Rule Interchange Format: The Framework

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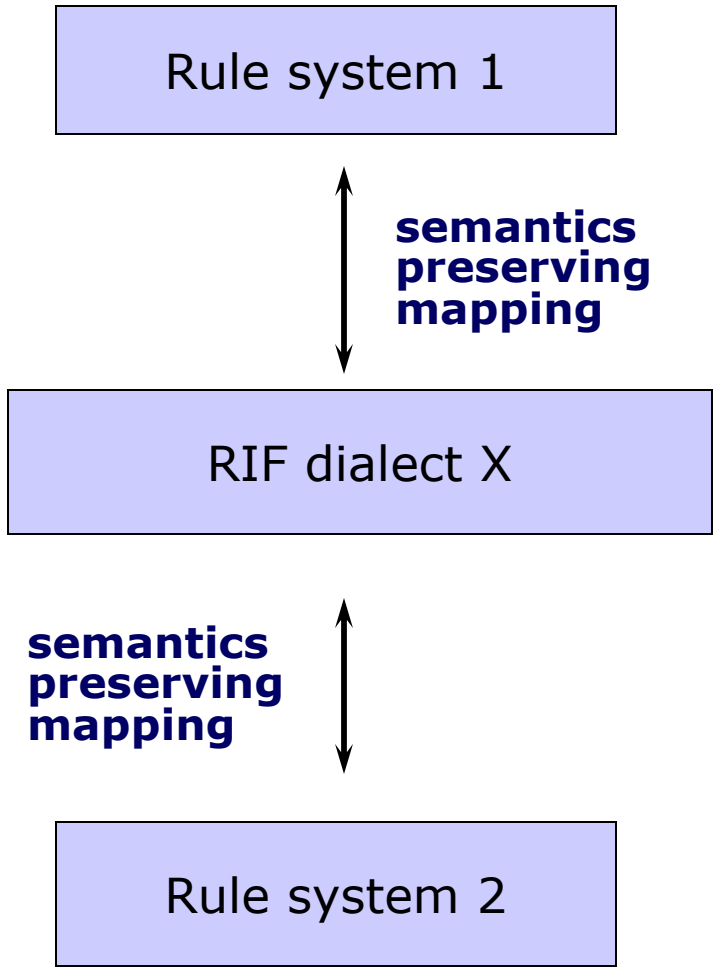
Outline

- What is Rule Interchange Format (RIF)?
- RIF Framework
- Basic Logic Dialect (BLD)

What is RIF?

- A collection of *dialects* (rigorously defined rule languages)
- Intended to facilitate rule sharing and exchange
- Dialect consistency

  Sharing of RIF machinery:
  - XML syntax
  - Presentation syntax
  - Semantics



Why Rule *Exchange*? (and not The One True Rule Language)

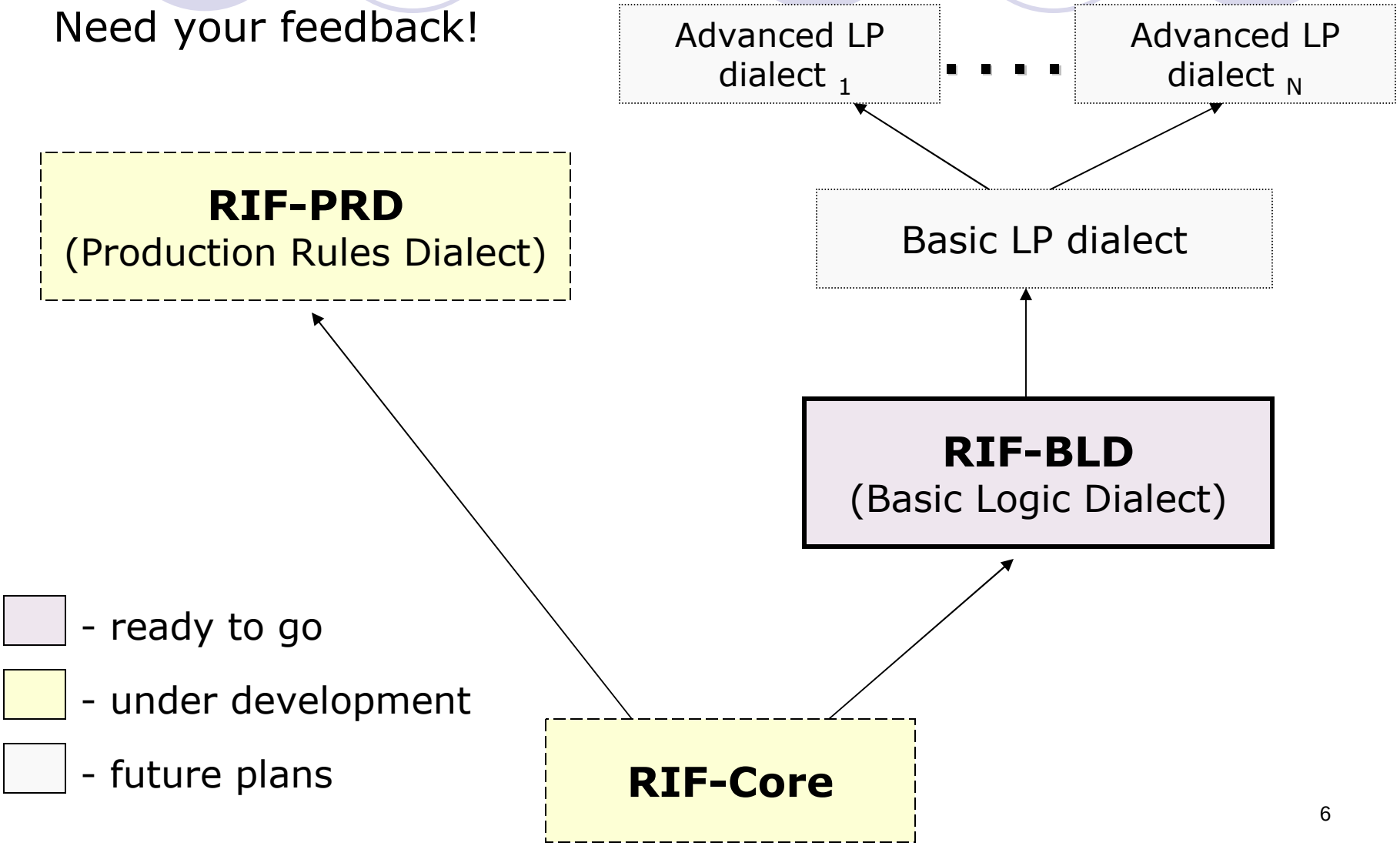
- Many different paradigms for rule languages
  - Pure first-order
  - Logic programming/deductive databases
  - Production rules
  - Reactive rules
- Many different features, syntaxes
- Different commercial interests
- Many egos, different preferences, ...

Why RIF *Dialects*? (and not just *one* dialect)

- Again: many paradigms for rule languages
  - First-order rules
  - Logic programming/deductive databases
  - Reactive rules
  - Production rules
- Many different semantics
  - Classical first-order
  - Stable-model semantics for negation
  - Well-founded semantics for negation
  - ... ...
- A carefully chosen set of interrelated dialects can serve the purpose of sharing and exchanging rules over the Web

Current State of RIF Dialects

Need your feedback!



Why Is RIF Important?

- Best chance yet to bring rule languages into mainstream
- Can make Web programming truly cool!
- For academic types:
  - A treasure-trove of interesting problems
- For industrial types:
  - A vast field for entrepreneurship
  - A great potential for new products

What YOU Can Do

- AND/OR:
  - Review RIF WG documents
  - Join the RIF Working Group
  - Help define new RIF dialects

Technical Part

- RIF Framework
  - What?
  - Why?
  - How?

What Is The RIF Framework?

- A set of rigorous guidelines for constructing RIF dialects in a consistent manner
  - Initially: just the logic-based dialects
- Includes several aspects:
  - Syntactic framework
  - Semantic framework
  - XML framework

Why Create The RIF Framework?

- Too hard to define a dialect from scratch
  - RIF-BLD is just a tad more complex than Horn rules, but requires more than 30 pages of dense text
- Instead: define dialects by *specializing* from another dialect
  - RIF-BLD can be specified in < 3pp in this way
- A “super-dialect” is needed to ensure that all dialects use the same set of concepts and constructs
- RIF Framework is intended to be just such a super-dialect

RIF-FLD:
A Framework for *Logic-based* Dialects

- Too hard to come to an agreement across all paradigms
- Not clear if a super-dialect for all rule paradigms is feasible
- Defining a super-dialect even for one paradigm (logic) is quite hard
- Logical framework may also help with other paradigms
- So, let's start with just a framework for logic-based dialects (FLD)

RIF-FLD (cont'd)

- "Super", but not really a dialect ...
  ... rather a framework for dialects
- Very general syntax, but several parameters are not specified – left to dialects
- Very general semantics, but several aspects are under-specified – left to dialects
- General XML syntax – dialects can specialize
- Currently 90% complete

RIF-FLD's Syntactic Framework

- Presentation syntax
  - Human-oriented
  - Designed for
    - Precise specification of syntax and semantics
    - Examples
    - Perhaps even rule authoring
  - Mapable to XML syntax
- XML syntax
  - For exchange through the wire
  - Machine consumption
- Will use only the presentation syntax in this talk

RIF-FLD Syntactic Framework (cont'd)

- Must be general (and extensible) so that other dialects' syntaxes could be expressed by *specializing* the syntax of FLD
- Should be interpretable in model-theoretic terms
  - because FLD is intended as a framework for dialects with model-theoretic semantics

Why So Many Syntactic Forms?

- Richer syntax allows more direct interchange
- Exchange should be *round-trippable*
  - RIF ≠ encoding

    Translation to RIF and back should preserve modeling aspects of rule sets:
    - Relations should be mapped to relations
    - Objects to objects
    - Subclass/membership to be preserved
    - Etc.
- Otherwise, meaningful sharing and reuse of rules among systems will be impossible

Examples of Syntactic Forms Supported in RIF-FLD

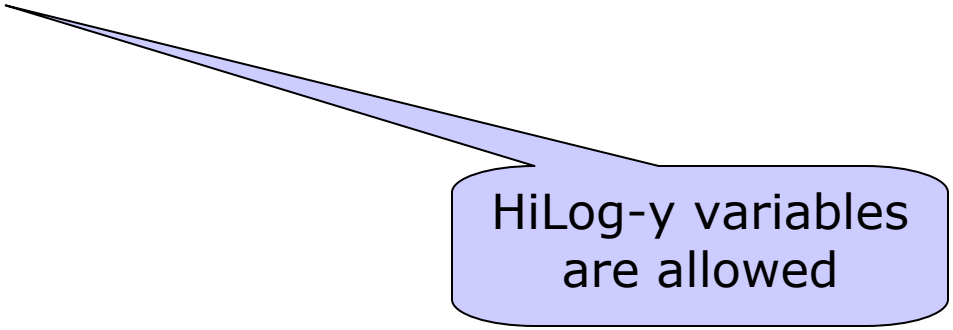
- Function/predicate application

  Point(?X abc)

  ?X(Amount(20) ?Y(cde fgh))

- Functions/predicates with named arguments

  ?F(name->Bob age->15)



Examples of Syntactic Forms (cont'd)

- Frame (object-oriented F-logic notation)

  $Obj[Prop_1 \text{->} Val_1 \ \ldots \ Prop_n \text{->} Val_n]$

- Member/Subclass (: and :: in F-logic)

  Member#Class

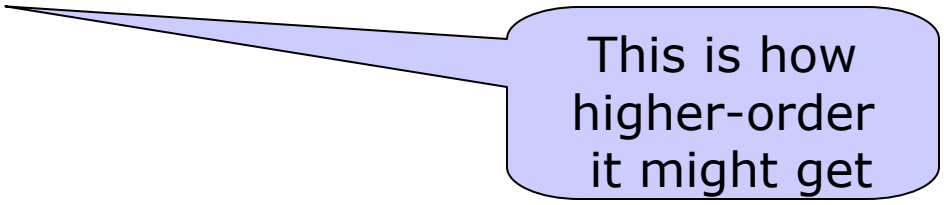
  SubCl##SupCl

- Higher-order functions

  ?F(a)(b c)

  f(?X(a b)(c)(d ?E) ?X ?Y(ab)(?Z))

  ?O[?P->a](f(?X b) c)



Examples of Syntactic Forms (cont'd)

- Equality
  - Including in rule conclusions
- Negation
  - Symmetric (classical, explicit): Neg
  - Default (various kinds – stable/ASP, well-founded): Naf
- Connectives, quantifiers

  Or (And(?X And p(?X ?Y)) ?Z(p))

  Forall ?X ?Y **(**Exists ?Z

  (f(?X(a b)(c)(d ?E) ?X ?Y(ab)(?Z)**))**

  - New connectives/quantifiers can be added

Syntactic Forms (Cont'd)

- Some dialects may allow/disallow some syntactic forms
  - For instance, no frames
- Some may restrict certain symbols to only certain contexts
  - For instance, no variables over functions, no higher-order functions
- A syntactic form can occur
  - as a *term* (i.e., in an object position)
  - or as a *formula*, or both (*reification*)
- How can all this be specified without repeating the definitions?

Signatures

- Every symbol is given a *signature*
  - Specifies the contexts where the symbol is allowed to occur
  - Symbols can be *polymorphic* (can take different kinds of arguments)
  - And *polyadic* (can occur with different numbers of arguments)
- Each dialect defines:
  - Which signatures are to be given to which symbols
  - How this assignment is specified

Signatures (cont'd)

- Arrow expression

  ($sigName_1$ ... $sigName_k$) => sigName

- Signature

  sigName{$arrEx_1$, …, $arrEx_m$}

  where the $arrEx_i$ are arrow expressions

Examples of Signatures

- Functions of arities 1 or 2:

  $fun_{1,2}${(obj)=>obj, (obj obj)=>obj}

- Unary functions or predicates:

  pf_1{(obj)=>obj, (obj)=>atomic}

- Higher-order binary functions that yield unary predicates or functions:

  hf_2pf_1{(obj obj)=>pf_1}

- Binary functions that take arbitrary predicates as arguments:

  f_2p{(atomic atomic)=>obj}

Signatures of Terms

- Composite terms can also have signatures
- If f has the signature $fun_1\{(obj)=>obj\}$,
  and t has the signature obj
  then f(t) *has the signature* obj
- If f has the signature
  $hf_2p_1\{(obj\ obj)=>p_1\}$, where p_1 denotes
  the signature: $p_1\{(obj)=>atomic\}$.
  then f(t t)(t) *has the signature* atomic

Well-formed Terms and Formulas

- Well-formed *term*
  - Each symbol occurs only in the contexts allowed by that symbol's signature

    If f has signature $fun_1\{(obj)=>obj\}$,

    and t has signature obj

    then f(t) is well-formed with signature obj.

    But f(t t) is *not* well-formed
- Well-formed atomic *formula*
  - Well-formed term that has the designated signature atomic

Is the syntactic framework too fancy?

- Cannot be rich enough!
- Cf. languages like
  - FLORA-2
  - And especially Vulcan's SILK project

  http://silk.projects.semwebcentral.org

RIF-FLD Semantic Framework

- Defines *semantic structures* (a.k.a. *interpretations*)
  - Structures that determine if a formula is true
  - Must be very general to allow:
    - Interpretation of all the supported syntactic forms
    - Higher-order features
    - Reification
  - Multivalued logics, not necessarily Boolean
    - For uncertainty, inconsistency

Semantic Framework (cont'd)

- Logical entailment
  - Central to any logic
  - Determines which formulas entail which other formulas
- Unlikely to find one notion of entailment for all logic dialects because …

Semantic Framework (cont'd)

p <- not p

- In first-order logic:
  - ≡ p
  - 2-valued
- In logic programming:
  - Well-founded semantics
    - p is undefined
    - 3-valued
  - Stable model semantics
    - inconsistent
    - 2-valued
- And there is more ...

Semantic Framework (cont'd)

- Solution: under-specify
  - Define entailment parametrically, leave parameters to dialects
  - Parameters: *intended models*, truth values, etc.
  - Entailment (between sets of formulas)
    - P |= Q iff for every *intended* model **I** of P, **I** is also a model of Q
  - Overall framework is based on Shoham (IJCAI 1987)

What Are These Intended Models?

- Up to the dialect designers!
- First-order logic:
  - All models are intended
- Logic programming/Well-founded semantics
  - 3-valued well-founded models are intended
- Logic programming/Stable model semantics
  - Only stable models are intended

Other Issues: Link to the Web World

- Symbol spaces
  - Partition all constants into subsets; each subset can be given different semantics
- Some RIF symbol spaces
  - rif:iri – these constants denote objects that are universally known on the Web (as in RDF)
  - rif:local – constants that denote objects local to specific documents
- Other symbol spaces: Data types
  - Symbol spaces with fixed interpretation (includes most of the XML data types + more)
- Document formulas, meta-annotations, ...

Other Issues (cont'd)

- Built-ins (mostly adapted from XPath)
- Aggregate functions
- Externally defined objects/predicates
  - External sources accessed by rule sets
- Imports/Modules
  - Integration of different RIF rule sets

Describing RIF Logic-based Dialects By Specializing RIF-FLD

- Syntactic parameters
  - Signatures, syntactic forms
  - Quantifiers, connectives
  - Symbol spaces
  - Types of allowed formulas (e.g., just Horn rules or rules with Naf in premises)
- Semantic parameters
  - Truth values
  - Data types
  - Interpretation of new connectives and quantifiers (beyond And, Or, :-, Forall, Exists)
  - Intended models
- Much easier to specify (< 10% of the size of a direct specification)
- Much easier to learn/understand/compare different dialects

The Basic Logic Dialect

- Basically Horn rules (no negation) plus
  - Frames
  - Predicates/functions with named arguments
  - Equality both in rule premises and conclusions
  - But no polymorphic or polyadic symbols
- This dialect is called "*basic*" because
  - Here classical semantics = logic programming semantics
  - Bifurcation starts from here on

Basic Logic Dialect (cont'd)

- Can import RDF and OWL
  - RIF RDF+OWL Compatibility document: http://www.w3.org/2005/rules/wiki/SWC
  - Semantics: a la Rosati et. al.
- BLD with imported OWL
  - Is essentially SWRL (but has frames and other goodies)

Basic Logic Dialect (cont'd)

- Specified in two *normative* ways:
  - As a long, direct specification
  - As a specialization from RIF-FLD
- These two specifications are supposed to be equivalent
  - This double specification has already helped debugging both BLD and FLD

Conclusions

- RIF is good for rules research and industry.
- Need help – take part, save the world!

- RIF Web site:
  http://www.w3.org/2005/rules/wiki/RIF_Working_Group
- FLD – the latest:
  http://www.w3.org/2005/rules/wiki/FLD
- BLD – the latest:
  http://www.w3.org/2005/rules/wiki/BLD
- Production rules (in progress):
  http://www.w3.org/2005/rules/wiki/PRD

Thank You!

Questions?