DAML Rules
Report for PI Mtg. May 2004

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BBN Technologies

Presented at DAML PI Mtg., May 25, 2004, New York City

OTHER PRESENTATIONS ON RULES IN TODAY'S SESSIONS

- SWRL V0.5 overview by Peter Patel-Schneider
- SWRL V0.6 overview by Mike Dean
- SWRL Implementation (incl. Hoolet) by Ian Horrocks
- WWW-2004 DevDay Rules Track Overview by Harold Boley

Usage Comments about SWRL V0.6

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Usage Comments about SWRL V0.6

- Outline:
  - Expressiveness
  - "Warning Label"
  - *Later today:* Implementation strategy

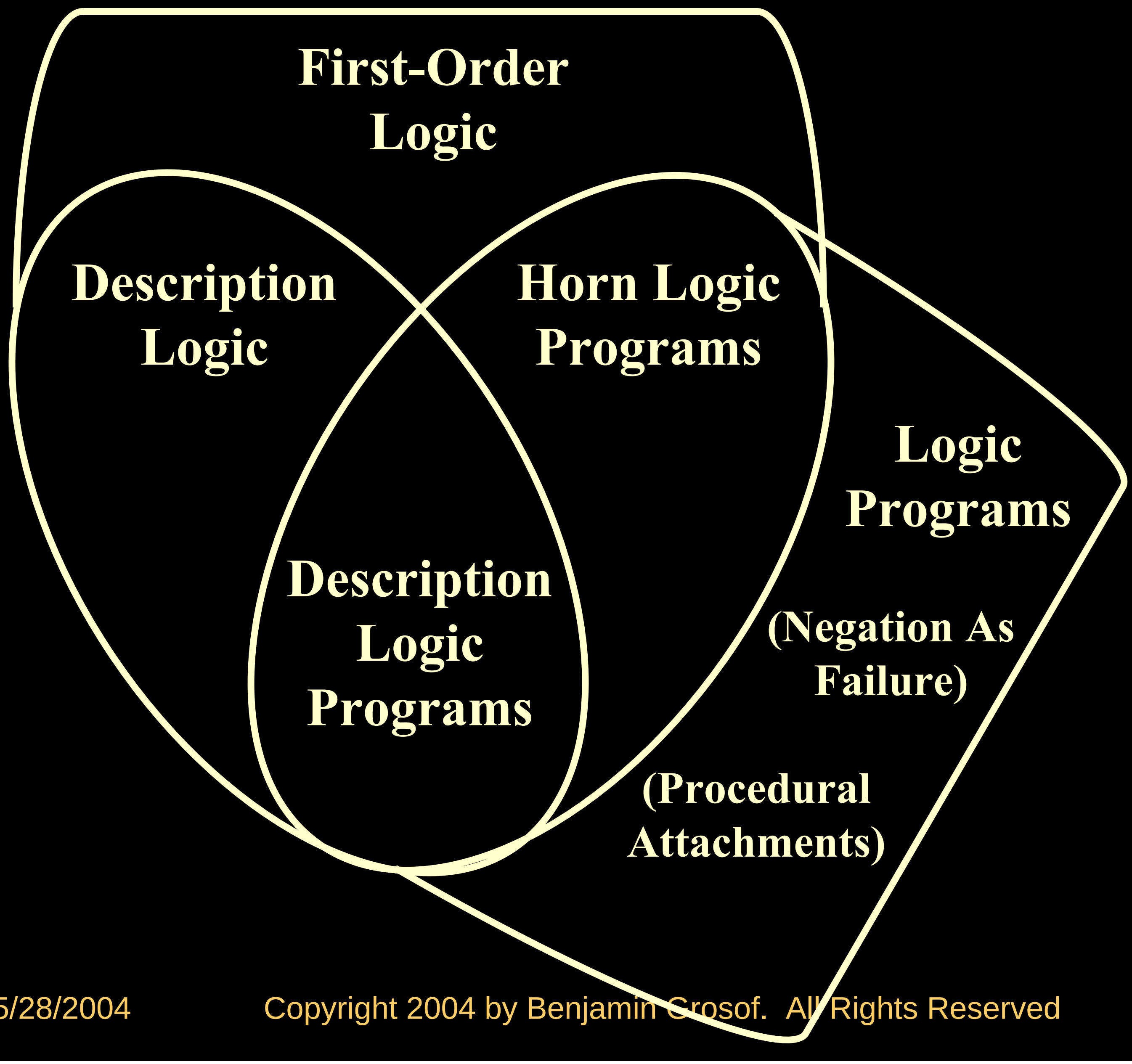
Expressiveness of SWRL (V0.6)

SWRL expressiveness =

1. OWL-DL (i.e., SHOIQ Description Logic (DL) which is an expressive subset of FOL)
2. \+ Horn FOL rules, with no logical functions, where each predicate may be:
   - OWL named class (thus arity 1)
     - More generally, may use a complex class, but this is expressively inessential – can just replace by a named class and define that named class as equivalent to the complex class.
   - OWL property (thus arity 2)
   - OWL data range (thus arity 1)
     - RDF datatype
     - set of literal values, e.g., {3} or {1,2,3,4,5} or {"Fred","Sue"}
3. \+ some built-ins (mainly XML-Schema datatypes and operations on them)
   - This is new with V0.6
   - (All have arity 1 or 2.)
   - Plan: the set of built-ins is extensible

- The fundamental KR is an expressive subset of FOL
  - We'll call it "DH" here. (It doesn't have a real name yet.)
  - Its expressiveness is equivalent to: DL + function-free Horn.

Venn Diagram: Expressive Overlaps among KR's



"Warning Label"

1. The Theory of DH is Little Explored Territory as a KR.
   - In its full generality, DH is a relatively unstudied fragment of FOL.
   - Its worst-case computational complexity is undecidable and is not known to be better than that of full FOL (e.g., for the propositional case).
   - There are not yet efficient algorithms known for inferencing on it "natively" as a KR.

2. To ensure extensibility of SWRL rulebases to include LP features that go beyond Horn expressiveness, restrict the OWL ontologies used within SWRL to be in the DLP subset of OWL-DL. E.g.:
   - If you want to use nonmonotonicity / negation-as-failure / priorities in your rules
   - If you want to use procedural attachments that go beyond the SWRL built-ins
     - E.g., effectors/actions with side effects

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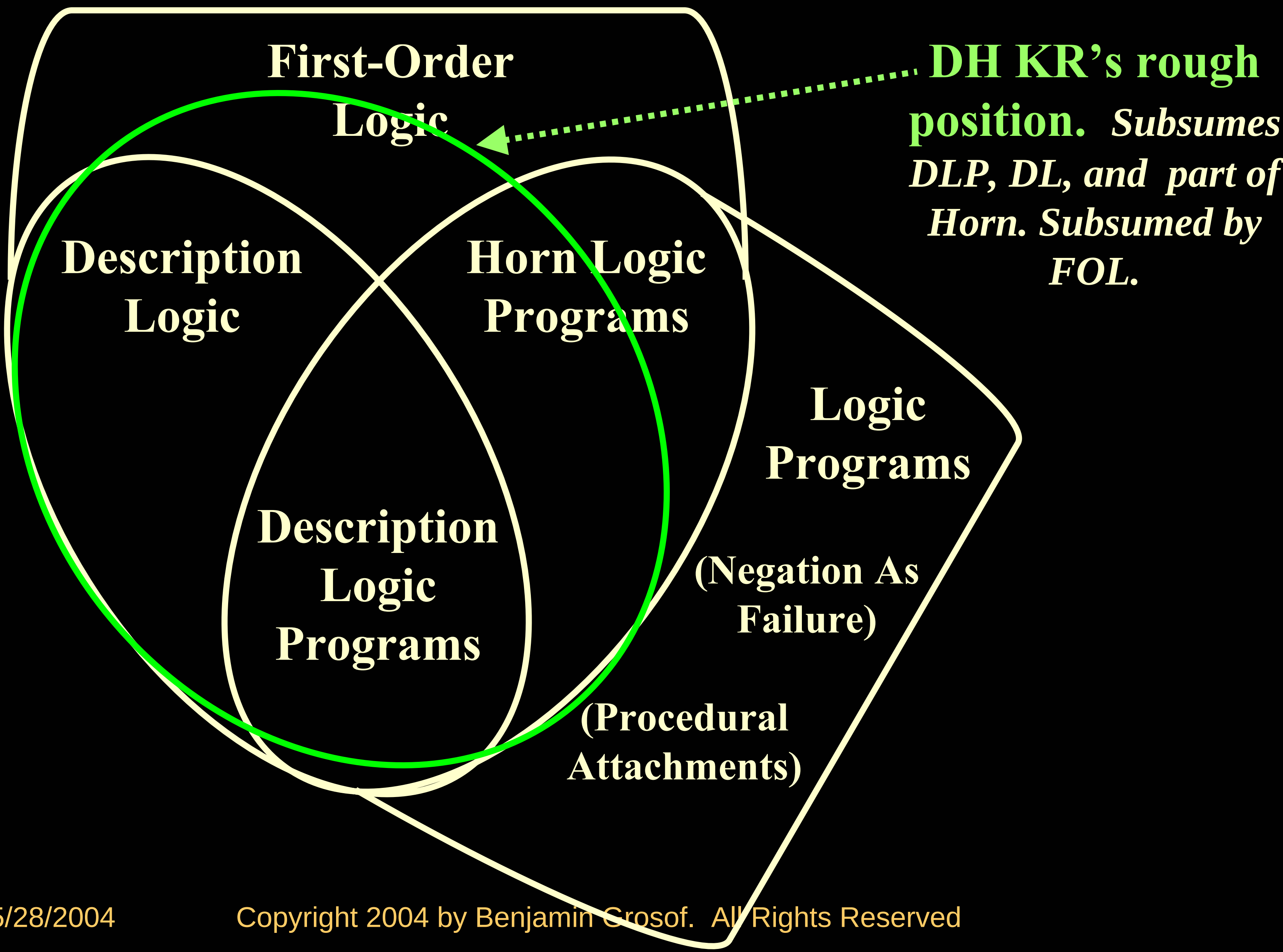

Design Perspective

Alternative points in design space:

1. partial LP + full DL = SWRL V0.6

versus

2. full LP + partial DL = SCLP RuleML V0.8+ (with DLP OWL2RuleML)

(SCLP = Situated Courteous Logic Programs KR)

DAML
Tools for Rules
Next-Phase Plan

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WWW-2004 DevDay last week

- Way cool!
- Lots of tools and use cases now!

- Themes:
  - Mostly LP/RuleML expressible rules
  - Many combine LP or HornFOL rules with OWL ontologies or OO syntax

DAML Rules Plan Overview

- Vision: studio for developers, studio for rule authors and users
- Approach: Composable Tools Suite supporting RuleML/SWRL
  - inferencing, translation/interoperability, authoring, testing
- Infrastructure: SemWebCentral, SWeDE
- MIT Sloan (Benj. Grosof lead) : SweetRules RuleML tools:
  - translation and inferencing; architecture for suite integration
- BBN (Mike Dean lead): SWRL tools:
  - translator to Jena2; editor; validator
- Stanford (Mark Musen lead): Protégé support for rule authoring
- More about Implementing SWRL
- *Later: More about FOL*
- Others Very Much Invited!
  - some good candidates: those presented at WWW-2004 Developers Day Rules on the Web Track

MIT Sloan Plan:

SweetRules:
Tools for RuleML Inferencing and Translation

Outline

- Concept, Architecture, and Goals
- Rule and Ontology Languages/Systems involved
- Capabilities and Components Today
- More about Combining Rules with Ontologies
- Application Scenarios and Examples
- Plans
- Motivations, revisited: Conclusions and Directions
- Acknowledgements
- Resources

Context and Players

- Part of SWEET = "<u>S</u>emantic <u>WE</u>b <u>E</u>nabling <u>T</u>ools" (2001 –)
  - Other parts:
    - SweetDeal for e-contracting
      - Which uses SweetRules
- <u>Cross-institutional. Collaborators invited!</u>
  - Originated and coordinated by MIT since 2001
  - Code by MIT, UMBC, U. Karlsruhe, U. Zurich
  - Uses code by IBM, SUNY Stonybrook, Sandia Natl. Labs, Helsinki
  - More loosely, several other institutions cooperating: BBN, NRC/UNB, Stanford
  - Many more are good targets: subsets of Flora, cwm, Hoolet, ROWL, Triple, Jena, DRS, KAON (main), JTP, SWI Prolog, ...

Concept, Architecture, and Goals

- Concept and Architecture: Tools suite for Rules and RuleML
  - Translation and interoperability between heterogeneous rule systems (forward- and backward-chaining) and their rule languages/representations
  - Inferencing including via translation between rule systems
  - Authoring and testing of rulebases
  - Open, lightweight, extensible, pluggable architecture overall

- Goals:
  - Research vehicle: embody ideas, implement application scenarios (e.g., contracting, policies)
    - Situated Courteous Logic Programs (SCLP) KR
    - Description Logic Programs (DLP) KR which is a subset of SCLP KR
  - Proof of concept for feasibility, including of translations between heterogenous families of rule systems
    - Encourage others: researchers; industry esp. vendors

SweetRules Overview

Key Ideas:

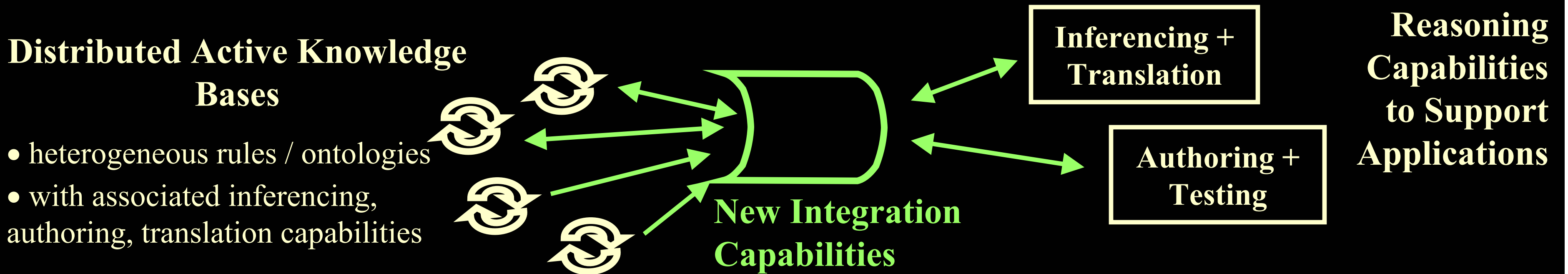
– Unite the commercially most important kinds of rule and ontology languages via a a new, common knowledge representation (SCLP) in a new standardized syntax (RuleML), including to cope with *heterogeneity* and resolve contradictory *conflicts*.
  - Capture most of the useful expressiveness, interoperably and scalably.

– Combine a large *distributed* set of rule and ontology knowledge bases that each are *active:* each has a different *associated engine* for reasoning capabilities (inferencing, authoring, and/or translation).

– Based on recent fundamental KR theory advances, esp. Situated Courteous Logic Programs (SCLP) and Description Logic Programs.
  - Plus semantics-preserving translations between different rule languages/systems/families

Application Areas (prototyped scenarios):

– Policies and authorizations; contracting, supply chain management; retailing, customer relationship management; business process automation and e-services; financial reporting and information; etc.



RuleML KR Expressiveness

- SweetRules supports: RuleML in its highly expressive Situated Courteous Logic Programs (SCLP) extension, V0.8
  - Horn LP …
  - \+ Negation-As-Failure = "Ordinary" LP (OLP)
  - \+ Courteous feature: prioritized conflict handling (partially ordered priorities, mutual exclusion integrity constraints, e.g., for partial-functionality; limited classical negation of atoms, e.g., p vs. not-p in heads)
  - \+ Situated feature: procedural attachments
    - Sensors: external queries when rule body atoms are tested
      - Built-ins in SWRL V0.6 correspond to sensors.
    - Effectors: external actions triggered when rule head atoms are concluded
- RuleML also supports *referencing* OWL/DAML+OIL ontologies
    - URI predicate name (in RuleML rule) refers to class or property (in OWL axioms)
  - This was pioneered in SweetDeal using SweetRules
  - The same approach was then taken in SWRL V0.5+

Rule and Ontology Languages/Systems That Interoperate via SweetRules and RuleML, Today

1. RuleML
   – SCLP extension, V0.8
2. XSB (the pure subset of it = whole Ordinary LP)
   – Backward. Prolog. Fast, scalable, popular. Good support of SQL DB's (e.g., Oracle) via ODBC backend. Full well-founded-semantics for OLP. Implemented in C. By SUNY Stonybrook. Open source on sourceforge. Well documented and supported. Papers.
3. Jess (a pure subset of it = a large subset of Situated Ordinary LP)
   – Forward. Production Rules (OPS5 heritage). Flexible, fast, popular. Implemented in Java. By Sandia National Labs. Semi-open source, free for research use. Well documented and supported. Book.
   – *Uses recent novel theory for translation between SOLP and Production Rules.*
4. IBM CommonRules (whole = large subset of stratified SCLP)
   – Forward. SCLP. Implemented in Java. Expressive. By IBM Research. Free trial license, on IBM AlphaWorks (since 1999). Considerable documentation. Papers. Piloted.
   – Implements the Courteous Compiler (CC) KR technique.
     • which reduces (S)CLP to equivalent (S)OLP, tractably.
   – Includes bidirectional translators for XSB, KIF, Smodels.
   – Its overall concept and design was point of departure for several aspects of SweetRules

Rule and Ontology Languages/Systems That Interoperate via SweetRules and RuleML, Today, continued

5. Knowledge Interchange Format (KIF) (a subset of it = an extension of Horn LP)
   - First Order Logic (FOL). Semi-standard, morphing into Simple Common Logic ISO standard. Several tools support, e.g., JTP. Research language to date.
     - Note: FOL is superset of DLP and of SWRL's fundamental KR.
6. OWL (the Description Logic Programs subset)
   - Description Logic <u>ontologies</u>. W3C standard. Several tools support, e.g., FACT, RACER, Jena, Hoolet, etc.
   - *Uses recent novel DLP theory for translation between Description Logic and Horn LP.*
7. Process Handbook (large subset = subset of SCLP)
   - Frame-style object-oriented <u>ontologies</u> for business processes design, i.e., for services descriptions. By MIT and Phios Corp. (spinoff). Large (5000 business processes). Practical, commercial. Good GUI. Open source license in progress. Available free for research use upon request. Includes extensive textual information too. Well documented and supported. Papers. Book. Dozens of research users.
   - *Uses recent novel SCLP representation of Frames with multiple default inheritance.*
8. Smodels (NB: somewhat old version; large subset = finite OLP)
   - Forward. Ordinary LP. Full well-founded-semantics or stable semantics. Implemented in C. By Helsinki univ. Open source. Research system.

Capabilities and Components Today

- Translators in and out of RuleML:
  - RuleML ↔ {XSB, Jess, CommonRules, KIF, Smodels}
  - RuleML ← {OWL, Process Handbook} (one-direction only)
  - SOLP RuleML ← SCLP RuleML (Courteous Compiler)
- Inferencing engines in RuleML via translation:
  - Simple drivers translate to another rule system, e.g., CommonRules, Jess, or XSB, then run inferencing in that system's engine, then translate back.
  - Observation: Can easily combine components to do other kinds of inferencing, in similar indirect style, by combining various translations and engines.
- Authoring and Testing front-end: currently rudimentary, partial
  - Command-line UI + Dashboard GUI with set of windows
  - Edit rulebases. Run translations. Run inferencing. Compare.
  - Edit in RuleML. Edit in other rule systems' syntaxes. Compare.
  - View human-oriented presentation syntax. View XML syntax. (Future: RDF.)

Capabilities and Components Today, cont.'d

- Uses Courteous Compiler to support Courteous feature (prioritized conflict handling) even in systems that don't directly support it, as long as they support negation-as-failure
  - E.g., XSB Prolog, Jess, Smodels
  - Uses Courteous Compiler component from IBM CommonRules
- Uses IBM CommonRules translators: CommonRules ↔ {XSB, KIF, Smodels}
- Some components have distinct names (for packaging or historical reasons):
  - SweetJess translation and inferencing RuleML ↔ Jess
    - Available upon request free for research use as download.
  - SweetOnto translation RuleML ← OWL
    - Available currently as part of KAON open-source code base, called "DLP" component there
- Code base: Java, XSLT, shell scripts (for testing drivers)

More about Combining Rules with Ontologies

There are several ways to use SweetRules to combine rules with ontologies:

1. By reference: via URI as name for predicate
2. Translate DLP subset of OWL into RuleML
   - Then can add SCLP rules
     - E.g., add Horn LP rules and built-in sensors ⇒ interesting subset of the SWRL V0.6 KR
     - E.g., add default rules or procedural attachments
3. Translate non-OWL ontologies into RuleML
   - E.g., object-oriented style with <u>default inheritance</u>
     - E.g., Courteous Inheritance for Process Handbook ontologies
4. Use RuleML Rules to map between ontologies
   - E.g., in the spirit of the Extended COntext Interchange (ECOIN) approach/system.
   - SWRL V0.6 good start for mapping between non-DLP OWL ontologies.

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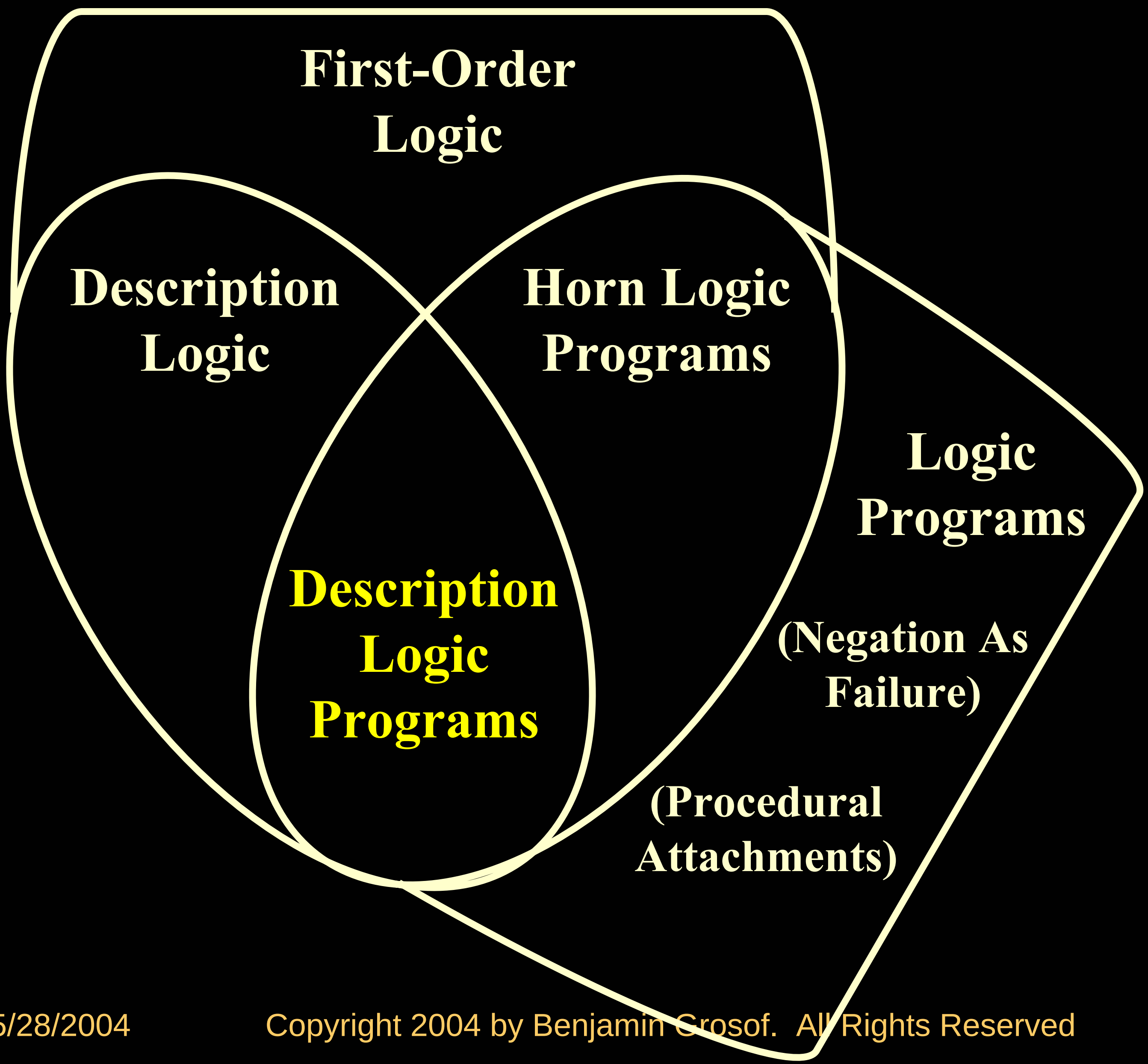

Some New Research Application Scenarios for Rule-based Semantic Web Services

- SweetDeal [Grosof & Poon WWW-2003] configurable reusable e-contracts:
  - Represents modular modification of proposals, service provisions
    - LP rules as KR. E.g., prices, late delivery exception handling.
    - On top of DL ontologies about business processes from MIT Process Handbook
  - Evolved from EECOMS pilot on agent-based manufacturing SCM
    ($51M NIST ATP 1996-2000 IBM, Boeing, TRW, Vitria, others)

- Financial knowledge integration (ECOIN) [Firat, Madnick, & Grosof 2002]
  - Maps between contexts using LP rules, equational ontologies, SQL DB's.

- Business Policies:
  - Trust management (Delegation Logic) [Li, Grosof, & Feigenbaum 2003]: Extend LP KR to multi-agent delegation. Ex.: security authorization.

SweetRules Tools Available Now

- Available currently:
  - SweetJess
  - SweetOnto = KAON's DLP component
- Rest of Suite being updated and prepared for release on SemWebCentral

SweetRules Plans

- Update, integrate, and polish suite overall
- Support latest versions of RuleML and CommonRules
- Open source on semwebcentral.org
- Scenarios: Explore applications in SW Services, e.g., trust policies, contracting, monitoring, semantic interoperability mappings
- Requirements analysis

SweetRules Plans, cont.'d

- Pluggable architecture for Rules tools
  - SemWebCentral aspects
  - SWeDE aspects
  - Eclipse wrappers for tools
  - Ontology of tools
  - Composition patterns, high-level interfaces design

SweetRules Plans, cont.'d

- Additional Goals:
  - *Via suite integration:* More interoperability between SWRL and RuleML
  - *Ongoingly:* Update RuleML spec in synch with SWRL spec (in RuleML Initiative, Joint Committee)
  - *Via suite integration:* More authoring/UI capabilities

SweetRules Plans, longer-term

– *Later:* Justifications and proof, e.g., via suite integration with InferenceWeb
– *Later:* More wrt additional kinds of rule systems:
  - ECA rules, SQL (needs some theory work, e.g., events for ECA)
  - RDF-Query and XQuery
– *Later:* More wrt connections-to / support-of web services:
  - Importing knowledge bases / modules, procedural attachments, translation/inferencing, events, …

SweetRules Groups/People

- Collaborators: Said Tabet, RuleML; Mike Dean, BBN; Mark Musen, Stanford; Harold Boley, NRC/UNB

- More Collaborators Invited!
  - Many more rule/ontology systems are good targets for interoperation/translation:
    - Flora, cwm, ROWL, Hoolet, Triple, DRS, KAON, JTP, SWI Prolog, …

Resources

- See papers, talk slides, and links at http://ebusiness.mit.edu/bgrosof
- ../#RecentSoftware : Links to SweetJess, SweetOnto, CommonRules (where can download)
- ../#RecentPapersByTopic : (for most below, there are earlier versions too)
  - "Representing E-Commerce Rules Via Situated Courteous Logic Programs in RuleML", *Electronic Commerce Research and Applications*, 2004.
  - "SweetDeal: Representing Agent Contracts With Exceptions using Semantic Web Rules, Ontologies, and Process Descriptions", *International Journal of Electronic Commerce*, to appear summer 2004.
  - "Description Logic Programs: Combining Logic Programs with Description Logic", WWW-2003.
  - "SweetJess: Inferencing in Situated Courteous RuleML via Translation to and from Jess Rules", 2003 working paper updating RuleML-2002 Workshop paper.
  - "A Declarative Approach to Business Rules in Contracts: Courteous Logic Programs in XML", EC-99.
  - "Beyond Monotonic Inheritance: Towards Semantic Web Process Ontologies", 2003.
  - "SWRL: A Semantic Web Rules Language Combining OWL and RuleML", 2004.
- RuleML http://www.ruleml.org
- DAML Rules http://www.daml.org/rules
- Joint Committee http://www.daml.org/committee
- SemWebCentral http://www.semwebcentral.org

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- More about Implementing SWRL
- *Later: More about FOL*
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More about Implementing SWRL

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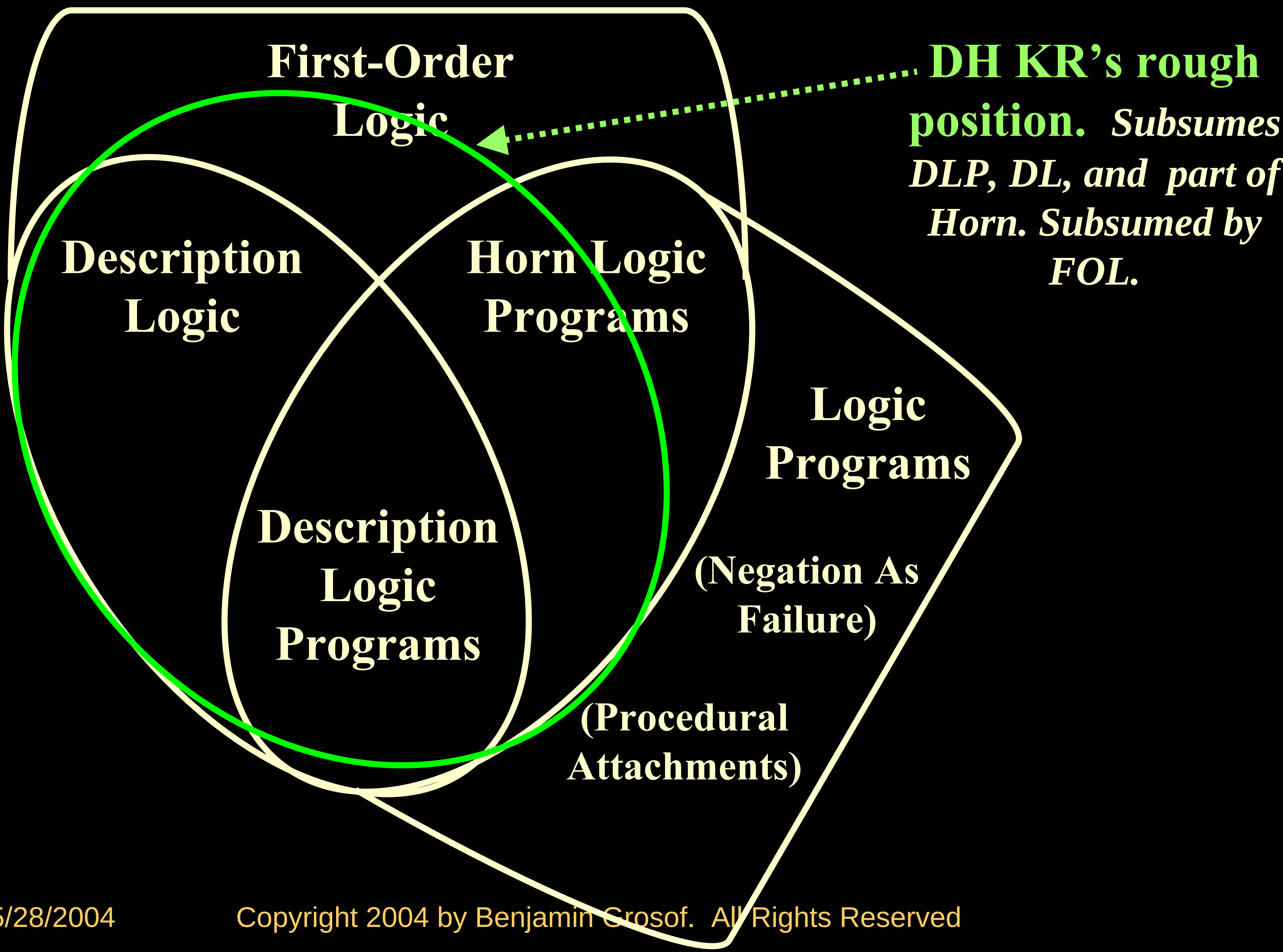

Design Perspective

Alternative points in design space:

1. partial LP + full DL = SWRL V0.6

versus

2. full LP + partial DL = SCLP RuleML V0.8+

(with DLP OWL2RuleML)

(SCLP = Situated Courteous Logic Programs KR)

More SWRL Implementation Strategy

- Named-classes-only restriction on SWRL rules simplifies implementation including translation to rule systems (e.g., RuleML, Jess, XSB), yet does not sacrifice fundamental expressiveness.
  - Both current implementations of SWRL do this.

- Can translate full SWRL / DH ⇒⇒ FOL for which "native" (general-purpose) reasoners are indeed available.
  - E.g., OTTER or Simple Common Logic / KIF
  - The Manchester implementation of SWRL does this.
  - Drawbacks:
    - General-purpose FOL reasoners are often not very efficient.
    - Today, they also usually don't directly support Webized syntax.

More SWRL Implementation Strategy, cont.'d

- Can translate subset of SWRL / DH into a KR for which "native" reasoners are indeed available. E.g.:

1. Horn LP expressible subset ⇒⇒ LP, e.g., RuleML, Jess, XSB

– E.g., Horn LP SWRL rules + DLP OWL ontologies
  - Horn LP restriction on the SWRL rules means that:
    – rules are named-classes-only (no complex class expressions appear)
    – rules are definite (consequent is non-empty); and
    – ground atomic conclusions suffice.
  - The BBN implementation does this (Horn rules ⇒⇒ Jess)

2. DL-expressible subset of DH ⇒⇒ DL, e.g., OWL

– E.g., DLP SWRL rules + any OWL-DL
  - E.g., SWRL rules are used to define some ontologies
  - No implementation of this is yet available.

More about SWRL V0.6 Built-Ins

- The built-ins (3.) can be viewed as predicates/relations that have a fixed extension.
  - Alternatively, the set of tuples satisfied by calls to the built-ins can be viewed as corrresponding to a virtual fact set adjoined to the FOL theory.
- These are similar to sensors in Situated Logic Programs RuleML.

- The built-ins can be implemented via procedural attachments that are purely informational (free of side effects)
  - Intuitively, they are typically evaluated when rule body is tested.

Punchline on Near-term Implementation Strategy

- (Unless you can invent a whole new technique…)

1. If you want full SWRL expressiveness, translate to some FOL syntax and then use a FOL theorem-prover to do inferencing.

2. If you want to translate to LP to exploit one of the many LP rule engines available (e.g., RuleML, Jess, XSB), or to exploit beyond-Horn LP expressive features (e.g., nonmon or actions), then restrict the SWRL ontologies to DLP.
   - RuleML is the obvious choice of translation target: it's SWRL's extension in direction of fuller LP expressiveness, and facilitates translations to multiple other rule languages' engines (e.g., Jess, XSB).
   - SweetOnto tool (a.k.a. KAON DLP package) translates DLP OWL to RuleML. (There are other DLP implementations too.)

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Getting Involved!

- Please contact Benjamin Grosof and Mike Dean (DAML Rules co-chairs) with your rules …
- Tools
- Ideas
- Rulebases
- Use cases
- Other resources
- Relevant plans

SWSI Rules

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SWSL Plan includes large role for Rules

- LP Rules together with Ontologies, for “SCAMP” group of tasks:
  - Trust Policies representation, enforcement: Security, privacy, authorization, access control
  - Contracting: contracts, advertising and some matchmaking, proposals, requests for proposals, some negotiation (modification of proposals)
  - Monitoring: exception handling, compliance, problem resolution, compliance
    - With Trust policies or Contracts
- LP or FOL Rules together with Ontologies for Semantic Interoperability: data mappings, ontology translation
- LP or FOL Rules together with Ontologies, for Process Models
  - OWL-S Preconditions and Effects
  - PSL-style Process Models

Outbrief from SWSL group

at SWSI F2F

May 24, 2004

Deliverable

Single document covering both:

1. OWL-S Profile + Atomic Process + Grounding, enhanced with Rules
2. Process model with concepts from the core of PSL that replaces the OWL-S (composite) Process model

Target date: September 30, 2004

Target place: W3C (e.g., Member Submission)

The Why and How of Near-term Impact in SWS's

- Policies in Security/Trust, Contracts, Advertising, Monitoring
  - Combine rules + ontologies in LP
  - Extend OWL-S profile
- Verification of process properties, compatibility; and enactment
  - Combine ordering constraints with pre-conditions/effects as in PSL
  - Extend OWL-S grounded atomic processes
  - Longer term: (semi-)automated composition

SCAMP drill down: Goals of Version1

- Key foci
  - Policy specification and enforcement
    - Trust: policies for security authorization, access, privacy/confidentiality
    - Contracts: pricing, delivery, refunds, cancellations, non-performance, …
      - Contract agreements, proposals, requests for proposals, advertisements
    - Monitoring: task of enforcing policies (e.g., for trust or contracts), policies to handle exceptions & non-compliance (compare results to promises)
    - Borrow from ebXML, EDI, XACML, P3P, LegalXML,…??
  - Start from spirit and particulars of OWL-S Profile
    - Add more particular "service ontologies"
  - Choosing good rule language
    - RuleML with extensions, e.g., ontology import/incorporation (DLP OWL and later OO with default inheritance), HiLog, and F-Logic syntax.
    - Need a surface syntax
  - Framework for negotiation
- Primary deliverable: technical document - proposal & rationale
- Later deliverable: illustrative application scenario examples
- Defer: Complex discovery/matchmaking

SCAMP drill down, cont'd

- Develop upper and middle ontology in selected areas
  - Borrow from ebXML, EDI, XACML, P3P, LegalXML,…??
- Simple advertising/discovery
  - E.g., based on keywords and simple ontology
  - More complex dynamic discovery not focus of version 1

Business Value ⇒ Strategy

1. Policies for security and monitoring and contracts would meet immediate needs in WS today
   - Want them checked at run time
   - Ensuring compliance with trust policies has become high-priority in many areas of business today:
     - USA: Sarbanes-Oxley (financial reporting liability), HIPAA (patient records privacy)
     - EU: privacy reg's

- Yet to a great extent they can be specified and enforced using a relatively simple and mature technology: LP rules.
  - Most trust policy languages / engines today are based on, or equivalent to, rules (+ DLP-expressible ontologies).
  - Ditto for Web standards for trust policies e.g., XACML, P3P both have (prioritized) rules.

More about Game Plan, cont.'d

- Have more in the way of formal coordination with W3C and Oasis etc.
  - Liaison members officially in relevant W3C and Oasis etc. working groups:
    - W3C: WSDL, WS Choreo, SWS Interest Group, WS Policy; P3P, Semantic Web activity incl. www-rdf-rules
    - Oasis: WS Security, XACML, Legal XML, ?ebXML,
    - RuleML; ISO Common Logic
    - ?RosettaNet; ? UN CEFACT EDI / UBL

Policies and Compliance in US Financial Industry Today

- Ubiquitous high-stakes Regulatory Compliance requirements
  - Sarbanes Oxley, SEC, HIPAA, etc.
- Internal company policies about access, confidentiality, transactions
  - For security, risk management, business processes, governance
- Complexities guiding who can do what on certain business data
- Often implemented using rule techniques

- Often misunderstood or poorly implemented leading to vulnerabilities
- Typically embedded redundantly in legacy silo applications, requiring high maintenance
- Policy/Rule engines lack interoperability

Example Financial Authorization Rules

Classification	Application	Rule
Merchant	**Purchase Approval**	If credit card has fraud reported on it, or is over limit, do not approve.
Mutual Funds	**Rep trading**	*Blue Sky*: State restrictions for rep's customers.
Mortgage Company	**Credit Application**	TRW upon receiving credit application must have a way of securely identifying the request.
Brokerage	**Margin trading**	Must compute current balances and margin rules before allowing trade.
Insurance	**File Claims**	Policy States and Policy type must match for claims to be processed.
Bank	**Online Banking**	User can look at own account.
All	**House holding**	For purposes of silo (e.g., statements or discounts), aggregate accounts of all family members.

Advantages of Standardized SW Rules

- Easier Integration: with rest of business policies and applications, business partners, mergers & acquisitions
- Familiarity, training
- Easier to understand and modify by humans
- Quality and Transparency of implementation in enforcement
  - Provable guarantees of behavior of implementation
- Reduced Vendor Lock-in
- Expressive power
  - Principled handling of conflict, negation, priorities

Advantages of SW Rules, cont'd:
Loci of Business Value

- Reduced system dev./maint./training costs
- Better/faster/cheaper policy admin.
- Interoperability, flexibility and re-use benefits
- Greater visibility into enterprise policy implementation => better compliance
- Centralized ownership and improved governance by Senior Management
- Rich, expressive trust management language allows better conflict handling in policy-driven decisions

Policies for Compliance and Trust Mgmt.: Role for Semantic Web Rules

- Trust Policies usually well represented as rules
  - Enforcement of policies via rule inferencing engine
  - E.g., Role-based Access Control
    - This is the most frequent kind of trust policy in practical deployment today.
  - W3C P3P privacy standard, Oasis XACML XML access control emerging standard, …

- Ditto for Many Business Policies beyond trust arena, too
  - "Gray" areas about whether a policy is about trust vs. not: compliance, regulation, risk management, contracts, governance, pricing, CRM, SCM, etc.
  - Often, authorization/trust policy is really a part of overall contract or business policy, at application-level. Unlike authentication.
  - Valuable to reuse policy infrastructure

Deeper Research Directions

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Presented at DAML PI Mtg., May 25, 2004, New York City

Basic Design-Space Points for Rules

- FOL -- ISO Common Logic
- LP -- RuleML
- OWL + Horn -- SWRL
- Pick your favorite for your application!
  - But some are Webized better

More Research Challenges: Core

- Integrating rules with ontologies
  - Rules refer to ontologies (e.g., in RuleML)
  - Rules to specify ontologies (e.g., Description Logic Programs)
  - Rules to map between ontologies (e.g., ECOIN)
  - Combined rules + ontologies knowledge bases (e.g., RuleML + OWL)

- Describing business processes & web services via rules + ontologies
  - Rules query web services (e.g., in RuleML Situated feature)
  - Rules trigger actions that are web services (e.g., ditto)
  - Capture object-oriented process ontologies
    - Default inheritance via rules (e.g., Courteous Inheritance)
    - Wrapper/transform to legacy C++, Java, UML
    - Develop open source knowledge bases (e.g., MIT Open Process Handbook Initiative)
  - Event triggering of rules (e.g., capture ECA rules in RuleML)
  - Rules in process models, e.g., cf. OWL-S, PSL

More Research Challenges: Business Policies

- Apply advanced rule and ontology representation to business policies in compliance, trust, contracts, etc.
  - Application scenarios for compliance checking/support services intra- and inter- enterprise
  - Policy language & engines on top of rule language & engines
  - In/with existing/emerging standards: XBRL, XACML, P3P, ebXML, EDI, Legal XML, …
  - Strategy and roles in the market ecology: regulators, communal repositories, service providers, etc.
  - Embedding into the bigger pictures of financial services, e-commerce, semantic web services, business process automation

Some Interesting Directions for DAML Rules (- but most of it beyond Program End)

- *Preamble: …*

- *These directions are for both RuleML and SWRL.*

- *CAUTION: Most of these directions have time horizon beyond the end of the DAML Program.*

Some Interesting Directions for DAML Rules - some of it nearer term

- Alternative syntaxes
  - Presentation Syntax for human authoring
    - Draw upon ideas in Prolog, N3, HiLog/F-Logic, XQuery, RDF-Query
  - RDF syntax for RuleML

- Extend SWRL and RuleML towards FOL
  - Focus: define syntax
  - Coordinate with Simple Common Logic, DRS

- Application scenarios, use cases
  - E.g., Services SCAMP
  - E.g., ontology translation / data mappings

Some Interesting Directions for DAML Rules - some of it nearer-term

- Inferencing techniques, with associated theory and complexity

- Translation mappings and techniques b/ rule systems
  - More rule systems/languages, esp. of types important commercially
  - ↔ Ontology systems too

- More implementation experience, generally
- Refine application ⇒ technical requirements/focus, generally
  - where's the business/social value

Some Interesting Directions, cont.'d

- Combine SWRL with Nonmon
  - A requirement from SWSI Rules
  - Negation-As-Failure, Priorities; Aggregations (require closing)
  - It's already available in RuleML
    - So one obvious approach is to translate SWRL to RuleML
      - … using DLP OWL2RuleML translator (e.g., SweetOnto)
- Extend SWRL to OWL-Full
  - How much immediate demand is there for this?
  - Can use HiLog techniques (e.g., in Flora-2)

Some Interesting Directions for DAML Rules

- More expressiveness in direction of existentials (head/outer).
  - E.g., simpler semantics/theory for anonymous existentials, bnodes, and their relationship to skolemization (cf. recent Yang & Kifer work)

- More about attached procedures cf. Situated LP and Jess/production rules, and some policy languages:
  - Dynamic sensing, e.g, query a web service
  - Actions/effectors with side effects
  - Develop use cases to start, e.g., in SCAMP

- Justifications, proofs, explanations – interchangeably
  - E.g., use and extend InferenceWeb

- Extension toward HiLog limited higher-order expressiveness (esp. LP)

- Extension toward Lloyd-Topor style syntactic sugar (esp. LP)
- Extension towards F-Logic extension, esp. in presentation syntax

OPTIONAL SLIDES FOLLOW

Overview of Approaches to Implementing SWRL

- Translate full SWRL to FOL (then use FOL theorem-provers)
- Translate subsets
  - Horn-expressible to LP
  - DL-expressible to OWL
  - In more detail:
    - Horn subset of SWRL to LP-type rules – e.g. RuleML, Jess, XSB (then use rule engine)
      - E.g., just translate subset of definite Horn rules
      - E.g., translate definite named-classes-only SWRL rules and DLP subset of OWL
      - E.g., further use DLP techniques on complex classes within SWRL rules
    - Translate to DL subset to OWL and use DL inferencing engines

Flavors of Rules Commercially Most Important today in E-Business

- E.g., in OO app’s, DB’s, workflows.

- Relational databases, SQL: Views, queries, facts are all rules.
- Production rules (OPS5 heritage): e.g.,
  - Jess, CLIPS, ILOG, Blaze, Haley: rule-based Java/C++ objects.
- Event-Condition-Action rules (loose family), cf.:
  - business process automation / workflow tools.
  - active databases; publish-subscribe.
- Prolog. *“logic programs” as a full programming language.*
- *(Lesser: other knowledge-based systems.)*

Summary of Objectives Motivating SweetRules: Integrating Distributed Rules and Ontologies

Address “the 5 D’s” of real-world reasoning ⇒ *desired improvements*:

1. **D**iversity – Existing/emerging kinds of ontologies and rules have heterogeneous KR's. *Handle more heterogeneous systems.*
2. **D**istributedness - of ownership/control of ontology/rule active KB's. *Handle more source active KB’s.*
3. **D**isagreement - Conflict (contradiction) will arise when merging knowledge. *Handle more conflicts.*
4. **D**ynamism - Updates to knowledge occur frequently, overturning previous beliefs. *Handle higher rate of revisions.*
5. **D**elay - Computational scaleability is vital to achieve the promise of knowledge integration. *Achieve Polynomial-time (~ databases).*

Summary of Objectives Motivating SweetRules: Integrating Distributed Rules and Ontologies, cont.'d

BEFORE

AFTER

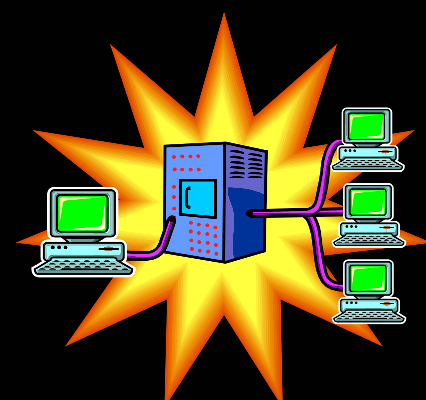
Contradictory conflict is globally contagious, invalidates all results.

⇒

Contradictory conflict is contained locally, indeed tamed to aid modularity.

Knowledge integration tackling the 5 D's (esp. diversity and distributedness) is labor-intensive, slow, costly.

⇒



Knowledge integration is highly automated, faster, cheaper.

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More Details on SWSI Rules

from SWSI F2F Discussion on May 24, 2004

New Tasks for SWSL Requirements from SWSA Requirements Analysis

- "New" here = wrt current emphasis in SWSL Requirements doc
- Tasks focus to add to requirements:
  - Security
    - Esp. policy / decision-making aspects
  - Semantic Interoperability
    - Esp. mapping outputs of one service to inputs of another service
      - E.g., Semantic Web based "glue" processes/services
- These were of broadest need according to the SWSA scenarios requirements analysis
    - (Presented by Mark Burstein at Oct. 2003 SWSI F2F)

Focus Tasks for nearer-term

- Focus on pieces to support particular set of tasks
  - Which need little or no procedural process modeling, temporality, or planning.
  - Start with what rules + ontologies alone can handle

1. Policies for trust:
   – For task of security/privacy/authorization
2. Mapping-type mediation, e.g., of input and output info, or very light workflow:
   – for task of semantic interoperability

Focus Tasks for nearer-term, cont.'d

3. Contracts, incl. advertising, request for proposals, proposals, selection
   - Focus on policy provisions/aspects and decision making in terms of those
   - For task of contracts and negotiation
   - For tasks of advertising and discovery
4. Monitoring and exception handling
   - Focus on contract/policy aspects
   - For task of monitoring and exception handling

Examples of Contract Provisions Well-Represented by Rules in Automated Deal Making

- Product descriptions
  - Product catalogs: properties, conditional on other properties.
- Pricing dependent upon: delivery-date, quantity, group memberships, umbrella contract provisions
- Terms & conditions: refund/cancellation timelines/deposits, lateness/quality penalties, ordering lead time, shipping, creditworthiness, biz-partner qualification, service provisions
- Trust
  - Creditworthiness, authorization, required signatures
- *Buyer Requirements (RFQ, RFP) wrt the above*
- *Seller Capabilities (Sourcing, Qualification) wrt the above*

Business Value ⇒ Strategy, cont.'d

2. Semantic interoperability mappings between information models used by different services – e.g., output of one service to input of another service – would also meet an immediate need in WS today.
   – Rules + ontologies – e.g., SWRL – are good for doing such mappings.
     - More clean, and more cleanly expressive, than XSLT – the state of the art for XML stuff today.
     - Today's thriving commercial vendors in the overall (not-necessarily-XML) space, such as Vitria, often use Rules heavily for this (e.g., Event-Condition-Action rules).

- This is intrinsically "semantic" stuff where Semantic Web techniques can shine. It's another WS niche we should "own" as SW'ers.

Summary of Technical Approach

- Basic KR foundation:
  - Start with LP expressiveness
  - Add nice generic LP extensions:
    - Courteous priorities
    - Situated procedural attachments for queries (sensing) and actions (effecting)
    - HiLog "higher-order" expressiveness
    - F-Logic syntax for 2-ary properties etc.
    - Etc.
- Generic ontology capabilities – from the basic KR foundation:
  - Expresses a considerable fragment of OWL: DLP+extensions
  - Can express OO process ontologies with default inheritance, cf.:
    - Process Handbook frames, C++, Java, UML

Summary of Technical Approach, cont.'d

- Develop Service Ontologies – with associated definitional knowledge bases
  - Start with OWL-S (esp. its profiles aspect); draw also from FLOWS, (?)CTR++
  - In overall spirit of OWL-S profile, but can go further/deeper
  - Service Ontology here = talks about relevant aspects of services, e.g., activities, WSDL "interfaces", WS-Choreo messages, profile aspects, etc.
  - Provide & use hooks to WSDL, WS-Choreo, ?BPEL, ?SOAP
  - Extend info models in those
  - Draw upon the LP-expressible subsets of the above
- Later: more extensions
  - E.g., for procedural process modeling, temporality, planning, etc.
  - E.g., hopefully to get more of "LP union FOL" as fundamental expressiveness

Example I – Credit Card Verification System

- Typical for eCommerce websites accepting credit cards – Visa, MC, Discover, Amex
- Rules for transaction authorization
  - Bank performs account limit, expiration, address and card code verification
  - A fraud alert service may flag a card
  - Service provider may blacklist customer
- Overrides, e.g., alert service over bank rules

CommonRules Implementation for Credit Card Verification Example

Sample Rule Listing

```
<bankResp>
  if checkTran(?Requester)
  then
    transactionValid(self,?Requester);
<cardRules2>
    if      checkCardDet(?Requester, ?accountLimit, ?exp_flag, ?cardholderAddr,
    ?cardholderCVC) and
    checkTranDet(?Requester, ?tranAddr, ?tranCVC) and
    notEquals(?tranCVC, ?cardholderCVC)
    then
    CNEG transactionValid(self,?Requester);
…
overrides(cardRules2, bankResp);
checkTran(Joe);
checkCardDet(Joe, 50, "false", 13, 702);
checkTranDet(Joe, 13, 702);
cardGood(Fraudscreen.net,Joe,good);
customerRating(Amazon.com, Joe, good);
```

CommonRules translates straightforwardly ↔ RuleML.

We show its human-oriented syntax as a presentation syntax for RuleML.

Runtime Results for Credit Card Verification

Sample Output

SCLPEngine: Adorned Derived Conclusions:

CNEG transactionValid_c_3(self, Mary);
transactionValid_c_2(self, Joe);
transactionValid_c_2(self, Mary);
transactionValid_r_2(self, Mary);
transactionValid_u(self, Joe);
CNEG transactionValid_u(self, Mary);

transactionValid(self, Joe);
CNEG transactionValid(self, Mary);

Adorned **conclusions represent intermediate phases of prioritized conflict handling in Courteous Logic Programs**

CNEG **= limited classical negation (which is permitted in Courteous LP)**

CNEG p means p is (believed to be) false

Self **= the agent making the authorization decision, i.e., the viewpoint of this local rulebase.**

(This is as usual in trust management.)