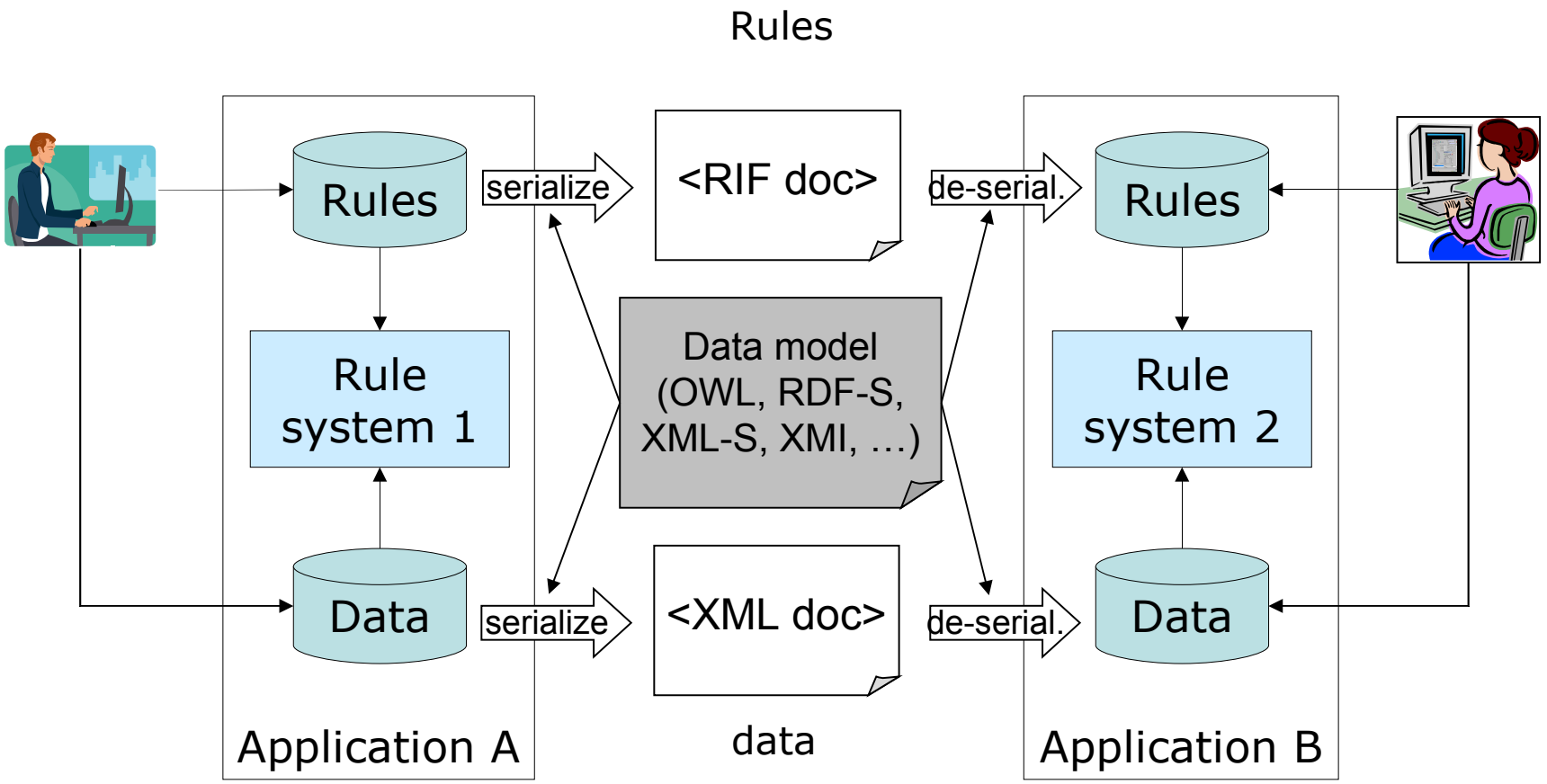
W3C rule interchange format

Production Rule Dialect
and relation to Core

Rule interchange



What is the Rule Interchange Format?

- Format for interchanging rules, so they can be used across diverse systems
  - allowing rules written for one application to be published, shared, and re-used in other applications and other rule engines.
  - In a semantic preserving way (between languages with compatible semantics)
  - Encouraging interoperability
  - XML syntax
  - Compatible with relevant standards (PRR, RDF, OWL, …)
- A rule is (just another) data item
  - RIF provides a standard means to feed rules into an application (at run time)
  - Semantics to prescribe (intended) application's behaviour

RIF Background: standards

- The early days of rule interchange
  - 1998: KIF – Knowledge Interchange Format
  - 2000: RuleML
  - 2001: SRML – Simple Rule Markup Language (Colleen and Changhai)
  - …
- 2001-2004: JSR 94 – Java rule engine API
  - Prescribes a set of fundamental rule engine operations (i.e. loading rulesets, parsing rules, adding objects to an engine, firing rules, and getting resultant objects from the engine)
  - Engine semantics are not defined, so the API and specification are very high level (JDBC API ... without SQL)
  - No underlying rule language, hence no API to introspect rules, create rulesets, provide pluggable parsers etc.
- 2003-2008: OMG PRR – Production Rule Representation
  - "A metamodel for a language that can be used with UML models for explicitly representing production rules as visible, separate and primary model elements in UML models"
    - A MOF/UML meta-model and an UML profile
    - Addresses the PIM level of MDA
  - Engine semantics are defined (forward chaining + sequential)
  - No underlying rule language: PRR Core + non-normative PRR OCL
- April 2005: W3C workshop on rule languages for interoperability
- November 2005: W3C Rule Interchange Format working group chartered
- OMG SBVR, ISO Common Logic, …

RIF Background: semantic Web

- Semantic web approach
  - interoperability requires a formal semantics
- The OWL WG approach
  - Start with something (DAML+OIL)
- Literally *hundreds* of rule system implementations
  - ISO-Prolog, CLIPS, OPS…
  - http://www.w3.org/2005/rules/wg/wiki/List_of_Rule_Systems
  - Already several “SW” rule languages
    - SWRL, RuleML, WRL, SWSL, KAON2, TRIPLE, JenaRules…
  - Everyone wants “their” system/technique/theory to be the SW rule standard

Wherefore the RIFt(s)?

- OWL DL < OWL < FOL
  - Original idea to add full first-order at the logic level
  - Semantic web *very* “open world”
- Most back-end DBs support closed queries
- Many rule systems have non-FO features
  - CWA/NAF
  - Procedural Attachment
  - Rule ordering
  - Non-monotonicity

  … can’t be layered on OWL
- Not a strict SW layering already
  - OWL restricted dialects (DL) not layered on (all of) RDF/S semantics
  - RDF & RDFS not layered at all

RIF Background: Business rules

- "Business Rule systems" Vendors
  - $1B/year existing market
  - 1,000's end users
  - 1,000,000's rules in use
  - ILOG, Fair Isaac, PegaSystem, Tibco, Corticon, Haley, …
- Database vendors
  - Oracle, IBM
- OMG PRR effort
  - Simple production rules
  - Event-condition-action
  - Vendors understand the value of standardization (see also JSR 94)
  - Interchange already a priority
  - …a common *semantics?*

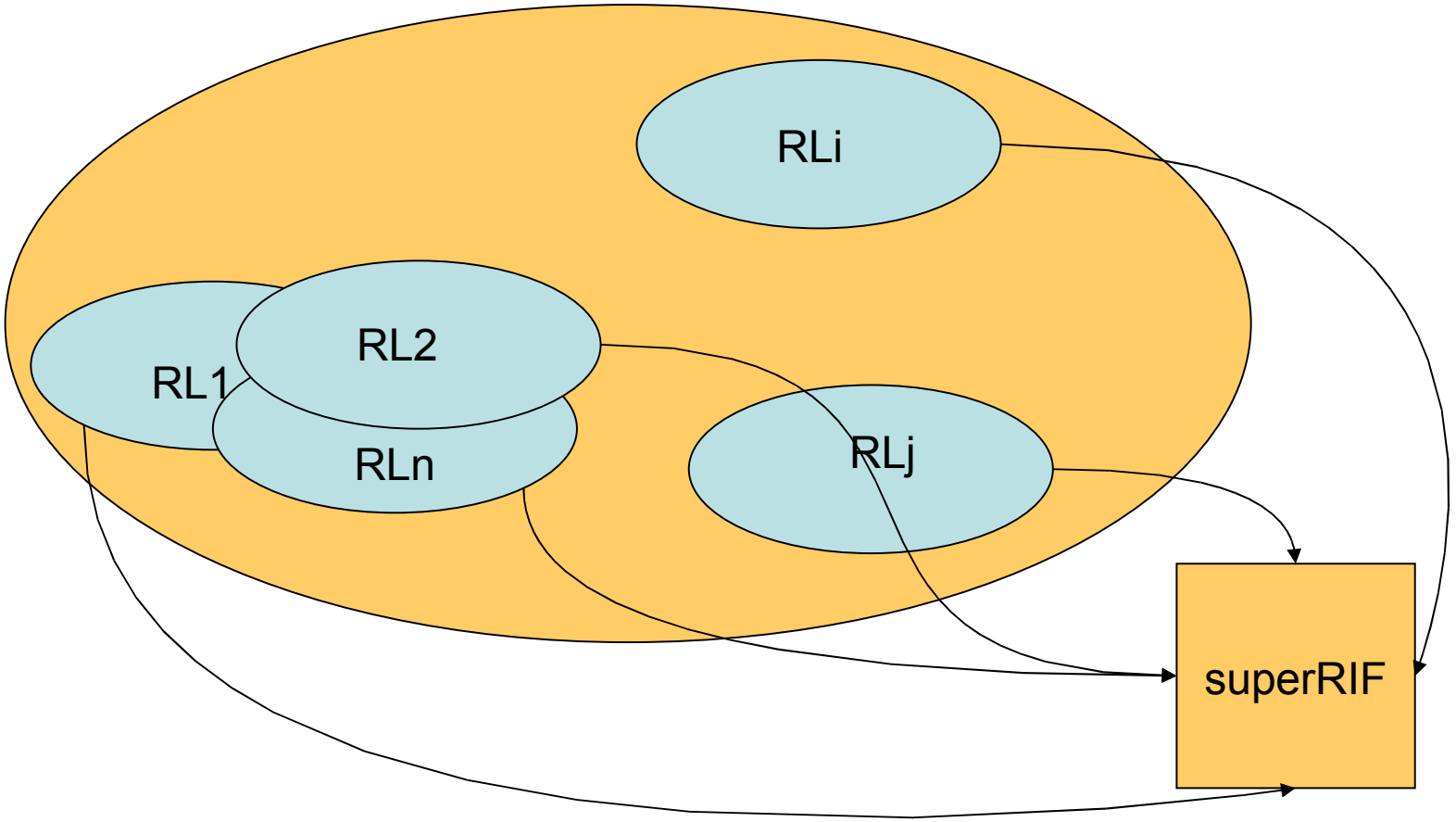
W3C RIF working group

- W3C working group
  - Chartered Nov. 05 (for 2 years)
    - Phase 1: extensible XML rule interchange format, Horn expressiveness, semantic Web compatibility
  - Kick-off Dec. 05
    - March 06: FPWD UCR
    - March 07: FPWD Core
    - Oct. 07: FPWD BLD
  - Extended Nov. 07 (for 6 months)
    - BLD to Last Call
  - Extended May 08 (for 1 year)
    - BLD, SWC to REC
    - FLD, DTB, PRD, extensibility
- 74 participants from 35 organisations
  - IBM, HP, Oracle, ILOG, JBoss, Fair Isaac, Corticon, Tibco, MITRE…
  - NIST, OMG (esp. SBVR and PRR), RuleML…
  - Research organisations, universities…
  - And 4 invited experts
  - Chairs: Chris Welty (IBM), Christian de Sainte Marie (ILOG)
- Working in the public eye
  - http://www.w3.org/2005/rules/wiki/RIF_Working_Group
  - Under the W3C patent policy

W3C RIF: Design issues

- Very large number of rule users/use cases and types to satisfy!!!
  - Descriptive {OMG MDA level = CIM} VS executable rules {OMG MDA level = PIM & PSM}
  - Logical (side-effect free) VS active (side-effect full) rules
  - Data-oriented (SQL triggers, PR, …) VS proof-oriented (FOL…)
    - All kinds of different data sources (DB, WM, OO, OWL…)
  - Semantic Web VS non-SW usage
- Simplicity VS coverage
- Extensibility VS compliance VS interoperability
- Executable (AST) VS human-readable syntax
- …

Superset approach

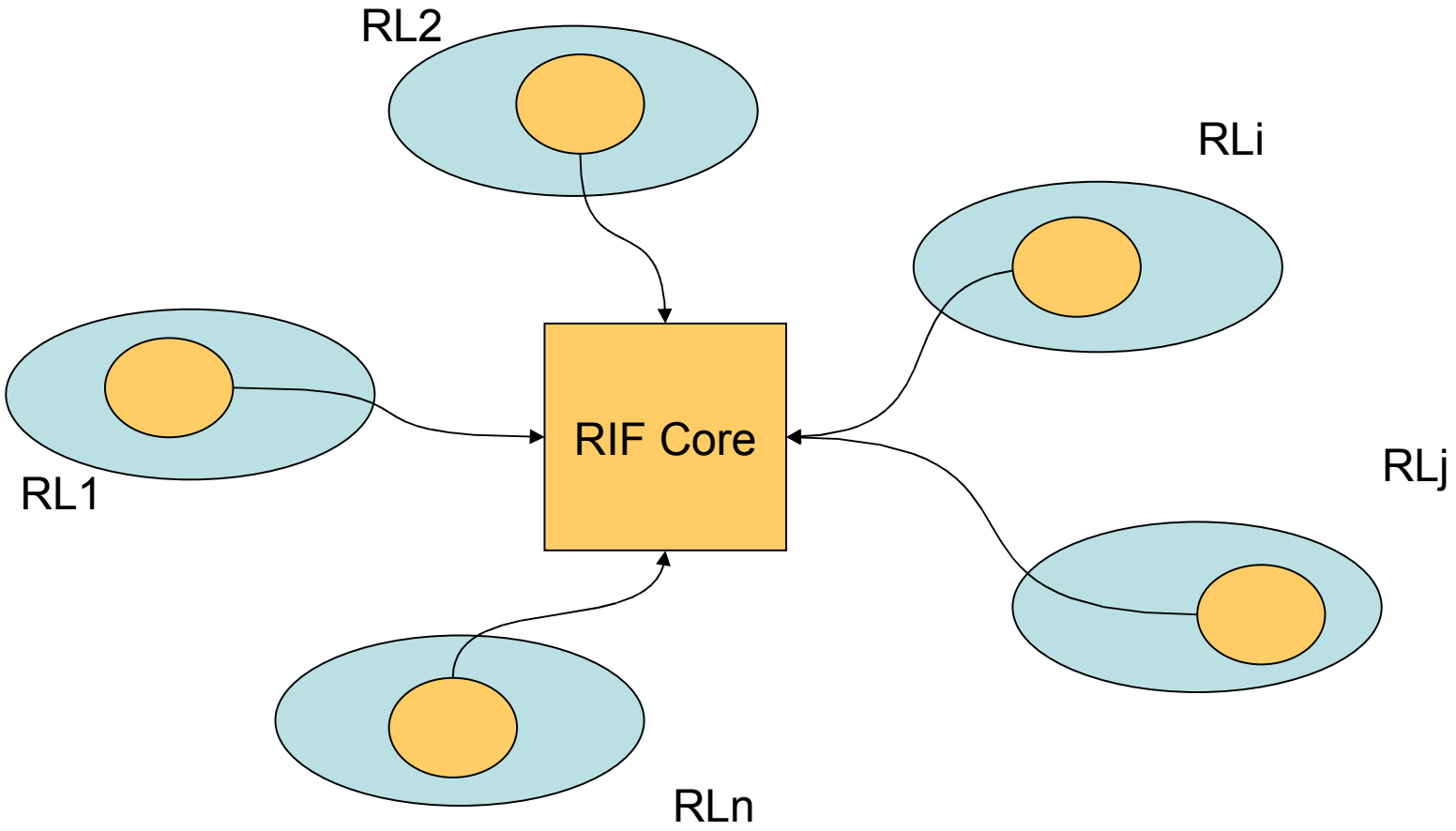


Super-set approach

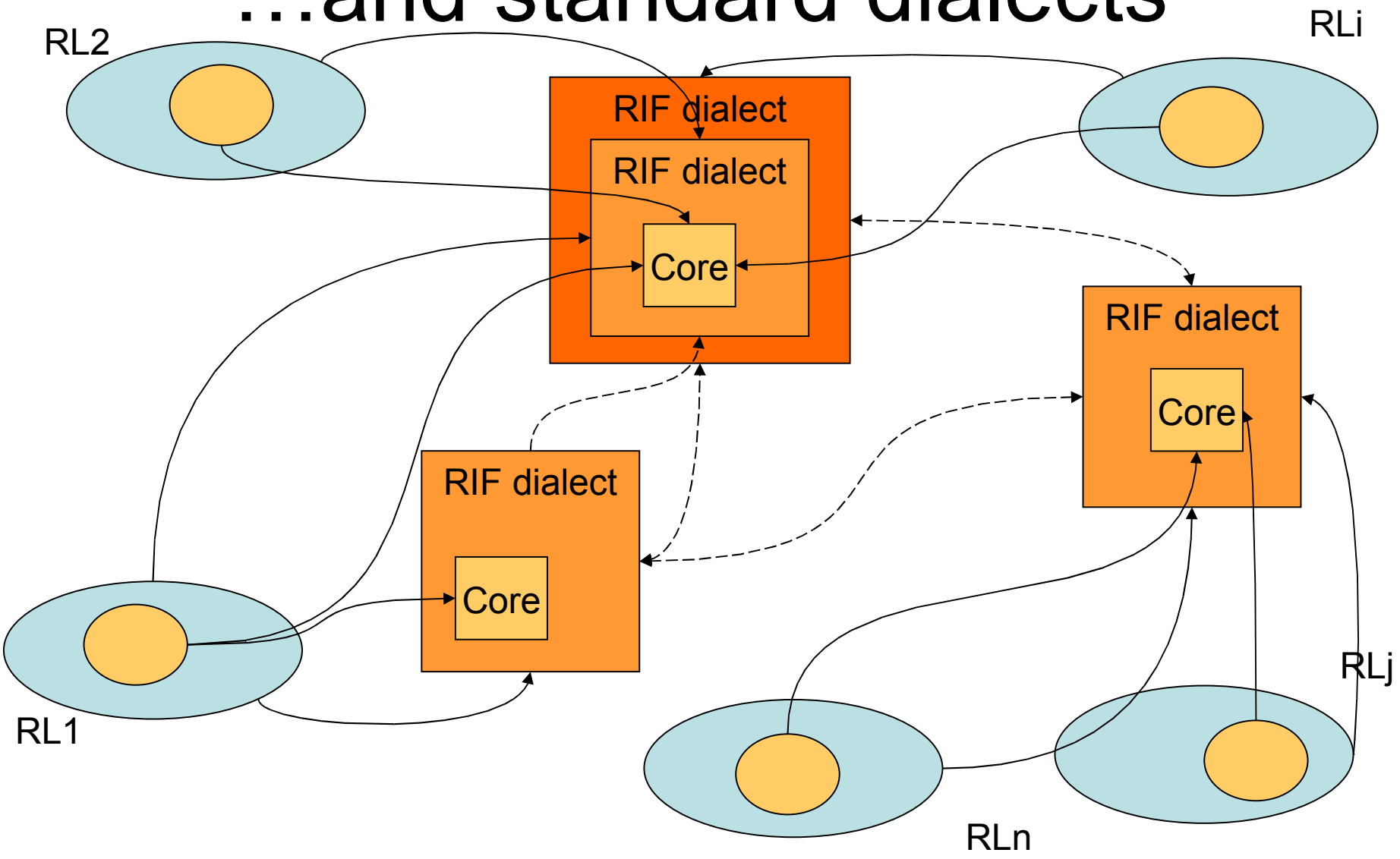
- Define a super-language so expressive that any language can be translated to/from it
  - The CL and IKL approach

  @deprecated: infeasible for this group, as major differences appeared irreconcilable (e.g. non-mon vs. mon)

A common core…



…and standard dialects

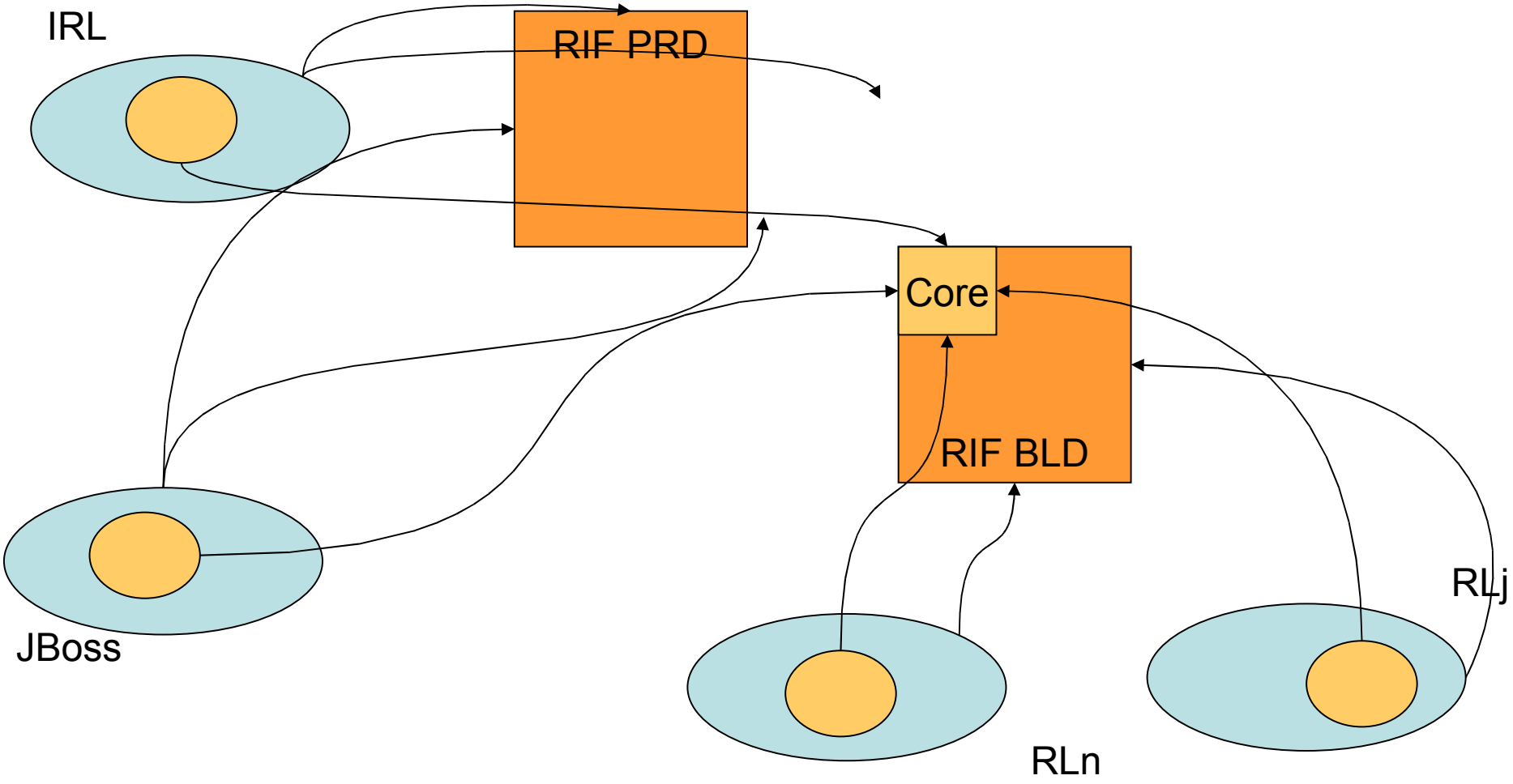


Core + standard dialects

- Define a *core* language that accounts for the intersection of all rule language capabilities
  - E.g. Horn, datalog, …

  @postponed: The production rule, logic programming, and FO core is not clear

Separate families + Core



Separate families + Core

- Define a logic-based core and a separate production-rule core
- If there is an intersection, define the common core (which may possibly be just a syntax)

  @version 0.1: BLD LC (July 08)

  @version 0.0.2: PRD WD2 (December 08)

  @version 0.0.2: Core WD2 (December 08)

Approach 3a

- Define a *framework* in the form of a menu of syntactic and semantic features that can be combined into dialects
  - @version 0.0.9: FLD

Design principles

- Translation paradigm
  - No intrusion in covered rule languages and rule sets
- Same semantics ⇔ same syntax
  - Share constructs accross dialects wherever they agree on the semantics
  - Different constructs where semantics do not agree
- Fully striped XML (type-tagged, object-oriented, …)
  - alternating Class and role tags
  - Metadata can be attached to any class element
- Only XML schema is normative
  - Presentation syntax added for specification's readability (examples, semantics etc)

- Principles are there so you can rest on them…until they break

BLD Overview

- Definite Horn rules
  - Disjunction of atoms with exactly one positive literal
- Equality, functions, and a standard *first-order* semantics
- Syntactic features
  - relations and frames
  - internationalized resource identifiers (IRIs) as identifiers
  - XML Schema data types and builtins
- XML (1.0) syntax with normative XMLS definition
- Non-normative presentation syntax
- Metadata and (RDF+OWL) imports

Symbols

- Used to identify constants, variables, functions, predicates
- "*literal*"^^<symspace-*identifier*>
  - Notable symbol spaces: xsd:string, rif:local, rif:iri
  - “Chris”^^<xsd:string>
  - “http://www.w3.org/1999/02/22-rdf-syntax-ns#ty rif:iri>
  - “Person1”^^rif:local

Rules

- IF <condition> THEN <conclusion>
  - <condition> aka rule body, antecedent
  - <conclusion> aka rule head, consequent
- BLD rule:
  - (**Forall** var* <conclusion> **:-** <condition>)
  - Conclusions may contain conjunction
  - Conditions may contain conjunction, disjunction, and existential
- Restrictions on conclusion
  - No existential, disjunction, external functions

Horn Extensions

- Functions and external calls (DTB)
- Equality (in conclusion and condition)
- Frames
  - Objects with slots and (multiple) values
    - Used to map to RDF and OWL (SWC)
  - Special syntactic treatment of class membership and subclass
- Named argument functions and predicates
  - However all arguments must be provided

Structure

- Rules occur in Groups

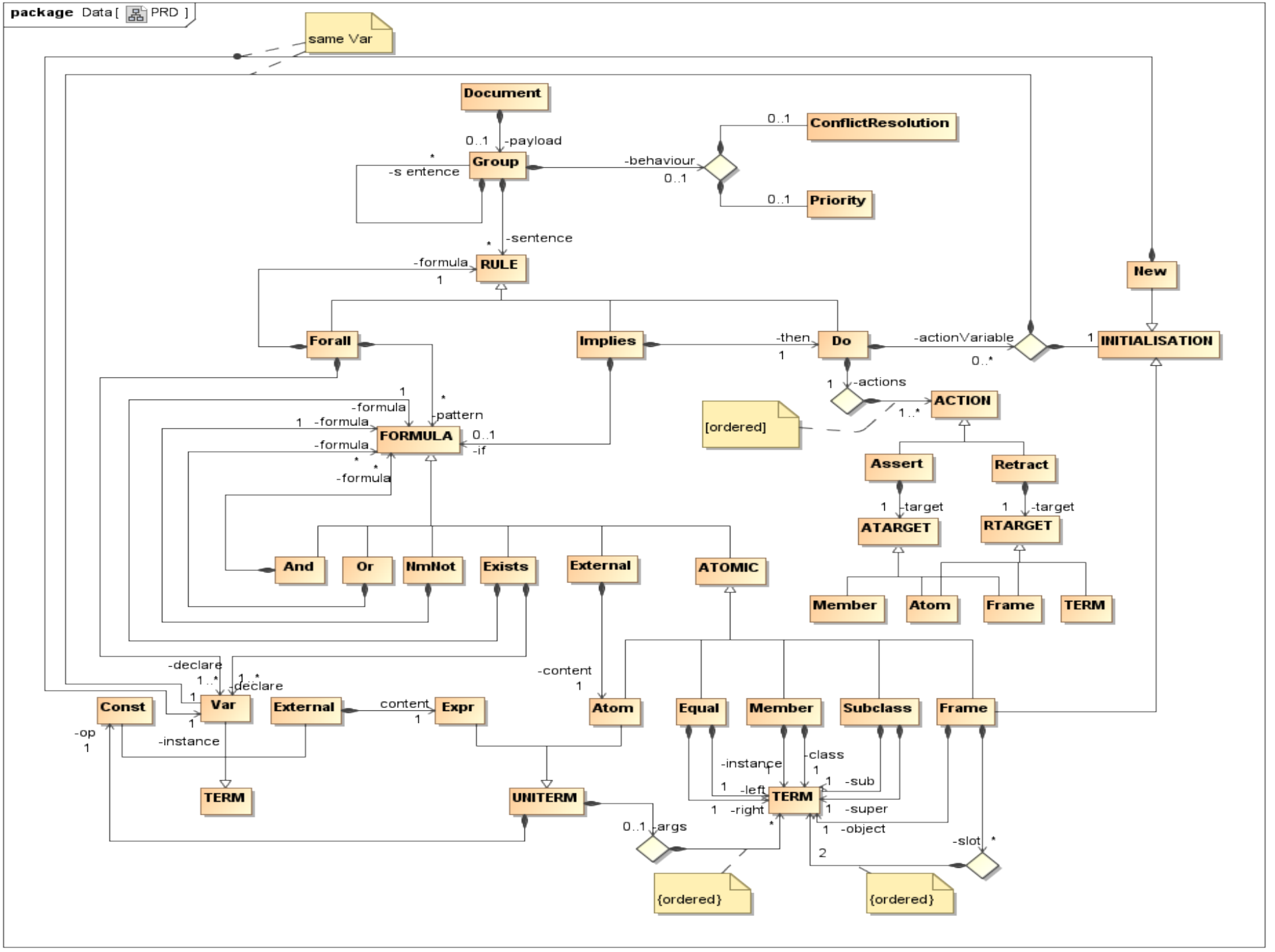
```
Group(  (Forall ?x _Q(?x) :- _P(?x))
        (Forall ?x _Q(?x) :- _R(?x)) )
```

- Groups occur in Documents

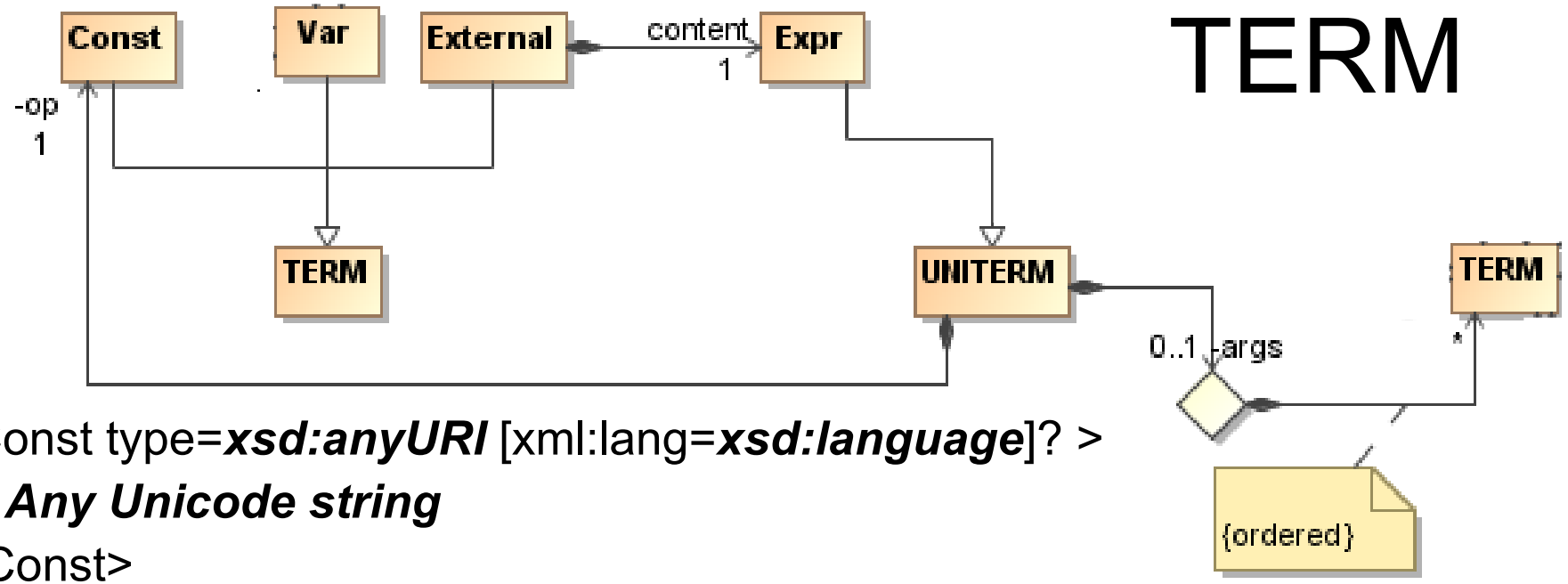
```
Document(
  Group((Forall ?x _Q(?x) :- _P(?x))
        (Forall ?x _Q(?x) :- _R(?x))))
```

PRD Overview

- Production rules
  - FOR <variables> WITH <binding patterns>,
    IF <condition> THEN <actions>
  - FORALL Var* (IF patterns AND condition THEN action)
  - With an operational semantics as a labelled transition system
- Patterns and condition
  - BLD condition language
    minus logic functions and named argument terms
    plus negation
  - With a model-theoretic semantics (compatible with BLD)
- Assert, Retract, New
  - Defining a transition relation
  - *Modify, Remove, Execute*
- Syntactic features
  - Relations and frames: *objects?*
  - internationalized resource identifiers (IRIs) as identifiers
  - XML Schema data types and builtins
- Metadata


package Data [PRD]
same Var
Document
0..1
-payload
Group
*
-s entence
-behaviour
0..1
0..1
ConflictResolution
0..1
Priority
*
-sentence
-formula
1
RULE
New
Forall
Implies
-then
1
Do
-actionVariable
0..*
1
INITIALISATION
1
-actions
1..*
ACTION
[ordered]
1
-formula
*
-pattern
1
-formula
FORMULA
0..1
-if
-formula
*
-formula
Assert
Retract
1
-target
1
-target
ATARGET
RTARGET
And
Or
NmNot
Exists
External
ATOMIC
Member
Atom
Frame
TERM
-declare
1..*
1
-declare
1..*
-content
1
Const
Var
External
content
1
Expr
Atom
Equal
Member
Subclass
Frame
-op
1
1
-instance
-instance
1
-class
1
1
-sub
1
-left
TERM
1
-right
1
-super
1
-object
TERM
UNITERM
0..1
-args
*
-slot
*
2
{ordered}
{ordered}

TERM

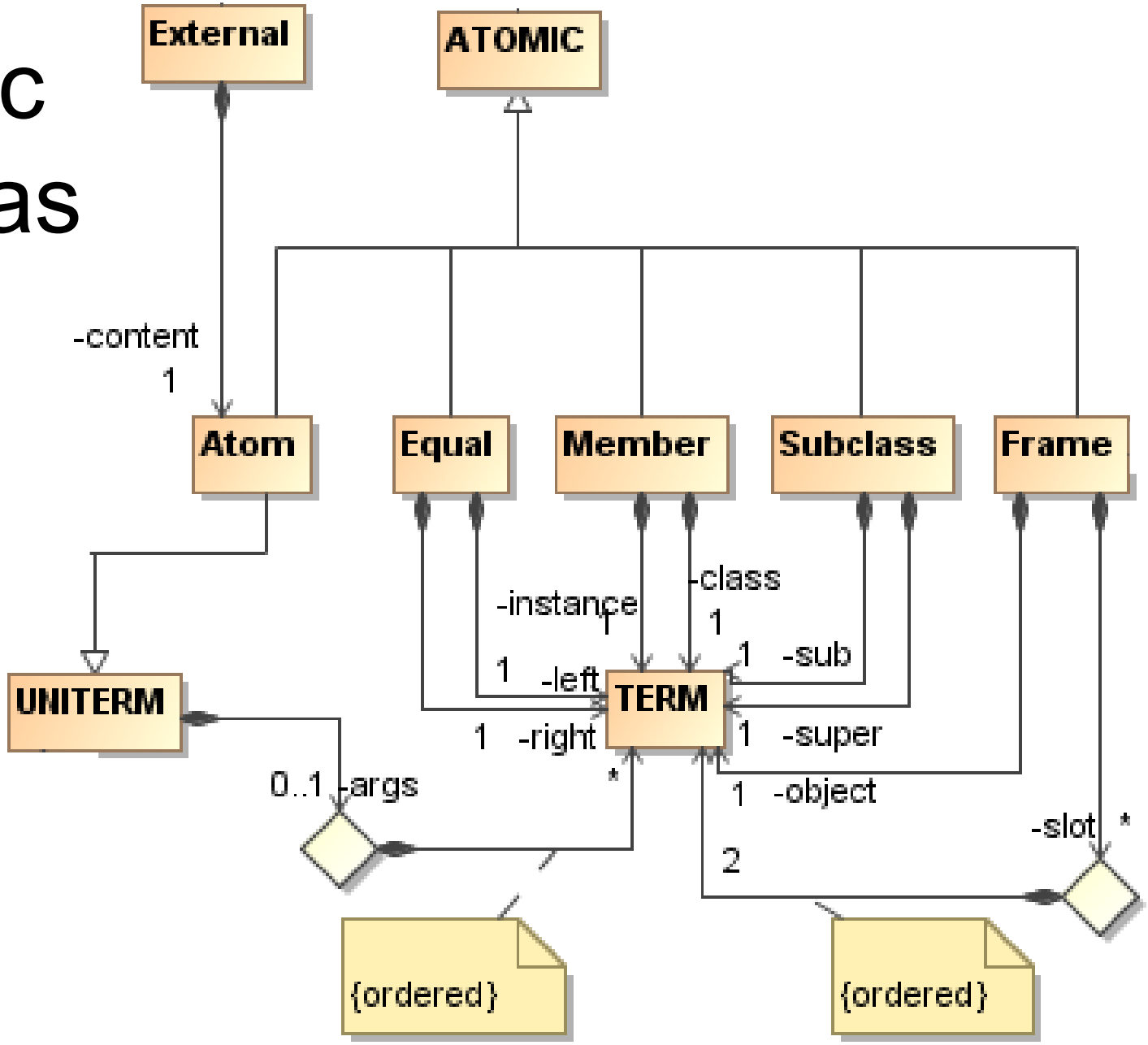


<Const type=***xsd:anyURI*** [xml:lang=***xsd:language***]? >
Any Unicode string
</Const>

<Var> ***any Unicode string*** </Var>

<External>
<content>
<Expr> <op> ***Const*** </op>
<args rif:ordered="yes"> ***TERM**** </args>?
</Expr>
</content>
</External>

Atomic formulas



Atomic formulas

```
<Atom>
  <op> Const </op>
  <args rif:ordered="yes"> TERM*
  </args>?
</Atom>

<External>
  <content> Atom </content>
</External>
```

```
<Equal>
  <left> TERM </left>
  <right> TERM </right>
</Equal>

<Member>
  <instance> TERM </instance>
  <class> TERM </class>
</Member>

<Subclass>
  <sub> TERM </sub>
  <super> TERM </super>
</Subclass>
```

```
<Frame> <object> TERM </object>
          <slot rif:ordered="yes"> TERM TERM </slot>*
</Frame>
```

Atomic formulas

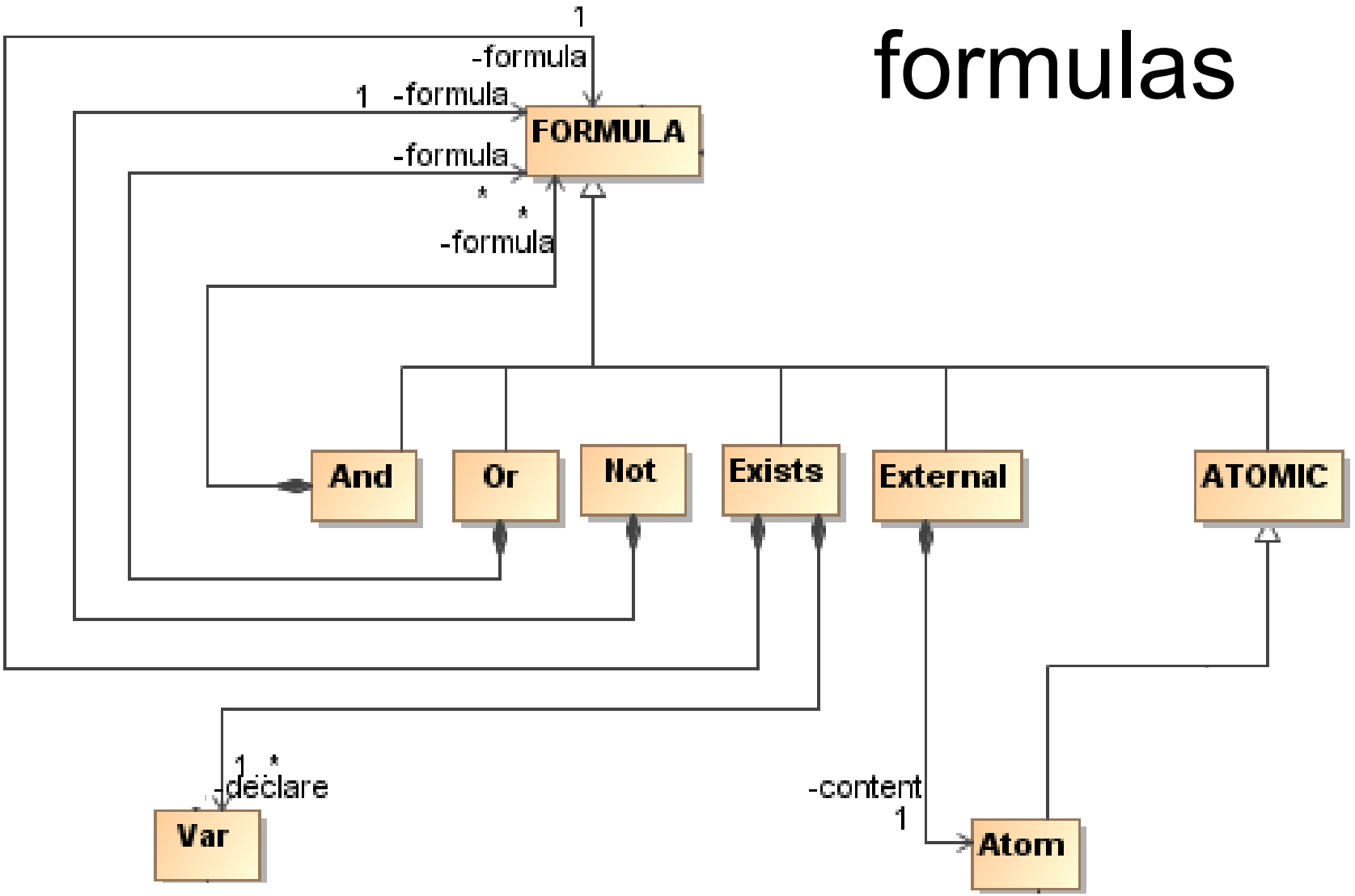
- jim:owns(?c ?p)

```
<Atom>
    <op>
      <Const type="rif:iri">http://rif.examples.com/2008/jim#owns</Const>
    </op>
    <args rif:ordered="yes">
      <Var> ?c </Var>
      <Var> ?p </Var>
    </args>
</Atom>
```

- ?c[age -> ?a]

```
<Frame>
    <object> <Var> ?c </Var> </object>
    <slot rif:ordered="yes">
      <Const type="xs:string">
         child::age                    <!-- http://rif.examples.com/2008/jim#Chicken/age -->
      </Const>
      <Var> ?a </Var>
    </slot>
</Frame>
```

Condition formulas



Condition formulas

- Atomic formulas

<[And|Or|NmNot]>
  <formula> ***FORMULA*** </formula>*
</[And|Or|NmNot]>

<Exists>
  <declare> ***Var*** </declare>+
  <formula> ***FORMULA*** </formula>
</Exists>

Condition formula

- Exists Chicken(age>8)

```
<Exists>
  <declare> <Var> ?c </Var> </declare>
  <declare> <Var> ?a </Var> </declare>
  <formula>
    <And>
      <formula> <Member> ?c # jim:Chicken </Member> </formula>
      <formula> <Frame> ?c[age->?a] </Frame> </formula>
      <formula>
        <External>
          <content>
            <Atom>
              <op> <Const type="rif:iri"> op:numeric-greater-than</Const> </op>
              <args rif:ordered="yes">
                <Var> ?a </Var>
                <Const type="xsd:decimal"> 8 </Const>
              </args>
            </Atom>
          </content>
        </External>
      </formula>
    </And>
  </formula>
</Exists>
```

Semantics of PRD conditions

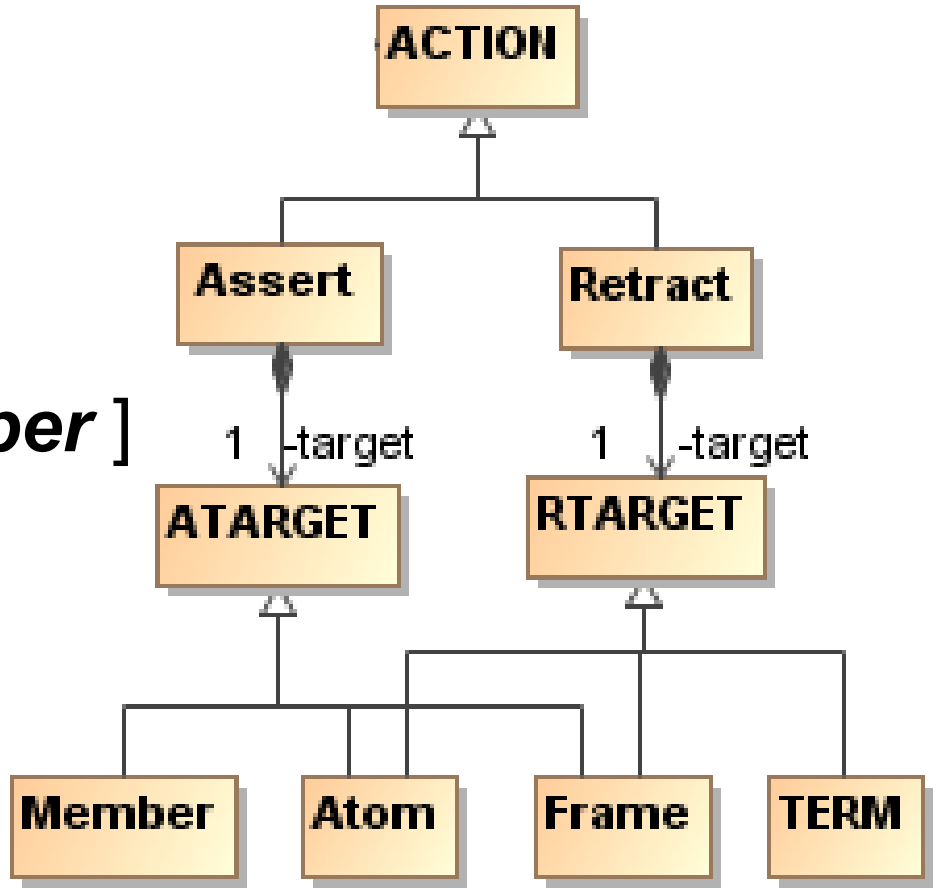
- A state ***S*** is a Herbrand Interpretation ***I***H.
- A condition formula, ***φ*** is satisfied under variable assignment ***σ*** in a state ***S***, written as ***S*** |= ***φ***[***σ***], iff ***TVal***S(***φ***[***σ***]) = **t**
- Let *ψ* be a condition formula, and *φ* be a set of ground formulas that satisfies *ψ*. We say that *ψ* matches *φ* with substitution *σ* : Var -> Terms if and only if there is a syntactic interpretation *I* such that for all ?*x*i in *Var(σ)*, *I*(?*x*i) = *I(*σ(?*x*i)).

Atomic action

<Assert>
  <target>
    [***Atom*** | ***Frame*** | ***Member***]
  </target>
</Assert>

<Retract>
  <target>
    [***Atom*** | ***Frame*** | ***TERM***]
  </target>
</Retract>

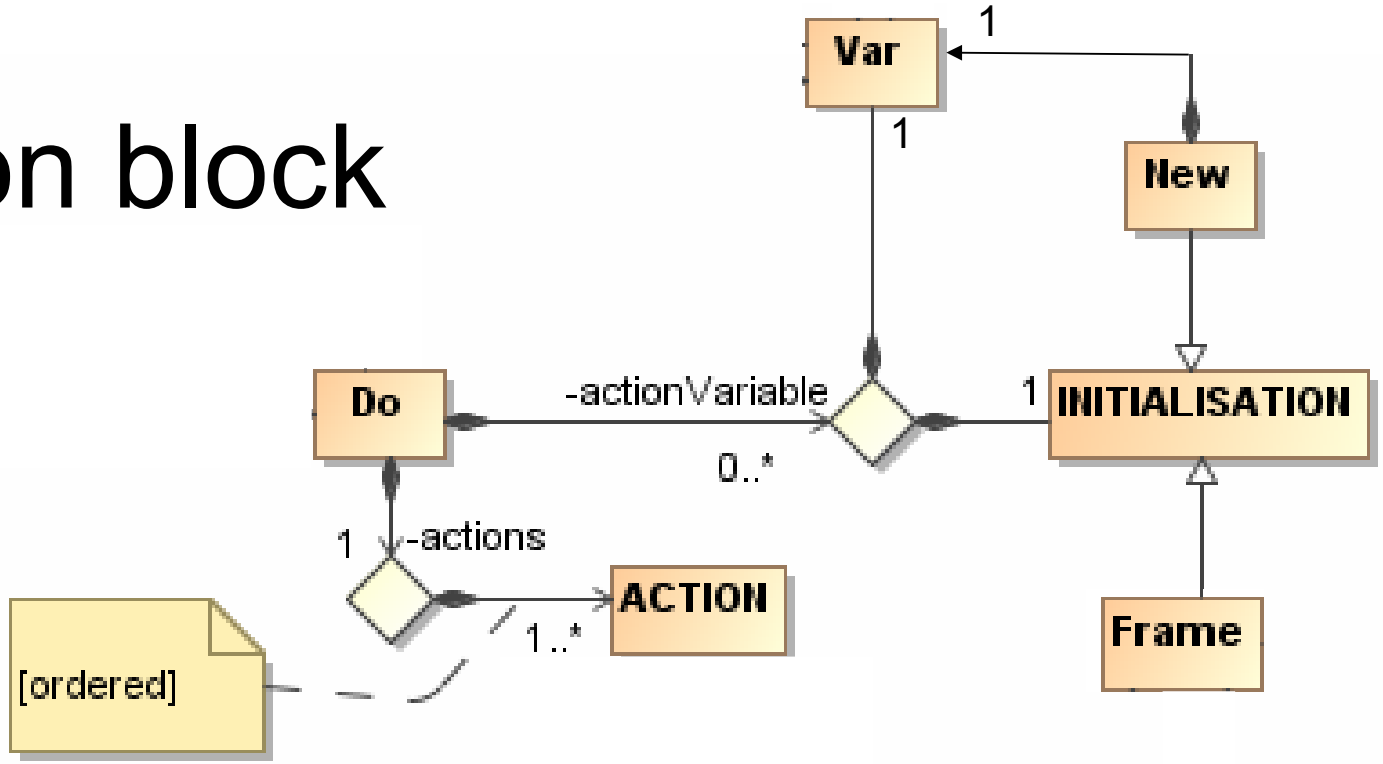
Only if new object created in the same block



Semantics of atomic actions

- Assuming a facts base *W* that contains every true facts, the intended semantics of RIF-PRD atomic actions is completely specified by the **transition relation →RIF-PRD** $\subseteq W \times L \times W$, where *L* is the set of all the ground atomic actions.
- *(w, α, w′)* $\in$ *→RIF-PRD* if and only if $w \in W$, $w' \in W$, α is a ground atomic action, and one of the following is true:
  - α is Assert(φ), where φ is a ground atomic formula, and $w' = w + \varphi$;
  - α is Retract(φ), where φ is a ground atomic formula, and $w' = w - \varphi$;
  - α is Retract(o), where o is a constant, and *w′ = w - {o[s->v]* | *for all the values of terms s and v} - {o#c* | *for all the values of term c}*.

Action block



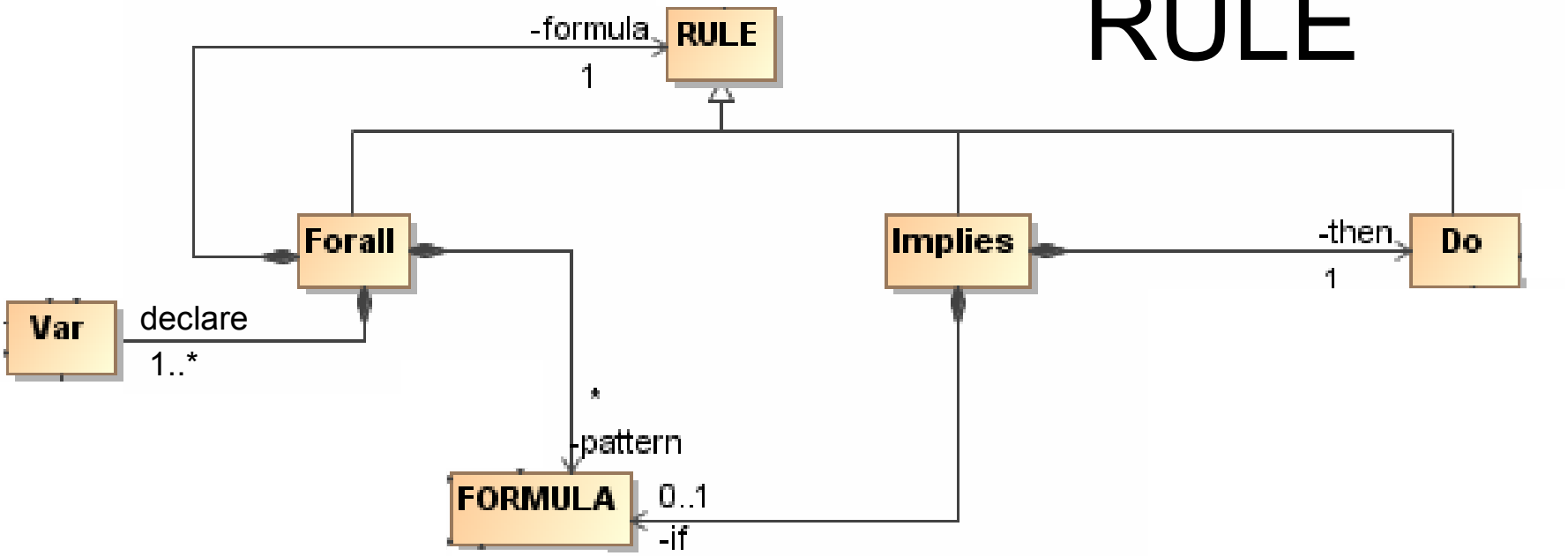
<Do>
  <actionVar rif:ordered="yes">
    Var
    INITIALIZATION
  </actionVar>*
  <actions rif:ordered="yes">
    ATOMIC_ACTION+
  </actions>
</Do>

Action block

- *Do((?p New(?p)) Assert(?p#joe:Potato) Assert(…))*

```
<Do>
  <actionVar> <Var>p</Var>
                  <New>
                     <instance><Var>p</Var></instance>
                  </New>
  </actionVar>
  <actions rif:ordered="yes">
     <Assert> <target> p # joe:Potato </target> </Assert>
     <Assert>
        <target> p [ child::weight -> 100 </target>
     </Assert>
   </actions>
</Do>
```

RULE



<Forall>
  <declare> ***Var*** </declare>+
  <pattern>
    FORMULA
  </pattern>*
  <formula> ***RULE*** </formula>
</Forall>

<Implies>
  <if> ***FORMULA*** </if>?
  <then>
    ACTION_BLOCK
  </then>
</Implies>

RULE

- When

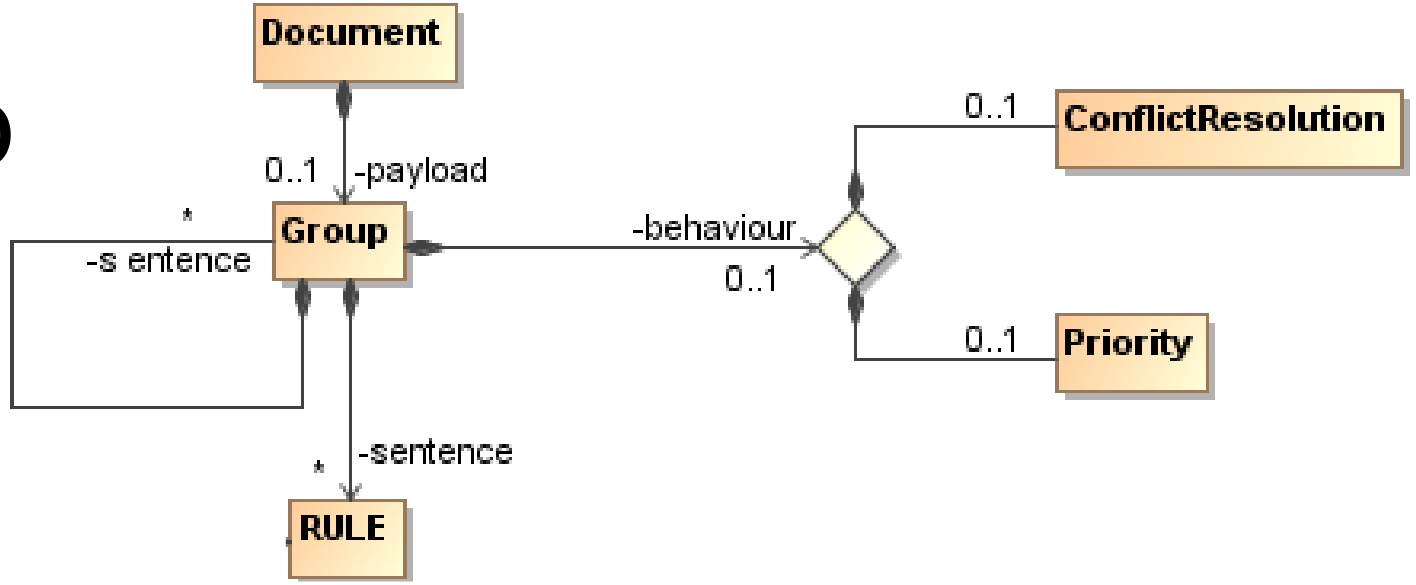
  ?c Chicken(age==8)

  evaluate(today()=’’Monday’’)

  Then …

```
<Forall>
   <declare> <Var> ?c </Var> </declare>
   <pattern>
     <And>
                <Member> ?c jim:Chicken </Member>
                <Frame> ?c.age=8 </Frame>
                </And>
   </pattern>
   <formula>
     <Implies>
       <if> <External> today()=’’Monday’’ </External>
      <then> … </then>
     </Implies>
   </formula>
</Forall>
```

Group



<Group>
  <behavior>
    <ConflictResolution>
      xsd:anyURI
    </ConflictResolution>?
    <Priority> ***-10,000 ≤ xsd:int ≤ 10,000*** </Priority>?
  </behavior>?
  <sentence> [***RULE*** | ***Group***] </sentence>*
</Group>

Semantics of a rule set

A ***RIF-PRD production rule system*** is defined as a labeled terminal transition system *PRS = {S, A, →PRS, T}*, where :

- *S* is a set of system states;
- *A* is a set of transition labels, where each transition label is a sequence of ground RIF-PRD atomic actions;
- The transition relation →PRS ⊆ *S* × *A* × *S*, is defined as follows:
  ∀ (*s*, *a*, *s′*) ∈ *S* × *A* × *S*, (*s*, *a*, *s′*) ∈ →PRS if and only if all of the following hold:
  - *(facts(s), a, facts(s'))* ∈ →*RIF-PRD;
  - *a = actions(picked(s))*;
- *T* ⊆ *S*, a set of final system states.

Semantics of a rule set (cont'd)

- Given a rule, $r \in R$ and a ground substitution, σ, such that $Var(r) \subseteq Dom(\sigma)$, where *Var(r)* denotes the set of the rule variables in *r*, the result, $ri = \sigma(r)$, of the substitution of the constant $\sigma(?x)$ for each variable ?x $\in$ *Var(r)* is a ***rule instance*** (or, simply, an ***instance***) of *r*.
- A rule instance *ri* **matches** a state of facts *w* iff […]
  - *rule(ri)* is `Forall ?v1...?vn (p1...pn) (r')`, $n \geq 0$, $m \geq 0$, and *substitution(ri)* matches each of the condition formulas pi, $0 \leq i \leq m$, to the ground condition formula that represents *w*, and the rule instance *ri'* matches *w*, where *ri'* is the instance of rule *r'* such that *substitution(ri') = substitution(ri)*
- Given a rule set, $RS \subseteq R$, and a system state, *s*, the set, *conflictSet(RS, s)* of all the different instances of the rules in *RS* that match the state of the fact base, *facts(s)* $\in W$ is called the ***conflict set*** determined by *RS* in *s*.

Semantics of a rule set (cont'd)

Given a conflict set, *cs*, the conflict resolution strategy rif:forwardChaining is the successive application of four rules, where *ri* and *ri'* are rule instances:

- **Refraction rule**: if $ri \in cs$ and $lastPicked(ri, s) \leq recency(ri, s)$, then $cs = cs - ri$;
- **Priority rule**: if $ri \in cs$ and $ri' \in cs$ and $priority(ri) < priority(ri')$, then $cs = cs - ri$;
- **Recency rule**: if $ri \in cs$ and $ri' \in cs$ and $recency(ri, s) > recency(ri', s)$, then $cs = cs - ri$;
- **Tie-break rule**: if $ri \in cs$, then $cs = \{ri\}$.

A system state, *s*, is ***final*** given a rule set, *RS* if and only if the remaining conflict set is empty after application of the *refraction rule* to all the rule instances in *conflictSet(RS, s)*

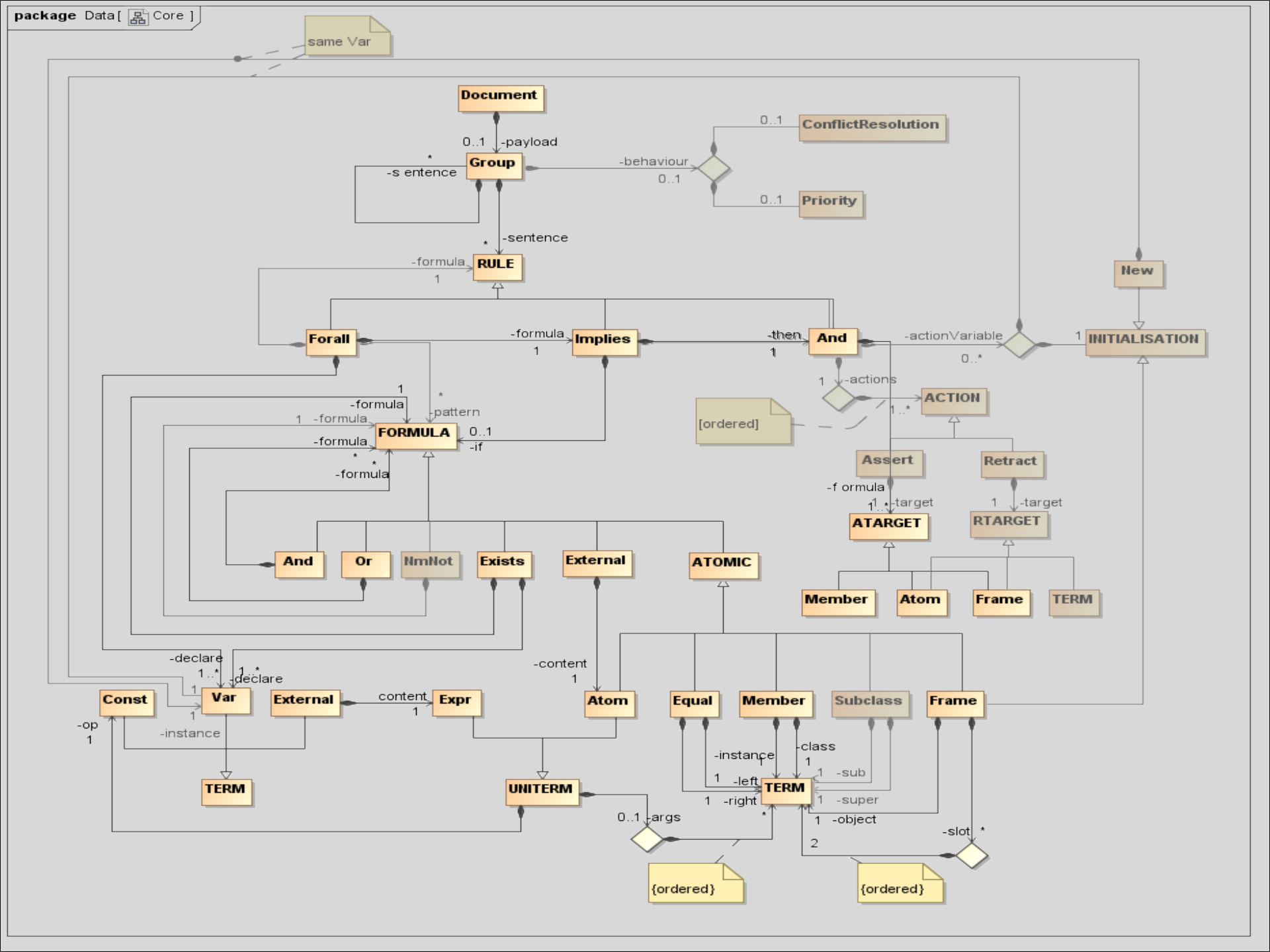
Metadata

<CLASSELT>
  <id> ***Const*** </id>?
  <meta>
    [***Frame***
    |
    <And>
      <formula> ***Frame***
      </formula>*
    </And>]
  </meta>?
  other CLASSELT content
</CLASSELT>

<Forall>
  <id><Const type="rif:iri">*jim:CMP*</Const></id>
  <meta><Frame>
    <object ><Const type="rif:iri">
      jim:CMP
      </Const>
    </object>
    <slot rif:ordered="yes">dc:creator csma</slot>
    <slot rif:ordered="yes">…</slot>
    …
  </Frame>
  </meta>
  <declare> <Var> ?c </Var> </declare>
  <pattern>…</pattern>
  <formula>…</formula>
</Forall>

Core overview

- Definite Horn rules without function symbols + safeness
  - Essentially safe Datalog
  - Notice PRD rules are safe
- Condition formulas like PRD
  - minus subclass atomic formula
  - minus negation (NmNot)
- Conclusion restricted to (the assertion of) (conjunction of) atoms, frames and membership formula
  - With same restriction on membership formulas as in PRD


package Data [Core]
same Var
Document
0..1
-payload
Group
-s entence
*
-behaviour
0..1
0..1
ConflictResolution
0..1
Priority
-sentence
*
-formula
1
RULE
New
Forall
-formula
1
Implies
-then
1
And
-actionVariable
0..*
1
INITIALISATION
1
-actions
1..*
ACTION
[ordered]
1
-formula
*
-pattern
1
-formula
FORMULA
0..1
-if
-formula
*
-formula
*
Assert
Retract
-f ormula
1..*
-target
1
-target
ATARGET
RTARGET
And
Or
NmNot
Exists
External
ATOMIC
Member
Atom
Frame
TERM
-declare
1..*
1
-declare
1..*
-content
1
Const
Var
External
content
1
Expr
Atom
Equal
Member
Subclass
Frame
-op
1
1
-instance
TERM
UNITERM
-instance
1
-class
1
1
-left
1
-right
TERM
1
-sub
1
-super
1
-object
0..1
-args
*
-slot
*
2
{ordered}
{ordered}

Semantics of Core

- Standard first order semantics
  - For that subset, equivalent to Herbrand semantics

RDF and OWL compatibility

- RDF triple *s p o* mapped to frame *s'[p'->o']*
  - *s'[p'->o']* is true iff *s p o* is in the imported RDF graph
  - Condition on data types alignment
  - Simple, RDF, RDFS, D-RDF interpretation iff vocabulary included and axioms satisfied
  - Graph/formula entailed iff satisfied in every interpretation
- OWL 2 Full compatibility is straightforward extension of RDF compatibility
- OWL 2 DL requires syntactic restrictions and semantic extension of RIF frames
  - RIF frame *o[p->v]* is an OWL 2 DL frame iff *p* is a constant and *v* is a constant if *p* is *rdf:type*
  - A variable is DL-safe if it does not occur in a DL frame such that *p* belongs to an imported ontology or *p* is *rdf:type* and *v* belongs to an imported ontology
  - Frame *o[p->v]* is interpreted as relation *p(o, v)* if *p* is not *rdf:type*, and as *o* belonging to set *v* if *p* is *rdf:type*

RIF Documents

- BLD: RIF basic logic dialect
  - LC July 2008
  - REC by May 2009?
- FLD: RIF framework for logic dialects
  - 2nd public WD July 2008
  - LC November 2008?
- PRD: RIF production rule dialect
  - WD2 December 2008
  - LC May 2009?
- DTB: RIF data types and builtins
  - WD2 December 2008
  - LC May 2008?
- SWC: RIF RDF and OWL compatibility
  - LC July 2008
  - REC by May 2008?
- UCR: RIF use cases and requirements
  - 5th public WD December 2008
- Test Cases: FPWD December 2008
- rdf:text: FPWD December 2008 (common with OWL WG)

Web site: http://www.w3.org/2005/rules/wiki/RIF_Working_Group

Credits

- BLD and FLD Editors
  - Michael Kifer (U. Stonybrook), Harold Boley (NRCC)
- PRD Editors
  - Christian de Sainte Marie (ILOG), Adrian Paschke (FUBerlin), Gary Hallmark (ORACLE)
- SWC Editor
  - Jos de Bruijn (FUB)
- DTB Editors
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Thank you!

Questions?