MDA & Semantic Web Services
Extending ODM with Service Semantics

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Outline

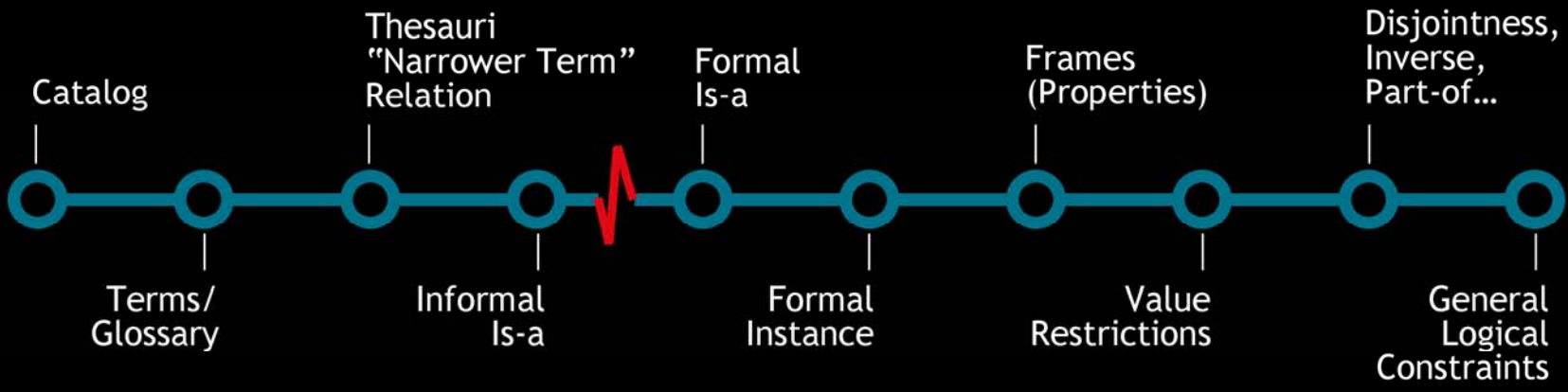
- ODM as a Bridge between MDA and KR
- Quick ODM Overview
- Relationship to other Standards
- Why Semantics for Web Services
- OWL-S Overview
- Semantic Web Services Framework (SWSF)
- Summary
- Acronym Soup

Level Setting

An ontology specifies a rich description of the

- **Terminology, concepts, nomenclature**
- **Properties explicitly defining concepts**
- **Relations among concepts (hierarchical and lattice)**
- **Rules distinguishing concepts, refining definitions and relations (constraints, restrictions, regular expressions)**

relevant to a particular domain or area of interest.



**Based On Aaai '99 Ontologies Panel - Mcguinness, Welty, Ushold, Gruninger, Lehmann*

MDA from the KR Perspective

- EII solutions rely on strict adherence to agreements based on common information models that take weeks or months to build
- Modifications to the interchange agreements are costly and time consuming
- Today, the analysis and reasoning required to align multiple parties' information models has to be done by people
- Machines display only *syntactic* information models and informal text describing the semantics of the models
- Without formal *semantics*, machines cannot aid the alignment process
- Translations from each party's syntactic format to the agreed-upon common format have to be hand-coded by programmers
- MOF® and MDA® provide the basis for automating the syntactic transformations

Ontology-Based Technologies

- Ontologies provide a **common vocabulary** and definition of rules for use by independently developed resources, processes, services
- **Agreements** among companies, organizations sharing common services can be made with regard to their **usage** and the **meaning** of relevant concepts can be **expressed unambiguously**
- By **composing** component ontologies, **mapping** ontologies to one another and **mediating** terminology among participating resources and services, independently developed systems, agents and services can work together to share information and processes consistently, accurately, and completely.
- Ontologies also facilitate conversations among agents to collect, process, fuse, and exchange information.
- Improve search accuracy by enabling contextual search using concept definitions and relations among them instead of/in addition to statistical relevance of keywords.

MOF and KR Together

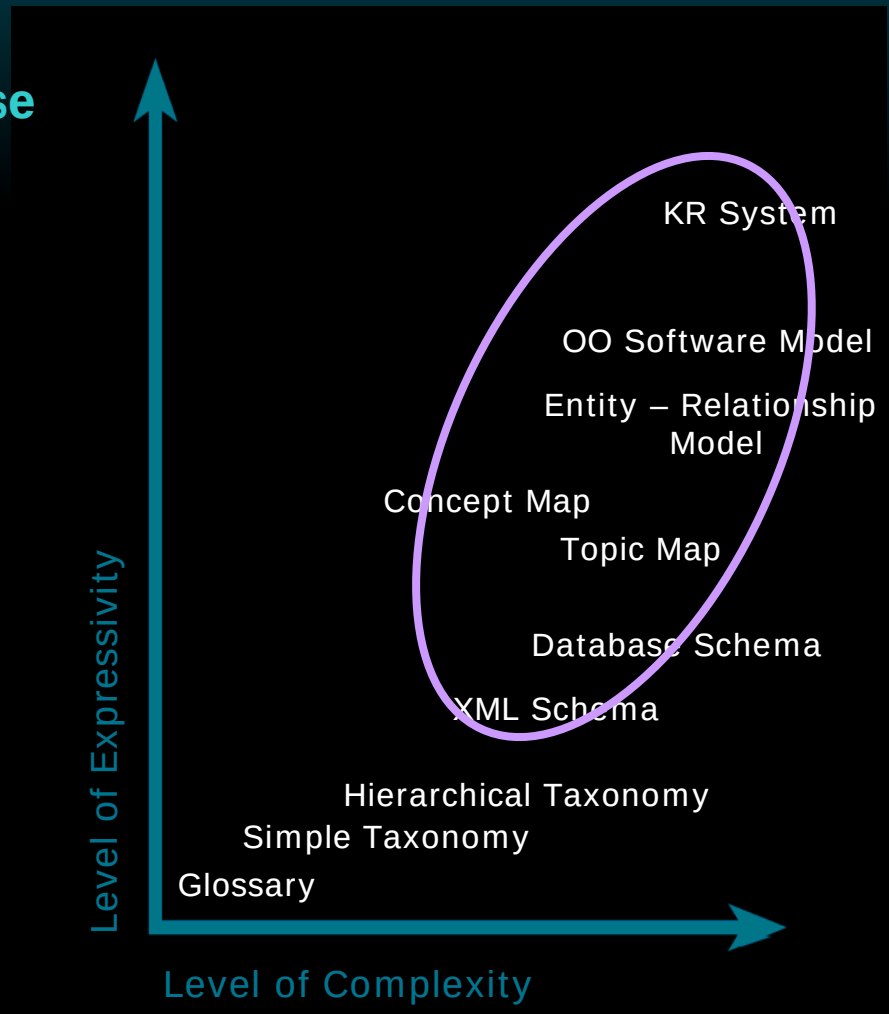
- MOF technology streamlines the *mechanics* of managing models as XML documents, Java objects, CORBA objects
- Knowledge Representation supports *reasoning* about resources
  - Supports semantic alignment among differing vocabularies and nomenclatures
  - Enables consistency checking and model validation, business rule analysis
  - Allows us to ask questions over multiple resources that we could not answer previously
  - Enables policy-driven applications to leverage existing knowledge and policies to solve business problems
    - Detect inconsistent financial transactions
    - Support business policy enforcement
    - Facilitate next generation network management and security applications

  while integrating with existing RDBMS and OLAP data stores
- MOF provides no help with reasoning
- KR is not focused on the mechanics of managing models or metadata
- Complementary technologies – despite some overlap

Ontology Definition Metamodel Coverage

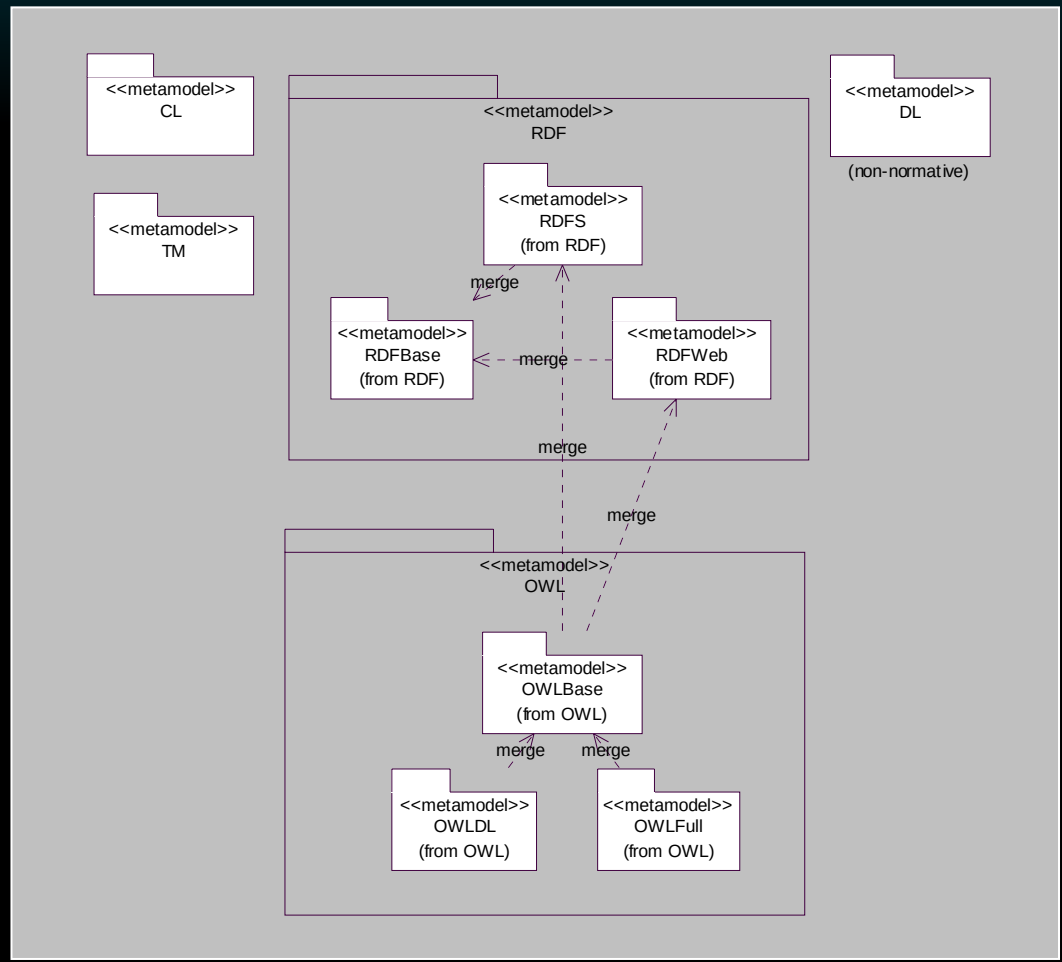
Classification techniques are as diverse as conceptual models; and generally include understanding

- **Methodology**
- **Target Usage**
- **Level of Expressivity**
- **Level of Complexity**
- **Reliability / Level of Authoritativeness**
- **Relevance**
- **Amount of Automation**
- **Metrics Captured and/or Available**



Towards Model Driven Ontology Development

- Five EMOF platform independent metamodels (PIMs), four normative
- Mappings (MOF QVT)
- UML2 Profiles
  - RDFS & OWL
  - TM
- Collateral
  - XMI
  - Java APIs
  - Proof-of-concepts
- Conformance
  - RDFS & OWL
  - Multiple Options
  - TM, CL Optional
  - Informative Mappings



First Order Logic – Common Logic

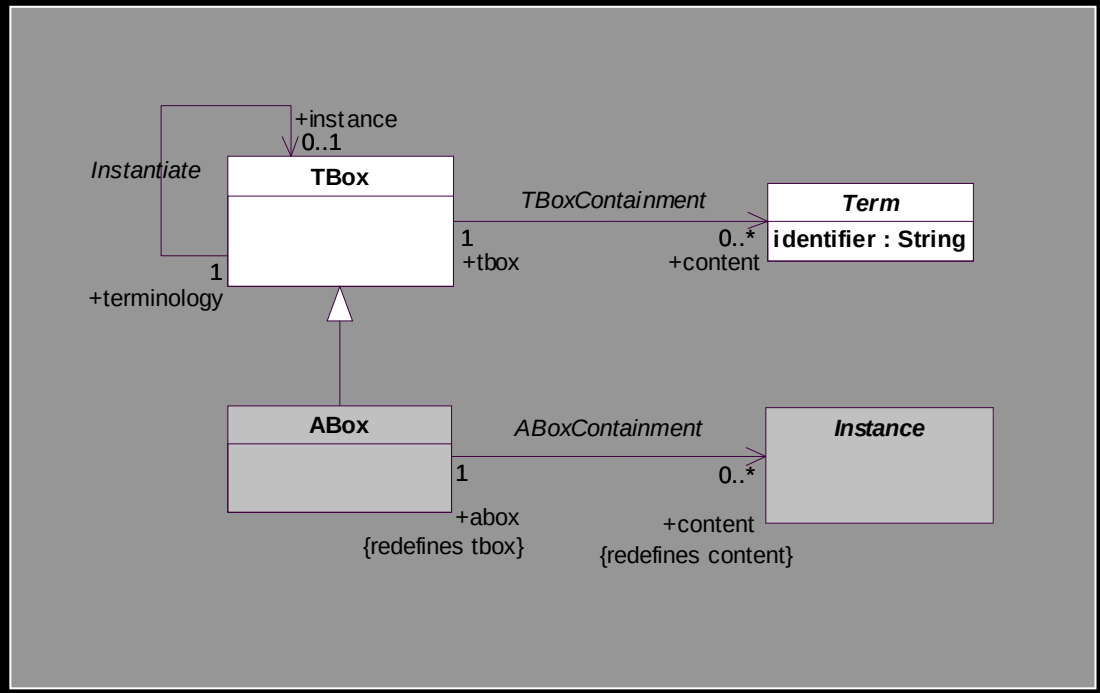
- The Knowledge Interchange Format (KIF) – developed in the late 1980s
- KIF Reference Manual, Version 3.0 – http://ksl.stanford.edu/KSL_Abstracts/KSL-92-86.html
- Several "flavors" of KIF have emerged since:
  - IDEF5 (1994) – http://www.kbsi.com/technology/methods/sbont.htm
  - Draft ANSI KIF (1998) – http://logic.stanford.edu/kif/dpans.html
  - FIPA KIF Content Specification Language (2000 / 2001) – http://www.fipa.org/specs/fipa00010/XC00010C.html
  - Draft ISO KIF Part 1: First Order KIF (2001) – http://cl.tamu.edu/discuss/prop.html
  - Draft IEEE SUO KIF (2002) – http://suo.ieee.org/KIF/
- Common Logic (CL) initiative brought to ISO JTF 1 / SC 32 / WG 2 on metadata standards by John Sowa (ANSI NCITS L8 – March 2002)
- ISO Common Logic based on Simple Common Logic (SCL) by Pat Hayes
- Languages initially proposed under the CL umbrella included KIF, Prolog, Conceptual Graphs, OCL, Z; Intent was to support vendor representations – Cyc-L, Ontos', XSB, Haley Eclipse, NASA CLIPS
- CL – a simple, powerful representation: ISO FDIS 24707 (4/16/2006, http://cl.tamu.edu/)

Topic Maps

- Topic Maps represent another XML Schema based approach for conceptual knowledge representation
  - Part of the semantic web family of standards
  - Less expressive than RDFS/OWL
- Topic Maps are collections of topics, each of which represent a single subject, that are related to one another by associations.
  - Similar to RDF, but less expressive (currently)
  - Originally based on the notion of a publications index
  - Used primarily by the business community in Europe
- Recently standardized through the ISO
  - ISO 13250 – Data Model and XML Serialization
  - ISO 18024 – Query Language (early draft)
  - ISO 19756 – Constraint Language (early draft)

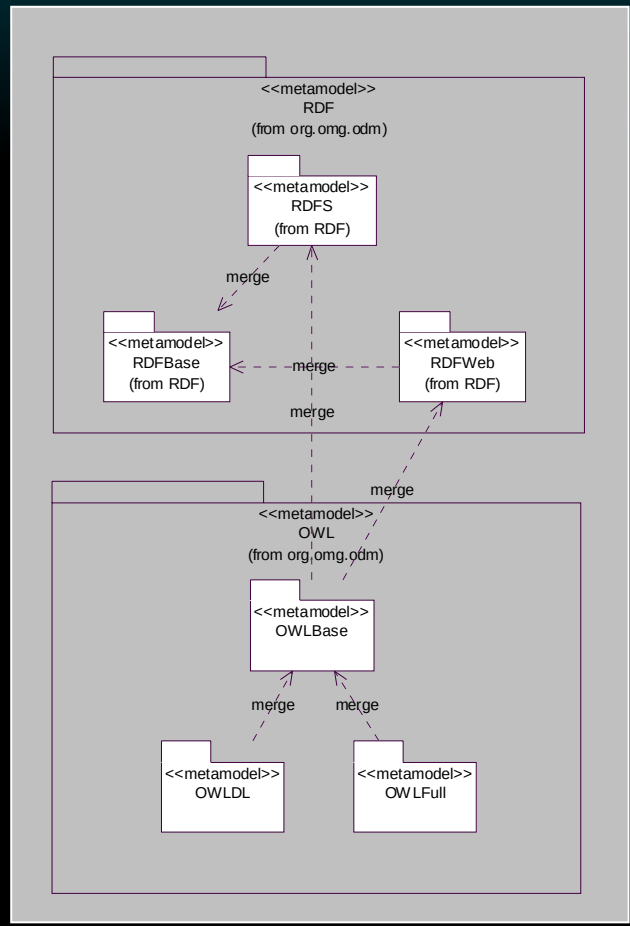
DL Metamodel

- Many variations on DLs, depending on application requirements and reasoning capabilities (OWL represents a commonly used subset)
- Developed primarily as an educational tool, to assist in understanding description logics in general



Semantic Web Language Metamodels

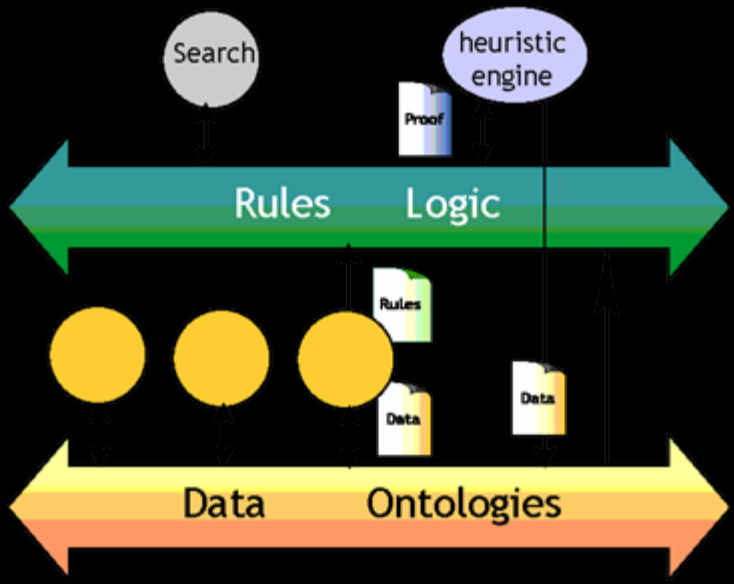
- Focus is on abstract syntax of the Resource Description Framework (RDF), RDF Schema, & the Web Ontology Language (OWL)
- Components build on one another, but RDF can be used either standalone or as the basis for OWL ontology development
- Both OWL DL and OWL Full dialects are supported; OWL Lite applications can use a subset of constructs from the OWL DL metamodel



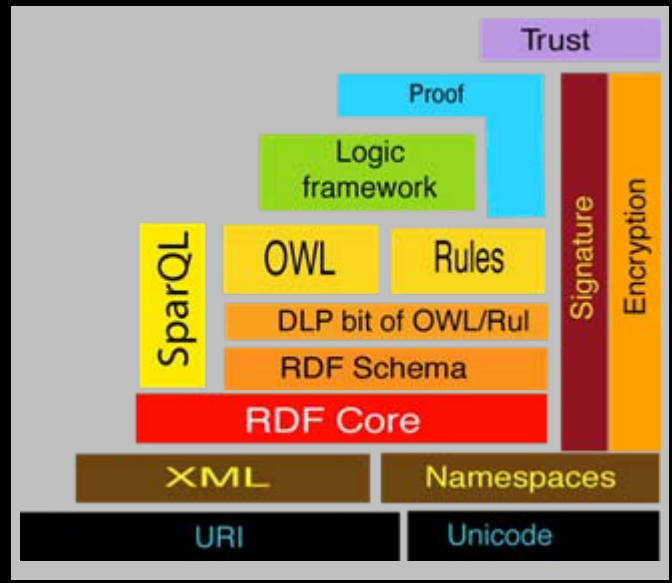
The Semantic Web

"The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation."

-- Tim Berners-Lee



"the bus"



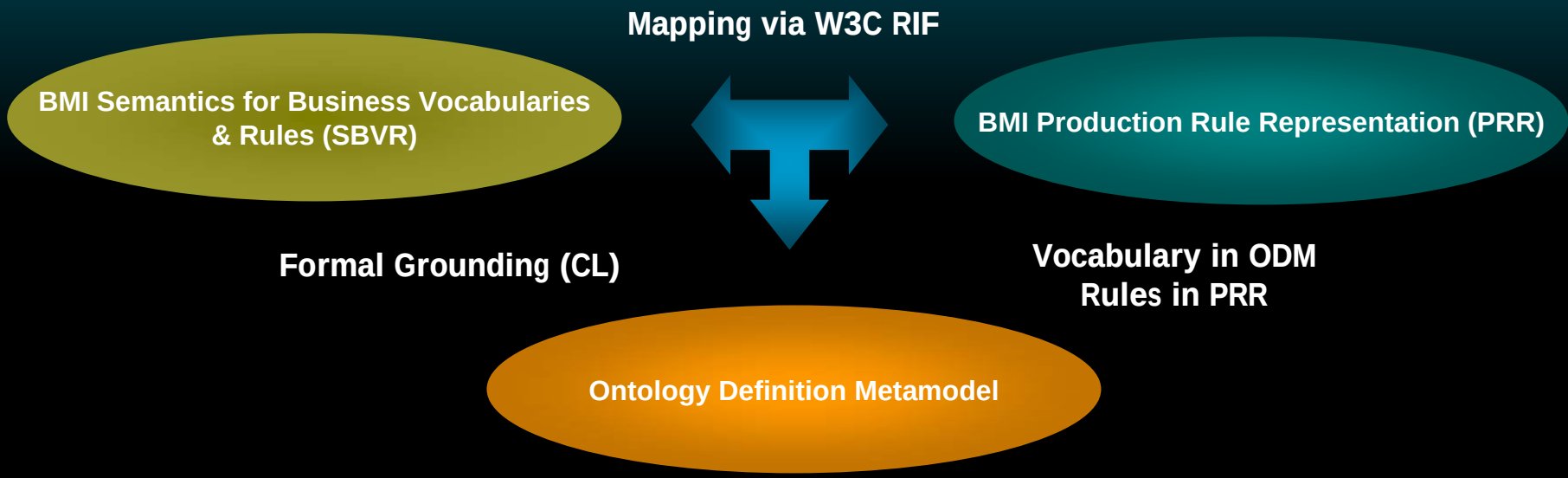
"the wedding cake" also *"the stack"*

Semantic Web stack from "Putting the Web back into Semantic Web", Tim Berners-Lee, ISWC2005 Keynote

ODM Status

- Recommended for adoption in PTC, June 2006
- Informative discussions of Usage Scenarios, differences between UML & OWL
- Platform Independent (Normative) Metamodels (PIMs) include
  - RDF & OWL – abstract syntax, constraints for OWL DL & OWL Full, several compliance options
  - ISO Common Logic (CL)
  - ISO Topic Maps (TM)
- Informative Models
  - DL Core – high-level, relatively unconstrained Description Logics based metamodel (non-normative, informational)
  - Identifier (keys) model extension to UML for ER
- Latest draft adopted specification available at *http://www.omg.org/docs/ad/06-05-01.pdf)*

ODM Relationship to Other OMG Standards



ODM extensions under consideration

- Lossy mapping from CL to RDF/S & OWL
- Support for Semantic Web Services (SWSF, OWL-S), bindings to WSDL & SOAP
- Mappings for W3C Rule Interchange Format (RIF) (*i.e.* vocab/ontology → rules, including PRR)
- Mappings for Emerging OMG Information Management Metamodel (IMM) – including potentially ER, ISO Express
- New requirements from SOA ABSIG anticipated

Relationship to ISO Standards

- CL Metamodel is included in ISO FDIS 24707
- High degree of synergy between ODM and Topic Maps ISO FCD 13250-2 working group
- All ODM metamodels are referenced and used in ISO CD 19763 (MMF – Metamodel Framework, Model Registry specification)
- All ODM metamodels inform latest modifications proposed in ISO draft 11179 Metadata Registration specification
- ODM team is working with DoD XMDR team to promote interoperability among ODM, ISO 19763, ISO 11179 metadata standards efforts
- Current work in OMG to develop a metamodel for ISO Express will include mappings to ODM
- Mappings from multiple components of IMM (*e.g.*, ER, ISO Express) are under consideration

ODM Application Vision

- Rich content services
  - Search relevance
  - Collaborative applications
  - Dramatic increases in personalization
  - New analytics and business intelligence capabilities
- Dramatic increases in interoperability through much deeper semantic integration
- Achieve MDA vision through
  - Model validation
  - Separation of vocabulary from software & rules – increased value in patterns, abstraction
  - Component based vocabulary & semantics – increased scalability, support for grid-based applications, Web 2.0
  - Semantics for Web services
- New capabilities in policy and context based applications

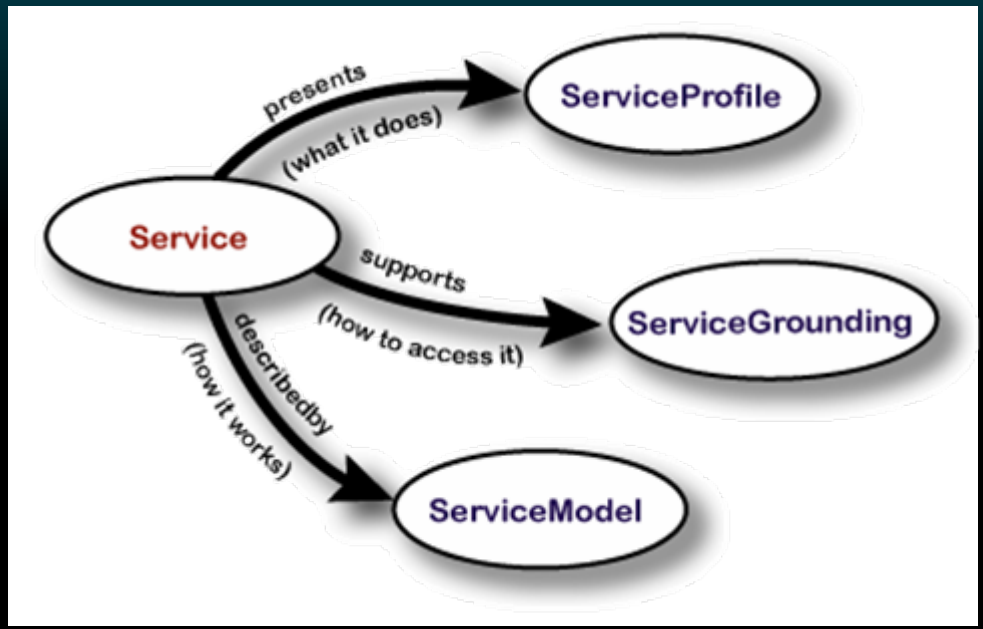
Semantics for Web Services

- Ontologies provide a common vocabulary and definition of rules for use by independently developed services
- Companies and organizations sharing common services can declaratively specify the *behaviors*, *policies* and *agreements* relevant to their usage
- Automation of service use by software agents
  - Declarative exchange of behaviors, policies, and agreements
  - Dynamic discovery of new services
  - Reasoning to support on-the-fly composition
  - Integrated use with discovered information services → ultimate fully-automated & customized user experience
- Composition, mapping and vocabulary brokering for independently developed resources and services – enables information sharing & process enactment consistently, accurately, and dynamically
- OWL-S complements WSDL by providing an abstract or application level description lacking in WSDL

OWL-S: Enabling Infrastructure for Web Services

- Based on research from the DARPA/DAML program in DAML-S (2000/2001 – SRI, Stanford, CMU)
- OWL-S – an ontology that sits at the application level, above WSDL, and describes *what* is being exchanged and *why*, not just the *how*
- OWL-S enables
  - *discovery* – of services that meet particular requirements and adhere to specified constraints
  - *invocation* – and execution by agents or other services
  - *interoperation* – through specification of the appropriate vocabularies (semantics) and message parameter translation as required based on service specifications
  - *composition* – automated service composition and interoperation to provide new services
  - *verification* – of service properties
  - *execution monitoring* – tracking of execution of complex services and transactions

Top-Level of the Service Ontology



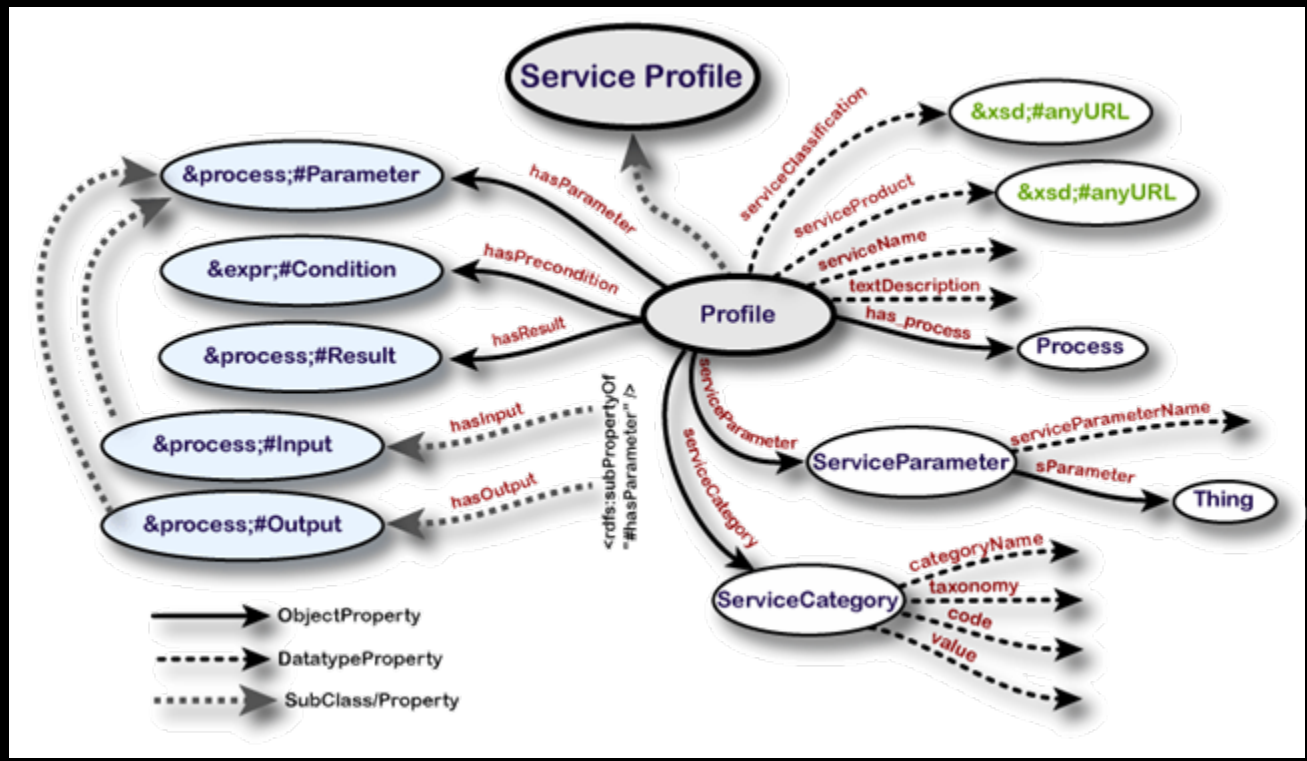
OWL-S: Semantic Mark-up for Web Services, David Martin, SRI (editor) et al

Three essential types of knowledge about services

- **The *what*, its capabilities and parameters, through a *ServiceProfile*, which can answer questions such as what does the service require of agents and provide for them**
- **The *how*, through a *ServiceModel* that describes the workflow and possible execution paths**
- **Accessibility and usage through a *ServiceGrounding***

OWL-S Structure

- Service profiles are used to request or advertise services with discovery services and capabilities registries:
  - Descriptions of services and providers
  - Functional behavior & attributes



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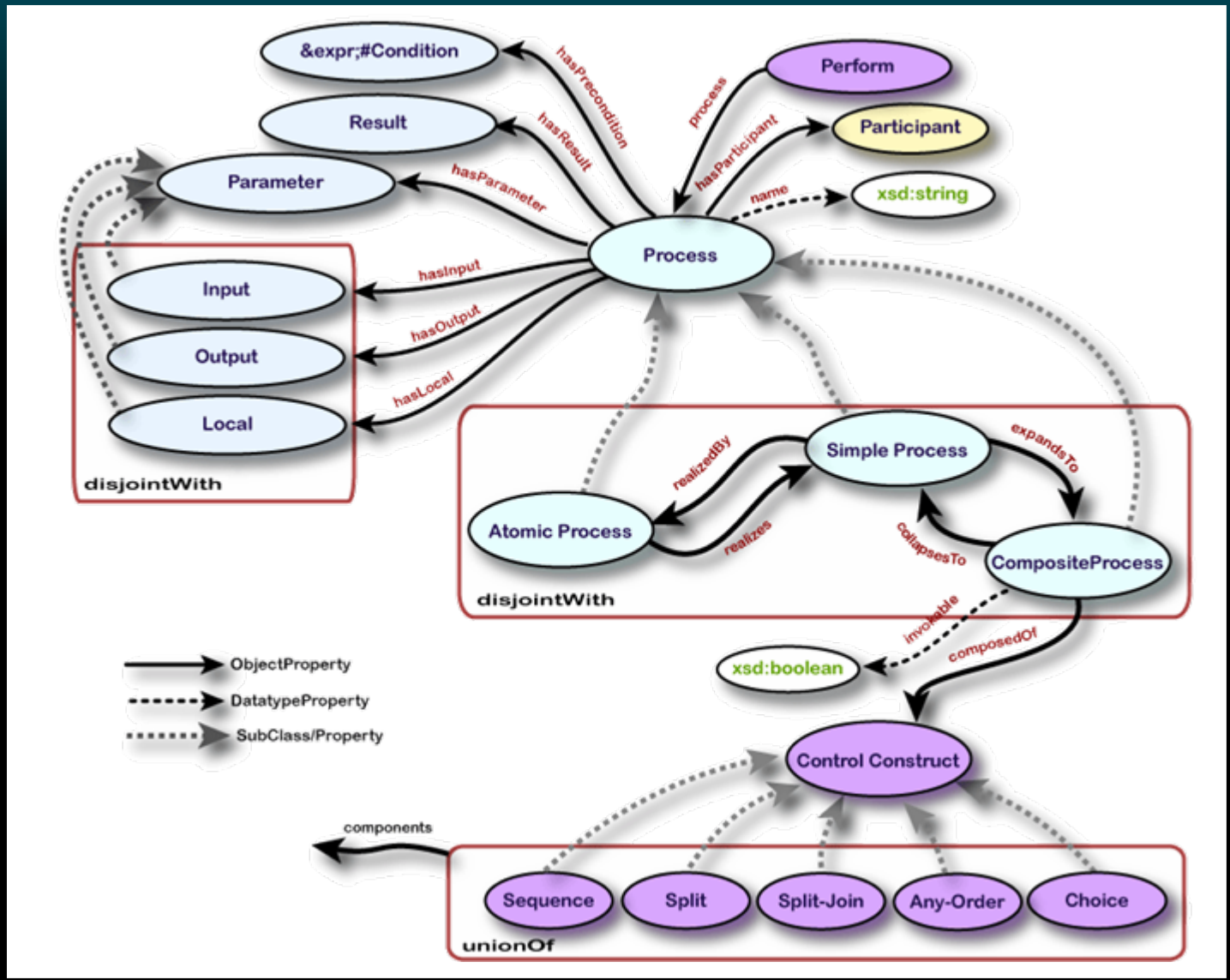
Top-Level of Process Ontology



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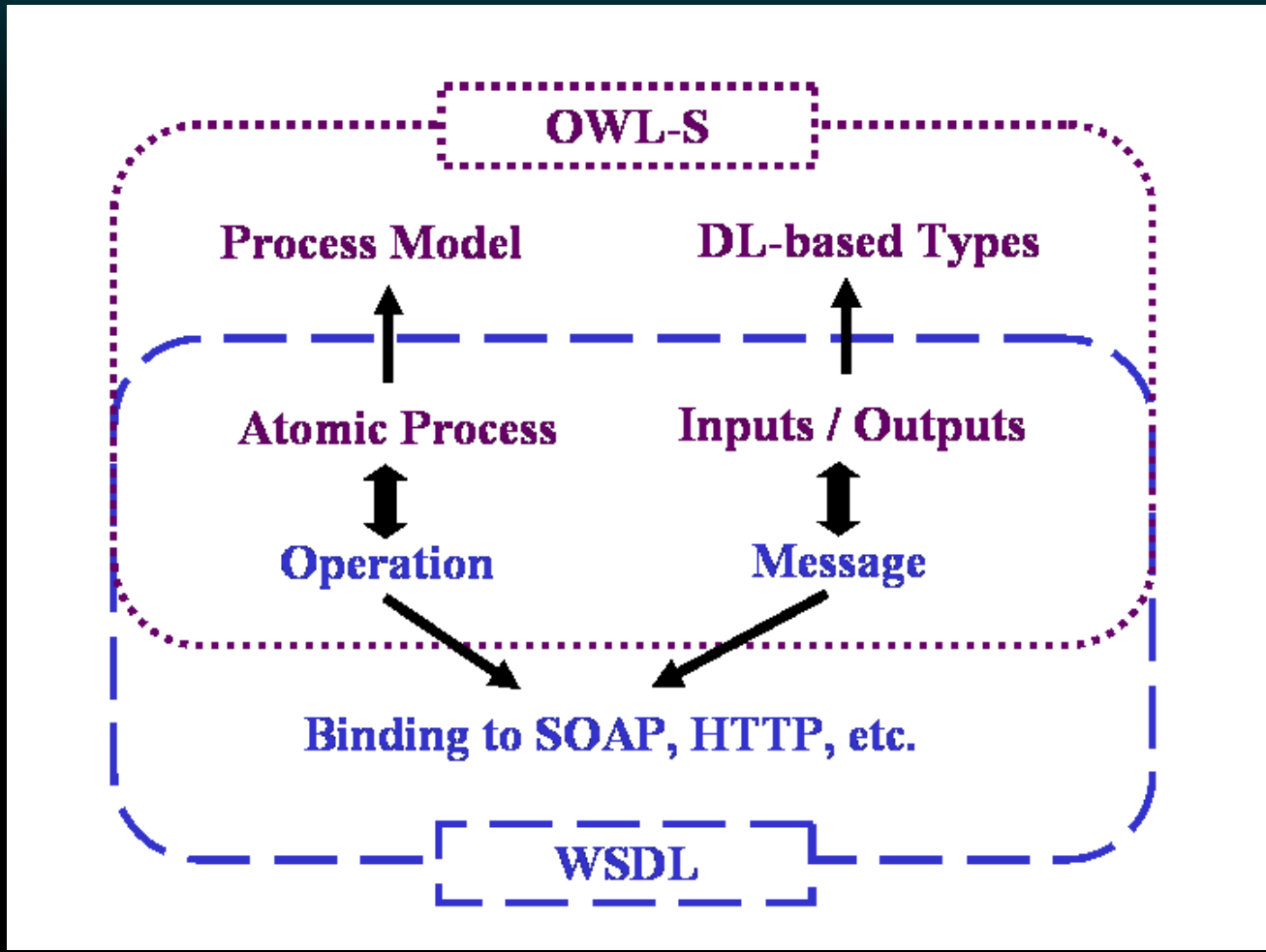
Mapping Between OWL-S & WSDL



OWL-S: Semantic Mark-up for Web Services, David Martin, SRI (editor) et al

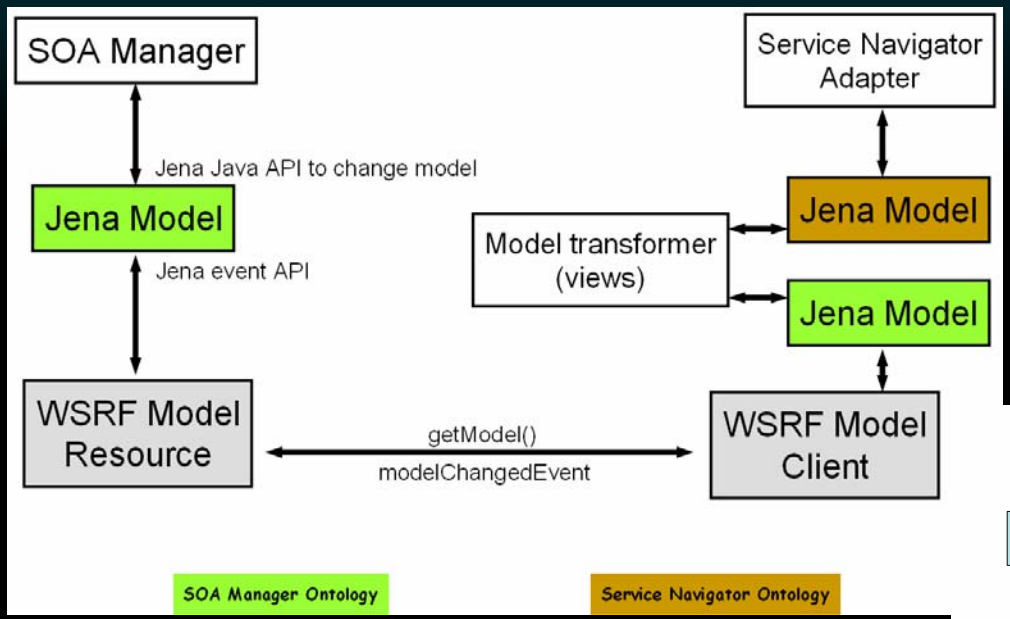
Semantic Web Services Framework (SWSF)

- Emerged from work in services composition
  - May require more expressivity than is available in OWL
  - Based on logic programming, first-order logic, policy research
- Considered smorgasbord of standards
  - Web Services Description Language (WSDL) – for input & output messaging, invocation (W3C)
  - Business Process Execution Language for Web Services (BPEL4WS) – workflows of basic services (OASIS)
  - Choreography Description Language (WS-Choreography) – more global view of information exchange from a transaction perspective (W3C)
  - UDDI – standard approach for service registration, discovery, & advertising
- Builds on DAML-S, OWL-S, WSMO
- Provides rich semantics for greater automation of discovery, selection & invocation, content transformation, composition, monitoring & recovery, verification

Semantic Web Services Framework
SWSL & SWSO

- Semantic Web Services Language (SWSL)
  - SWSL-FOL – first order language for ontology representation, builds on CL
  - SWSL-Rules – logic programming to enable ontology use in reasoning and execution environments
- Semantic Web Services Ontology (SWSO)
  - Conceptual model, complete axiomatization expressed in SWSL-FOL
  - Called FLOWS – First-Order Logic Ontology for Web Services
  - Includes model theoretic semantics
  - Ontology translated to SWSL-Rules is slightly more constrained,
  - Called ROWS – Rules Ontology for Web Services
- W3C Note & member submission
  - http://www.w3.org/Submission/SWSF/

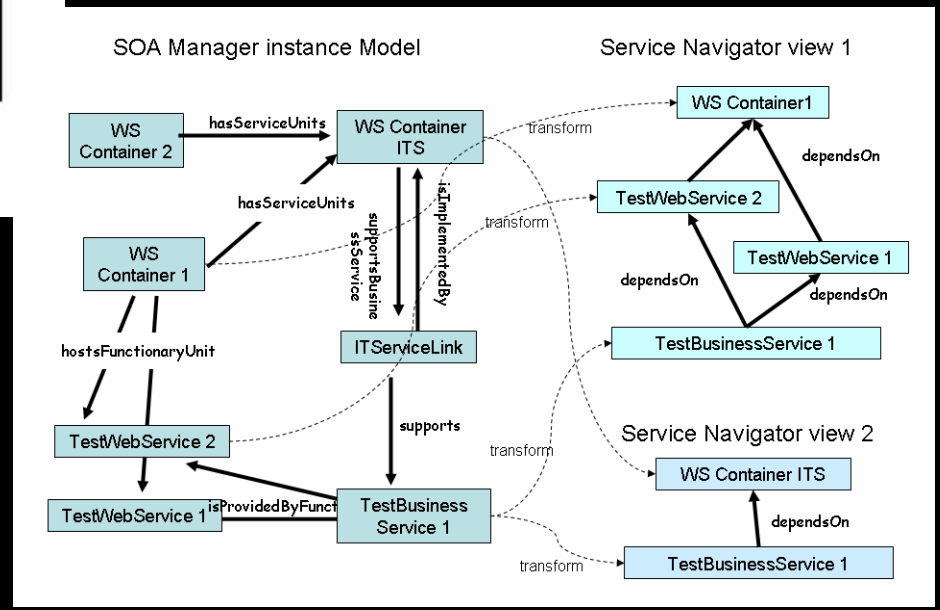
Management Application Integration (MAI)



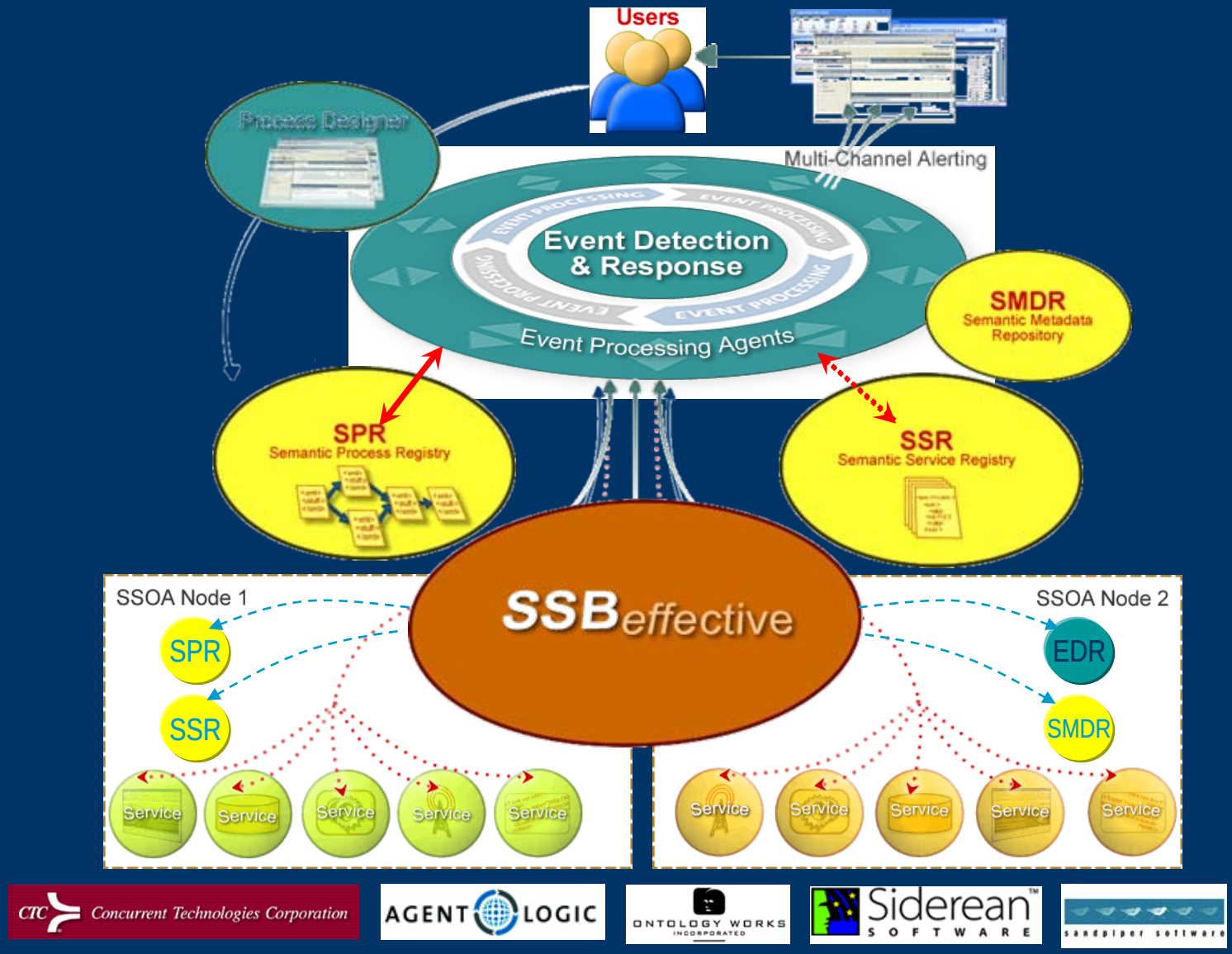
Synchronization of model repositories using RDF/S & OWL based representation & transformations provides new integration capabilities for HP OpenView

Ontology was developed using an ODM-based development environment;

Jena Rules support model transformations



SSOA System View



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Summary

- Semantic Web Services standards are converging
- OMG RFP under consideration for extensions to ODM to support W3C Semantic Web Services
  - OWL-S, building on the RDF & OWL metamodels
  - SWSF, building on the CL metamodel, with mappings to OWL-S
  - Mappings to standardize bindings to WSDL, SOAP
  - Potential use of activity diagrams in addition to class diagrams for choreography, process semantics
- Leverage mapping from UML for BPEL to ODM extensions (*e.g.*, to the PSL component of SWSF)

Questions

Acronym Soup

- **AD PTF** – OMG Analysis & Design Task Force
- **BMI DTF** – OMG Business Modeling & Integration Domain Task Force
- **BPEL** – Business Process Execution Language (OASIS), http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsbpel
- **BPEL4WS** – Business Process Execution Language for Web Services
- **CL** – ISO 24707 Common Logic: a family of first order logic languages, including Conceptual Graphs & Common Logic Interchange Format – a successor to the Knowledge Interchange Format (KIF), http://cl.tamu.edu/
- **DAML** – DARPA Agent Mark-up Language, one of the primary languages leading to the development of OWL, http://www.daml.org/
- **DAML-S** – Services ontology for DAML, http://www.daml.org/services/
- **DARPA** – Defense Advanced Research Projects Agency, http://www.darpa.mil/
- **DL** – Description Logics: a subset of first order logic, for which tractable & complete reasoning systems are available
- **ER** – Entity Relationship modeling
- **IMM** - Information Management Metamodel (a.k.a CWM2)
- **MDA** – Model-Driven Architecture, http://www.omg.org/mda/
- **MMF** - Metamodel Management Framework (ISO 19763)
- **ODM** – Ontology Definition Metamodel

More Acronym Soup

- **OWL** – W3C Web Ontology Language, a formal W3C Recommendation as of 10 February 2004, http://www.w3.org/TR/owl-semantics/
- **OWL DL** – the normative description logics dialect of OWL
- **OWL Full** – the normative OWL dialect that has increased expressivity over OWL DL, but does not conform to DL reasoning requirements
- **OWL-S** – a set of OWL ontology components that extend the W3C OWL specifications to support Semantic Web Services, http://www.daml.org/services/
- **PRR** – Production Rules Representation
- **QVT** – MOF Query / View / Transformations Specification, http://www.omg.org/docs/ptc/05-11-01.pdf
- **RIF** – Rule Interchange Format, http://www.w3.org/2005/rules/wg
- **RDF** – Resource Description Framework, http://www.w3.org/TR/rdf-concepts/
- **SBVR** – Semantics for Business Vocabularies and Rules
- **SOA** – Service Oriented Architecture
- **SOAP** – Simple Object Access Protocol, http://www.w3.org/TR/soap/
- **SWSF** – Semantic Web Services Framework, http://www.w3.org/Submission/SWSF/
- **TM** – ISO 13520 Topic Maps, http://www.isotopicmaps.org/sam/sam-model/
- **WSDL** – Web Services Description Language