

Omni-directional Hyper Logic Programs in SILK and RIF

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October 22, 2010

20-min. demo presentation at RuleML-2010,
in the RuleML Challenge track,
Alexandria, VA, USA**

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For More Info: <http://silk.semwebcentral.org>
<http://projecthalo.com>

** <http://2010.ruleml.org>



Outline

- **Intro: SILK overall, esp. its KR**
 - Higher-order defaults, external actions/events/queries
 - RIF-SILK dialect extends RIF-BLD
- **Omni-directionality: concept and approach**
- **Demo of omni-directionality**
 - Scenario of business policies about ad placements in news
 - Show in new SILK GUI, with justification browsing
- **Discussion, Conclusions, Future Work**
 - Higher-abstraction KR closer to human cognition and social pragmatics
 - Sound Interchange with FOL
 - Remedies major limitations of semantic web's current KR foundation

SILK's KR: **Hyper** Logic Programs

- **New Extension of LP that is the first to combine key advanced features**
- **Defaults + Higher-Order + External Actions/Events/Queries**
 - + Webized, Frames, Negation (neg and naf), Equality, Functions, Skolems, Aggregates, Integrity Constraints, Lloyd-Topor, ...
- **Omni-directionality: new feature, focus in this talk+demo**
 - Permit head disjunction, treat via directionalization. Handle multi-way conflicts.
 - Much broader FOL-sound interchange: any clause or universal formula, not just Horn
- **Transforms knowledge from higher to lower abstraction levels**
 - Raises expressive abstraction level. Higher is good for **knowledge acquisition (KA)**
 - Lower is good for reasoning (code reuse, optimization) and knowledge interchange
- **Tractable computationally – complexity is same as Horn LP**
 - Polynomial time -- similar to relational DBMS -- if there's no recursion thru functions
 - Retains pragmatic quality of LP: “intuitionistic” – lack general “reasoning by cases”
- **Uses new *argumentation theory* approach to defaults**
 - ~20 “meta-” rules specify debate principles for defeat. Much easier to implement than code.
 - Enables much more expressiveness (e.g., HiLog). Much more efficient when updating.
- **RIF-SILK dialect extends RIF-BLD (Basic Logic Dialect)**

Representational Uses for Defaults and Higher-Order

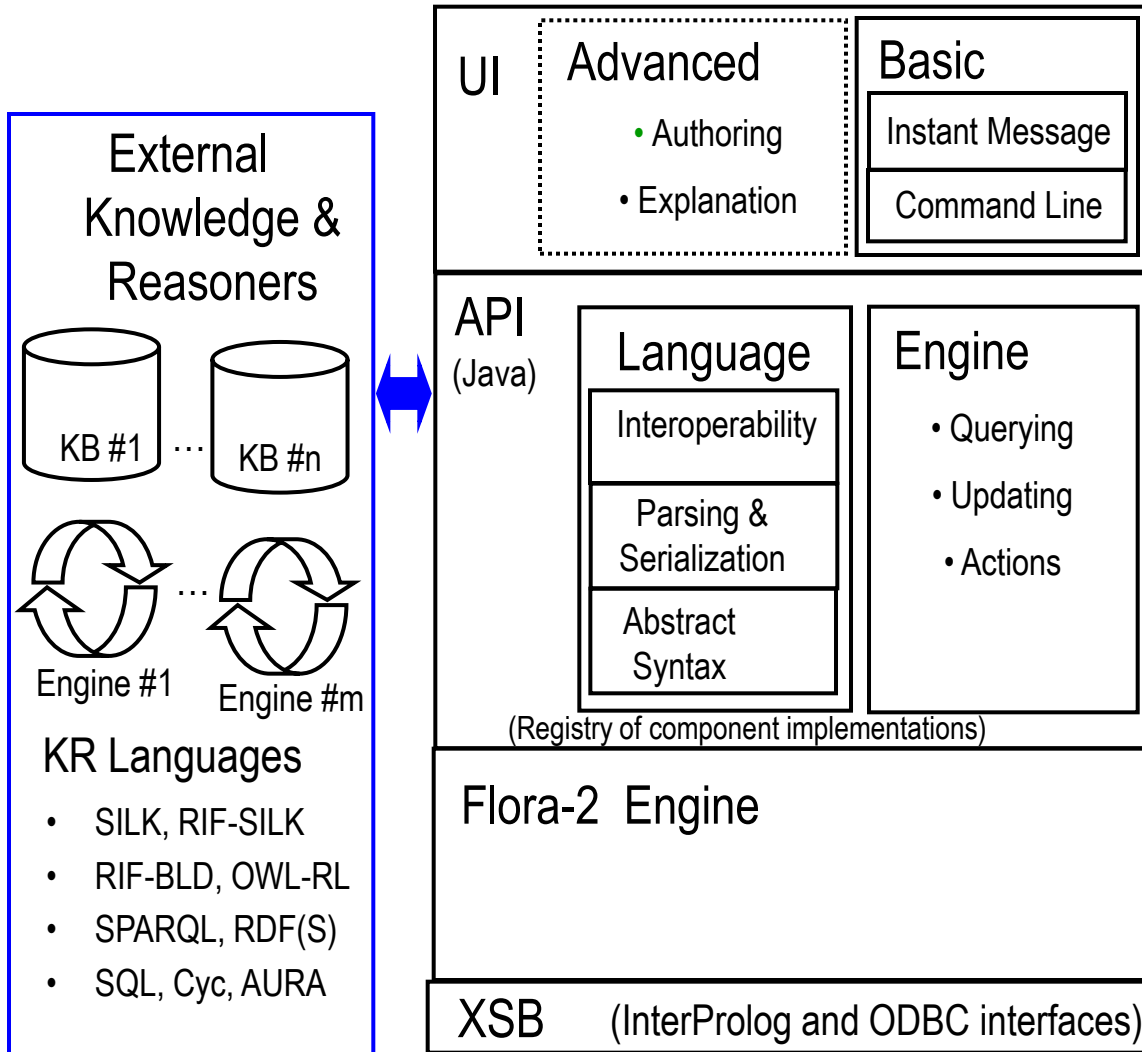
Defaults (cf. Courteous, with Prioritization)

- Negation
- Pragmatic knowledge/reasoning has potential for exceptions and revision
 - Learning and science: may falsify previous hypotheses after observation or communication
- **Debate and trust:** priorities from authority, reliability, recency
- Updating, merging, change: increase modularity/reuse in KA/KB lifecycle
- **Process causality:** persistence, indirect ramified effects, interference
- Hypotheticals, e.g., counterfactuals
- Inheritance: more-specific case overrides more-general case
- **Policies**, regulations, laws – the backbone of society and institutions
- Natural language understanding (NLU) aspects: e.g., co-reference

Higher-Order (cf. Hilog and reification)

- Meta- knowledge and meta- reasoning, generally
- **Ontology mapping**, KB translation, KR macros, reflection, NLU aspects
- Provenance, multi-agent belief, modals, many aspects of context

SILK Architecture today (V2.2)



- API Functionality
 - Higher-order defaults reasoning, combines many other advanced KR features
 - SILK and external KR language support integrated tightly with reasoning engine
- UI Functionality
 - Graphical, tabular
 - For Knowledge Engineers
- *Future Items*
 - *UI: SME-friendlier, English (NL)*
 - *KR: probabilistic, parallelization, more interchange KRs*
- Test Sets Focus
 - Defaults, Process
 - AP esp. Biology

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Omni-directional Rules: Clausal case

- **Hyper LP introduces the concept of an omni-directional (“omni”) rule. Basic case is clausal:**
 - $@G F$; where F has the syntactic form of a FOL clause
 - The tag ($@G$) is optional. Outer universal quantification is implicit.
 - $@hi\ wet(lawn, nextMorning(?night))$ or $neg\ occur(rain, ?night)$;
- **A clausal hyper rule is transformed, i.e., directionalized, from $@G L1\ or\ L2\ or\ \dots\ or\ Lk$; where each L_i is an atom or the neg of an atom into a set of k directed rules, one for each choice of head literal:**
 - $@G L1 :- neg\ L2\ and\ neg\ L3\ and\ \dots\ and\ neg\ Lk$;
 - $@G L2 :- neg\ L1\ and\ neg\ L3\ and\ \dots\ and\ neg\ Lk$;
 - ...
 - $@G Lk :- neg\ L1\ and\ neg\ L2\ and\ \dots\ and\ neg\ L_{k-1}$;
- **This is called the set of directional variant rules.**
- (NB: In a sophisticated Courteous variant, the directionalization transformation also outputs an *exclusion* statement that better handles multi-way conflicts. E.g., in SILK V2.2.)
- **Still no reasoning by cases!!! Cf. unit/linear resolution strategy in FOL.**

naf-free !

Examples of Directionalization

- **@hi wet(lawn, nextMorning(?night)) <== Occur(rain, ?night) ;** /* Causal */
is transformed into:
 - **@hi Wet(lawn, nextMorning(?night) :- Occur(rain, ?night) ;**
 - **@hi neg Occur(rain, ?night) :- neg Wet(lawn, nextMorning(?night) ;**
- **neg (Cat(?x) and Bird(?x)) ;** /* OWL-DL disjoint classes */
is transformed into:
 - **neg Cat(?x) :- Bird(?x) ;**
 - **neg Bird(?x) :- Cat(?x) ;**
- **neg Approved(?p) <== neg Validated(?p) ;** /* SBVR: Car Rental Constraint */
is transformed into:
 - **neg Approved(?p) :- neg Validated(?p) ;**
 - **Validated(?p) :- Approved(?p) ;**
- **mtg(3p) or mtg(4p) or mtg(5p) ;** /* Scheduling: Joe's meeting time */
is transformed into:
 - **mtg(5p) :- neg mtg(3p) and neg mtg(4p) ;**
 - **mtg(4p) :- neg mtg(3p) and neg mtg(5p) ;**
 - **mtg(3p) :- neg mtg(4p) and neg mtg(5p) ;**

Omni-directional Rules: General case

- **Permit the formula F to:**
 - Be a universal formula (reduces to clauses)
 - Use Skolemization ... Thus be “nearly full” FOL form
 - Use HiLog and Frame features
- **Permit a rule body too**
 - $@G \ F \ :- \ B \ ;$
 - Adds B to the body of each directional variant rule
 - Special case: F is a literal
- **Omni-directionality raises the KR abstraction level**
 - Hide directionality ($\ :- \$) as well as NAF ($\ naf \$)
 - Use instead: $\ neg \$ (strong negation), $\ <== \$ (strong/material implication), and defeasibility (Courteous)

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Interchange of Hyper LP \leftrightarrow FOL

- **Omnis are a natural source/target for interchange with FOL**
- There is a (bi-)mapping T that's useful for such interchange. Its essence is:

<u>Hyper LP</u>		<u>FOL</u>
@G E ;	\leftarrow	E ;
@G F :- B ;	\rightarrow	F <== B ;

(Certain restrictions apply: the formulas must be universal.)

- **W.r.t. T : Hyper LP is sound and incomplete from FOL viewpoint**
- **When there is conflict, Hyper LP reasoning is usefully selective unlike FOL**
- **Usage 1: Import clausal/universal FOL into Hyper LP**
 - Can give prioritization to the imported rules
 - E.g., based on source authority, recency, reliability
- **Usage 2: Import Hyper LP conclusions into FOL**
 - E.g., in conflict-free case. Hyper LP there lacks “reasoning by cases”
- **Greatly generalizes well-known special case for definite Horn LP**
 - Handles negation (neg) and attendant conflicts
 - Can cover “nearly full” OWL and Common Logic, most of SBVR

Remedying FOL Semantics' Lack of Scalability

- **Hyper LP handles conflict robustly – get consistent conclusions**
 - **Whereas FOL is a “Bubble” – it’s perfectly brittle semantically in face of contradictions from quality problems or merging conflicts.**
 - Any contradiction is totally contagious – the conclusions all become garbage
 - E.g., OWL beyond the RL subset suffers this problem. So does Common Logic. (Technically, RIF-BLD and RDF(S) are defined via FOL semantics too, although their typical implementations are essentially LP.)**

A KB with a million or billion axioms formed by merging from multiple Web sources, is unlikely to have zero KB/KA conflicts from:

- Human knowledge entry/editing
 - Implicit context, cross-source ontology interpretation
 - Updating cross-source
 - Source trustworthiness
- ***Hyper LP’s approach provides a critical advantage for KB scalability***
 - ***semantically, as well as computationally***

FOL: A Bubble

Extreme sensitivity to conflict limits its scalability in # of axioms and # of merges



Left:

<http://www.dailymail.co.uk/sciencetech/article-1199149/Super-slow-motion-pictures-soap-bubble-bursting-stunning-detail.html>

Above:

http://img.dailymail.co.uk/i/pix/2007/11_03/BubblePA_468x585.jpg

Current and Future Directions for Omnis

- **Special treatment for certain expressive constructs**
 - External actions are head-only. External queries and aggregates are body-only.
- **Value in KA tasks and domains**
- **Optimize**
- **Multi-way conflicts: nuances of edge-case behavior**
- **Existentials**
- **Extensibility towards “reasoning by cases” in FOL and ASP**
- **Other study & theory**
 - Closed-world

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- SRI International (Vinay Chaudhri, David Martin, Ken Murray)
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- Ontoprise GmbH (Daniel Hansch, Jurgen Angele)
- Boeing
- Univ. of Texas (Bruce Porter, Ken Barker)
- Univ. of Amsterdam (Bert Bredeweg)
- Univ. of Freiburg (Georg Lausen)
- Univ. of Michigan (Michael Wellman)
- Raphael Volz, consultant
- Acknowledgements to RuleML (Harold Boley, Said Tabet)



SILK – Transforming Knowledge

Thank You



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