RuleML Rules Lite

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With Key Contributions from the Joint Committee

www.w3.org/2001/sw

www.ruleml.org

www.daml.org/committee

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Introduction

- Starting point of **RuleML Rules Lite** is Datalog RuleML 0.8
- Main elements: facts and rules (also queries)
- „Minimal“: Predicates restricted to unary/binary
  - Compatible with OWL-DL
  - Certain unary predicates also usable for typing rule variables (untyped ones being of type 'any')
- In the following:
  - Use case
  - Data model
  - Concrete syntax
  - Herbrand-like models

BinDataLog Rules Lite: Source Variants

Use case: Geography   Example: **stretches** rule

English:

„An object *x* **stretches** an object *y* if
y **has** *x* **as** a **part** and
x and *y* are **co-flanked**“

PR-Prolog:

```
stretches(?x,?y) :-
                  has_as_part(?y,?x),
                  co-flanked(?x,?y).
```

Rules and Facts from PR-Prolog Source

```
stretches(?x,?y) :- has_as_part(?y,?x), co-flanked(?x,?y).

co-flanked(?x,?y) :- flanked_by(?x,?z), flanked_by(?y,?z).
```

```
continent(North_America).
country(Canada).
country(USA).
province(Ontario).
oceanpair(Oceanics).
ocean(Atlantic).
ocean(Pacific).

has_as_part(North_America,Canada).
has_as_part(North_America,USA).
has_as_part(Canada,Ontario).

area(Canada,sqkm9976140).
area(USA,sqkm9629091).

flanked_by(North_America,Oceanics).
flanked_by(Canada,Oceanics).
flanked_by(USA,Oceanics).

eastern(Oceanics,Atlantic).
western(Oceanics,Pacific).
```

The Data Model of RuleML Rules Lite Unifies the XML and RDF Models

XML and RDF employ different data models:

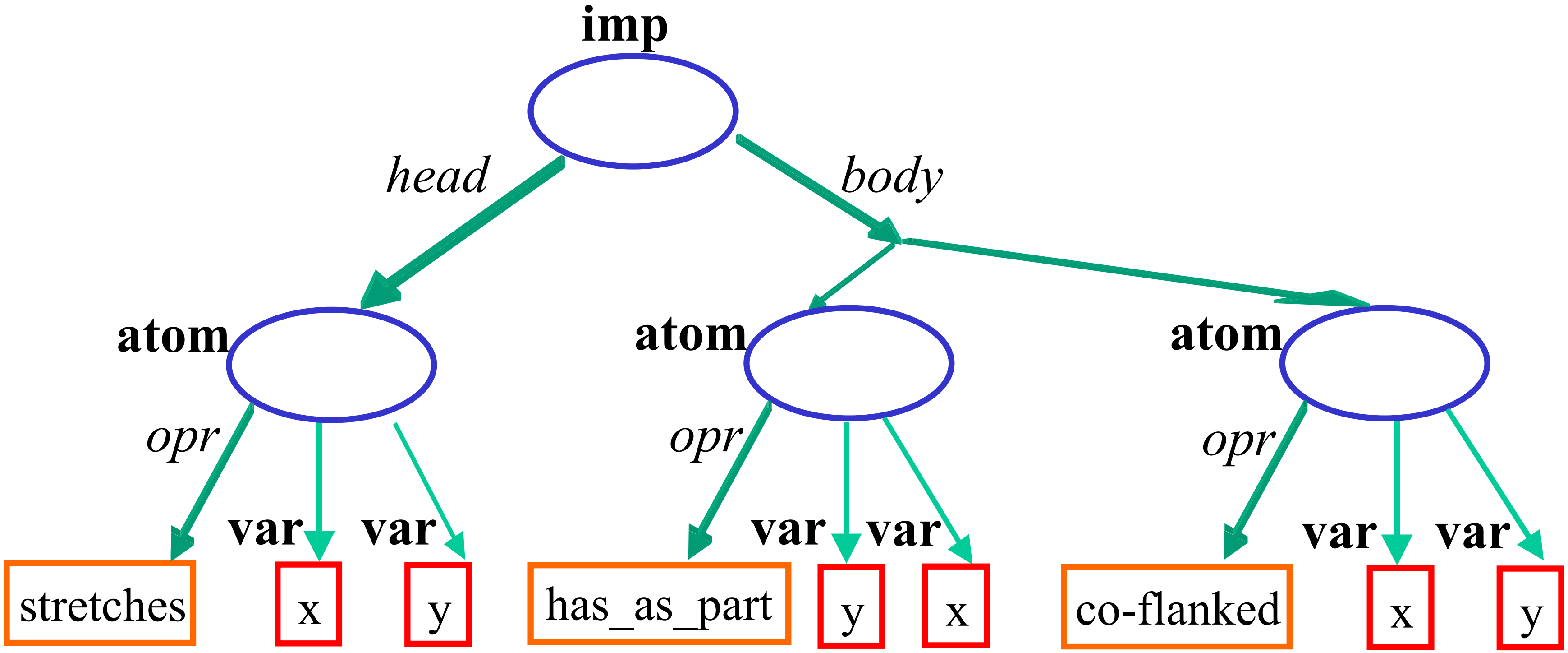
- XML based on, possibly attributed, **left-to-right ordered, node-labeled trees**, reminiscent of parse (syntax) trees
- RDF based on **directed, arc-labeled (unordered) graphs** with two kinds of nodes, resources and literals, the latter not allowing outgoing arcs

A unified data model is used in RuleML Rules Lite

BinDataLog Rules Lite: Tree Data Model

RuleML Lite rules are graphically modeled as trees, here illustrated for the **`stretches`** rule

- RDF graph for OO roles: (arc-)labeled, unordered children
- XML tree for predicate arguments: unlabeled, ordered children



```
stretches(?x,?y) :- has_as_part(?y,?x), co-flanked(?x,?y).
```

RuleML Rules Lite Concrete Markup Syntax

Webized-only, abridged version of the XML markup of RuleML 0.8, compatible with RDF and OWL

The (always empty) 'ind' element is used – in the first or second argument position – for 'href'-naming individual constants

A new 'data' element is used – in the second argument position – for tagging various data types as content (cf. RDF literals)

Webizing Constants and Relations

- Webized individual constants:

  <ind>*constant*</ind> is replaced by
  <ind href="*#constant*"/>

  <ind href="*u r i #constant*"/> as in RuleML 0.8

- Webized relation symbols:

  <_opr><rel>*relation*</rel></_opr> is replaced by
  <_opr href="*#relation*"/>

  <_opr href="*u r i #relation*"/>

Uniform Webizing Syntax

Individuals as well as unary and binary predicates can be webized by augmenting, within the href's, their symbolic "#"-names by URIs, so that two possibilities result:

1 Symbolic names: with "#"-prefixed fragment identifiers
(local only, corresponding to the pre-webized situation)

2 URIs: with "#"-separated fragment identifiers (cf. RDF)

Webizing – Use Case (I)

PR-Prolog (with N3-like URIs and namespace declarations):

```
w := http://www.waters.org.

continent(<http://www.north_america.org#North_America>).
...
<http://www.pairs.org/ocean#oceanpair>(<w#Oceanics>).
...
<http://www.mereology.org#has_as_part>(North_America,Canada).
...
<http://www.direction.org#western>(<w#Oceanics>,Pacific).
```

Webizing – Use Case (II)

XML:

```
<rulebase
  xmlns:w="http://www.waters.org">

  <facto>
    <_opr href="#continent"/>
    <ind href="http://www.north_america.org#North_America"/>
  </facto>
  ...
  <facto>
    <_opr href="http://www.pairs.org/ocean#oceanpair"/>
    <ind href="w#Oceanics"/>
  </facto>
  ...
  <facto>
    <_opr href="http://www.mereology.org#has_as_part"/>
    <ind href="#North_America"/>
    <ind href="#Canada"/>
  </facto>
  ...
  <facto>
    <_opr href="http://www.direction.org#western"/>
    <ind href="w#Oceanics"/>
    <ind href="#Pacific"/>
  </facto>
</rulebase>
```

Abridging RuleML 0.8 Tags in Rules Lite

1 The earlier <_opr><rel href="#relation"/></_opr> will be
abridged to <_opr href="#relation"/>

2 The earlier <_body><and>atom1...atomK</and></_body> will be
abridged to <_body>atom1...atomK</_body> (K = 0, 1, ...)

3 Similarly, <_head><and>atom1...atomK</and></_head> could be
abridged to <_head>atom1...atomK</_head> (for OWL Rules)

4 Prefix form <atom>**<_opr href="#relation"/>**term1...termN</atom>
will be allowed (0 < N < 3);
Postfix form <atom>term1…termN**<_opr href="#relation"/>**</atom>
will be forbidden (0 < N < 3)

5 The earlier <fact><_head><atom>...</atom></_head></fact> will
be further abridged to <facto>...</facto>

BinDataLog RuleML Lite: Use Case Rule

```
<imp>
  <_head>
    <atom>
      <_opr href="#stretches"/>
      <var>x</var>
      <var>y</var>
    </atom>
  </_head>
  <_body>
    <atom>
      <_opr href="#has_as_part"/>
      <var>y</var>
      <var>x</var>
    </atom>
    <atom>
      <_opr href="#co-flanked"/>
      <var>x</var>
      <var>y</var>
    </atom>
  </_body>
</imp>  stretches(?x,?y) :- has_as_part(?y,?x), co-flanked(?x,?y).
```

A rule in RuleML Lite is marked up as an **`imp`** element that has two children:

a **`_head`** role with an **`atom`** element

augmented – before or after – by

a **`_body`** role with 1 or more (here: 2) **`atom`** elements

BinDataLog RuleML Lite: Use Case Facts

```
<rulebase>
  . . .
  <facto>
    <_opr href="#country"/>
    <ind href="#Canada"/>
  </facto>
  . . .
  <facto>
    <_opr href="#has_as_part"/>
    <ind href="#North_America"/>
    <ind href="#Canada"/>
  </facto>
  <facto>
    <_opr href="#area"/>
    <ind href="#Canada"/>
    <data>sqkm 9976140</data>
  </facto>
  . . .
</rulebase>
```

A fact in RuleML Lite is marked up as a **`facto`** element that has two or three children:

an **`_opr`** role with a relation name

followed by

an argument that is an **`ind`** element and an optional argument that is an **`ind`** or **`data`** element

Conjunctive Retrieval Queries – as 'Negative' Integrity Constraints

```
PR-Prolog:

continent(x), ocean(x)


XML:

<query>
  <_body>
    <atom>
      <_opr href="#continent"/>
      <var>x</var>
    </atom>
    <atom>
      <_opr href="#ocean"/>
      <var>x</var>
    </atom>
  </_body>
</query>
```

A query in RuleML Lite is marked up as a **`query`** element that has one child:

a **`_body`** role with 1 or more (here: 2) **`atom`** elements

Inferential Queries – Step 1

PR-Prolog:

```
stretches(?x,North_America)
```

XML:

```
<query>
  <_body>
    <atom>
      <_opr href="#stretches"/>
      <var>x</var>
      <ind href="#North_America"/>
    </atom>
  </_body>
</query>
```

Inferential Queries – Step 2

PR-Prolog:

```
has_as_part(North_America,?x), co-flanked(?x,North_America)
```

XML:

```
<query>
  <_body>
      <atom>
        <_opr href="#has_as_part"/>
        <ind href="#North_America"/>
        <var>x</var>
      </atom>
      <atom>
        <_opr href="#co-flanked"/>
        <var>x</var>
        <ind href="#North_America"/>
      </atom>
  </_body>
</query>
```

Inferential Queries – Step 3

PR-Prolog:

```
co-flanked(?x,North_America)            where ?x = Canada
```

XML:

```
<query>
  <_body>
      <atom>
        <_opr href="#co-flanked"/>
        <var>x</var>
        <ind href="#North_America"/>
      </atom>
  </_body>
</query>
                  where <var>x</var> = <ind href="#Canada"/>
```

Inferential Queries – Step 4

PR-Prolog:

```
?x = Canada
```

XML:

```
<var>x</var> = <ind href="#Canada"/>
```

Inferential Queries – Step 2’

PR-Prolog:

```
has_as_part(North_America,?x), co-flanked(?x,North_America)
```

XML:

```
<query>
  <_body>
      <atom>
        <_opr href="#has_as_part"/>
        <ind href="#North_America"/>
        <var>x</var>
      </atom>
      <atom>
        <_opr href="#co-flanked"/>
        <var>x</var>
        <ind href="#North_America"/>
      </atom>
  </_body>
</query>
```

Inferential Queries – Step 3’

PR-Prolog:

```
co-flanked(?x,North_America)             where ?x = USA
```

XML:

```
<query>
  <_body>
      <atom>
        <_opr href="#co-flanked"/>
        <var>x</var>
        <ind href="#North_America"/>
      </atom>
  </_body>
</query>
               where <var>x</var> = <ind href="#USA"/>
```

Inferential Queries – Step 4’

PR-Prolog:

```
?x = USA
```

XML:

```
<var>x</var> = <ind href="#USA"/>
```

DL-Augmented Herbrand Model

PR-Prolog:

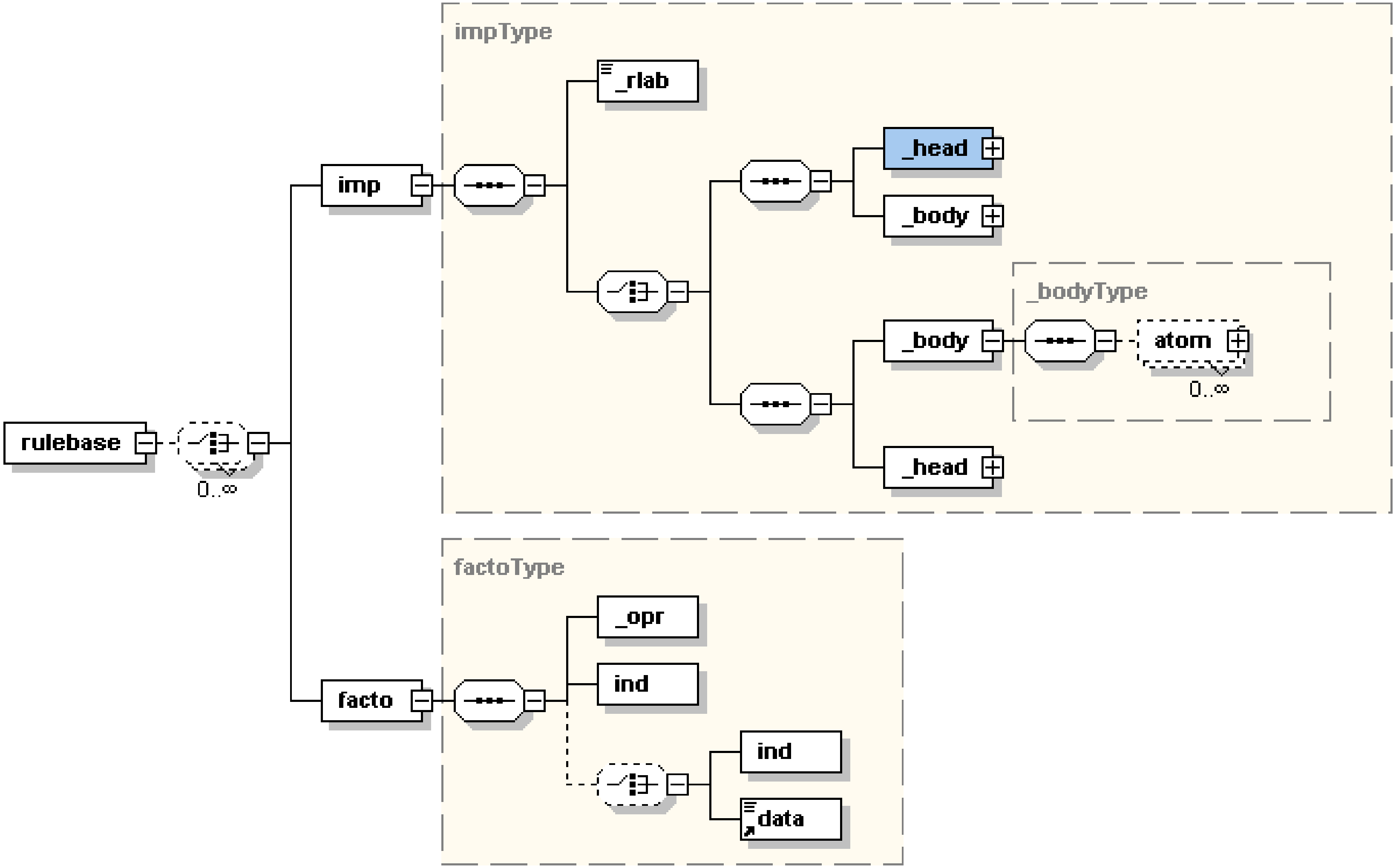
```
continent(North_America).
country(Canada).
country(USA).
province(Ontario).
oceanpair(Oceanics).
ocean(Atlantic).
ocean(Pacific).

has_as_part(North_America,Canada).
has_as_part(Canada,Ontario).

has_as_part(North_America,Ontario).  % from OWL

area(Canada,sqkm9976140).
area(USA,sqkm9629091).

flanked_by(North_America,Oceanics).
flanked_by(Canada,Oceanics).
flanked_by(USA,Oceanics).
```

```
flanks(Oceanics,North_America).    % from OWL
flanks(Oceanics,Canada).           % from OWL
flanks(Oceanics,USA).              % from OWL

co-flanked(North_America,Canada).
co-flanked(Canada,North_America).
co-flanked(North_America,USA).
co-flanked(USA,North_America).
co-flanked(Canada,USA).
co-flanked(USA,Canada).
co-flanked(North_America,North_America).
co-flanked(Canada,Canada).
co-flanked(USA,USA).

stretches(Canada,North_America).
stretches(USA,North_America).

eastern(Oceanics,Atlantic).
western(Oceanics,Pacific).
```

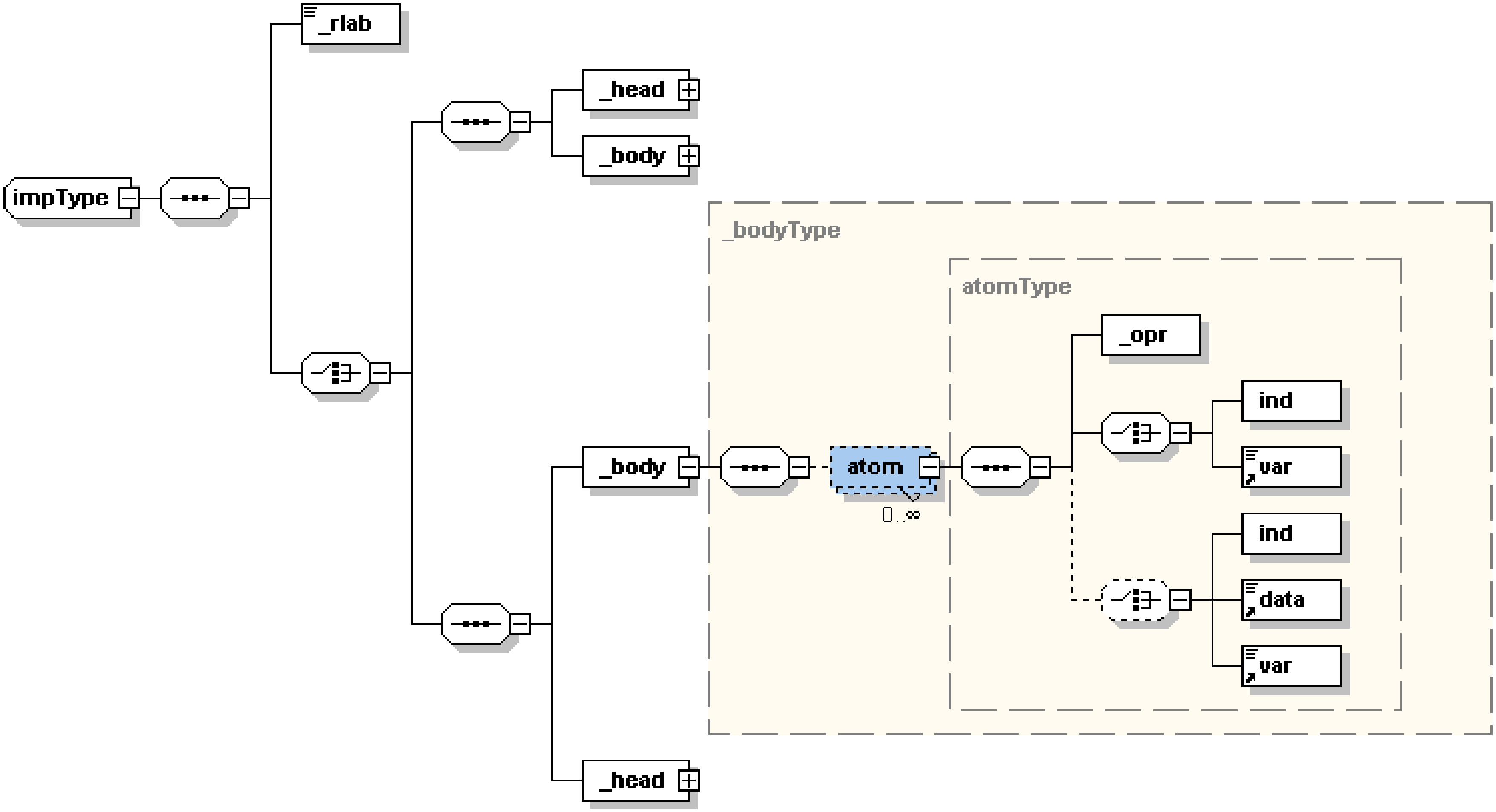
DTD for Rules Lite – Facts and Rules

```
<!ELEMENT rulebase ((imp | facto)*)>

<!ELEMENT imp ((_head, _body) | (_body, _head))>
<!ELEMENT facto (_opr, ind, (ind | data)?)>

<!ELEMENT _head (atom)>
<!ELEMENT _body (atom*)>
<!ELEMENT atom (_opr, (ind | var), (ind | data | var)?)>

<!ELEMENT _opr EMPTY>
<!ELEMENT ind  EMPTY>
<!ELEMENT data (#PCDATA)>
<!ELEMENT var  (#PCDATA)>

<!ATTLIST _opr href CDATA #REQUIRED>
<!ATTLIST ind  href CDATA #REQUIRED>

<!-- The CDATA must be either
     URIs with "#"-separated fragment identifiers (for URI naming) or
     local, "#"-prefixed fragment identifiers (for symbolic naming) -->
```

XML Schema (I) – Facts and Rules



XML Schema (II) – Facts and Rules



Work in Progress on Industrial Applications

- Fraud detection rules
- Mortgage loan rules
- Policies and regulations for financial services

Conclusions

- After definition of RuleML Rules Lite as an XML DTD & Schema, next step has been to modify existing parsers, generators, and XSLT translators to implement syntax for rule interchange
- Two engines running tested with discount rules (Jess, Rules.NET)
- Serialization to Java and .NET object models
- Further implementations have been envisaged for jDREW, OWL engines, Jena 2, and cwm
- Since RuleML Rules Lite semantically is a kind of RDF Rules, a pure RDF version is being considered
- Intertranslation and convergence with OWL Rules (Lite) will be important future JC work item to synergize communities
- To demonstrate the extension path to N-ary relations, ternary predicates could be added later as exemplified in http://www.daml.org/listarchive/joint-committee/1444.html
- As an alternative or complement, transition to full Horn logic could be attempted