*****DEMO***** POSTER

A SILK Graphical UI for Defeasible Reasoning, with Biology Causal Process Example

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Presentation at ISWC-2010****

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For More SILK Info: http://silk.semwebcentral.org

SILK is part of Vulcan's Project Halo: http://projecthalo.com

**** http://iswc2010.semanticweb.org Held in Shanghai, China, Nov. 7-11, 2010.

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Outline and Summary

- Background: SILK overall, esp. its Hyper Logic Programs KR
  - A rule language and system with reasoner, UI, interchange
  - Scalable higher-order defeasible rules, plus many other advanced features
    - Omni-directionality: a novel expressive feature
    - Sound Interchange with FOL
    - External actions, events, and queries
  - Higher-abstraction KR closer to human cognition and social pragmatics
    - Tolerates and handles conflict. Represents debate, trust, and meta-knowledge.
    - Radically extends expressive power of RIF-BLD, SPARQL, RDF(S), OWL-RL
    - RIF-SILK dialect extends RIF-BLD
    - Remedies major limitations of semantic web's current KR foundation

- In the Demo itself: a 1st SILK Graphical UI to query, edit, explain
- Focus here is browsing justifications of defeasible conclusions
  - Novel graphical approach for exploring prioritized defeat
    - Counterarguments; why-not. Drill-down.
  - Scenarios of rain, advertising policies, and biological causal process
    - These use omni-directionality

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Supporting "Knowledge Debugging"

- **Type 1 Problem: Some expected answer was not inferred**
- **Type 2 Problem: Some unexpected answer was indeed inferred**
- **SILK's defeasibility feature (desirable and powerful) raises new aspect:**
  - Type 1D Problem: Expected answers may have been unexpectedly defeated
  - Type 2D Problem: Unexpected answers may have been unexpectedly not defeated
  - $\Rightarrow$ Critical: Enable knowledge engineers (KEs) to explore justifications for Types 1D & 2D
  - E.g., to explore plausible but failed justifications for conclusions that do not appear
- **Justifications need to:**
  - Clearly show argumentation and its results
  - Support interactive exploration by the KE of the justification space
    - Hide most of the volume of justification graph, facilitate selective expansion and drill down
  - Clearly link operational-form lower-abstraction rules back to source-form higher-abstraction rules that have been transformed into operational-form
    - Link rules back to source files, to facilitate correction editing

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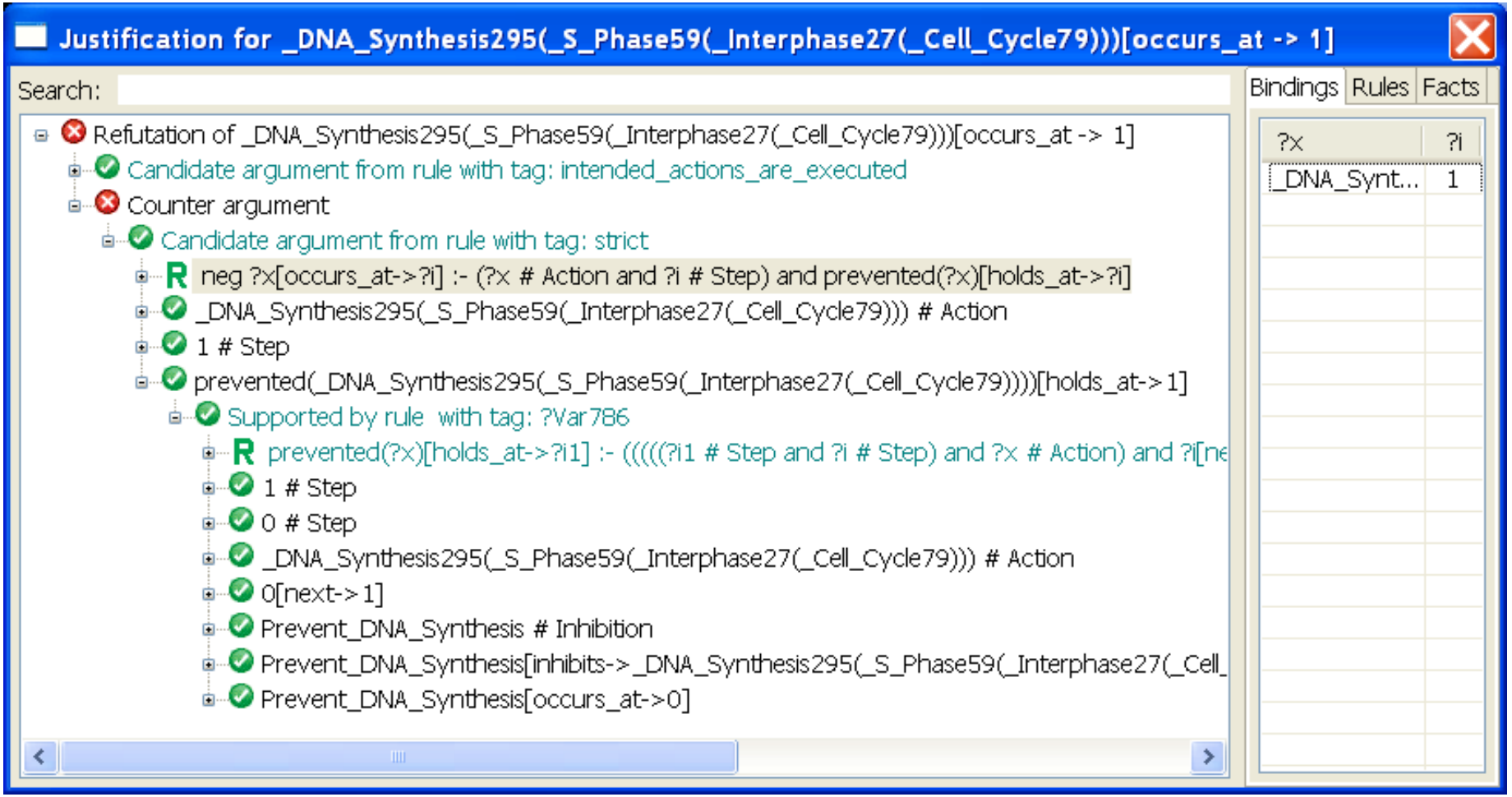
Demo Screenshot



SILK research program (2008-) in Vulcan's Project Halo

- **For Vision of Digital Aristotle: question-answering for science**
  - Put the bulk of the world's scientific and similar knowledge on-line
  - Answer questions, act as personal tutor, with deep reasoning. E.g., textbooks/exams.
  - 1st yr college-level Biology is current domain focus: complex causal processes
- **Advanced KR language and system, for esp. defaults & processes**
  - Largest* rule research program in USA. Multi-institutional: primarily via contractors.
  - Higher-abstraction KR closer to human cognition and social pragmatics
  - Radically extends expressive power of SQL, RDF(S), SPARQL, OWL-RL, RIF-BLD
  - Remedies major limitations of semantic web's current KR foundation
- **Potential application areas in business and government**
  - Horizontal: policies, workflows; ontology mapping, knowledge integration
  - Vertical: e-commerce, defense intelligence, trust, biomed, financial, mobile
- **http://silk.semwebcentral.org**

* (that we're aware of)

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Ecology Ex. of Causal Process Reasoning

```
/*    Toxic discharge into a river causes fish die-off.    */
/* Init. facts, and an "exclusion" constraint that fish count has a unique value */
  occupies(trout,Squamish);
  fishCount(0,Squamish,trout,400);  / * 1st argument of fishCount is an integer time */
  silk:opposes(fishCount(?s,?r,?f,?C1), fishCount(?s,?r,?f,?C2)) :- ?C1 != ?C2;
/* Action/event description that specifies causal change, i.e., effect on next state */
@tdf1 fishCount(?s+1,?r,?f,0) :- occurs(?s,discharge,?r) and occupies(?f,?r);
/* Persistence ("frame") axiom */
  @pefc1  fishCount(?s+1,?r,?f,?p) :- fishCount(?s,?r,?f,?p);
/* Action effect axiom has higher priority than persistence axiom */
 silk:overrides(tdf1,pefc1);
/* An action instance occurs */
  @UhOh  occurs(1,toxicDischarge,Squamish);
```

As desired: |= fishCount(1,Squamish,trout,400),
fishCount(2,Squamish,trout,0);

Notes: @… declares a rule tag. ? prefixes a variable. :- means if. != means ≠. opposes indicates an exclusion constraint between two literals, which means "it's a conflict if".

SILK's Goals

- **Address fundamental requirements for scaling Semantic Web to widely-authored Very Large KBs in business and science that answer questions, proactively supply info, and reason powerfully**
- **Expressiveness + Semantics + Scalability**
  - Push the frontier. Language and system.
- **Better Knowledge Representation (KR)**
  - Expressive power: defeasibility, higher-order. E.g., causal processes in AP Biology.
  - Performance scalability of reasoning, including knowledge updates
- **More effective Knowledge Acquisition (KA)**
  - + By Subject Matter Experts (SMEs), not programmers or knowledge engineers
  - + Collaboratively – incorporate large #s of SMEs in KB construction & maintenance
    - + Leveraging the Web
- **Better KR also for sake of better KA**
  - Web knowledge interchange (with merging) for scalability of collaborative KA
  - The underlying KR is the target for KA: **"The KR is the deep UI"**
    - Understandability via semantics and expressiveness
    - Raise abstraction level closer to the user's natural language and cognition

Expressiveness "Brittleness" Areas Targeted

- **Defaults/Exceptions/Defeasible** *(incl. nonmonotonic reasoning, theory revision, argumentation, truth maintenance)*
  - A kinematics problem situation has standard earth gravity, and no air resistance. [physics AP]
  - A given organism has the anatomy/behavior that is typical/normal for its species, e.g., a bat has 2 wings and flies. [bio AP]
  - Price info for an airplane ticket on Alaska Air's website is accurate and up to date. [e-shopping]

  ❖ **Practical reasoning almost always involves a potential for exceptions**
- **Hypotheticals**
  - If Apollo astronaut Joe golfed a ball on the moon, then standard earth gravity would not apply. [negative hypothetical] [*conflict* between defaults, resolved by *priority* among them]
  - If I had swerved my car 5 seconds later than I did, I would have hit the debris in the left lane with my tire. [*counterfactual*]
- **Actions and Causality**
  - If a doorkey is incompletely inserted into the keyhole, turning the key will fail. [*precondition*]
  - During the mitotic stage of prometaphase, a cell's nuclear envelope fragments [biology AP]
  - After a customer submits an order on the website, Amazon will email a confirmation and ship the item. [Event-Condition-Action (*ECA*) rule] [policy]
- **Processes (i.e., representing and reasoning about processes)**
  - Mitosis has five stages; its successful completion results in two cells. [compose] [partial description]
  - If Amazon learns that it will take an unexpectedly long time to stock an ordered item, then it emails the customer and offers to cancel the order without penalty. [exception handling]
  - A Stillco sensor-based negative feedback thermal regulator is adequate to ensure the overnight vat fermentation of the apple mash will proceed within desired bounds of the alcohol concentration parameter. [science-based business process]

Ubiquitous in science, commonsense, business, etc. All are interrelated.

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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, a focus in this demo/poster**
  - 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)**

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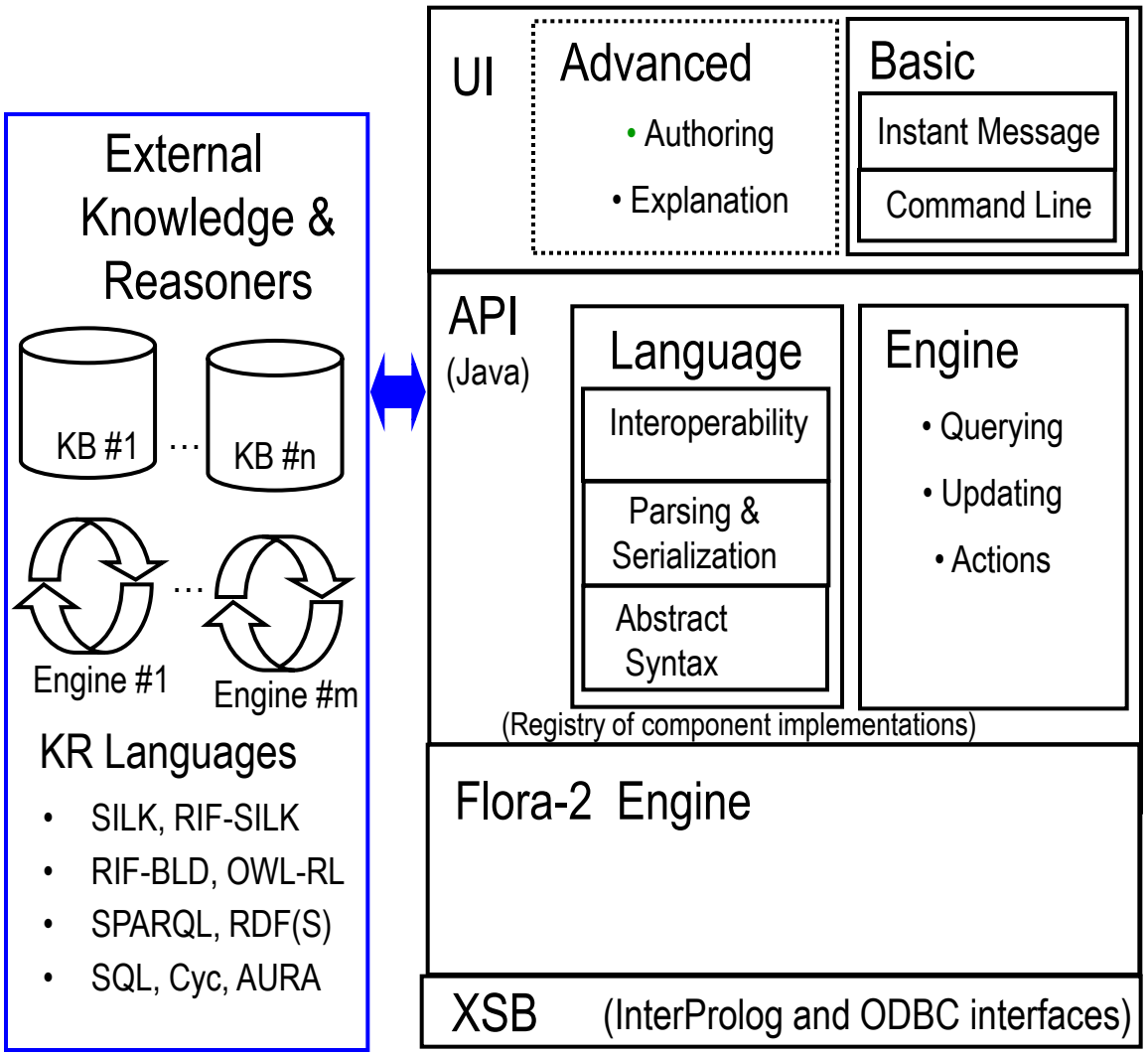
SILK Architecture today (V2.2)



- 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 prioritization tag (@G) is optional. Outer universal quantification is implicit.
  - E.g., @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 … or Lk; where each Li 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 … and neg Lk;
  @G L2 :- neg L1 and neg L3 and … and neg Lk;
  …
  @G Lk :- neg L1 and neg L2 and … and neg Lk-1;

  naf-free !

- **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.)

- **Still no reasoning by cases!!! Cf. unit/linear resolution strategy in FOL.**

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

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Complex AP Biology Examples

- **Causal process reasoning is a large portion of AP Biology, often requiring multi-step causal chains and/or multiple grain sizes of description to answer a question.**
- **Several such complex examples drawn from exams or textbooks have been successfully represented in SILK. E.g.:**
  - "A researcher treats cells with a chemical that prevents DNA synthesis from starting. This treatment traps the cells in which part of the cell cycle?"
    The correct answer is: G1 [which is a sub-phase of interphase]
  - "In some organisms, mitosis occurs without cytokinesis occurring. This will result in:
    a. cells with more than one nucleus
    b. cells that are unusually small.
    c. cells lacking nuclei.
    d. destruction of chromosomes.
    e. cell cycles lacking an S phase."
    The correct answer is: a. [two nuclei form in a cell, but no new cell wall splits the cell]
  - "Suppose the typical number of chromosomes in a human liver cell was 12. [Notice this is counterfactual; there are actually 46]. What would the typical number of chromosomes in a human sperm cell be?"
    The correct answer is: 6 [half of the number in the liver and most other organs]

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***

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Interchange of Hyper LP ← → 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:

Hyper LP		FOL
@G E ;	←	E ;
@G F :- B ;	→	F <== B ;

(E, F, and B are formulas. Certain restrictions apply: the formulas must be universal. The prioritization tag G is a term.)

- **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"* FOL, OWL, Common Logic, SBVR

* via skolemization