E-Services on the New Generation Web: Automating Business Process Knowledge Management

Benjamin Grosof

MIT Sloan School of Management

Information Technologies group

http://ebusiness.mit.edu/bgrosof

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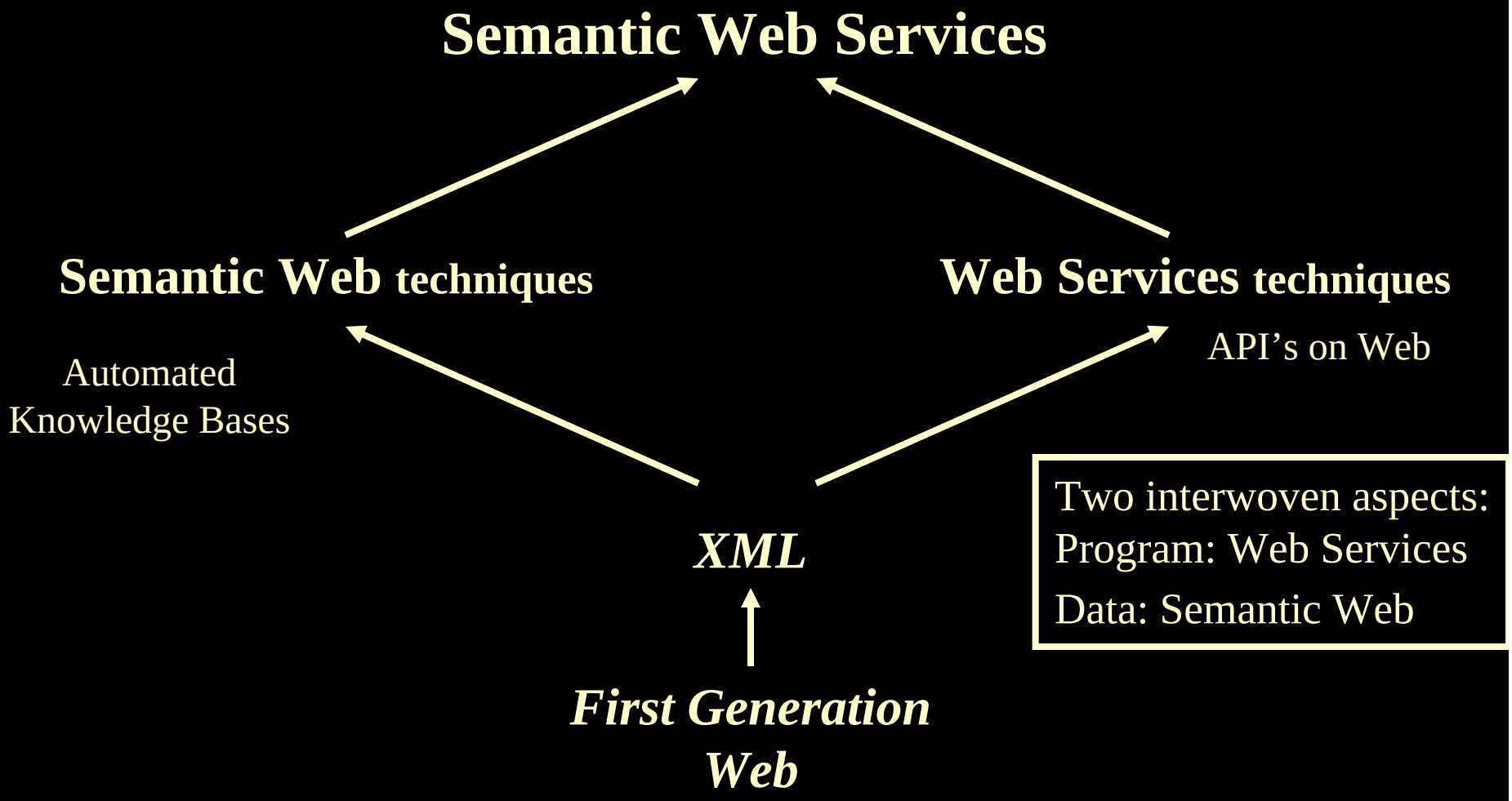
MIT Sloan School of Management

http://ebusiness.mit.edu

Outline of Talk

- Intro: Research on Semantic Web Services (SWS), its Business Uses
  - Rules, contracting, trust, policies
  - Integration, knowledge representation, standards
- Problem: Reusable Knowledge to Describe Services
  - Technique: knowledge representation to standardize on
  - Content investment: how to leverage legacy business process K
- New Technical Approach to represent OO Frameworks using SW
  - Courteous Inheritance: default rules increases reuse in ontologies
- New Strategy: go where the knowledge already is, then work outwards
  - Begin with MIT Process Handbook – open-source version in development
    - Example: process knowledge about selling
  - Future: Transformational wrappers around various legacy OO frameworks
- Roadmapping Market Evolution
  - Early adopters, creators, catalysts
  - Strategic players, forces

Next Generation Web



Brief Tour of some relevant websites

- http://ccs.mit.edu/ph MIT Process Handbook, Open Process Handbook Initiative
- http://www.w3.org/2002/ws World Wide Web Consortium, e.g., its Web Services and Semantic Web standards
- http://www.oasis-open.org Oasis, e.g., its web services standards
- http://www.amazon.com/gp/browse.html/ref=smm_sn_aws/002-8992958-7364050?node=3435361 Amazon's web services – 1000's of developers
- http://www.swsi.org Semantic Web Services Initiative standards – 40 partners
- http://zdnet.com.com/2100-1106-975870.html Fidelity's web services for EAI
- http://www.ruleml.org Rule Markup Language Initiative standards, - 30+ partners
- http://iswc2003.semanticweb.org Intl. Semantic Web Conference – 400 researchers

Big Questions
about the New Generation Web

- What are the critical features/aspects of the new technology?
- What business problems does it help solve?
- What are the likely innovation evolution paths, and associated entrepreneurial opportunities?

Our Overall SWS Research Agenda

- Invent Core Technologies and concepts of the New Generation Web
  - Semantic Web; Rules and RuleML emerging standard
    - supporting knowledge representation theory of Situated Courteous Description Logic Programs
  - Semantic Web Services; Business Process Automation for B2B and EAI
    - Requirements analysis

- Pilot Business Application Scenarios
  - End-to-end e-contracting, e.g., in manufacturing supply chain
    - SweetDeal approach using rules
  - Financial information and reporting:
    - ECOIN approach mapping ontologies
  - Other: security authorization, travel, …

- Analyze Prospective Early Adopter Areas
  - Strategy: Adoption Roadmap; Market Evolution
  - Entrepreneurial Opportunities

Some Answers to: "Why does SWS 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 structured knowledge.
  - Theme: *reuse* of knowledge across multiple tasks/app's/org's

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

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.

OPTIONAL BACKUP SLIDES FOLLOW

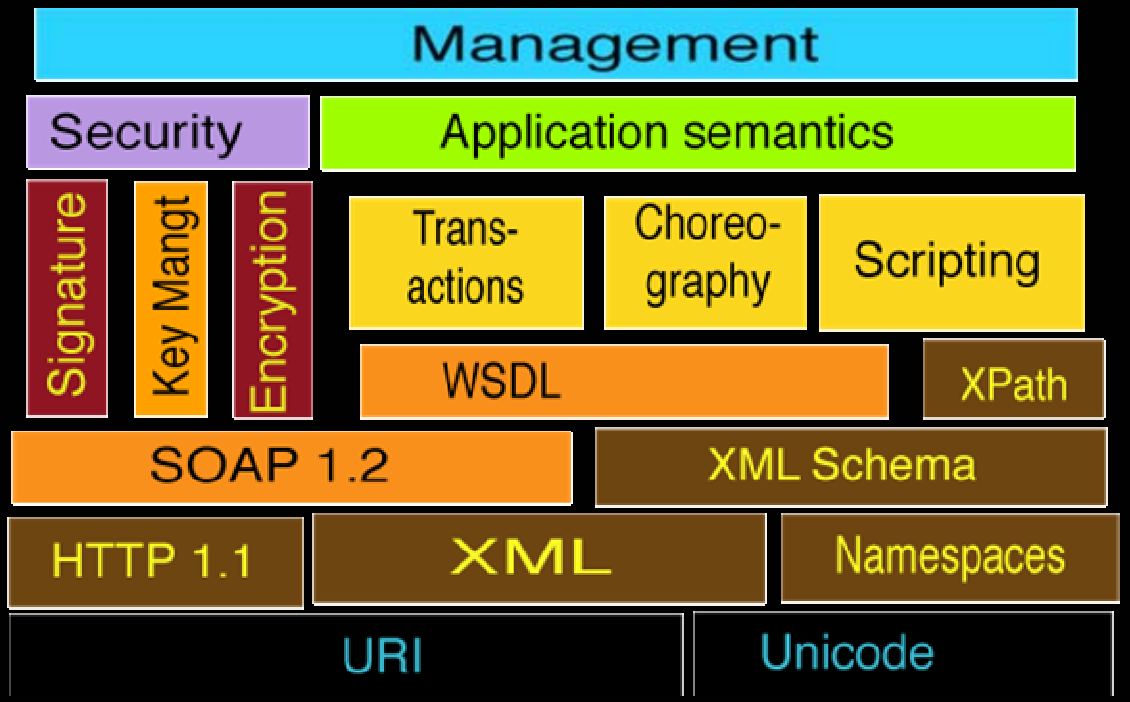
- About what are Semantic Web, Web Services, and Semantic Web Services

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

Web Services Stack outline



NOTES:

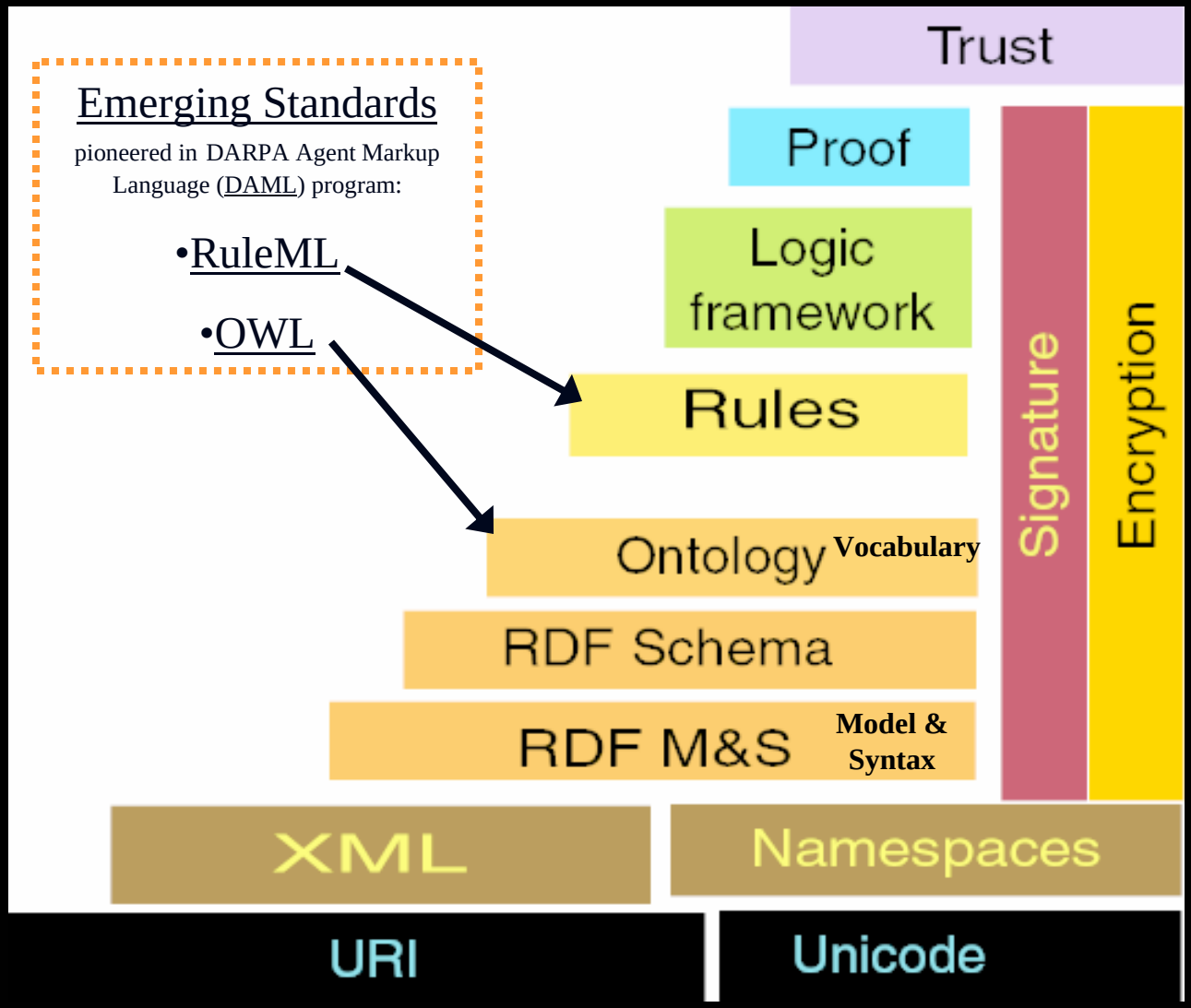
WSDL is a Modular Interface spec
SOAP is Messaging and Runtime
Also:
- UDDI is for Discovery
- BPEL4WS, WSCI, …
  are for transactions
- Routing, concurrency, …

Diagram courtesy Tim Berners-Lee: http://www.w3.org/2004/Talks/0309-ws-sw-tbl/slide6-0.html

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

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

END OF OPTIONAL BACKUP SLIDES

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Problem: Reusable Knowledge to Describe Services

- Has two aspects:

1. Technical/technique problem: what form of knowledge? I.e., what knowledge representation to standardize on?

2. Content investment problem: how to leverage to accomplish the reuse of legacy business process knowledge?

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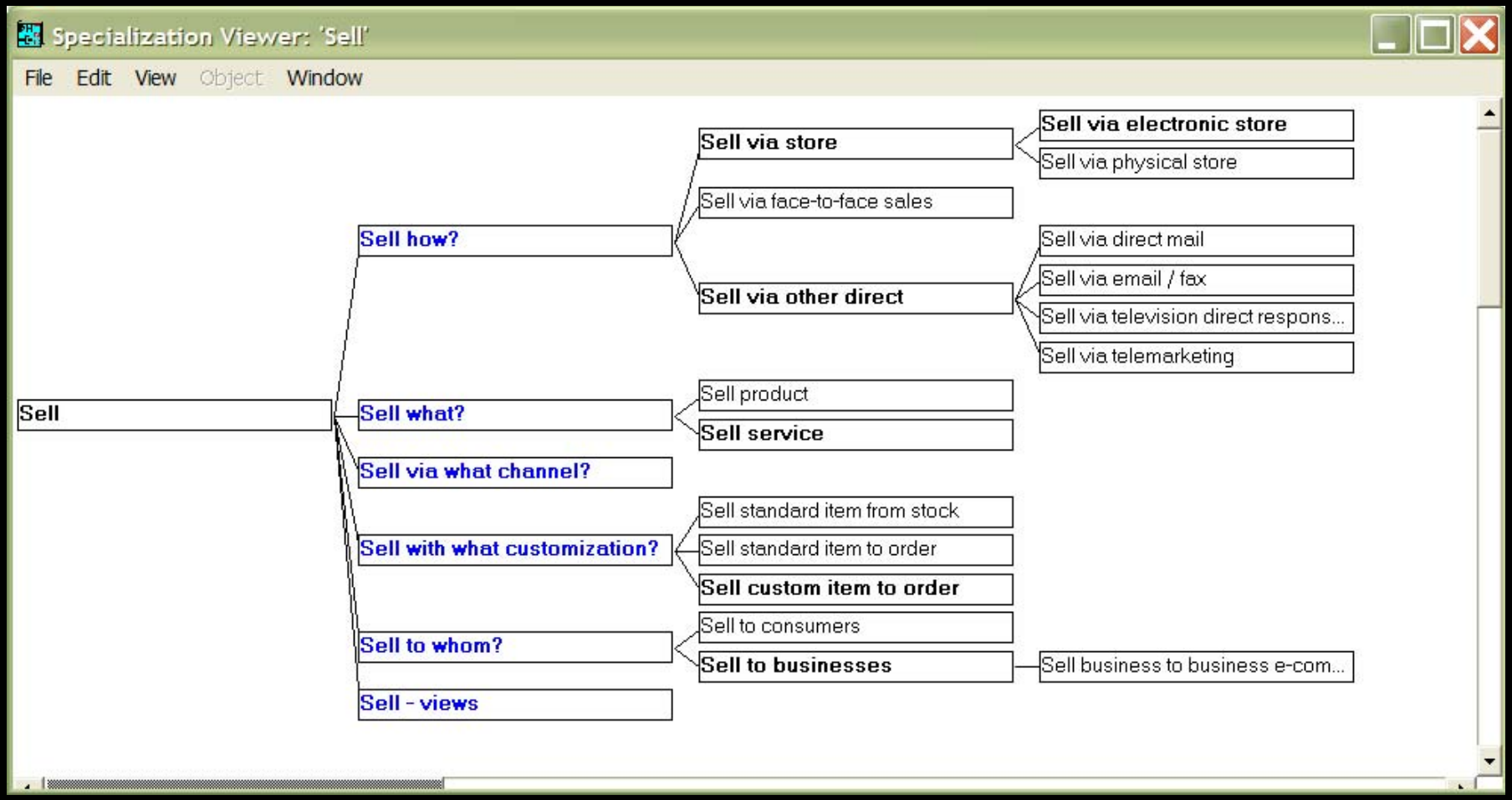
Opportunity for MIT Process Handbook in SWS

- Need for Shared Web Services / Business Processes Knowledge Bases

- MIT Process Handbook as candidate nucleus for shared business process ontology for SWS
  - 5000+ business processes, + associated class/property concepts, as structured knowledge
  - Open Process Handbook Initiative*: an open-source version, is in progress.* (http://ccs.mit.edu/ph)

- Related: use in particular for E-Contracting
  - Interoperable business objects, business processes
  - Also for policies (e.g., trust), 3rd-party services

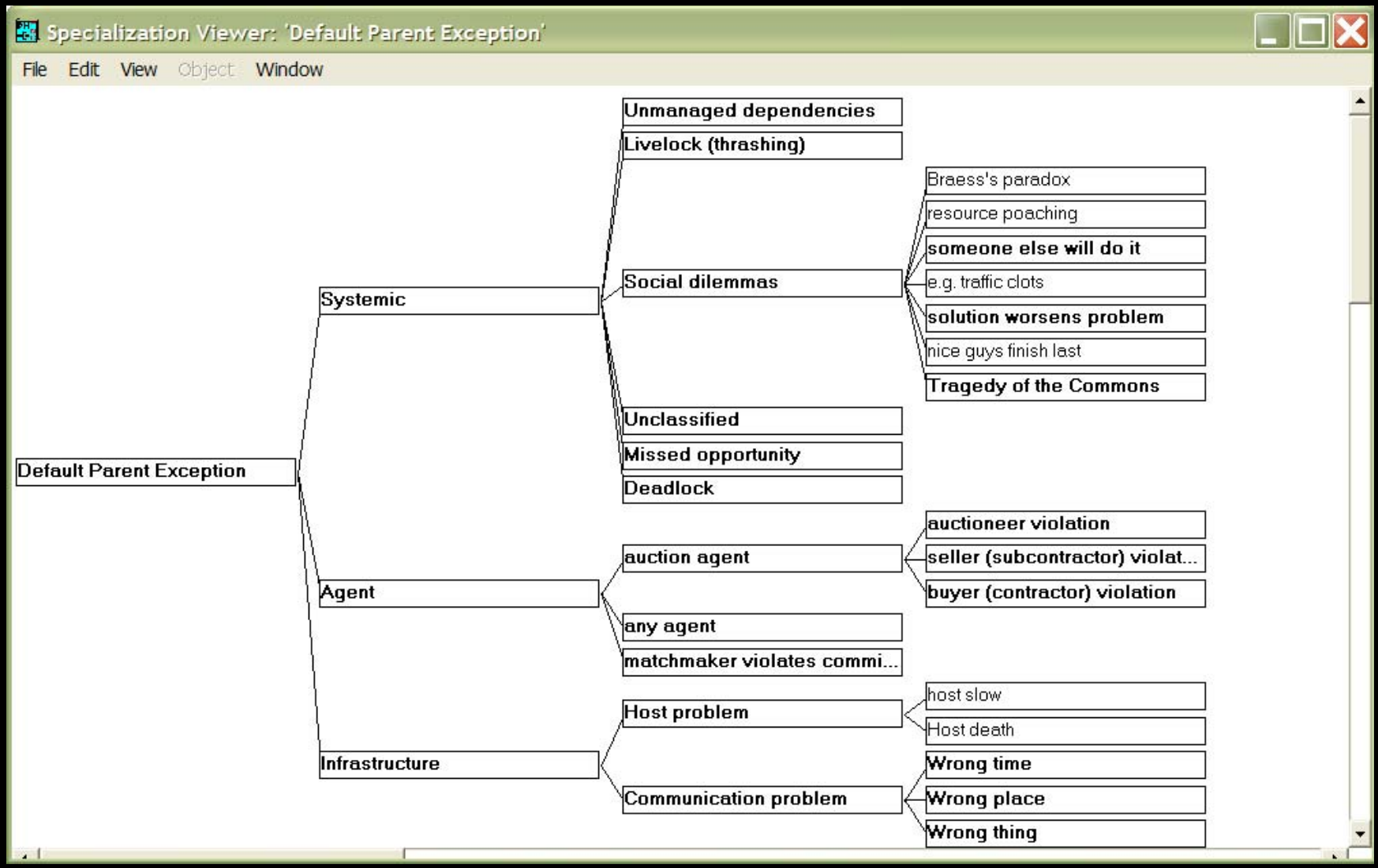
Some Specializations of "Sell" in the MIT Process Handbook (PH)



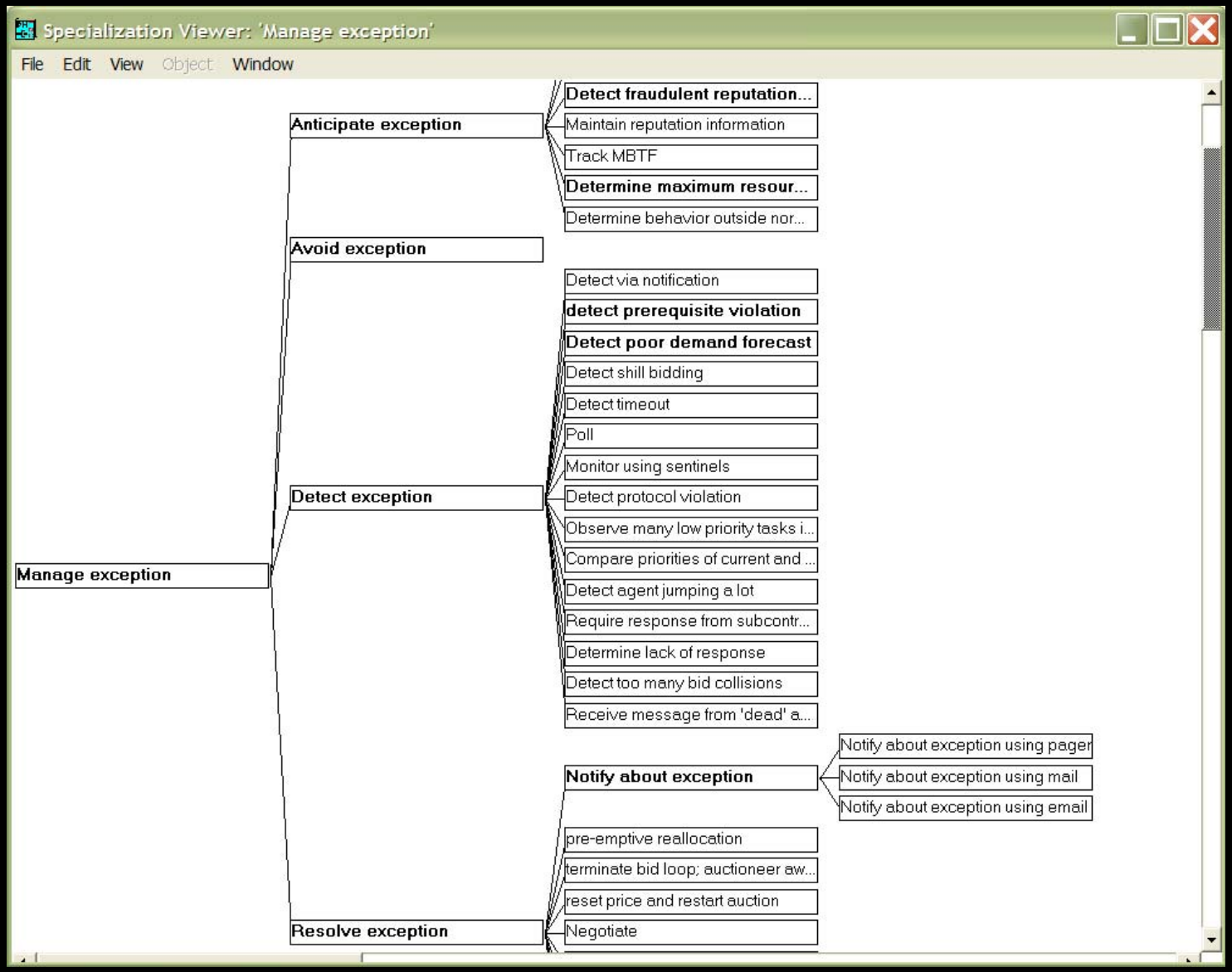
OPTIONAL BACKUP SLIDES FOLLOW

- About SweetDeal's use of Process Handbook ontology in rule-based e-contracts

Some Exceptions in the MIT Process Handbook



Some exception handlers in the MIT Process Handbook



SCLP TextFile Format for RuleML

```
payment(?R,base,?Payment) <-
http://xmlcontracting.org/sd.daml#result(co123,?R) AND
price(co123,?P) AND quantity(co123,?Q) AND
multiply(?P,?Q,?Payment) ;
```

```
<drm:imp>
  <drm:_head> <drm:atom>
     <drm:_opr><drm:rel>payment</drm:_opr></drm:rel>    <drm:tup>
     <drm:var>R</drm:var> <drm:ind>base</drm:ind> <drm:var>Payment</drm:var>
  </drm:tup></drm:atom> </drm:_head>
  <drm:_body>
   <drm:andb>
     <drm:atom> <drm:_opr>
       <drm:rel href= "http://xmlcontracting.org/sd.daml#result"/>
         </drm:_opr> <drm:tup>
           <drm:ind>co123</drm:ind> <drm:var>Cust</drm:var>
          </drm:tup> </drm:atom>

... </drm:andb> </drm:_body>  </drm:imp>
```

drm = namespace for RuleML

Example Contract Proposal, Continued: lateDeliveryPenalty exception handler module

```
lateDeliveryPenalty_module {
// lateDeliveryPenalty is an instance of PenalizeForContingency
//   (and thus of AvoidException, ExceptionHandler, and Process)
http://xmlcontracting.org/pr.daml#PenalizeForContingency(lateDeliveryPenalty) ;
// lateDeliveryPenalty is intended to avoid exceptions of class
// LateDelivery.
http://xmlcontracting.org/sd.daml#avoidsException(lateDeliveryPenalty,
  http://xmlcontracting.org/pr.daml#LateDelivery);
// penalty = - overdueDays * 200 ; (negative payment by buyer)
<lateDeliveryPenalty_def> payment(?R, contingentPenalty, ?Penalty) <-
  http://xmlcontracting.org/sd.daml#specFor(?CO,?PI) AND
  http://xmlcontracting.org/pr.daml#hasException(?PI,?EI) AND
  http://xmlcontracting.org/pr.daml#isHandledBy(?EI,lateDeliveryPenalty) AND
  http://xmlcontracting.org/sd.daml#result(?CO,?R) AND
  http://xmlcontracting.org/sd.daml#exceptionOccurred(?R,?EI) AND
  shippingDate(?CO,?CODate) AND shippingDate(?R,?RDate) AND
  subtract(?RDate,?CODate,?OverdueDays) AND
  multiply(?OverdueDays, 200, ?Res1) AND multiply(?Res1, -1, ?Penalty) ;
}
<lateDeliveryPenaltyHandlesIt(e1)> // specify lateDeliveryPenalty as a handler for e1
 http://xmlcontracting.org/pr.daml#isHandledBy(e1,lateDeliveryPenalty);
```

END OF OPTIONAL BACKUP SLIDES

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New Technical Approach: Courteous Inheritance in the Process Handbook

- Use SW KR and standards to represent Object-Oriented framework knowledge: class hierarchy, types, generalization-specialization, domain & range, properties/methods' association with classes
- Surprise: use SW *rule* language not the main SW *ontology* language! I.e., use RuleML not OWL.
- Exploit RuleML's nonmonotonic ability to represent prioritized default reasoning as kind of knowledge representation (KR)

New Technical Approach, continued

- Courteous Inheritance KR is built simply on top of the (Situated) Courteous Logic Programs KR of RuleML
  - A few dozen background axioms. Linear-size reformulation. Inferencing is tractable computationally.
- Particularly: represent PH's structured part
  - a scheme specific to PH's flavor of OO
- PH becomes a SWS process ontology

New Technical Approach, continued more

- Example(s): selling, PO, price, shipping, delivery, payment, lateness.

- For details, see submitted paper “Beyond Monotonic Inheritance: Towards Semantic Web Process Ontologies” on webpage.
  - Example: selling process

Brief Tour of selling example in the paper.

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Larger Approach: Transformation Wrappers for OO Frameworks

- New Strategy: go where the knowledge already is, then work outwards
- Future: Transformational wrappers around various legacy OO frameworks
  - C++
  - Java, C#
  - UML
- Can use XSLT, SW tools, and/or XQuery engines to implement the transformations, guided by SWS ontology standardization practices

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Some relevant example companies

- Users: *Amazon, Fidelity, Boeing; UPS, GM, *Orbitz, eBay
-
- Vendors: IBM, Microsoft, Oracle, HP, BEA, SAP; Sun, *Compiere
- Standards-oriented organizations: *SWSI, *BPMI, *OPHI, UN CEFACT

Brief Tour of some More relevant websites

- http://www.bpmi.org Business Process Management Initiative
- http://www.orbitz.com Orbitz, e.g., their vacation travel packages
- http://www.compiere.org Compiere open source ERP

Market Evolution: Discussion Questions

- Existing and prospective early adopters
- Importance of open source content: seems to be an assumption/axiom for many people
- Prospective sources of open source content

Strategy Questions for Discussion

- ? Who/players: adopters, creators, catalysts ?
- ? What forces/drivers for acceleration of adoption or investment, vs. inertia ?
- ? Which additional interesting questions ?

Yet More Discussion Questions: Early Adoption Application Prospects for SWS

- What business applications do you think are likely or interesting?
  - By vertical industry domain, e.g., health care or security
  - By task, e.g., authorization
  - By kind of shared information, e.g., patient records
  - By aspect of business relationships, e.g., provider network
- What do you think are entrepreneurial opportunity areas?

WRAP-UP: Outline of Talk

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OPTIONAL BACKUP SLIDES FOLLOW

- About early adopter prospects in SWS

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

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)

END OF OPTIONAL BACKUP SLIDES

- About early adopter prospects in SWS

OPTIONAL SLIDES FOLLOW

- About Presenter's SWS Research Agenda

Quickie Bio of Presenter

- MIT Sloan 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)

More about our SWS Technical Research Agenda

- Requirements Analysis *(Biz → Tech)*
  - New Application scenarios: e.g., SweetDeal e-contracting
  - Integrating rules, ontologies from many sources
  - Interoperability, power, consistency, scaleability
- New Fundamental Theory *(Theory → Tech)*
  - Description Logic Programs: bridging rules and ontologies
  - Situated Logic Programs: hooking rules to services
  - Courteous Logic Programs: prioritized conflict handling
- More:
  - Contributions to Early Standards Efforts: RuleML, SWSI
  - Piloting Early Adopter Areas: E-Contracts/SCM, Finance, Travel
  - Strategy Considerations and Implications

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

OPTIONAL SLIDES FOLLOW

- About Semantic Web, Web Services

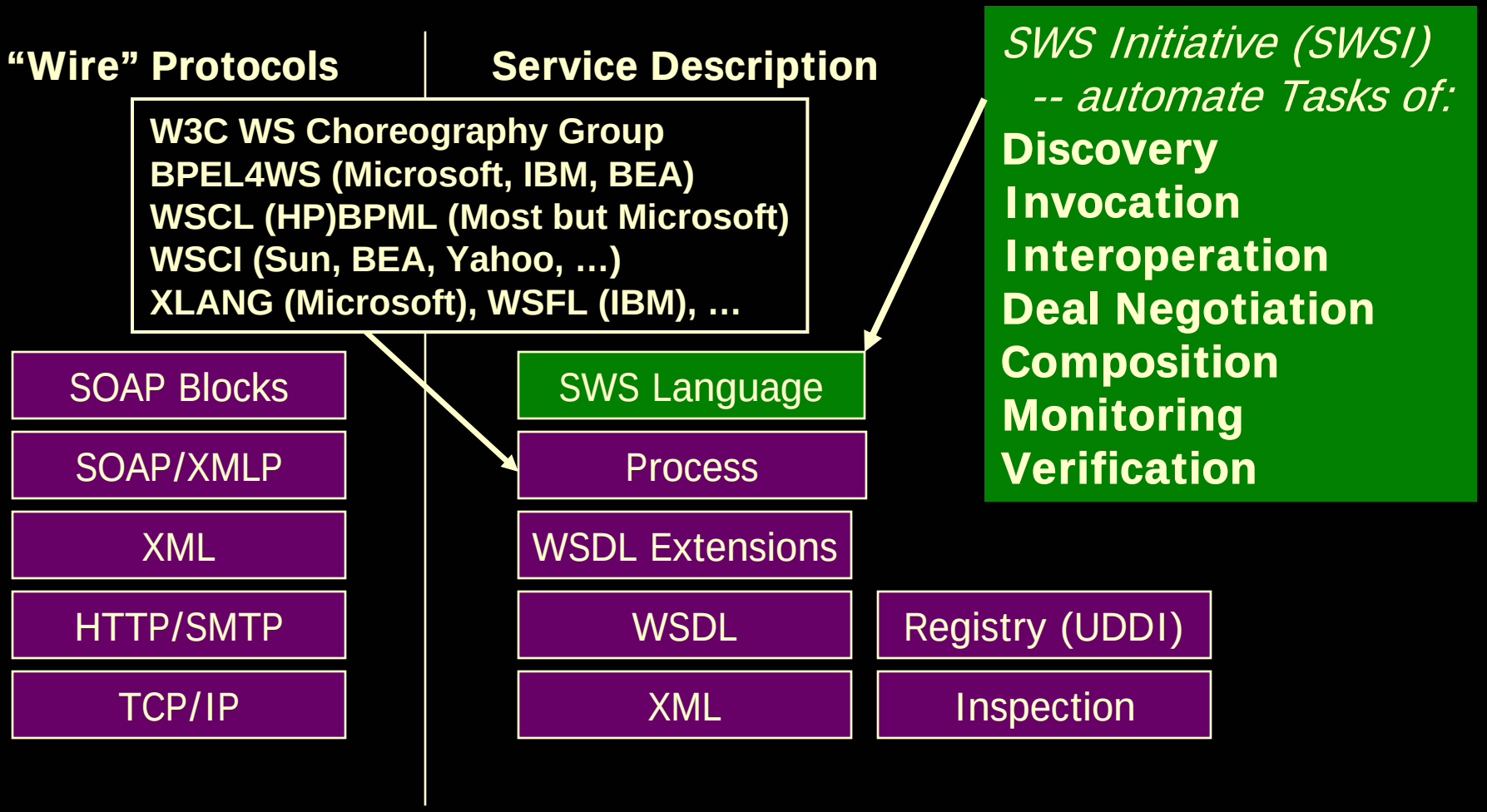
Some Semantic Web Advantages for Biz

- 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

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)]