# The RuleML System of Families of Languages

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# Outline

# The RuleML Families

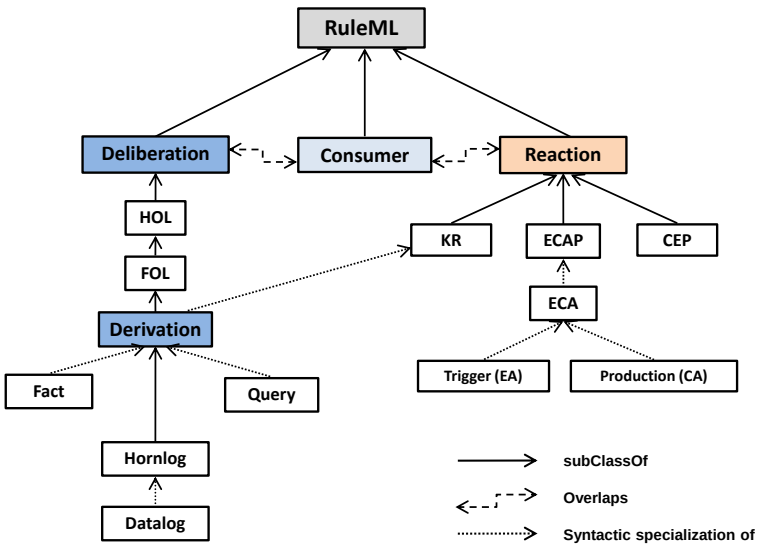



Figure: An overview of the subclass, syntactic specialization, and overlap relationships between the Deliberation, Reaction, and Consumer RuleML families of RuleML 1.02 is given in this diagram.

# The RuleML Feature Set

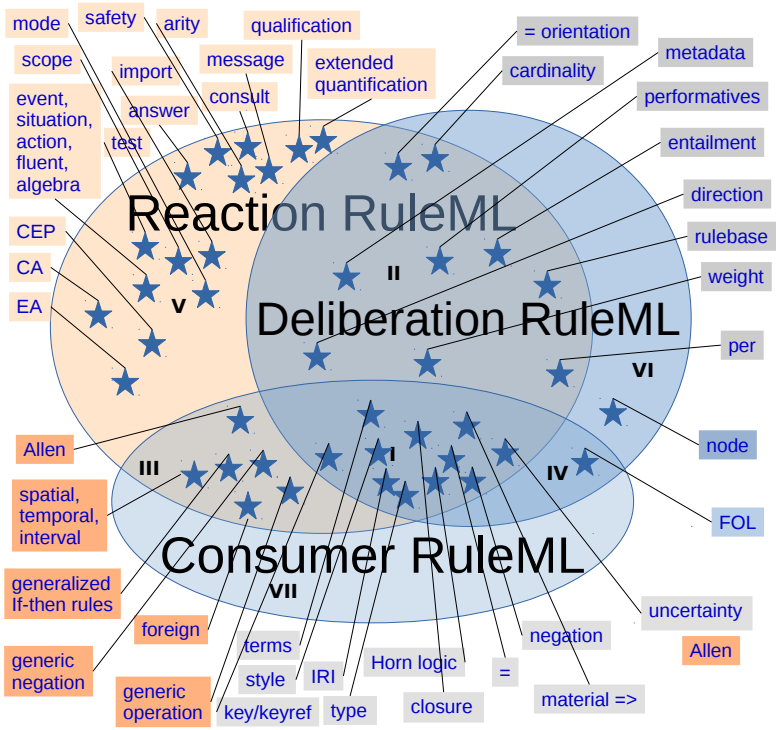



Figure: Details of the syntactic containment relationships between the Reaction, Deliberation and Consumer families are shown in this Venn diagram. The filled ellipses indicate sets of language *constructs*. The stars indicate language *features*, e.g. rules, first-order logic expressivity, or performatives, that may be combined to generate language constructs.

# Revised Approach to RuleML Semantics

- RuleML prior to 1.02 assumed **predefined default semantics**,
  - which could be overridden by explicit semantic variant attributes
- Rather than distinguishing one semantics for each language, RuleML 1.02 assumes **no default semantics but by default keeps the semantics unspecified**

# Advantages of the new RuleML Semantic System

**Safety:** semantics must be explicitly specified, avoiding incorrect assumptions

**Refinability:** semantics can be partially and gradually introduced

**Scalability:** syntactic extensions can be paired with semantic extensions

**Domain Requirements:** E.g.:

- Legal: multiple interpretations of legal texts
- Software specification: languages (e.g. UML) without complete formal semantics

# Predefined Semantic Styles of RuleML 1.02

- Underspecified profiles (partially constrained)
  - splittableHeadConjunction
  - reasoning
  - active
  - messaging
- Fully-specified semantics
  - Horn-PSOA Tarski
  - Horn Logic Herbrand
  - First-Order Logic Herbrand
  - First-Order Deontic Alethic Logic
  - Reified Classical Situation Calculus

# Features of Deliberation RuleML 1.x

- Highly-expressive First-Order logic, with variably polyadic functions and relations
- Flexible hybrid relational-graph syntax
- Oriented and unoriented equality
- Logic programming through weak negation
- Fuzzy and probabilisitic logics with uncertainty degree and slot weights
- IRIs and CURIEs as names, in addition to local vocabulary
- Metadata annotations
- Extralogical performatives and metalogic

# New Features in Deliberation RuleML 1.02

- Distributed representation (@key/@keyref newly adopted from Reaction RuleML)
- Increased semantic flexibility with references
  - Extended quantification (existing @closure attribute now takes an IRI or CURIE value)
  - Signatures (existing @type attribute now takes an IRI or CURIE value)
  - Semantic specification (@style is newly adopted from Reaction RuleML)

# Example

```
<Assert style="rp:splittableHeadConjunction">
  <Implies>
    <Atom><Rel>Wound</Rel></Atom>      <!-- if -->
    <And>                              <!-- then -->
      <Atom><Rel>Bandage</Rel></Atom>
      <Atom><Rel>Medication</Rel></Atom>
    </And>
  </Implies>
</Assert>
```

# Example

```
<Assert style="rp:splittableHeadConjunction">
  <Implies>
    <Atom key=":cond"><Rel>Wound</Rel></Atom>
    <Atom><Rel>Bandage</Rel></Atom>
  </Implies>
  <Implies>
    <Atom keyref=":cond"/>
    <Atom><Rel>Medication</Rel></Atom>
  </Implies>
</Assert>
```

# MYNG 1.02 Overview

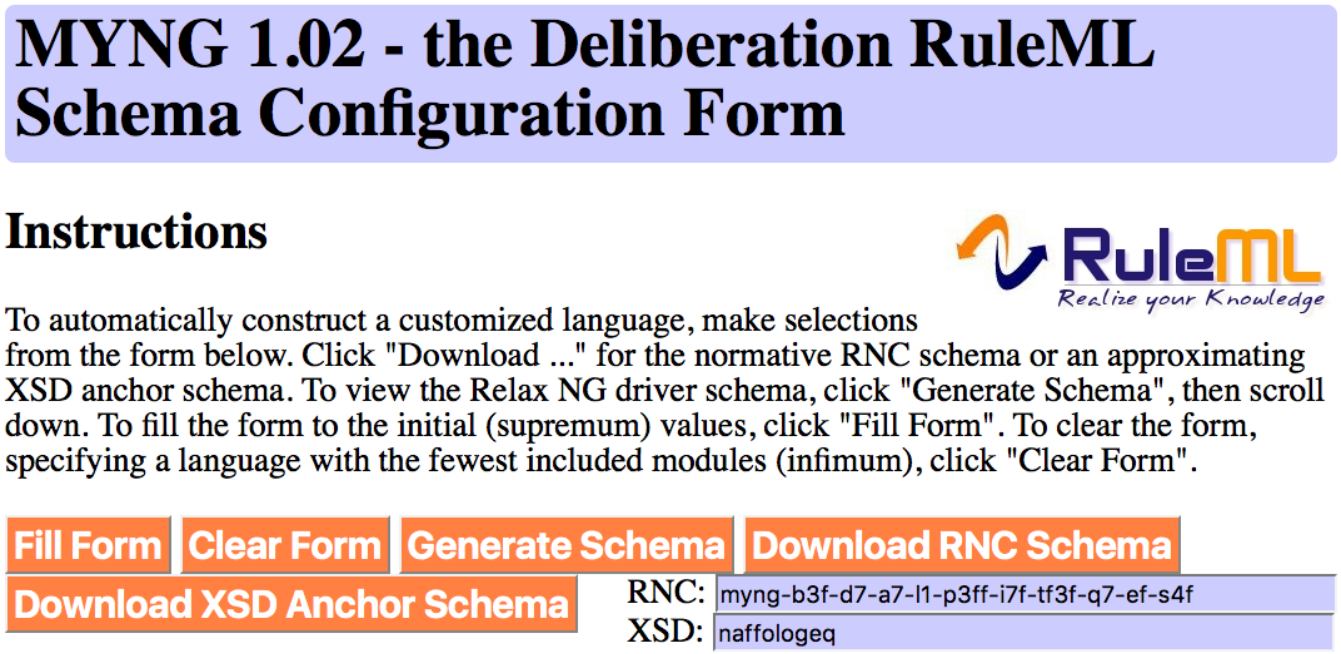



Figure: MYNG GUI for configuring a customized syntax containing selected features. Provides IRIs or download of the following:

- Precise schemas in Relax NG
- Lenient approximate (anchor) schemas in XSD.

# MYNG 1.02 Facets

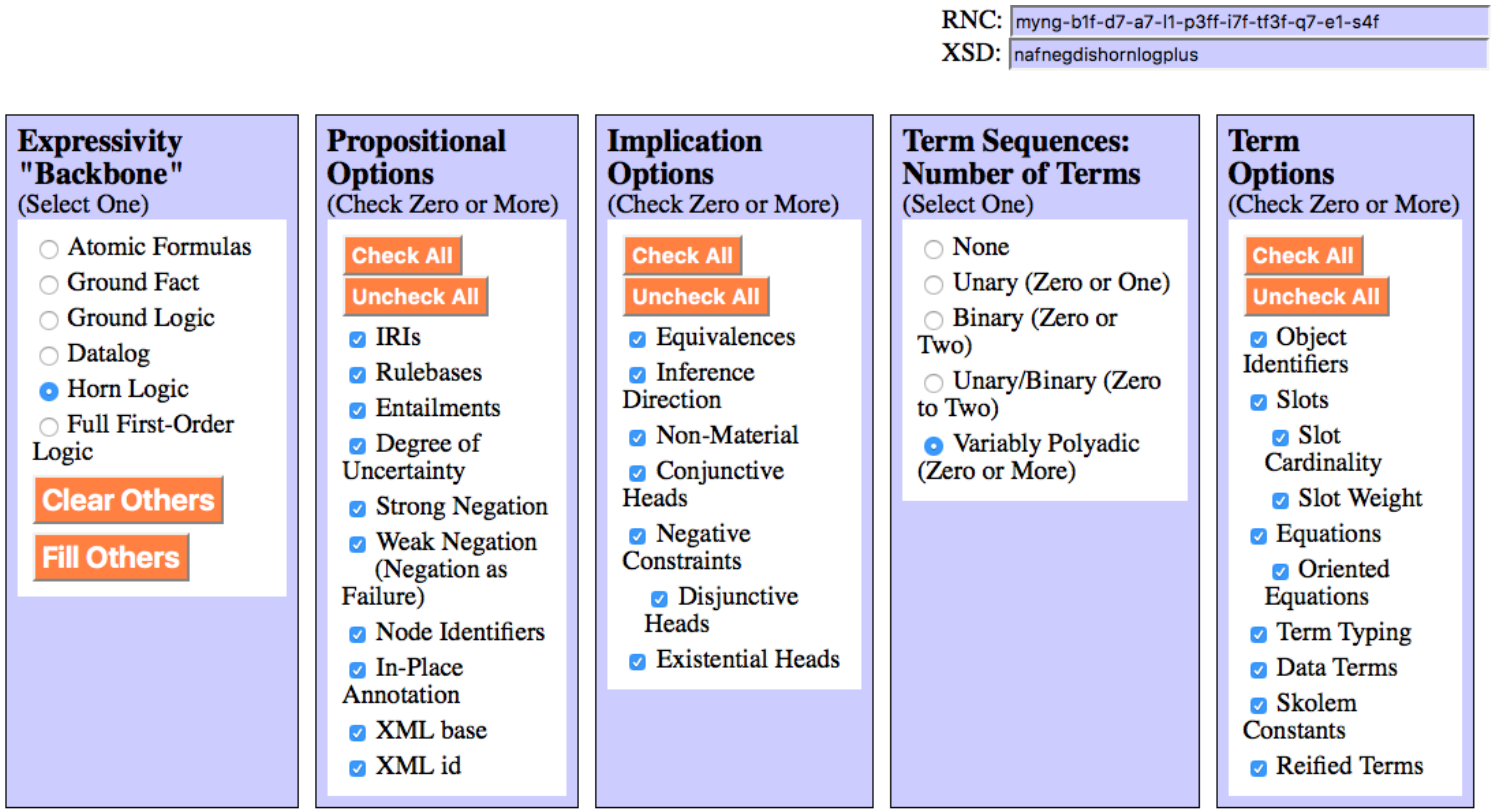
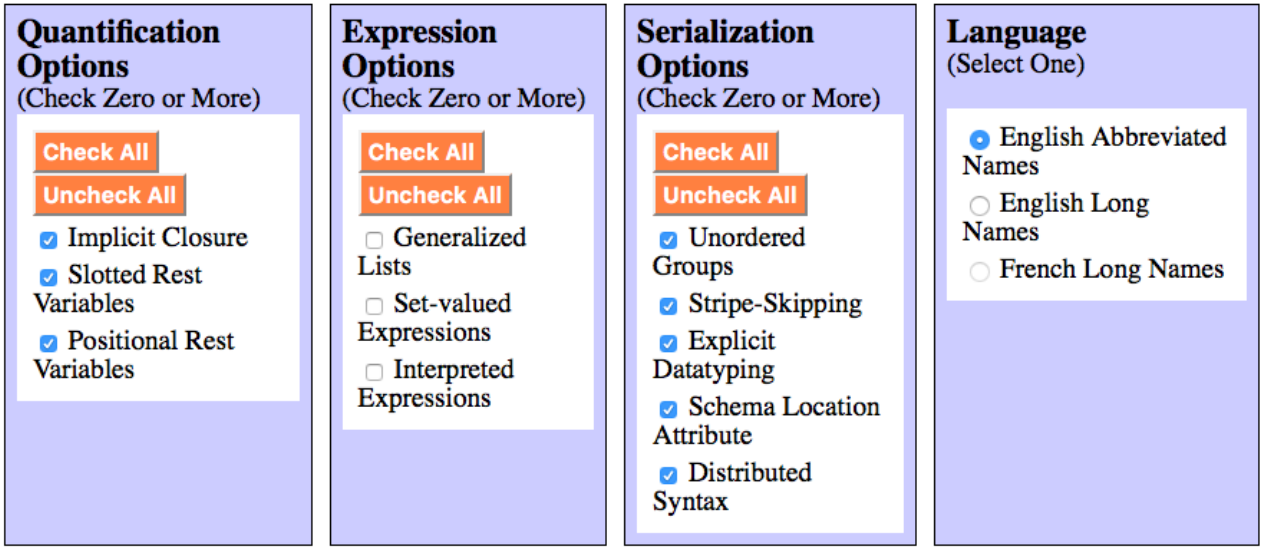



Figure: Fine-grained feature options grouped into related facets.

# MYNG 1.02 Facets, continued




Relax NG Schema
Relax NG Query String URL = http://deliberation.ruleml.org/1.02/relaxng/schema_rnc.php?backbone=x1f&default=x7&termseq=x7&lng=x1&propo=x3ff&implies=x7f&terms=xf3f&quant=x7&expr=x1&serial=x4f
Equivalent Relax NG myng-code URL = http://deliberation.ruleml.org/1.02/relaxng/myng-b1f-d7-a7-l1-p3ff-i7f-tf3f-q7-e1-s4f.rnc

XSD Anchor Schema URL = http://deliberation.ruleml.org/1.02/xsd/nafnegdishornlogplus.xsd

Figure: Additional facets, followed by referencable IRIs.

# MYNG 1.02 Usage

## Usage

The RNC and XSD Schema URLs may be used directly for online validation - copy and paste as required by the validator. For a demonstration of RNC validation using the online service Validator.nu, see How to Validate with the RuleML Parameterized Relax NG Schema. Some scripts and processing instructions may require that the character "&" be replaced by "&".

Clicking on the "Download RNC Schema" button downloads a copy of the schema driver into a file named according to the text labeled "RNC". To use the schema driver locally (offline), a local copy of the modules directory is also necessary - for download instructions, see the Deliberation RuleML 1.02 Relax NG Directory. For more information about the re-engineering of RuleML into Relax NG, which made this modularization possible, see the MYNG page on the RuleML Wiki.

Figure: IRIs may be used for online validation, or download.

# MYNG 1.02 Schema

**Schema Driver**

```
# Call parameters
# GET parameter: backbone=x1f
# GET parameter: default=x7
# GET parameter: termseq=x7
# GET parameter: lng=x1
# GET parameter: propo=x3ff
# GET parameter: implies=x7f
# GET parameter: terms=xf3f
# GET parameter: quant=x7
# GET parameter: expr=x1
# GET parameter: serial=x4f
namespace dc = "http://purl.org/dc/elements/1.1/"
namespace dcterms = "http://purl.org/dc/terms/"
default namespace ruleml = "http://ruleml.org/spec"

dcterms:title [ "Deliberation RuleML Custom-Built Schema" ]
dcterms:identifier [ "http://deliberation.ruleml.org/1.02/relaxng/schema_rnc.php?backbon
dcterms:isPartOf [ "http://deliberation.ruleml.org/1.02/spec" ]
dcterms:creator [ "http://wiki.ruleml.org/index.php/User:Athant" ]
dc:subject [ "Deliberation RuleML, custom-built" ]
dcterms:description [
    "custom-built main module for a Deliberation RuleML language."
]
dcterms:date [ "2016-07-02T07:27:19-04:00" ]
dcterms:language [ "en" ]
```

Figure: Relax NG driver schema displayed. Modular system depends on custom restriction of Relax NG schema language. Future work includes

- On-the-fly generation of precise XSD schemas,
- Determination of minimal validating schema for a RuleML instance document
- Online normalization and compactification

# New Functionality in MYNG 1.02

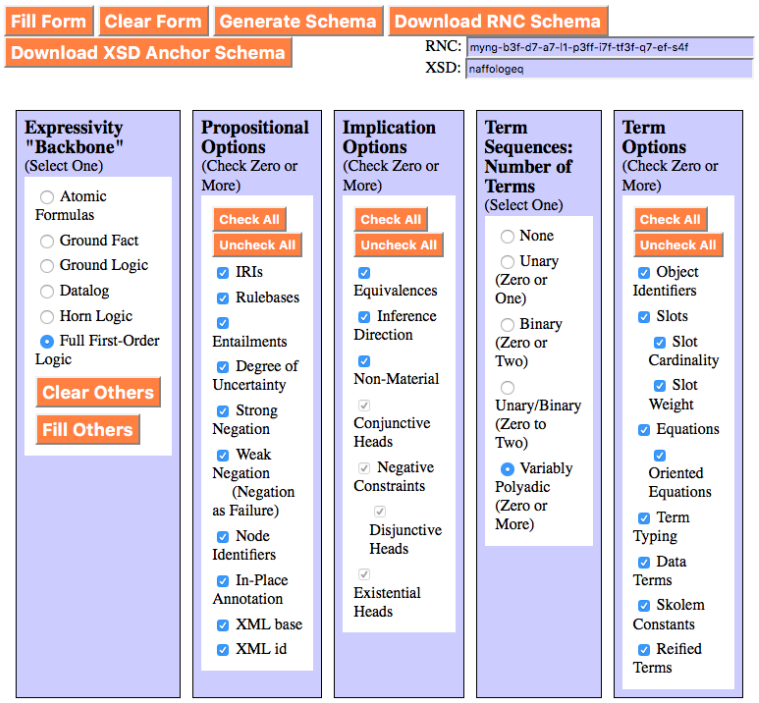



Figure: New in MYNG 1.02: Convenient buttons for clearing/filling form and facets

# Consumer RuleML 1.02 - Embedded

- Designed to be embedded into other languages - lacks extra-logical features:
  - containers (e.g., <Rulebase>)
  - performatives (e.g., <Assert>, <Query>)
  - Consumer , for structure and pragmatics, of containers and performatives from other languages, e.g. from FIPA, SOAP, or domain-specific XML languages such as LegalRuleML.

# Consumer RuleML 1.02 - External Resources

- Consumes external resources, from other syntactic and semantic specifications, accessed by attributes linking to external definitions of
  - syntactic constraints (`@type`),
  - semantic profiles (`@style`)
  - extended quantifications (`@closure`).

  The external resources may be, for example, definitions in controlled natural language (e.g., in mathematical English) or formal specifications expressed in Reaction RuleML.

# Status of LegalRuleML

- LegalRuleML embeds and extends Consumer RuleML 1.02.
- Announcement on LegalRuleML is forthcoming.

# Reaction RuleML 1.02 - Highlights

- Rules (Rule) generalizing Implies, e.g., Production (CA) rules, Trigger (EA) and Event-Condition-Action (ECA) rules, distributed rule-based Complex Event Processing (CEP)
- Definition language for interface, signature, scopes, semantic profiles, qualifications, quantification, and corresponding referencing attributes for scope, mode, safety, arity, cardinality, qualifications, quantification
- Generics dedicated to specialization of terms, formulas, operations, connectors with e.g. spatial, temporal, interval, modal types
- Further actions/performatives for semantic import, updates, answers, justifications, tests, etc.
- Message descriptors for agent-based knowledge interchange

# Examples - Signature Definition and Generics

```
<signature> <!-- signature for TimeIntervalClass type  -->
 <Time>
        <oid><Ind>TimeIntervalClass</Ind></oid>
        <slot><Ind>start</Ind><Var type="xs:datetime"/></slot>
        <slot><Ind>end</Ind><Var type="xs:datetime"/></slot>
 </Time>
</signature>

<!-- Time generic using defined TimeIntervalClass type  -->
 <Time key=":t1">
  <oid><Ind type="TimeIntervalClass">interval1</Ind></oid>
  <slot><Ind>start</Ind><Data>2011-03-21T10:00:00-04:00</Data></sl
  <slot><Ind>end</Ind><Data>2012-03-21T10:00:00-04:00</Data></slot
 </Time>

<Neg> <!-- modal operation "it is not necessary that not"  -->
<Operation type="rulemlv:AlethicOperator" iri="rulemlv:Necessary">
  <Neg><Time keyref=":t1"/></Neg>
</Operation>
</Neg>
```

# Examples Performatives / Actions

```
<!-- semantically import knowledge base-->
<do> <Consult iri="../../kb.rrml"/> </do>

<!-- consult enclosed message content -->
<do> <Consult>
 <enclosed><Message> ... </Message></enclosed>
</Consult></do>

<!-- send and receive message -->
<do><Send><Message> ...  </Message></Send></do>
<do><Receive><Message> ...  </Message></Receive></do>

<!-- preform test with test suite -->
<do>
 <Test>
  <vvi><TestSuite> ... </TestSuite></vvi>
 </Test>
</do>
```

# Conclusion

- Release of Consumer RuleML 1.02 in 2015 and contribution to OASIS LegalRuleML
- Recent release of Deliberation RuleML 1.02
- Releases of Reaction RuleML 1.02 and RuleML 1.02 as a whole (including semantics) are forthcoming.
- See `http://ruleml.org` for more details.