Semantic Web Services, Rules, and E-Contracting: Overview and Relationship to AutoID

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Slides presented at MIT Auto-ID Labs Web Services WAN SIG Launch Workshop, Mar. 9, 2004

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Outline of Talk

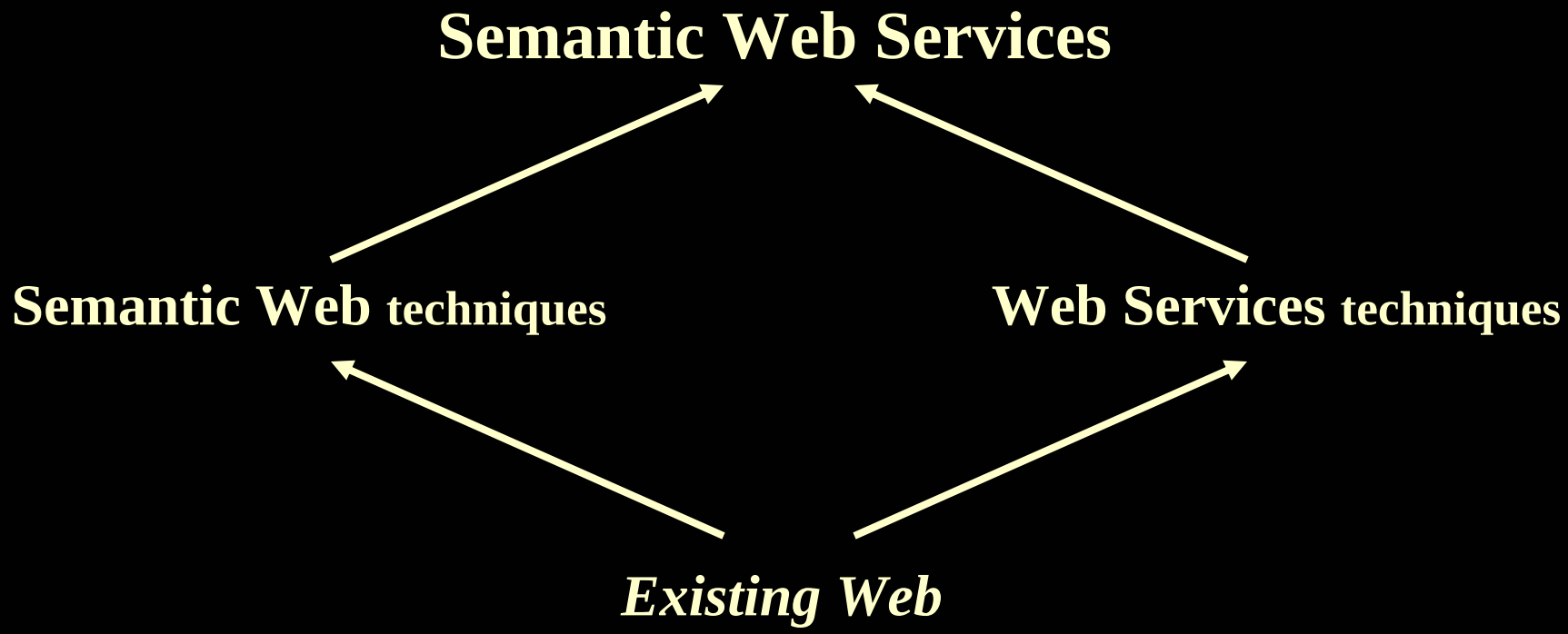
- I. Overview: Semantic Web Services (SWS) and Rules
  - Concepts, Today's Scene, Visions
  - Applications, incl. B2B
  - End-to-end e-contracting, and policies
  - Strategy: adoption roadmap
- II. How does this apply to AutoID?
  - B2B Tasks; end-to-end e-contracting, and policies
  - SWS Research Directions

- Optional: More Details, esp. on e-contracting and rules

Quickie Bio of Presenter

- MIT professor since 2000
- 12 years at IBM T.J. Watson Research; 2 years at startups
- PhD Comp Sci, Stanford; BA Applied Math Econ/Mgmt, Harvard
- Semantic web services is main research area:
  - Rules as core technology
  - Business Applications, Implications, Strategy:
    - e-contracting/supply-chain; finance; trust; …
  - Overall knowledge representation, e-commerce, intelligent agents
- Co-Founder, Rule Markup Language Initiative – the leading emerging standards body in semantic web rules (http://www.ruleml.org)
- Core participant in Semantic Web Services Initiative – which coordinates world-wide SWS research and early standards (http://www.swsi.org)
  - Area Editor for Contracts & Negotiation, Language Committee
  - Co-Chair, Industrial Partners program (SWSIP)

Next Generation Web



Web Service -- definition

- *(For purposes of this talk:)*

- A procedure/method that is invoked through a Web protocol interface, typically with XML inputs and outputs

Semantic Web: concept, approach, pieces

- Shared semantics when interchange data ∴ knowledge
- Knowledge Representation (cf. AI, DB) as approach to semantics
  - Standardize KR syntax, with KR theory/techniques as backing
- Web-exposed Databases: SQL; XQuery (XML-data DB's)
  - Challenge: share DB schemas via meta-data
- RDF: "Resource Description Framework" W3C proposed standard
  - Meta-data lower-level mechanics: unordered directed graphs (vs. ordered trees)
  - RDF-Schema extension: simple class/property hierarchy, domains/ranges
- Ontology = formally defined vocabulary & class hierarchy
  - OWL: "Ontologies Working Language" W3C proposed standard
    - Subsumes RDF-Schema and Entity-Relationship models
    - Based on Description Logic (DL) KR ~subset of First-Order Logic (FOL))
- Rules = if-then logical implications, facts ~subsumes SQL DB's
  - RuleML: "Rule Markup Language" emerging standard
    - Based on Logic Programs (LP) KR ~extension of Horn FOL

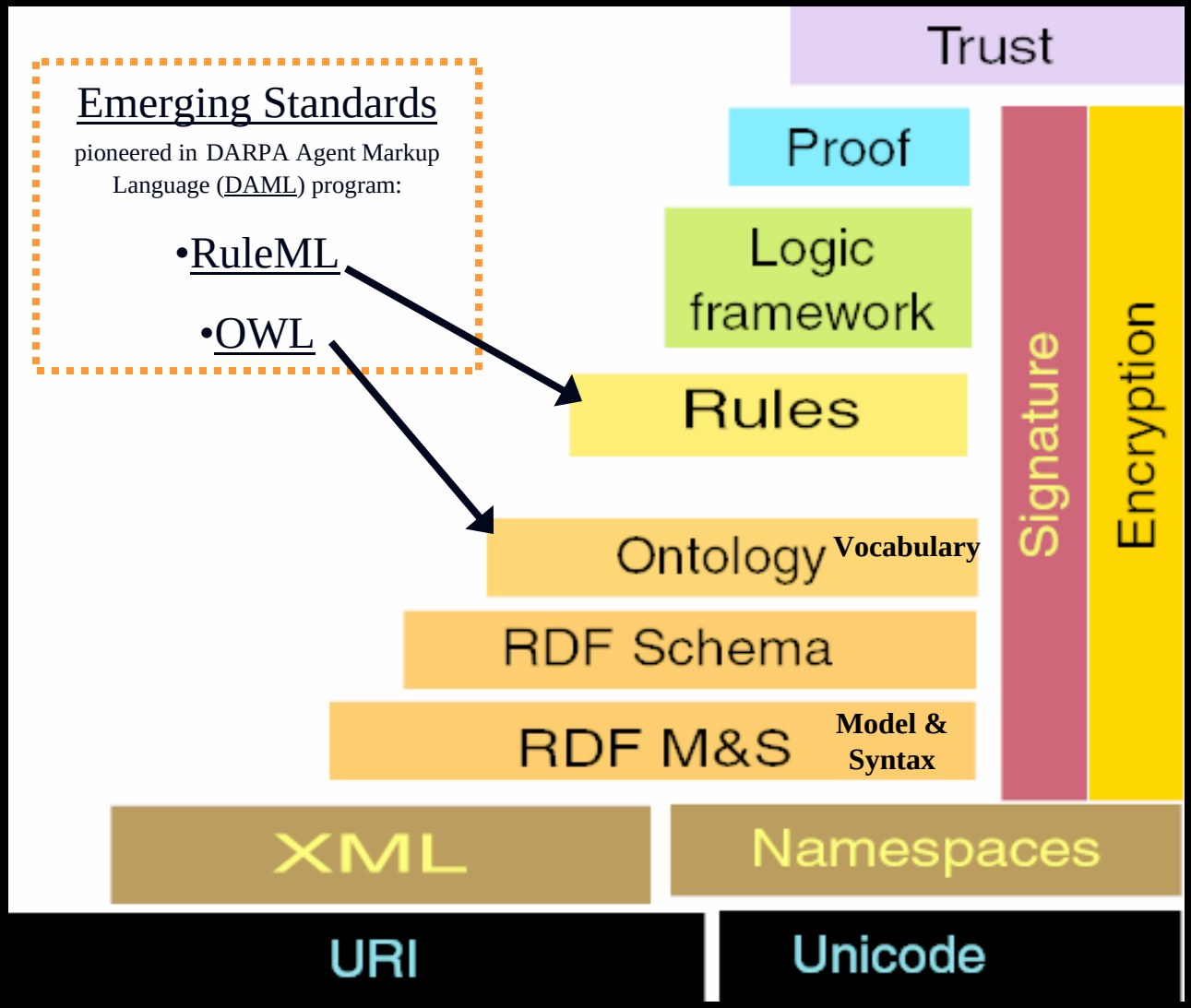
Some Semantic Web Advantages for Biz

- Builds upon XML's much greater capabilities (vs. HTML*) for structured detailed descriptions that can be processed automatically.
  - Eases application development effort for assimilation of data in inter-enterprise interchange
- Knowledge-Based E-Markets -- where Agents Communicate

  (Agent = knowledge-based application)
  - ∴ potential to revolutionize *interactivity* in Web marketplaces: B2B, …
- Reuse same knowledge for multiple purposes/tasks/app's
  - Exploit declarative KR; Schemas

- * new version of HTML itself is now just a special case of XML

W3C Semantic Web "Stack": Standardization Steps

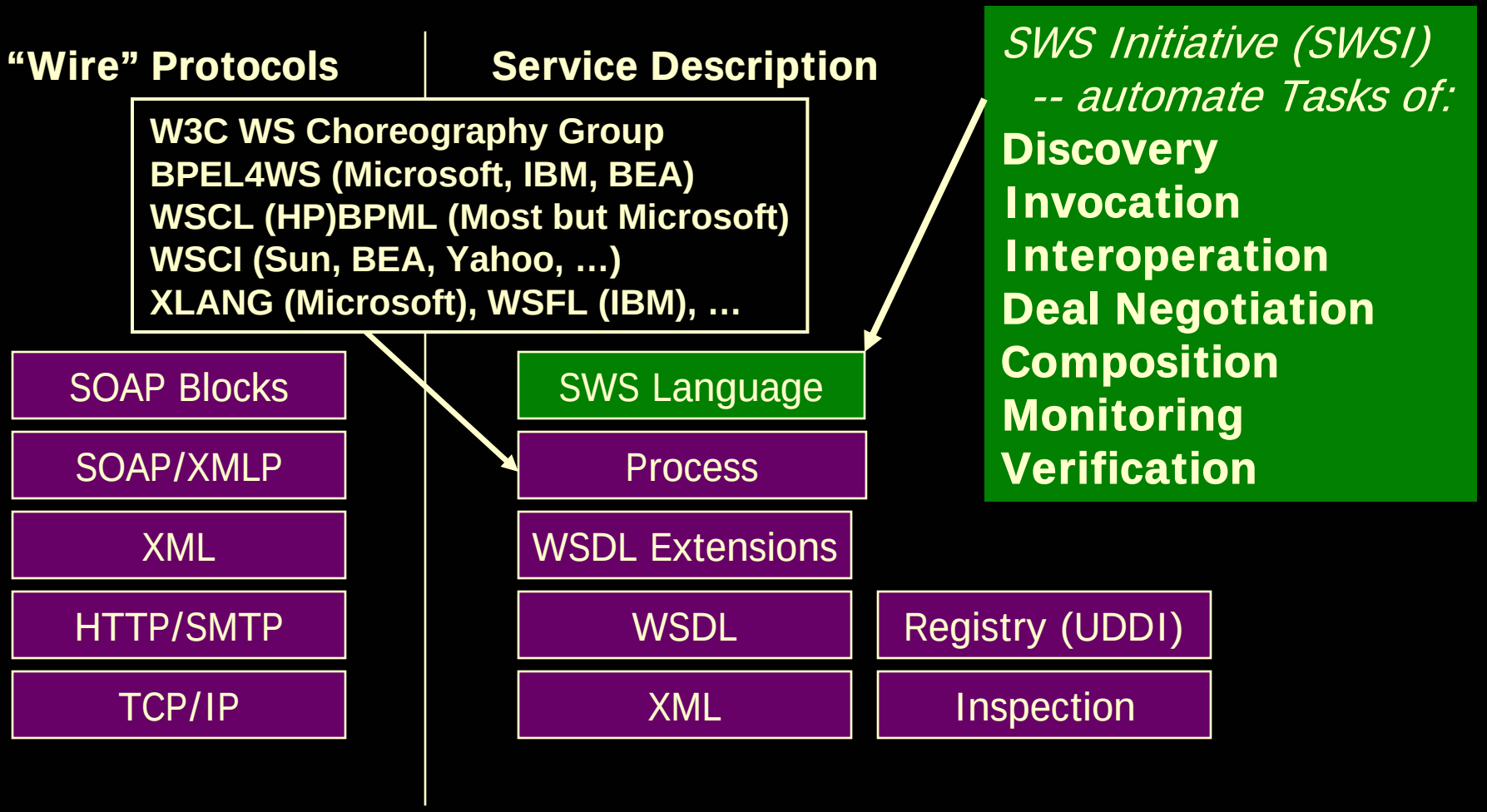


[Diagram http://www.w3.org/DesignIssues/diagrams/sw-stack-2002.png is courtesy Tim Berners-Lee]

Semantic Web Services

- Convergence of Semantic Web and Web Services
- Consensus definition and conceptualization still forming
- Semantic (Web Services):
  - Knowledge-based service descriptions, deals
    - Discovery/search, invocation, negotiation, selection, composition, execution, monitoring, verification
  - Integrated knowledge
- (Semantic Web) Services: e.g., infrastructural
  - Knowledge/info/DB integration
  - Inferencing and translation

SWS Language effort, on top of Current WS Standards Stack



[Slide authors: Benjamin Grosof (MIT Sloan), Sheila McIlraith (Stanford) , David Martin (SRI International), James Snell (IBM)]

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  - B2B Tasks; end-to-end e-contracting, and policies
  - SWS Research Directions

- Optional: More Details, esp. on e-contracting and rules

B2B Tasks: Communication for Business Processes with Partners

- B2B business processes involving significant Communication with customers/suppliers/other-partners is overall a natural locus for future first impact of SWS.
- Customer Relationship Management (CRM)
  - sales leads and status
  - customer service info and support
- Supply Chain Management (SCM):
  - source selection
  - inventories and forecasts
  - problem resolution
  - transportation and shipping, distribution and logistics
- orders; payments, bill presentation

Some B2B Tasks (continued)

- bids, quotes, pricing, CONTRACTING; AUCTIONS; procurement
- authorization (vs. authentication) for credit or trust
- database-y: e.g.,
  - catalogs & their merging
  - policies
- inquiries and answers; live feedback
- notifications
- trails of biz processes and interactions
- ratings, 3rd party reviews, recommendations
- knowledge management with partners/mkt/society

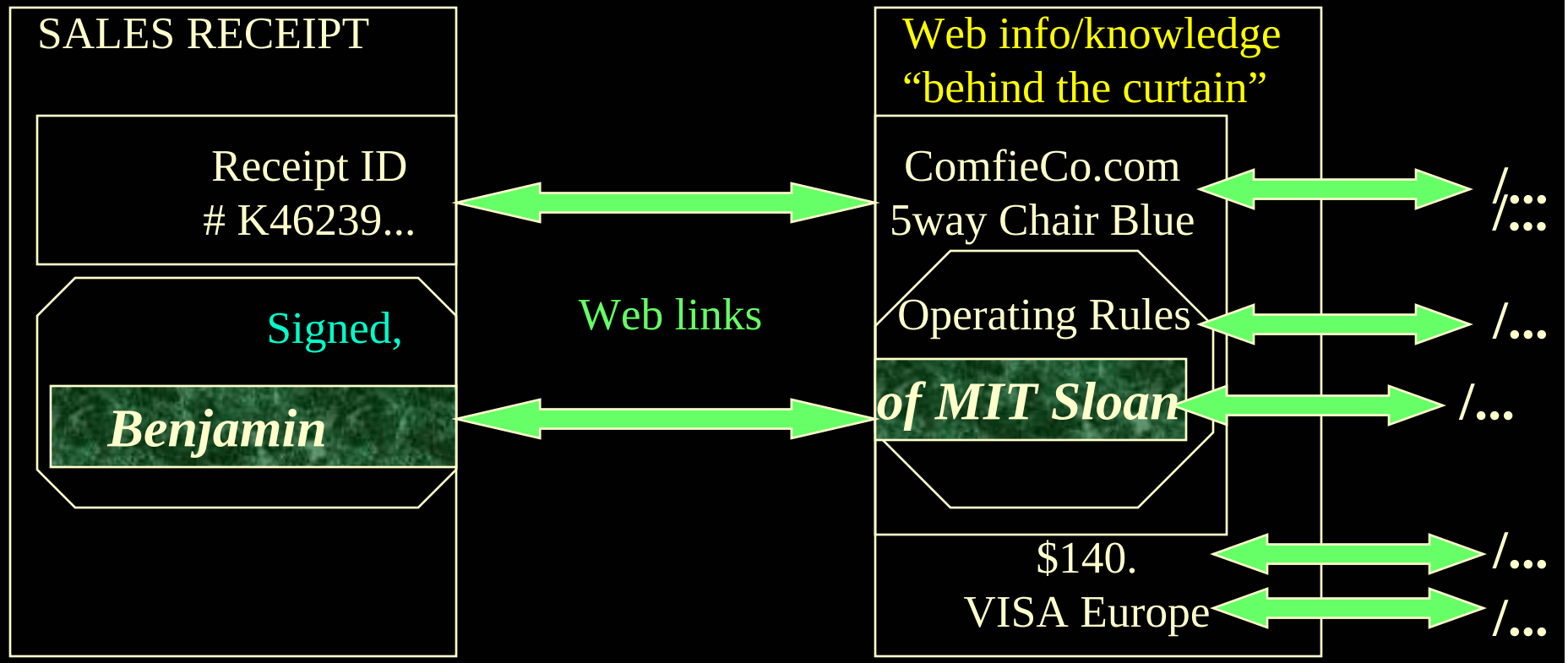
Vision of Evolution: Agents in Knowledge-Based E-Markets

Coming soon to a world near you:...

- billions/trillions of agents (= k-b applications)
- ...with smarts: knowledge gathering, reasoning, economic optimization
- ...doing our bidding
  - but with some autonomy
- *A 1st step: ability to communicate with sufficiently precise shared meaning... via the SEMANTIC WEB*

Looks Simple To Start... then Gets Interestingly Precise

A Vision/Approach of what Web & Agents enable



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

SWS Tasks at higher layers of WS stack

Automation of:

- Web service discovery

  Find me a shipping service that will transport frozen vegetables from San Francisco to Tuktoyuktuk.

- Web service invocation

  Buy me "Harry Potter and the Philosopher's Stone" at www.amazon.com

- Web service deals, i.e., contracts, and their negotiation

  Propose a price with shipping details for used Dell laptops to Sue Smith.

- Web service selection, composition and interoperation

  Make the travel arrangements for my WWW11 conference.

[Modification of slide also by Sheila McIlraith (Stanford) and David Martin (SRI International)]

SWS Tasks at higher layers of WS stack, continued

- Web service execution monitoring and problem resolution
  Has my book been shipped yet? … [NO!] Obtain recourse.
- Web service simulation and verification
  Suppose we had to cancel the order after 2 days?
- Web service executably specified at "knowledge level"
  The service is performed by running the contract ruleset through a rule engine.

[Modification of slide also by Sheila McIlraith (Stanford) and David Martin (SRI International)]

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.

What's Doable Today *in rule-based agent contracting, based on our approach to rule representation ("SweetDeal")*

- Communicate: with deep shared semantics
  - XML, inter-operable with same sanctioned inferences
  - ⇔ heterogeneous rule systems / rule-based 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)*

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 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*

SW Early Adoption Candidates: High-Level View

- "Death. Taxes. Integration."
- Application/Info Integration:
  - Intra-enterprise
    - EAI, M&A; XML infrastructure trend
  - Inter-enterprise
    - E-Commerce: procurement, SCM
  - Combo
    - Business partners, extranet trend

SWS Adoption Roadmap: Strategy Considerations

- Expect see beginning in a lot of B2B interoperability or heterogeneous-info-integration intensive (e.g., finance, travel)
  - Actually, probably 1st intra-enterprise, e.g., EAI
- Reduce costs of communication in procurement, operations, customer service, supply chain ordering and logistics
  - increase speed, creates value, increases dynamism
  - macro effects create
    - stability sometimes (e.g., supply chain reactions due to lag; other negative feedbacks)
    - volatility sometimes (e.g., perhaps financial market swings)
  - increase flexibility, decrease lock-in
- Agility in business processes, supply chains

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- Optional: More Details, esp. on e-contracting and rules

AutoID in B2B Tasks: Communication for Business Processes with Partners

- B2B business processes involving significant Communication with customers/suppliers/other-partners is overall a natural locus for future first impact of SWS.
  - Green underlined stuff seems especially relevant to AutoID
- Customer Relationship Management (CRM)
  - sales leads and status
  - customer service info and support
- Supply Chain Management (SCM):
  - source selection
  - inventories and forecasts
  - problem resolution
  - transportation and shipping, distribution and logistics
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AutoID in Some B2B Tasks (continued)

- bids, quotes, pricing, CONTRACTING; AUCTIONS; procurement
- authorization (vs. authentication) for credit or trust
- database-y: e.g.,
  - catalogs & their merging
- policies
- inquiries and answers; live feedback
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- trails of biz processes and interactions
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- knowledge management with partners/mkt/society

Some more Thoughts on AutoID and SWS

- AutoID needs infrastructure that provides abstraction layers above basic logistics and networked data, and integrates into e-commerce generally
  - Info about goods/objects
  - Info about services surrounding those goods
  - Business processes, their automation
- End-to-end Contracting is at the heart of e-commerce, SCM, CRM
  - Can view as one big business process, composed of many smaller ones

Some more Thoughts on AutoID and SWS, continued

- Policies are at the heart of contracts. E.g.,
  - Pricing
  - Lead time for ordering, shipping
  - Exceptions, returns, problem resolution
  - Authorization for access, transactions.
- Rules often good for representing policies. E.g., in RuleML, SweetDeal
- Need business process ontologies, too.

SWS Research Directions

- Requirements Analysis
- Fundamental KR theory, techniques, tools:
  - Recent: Courteous LP, Situated LP, Description LP
  - More: nonmon OO ontologies, multi-agent nonmon, equational ontologies, context mappings, …
- Fundamental theory of semantic descriptions of services
- Web Services / Business Processes Knowledge Bases:
  - MIT Process Handbook as candidate nucleus for shared business process ontology for SWS
    - Open Process Handbook Initiative: *an open-source version, is in progress.* (http://ccs.mit.edu/ph)

SWS Research Directions, continued

- Standards: Rules (RuleML/DAML), SWS (SWSI); W3C; Oasis; (also OAG, OMG, others); incl. wrt e-commerce (e.g., ebXML, EDI), vertical industries, horizontal tasks
- Applications: e-contracting, finance, trust mgm., travel
- Fundamental theory for e-contracting
  - Interoperable business objects, policies (e.g., trust), business processes, 3rd-party services
- Strategy wrt SWS uses, adoption, markets

Opportunities for Auto-ID Focus wrt SWS Research Directions

- Usage Scenarios – e.g., driven by sponsors
  - Tasks, business processes, vertical-industry domains
  - Combine selected technologies and standards
- Shared Business Process Semantics in support of those

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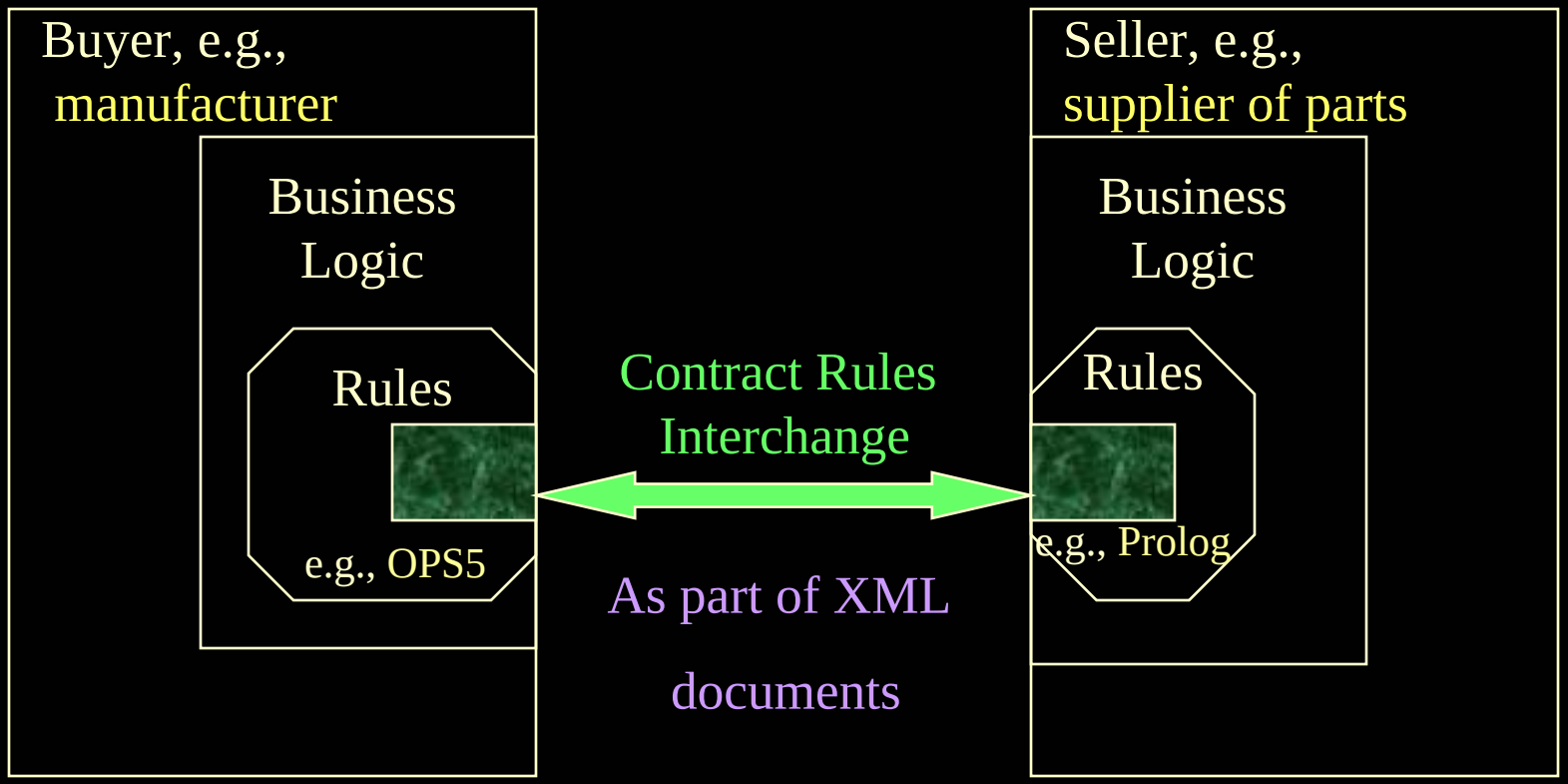
Optional Slides with More Details,

esp. on rules and e-contracting,

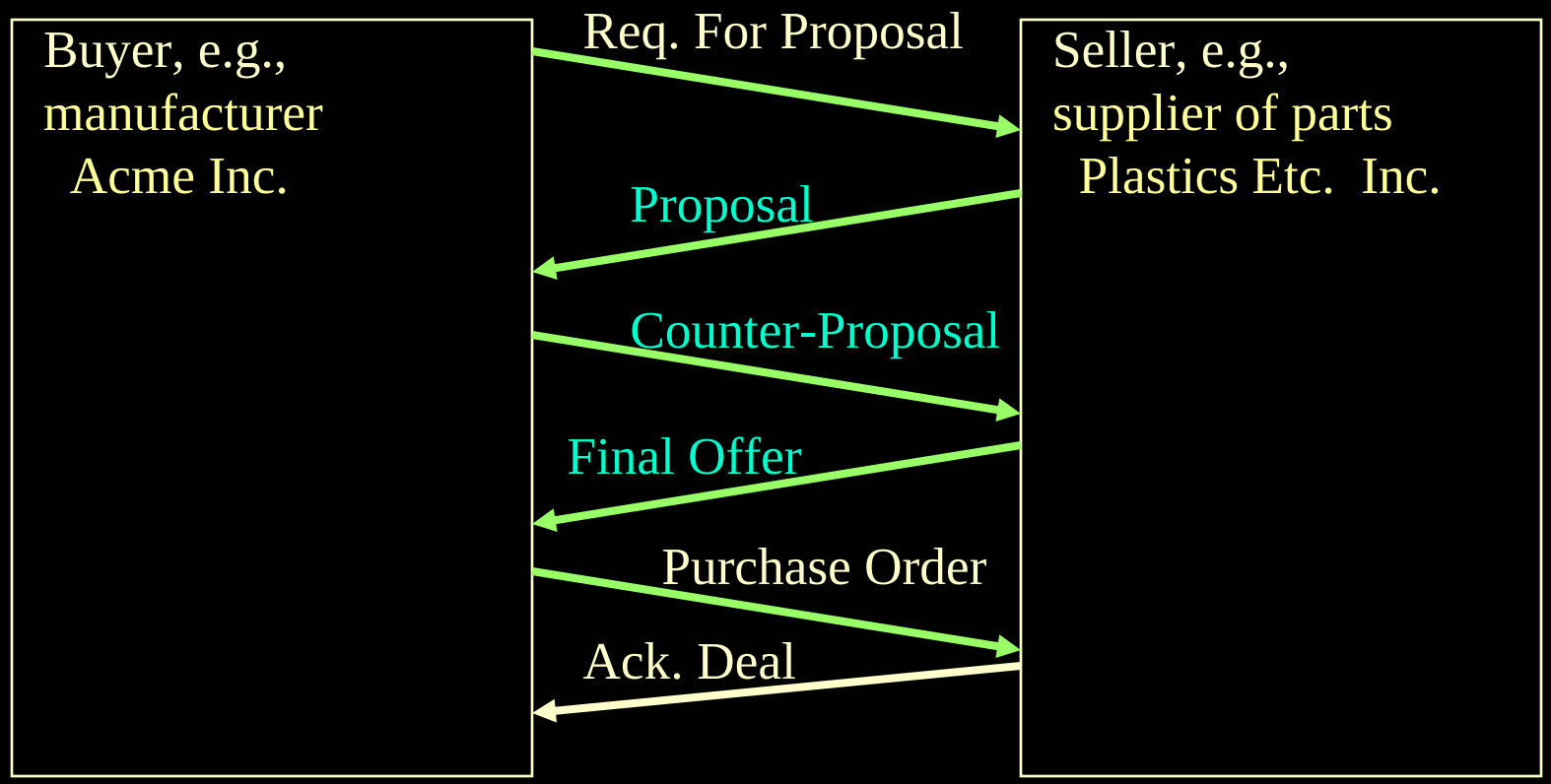
FOLLOW

Contract Rules during Negotiation



Contracting parties NEGOTIATE via shared rules.

Exchange of Rules Content during Negotiation: example



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>
   <cslit>
    <_opr><rel>price</rel></_opr>
     <ind>per_unit</ind>
     <var>PO</var>
     <ind>$60</ind>
   </cslit>
  </_head>
  <_body>     …  (see next page)    </_body>
 </imp>
…
</rulebase>
```

Negotiation Example -- XML Encoding of Rules in RuleML, Continued

```
<_body>
 <andb>
  <fclit>
   <_opr><rel>purchaseOrder</rel></_opr>
    <var>PO</var>
    <ind>supplierCo</ind>
    <var>AnyBuyer</var>
  </fclit>
  <fclit>
  …
  </fclit>
  ...
 </andb>
</_body>
```

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

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.
  - SQL99 even has recursive 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.)*

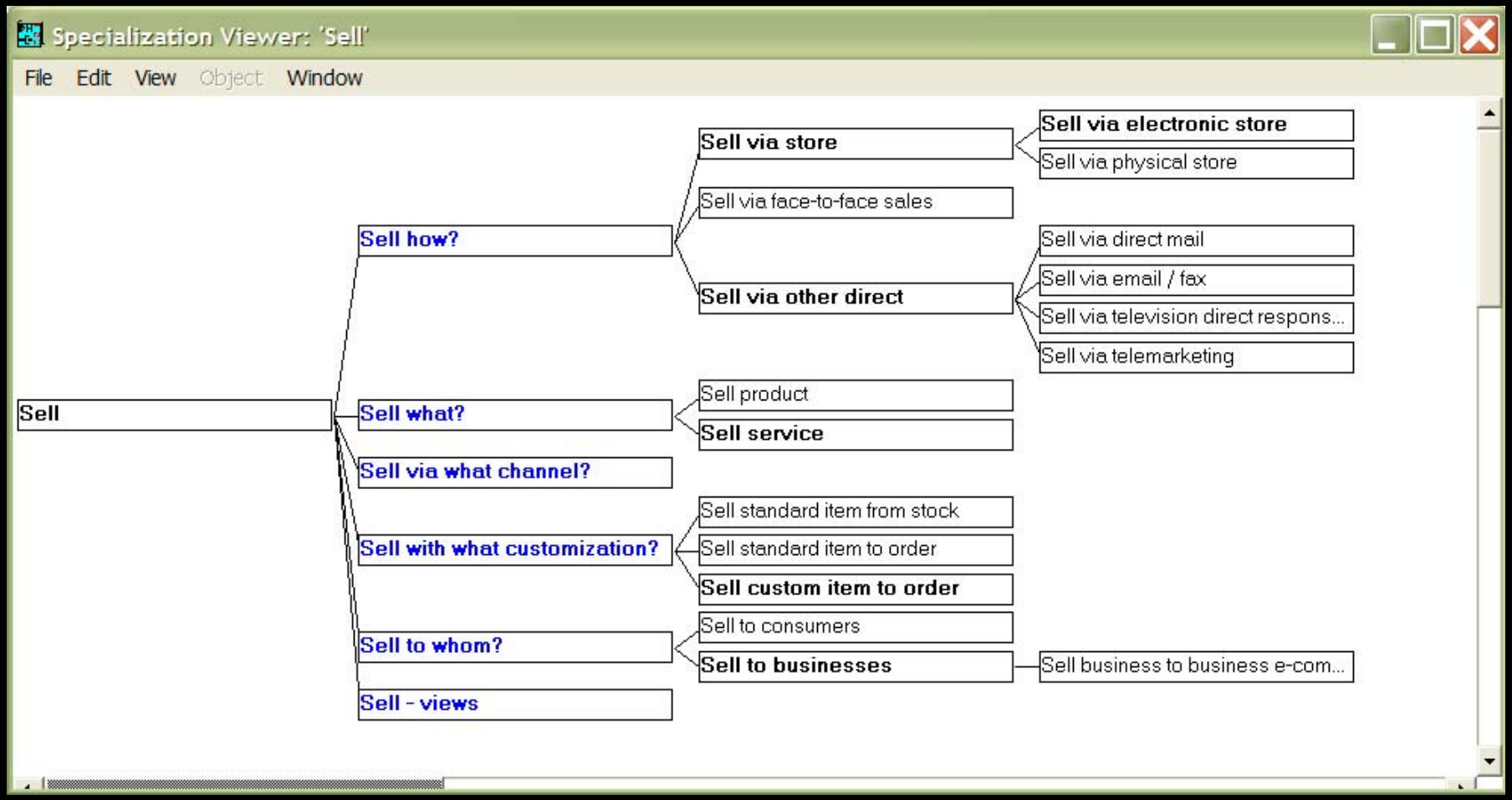
Using: MIT Process Handbook

- Our example scenario's process ontologies are drawn partly from the MIT Process Handbook (PH) …
- A previously-existing repository of business process descriptions
- Uniquely large & well-used (by industry biz process designers) [Malone *et al* '95-]
- Includes taxonomic/hierarchical aspects, as a fraction
- Includes exception handling ontology [Klein *et al* 2002]

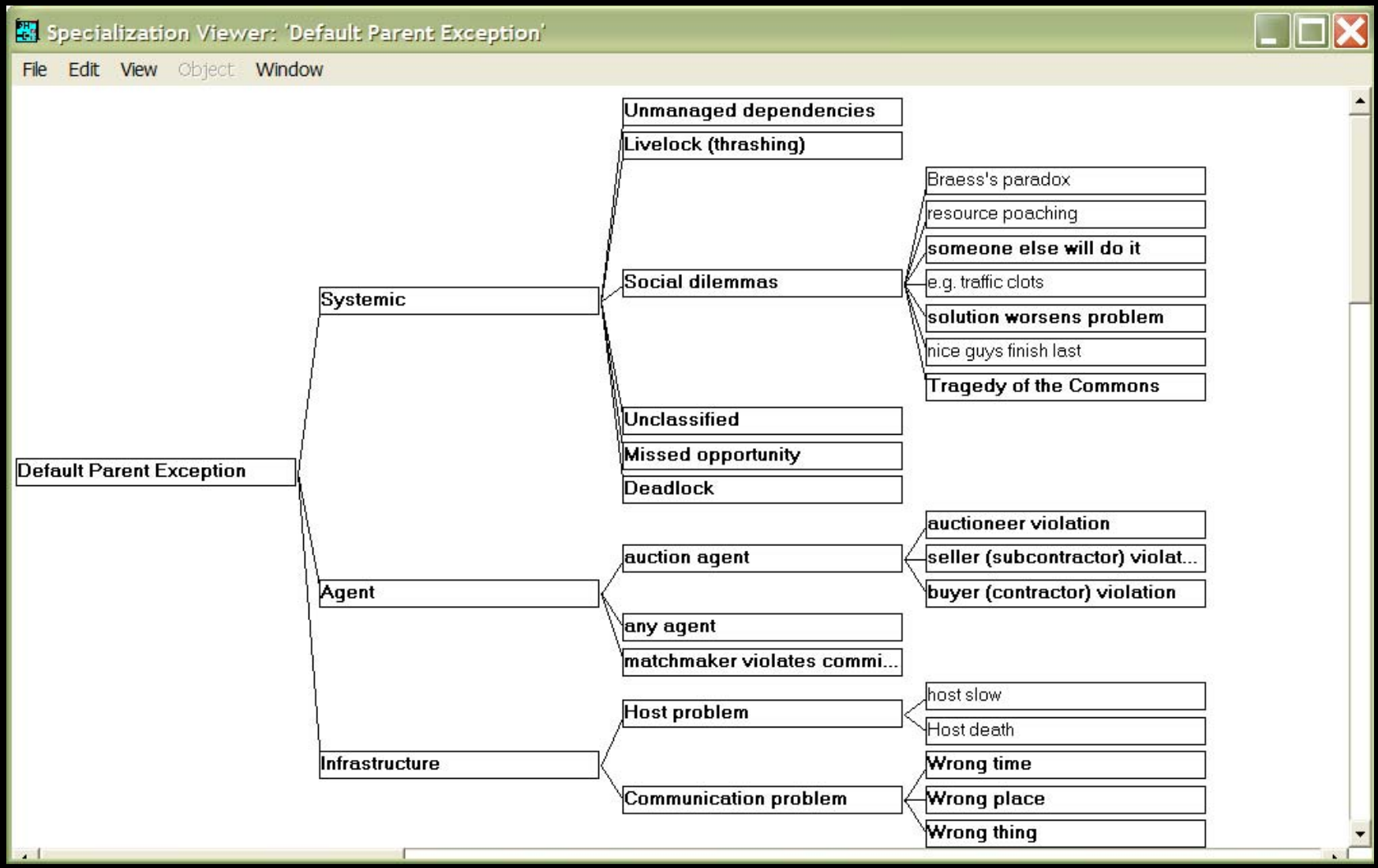
- New here:
  - formalize PH knowledge in XML Description Logic: DAML+OIL
    - (only a small fraction of its content, so far)
  - enables practical deep inferencing with the PH knowledge
    - … using Semantic Web tools (RuleML/LP and DAML+OIL/OWL/DL)

- Previously PH content was only shallowly automated for inferencing
  - Was NOT represented in Description Logic KR nor in XML (not Webized)
  - (there was a partial PIF encoding, mapping to KIF)

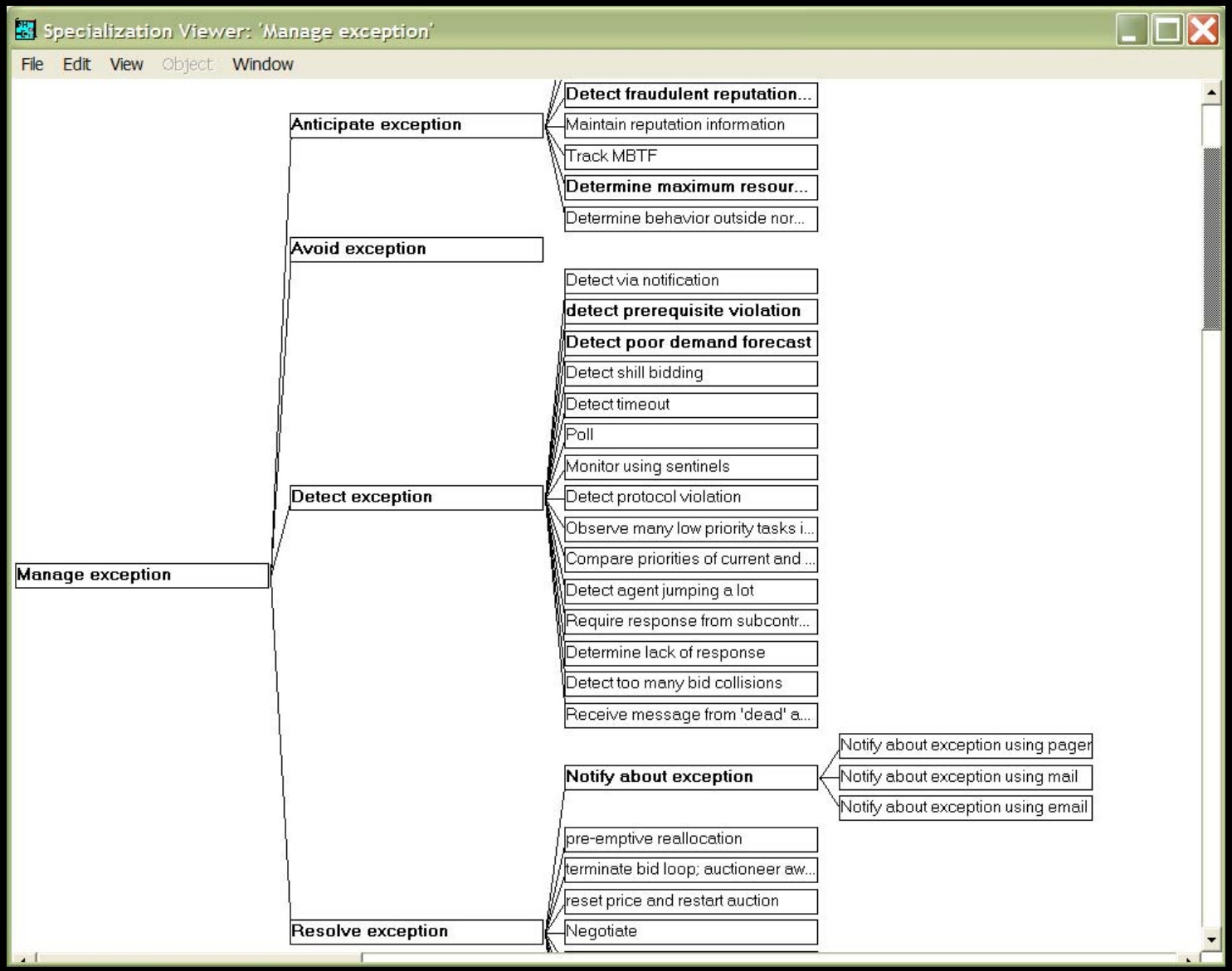
Some Specializations of "Sell" in the MIT Process Handbook (PH)



Some Exceptions in the MIT Process Handbook



Some exception handlers in the MIT Process Handbook



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, incl. Web services
  - Agents, Business Processes, Workflow
  - E-Commerce: ebXML, ...
  - Industry-Specific
  - *Legal XML*
- *Law: Electronic Signatures, …*
- *Reusable Contract doc's on Web: CommonAccord, our work, ...*

Rule-based Semantic Web Services

- Rules/LP in appropriate combination with DL as KR, for RSWS
  - DL good for categorizing: a service overall, its inputs, its outputs
- Rules to describe service process models
  - rules good for representing:
    - preconditions and postconditions, their contingent relationships
    - contingent behavior/features of the service more generally,
      - e.g., exceptions/problems
  - familiarity and naturalness of rules to software/knowledge engineers
- Rules to specify deals about services: cf. e-contracting.

Rule-based Semantic Web Services

- Rules often good to executably specify service process models
  - e.g., business process automation using procedural attachments to perform side-effectful/state-changing actions ("effectors" triggered by drawing of conclusions)
  - e.g., rules obtain info via procedural attachments ("sensors" test rule conditions)
  - e.g., rules for knowledge translation or inferencing
  - e.g., info services exposing relational DBs
- Infrastructural: rule system functionality as services:
  - e.g., inferencing, translation

Analysis: High-Level Requirements for SWS

- Support Biz-Process Communication
  - E.g., B2B SCM, CRM
  - E.g., e-contracts, financial info, trust management.
- Support SWS Tasks above current WS layers:
  - Discovery/search, invocation, deal negotiation, selection, composition, execution, monitoring, verification

New Analysis: Key Technical Requirements for SWS

- 1. Combine rules with ontologies, from many web sources, with:
  - Rules on top of ontologies
  - Interoperability of heterogeneous rule and ontology systems
  - Power in inferencing
  - Consistency wrt inferencing
  - Scaleability of inferencing

- 2. Hook rules (with ontologies) up to web services
  - Ex. web services: enterprise applications, databases
  - Rules use services, e.g., to query, message, act with side-effects
  - Rules constitute services executably, e.g., workflow-y business processes
  - Rules describe services non-executably, e.g., for discovery, deal negotiation
  - On top of web service process models, coherently despite evolving messiness

3 Areas of New Fundamental KR Theory

that enable Key Technical Requirements for SWS

- 1. Description Logic Programs:

  KR to combine LP (RuleML) rules on top of DL (OWL) ontologies, with:

  - Power in inferencing (including for consistency)
  - Scaleability of inferencing
- 2. Situated Logic Programs:

  KR to hook rules (with ontologies) up to (web) services

  - Rules use services, e.g., to query, message, act with side-effects
  - Rules constitute services executably, e.g., workflow-y business processes
- 3. Courteous Logic Programs:

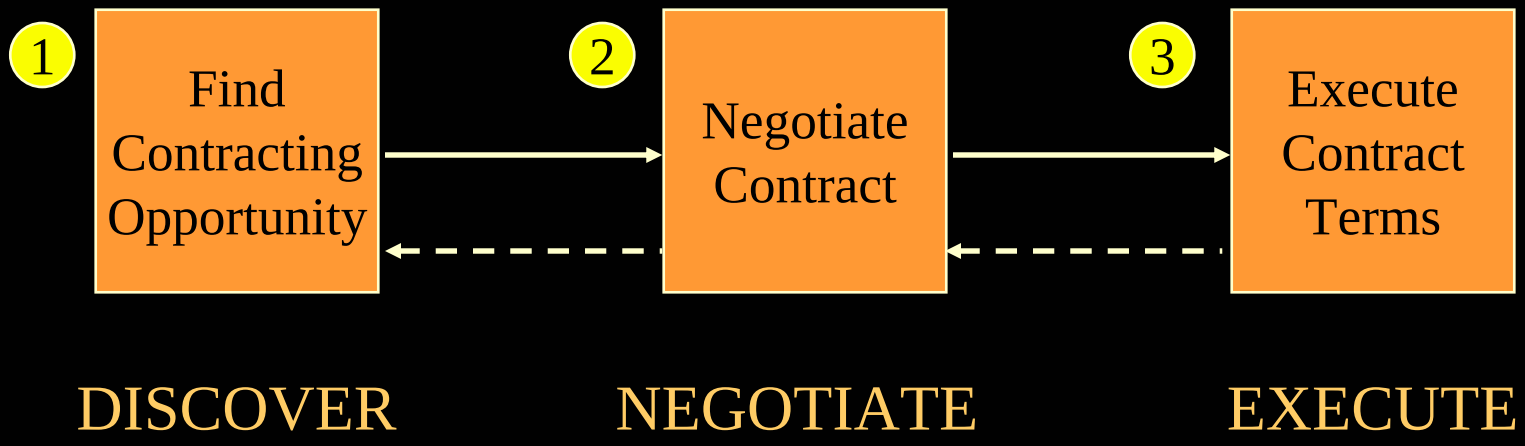
  KR to combine rules from many sources, with:

  - Prioritized conflict handling to enable consistency, modularity; scaleably
  - Interoperable syntax and semantics

Contributions to Early Standards Efforts: RuleML, SWSI

- RuleML Initiative
  - Co-Lead, Co-Founder
  - RuleML based largely on IBM CommonRules
  - Designed most key RuleML features
  - RuleML already has basic support for Description LP, Situated LP, Courteous LP
- Active in SWSI, esp. on Rules
  - Member of SWS Language committee
  - Co-chair Industrial Partners forum: several dozen companies
  - Technical challenge: representing service pre- / post-conditions, coherently on top of evolving messiness of WS process models (e.g., BPEL4WS)

Contracting 1-2-3



- Applies to any contracting, electronic or not.
- May iterate or interleave these steps.
- Boundaries not necessarily sharp.

SW Early Adopters: Areas by Industry or Task

- Early SW techniques already in use:
  - e-contracting, supply chain incl. procurement
    - manufacturing, e.g. computer/electronics (RosettaNet), automotive (Covisint),
    - EECOMS pilot (Boeing, IBM, TRW, Baan)
    - office supplies (OBI)
    - retailing: shopbots and salesbots: comparisons, recommendations
    - extensive standards activity: Oasis ebXML, XML eContracts, UN UBL, EDI

SW Early Adopters: Areas by Industry or Task

- *Continued:* Early SW techniques already in use:
  - cyber goods:
    - financial services (rules; onto translation)
    - travel "agency", i.e.: tickets, packages (AI smarts for scheduling)
  - military intelligence (e.g., funded DAML)