MDA & Semantic Web Services
Extending ODM with Service Semantics

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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

Level of Complexity vs. Level of Expressivity

- KR System
- OO Software Model
- Entity – Relationship Model
- Concept Map
- Topic Map
- Database Schema
- XML Schema
- Hierarchical Taxonomy
- Simple Taxonomy
- Glossary
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
The Knowledge Interchange Format (KIF) - developed in the late 1980s


Several “flavors” of KIF have emerged since:

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

**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

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

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 \(\rightarrow\) rules, including PRR)
- Mappings for Emerging OMG Information Management Metamodel (IMM) - including potentially ER, ISO Express
- New requirements from SOA ABSIG anticipated

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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

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

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

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Top-Level of Process Ontology
Mapping Between OWL-S & WSDL

OWL-S

Process Model
- Atomic Process
  - Operation
- Binding to SOAP, HTTP, etc.

DL-based Types
- Inputs / Outputs
  - Message

WSDL
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/](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
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
- 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/
- 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)
- 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/](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/](http://www.daml.org/services/)
- **PRR** - Production Rules Representation
- **RDF** - Resource Description Framework, [http://www.w3.org/TR/rdf-concepts/](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/](http://www.w3.org/TR/soap/)
- **SWSF** - Semantic Web Services Framework, [http://www.w3.org/Submission/SWSF/](http://www.w3.org/Submission/SWSF/)
- **WSDL** - Web Services Description Language