Extending the SweetDeal Approach for E-Procurement using SweetRules and RuleML

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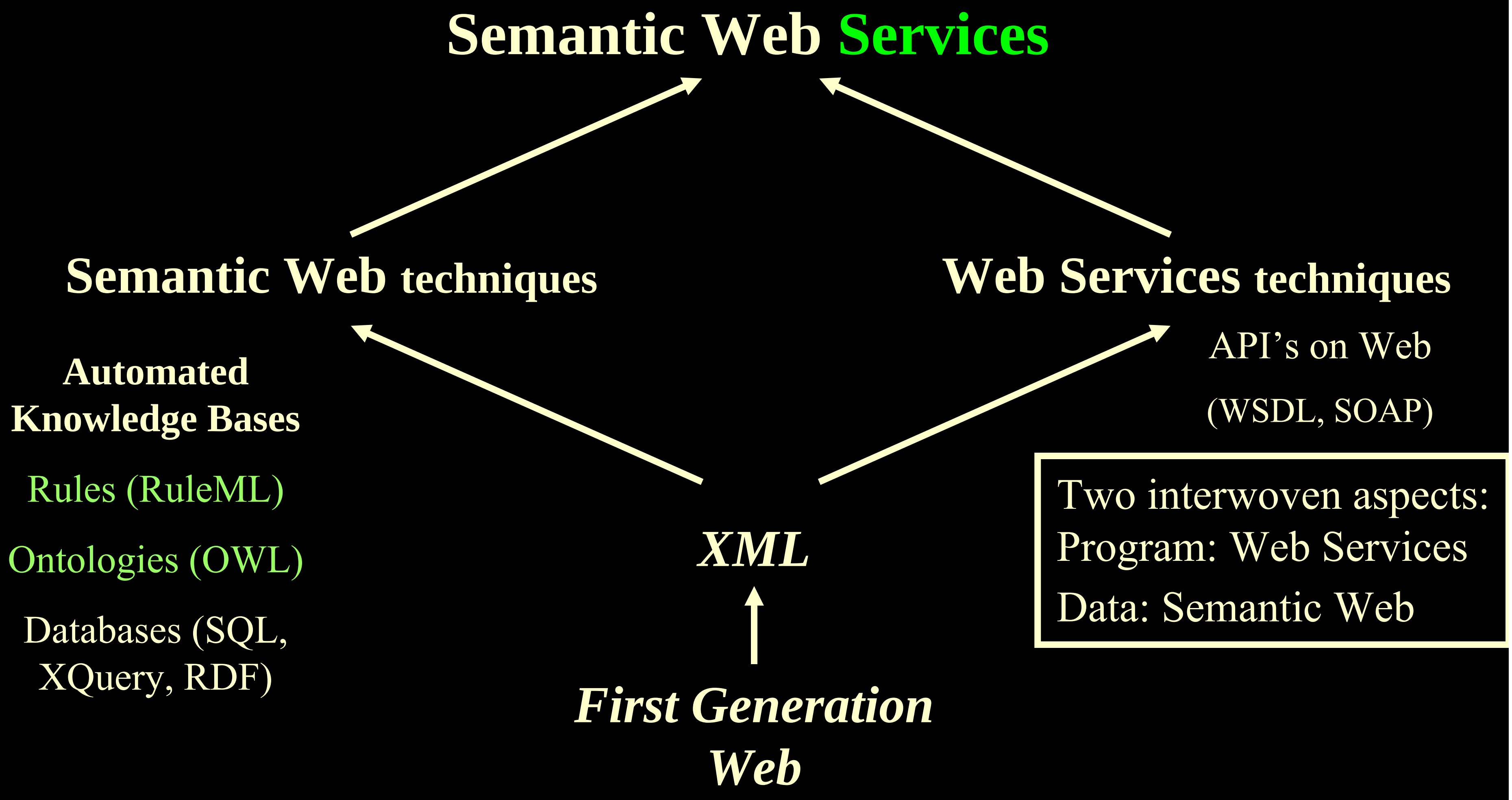
Paper Presentation (30-minutes) at International Conference on Rules and Rule Markup Languages for the Semantic Web (RuleML-2005), Galway, Ireland, Nov. 10-12, 2005 *http://2005.ruleml.org*

Outline

- Introduction and Context: Semantic Web Services for E-Business; Policies
- Overview: SweetDeal Approach, New Extensions
- More Details: SweetDeal, SCLP, KB merging, SweetRules
- Procurement Scenario
- Fact-queries, as part of communicated KB’s
- OO default inheritance ontologies, as Courteous LP
- Relationship to E-Business Messaging Standards / Platforms
- Business Value Analysis
- Conclusions & Future Work

Next Generation Web



Semantic Web Services

Semantic Web techniques

Web Services techniques

Automated Knowledge Bases

Rules (RuleML)

Ontologies (OWL)

Databases (SQL, XQuery, RDF)

API's on Web

(WSDL, SOAP)

XML

First Generation Web

Two interwoven aspects:
Program: Web Services
Data: Semantic Web

Our Research Aspects/Questions about the Semantic Web

- Core technologies: Requirements, concepts, theory, algorithms, standards?
  - Rules in combination with ontologies; probabilistic, decision-/game-theoretic

- Business applications and implications: concepts, requirements analysis, techniques, scenarios, prototypes; strategies, business models, market-level evolution?
  - End-to-end e-contracting, finance, trust; …

Some Answers to:
“Why does SW Matter to Business?”

- 1. “Death. Taxes. Integration.” - They’re always with us.

- 2. “Business processes require communication between organizations / applications.” - Data and programs cross org./app. boundaries, both intra- and inter- enterprise.

- 3. “It’s the *automated knowledge* economy, stupid!” - The world is moving towards a knowledge economy. And it’s moving towards deeper and broader automation of business processes. The first step is automating the use of <u>structured</u> knowledge.
  - Theme: *reuse* of knowledge across multiple tasks/app’s/org’s

Strategic Business Foci in our SW Research

- Knowledge-based Services Engineering: intra- and inter- enterprise

- Target "killer app" known for 30 years: do better job of EDI

- Challenges:
  - Ease of development, deployment ↑
  - Reuse of knowledge ↑
  - ⇒ life cycle costs ↓ , agility ↑

- Starting with: Policies
  - Using recent theory breakthroughs in semantic rules
  - E.g., for end-to-end contracting and authorization (incl. security)

- Starting with: EAI as well as B2B

SW Rules: Use Cases *from our research*

- Contracts/negotiation, advertising/discovery
  - E-procurement, E-selling
  - Pricing, terms & conditions, supplier qualification, …

- Monitoring:
  - Exception handling, e.g., of contract violations
    - Late delivery, refunds, cancellation, notifications
  - Notifications, personal messaging, and other workflow

- Trust Policies: authorization, confidentiality & privacy, security, access control
  - E.g., financial services, health care
    - *Extensive analysis of business case/value*

- Semantic mediation: rule-based ontology translation, context-based information integration

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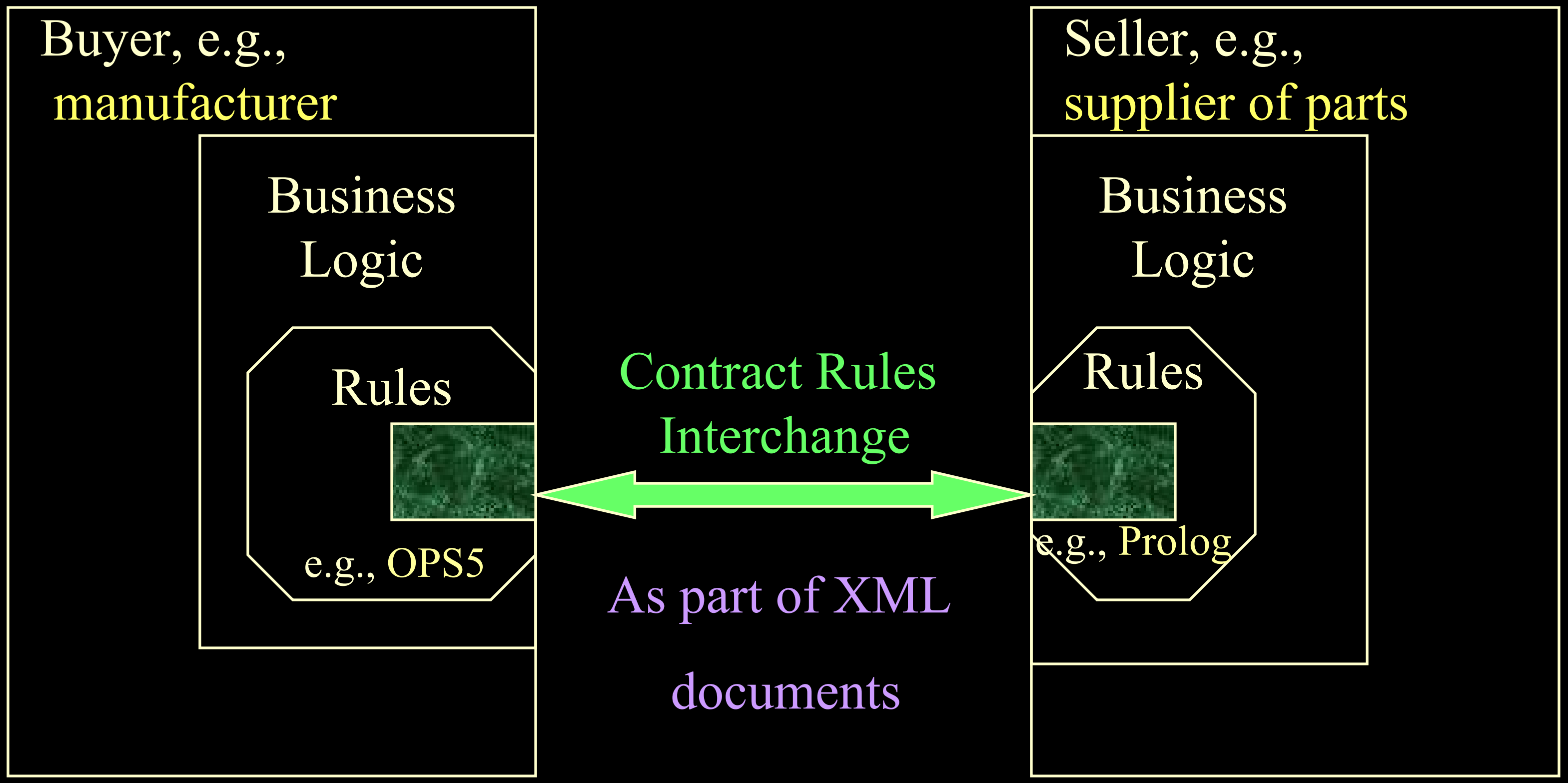
End-to-End E-Contracting Tasks

- Discovery, advertising, matchmaking
  - Search, sourcing, qualification/credit checking
- Negotiation, bargaining, auctions, selection, forming agreements, committing
  - Hypothetical reasoning, what-if'ing, valuation
- Performance/execution of agreement
  - Delivery, payment, shipping, receiving, notification
- Problem Resolution, Monitoring
  - Exception handling

SweetDeal Approach: Rule-based Contracts for E-commerce

- Rules as way to specify (part of) business processes, policies, products: as (part of) contract terms.
- Complete or partial contract.
  - As default rules. Update, e.g., in negotiation.
- Rules provide high level of conceptual abstraction.
  - easier for non-programmers to understand, specify, dynamically modify & merge. E.g.,
  - by multiple authors, cross-enterprise, cross-application.
- Executable. Integrate with other rule-based business processes.

Contract Rules during Negotiation



Buyer, e.g., manufacturer

Business Logic

Rules

e.g., OPS5

Contract Rules Interchange

As part of XML documents

Seller, e.g., supplier of parts

Business Logic

Rules

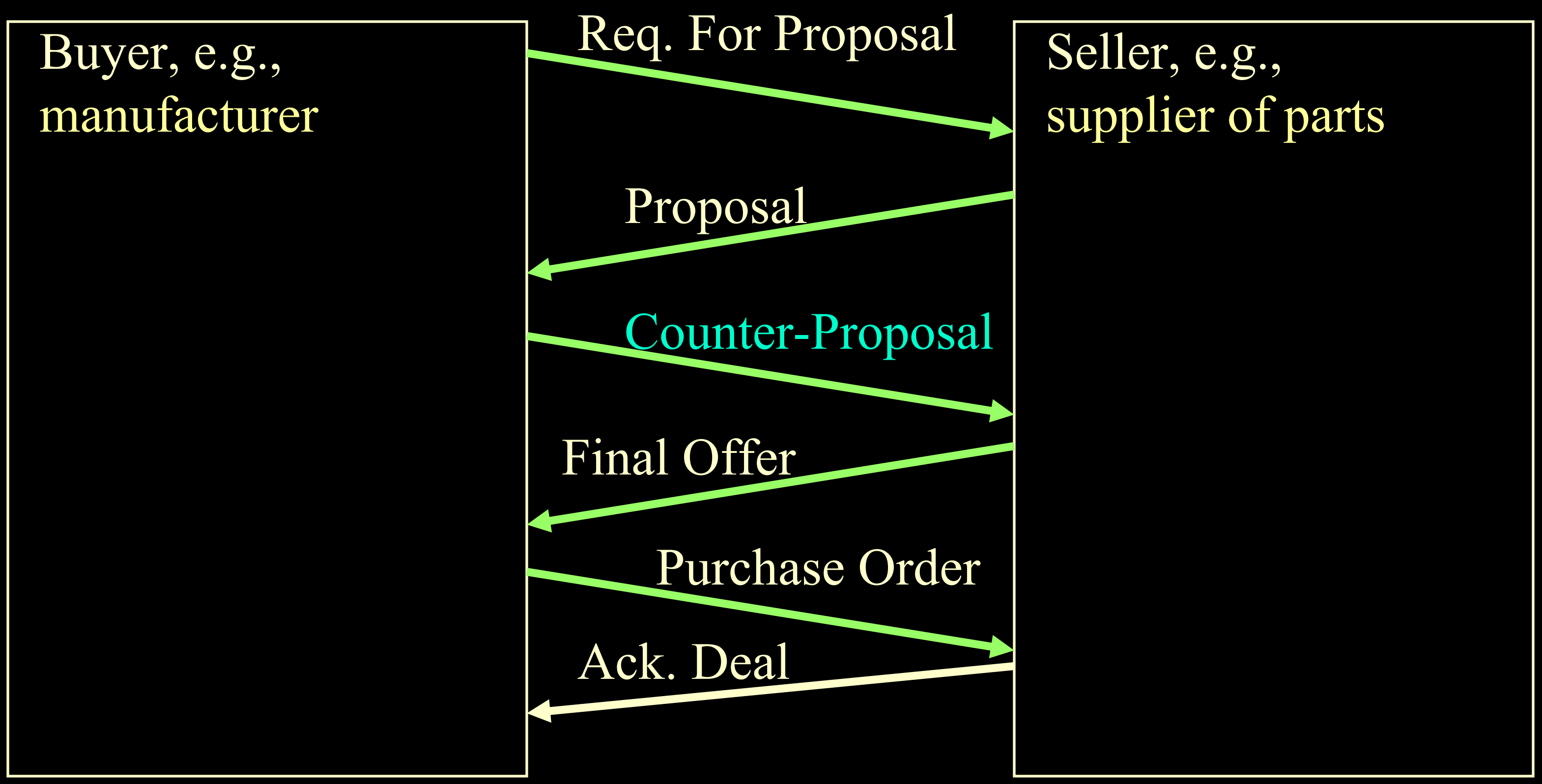
e.g., Prolog

Contracting parties NEGOTIATE via shared rules.

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*

Exchange of Rules Content during Negotiation: example



Buyer, e.g., manufacturer

Seller, e.g., supplier of parts

Req. For Proposal

Proposal

Counter-Proposal

Final Offer

Purchase Order

Ack. Deal

Example: E-Contract

Proposal from supplierCo to manufCo

- …
  {usualPrice} price(per_unit, ?PO, $60) ←
- purchaseOrder(?PO, supplierCo, ?AnyBuyer) ∧
- quantity_ordered(?PO, ?Q) ∧ (?Q ≥ 5) ∧ (?Q ≤ 1000) ∧
- shipping_date(?PO, ?D) ∧ (?D ≥ 24Apr00) ∧ (?D ≤ 12May00).
- {volumeDiscount} price(per_unit, ?PO, $51) ←
- purchaseOrder(?PO, supplierCo, ?AnyBuyer) ∧
- quantity_ordered(?PO, ?Q) ∧ (?Q ≥ 100) ∧ (?Q ≤ 1000) ∧
- shipping_date(?PO, ?D) ∧ (?D ≥ 28Apr00) ∧ (?D ≤ 12May00) .
  overrides(volumeDiscount , usualPrice) .
- ⊥ ← price(per_unit, ?PO, ?X) ∧ price(per_unit, ?PO, ?Y) GIVEN (?X ≠ ?Y).
- ...

Negotiation Ex. Doc. Rules: Counter-Proposal *from manufCo to supplierCo*

- …
  {usualPrice} price(per_unit, ?PO, $60) ← ...
- {volumeDiscount} price(per_unit, ?PO, $51) ←
- purchaseOrder(?PO, supplierCo, ?AnyBuyer) ∧
- quantity_ordered(?PO, ?Q) ∧ (?Q ≥ 5) ∧ (?Q ≤ 1000) ∧
- shipping_date(?PO, ?D) ∧ (?D ≥ 28Apr00) ∧ (?D ≤ 12May00) .
  overrides(volumeDiscount , usualPrice) .
- ⊥ ← price(per_unit, ?PO, ?X) ∧ price(per_unit, ?PO, ?Y) GIVEN (?X ≠ ?Y).
- {aSpecialDeal} price(per_unit, ?PO, $48) ←
- purchaseOrder(?PO, supplierCo, manufCo) ∧
- quantity_ordered(?PO, ?Q) ∧ (?Q ≥ 400) ∧ (?Q ≤ 1000) ∧
- shipping_date(?PO, ?D) ∧ (?D ≥ 02May00) ∧ (?D ≤ 12May00) .
- overrides(aSpecialDeal, volumeDiscount) .
- overrides(aSpecialDeal , usualPrice) .
- ...

Simply *added* rules!

Negotiation Example --

XML Encoding of Rules in RuleML

```
•  <rulebase>
•    <imp>
•      <rlab>usualPrice</_rlab>
•      <head>
•        <atom>
•          <opr><rel>price</rel></_opr>
•            <ind>per_unit</ind>
•            <var>PO</var>
•            <ind>$60</ind>
•         </atom>
•       </head>
•       <body>    …  (see next page)    </_body>
•    </imp>
•  …
•  </rulebase>
```

SweetDeal V2 Demo Outline

- SweetDeal E-Contracting Application using SweetRules (supply chain)
  - SCLP RuleML that includes OWL ontologies
  - Contract proposals/final-agreements are SCLP RuleML rulebases that reference/include OWL ontologies
  - Humans edit & communicate, supported by automated agents
  - Proposal evaluation supported by inferencing
  - Agreed business process is executable via inferencing+action

What Can Be Done with the Rules in contracting, & negotiation, based on our SweetDeal approach to rule representation

- Communicate: with deep shared semantics
  - via RuleML, inter-operable with same sanctioned inferences
  - ⇔ heterogeneous rule/DB systems / rule-based applications (“agents”)
- Execute contract provisions:
  - infer; ebiz actions; authorize; ...
- Modify easily: contingent provisions
  - default rules; modularity; exceptions, overriding
- Reason about the contract/proposal
  - hypotheticals, test, evaluate; tractably
  - *(also need “solo” decision making/support by each agent)*

RECAP FOLLOWS

Overview of SweetDeal Approach I

SweetDeal approach: [EC-99, WWW-2003, IJEC 2004]; part of [SWSF 2005]

- Represent (parts of) e-contracts via webized semantic rules. Communicated.
- Contracts are partial or complete, proposed or final.
- Situated Courteous Logic Programs, in Webized syntax (RuleML) as representation. (Declarative. Similar
  - Prioritized defaults, with negation.
    - Modular modification. Default OO inheritance.
  - Procedural attachments for actions/effecting and queries/sensing. Execute business processes.
- With restricted OWL ontologies. The original use case & design pattern for Description Logic Programs (DLP).

Overview of SweetDeal Approach II

- Handles “end-to-end” e-contracting tasks, i.e., knowledge-based services tasks:
  - advertising & discovery, negotiation & selection, agreement, authorization, monitoring & exception handling, modification & renegotiation, execution/enactment & business process automation.

- Many application scenarios, incl. of all these tasks:
  - pricing & discounting, refunds & customer service, ordering and lead time, late delivery, supply chain / B2B, retail / B2C, auctions, credit approval

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New Extensions to SweetDeal I

- New particular procurement application scenario
  - Utilizes and exercises several advanced expressive features of the SweetDeal approach
    - Merge restricted DL ontologies: import OWL-DLP (DLP-fusion)
    - Effectors to perform business actions
    - Merge default-inheritance OO ontologies: as Courteous rules
  - Prototype, built using SweetRules V2.1 [demo'd 1st at DAML Winter 2004 PI Meeting]
    - Utilizes and exercises several new features of SweetRules
      - KB merging, e.g., OWL-DLP ontologies + Courteous policy RuleML rules.
      - Situated effecting incl. WSDL actions.

Overview of Procurement Scenario

- B2B: Purchase of bunch of computers
  - Rebates; Financing Options (new aspects)
  - Pricing options, delivery details, …
- Buyer and sellers exchange contract proposals of increasing completeness
- Each does SCLP inferencing to evaluate implications of a given proposal, including relative to private info/criteria, and to trigger messaging sending/response

New Extensions to SweetDeal II

- New expressive features and design understanding
  - Build on top of SW Rules tools: SweetRules
  - Merge heterogeneous KB’s
  - Expressive Reasoning: Courteous, effecting, SCLP+DL
  - Reasoning & translation interoperably on/across heterogeneous rule-based systems/applications
  - … with strong semantics
  - Communication interaction protocol aspects represented using rules with effectors, e.g., to trigger contracting messages
  - Message contains a KB consisting of *queries* + rules
  - *Fact-queries* as expressive feature, natural & convenient
    - Experimental extension of RuleML markup

New Extensions to SweetDeal III

- Initial steps of analysis/design of how fit as “letters content” within important e-business communication standards/platforms
  - RosettaNet, ebXML.
  - Fits nicely within their messages = “envelopes”.

RULE/ONT EXAMPLES

- Walk thru of some example SCLP RuleML and OWL-DLP contract knowledge from the RuleML-2005 proceedings paper

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Overview of SweetRules V2.1:
Tools for Semantic Web Rules and Ontologies, including Translation, Inferencing, Analysis, and Authoring

http://sweetrules.projects.semwebcentral.org

Presentation (15-min.) by Benjamin Grosof and Mike Dean***
Tools by multi-institutional team (MIT, UMBC, BBN, …)

Invited Poster at RuleML-2005 (International Conference on Rules and Rule Markup Languages for the Semantic Web) http://2005.ruleml.org
held Galway, Ireland, Nov. 10-12, 2005.

**MIT Sloan School of Management, http://ebusiness.mit.edu/bgrosof*

***BBN Technologies, http://www.daml.org/people/mdean*

SweetRules V2.1 Overview

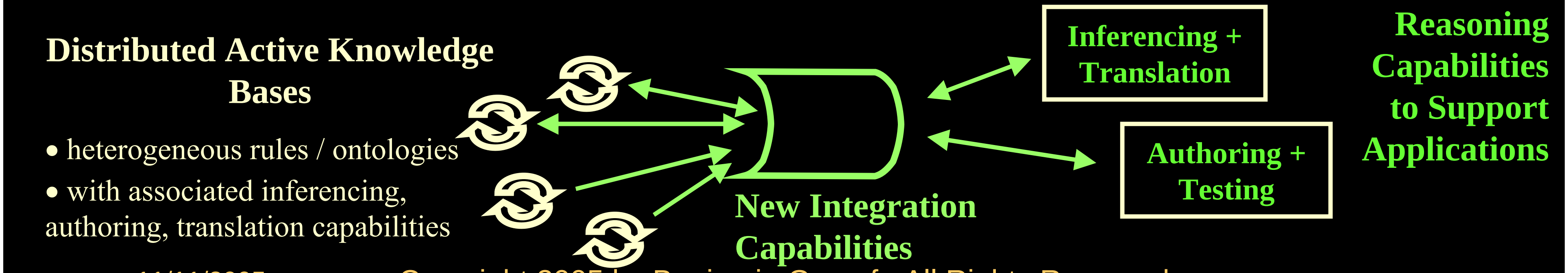
Key Ideas:

http://sweetrules.projects.semwebcentral.org

- 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.
- Provide an open source tool platform to 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.
    - Including semantics-preserving translations between different rule languages/systems/families, e.g., Situated LP ↔ production rules

Application Areas (prototyped scenarios):

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



Distributed Active Knowledge Bases

- heterogeneous rules / ontologies
- with associated inferencing, authoring, translation capabilities

Inferencing + Translation
Authoring + Testing
New Integration Capabilities
Reasoning Capabilities to Support Applications

SweetRules Concept and Architecture

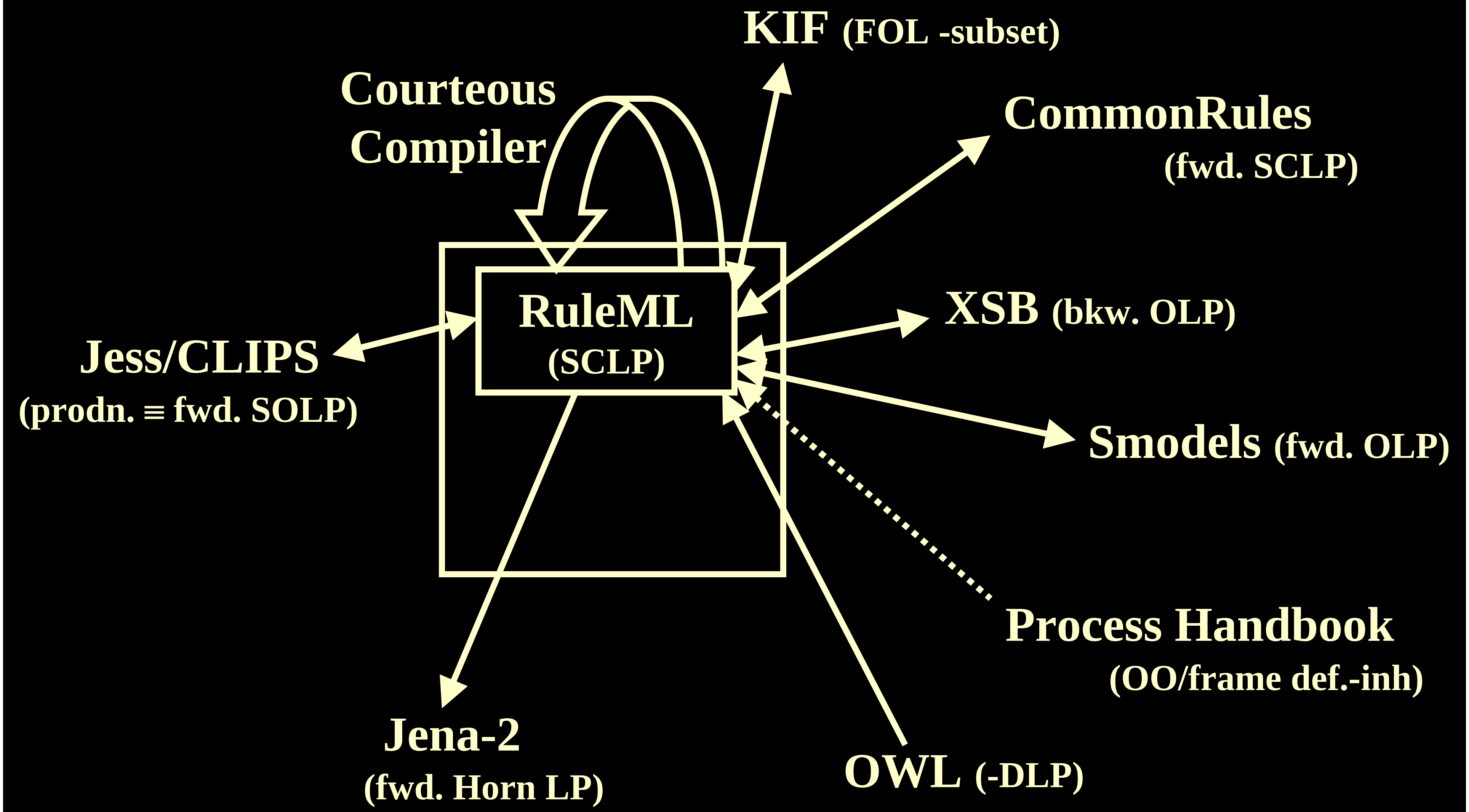
- Concept and Architecture: Tools suite for Rules and RuleML
  - Translation and interoperability between heterogeneous rule systems (forward- and backward-chaining) and their rule languages/representations
  - Inferencing including via translation between rule systems
  - Authoring, Analysis, and testing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

  - Merge knowledge bases
    - Combine rules with ontologies, incl. OWL
  - SWRL rules as special case of RuleML
  - Focus on kinds of rule systems that are commercially important

SweetRules V2.0+ Fundamental KR Today

- Fundamental KR: Situated Courteous Logic Programs (SCLP)
  - – Horn
  - – + Negation-As-Failure (NAF) = Ordinary LP
  - – + Courteous prioritized conflict handling
    - overrides relation on rule labels, classical negation, mutex integrity constraints
  - – + Situated sensing & effecting
    - Invoke external procedural attachments
    - Sensing = tests/queries; e.g., built-ins
    - Effecting = side-effectful actions, triggered by conclusions

SweetRules V2.1   Translators Graph



KIF (FOL -subset)

Courteous Compiler

CommonRules (fwd. SCLP)

RuleML (SCLP)

XSB (bkw. OLP)

Jess/CLIPS (prodn. ≡ fwd. SOLP)

Smodels (fwd. OLP)

Process Handbook (OO/frame def.-inh)

Jena-2 (fwd. Horn LP)

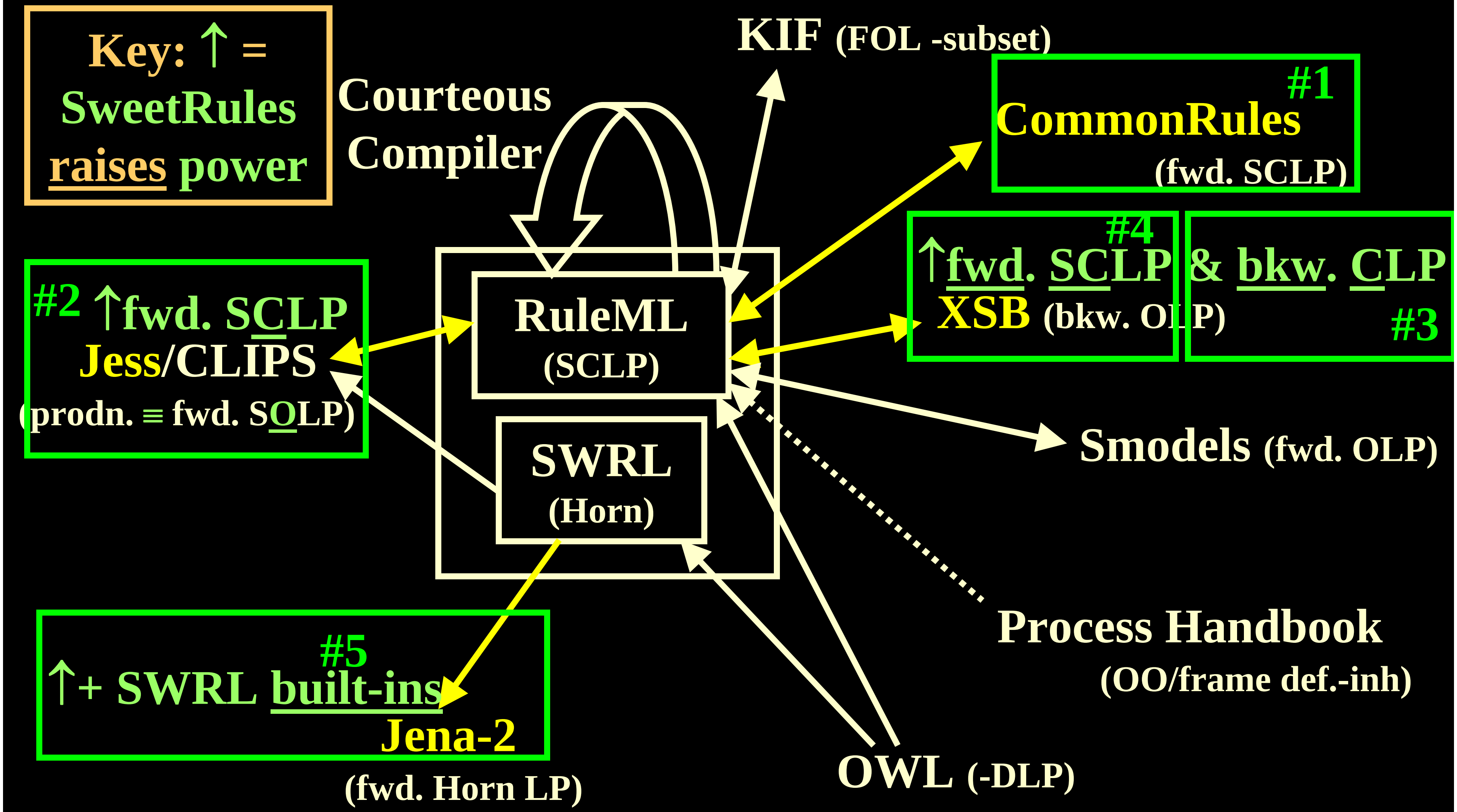
OWL (-DLP)

(SCLP = Situated Courteous Logic Programs. OLP = Ordinary LP (plain NAF))

SweetRules Inferencing Capabilities Today: Overview

- Inferencing engines in RuleML/SWRL via translation:
  - Indirect inferencing:
    1. translate to another rule system, e.g., {XSB, Jess, CommonRules, or Jena}
    2. run inferencing in that system's engine
    3. translate back
  - Can use composite translators

SweetRules V2.0+ New Inferencing Engines



Key: ↑ = SweetRules raises power

Courteous Compiler

KIF (FOL -subset)

#1 CommonRules (fwd. SCLP)

#4 ↑fwd. SCLP & bkw. CLP #3

XSB (bkw. OLP)

#2 ↑fwd. SCLP

Jess/CLIPS

(prodn. ≡ fwd. SOLP)

RuleML (SCLP)

SWRL (Horn)

Smodels (fwd. OLP)

Process Handbook (OO/frame def.-inh)

#5 ↑+ SWRL built-ins

Jena-2

(fwd. Horn LP)

OWL (-DLP)

Novel Capabilities I

- RuleML-based interoperability, knowledge-merging, reasoning for commercially important kinds of rules, e.g.,
  - Production rules ↔ Prolog, with strong semantic equivalence
  - Platform with pluggability and automatic tool composition
- Supports Correct Negation-As-Failure in Production Rules, via new techniques
- Newly 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., in XSB Prolog, Jess, Smodels
- New Include-a-KB mechanism, similar to owl:imports (prelim. RuleML V0.9)
  - Include a remote KB that is translatable to RuleML
- Uses New Action Launcher component to support Situated effecting feature (actions triggered by conclusions) even in systems that don't directly support it. Facts input, actions output.
  - E.g., in SweetXSB forward inferencing

Additional Firsts in Implementation

- Forward Situated Courteous LP inferencing+action with intrinsically highly scaleable run-time performance, and moreover with general non-stratified NAF
    - Both XSB/Prolog and Jess/Rete/production-rules reportedly scale very well to very large rulebases (~100K+ non-fact rules, many Millions facts)
- Backward Courteous LP inferencing for general non-stratified NAF, and scaleably in above sense
- RuleML Presentation Syntax Support:
    - Includes Situated feature
    - Generator. *Parser is in testing.*
- WSDL Web Services permitted as procedural attachments
    - Initially, only for effecting not yet sensing. Dynamic.

Novel KB Merging of Rules + Ontologies

- Combine:
  - Multiple SCLP RuleML (/ SWRL) rulebases
    - Or any knowledge base that is translatable into RuleML
  - Heterogeneous kinds of rules
    - E.g., originally XSB rules + Jess facts
    - These get translated and union’d into a single RuleML rulebase (possibly virtual)
  - OWL ontologies
    - Translate Description Logic Programs (DLP) subset of OWL into RuleML
    - Hybrid reasoning via DLP-fusion, i.e., LP inferencing after translate
  - OO/Frame ontologies with default inheritance
    - E.g., Process Handbook ontologies
    - … which get translated to (S)CLP rules

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F(act)-Queries

- Queries that return facts, rather than bindings
  - I.e., the facts that correspond to substituting ground bindings
- It’s convenient and natural to send such queries, and expect such fact-set answers, in e-contracts.
- E.g., “please tell me your price”, “please give me your billing address”.
- Experimental extension of RuleML syntax to support this

Communicated KB of Queries+Rules

- Include queries along with rules in communicated KB’s
  - E.g., in exchanged contract proposals
- Experimental extension of RuleML syntax to support this

Represent Default-Inheritance Object-Oriented Ontologies Via Courteous LP

- Default-inheritance object-oriented ontologies are ubiquitous in business process realm:
  - Java, C++ frameworks
  - Frame-based systems
- Override or cancel inheritance at subclass.
- OWL, Description Logic, FOL cannot represent default behavior: monotonic only.
- Nonmonotonic/default character increases reuse as compared to monotonic-only.
- Courteous LP can represent them nicely.
  - E.g., SweetPH represents Process Handbook OO businss process ontology (5000 processes, 38000 axioms) [Grosof & Bernstein 2003]

Example of Default-Inheritance OO Ontologies in Courteous LP

```
{buyRegular} paymentMode(?quoteID,invoice) :- Buy(?quoteID).

  /* BuyWithCredit is a subclass of Buy */
Buy(?quoteID) :- BuyWithCredit(?quoteID).

{buyCredit} paymentMode(?quoteID,credit)
                                  :- BuyWithCredit(?quoteID).
overrides(buyCredit, buyRegular).
```

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Advantages of Standardized SW Rules for Policies, e.g., Authorization/Security

- Easier Integration: with rest of business policies and applications, business partners, mergers & acquisitions
  - Enterprise integration, B2B
- Familiarity, training
- Easier to understand and modify by humansChange management
- 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
- ⇒ Agility, change management ↑

Advantages of SW Rules, cont'd:

Loci of Business Value in Policy Management

- 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 policy management language allows better conflict handling in policy-driven decisions
- Strategic agility, incl. wrt business model

SWS and Rules   Summary

*** SWS Tasks Form 2 Distinct Clusters,*

each with associated Central Kind of Service-description Knowledge and Main KR

1. Security/Trust, Monitoring, Contracts, Advertising/Discovery, Ontology-mapping Mediation
   - Central Kind of Knowledge: Policies
   - Main KR: Nonmon LP (rules + ontologies)
2. Composition, Verification, Enactment
   - Central Kind of Knowledge: Process Models
   - Main KR: FOL (axioms + ontologies)
     - + Nonmon LP for ramifications (e.g., cf. Golog)

- Thus RuleML & SWSF specify both Rules, FOL
  – Fundamental KR Challenge: “Bridging” Nonmon LP with FOL
    - SWSF experimental approach based on hypermon. [Grosof & Martin]

SW Rules: Use Cases from our research

- Contracts/negotiation, advertising/discovery
  - E-procurement, E-selling
  - Pricing, terms & conditions, supplier qualification, …

- Monitoring:
  - Exception handling, e.g., of contract violations
    - Late delivery, refunds, cancellation, notifications
  - Notifications, personal messaging, and other workflow

- Trust Policies: authorization, confidentiality & privacy, security, access control
  - E.g., financial services, health care
    - *Extensive analysis of business case/value*

- Semantic mediation: rule-based ontology translation, context-based information integration

Future Work Directions

- More scenarios, esp. in SWS policy/SCAMP task cluster
- Integration of more expressive ontologies from OWL, FOL (beyond DLP)
  - Extend DLP in various ways
  - Use hypermonotonic reasoning approach (new KR theory) [SWSF 2005]
    - Map FOL ↔ Courteous LP
    - View nonmon LP as weakened FOL: sound, incomplete
- More integration into e-business communication and Web Services, following our SWS vision

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