle I(p_n), I(t_n)\rangle\})$
  - Here, each pair $\langle s, v\rangle \in D \times D$ represents a slot name-value pair
- I_{SR}: interprets predicates with slotted arguments
  - $I_{Truth}(p(p_1\text{->}val_1 \ldots p_k\text{->}t_k)) = I_{SR}(p)(\{\langle I(p_1)I(t_1)\rangle, \ldots, \langle I(p_k)I(t_k)\rangle\})$
- I_{sub}: gives meaning to the subclass relationship
  - $I_{Truth}(sc\#\#cl) = I_{sub}(I(sc), I(cl))$
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Signatures

- Under discussion how to model signatures
- Aim: Generalization of first-order signatures
- how to define/restrict what may appear in function/predicate/constant positions
- whether or not same symbol is allowed with different arities
- whether or not complex terms are allowed as term constructors
- etc.

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RDF Compatibility

As mentioned in examples before, several options to embed RDF into RIF.[2]

Overall idea

```
embed(rdfset1) ---> rif-entailed ---> embed(rdfset2)
   ^                                      ^
   |                                      |
   |                                      |
   |                                      |
   |                                      |
rdfset1 ---------- rdf-entailed ----> rdfset2
```

[2] Some ASCII art from a WG mail from Michael Kifer from yesterday ;-)

RDF Compatibility – example RDFS embedding

RDF semantics defines three semantic “flavors”

- simple RDF (define only equivalence between two RDF graphs modulo blank node renaming)
- RDF (takes RDF vocabulary into account)
- RDFS (takes RDFS vocabulary into account)

Idea: All embeddable in RIF by kind of “axiomatic” rulesets

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RDF entailment embedding (recent proposal by WG member Jos de Bruijn[3]):

R^{RDF}	=	(`Forall` tr(`s p o .`)) for every RDF axiomatic triple `s p o .`) union
		(`Forall ?x ?x[rdf:type -> rdf:Property] :- Exists ?y,?z (?y[?x -> ?z]),`
		`Forall ?x ?x[rdf:type -> rdf:XMLLiteral] :- wellxml(?x)`)

C^{RDF}	=	(`Exists ?x (And(?x[rdf:type -> rdf:XMLLiteral] illxml(?x))`)

- R^{RDF} . . . a set of RIF axiomatic deductive rules
- C^{RDF} . . . normative rule which *must not* be entailed (constraint on the data)
- Here, fixed interpretation (often called "built-in") predicates `wellxml` and `illxml` are assumed.
  - BTW: How to define, in general, built-in predicates is another issue, many rule languages and systems provide these.

[3] `http://www.w3.org/2005/rules/wg/wiki/Core/RIF-RDF_Compatibility`

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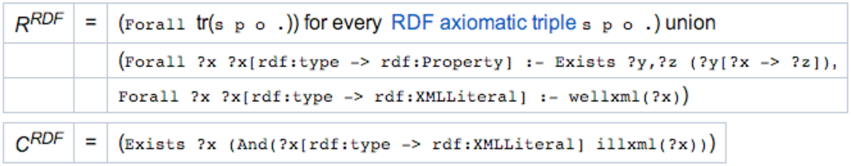

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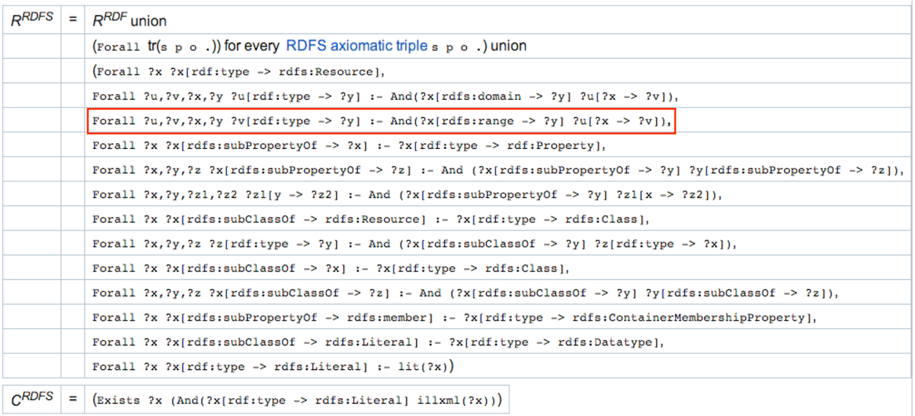

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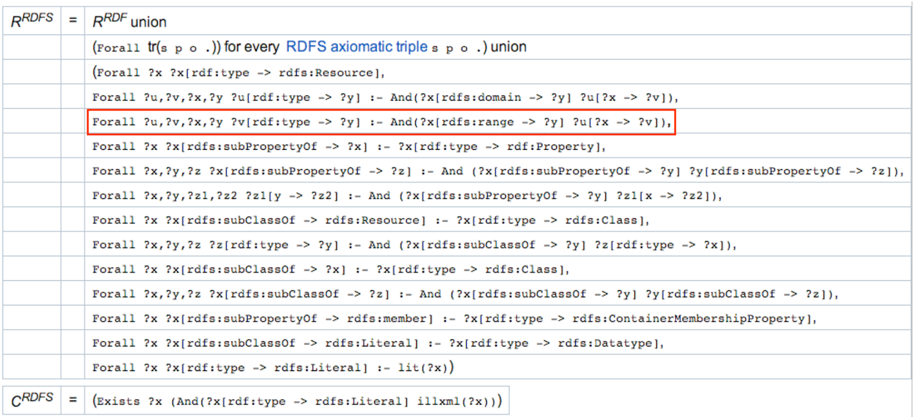

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- a (still ongoing work on a) core interchange format and
- a strong interest in extending it with PRs

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- first steps towards a RIF dialect for Production Rules
- extends the existing RIF Core
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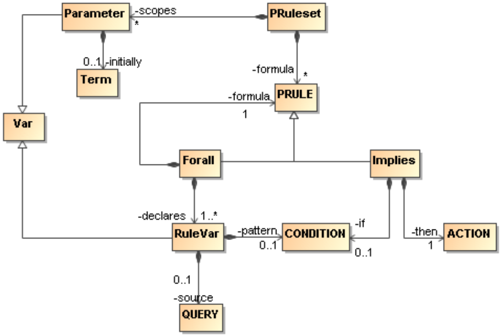

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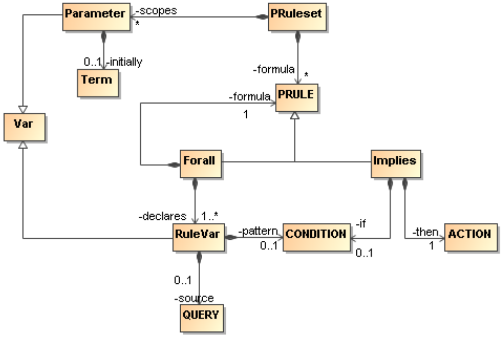

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Current status

- very simple actions (assert and retract facts)
- no proposal for concrete syntax
- semantics not yet specified
- as RIF Core, the proposal for the PR dialect is ongoing work
- (probably) focus of Phase II work

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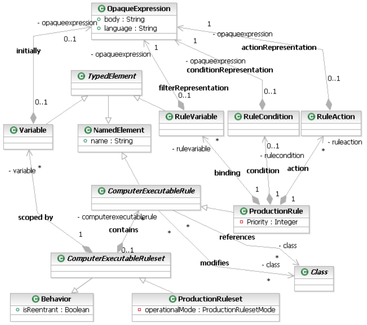
Related Efforts: W3C RIF and OMG PRR



- Alignment definitely desirable
- Alignment with related efforts in W3C (and not only) via so-called "*Liaisons*"

Concluding Remarks

- Developing a useful format for rules on the Web
  - is a challenging and time-consuming task
  - different communities (e.g. PR vendors, Semantic Web researchers) are interested in it
- First steps towards a simple and extensible core format
  - for interchanging derivation rules
  - published as RIF Core in a 1st Working Draft of W3C
- More interesting and useful extensions to RIF Core in the near future
- ... follow the work at `http://www.w3.org/2005/rules/`

This presentation: Axel Polleres (DERI Galway), Paula Pătrânjan (REWERSE)

(both W3C WORLD WIDE WEB consortium member organisations)