Omni-directional Hyper Logic Programs in SILK and RIF

Benjamin Grosof*

October 22, 2010
20-min. demo presentation at RuleML-2010,
in the RuleML Challenge track,
Alexandria, VA, USA**

* Vulcan Inc., benjaming@vulcan.com
http://www.mit.edu/~bgrosof/

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

** http://2010.ruleml.org

© Copyright Benjamin Grosof and Vulcan Inc., 2010. All rights reserved.
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
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
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.
    - \(@hi \text{ wet(lawn, nextMorning(?night)) or neg occur(rain, ?night)}\);

- A clausal hyper rule is transformed, i.e., **directionalized**, from
  \(@G \; L_1 \text{ or } L_2 \text{ or } \ldots \text{ or } L_k\); 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:
    - \(@G \; L_1 \; :- \; \text{neg } L_2 \text{ and neg } L_3 \text{ and } \ldots \text{ and neg } L_k\);
    - \(@G \; L_2 \; :- \; \text{neg } L_1 \text{ and neg } L_3 \text{ and } \ldots \text{ and neg } L_k\);
    - \ldots
    - \(@G \; L_k \; :- \; \text{neg } L_1 \text{ and neg } L_2 \text{ and } \ldots \text{ and neg } L_{k-1}\);

- 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.
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)
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
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:**

<table>
<thead>
<tr>
<th>Hyper LP</th>
<th>FOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>$@G \ E ;$</td>
<td>$E ;$</td>
</tr>
<tr>
<td>$@G \ F :- B ;$</td>
<td>$F \leftarrow B ;$</td>
</tr>
</tbody>
</table>

  (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
SILK Contributors current/past (partial list)

- Vulcan (Benjamin Grosof, Mark Greaves, Dave Gunning, Peter Clark)
- Stony Brook Univ. (Michael Kifer, H. Wan, S. Liang, P. Fodor)
- Raytheon BBN Technologies (Mike Dean, C. Andersen, B. Benyo, B. Ferguson)
- SRI International (Vinay Chaudhri, David Martin, Ken Murray)
- Cycorp (Keith Goolsbey, Doug Lenat, Jon Curtis)
- Automata (Paul Haley)
- Terrance Swift, consultant
- Smart Info Flow Technologies (Mark Burstein)
- Richard Fikes, consultant (Stanford Univ.)
- Texas Tech Univ. (Michael Gelfond, D. Inclezan)
- University of Toronto (Sheila McIlraith, S. Sohrabi, H. Ghaderi)
- 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)
Thank You

SILK – Transforming Knowledge

Disclaimer: The preceding slides represent the views of the author only. All brands, logos and products are trademarks or registered trademarks of their respective companies.

© This presentation is copyright Benjamin Grososf and Vulcan Inc. All rights reserved.