s a n d p i p e r s o f t w a r e

The Model-Driven Semantic Web

Emerging Technologies & Implementation Strategies

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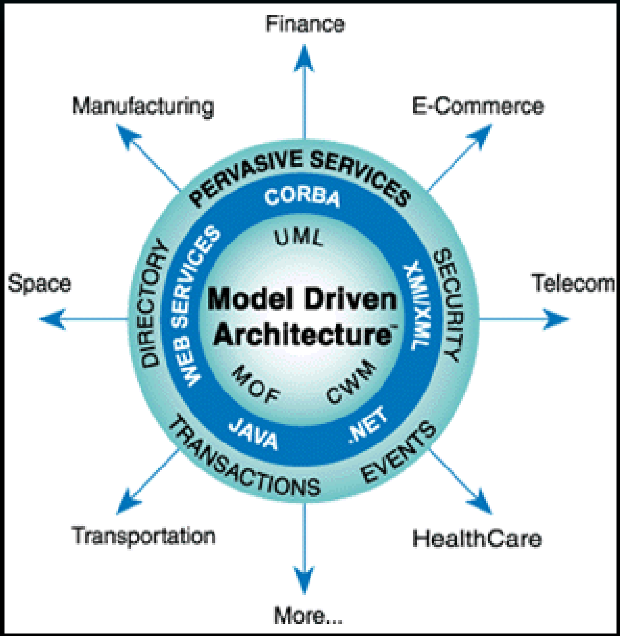
Model Driven Architecture® (MDA®)

- Insulates business applications from technology evolution, for
  - Increased portability and platform independence
  - Cross-platform interoperability
  - Domain-relevant specificity
- Consists of standards and best practices across a range of software engineering disciplines
  - The Unified Modeling Language (UML®)
  - The Meta-Object Facility (MOF™)
  - The Common Warehouse Metamodel (CWM™)
- MOF defines the metadata architecture for MDA
  - Database schema, UML and ER models, business and manufacturing process models, business rules, API definitions, configuration and deployment descriptors, etc.
  - Supports automation of physical management and integration of enterprise metadata
  - MOF models of metadata are called *metamodels*



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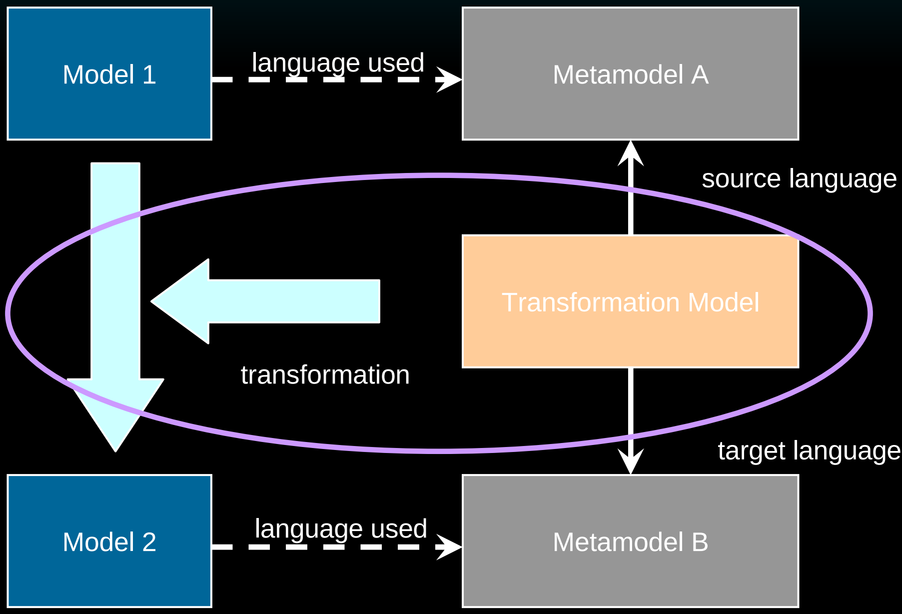
MOF-Based Metadata Management

- MOF tools use metamodels to generate code that manages metadata, as XML documents, CORBA objects, Java objects
- Generated code includes access mechanisms, APIs to
  - Read and manipulate
  - Serialize/transform
  - Abstract the details based on access patterns
- Related standards:
  - XML Metadata Interchange (XMI®)
  - CORBA Metadata Interface (CMI)
  - Java Metadata Interface (JMI)
- Metamodels are defined for
  - Relational and hierarchical database modeling
  - Online analytical processing (OLAP)
  - Business process definition, business rules specification
  - XML, UML, and CORBA IDL



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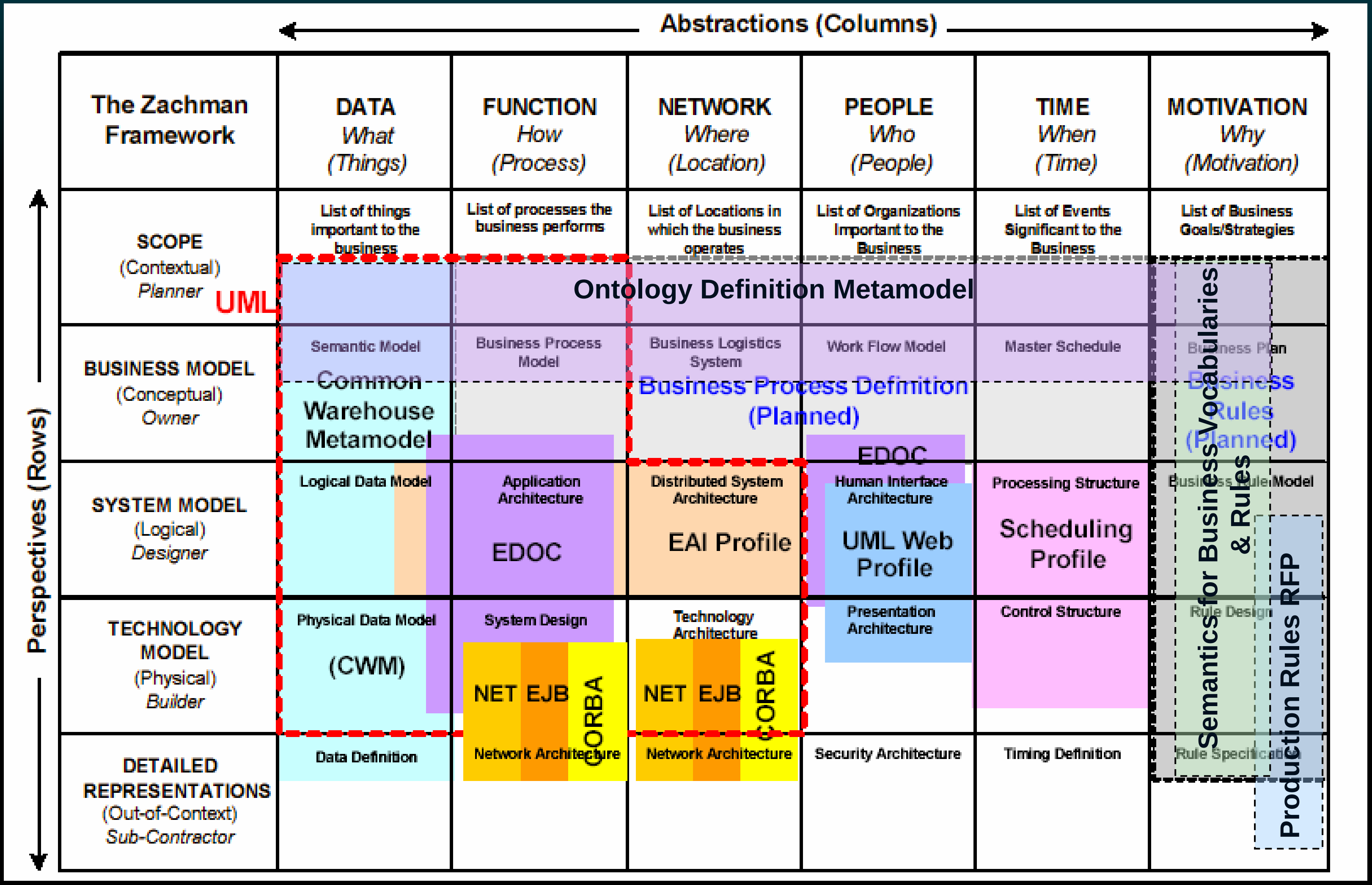
OMG Standards & Zachman Framework



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

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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

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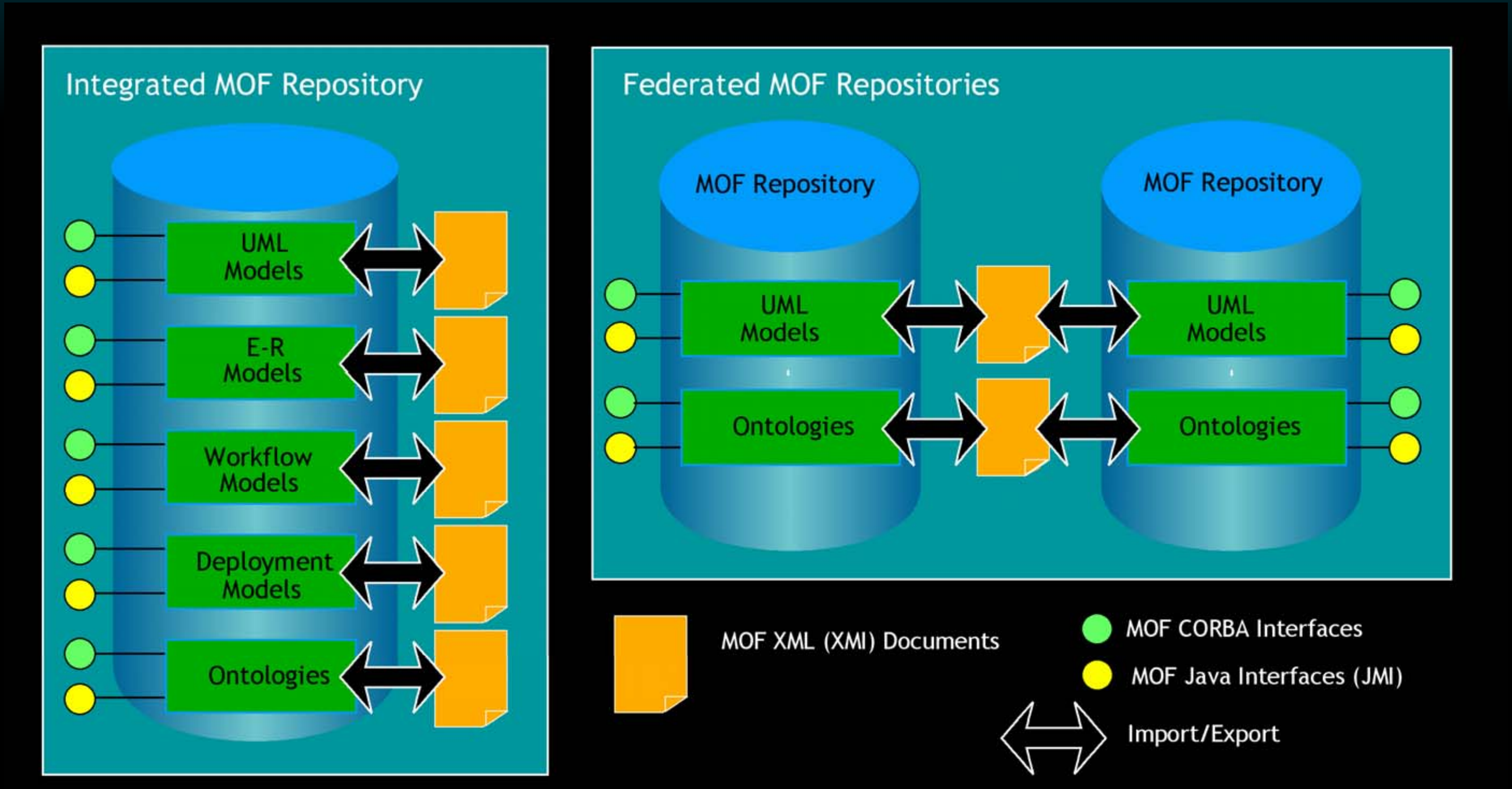
Metadata Management Scenarios



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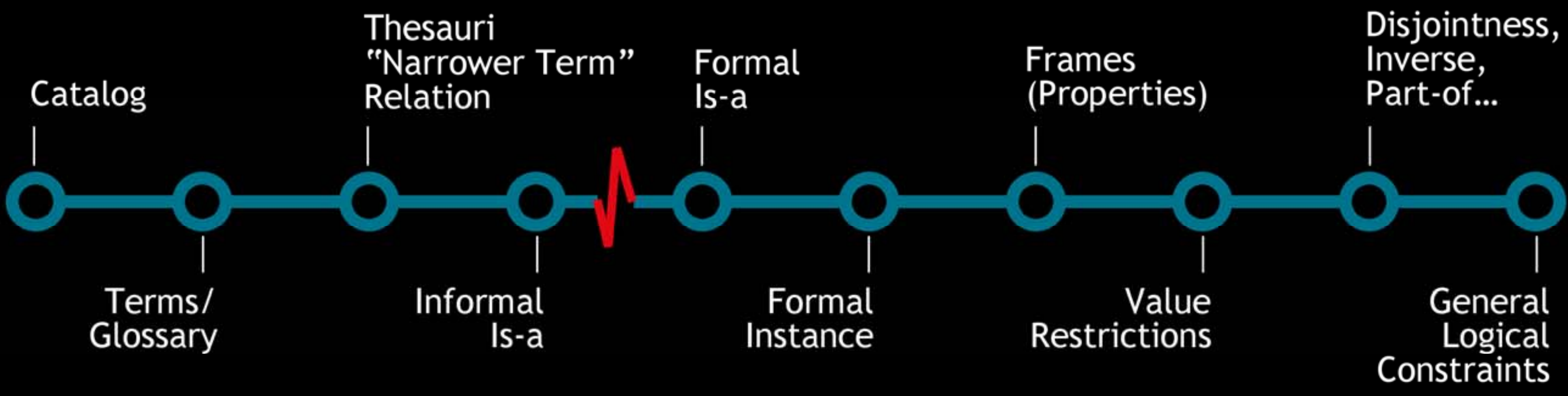
Level Setting

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

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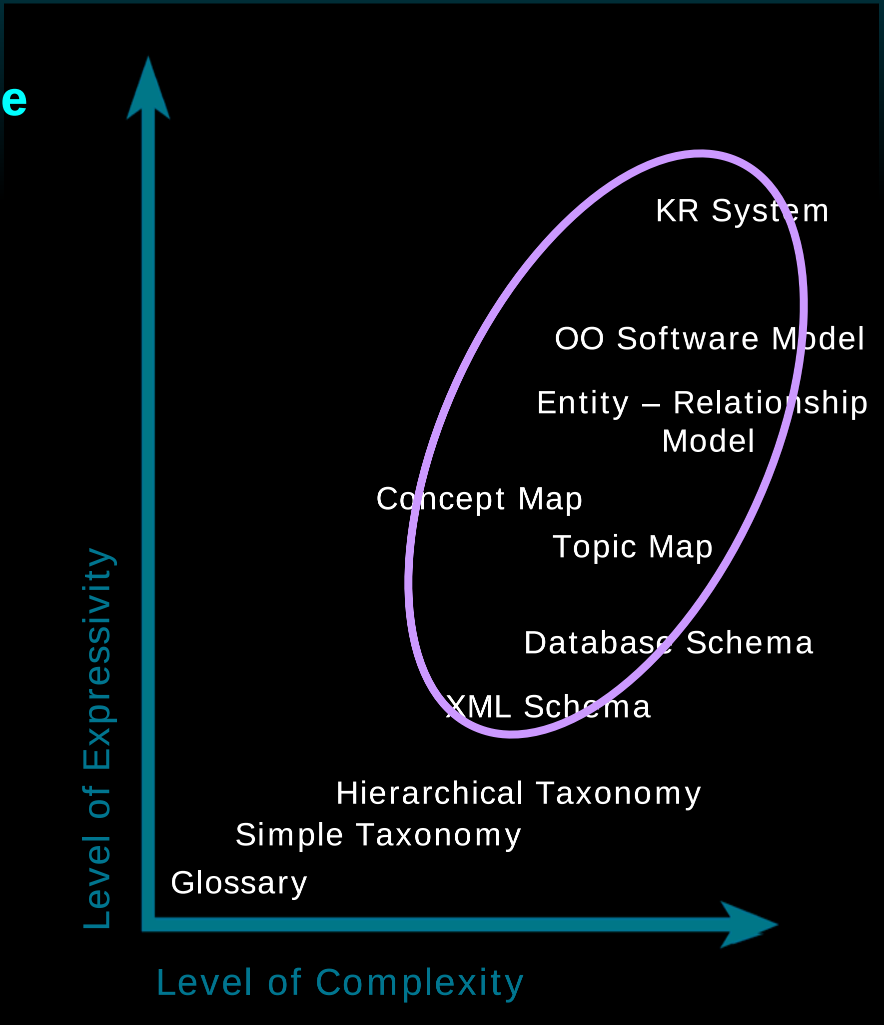
Classifying Ontologies

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



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Model Dynamics

Model centric perspectives characterize the ontologies themselves and are concerned with their structure, formalism and dynamics.

Perspective	*One Extreme*	*Other Extreme*
Level of Authoritativeness	Least authoritative, broader shallowly defined ontologies	Most authoritative, narrower, more deeply defined ontologies
Source of Structure	Passive (Transcendent) - Structure originates outside the system	Active (Immanent) - Structure emerges from data or behavior
Degree of Formality	Informal or primarily taxonomic	Formal, having rigorously defined types, relations, and theories or axioms
Model Dynamics	Read-only, ontologies are static	Volatile, ontologies are fluid and changing
Instance Dynamics	Read-only, resource instances are static	Volatile, resource instances change continuously

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Application Characteristics

Application centric perspectives are concerned with how applications use and manipulate ontologies.

Perspective	*One Extreme*	*Other Extreme*
Control/Degree of Manageability	Externally focused, public (little or no control)	Internally focused, private (full control)
Application Changeability	Static (with periodic updates)	Dynamic
Coupling	Loosely-coupled	Tightly-coupled
Integration Focus	Information integration	Application integration
Lifecycle Usage	Design Time	Run Time

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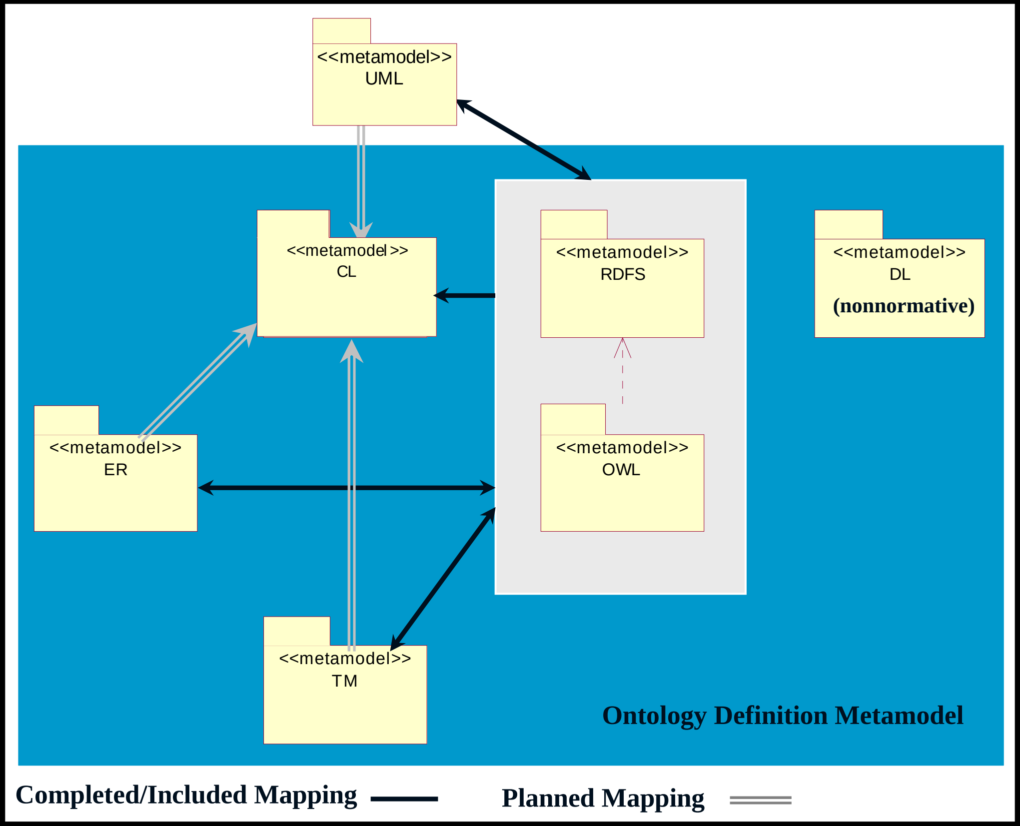
Towards a Model Driven Semantic Web - ODM

- Six EMOF platform independent metamodels, (PIMs), five normative
- Mappings (MOF QVT Relations Language planned)
- UML2 Profiles
  - RDFS & OWL
  - TM
- Collateral
  - XMI
  - Java APIs
  - Proof-of-concepts
- Conformance
  - RDFS & OWL
  - All else optional



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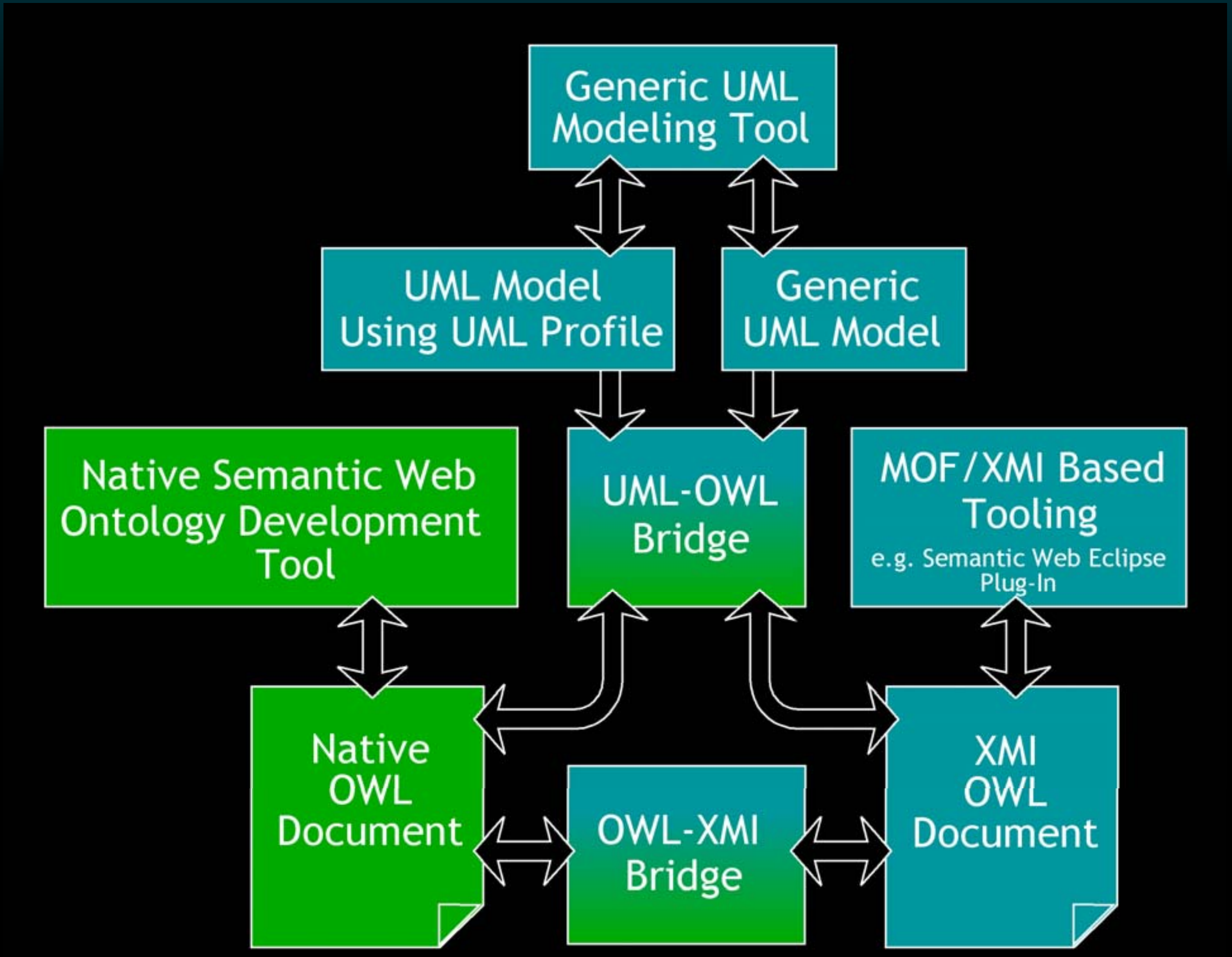
Bridging KR and MDA



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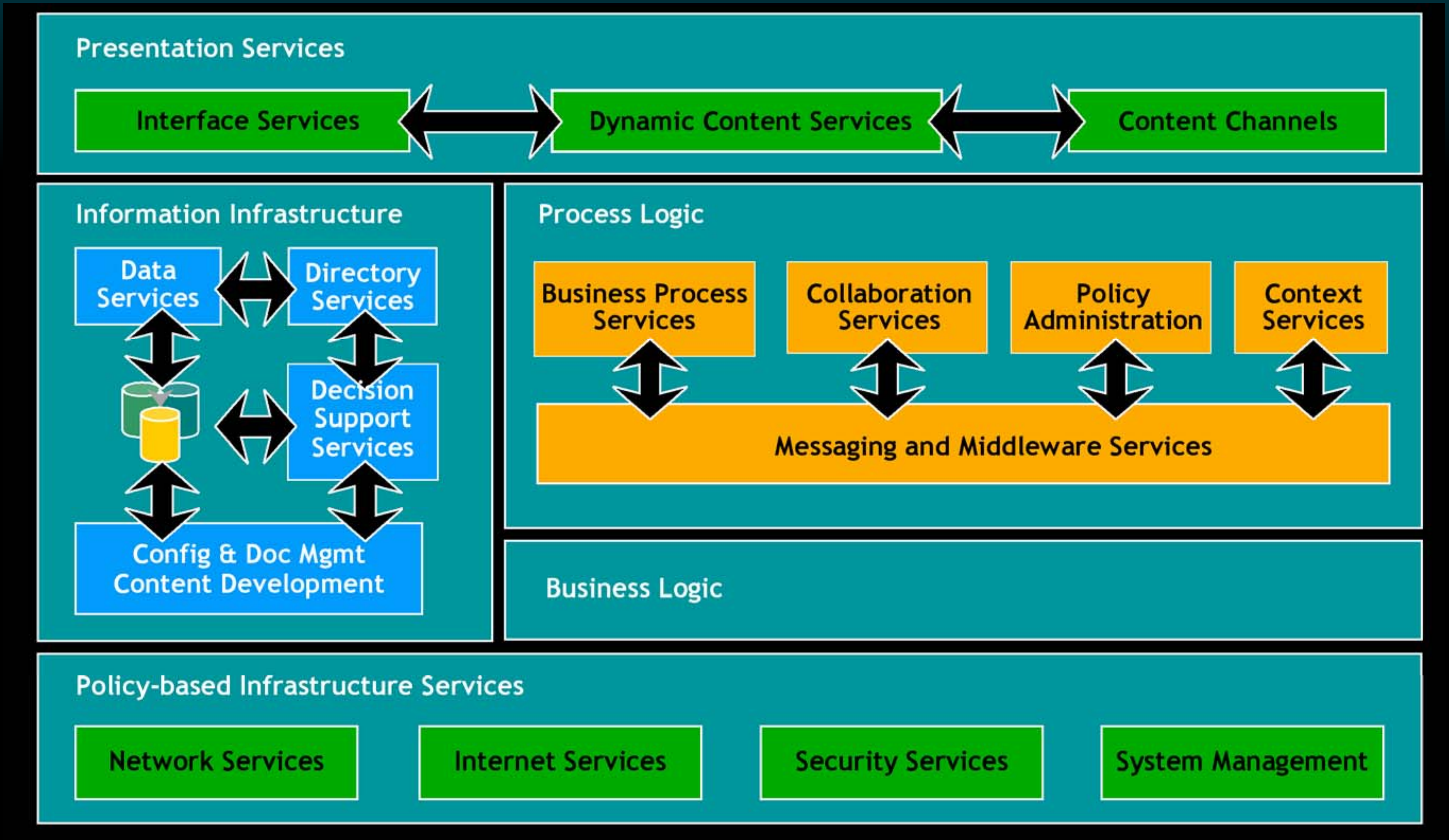
Technology Architecture



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ODM Status

- Several revision cycles on the specification to date
- Informative discussions of Usage Scenarios, differences between UML & OWL
- Platform Independent Metamodels (PIMs) include
  - Resource Description Framework and Web Ontology Language (covers abstract syntax, common concrete syntactic elements from both)
  - Common Logic (CL), based on draft ISO CD 24707
  - Topic Maps (TM), based on draft ISO 13250-2 specification
  - ER – based on de facto industry standards
  - DL Core – high-level, relatively unconstrained Description Logics based metamodel (non-normative, informational)
- Revised submission (next iteration) will be posted 8/22 to the OMG web site
- Presentation on 8/22 revision planned for OMG Atlanta meeting (September 12-16)
- Plans for recommendation / vote for adoption December meeting

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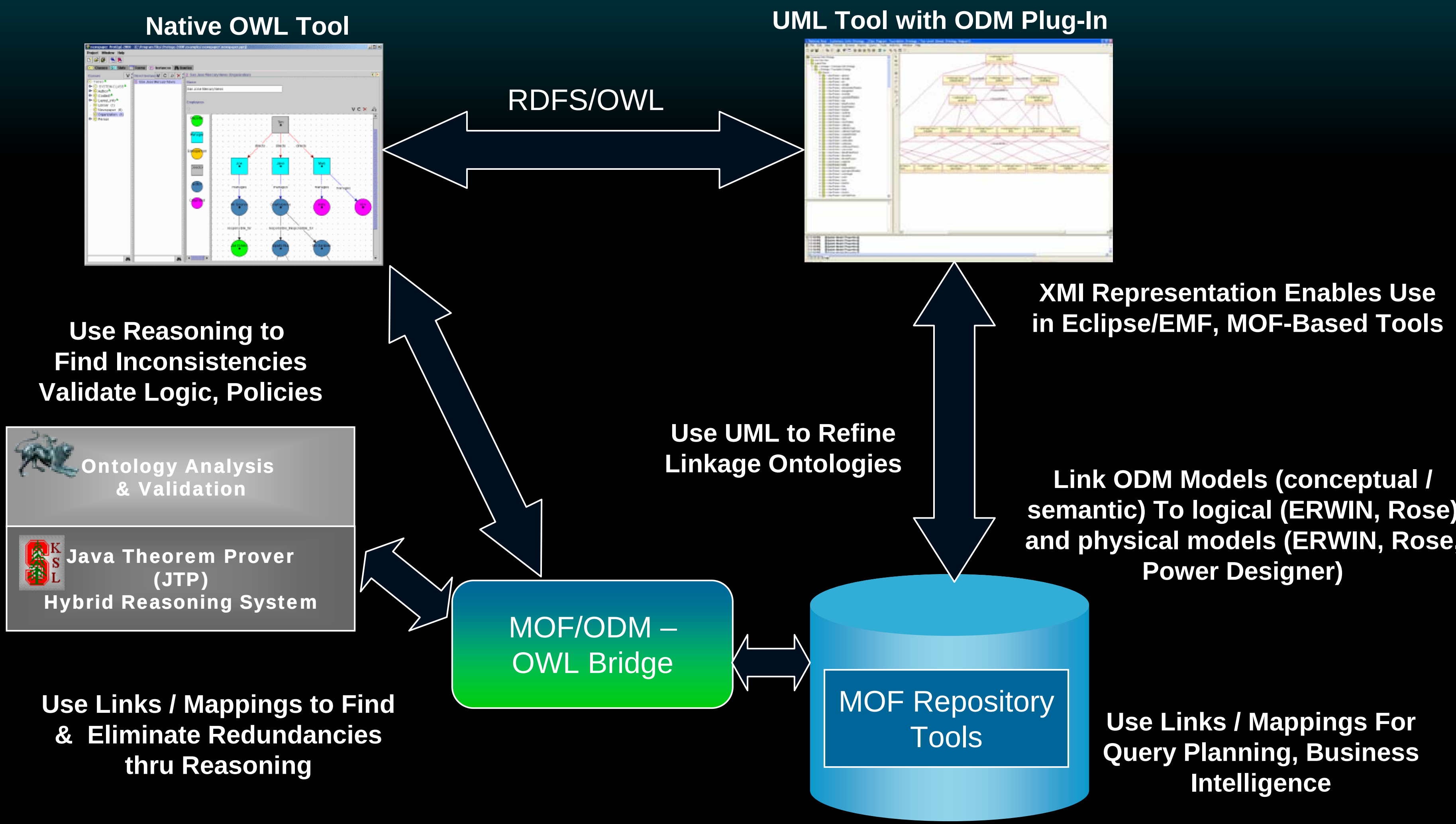
Implementation Strategies



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Business Integration

- Semantic Web Services standards are converging (OWL-S and SWSL)
- OMG RFP forthcoming for extensions to ODM to support Semantic Web Services, EXPRESS, eventually SWRL (when a rule language is selected/formalized)
- Business Semantics for Business Rules joint revised submission, called "Semantics for Business Vocabularies & Rules (SBVR)" is logically grounded in Common Logic / ODM CL Metamodel
- Potential mapping to forthcoming Production Rule specification
- Leverage mapping from UML for BPEL to ODM extensions
- Strategy:
  - Link business process models through MOF environment
  - Generate OWL for the linkage
  - Use linkage as basis for mediating business process semantics

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A Framework for Next Generation Interoperability

- MOF's model management facilities and KR capabilities for machine interpretable semantics and reasoning are separate, complementary concerns
- The ability of reasoners to find discrepancies in invariant rules, preconditions, and post conditions, can add scalability to MDA's use of Design-by-Contract (DBC)
- UML profiles can serve as graphical notations for Semantic Web languages, dramatically increasing ease of use
- The combination of MDA and SW technologies promises to
  - Address the missing link in business process automation
  - Enable true information interoperability and continuity
  - Support next generation policy-based applications development

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The Model-Driven Semantic Web

- Knowledge acquisition, developing the semantics is the bottleneck
- Leveraging existing assets breaks that bottleneck
- Correlation through reasoning provides the utility
  - Multi-dimensional, cross organizational tailored semantic views
  - “Virtual” repository approach enables elimination of redundancy
  - Reasoning supports quality initiatives through inconsistency discovery, model and content validation
- MDA and MOF coupled with Semantic Web technologies are the key

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