

Automating Law in the Small: Contracts, Regulations, and Prioritized Argumentation

Invited Talk for the

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Overview

- *Aiming to be provocative*
- What is Law in the Small
 - example: e-signatures: issues & opportunities
- 1st Steps: Automating Agent Contracting
 - Approach: Inter-operable XML Rules represent parts of Contract Content
 - knowledge representation: declarative rules in XML
 - specify, infer/act, assemble, evaluate, modify
 - value of prioritized default reasoning/argumentation
 - pragmatics, modularity ; via Courteous Logic Programs
- Discussion: Directions for the Glorious Future
 - regulations, bureaucratic policies & processes

What is “Law in the Small”

- “Hum-drum”: agreements, “rules & regulations”
- **contracts; e-signatures; authorizations**
- **regulations; bureaucratic forms, processes**
- routine, but lots of details to be worked out & dealt with
 - what we deal with every day
 - not intrinsically controversial, usually doesn’t → court
 - no TV channels or shows, lacks glamour
- goal: minimize run-time human lawyer labor
- represent **business policies and processes**, many of which have legal aspects or legal weight

Law in the Small (continued)

- *Dream: Automate it*

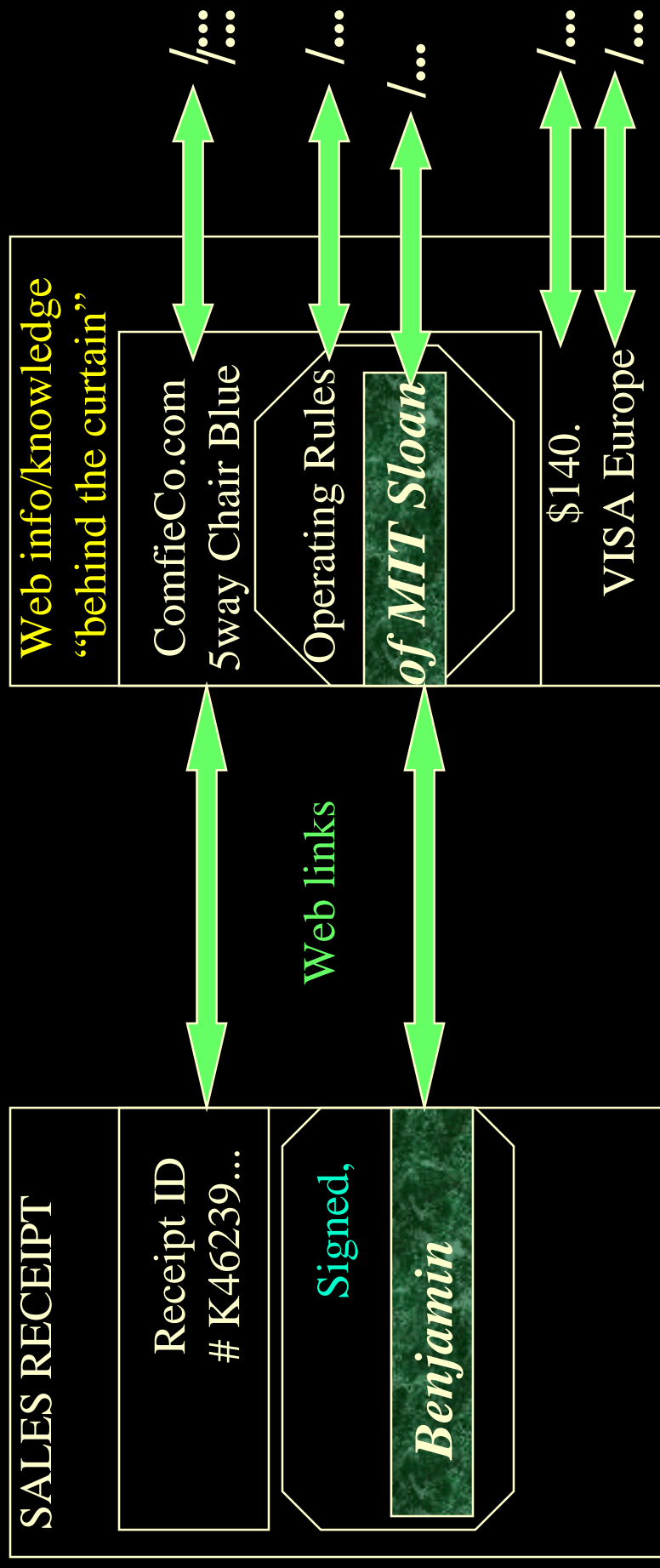
- specify
 - modify
- infer
 - act, decide
- communicate
 - find relevant

Deeper Issues of E-Signatures

- WHAT'S THE DEAL ? ... !!
- SIGN AS WHAT ?? ... !!
- *Vision/Approach:* A net of documents combined by links, on the Web

Looks Simple To Start... then Gets Interestingly Precise

A Vision/Approach of what Web & Agents enable



Intelligent Agents in Web E-Commerce

- *Today:* especially in the discovery phase of shopping
 - sales agents: recommend products, target ads
 - buyer agents: find vendors; compare offers on price, delivery, and availability
- *Coming soon to a world near you:...*
 - billions/trillions of agents
 - ...with smarts: knowledge gathering, reasoning, economic optimization
 - ...**doing our bidding**
 - but with some autonomy

Outline

- Intro; Law in the Small
- Automating Agent Contracting
 - intro
 - examples, illustrating approach
 - approach details: KR, design rationale
 - Courteous Logic Programs in XML
 - value of prioritized default reasoning/argumentation
 - pragmatics, modularity
 - Commercial Implementation and Piloting
- Current Work; Related Work; the Glorious Future
 - regulations, bureaucratic policies & processes
 - XML standards, the Semantic Web

Automating Contracting

- “Contract” in broad sense: = offering or agreement.
- “Automate” in deep sense: =
 - 1. Communicatable automatically.
 - 2. Executable within appropriate context of contracting parties’ business processes.
 - 3. Evaluable automatically by contracting parties.
 - “reason about it” .
 - 4. Modifiable automatically by contracting parties.
 - negotiation, auctions.

Approach:

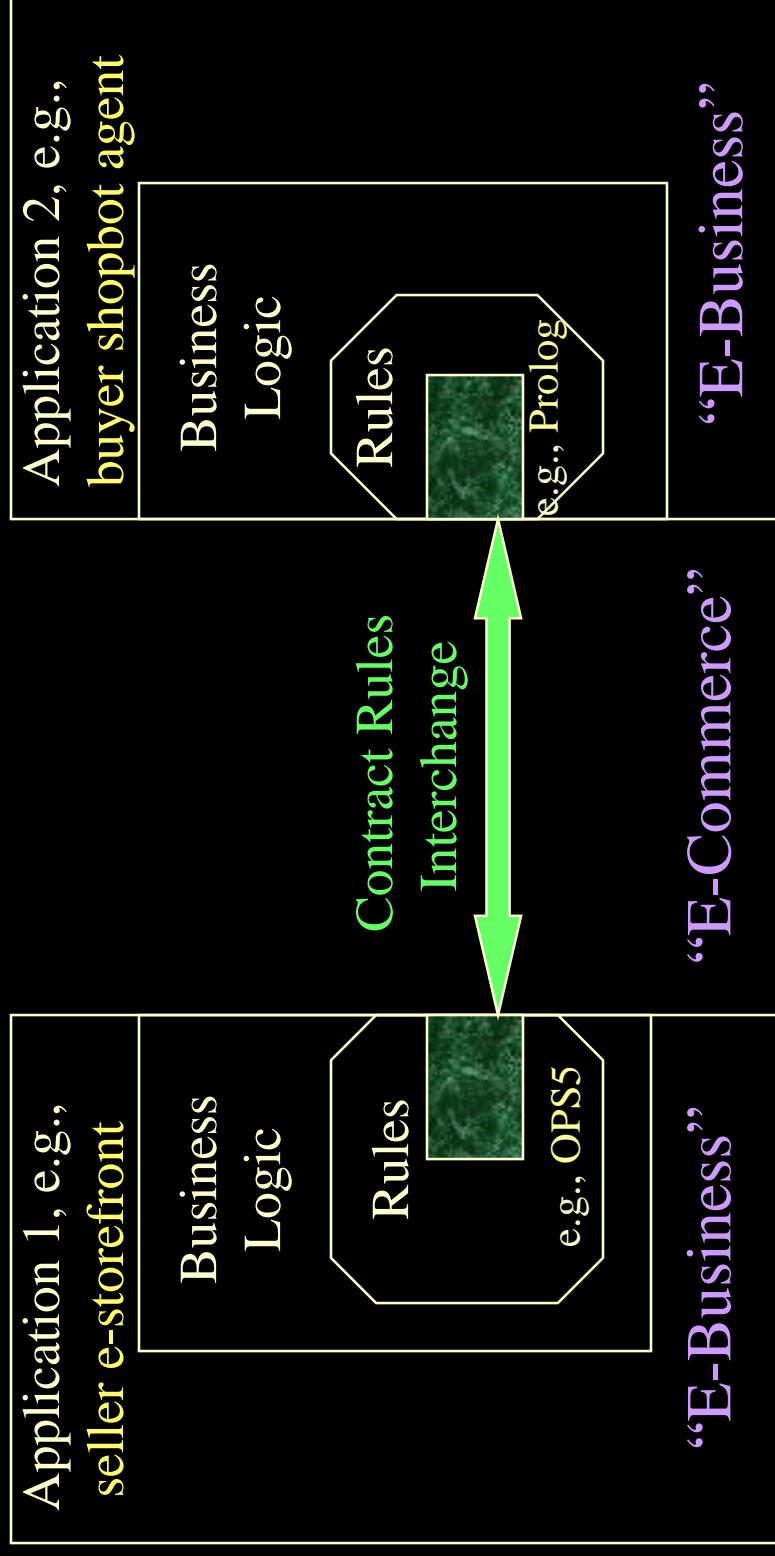
Rule-based Contracts for E-commerce

- 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.

Examples of Rules in Agent Contracts & Deal Making

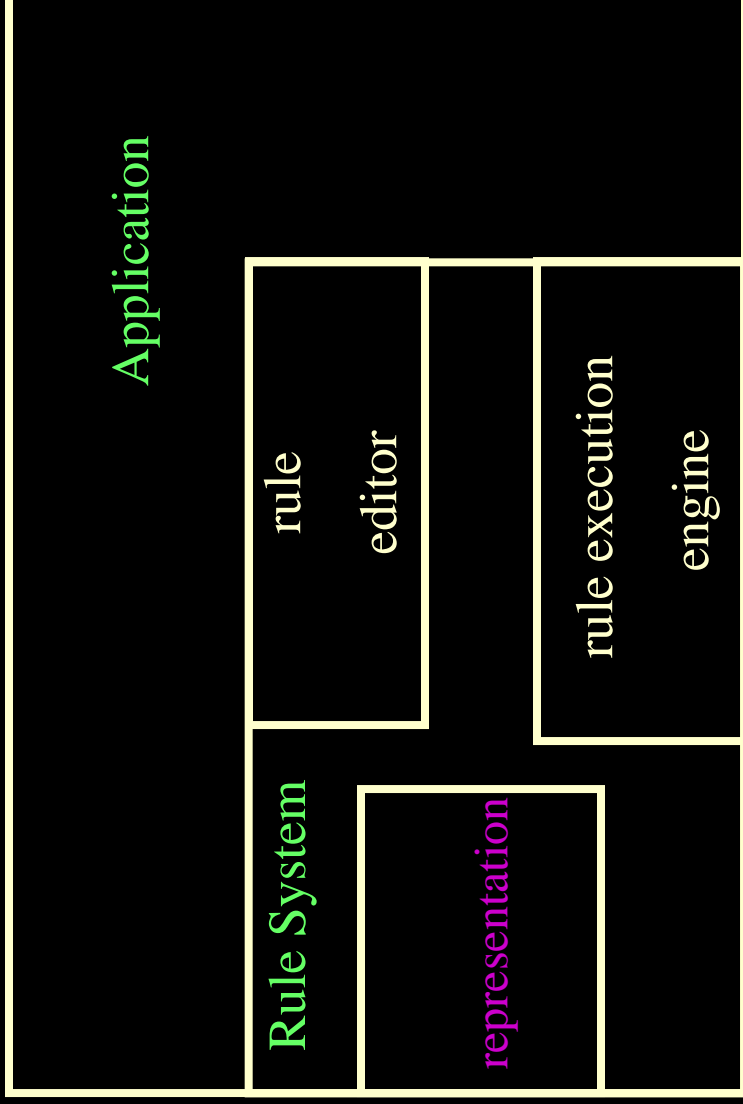
- Product descriptions
 - Product catalogs: properties, conditional on other properties.
- **Price vs. quantity vs. delivery date.**
 - Discounting, incl. for groups.
- Terms & conditions
 - Service provisions
 - Refunds, cancellations.
 - Surrounding business processes, e.g., **lead time** to order.
- Trust
 - Creditworthiness, authorization, required signatures
- *Buyer Requirements (RFQ, RFP) wrt the above*
- *Seller Capabilities (Sourcing, Qualification) wrt the above*

Contract Rules across Applications / Enterprises



Contracting parties integrate e-businesses via shared rules.

Application Using Rules



ZOOM-OUT:

larger Vision: rules in e-business overall

- Rules as an important aspect of coming world of Internet e-business: rule-based business policies & business processes, for B2B & B2C.
 - represent seller's offerings of [products & services](#), capabilities, bids; map offerings from multiple suppliers to common [catalog](#).
 - represent buyer's [requests, interests, bids](#); → [matchmaking](#).
 - represent sales help, [customer help, procurement, authorization/trust](#), brokering, [workflow](#).
 - high level of conceptual abstraction; [easier for non-programmers to understand, specify, dynamically modify & merge](#).
 - executable but can treat as data, separate from code
 - [potentially ubiquitous](#); already wide: e.g., SQL views, queries.
- Rules in communicating applications, e.g., embedded intelligent agents.

Outline

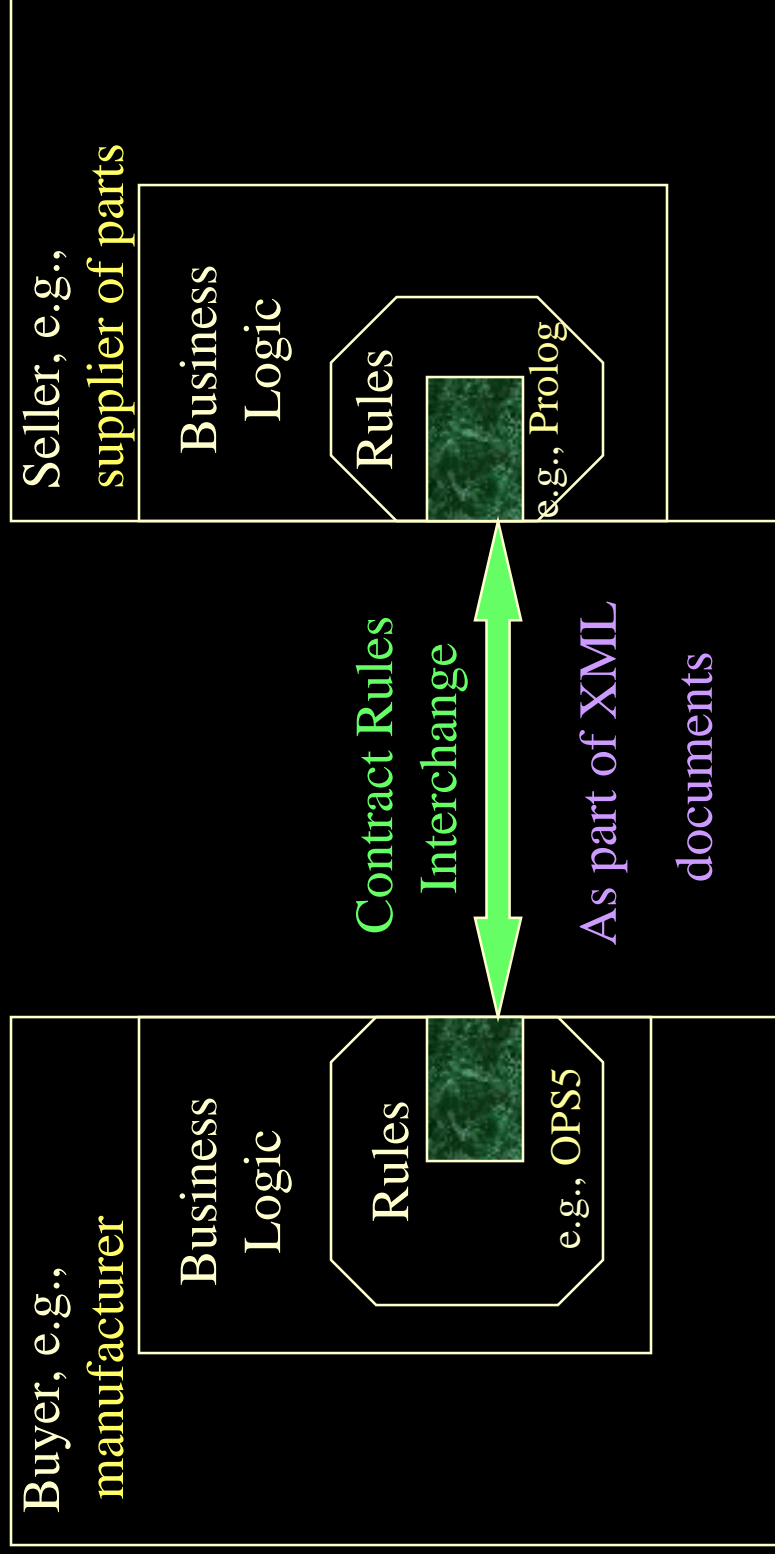
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Bidding in Negotiation

(e.g., in manufacturing supply chain)

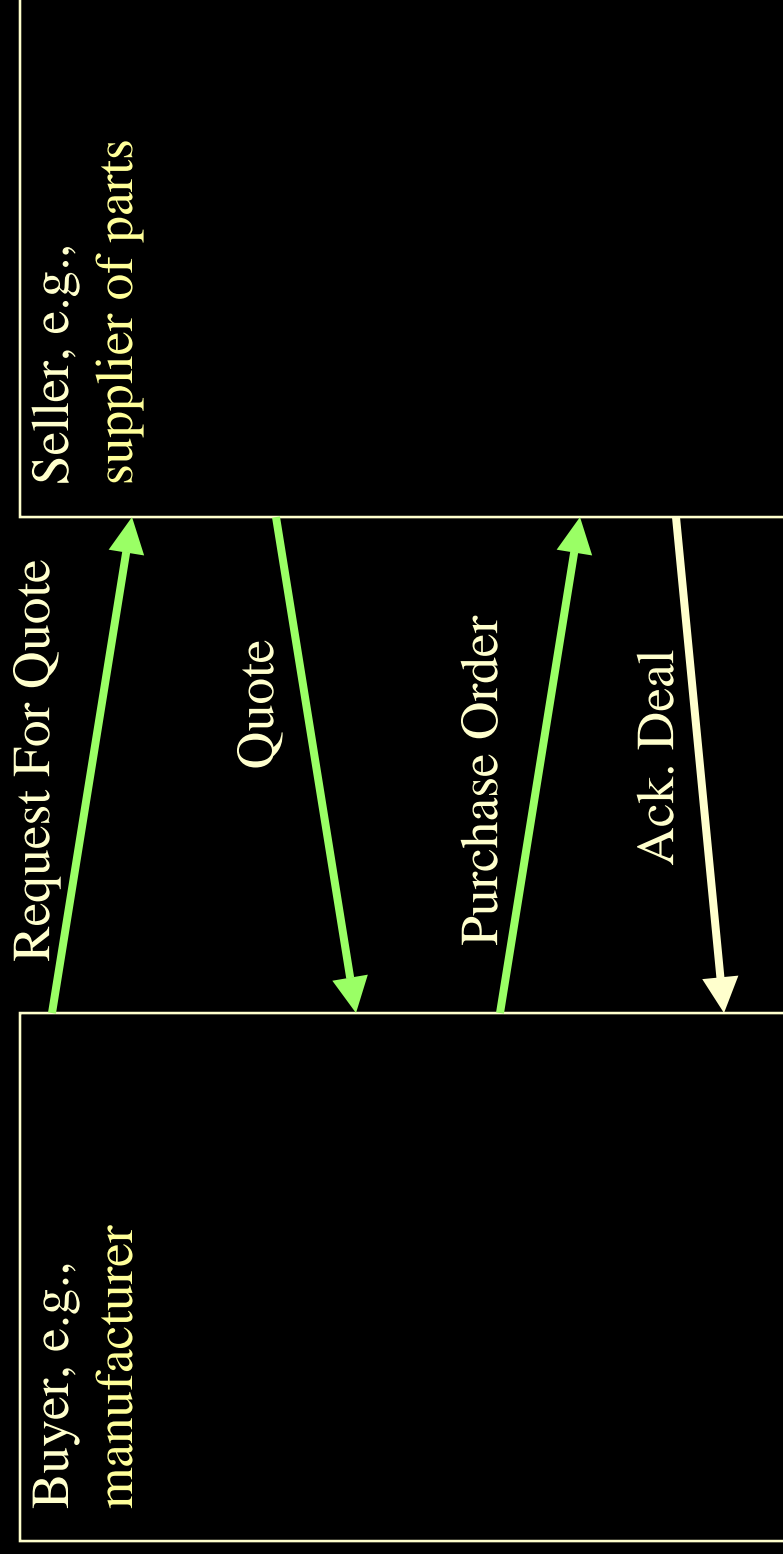
- Use Interlingua to represent contents of:
 - Requests For Quotation or Proposal, i.e., statements of buyer interests, that initiate negotiation, esp. inter-enterprise in B2B.
 - responses to such RFQ's / RFP's by seller: bids, proposals, quotes,
 - proposals and counter-proposals and “side information” exchanged during back-and-forth negotiation / bargaining between buyer and seller.
 - *In short: content of bids and requests for bids:*
 - partial then complete.
 - statements of seller/supplier capabilities/interests, e.g., important for source selection as well as bargaining.

Contract Rules during Negotiation

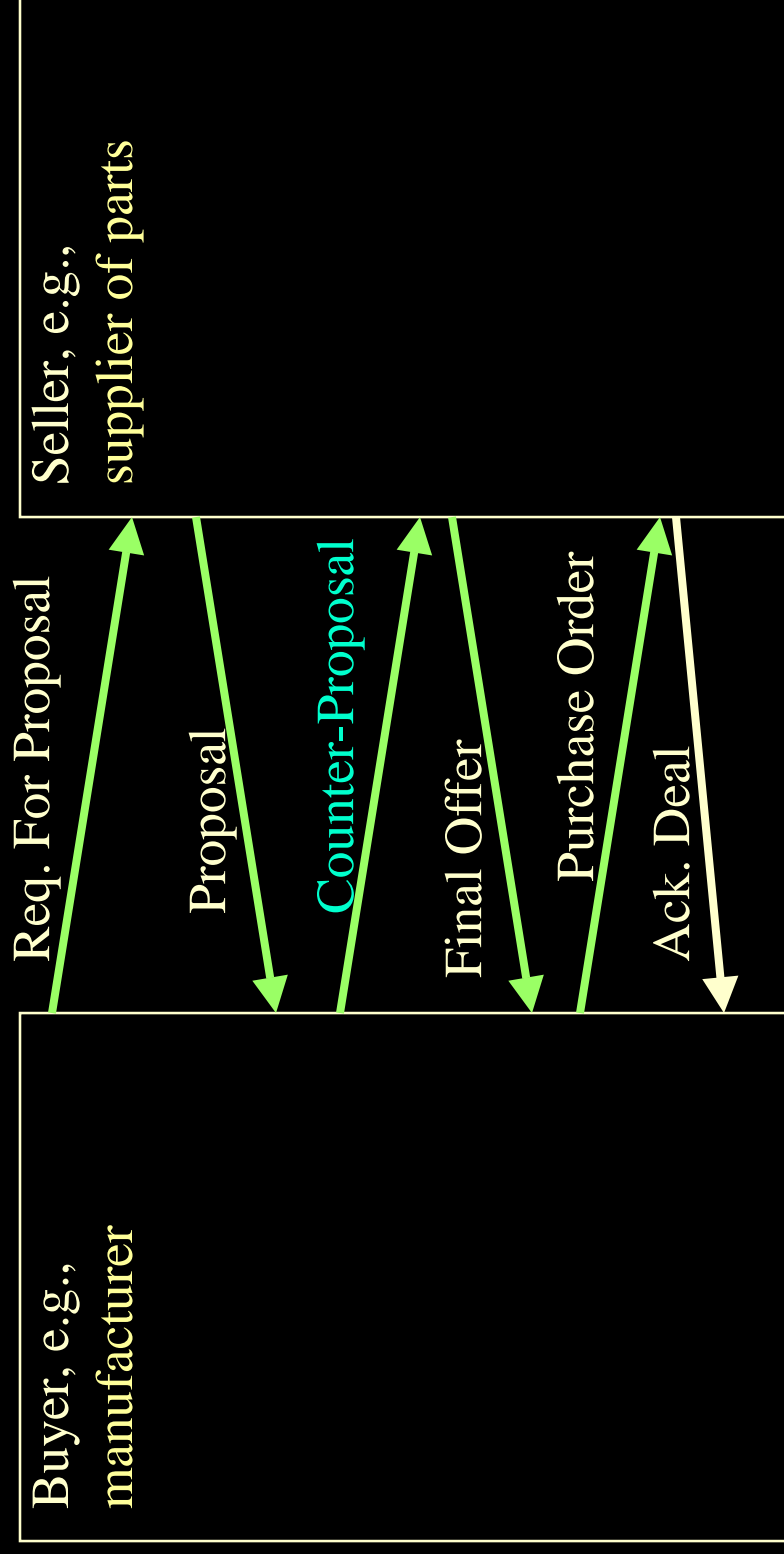


Contracting parties NEGOTIATE via shared rules.

Exchange of Rules Content during Negotiation: example



Exchange of Rules Content during Negotiation: example



Negotiation Example XML Document: Proposal from supplierCo to manufCo

```
<negotiation_message>  
<message_header>  
  <proposal/>  
  <from> supplierCo </from>  
  <to> ManufCo </to>  
</message_header>  
<rules_content>  
  ...[see next slide]  
</rules_content>  
  ...  
</negotiation_message>
```

Example of similar message document format:

FIPA Agent Communication Markup Language (draft industry standard).

Negotiation Ex. Doc. Rules: 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!

In XML: Business Rules Markup Language

- `<clp>`
- `<erule rulelabel="usualPrice">`
- `<head>`
- `<cliteral>`
- `<predicate name="price" arity="3" />`
- `<larglist>`
- `<lfunction name="per_unit" />`
- `<variable name="PO" />`
- `<function name="$60" />`
- `</larglist>`
- `</cliteral>`
- `</head>`
- `<body> ... (see next page) </body>`
- `</erule>`
- ...
- `</clp>`

Business Rules Markup Language for Negotiation Example (continued)

- `<body>`
- `<andb>`
- `<fcliteral>`
- `<predicate name="purchaseOrder" arity="3"/>`
- `<larglist>`
- `<variable name="PO"/>`
- `<lfunction name="supplierCo"/>`
- `<variable name="AnyBuyer"/>`
- `</larglist>`
- `</fcliteral>`
- `<fcliteral>`
- `...`
- `</fcliteral>`
- `...`
- `</andb>`
- `</body>`

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EECOMS Example of Conflicting Rules: Ordering Lead Time

- Vendor's rules that prescribe how buyer must place or modify an order:
- A) 14 days ahead if the buyer is a qualified customer.
- B) 30 days ahead if the ordered item is a minor part.
- C) 2 days ahead if the ordered item's item-type is backlogged at the vendor, the order is a modification to reduce the quantity of the item, and the buyer is a qualified customer.
- Suppose more than one of the above applies to the current order? **Conflict!**
- Helpful Approach: **precedence** between the rules. Often only *partial* order of precedence is justified. E.g., $C > A$.

Courteous LP's:

Ordering Lead Time Example

- `<leadTimeRule1> orderModificationNotice(?Order,14days)`
- `← preferredCustomerOf(?Buyer,?Seller) ^`
- `purchaseOrder(?Order,?Buyer,?Seller) .`
- `<leadTimeRule2> orderModificationNotice(?Order,30days)`
- `← minorPart(?Buyer,?Seller,?Order) ^`
- `purchaseOrder(?Order,?Buyer,?Seller) .`
- `<leadTimeRule3> orderModificationNotice(?Order,2days)`
- `← preferredCustomerOf(?Buyer,?Seller) ^`
- `orderModificationType(?Order,reduce) ^`
- `orderItemIsInBacklog(?Order) ^`
- `purchaseOrder(?Order,?Buyer,?Seller) .`
- `overrides(leadTimeRule3 , leadTimeRule1) .`
- `⊥ ← orderModificationNotice(?Order,?X) ^`
- `orderModificationNotice(?Order,?Y); GIVEN ?X ≠?Y .`

EECOMS Supply Chain Project: Overview

- EECOMS = Extended Enterprise Consortium for Integrated Collaborative Manufacturing Systems. Completed Project: 3/98 - 2/01
- Inter-enterprise supply chain integration/collaboration, in manufacturing.
- IBM-led consortium includes Baan, Boeing, TRW Consulting, smaller rules & tools co.'s, 3 universities.
- 50%-funded by US government's NIST Advanced Technology Program. \$29Million over 3 years (3/98 - 2/01).
- Business Focus: improve “**agility**”: late delivery, plant line breakdown, larger than expected order. React quickly, including modify plans, schedules.
- Technical Focus: **rules and conflict handling** for automated collaboration: **contracts, negotiation, authorization, workflow**; virtual situation room for human collaborative workflow.
- Is follow-on to CIIMPLEX (IBM-led NIST ATP \$22M) & challenges it identified. Shares: consortium, scenarios, agent-based approach.

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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.,
 - Blaze, ILOG, 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.*)

Contract Rules: Overall Approach

- Use Rule Interlingua to represent products (or services), related business policies and/or processes, e.g., in catalog or during negotiation.
 - E.g., conditions on how to return an item for repair, or to deliver an order.
 - Key: declarative knowledge representation:
 - begin with Ordinary Logic Programs; then extend; encode/Webize in XML.
- Executable specification; “situated” LP / procedural attachments is esp. useful.
- Partially-specified / template, esp. during process of negotiation.
- Complement XML ontologies already evolving for various domains.
 - Ontology = formally-represented vocabulary / definitions.
- Specify negotiations including to configure auction mechanisms.
 - content of bids and requests for bids: partial then complete.
 - which goods, which attributes (e.g., price, delivery-date) are at issue.
- *Later: Specify trust/authorization, including via delegation.*

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Overview of Approach to Contract Rule Representation

- **Wanted:** Interlingua between heterogeneous: SQL, Prolog, OPS5, ECA.
- **1. Choose: Ordinary Logic Programs.** Forward or backward chaining.
- **2. Generalize: Courteous Logic Programs.** Prioritized Conflict handling; Compiler to OLP. Modularity in specification and software engineering.
- **3. XML-ify:** cf. RuleML emerging industry standard (updates BRML).
- **4. Generalize: Situated LP's.** Procedural Attachments for tests, actions.
- **Implementation: IBM CommonRules** free on AlphaWorks: V1.0 7/99, V2.1 currently.

Detailed in this talk: (1.)--(3.).

Criteria for Contract Rule Representation

- 1 • *High-level*: Agents reach common understanding; contract is easily modifiable, communicatable, executable.
- 2 • Inter-operate: heterogeneous commercially important rule systems.
• Expressive power, convenience, natural-ness.
• ... but: computational tractability.
- 3 • Modularity and locality in revision.
• Declarative semantics.
• Logical non-monotonicity: default rules, negation-as-failure.
• – essential feature in commercially important rule systems.
• Prioritized conflict handling.
• Ease of parsing.
• Integration into Web-world software engineering.
• Procedural attachments.

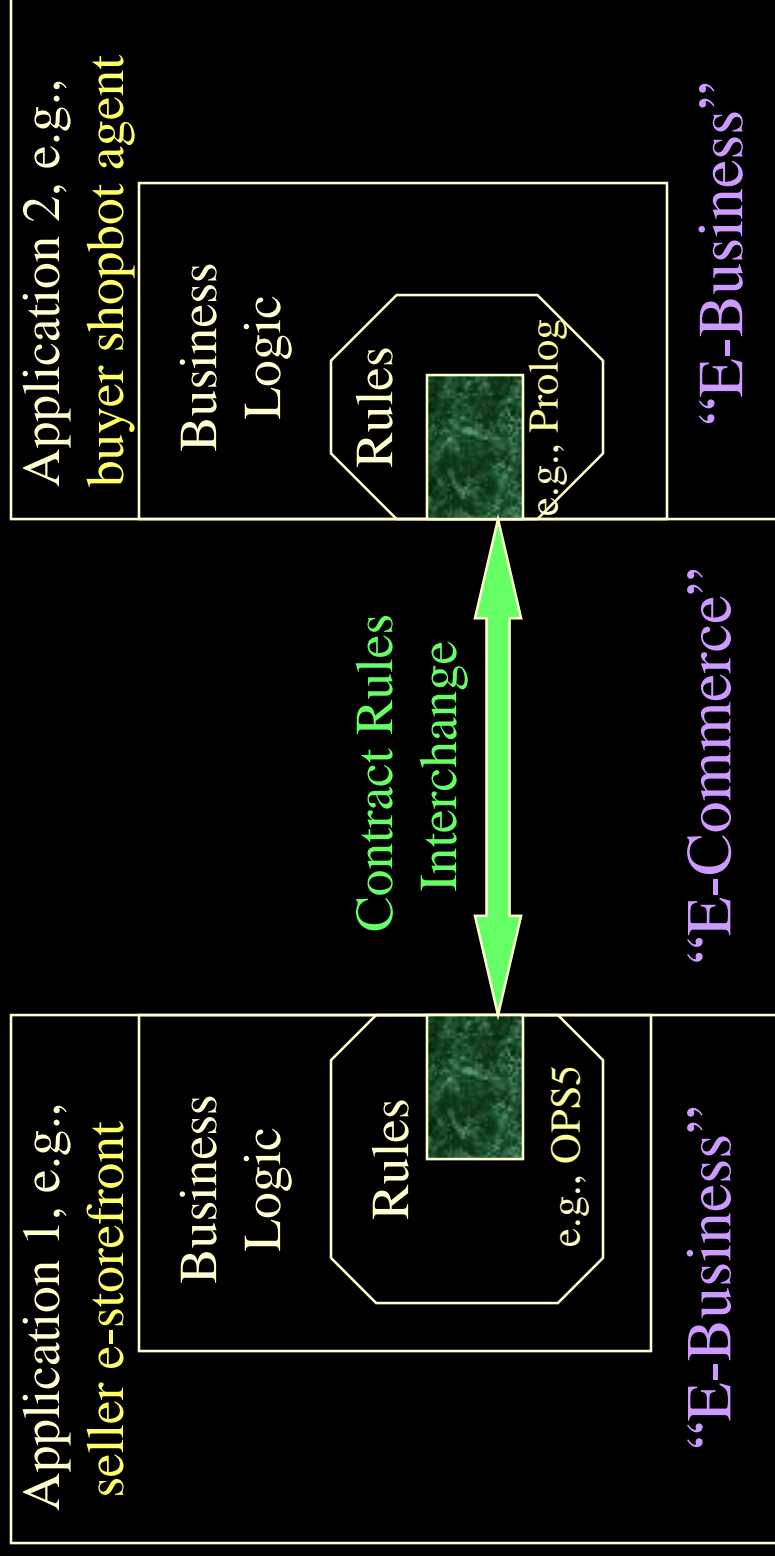
OLP

Courteous

XML

Situated

Contract Rules across Applications / Enterprises



Contracting parties integrate e-businesses via shared rules.

Ordinary Logic Programs as basic representation: Advantages

- Declarative: semantics is independent of inferencing procedure implementation, e.g., forward vs. backward chaining, sequencing of executing rules or conditions within rules.
- Expressive: relational expressions cf. SQL, large fragment of first-order logic, chaining, basic logical non-monotonicity (unlike first-order logic / ANSI-draft Knowledge Interchange Format).
- Efficient: computationally tractable given two reasonable restrictions:
 - 1. Datalog = no logical functions of non-zero arity.
 - 2. Bounded number v of logical variables per rule.
 - $m = O(n^{v+1})$, where $n = \|LP\|$, $m = \|\text{ground-instantiated LP}\|$.
 - Inferencing time is $O(m)$ for broad case (stratified), $O(m^2)$ generally (for well-founded semantics).
 - By contrast, first-order-logic inferencing is NP-hard.

Ordinary Logic Programs: Advantages (continued)

- Widely deployed and familiar:
 - relational DB's, SQL
 - Prolog
 - knowledge-based systems and intelligent agents
 - (e.g., IBM's Agent Building Environment)
- Common core shared semantically by many rule systems: e.g.,
 - relational DB's, SQL
 - Prolog
 - production rules (OPS5 heritage)
 - Event-Condition-Action rules
 - first-order-logic

Courteous LP's: the What

- Updating/merging of rule sets: is crucial, often generates conflict.
- Courteous LP's feature prioritized handling of conflicts.
- Specify scope of conflict via a set of *pairwise mutual exclusion* constraints.
 - E.g., $\perp \leftarrow \text{discount}(\text{product}, 5\%) \wedge \text{discount}(\text{product}, 10\%)$.
 - E.g., $\perp \leftarrow \text{loyalCustomer}(\text{?c}, \text{?s}) \wedge \text{premiereCustomer}(\text{?c}, \text{?s})$.
 - Permit classical-negation of atoms: $\neg p$ means p has truth value *false*
 - implicitly, $\perp \leftarrow p \wedge \neg p$ for every atom p .
- Priorities between rules: partially-ordered.
 - Represent priorities via reserved predicate that compares rule labels:
 - `overrides(rule1, rule2)` means rule1 is higher-priority than rule2.
 - Each rule optionally has a rule label whose form is a functional term.
 - `overrides` can be reasoned about, just like any other predicate.

Priorities are available and useful

- Priority information is naturally available and useful. E.g.,
 - recency: higher priority for more recent updates.
 - specificity: higher priority for more specific cases (e.g., exceptional cases, sub-cases, inheritance).
 - authority: higher priority for more authoritative sources (e.g., legal regulations, organizational imperatives).
 - reliability: higher priority for more reliable sources (e.g., security certificates, via-delegation, assumptions, observational data).
 - closed world: lowest priority for catch-cases.
- Many practical rule systems employ priorities of some kind, often implicit, e.g.,
 - rule sequencing in Prolog and production rules.
 - courteous subsumes this as special case (totally-ordered priorities), plus enables: merging, more flexible & principled treatment.

Prioritized argumentation in an opposition-locale.

Conclusions from opposition-locales previous to this opposition-locale $\{p_1, \dots, p_k\}$
↓
(Each p_i is a ground classical literal. $k \geq 2$.)

Run Rules for p_1, \dots, p_k

↓
Set of Candidates for p_1, \dots, p_k :
Team for p_1, \dots , Team for p_k

↓
Prioritized Refutation

↓
Set of Unrefuted Candidates for p_1, \dots, p_k :
Team for p_1, \dots , Team for p_k

↓
Skepticism

↓
Conclude Winning Side if any: at most one of $\{p_1, \dots, p_k\}$

Courteous LP's: Advantages

- Facilitate updating and merging, modularity and locality in specification.
- Expressive: classical negation, mutual exclusions, partially-ordered prioritization, reasoning to infer prioritization.
- Guarantee consistent, unique set of conclusions.
 - **Mutual exclusion is enforced.** E.g., never conclude both p & $\neg p$.
- Efficient: low computational overhead beyond ordinary LP's.
 - Tractable given reasonable restrictions (Datalog, bound v on #var's/rule):
 - extra cost is equivalent to increasing v to $(v+2)$ in ordinary LP's.
 - By contrast, more expressive prioritized rule representations (e.g., Prioritized Default Logic) add NP-hard overhead.
- Modular software engineering: via courteous compiler: CLP \rightarrow OLP.
 - A radical innovation. Add-on to variety of OLP rule systems. $O(n^3)$.

Courteous LP's: Keys to Tractability

- Overall: mutex's & conflict locales \rightarrow keep tractability.
- LP's: disallow disjunctive conclusions, essentially. **Classical allows \Rightarrow NP-hard.**
- LP's: disallow contraposition ($= \{ \neg a \leftarrow \cdot, a \leftarrow b \wedge c. \} \Rightarrow (\neg b \vee \neg c)$) which requires disjunctive conclusions. "Directional". **Classical allows \Rightarrow NP-hard.**
- **Highly expressive prioritized rule representations** (e.g., Prioritized Default Logic, Prioritized Circumscription) **allow minimal conflict sets of arbitrary size \Rightarrow NP-hard overhead for conflict handling.**
- Courteous conflict handling involves essentially only pairwise conflicts, i.e., minimal conflict sets of size 2. (Current work: possibly generalize to size k.)
 - Novelty: generalize to pairwise mutex's beyond $\perp \leftarrow p \wedge \neg p$, e.g., partial-functional, thus avoid need for contraposition and larger conflict sets.
- Courteous conflict handling is local within an opposition locale: a set of rules whose heads oppose each other through mutex's. Refutation and Skepticism are applied within each locale.

Summary: Courteous LP's in XML as Core KR

- Key Observations about Declarative OLP:
 - captures common core among commercially important rule systems.
 - is expressive, tractable, familiar.
 - advantages compared to classical logic / ANSI-draft KIF:
 - ++ logical non-monotonicity, negation-as-failure.
 - -- disjunctive conclusions.
 - ++ tractable.
 - ++ procedural attachments: situated LP's.
- Cleverness of Courteous extension to the OLP representation:
 - prioritized conflict handling → modularity in specification.
 - courteous compiler → modularity in software engineering.
 - mutex's & conflict locales → keep tractability. (Compiler is $O(n^3)$.)
- Novelty: do it in XML → ease of parsing, integration in Web engineering.

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Situated LP's: Motivation from Contracts

- For executable contract specification:
 - **procedural attachments** is esp. useful
 - ... thus situated logic programs is esp. useful
 - a new abstraction, highly declarative
 - introduced in: IBM Agent Building Environment '96.

Situated LP's: Overview

- Point of departure: LP's are pure-belief representation, but most practical rule systems want to invoke external procedures.
- Situated LP 's feature a semantically-**clean** kind of **procedural attachments**. I.e., they hook beliefs to drive procedural API's outside the rule engine.
- Procedural attachments for **sensing** (queries) when testing an antecedent condition or for **effecting** (actions) upon concluding a consequent condition. Attached procedure is invoked when testing or concluding in inferencing.
- Sensor or effector **link** statement specifies an association from a predicate to a procedural call pattern, e.g., a method. A link is specified as part of the representation. I.e., a SLP is a conduct set that includes links as well as rules.

Situated LP's: Overview (cont.'d)

- `phoneNumberOfPredicate ::s:: BoeingBluePagesClass.getPhoneMethod .`
ex. sensor link
- `shouldSendPagePredicate ::e:: ATTPagerClass.goPageMethod .`
ex. effector link
- Sensor procedure may require some arguments to be ground, i.e., bound; in general it has a specified binding-signature.
- Enable dynamic loading and remote loading of the attached procedures (exploit Java goodness).
- Overall: cleanly separate out the procedural semantics as a declarative extension of the pure-belief declarative semantics. Easily separate chaining from action.

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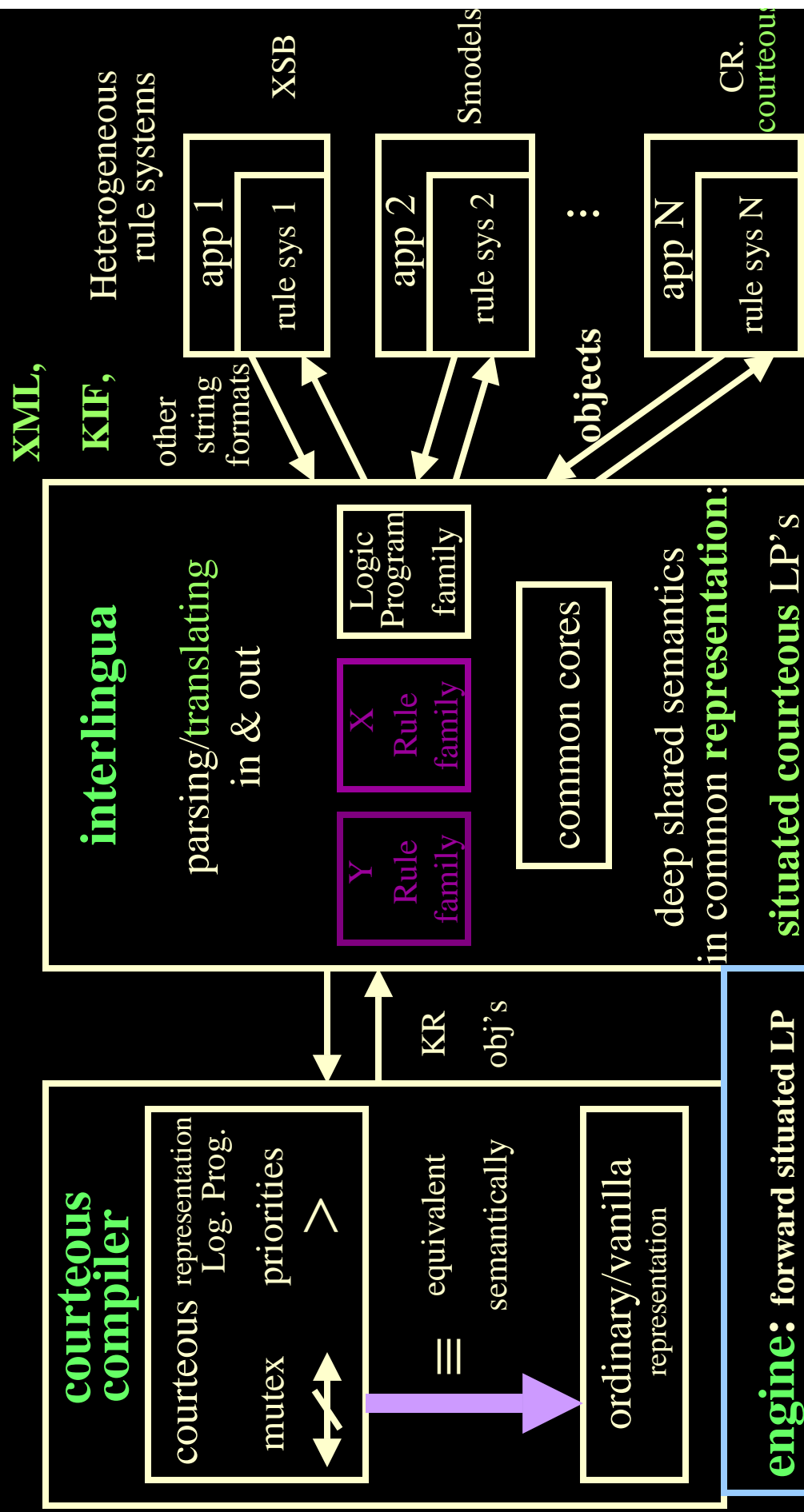
Commercial Implementation & Piloting

- **IBM CommonRules:** AlphaWorks Java library
 - implements rule-based capabilities:
 - XML inter-operability; prioritized conflict handling
- **Rule Markup Language:** nascent industry standards effort
 - XML Knowledge Representation (KR) → make the Web be “Semantic”
 - KR: **Situated Courteous Logic Programs in XML**
- EECOMS industry consortium including Boeing, Baan, TRW, Vitria, IBM, universities, small companies
 - \$29Million 1998-2000; 50% funded by NIST ATP
 - application piloted
 - contracting & negotiation; authorization & trust

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Current-version IBM CommonRules



What's Doable Today in rule-based agent contracting, *based on our approach*

- Communicate:
 - XML, interoperable
 - \Leftrightarrow heterogeneous rule systems / rule-based agents
- Execute contract provisions:
 - infer; ebiz actions; authorize; ...
- Modify easily: contingent provisions
 - default rules; modularity
- Reason about the contract/proposal
 - hypotheticals, test, evaluate

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Related Work on Prioritized Rule KR

- Other approaches to prioritized logic programs
 - close: **Defeasible Logic**: Nute, Maher, Antoniou, *et al*
 - Prakken, Sartor
- Less close, less tractable: very-expressive prioritized logics
 - Prioritized Default Logic (Brewka),
 - Prioritized Circumscription (McCarthy, Lifschitz, Groszof)

Examples of Rules in Regulations & Bureaucratic Policies/Processes

- Taxes and Tariffs
 - rules from a variety of sources, e.g., jurisdictions
- Social Services: e.g., qualifying for benefits
- Notifications
- Penalties, Liabilities
- Authorizations, Permissions
 - e.g., access to medical records
- ...

Overview of Approach to: Policies for Trust and Security Authorization

- Use rule-based executable specification of security authorization policies, a.k.a. trust management: including delegation, certificates.
 - Straightforwardly generalizes Role-Based Access Control (RBAC).
 - We have the first step of an expressive extension of courteous LP's to handle delegation and certificates: Delegation Logic.
- Often, authorization/trust policy is really a part of overall contract or business policy, at application-level. This contrasts with authentication.
- Advantages of rule-based approach, esp. from declarative semantics:
 - easier integration with general business policy.
 - easier to understand and modify by humans.
 - provable guarantees of behavior of implementation.
 - principled handling of negation and conflict.

Delegation Logic (DILLP) Example: accessing medical records

- **Problem:** Hospital HM to decide: requester Alice authorized for patient Peter?
- **Policies:** HM will authorize only the patient's physician. HM trusts any hospital it knows to certify the physician relationship. Two hospitals together can vouch for a 3rd hospital.
 - HM says **authorized**(?X, read(medRec(?Y))) if HM says inRole(?X, **physic**(?Y)).
 - HM **delegates** inRole(?X, **physic**(?Y))^1 to threshold(1,?Z, HM says inRole(?Z,hosp)).
 - HM **delegates** inRole(?H,hosp)^1 to threshold(2 , ?Z, HM says inRole(?Z,hosp)).
- **Facts:** HC certifies Alice is Peter's physician. HM knows two hospitals HA and HB. HA and HB each certify HC as a hospital.
 - HC says inRole(Alice, **physic**(Peter)). HA says inRole(Joe, **physic**(Sue)).
 - HM says inRole(HA,hosp). HM says inRole(HB, hosp).
 - HA says inRole(HC,hosp). HB says inRole(HC, hosp).
- **Conclusion:** HM says **authorized**(Alice, read(medRec(Peter))). *Joe NOT authorized.*

More Legal Applications: Visions

- regulations
- Alternative Dispute Resolution
- adjudication, legal decision-making
- ...
?pointers?

Also Currently Being Developed in the world today

- Delegations between agents
- XML Ontologies (Vocabularies)
 - knowledge representation: infer with definitional knowledge
 - specific domain/industry vocabularies
- DARPA Agent Markup Language: ontologies, rules
- Industry Standards:
 - Web
 - Agents, Business Processes, Workflow
 - E-Commerce
 - Industry-Specific
 - *Legal XML*
- *Law: Electronic Signatures, ...*

Current Work:

Knowledge Representation on the Web

- Apply KR viewpoint and techniques to Web info
- “Web-ize” the KR’s
 - exploit Web/XML hyper-links, interfaces, tools
 - think global, act global : as part of whole Web
- Radically raise the level of shared meaning
 - level = conceptual/abstraction level
 - meaning = sanctioned inferences / vocabularies
 - shared = tight correspondence
- “The Semantic Web”, “The Web of Trust” [Tim B-L]
- Build: The Web Mark II

Current Work in KR on the Web: Challenges & Opportunities; Issues

- exploit emerging Web standards in XML suite
 - XML data, XML-ified APIs generally
 - beginning Rule Markup Language industry standards effort
 - related: Java Rule Engines standards effort
 - RDF, DAML+OIL Description Logic, Topic Maps, XML Query, P3P
 - XML-EDI, EDIFAC, EBXML, UDDI, ...
 - Industry verticals ontologies, IEEE Upper Ontologies, ...
 - Legal XML, ...
- exploit other emerging agent-communication standards:
 - FIPA, OMG, ANSI Knowledge Interchange Format (KIF)
- inter-source context, conflicts, trust

- Thanks!
- Questions?
- Comments? Pointers?
- For More Info:
 - <http://www.mit.edu/~bgrosof/>
 - links to <http://www.research.ibm.com/rules/>

Outline

- Intro; Law in the Small
- Automating Agent Contracting
 - intro
 - examples, illustrating approach
 - approach details: KR, design rationale
 - Courteous Logic Programs in XML
 - value of prioritized default reasoning/argumentation
 - pragmatics, modularity
 - Commercial Implementation and Piloting
- Current Work; Related Work; the Glorious Future
 - regulations, bureaucratic policies & processes
 - XML standards, the Semantic Web

OPTIONAL SLIDES FOLLOW

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Launch Vector: My Background

E-Commerce Agents, Rules: Techno + Biz

- Harvard BA math econ & mgm sci
- startups
- Stanford CS (Computer Science) PhD in AI
- IBM Watson Research: IA for EC
 - Led Intelligent Agents, Business Rules for E-Commerce
- MIT Sloan: Information Technology group
- Technology end of B-school IT world
- CS + Business Perspective (cf. Industry, cf. B-school):

theory theory



*practical
theory
+ pilot app's*

- how/where the technology is useful, important
- business value; implications for processes & strategies
- market evolutions; innovation paths; organizational changes

Background in Law-related Research

- Overall: formally represent policies and info as rules
- Evidential Reasoning: probabilistic, fuzzy, ...
- Bureaucratic Processes as domain
 - pioneer within AI knowledge representation community
- Argumentation with rule-based beliefs:
 - efficient algorithms
 - theory
 - bridge to commercially practical rule-based/database systems
- Contracting & Negotiation, Authorization & Trust
- *Invited Speaker at 2001 ABA Spring Meeting > Business Law > Cyberlaw > Internet Law > E-Agents Task Force*
- *Invited Speaker at 2001 International Conference on AI & Law:*
 - “Automating Law in the Small: Contracts, Regulations, and Prioritized Argumentation”

The Web is becoming XML

- XML (vs. HTML) offers much greater capabilities for structured detailed descriptions that can be processed automatically.
 - Eases application development effort for assimilation of data in inter-enterprise interchange
 - A suite of open standards both current and emerging
- *Soon, Agents will Talk according to these standards...*
 - ∴ potential to revolutionize interactivity in Web marketplaces
 - B2B, ...

Declarative Semantics at Core

- Desire: deep semantics (model-theoretic) to
 - understand and execute imported rules.
- Possible only for shared expressive subsets: “cores”.
 - Rest translated with superficial semantics.
- Approach: declarativeness of core / rep'n (in sense of knowledge representation theory).
 - A given set of premises entails a set of sanctioned conclusions. Independent of implementation & inferencing control (bkw vs. fwd).
 - Maximizes overall advantages of rules:
 - Non-programmers understand & modify.
 - Dynamically (run-time) modify.

Interlingua: Need Go Beyond KIF

- KIF has major limitations:
 - **logically monotonic.**
 - yet virtually all practical rule (and probability) systems are non-monotonic.
 - **pure-belief, no procedural attachments.**
 - yet most practical rule systems do invoke procedures external to the inference engine.
- **Candidates to complement KIF exist:**
 - **logic programs, Bayes nets, ...**

Ordinary Logic Programs as basic representation: Definition

- A LP is a set of (premise) rules; semantically, it specifies a set of conclusions.
- `replyInterval(?msg, CustomerRep)`
- `← from(?msg, ?s) ∧ customer(?s) ∧ ~urgency(?msg, low)`.
-
- where the “?” prefix indicates a logical variable.
- Generally, a rule has the form of `Head IF Body` :
- $H \leftarrow B_1 \wedge \dots \wedge B_j \wedge \sim B_{j+1} \wedge \dots \wedge \sim B_m$.
- where $m \geq 0$; \wedge stands for logical “AND”; \leftarrow stands for logical “IF”; and H, B_1, \dots, B_m are each an atom with form: `Predicate(Term_1, ..., Term_k)`.
- A predicate = a relation. An atom semantically denotes a boolean.
- \sim stands for negation-as-failure (a.k.a. weak negation, default negation).
 - The negation-as-failure construct is logically non-monotonic.
 - Intuitively, $\sim p$ means p 's truth value is either *false* OR *unknown*.

Example Rule

Ordinary Logic Programs: Definition (continued)

- Each argument Term₁, ..., Term_k is a term.
- A term is either a logical constant (e.g., “Joe”) OR a logical variable (e.g., “?msg”) OR a functional expression of the form:
 - LogicalFunction(Term₁, ..., Term_k)
- A functional expression semantically essentially denotes a logical constant.
- A term, atom, or rule is called “ground” when it has no logical variables.
- A fact is a ground rule with empty body.
- A primitive conclusion has the form of a ground atom (compound conclusions are built up from these via logical operators such as AND etc.).
- Semantically, a rule or LP stands for the set of all its ground instances.
- (Observe that a rule body can represent an expression in relational algebra cf. relational DB’s (e.g., SQL).)

IBM CommonRules technology overview

- Java library: V1.0 released 7/30/99 on IBM AlphaWorks.
 - thousands of downloads via Web.
 - piloting in EECOMS \$29Million NIST ATP project (IBM, Baan, Boeing, TRW, universities, other co.'s) on agile manufacturing.
 - negotiation & trust/security in supply chain collaboration.
- Basic rule representation: Logic programs (LP's).
 - LP's in declarative sense, not Prolog. E.g., forward or backward chaining.
 - representation = syntax + deep semantics.
 - semantics of rule set = its set of valid conclusions.

CommonRules technology overview (continued)

- Extends rule representation to:
 - Courteous LP's:
 - prioritized handling of **conflicts**, e.g., in updating/merging.
 - Situated (Courteous) LP's:
 - **procedural attachments** to invoke non-reasoning actions or queries, via methods external to inferencing engine.
- Courteous Compiler from courteous LP's to ordinary LP's.
- XML Interlingua and sample translators.
 - interlingua = common rule representation for translation between heterogeneous rule systems. Suitable to become industry standard.
- Sample Inferencing/Execution Engine:
 - forward-chaining situated courteous LP's.

Delegation Logic: Goal and Basic Approach

- Our goal: Develop a language that
 - can represent, with significant expressive power, policies and credentials for authorization in Internet scenarios
 - can provide mechanisms for delegation
 - has a clear declarative semantics
- Our approach: Delegation Logic (DL): multi-agent logic programs with *delegation to complex delegates*
 - D1LP: extends negation-free OLP \Rightarrow with delegation
 - D2LP: extends Courteous LP \Rightarrow with delegation
 - Tractable “Delegation compiler” similar to courteous compiler.
- Collaborators: Ninghui Li (NYU \rightarrow Stanford), Joan Feigenbaum (ATT \rightarrow Yale)