Version of Feb. 2, 2009, incorporating typo fixes

Hyper Logic Programs in SILK:
Redefining the KR Playing Field
for Business and VLKB

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Invited Keynote presentation at RuleML-2008**

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** The International RuleML Symposium in Rule Interchange and Applications,
http://2008.ruleml.org

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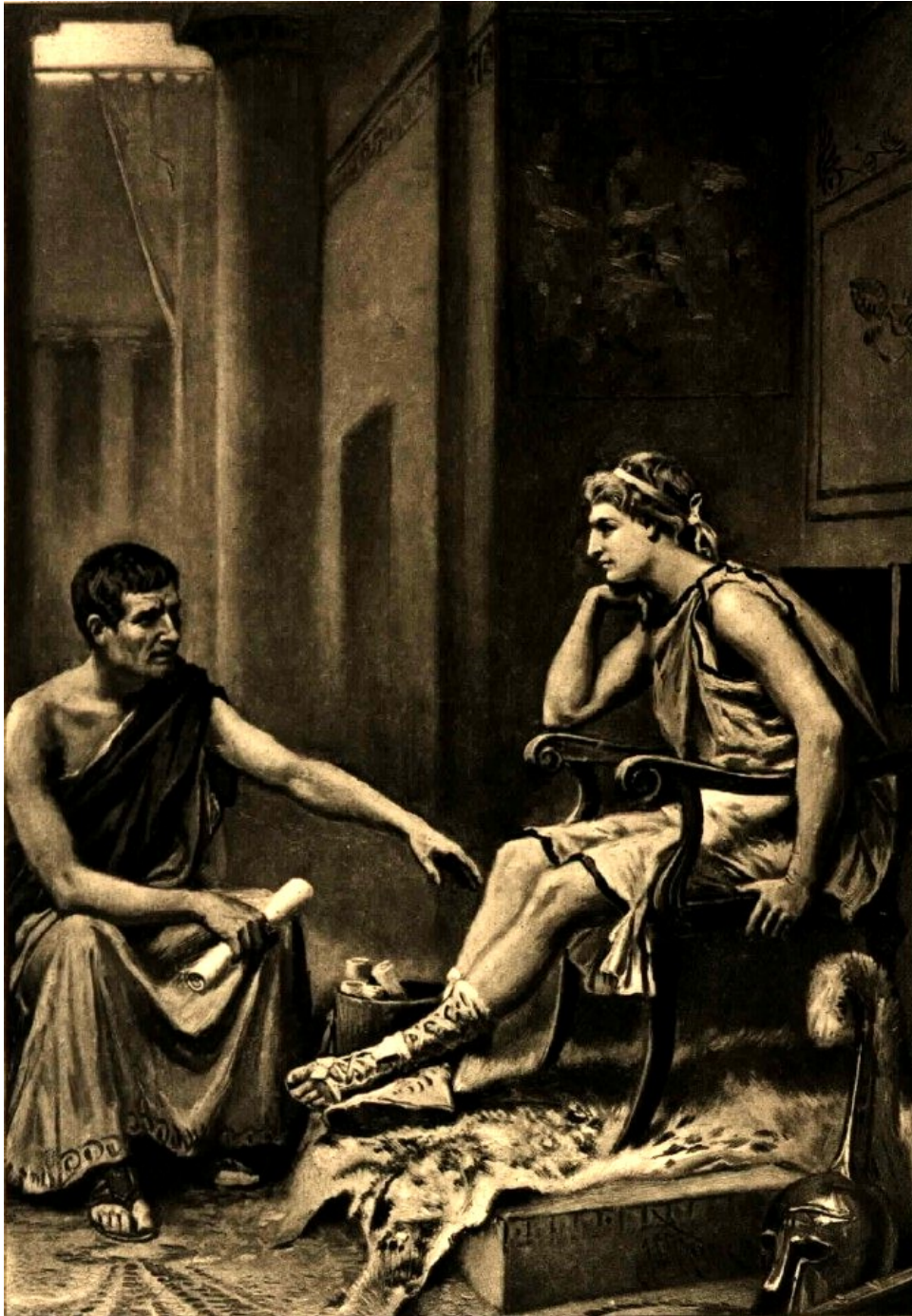
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Outline of Talk

- **Introduction**
  - Project Halo
- **SILK**
  - Overall Approach, Vision, Goals, and Plan
  - Hyper Logic Programs KR
- **Conclusions**
  - How You can be Involved

Project Halo Starts

- Begun by Vulcan in 2002

- Vision of Digital Aristotle
    - Put the bulk of the world's scientific and similar knowledge on-line
    - Answer questions, act as personal tutor, with deep reasoning

Aristotle Tutoring Alexander

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Project Halo Builds

- How to operationalize Digital Aristotle as a research effort?

- College-level science
  - Selected as initial domain focus
  - Medium wide, medium deep
  - Good metrics available: textbook-type exam questions

- Advanced Placement Exam (AP) in Physics, Chemistry, and Biology
  - Selected as initial domain task metric focus
  - Taken by USA high-school students to get credit for 1st-year college courses

- AURA expert system developed
  - Novel combination of available techniques from AI
  - Controlled Natural Language, GUI, Frame-based KR, Problem-Solving
  - Students as users
  - Initial version 2004, then refined extensively and tested rigorously
  - For recent info, see http://www.ai.sri.com/project/aura

Another Bit of Inspirational Ancient History ...

- "It's the Economy, Stupid!"

- Campaign slogan that helped Clinton beat Bush in 1992 US presidential election. Despite military success in the Persian Gulf war in 1991, the US economy suffered a recession later in 1991.
  - E.g., see http://en.wikipedia.org/wiki/It's_the_economy,_stupid

Focus That Emerged during AURA Refinement

- "It's the <u>Knowledge Acquisition</u>, Stupid!"

- Big challenge:
  - How to enable Subject Matter Experts (SMEs), rather than Knowledge Engineers (KEs), to interact to:
    - State questions
    - Understand answers and explanations
  - How to reduce cost via KA by SMEs not KEs
    - Scaleability w.r.t. domains
    - Incrementally refine the knowledge base
    - Lower the cost of a textbook page of knowledge that users enter, edit, and utilize

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Enter the Semantic Web Era …

- **How to enable effective KA?**
  - + By <u>SMEs</u>
  - + <u>Collaboratively</u>
  - + Leveraging the <u>Web</u>

- **As a next step…**

- Halo Extension to Semantic MediaWiki (SMW+) **developed**
  - Open source extension of the MediaWiki software Wikipedia runs on
  - Supports RDF and OWL subset, interleaved tightly with hypertext
  - Rapid maturation of initial functionality
  - Strong community uptake, early commercial adoption already
  - For more, see http://wiki.ontoprise.de
  - Upcoming release includes simple semantic LP rules

- **Tool for mapping knowledge from SMW+ to AURA developed**
  - Import SME-entered knowledge about chemistry, for example

Meanwhile, on Another Battle Front …

- **Ran into limits of the KR in AURA**
  - Expressiveness
  - Understandability
  - Knowledge interchange
  - Performance scaleability of reasoning
    - Truth maintenance
    - Incompleteness
    - Web scale challenge

- **Ran into limits of the KR in SMW+, as well**
  - Expressiveness

Plus, Delving Deeper into KA Reveals …

- "It's the __Knowledge Representation__ too!"

- The underlying KR is the target for KA

- "The KR is the deep UI"

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  - Overall Approach, Vision, Goals, and Plan
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SILK KR Effort – High Level Goals

- ## Push the Frontier
  - ### High risk, high return

- ## Expressiveness +
- ## Semantics +
- ## Scaleability

- ## Address requirements for AURA on AP task
  - Understandability via semantics and expressiveness
  - Knowledge interchange via semantics and expressiveness

- ## Address requirements for longer-term Digital Aristotle vision
  - Leverage Web for knowledge acquisition and knowledge interchange
  - Wider set of domains and tasks

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**
  - 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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Vision for longer-term Impact

- Key KR infrastructure sufficient to enable creation of
    global, widely-authored, very large knowledge bases (VLKBs)
    about science and business
    that answer questions
    and proactively supply information,
    using powerful reasoning about rules and processes,
    that can be customized in their content and actions
    for individual organizations or people

"SILK" – The Name

- "**S**emantic **I**nferencing on **L**arge **K**nowledge"

- What the next generation Web will be spun from

SILK Effort Overview

- **Begun in 2008** (with preliminary studies in late 2007)
  - Part of Halo Advanced Research (HalAR), the new half of Project Halo
- **Largest rule research program in the US** (that we're aware of)
  - Primarily via contractors
- **Structured Knowledge as initial focus**
- **KR System with multiple software components**
  - Logical Language, incl. Syntax and Semantics
  - Reasoning, incl. Backward and Forward Inferencing
  - Web Knowledge Interchange, incl. Translators
  - KA/UI Support, incl. for Editing and Explanation
- **Evolutionary Approach**
  - Start from known core KR
  - Add more features in principled fashion
  - Requirements, use cases, benchmarking, KB building;
    system design (incl. theory, usability), implementation, testing (incl. task)

SILK Contributors current/past (partial list)

- Vulcan (Benjamin Grosof, Mark Greaves, Dave Gunning)
- Stony Brook University (Michael Kifer; students S. Liang, H. Wan, P. Fodor)
- SRI International (Vinay Chaudhri, David Martin, Ken Murray, Bill Jarrold)
- BBN Technologies (Mike Dean)
- Ontoprise GmbH (Raphael Volz, Jurgen Angele, Daniel Hansch)
- Automata (Paul Haley)
- Cycorp (Keith Goolsbey, Doug Lenat, Ben Rode)
- Boeing (Peter Clark)
- University of Texas (Bruce Porter)
- University of Toronto (Sheila McIlraith; students H. Ghaderi, S. Sohrabi)
- University of Amsterdam (Bert Bredeweg)
- University of Freiburg (Georg Lausen)
- University of Michigan (Michael Wellman)
- Richard Fikes, consultant (Stanford University)
- (More to come in 2009)

SILK-relevant Cooperations (partial list)

- Project Halo has cooperations with other major research efforts:

- LarKC (The Large Knowledge Collider), funded by EU
  - http://www.larkc.eu

- NeOn (Lifecycle Support for Networked Ontologies), funded by EU
  - http://www.neon-project.org

- DARPA

SILK Language Starting Point is LP

- **Declarative Logic Programs (LP) is starting point for SILK language**
  - Normal LP, with well-founded semantics.   A rule has the form:
    - H :- B_1 and … and B_k and naf B_{k+1} and … and naf B_m .   (H, B_i are atoms)

- **It's the core logical KR of structured knowledge management today**
  - **Databases**
    - Relational / SQL
    - XML semi-structured / XQuery
    - RDF semi-structured / SPARQL (triple stores)
  - **Semantic Rule Standards**
    - RuleML standards design
    - Rule Interchange Format (RIF)*
  - **Most commercial implementations of OWL ontologies**
    - Based on Description Logic Programs (DLP) + moderate extensions
    - Oracle, for example
    - OWL-2* RL "profile", i.e., Rules subset of OWL V2

W3C® WORLD WIDE WEB consortium

RuleML
Realize your Knowledge

* W3C draft standard

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More Rationale about LP as Starting Point KR

- Semantics available, but enables nonmonotonicity, unlike classical

- A multitude of small and large expressive extensions available
  - Can hope to combine defaults with most of the other major ones

- Can realistically hope to be web-scaleable performance-wise, unlike highly expressive classical
  - Polynomial computational complexity, under non-onerous restrictions
  - Many optimizations available
  - Established track record of high scaleability for relational databases

What One Gives Up by choosing LP as Starting Point

- ## "<u>Disjunction</u>", i.e., <u>Reasoning By Cases</u>
  - ### By contrast:
    - LP concludes (A or B)   only if   conclude A or conclude B.
    - LP prohibits disjunction in head of rule.

- ## Disjunction is a source of exponential computational complexity (worst-case), when unrestricted
  - Classical logic is NP-complete, even for propositional (3-SAT)
  - Major disjunctive LP approaches are too
  - Stable semantics for LP is too (for unstratified, when it diverges from well founded)

- ## Can hope to reintroduce it in restricted or altered form, or develop work-arounds

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Major SILK Requirements on Expressiveness

- **Processes** *[For science, BPM. E.g., >50% of questions on Environmental Sci. AP.]*
  - Actions, Causality, Events, Reactivity, State Change

- **Defaults (beyond naf)** *[For many purposes, pervasively]*
  - Exceptions, Priorities, Inheritance, Strong Negation, Preventive Integrity Constraints
  - *For OO, robust KB merging/updating, process causality, policy and regulation/law, natural language incl. KA, import of classical, argumentation*

- **Object-Oriented and Frames** *[Convenient and familiar, e.g., RDF, UML, Aura]*
  - OO/Frame style syntax, Inheritance

- **Higher-order, incl. for Meta-reasoning** *[For many purposes, pervasively]*
  - *Convenient, concise abstraction for KR designers, and for KE/SME users*
  - *Many KRs have some of it, incl. RDF, OWL-Full, BRMS, Cyc. E.g., transitive_closure(?P).*
  - *Meta-reasoning uses include: KR macros, KB translation/import, ontology mappings, reasoning control, provenance, KB modularization, navigation in KA, multi-agent & nested belief, context, modals. Plus – the Web is about meta-data.*

Major SILK Expressive Requirements, continued

- **Import of External Knowledge** *[Knowledge, science, and business are societal]*
  - **Classical** as well as LP
  - Via Pull/Query, and Via Push/Events
  - From Web, built-ins, specialized local reasoners
  - *Classical uses include:*
    - *Background KBs, e.g., ontology, e.g., about processes*
    - *Existing techniques and KBs for equations, constraints, and processes*
    - *Common Logic (and KIF), SBVR, OWL, RDF*

More SILK Expressive Requirements

- **External Queries, Actions, and Events** *[For import/export and processes]*
  - Via **procedural attachments**. E.g., query **built-ins**.
  - Similar to production rules and Event-Condition-Action rules

- **Hypotheticals, incl. Counterfactuals** *[For processes and KA]*

- **Integrity constraints**
  - Report violations, Prevent violations

- **Lloyd-Topor (freer appearance of logical connectives)**
  - {and, naf, or, exists, forall, implies} in body, {and, implies, forall} in head

- **Skolemized existentials**

- **Aggregations, e.g., set_of, bag_of, count, total, average**

- **Equality, incl. complex explicit derived equalities/equations**

- **Inequalities and similar "constraints", incl. qualitatively**

SILK Other Reasoning Requirements

- Explanations: to users and machines
- Support Forward-Direction and Persistence in Inferencing
  - Persistent queries and conclusions
  - Truth Maintenance, handling nonmonotonicity and update/event flows
- Exploit Parallelism for inferencing performance
- Knowledge interchange, with translation between KRs/systems
  - Via Pull and Push, dynamically, over Web.
    - Data/Facts, Ontologies, Rules
  - Support relevant standards, therefore, e.g., RIF, OWL, RDF, Common Logic
  - Trust management
- *Live in a Distributed World, generally*

Strategy on Expressiveness

- **That's a Lot! Can We Do It? How?**
    - Where to Start?
    - How to Factor?

- **Opportunity**: newly combine tightly and synergize
                    several major strands of pure-research progress
                        in logical KR based on extensions of LP
                        from the last 20 years
    - Good stuff, but pieces on the floor

- **Build up expressiveness in layers (and by relaxing restrictions)**
    - Extend syntax and semantics as go

Hyper Logic Programs

- SILK uses a new KR: Hyper Logic Programs (HLP)
  - "Hyper" since it's Web (*hyper*text) centric, and it behaves *hyper*monotonically

- It integrates several major LP extensions never previously combined:

- Higher-order and Frames and Skolemization, cf. F-Logic

- + Defaults, cf. Courteous LP (and Defeasible Logic)
  - Newly generalized and modified approach

- + Weakened Full Classical Logic, cf. Hypermonotonic mapping
  - Greatly generalizes the approach of Description LP and OWL 2 RL
  - Unrestricted clauses, plus skolemization
  - Leverages Courteous feature
  - Give up disjunction / reasoning by cases, so is weakened
  - But behaves robustly in face of knowledge quality errors and conflictful merging

Hyper Logic Programs, continued

- HLP combines further a number of other extensions of LP, notably:

- Webizing, cf. RuleML and RIF
  - URIs for predicates and other logical constants
  - Load-time import of knowledge bases over the Web
- External Queries and Actions, cf. Production LP (and Situated LP)
  - Via procedural attachments. Including built-ins.
- External Events, via newly modified approach
- Equality, incl. explicit derived, via newly modified approach
- Lloyd-Topor, Aggregations, Integrity Constraints, misc. other features

- *HLP is still under development (there's a lot of new expressiveness)*

Basic Hypermonotonic Mapping
from Clausal FOL to/from NAF-Free Courteous LP

- An FOL clause C:

    L1 or L2 or … or Lk

    is mapped to k <u>directed</u> clauses, one for each choice of head literal:

    L1 :- neg L2 and neg L3 and … and neg Lk

    L2 :- neg L1 and neg L3 and … and neg Lk

    …

    Lk :- neg L1 and neg L2 and … and neg Lk-1

- This is called the *omnidirectional ruleset* for C, a.k.a. the *omni rule(s)*

- Conversely, a naf-free Courteous LP rule is mapped to FOL as a material implication, thus clausal. (It's fairly easy to stick to naf-free.)

- A KR S *behaves hypermonotonically* == S is nonmonotonic and when its premises are viewed classically, then entailment in S is sound but incomplete w.r.t. classical

    - Incompleteness is desirable when there's conflict

Examples of Hypermonotonic mapping

- /* Car rental: A driver ?p is approved only if ?p has a validated rental application. */
  - /* FOL: */ forall ?p.   validated(?p) <== approved(?p).

    becomes the ff. omnidirectional ruleset in Hyper LP:
  - neg approved(?p) :- neg validated(?p) .
  - validated(?p)   :-   approved(?p).
- /* Scheduling: Joe's meeting will be at 3pm or 4pm or 5pm today. */
    - /* FOL source: */   mtg(3p) or mtg(4p) or mtg(5p). /* becomes the ff. */
  - 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).
- /* OWL beyond DLP: A and B are disjoint.   P on C has min cardinality 1. */
    - /* FOL */   forall ?x. neg (A(?x) and B(?x)).
  - neg A(?x) :- B(?x).   /* Exploit neg . */
  - neg B(?x) :- A(?x).
  - P(?x, _# (?x)) :- C(?x).   /* Exploit skolemization feature. */
  - neg C(?x) :- neg P(?x,_# (?x)).

Hypermon Mapping from FOL++ to LP

- Greatly generalizes the approach of Description LP and OWL 2 RL
- Leverages Courteous feature of Hyper LP
- Covers unrestricted FOL clauses, plus skolemization, thus <u>full</u> FOL
- Can further add Frames and Hilog (and deontic etc. modals, esp. using Hilog)
- Thus can cover <u>full</u> OWL/RDF and Common Logic, most of SBVR
- Give up disjunction / reasoning by cases, so is <u>weakened</u>
- But Courteous/Hyper LP handles conflict robustly
  - Whereas FOL is <u>perfectly</u> brittle semantically in face of contradictions from …
  - Quality problems/errors in the data and knowledge
  - Conflict when merging KBs

  A VLKB with a million or billion axioms formed by merging from multiple Web sources, is unlikely to have <u>zero</u> KB/KA conflicts from
  - Human knowledge entry/editing, implicit context, updating cross-source, cross-source ontology interpretation, source trustworthiness, etc.

- *Weakening provides a <u>critical</u> advantage for VLKB scaleability*

Status of SILK Today – Highlights

- **Language** specification **(partial)**
  - Covers the majority of the key expressive features
  - Prototype parser
  - Semantics (draft) for generalized Courteous + Hilog
    - The most fundamental new aspect of Hyper LP

- **Use cases, incl. survey**
  - Science AP and business domains

- **Prototype Hyper LP rule engine**
  - Extends Flora-2 (F-Logic) system to add generalized Courteous

- **ReCyc: Rough prototype translator from Cyc to SILK**
  - 3 Million axioms from ResearchCyc

- *Near term steps on prototyping:*
  - *Integrate parser with engine*
  - *Add weakened classical (hypermonotonic mapping)*

Representing Process Models via Hyper LP

- There are a large number of process modeling KRs
  - UML (multiple components), Petri nets, Pi-calculus, messaging based, Golog, web services (WS-* multiple components), programming languages (Java, C++, C#, scripting languages), workflow languages, IDE tool languages, ...
- Wouldn't it be nice to have one semantic approach to capture these?
- Holy Grail of AI KR: combine classical and defaults
  - Need nonmonotonicity for the AI frame problem, i.e., causal actions having effects that override persistence
  - Need reasoning by cases for contingent branches / nondeterminism
- Hyper LP takes us part of the way
  - Combines defaults and weakened classical
  - Allows elegant formulation of basic process causality
  - *Under development: a higher-abstraction process description sub-language*
  - Do not yet have reasoning by cases

Example of Causal Process Reasoning in SILK

- /*   Toxic discharge into a river causes fish die-off.   */
- /* Initial facts, and "mutex" constraint that fish count has a unique value */
- occupies(trout,Squamish).
- fishCount(s0,Squamish,trout,400).
- !- fishCount(?s,?r,?f,?C1) and fishCount(?s,?r,?f,?C2) | ?C1 != ?C2.
- /* Action/event description that specifies causal effect on next state */
- {tdf1} fishCount(?s+1,?r,?f,0) :- occurs(?s,toxicDischarge,?r) and occupies(?f,?r).
- /* Persistence ("frame") axiom */
- {pe1} fishCount(?s+1,?r,?f,?p) :- fishCount(?s,?r,?f,?p).
- /* Action effect axiom has higher priority than persistence axiom */
- {pr1} overrides(tdf1,pe1).
- /* An action instance occurs */
- {UhOh} occurs(s0+1,toxicDischarge,Squamish).

- *As desired:* |= fishCount(s0+1,Squamish,trout,400) and
                        fishCount(s0+2,Squamish,trout,0).

Temporal Paradox Example (Science Fiction Time Travel)

- /*   joe travels back in time and shoots his parent before joe was conceived */

<div style="background:purple">

This SILK example is fun and takes expressive power.

It combines Higher-order + Courteous,
and is unstratified.

It runs correctly in the prototype Hyper LP rule engine.

</div>

- {pe} neg a(?x)(?s+1) :- neg a(?x)(?s).
- overrides(?r,pe) :- ?r != pe. /* persistence rules are lowest-priority */

- *As desired: |= the fluents caught up in the paradox all have truth value undefined:*
  a(p)(s2), neg a(p)(s2), a(j)(s3), neg a(j)(s3), t(j,s3,s1), f(j,p)(s1) all =u

For brevity, we write s0+1 as s1, s0+2 as s2, and s0+3 as s3
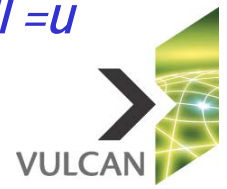
Temporal Paradox Example (Science Fiction Time Travel)

WWWe

- /* joe travels back in time and shoots his parent before joe was conceived */
- a(p)(s0). /* parent is alive in initial state s0, but joe is not */
- neg a(j)(s0).
- /* parent conceives joe if parent is alive in s2, so then joe is alive in s3 */
- a(j)(s3) :- a(p)(s2).
- /* if joe is alive in s3, then he time travels to s1..s2, then returns to s3 */
- t(j,s3,s1) :- a(j)(s3).
- /* if joe time travels, then he fires the gun at parent in s1 */
- f(j,p)(s1) :- t(j,s3,s1).
- /* if the gun is fired at parent in s1, then the parent is dead in s2 */
- neg a(p)(s2) :- f(j,p)(s1).
- /* persistence axioms about aliveness */
- {pe}   a(?x)(?s+1) :-   a(?x)(?s).
- {pe} neg a(?x)(?s+1) :- neg a(?x)(?s).
- overrides(?r,pe) :- ?r != pe. /* persistence rules are lowest-priority */

- *As desired: |= the fluents caught up in the paradox all have truth value undefined:*
  a(p)(s2), neg a(p)(s2), a(j)(s3), neg a(j)(s3), t(j,s3,s1), f(j,p)(s1) all =u

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For brevity, we write s0+1 as s1, s0+2 as s2, and s0+3 as s3

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Cyc "Microtheory Lifting" Example

- Cyc keeps its premises and conclusions in contexts called microtheories
- "Lifting" is transfer of beliefs between microtheories.
- Such transfer of beliefs may involve conflict.
- An axiomatization of such microtheory lifting is useful for
  - Translation of Cyc to SILK
  - Giving a better semantic account of Cyc
  - Merging translated Cyc knowledge with other knowledge
  - Learning from Cyc's design experience
- One principle in microtheory lifting is a kind of inheritance:
  - If a sentence S "is true" (ist) in microtheory M1, and M1 is a more general (scope) microtheory than M2, then S "is true" (ist) in M2.
  - If a microtheory is visible, and a sentence S "is true" in it, then S.
- This can be represented in Hyper LP via the ff. default rules (Hilog + Courteous):
  - ist(M2,S) :- genlMt(M2,M1) and ist(M1,S).
  - S :- ist(M,S) and visibleMt(M).

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SILK – Recap

- Vision: Key KR infrastructure for widely-authored VLKBs
           for science and business that answer questions,
           proactively supply information, and reason powerfully
- Goal: Expressiveness + Semantics + Scaleability + Web
- Focus: Defaults and Processes
- Hyper LP KR combines
  - Defaults and Weakened Full Classical (Import), cf. generalized Courteous LP
  - External Queries, Actions, Events, cf. generalized Production LP

  with
  - Higher-order, OO/Frames, and Skolemization, cf. Hilog and F-Logic
  - Lloyd-Topor and misc. other less glamorous features
- Status: language spec and prototype engine, for expressive heart

(Aimed) Broader AI Impacts of SILK and HaIAR

- Improve by orders of magnitude:
  - Scale of practical semantic default+actions reasoning
    - <~1000 rules ⟹ ?100,000+ rules
  - Collaboration costs of multifold KB merging when there's conflict (as is usual)
    - Can take human out of the loop at run time
  - Population of users capable of specifying semantic rules
    - "KR Power to the People!" Leverage Aura and SMW+ KA/UI front-ends.

- Synergize best of last 20 years of pure-research progress in LP KR
  - ⟹ Redefine KR playing field of semantic web, business rules, & process management

- Provide a key missing research piece for SOA / web services
  - Enable building shared business/govt KBs on processes & policies ⟹ virtuous circle

Key KR infrastruct. for widely-authored VLKBs for science and business
that answer questions, proactively supply information, and reason powerfully

Lay Foundations to Attack the Really Tough Further Brittleness Areas

The initially targeted areas are all needed as foundations for:
- Probabilistic and statistical reasoning

All the ff. areas depend largely on Probabilistic:
- Induction – e.g., in science, web mining, …
- Inexact and Qualitative
- Analogy
- Natural Language Understanding
- Design of Experiments

Key Next Challenges for SILK (partial list)

- Parallelism in reasoning

- Disjunction in expressiveness

- Exploiting natural language in user interaction

Coverage Goes Global?

Waystation:

- Prospects for the SILK approach to effectively
  interchange and integrate
  a high percentage of the world's structured knowledge
  starting from today's legacy forms
  (databases, data models, BRMS, semantic web, process models, AI)

- *What do YOU think?*

SILK Directions: Spec and Software

- **Intend to involve the broader R&D community in feedback on the language design**
  - Initial draft will be circulated probably by early 2009

- **Intend to release much or all of the software under a license that is free for research use**
  - Initial version probably sometime in 2009
  - Considering making it open source, but decision on that will not come until probably sometime in 2009

How You can be Involved

- General Contact: Benjamin Grosof benjaming@vulcan.com
  - Suggest design, use cases, contractors for work packages, cooperations

- Visit the SILK webpage and sign up for the mailing list so you'll be alerted of announcements about SILK
  - URL: http://silk.projects.semwebcentral.org
  - Mailing list: silk-announce@semwebcentral.org (very low volume)

- Provide comments on SILK language design
  - Initial draft will be circulated by probably early 2009

- Try out SILK software
  - Initial prototype, free for research use, available probably some time in 2009
  - Also SMW+ upcoming release has simple semantic LP rules of SILK-y flavor

Acknowledgements

- SILK contributors
  - (previously listed)

- Contributors to several key previous KR efforts
  - RuleML and SWSL (Semantic Web Services Language) standards designs
  - SweetRules and Flora-2 systems

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SILK –
What the next generation Web will be spun from

Thank You

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