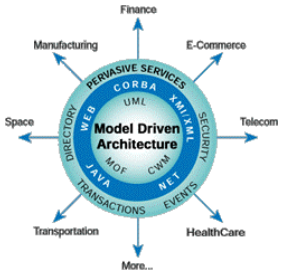

OBJECT MANAGEMENT GROUP

Setting vendor-neutral software standards, and enabling distributed, enterprise-wide interoperability

UNIFIED MODELING LANGUAGE

OMG Model Driven Architecture (MDA) meets Web Services

Web Services: From Technology to Reality Workshop
March 4-7, 2002

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Member, OMG Architecture Board
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Presentation Overview

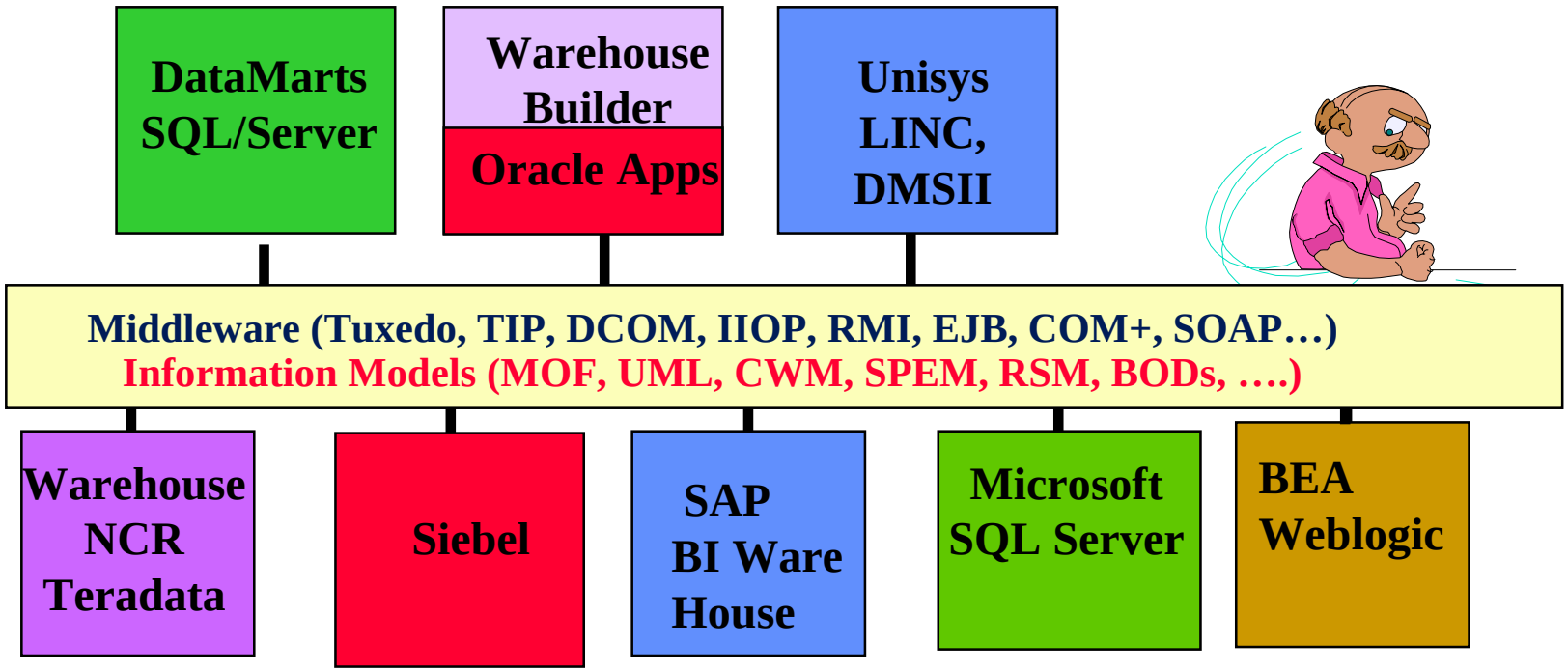
- Introduction - The integration problem
- Web Services Architecture Overview
- OMG Model Driven Architecture (MDA) Overview
- Mapping OMG MDA to Web Services Architecture
- OMG Web Services and XML Related Efforts
  - XMI 1.x
  - XMI Production of XML Schemas
  - CWM Web Services RFP
  - Web Services SIG Discussions
- Next Steps

UNISYS

- Global services and technology company
  - 2000 Revenues : $6.9 Billion
  - *www.unisys.com*
- Focus on Enterprise Class Servers and E-Business Solutions around the world
- Actively influenced and using several OMG Technologies : UML, XMI, MOF, CWM and MDA
- Member of W3C, UDDI Consortium, OASIS...
- Using MDA principles to integrate J2EE and .Net environments

'Muddleware' Architect's Dilemma

Architect (XML!)



Distributed, Heterogeneous, Client/Server !

Multiple Clients, Servers, Tools, Apps, O/S, File systems, Databases, Repositories, Data Models, Object Models...

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The Middleware Salad Bar

Capability	J2EE	COM+	CORBA/OMA	Web Services	OMG MDA*	.Net
Network Layer	TCP/IP	TCP/IP	TCP/IP	TCP/IP	TCP/IP	TCP/IP
Web Protocol	HTTP	HTTP	HTTP	HTTP	HTTP	HTTP
Interface Definition	Java	Microsoft IDL	CORBA IDL	WSDL	IDL/XMI/WSDL	WSDL
Meta Language	XML	XML	XML/XMI	XML	MOF/XML	XML
RPC Mechanism	RMI	DCOM	IIOP	SOAP; XMLP	SOAP; IIOP	SOAP
Registry/Repository	JNDI; LDAP	LDAP; ADSI	Repository	UDDI	MOF;UDDI	UDDI
Process Flow	Proprietary	Proprietary	Proprietary	ebXML; WSFL	UML	Proprietary
Modeling Language	UML	UML	UML	UML	UML	UML

*With OMG MDA - Multiple platforms are supported

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A short Introduction to Web Services Architecture

Since this topic has been covered well in this conference, I will focus on the highlights so we can define MDA, cover mapping MDA to Web Services

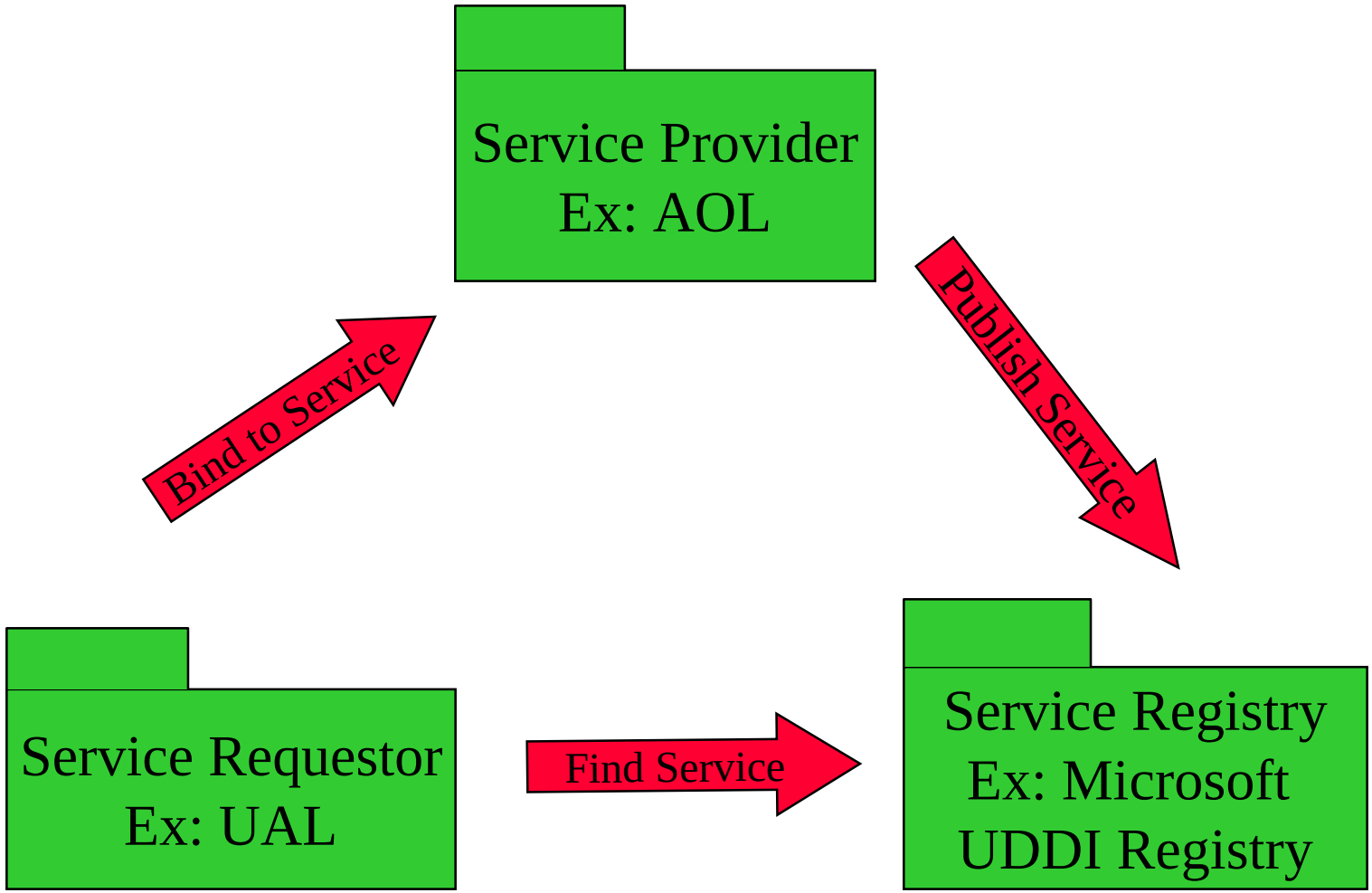
What are Web Services?

- 'Modular and reusable' applications that can be
  - Invoked over the web (using a protocol like SOAP)
  - Described using a service description language (like WSDL)
  - Published into a registry (like UDDI) so the service can be searched, bound and invoked
- Web Services do not imply component based development.
  - In fact a 20 year old TIP or CICS transaction can be wrapped as a web service
- Web Services need to be composable
- Can be simple to very complex; free to expensive

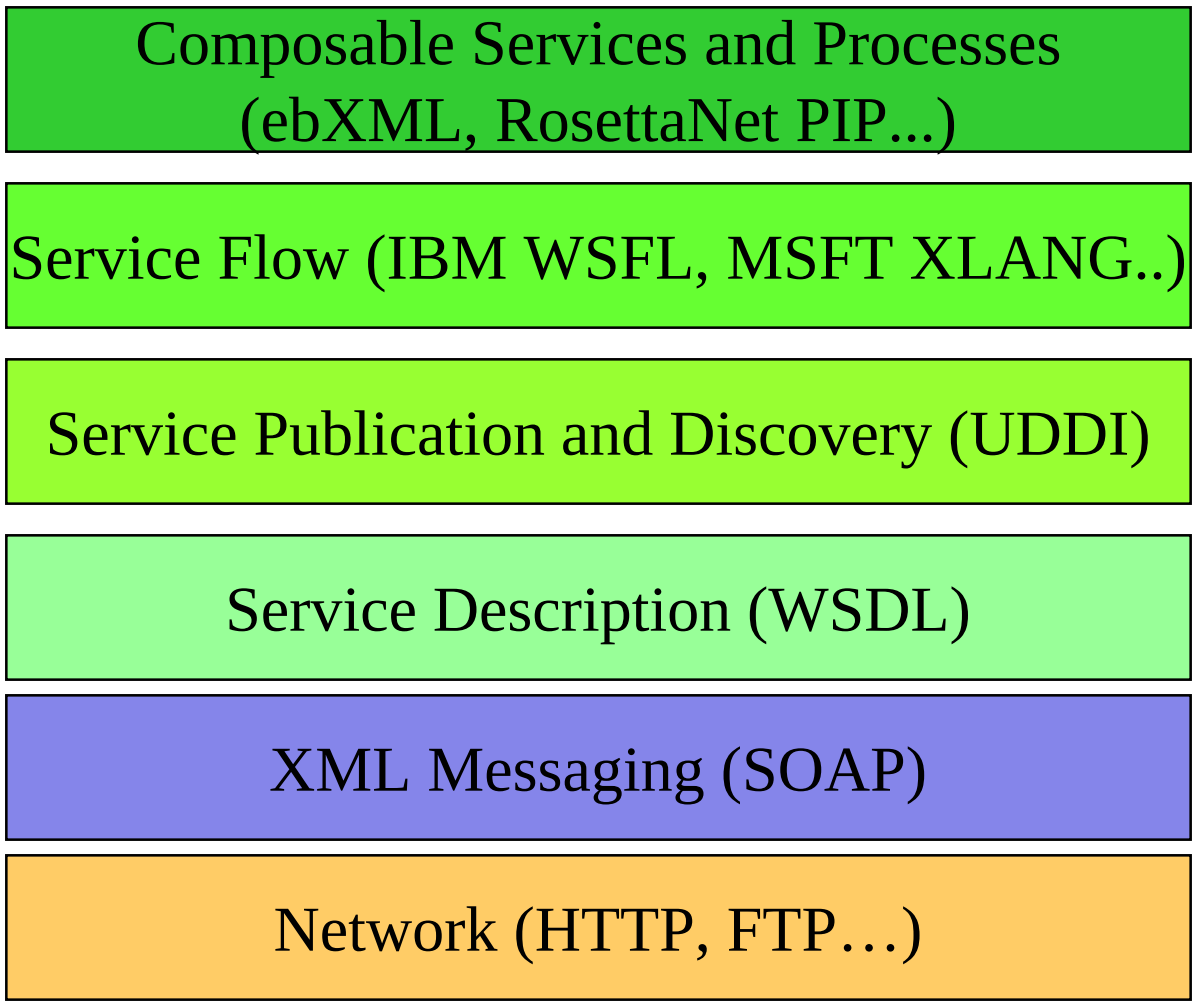
The Web Services Hype

- Microsoft brilliantly got the wagon rolling with the .Net vision
- The early work on SOAP (Simple Object Access Protocol) by Microsoft and Developmentor gradually attracted all the major players
  - IBM jumping on the bandwagon accelerated the momentum
- The UDDI (Universal Description, Discovery and Integration) efforts by Microsoft, IBM and Ariba gave another strong push
- Soon WSDL (Web Services Description Language) joined the party
- SOAP (XML/HTTP), UDDI and WSDL form the core formats and protocols of any Web Services Architecture today
- All major vendors, middleware platforms and architectures have embraced these technologies

Web Services : The basic idea



Web Services : The Stack Evolves



P.S : There are many flavors of this, many stop at UDDI layer

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Web Services : The Stack - 1

- Network
  - TCP/IP, HTTP, FTP, SMTP..
- XML Messaging
  - Messages conform to well defined XML Schemas
  - SOAP is the preferred messaging infrastructure
    - Eventually W3C XP will supplant SOAP
- Service Description
  - These are essentially interface definitions (we called these IDLs before!)
  - WSDL is the interface definition language for web services
  - Implementation information is also captured by WSDL

Web Services : The Stack - 2

- Service Publication and Discovery
  - Publish the service definition and implementation metadata
  - Capture additional business oriented service description information (D&B, Phone, URL…)
  - This metadata is published into a UDDI Registry
    - Registry is searchable
  - Service discovery happens dynamically at run time
    - Similar to CORBA Interface Repository and DII; Java Reflection…
  - Services are bound statically at design/development time
- Service sequencing and flows may extend WSDL

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Web Services : The Stack - 3

- Service Flows
  - Individual services can be steps in a work flow
  - Flows can be graphically modeled
    - Various notations including UML Activity Diagrams have been used
  - Service composition needed for multi party service integration
- This area does not have as much consensus as lower level protocols
- IBM WSFL, MSFT XLANG are among candidate proposals

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Web Services Architecture Summary

- Microsoft, IBM, BEA, BowStreet, HP, SUN are providing web services integration into their tool sets
- Microsoft has focused on the integration and ease of use/deployment the longest with its .Net initiative
- J2EE is rapidly embracing and extending Web Service formats and protocols
  - JAXR (Java API for XML Registries is an example)
  - IBM, BEA, SUN etc have integrated SOAP/WSDL/UDDI into their J2EE application servers
- Methodologies, modeling tools and middleware that support the web services life cycle are immature
- Back to the Integration Problem!

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Solving the Integration Problem What is needed?

- Short Answer is XML and HTTP!
- Slightly longer answer is SOAP, WSDL, UDDI
- Even longer answer is SOAP, WSDL, UDDI, WSFL, ebXML, XAML, ACML…
- The real answer is
  - We need to think and build software like engineers
  - All these acronyms are great, but where is the process, methodology and architecture!
  - We need to integrate the systems we have with the newer technologies
  - etc.

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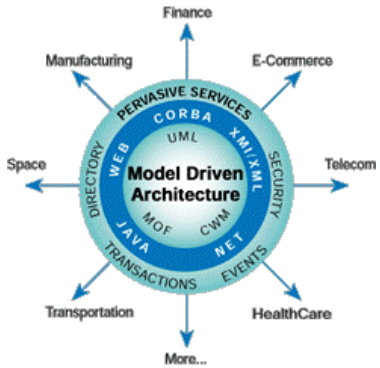

An Overview of OMG Model Driven Architecture

A vision that uses and integrates the 4M's - Models, Metadata, Mapping and Middleware of software.

MDA allows developers and users to productively design, build, integrate and manage applications throughout the lifecycle irrespective of hardware or middleware platform

Solving the Integration Problem What is needed?

- Methodology for building, evolving and integrating software across the life cycle
- A mechanism for cataloging and indexing and searching enterprise assets (metadata and data, internal and external)
- A flexible service based distributed component architecture that spans the enterprise
- A set of shared standard vocabularies (information models) and notation (meaning and context of data usage)
- A metadata driven approach to automate integration between islands of information
- A set of open modeling, metadata and distributed computing standards

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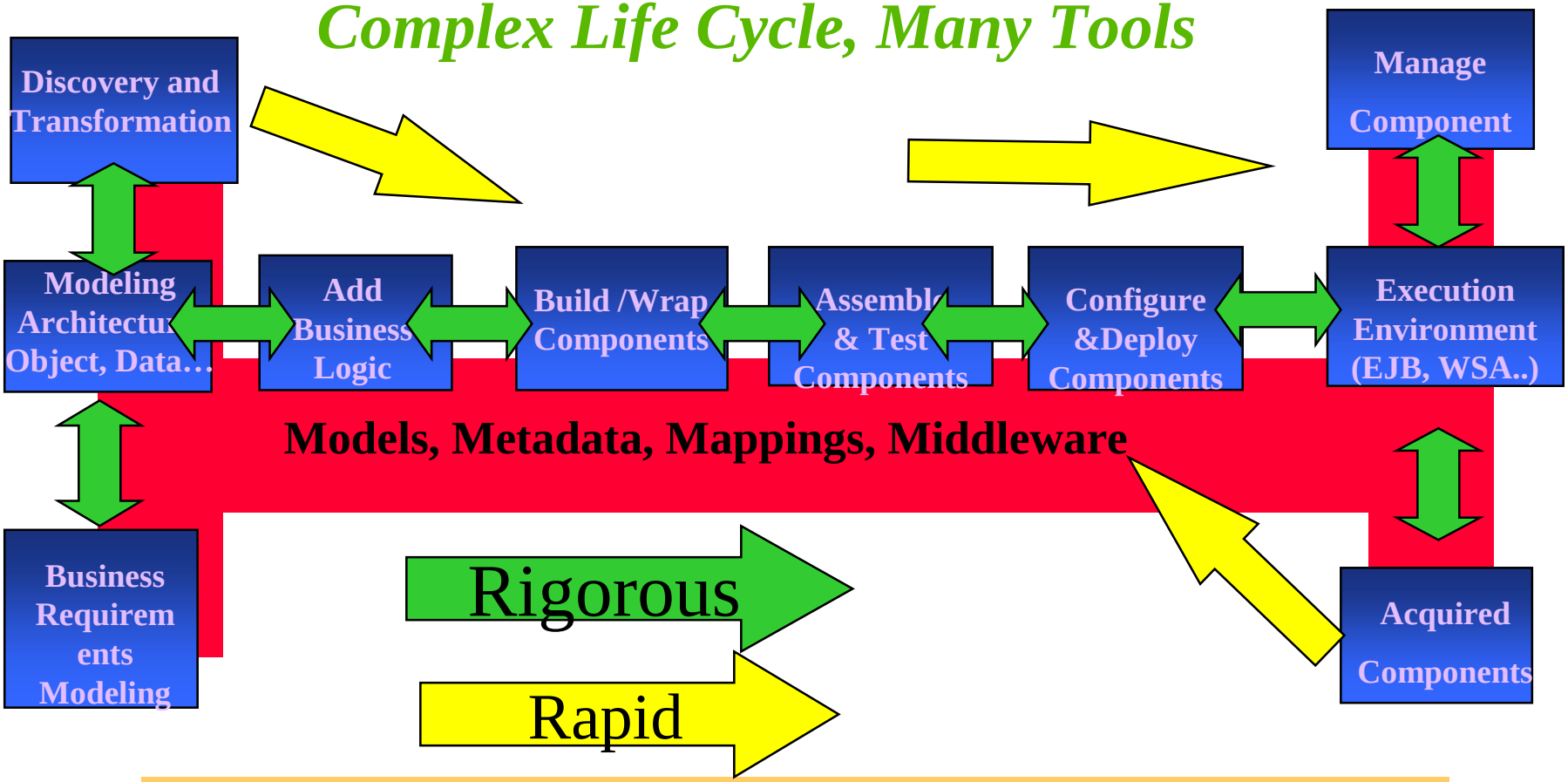
The Enterprise Application Life Cycle

Architecture Centric, Business driven, Complex Life Cycle, Many Tools



And do this with quality in a distributed environment

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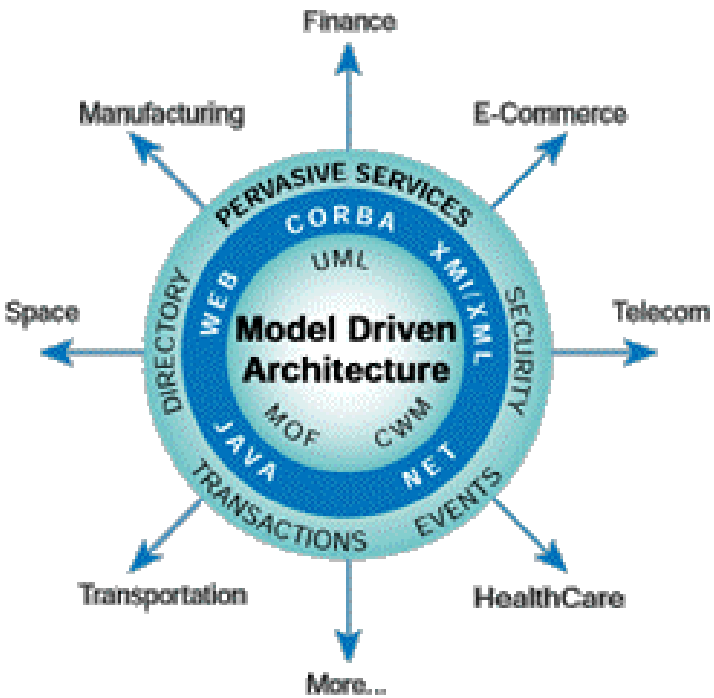
Solution for Managing Complexity : MDA: Model Driven Architecture



- An eclectic integration of best practices in Modeling , Middleware, Metadata, Internet and Software Architecture
- Model Driven (UML, MOF, CWM…)
  - Platform Independent Models (PIM)
  - Platform Specific Models (PSM)
  - Mappings : PIM <==> PSM
  - Applies across the software life cycle
- Key Benefits
  - Improved Productivity for Architects, Designers, Developers and Administrators
  - Lower cost of Application Development and Management
  - Enhanced Portability and Interoperability
  - Business Models and Technologies evolve at own pace on platform(s) of choice

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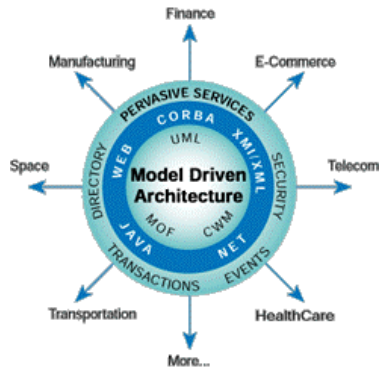
Mapping Platform Independent Models to Specific Platforms

PIM
Software
Infrastructure



UML

UML4EJB

PSM
J2EE

.Net

J2EE

PIM to PSM
Transformation
Model

UML

UML.Net

PIM
HealthCare Business
Application (CIAS)

PSM
.Net

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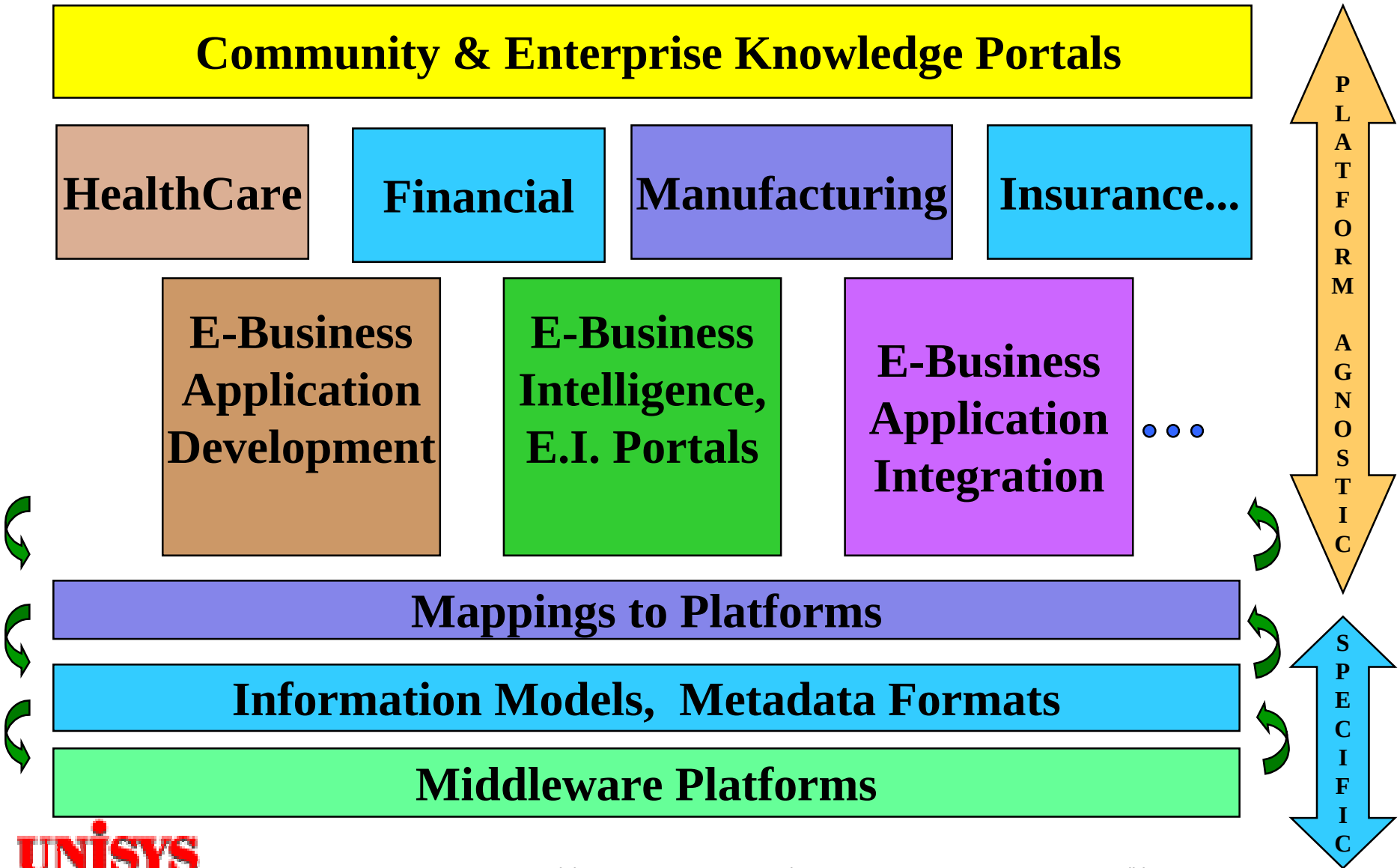
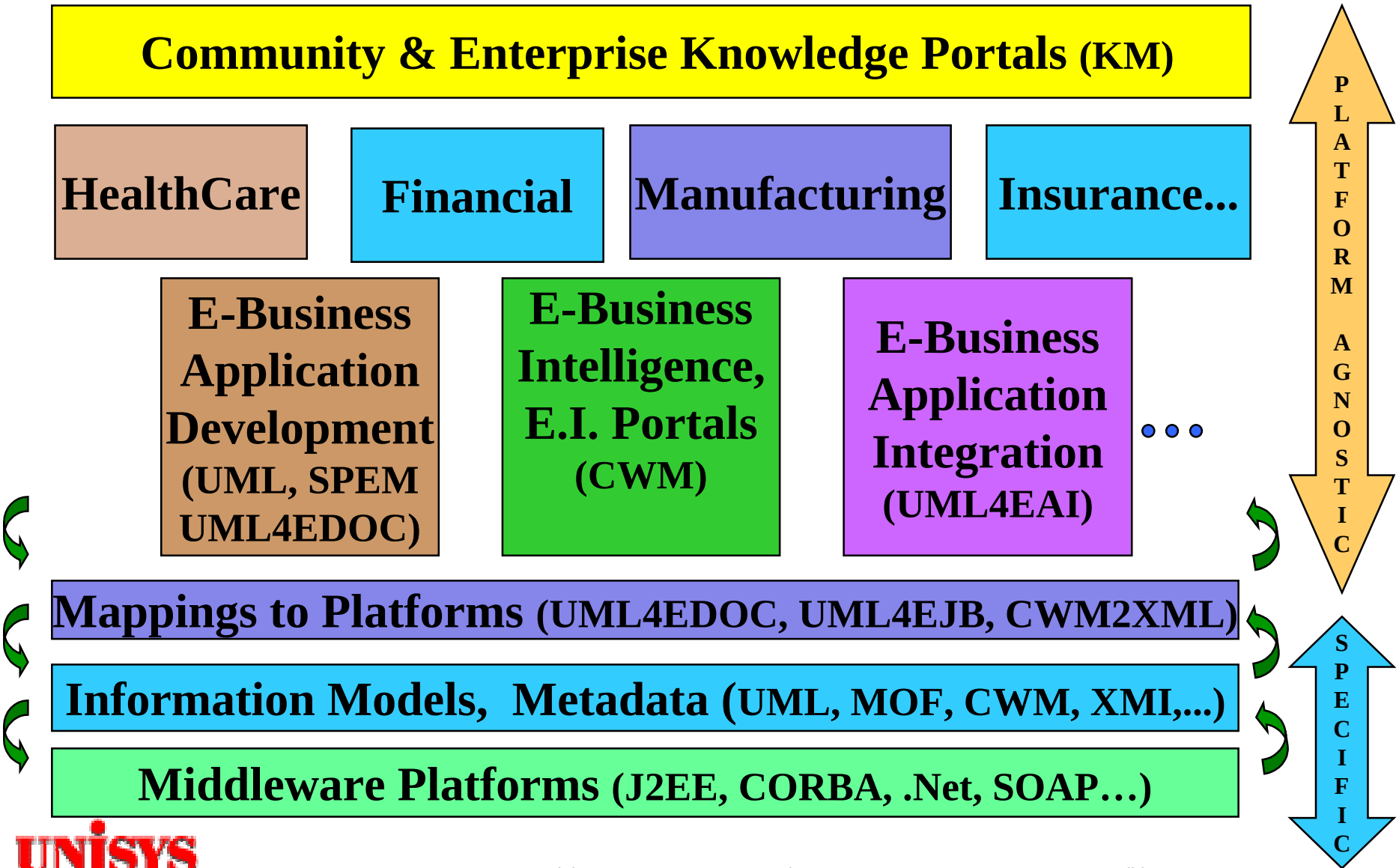
OMG MDA - Details



OMG MDA - Specific Models



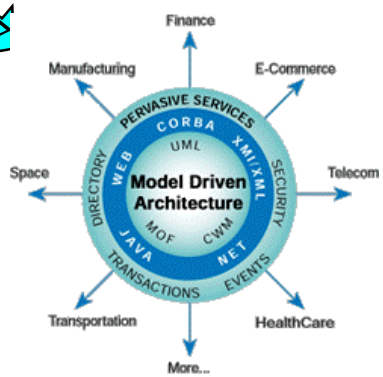
OMG Model Driven Architecture
MDA for Enterprise Integration

UML
Model & Design (PIM)

1997

2001

EDOC
UML4EDOC*(PSM)
UML4EAI*(PSM)



Integration for

- Vertical Industry Applications
- Business Components
- Model Driven App Integration
- Model Driven App Development
- MetaData Management
- Business Process Integration

2000

2001

CORBA
UML4CORBA(PSM)

EJB
UML4EJB* (PSM)

PIM : Platform Independent Model
PSM : Platform Specific Model

*Coming

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Early examples of MDA

- OMG has been using MDA principles for about 3 years in several specifications
- Metadata and Object Interchange/Integration
  - UML and MOF for modeling, MOF and XMI for metadata integration
  - MOF is a subset of UML (Class diagrams) used to model metadata
- Application Development
  - UML for modeling, XMI and IDL for tool integration and interchange
  - UML profile CORBA : UML for modeling, IDL for Integration
- Data Warehousing
  - UML and CWM for Modeling, XMI and IDL for Warehouse integration
- Application Integration
  - UML profile for Enterprise Application Integration (UML4EAI), Distributed Object Computing (EDOC)

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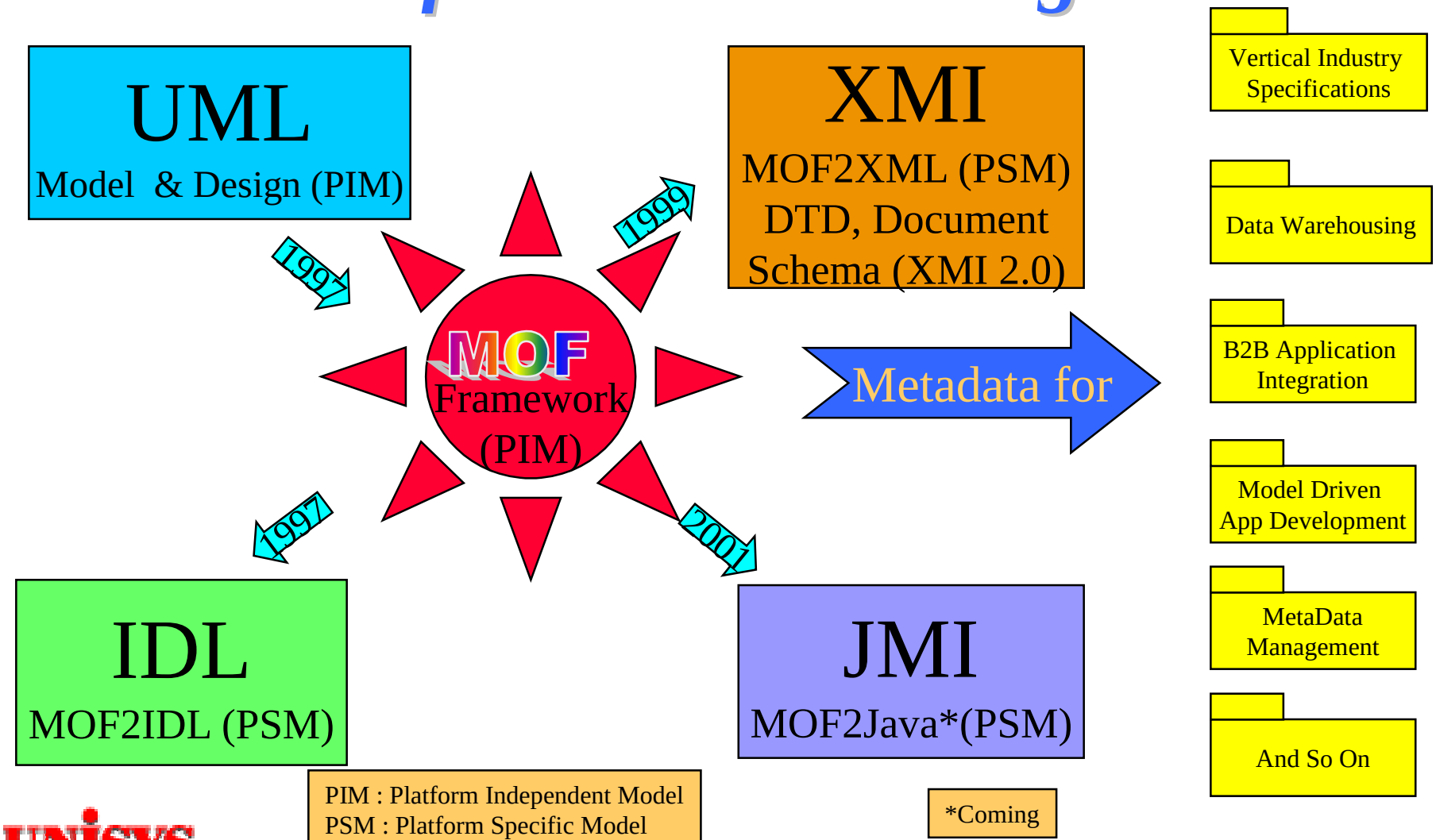
OMG Model Driven Architecture
MDA for Metadata Integration



UML Quick Tour

- The UML is a graphical language for
  - specifying
  - visualizing
  - constructing
  - documenting

  the artifacts of software systems
- Added to the list of OMG adopted technologies in November 1997 as UML 1.1
- Latest revision is UML 1.4
  - UML 1.5 Revision in progress
  - UML 2.0 major enhancement in progress

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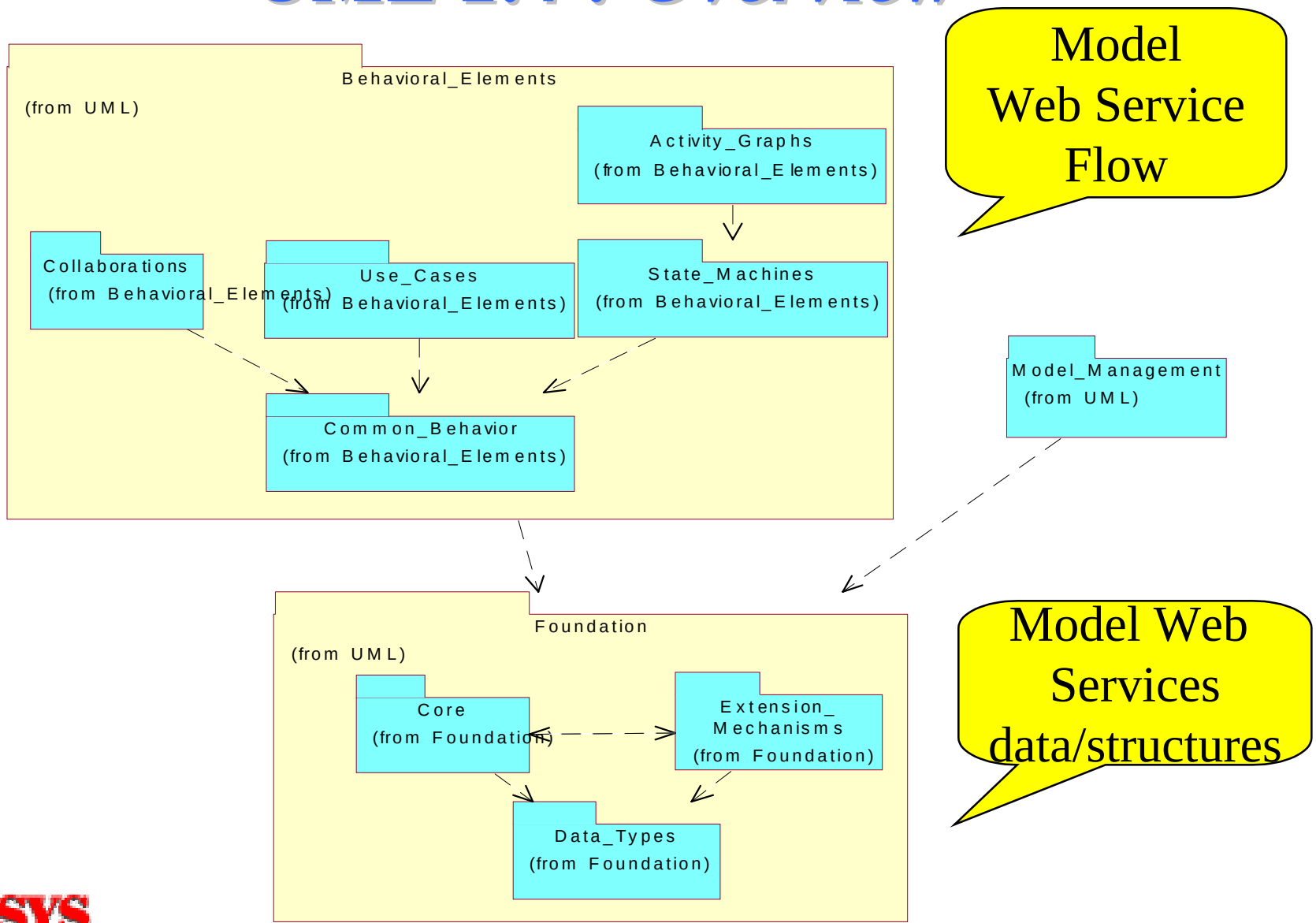
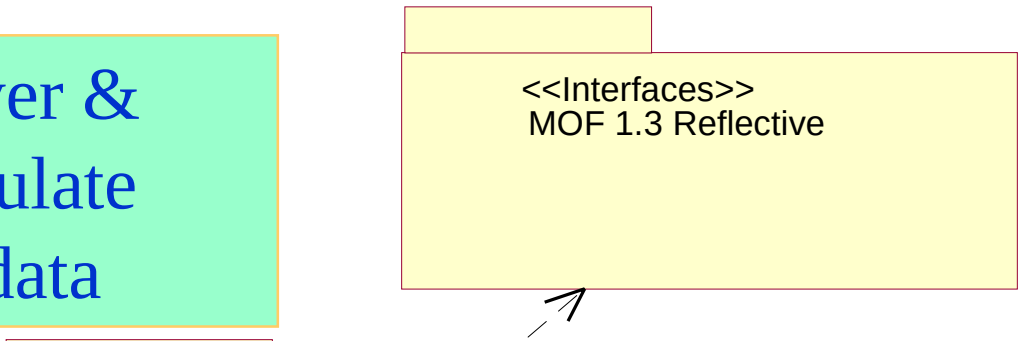
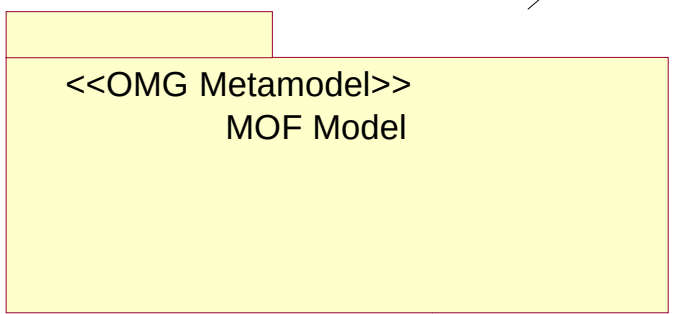
UML 1.4 : Overview



Meta Object Facility (MOF) Overview

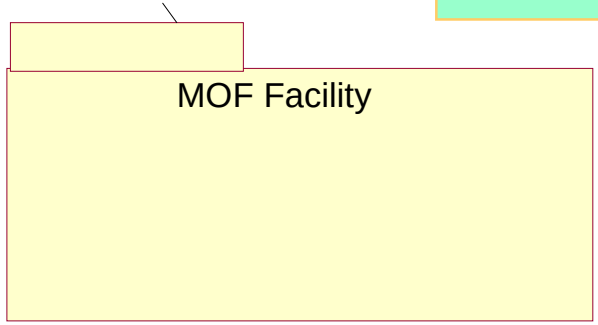
Discover & Manipulate metadata



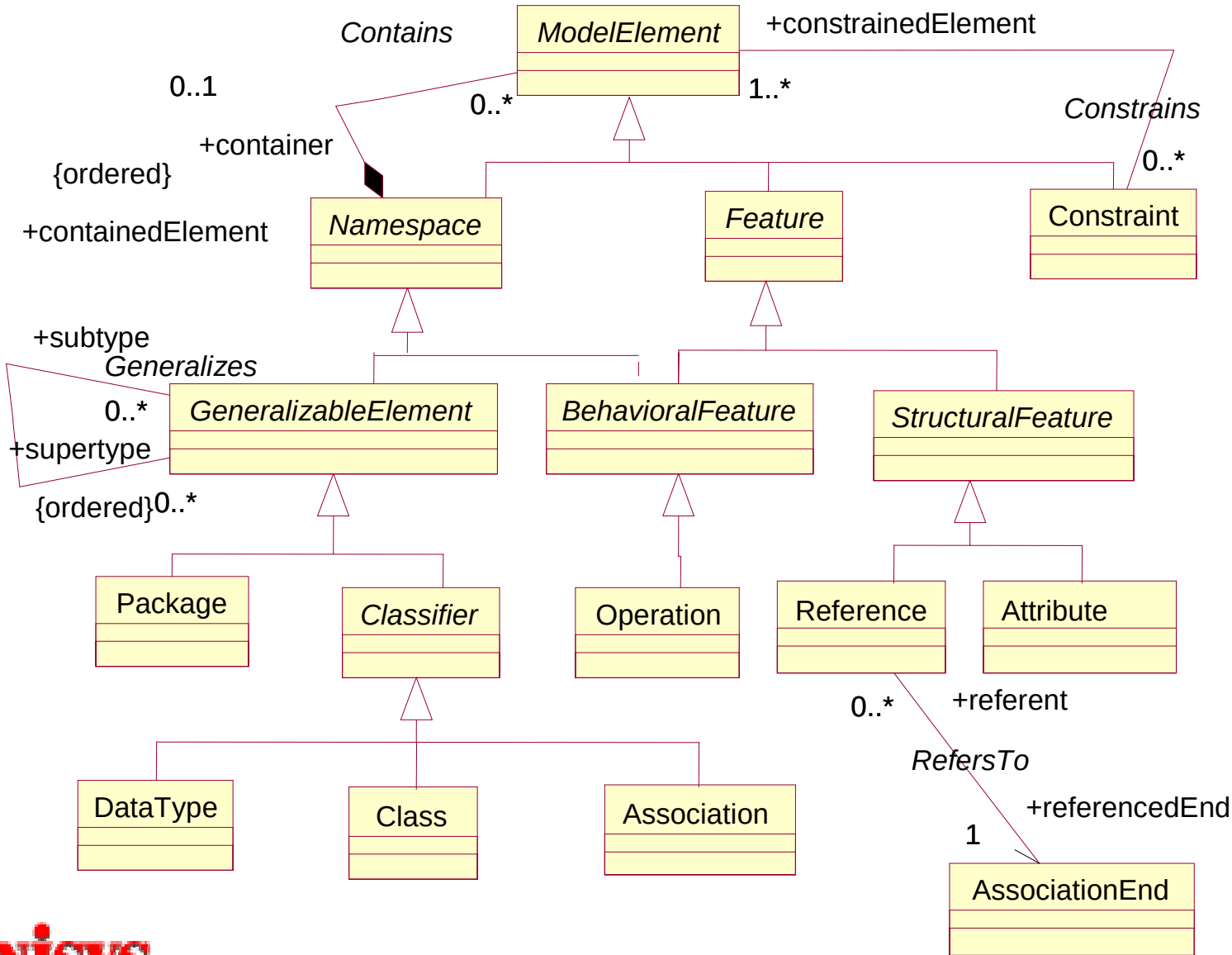


Model using UML Class Diagrams precisely

Find and Manage Metadata Repositories

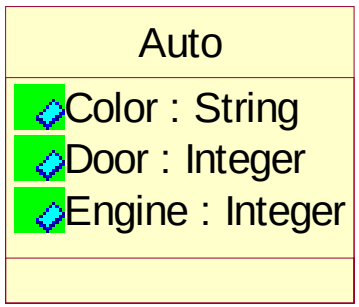


OMG MOF Model (UML Subset)



Mapping from PIM to PSM - Simple Example using MOF/XMI

UML Model (PIM)



XMI

<Auto>
<Color> Red </Color>
<Door> 4 </Door>
<Engine> 2 </Engine>
</Auto>

XMI Document (PSM)

MOF

IDL, Java… (PSM)

```
interface  Auto
{
};
Class Auto
    {public String  color;
     public int Door;
     public int Engine;
    }
```

XMI

XMI DTD, Schema (PSM)

```
<!Element Auto
   (Color*,
    Door*,
    Engine*)>
```

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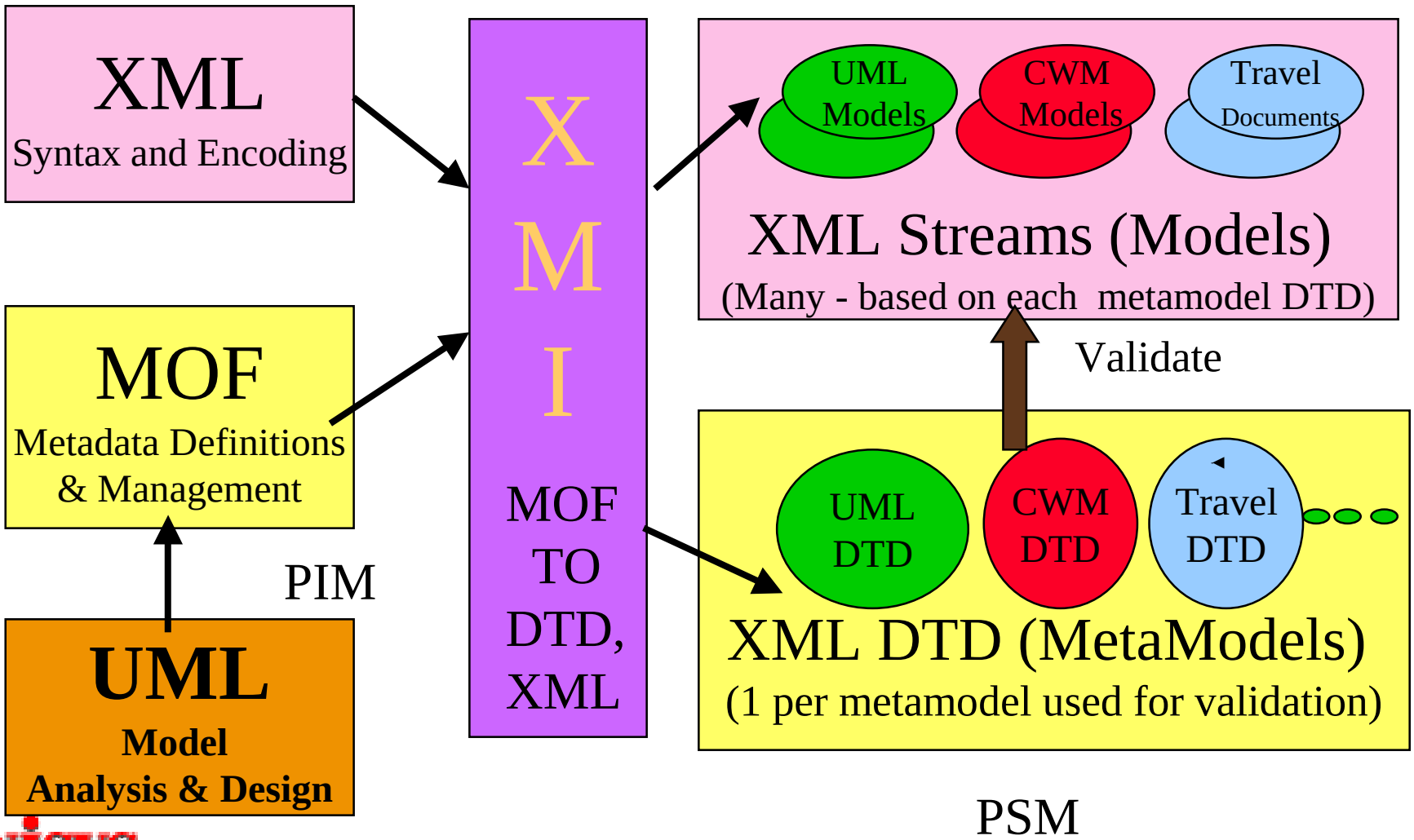
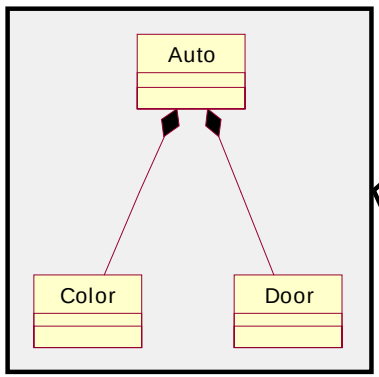
Transform UML models to DTD

XMI 1.1 or XMI 1.2



Design-driven XMI for a car

Objects and Designs



Model in XMI

```
<Class>
  <Name>Auto</Name>
</Class>
```

Model Interchange

XMI DTD, Schema

```
<element name="Auto" />
<!ELEMENT Auto (Color*, Door*)>
```

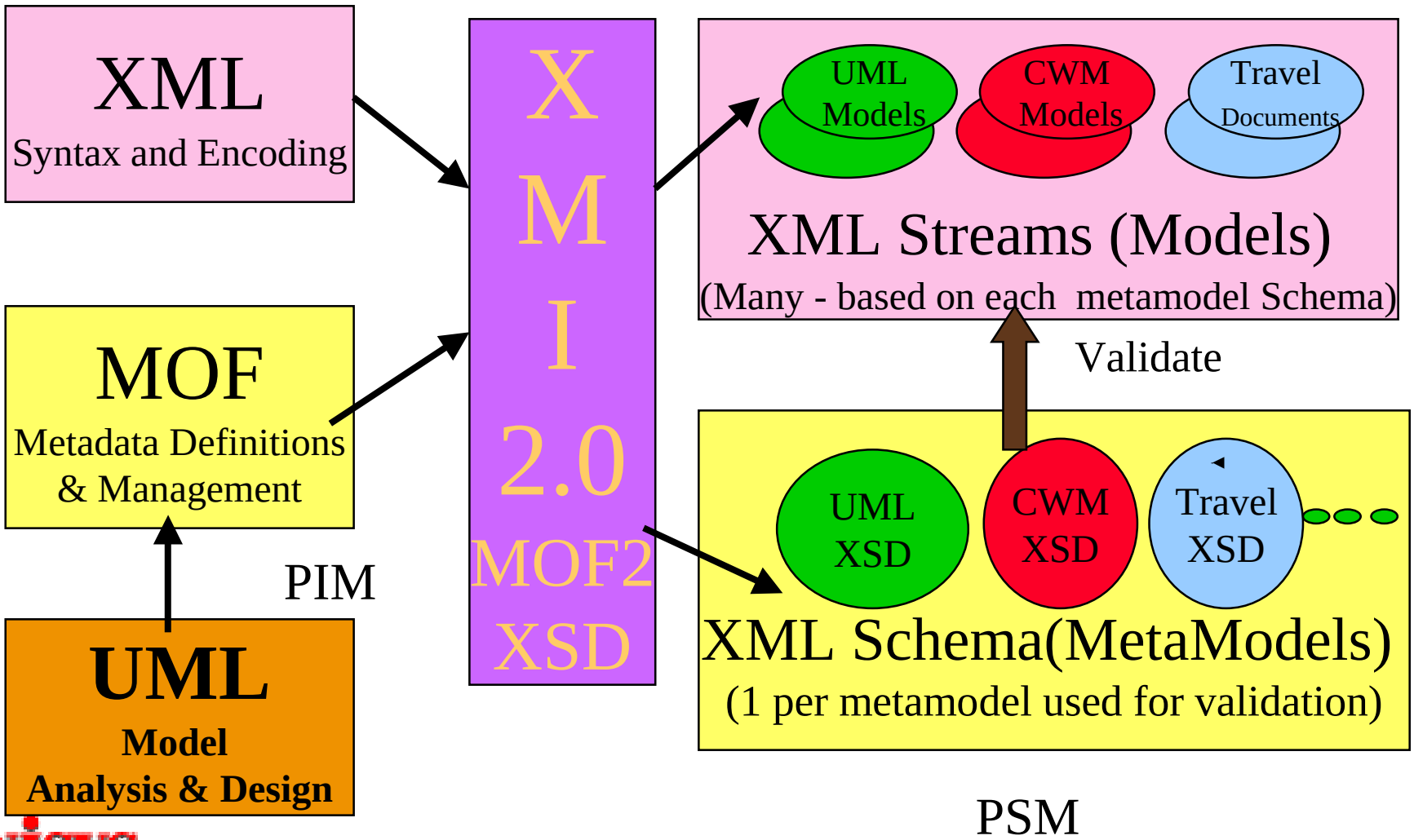
XMI Document

```
<Auto>
  <Color>red</Color>
  <Door>2</Door>
</Auto>
```

Instance Interchange

Transform UML Models to Schemas

XMI 2.0 OMG Document : ad/01-06-12,13



XMI Production of XML Schemas : Adoption Vote

- Bi-directional mappings from UML/MOF to XML Documents and XML Schema
- Formal metamodels for XML Schema and XML
- Reverse engineering of XML DTDs to assist transformation to schemas and UML
- Integrate the Analysis and Design of XML applications to be better integrated with the web services platform
- Accelerates tool integration and new methods for modeling web services

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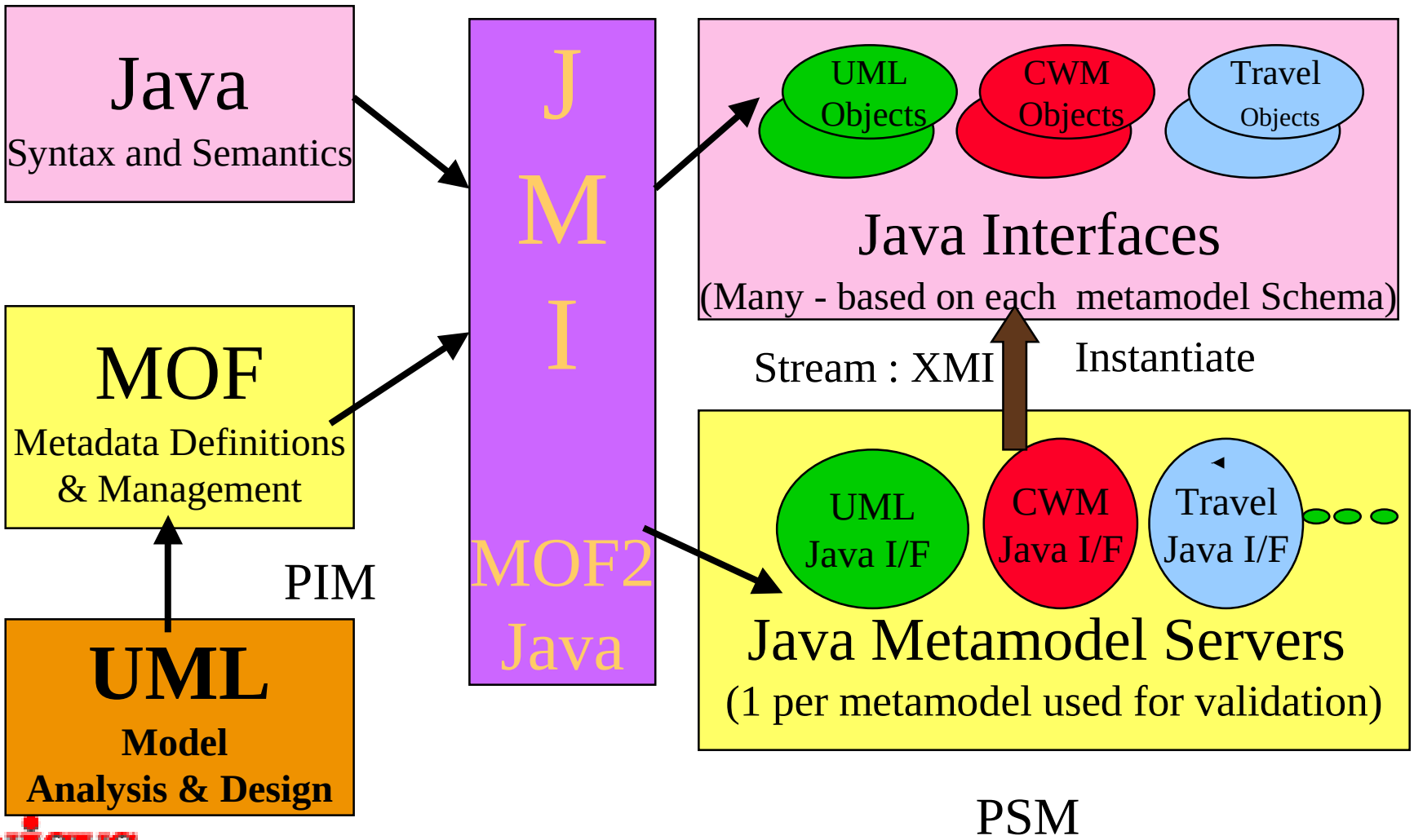
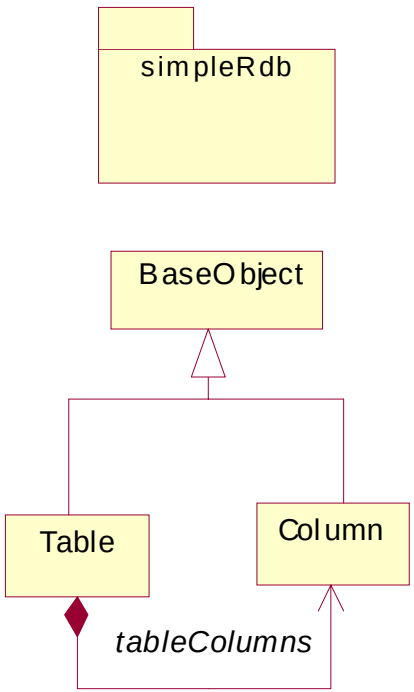
Transform UML/MOF to Java

JSR-40 : Java Metadata Interface (JMI)



JMI Mapping Example
BaseObjectClass.java




```
package jmi.eg.simpleRdb;
public interface BaseObjectClass
   extends javax.jmi.reflect.RefClass {
public BaseObject createBaseObject()
   throws
   javax.jmi.reflect.JmiException;
public Table createTable(
   java.lang.String name ) throws
   javax.jmi.reflect.JmiException;
public column createColumn(
   java.lang.String name ) throws
   javax.jmi.reflect.JmiException;
}
```

Quick Lessons Learned

- Platforms and protocols come and go
  - Some become ubiquitous over time; most don't
- Just in the pace of 2 years DTD mania has become XML Schema mania! { YML and ZML are next!)
- We used MDA to map UML/MOF to IDL and XML DTDs
- We used MDA to map UML/MOF to XML Schema
- We used MDA to map UML/MOF to EJB/Java respectively
- We even reverse mapped XML DTD and Documents to UML
- So design your models in UML and transform to DTD, XML Schema, Java, C#, IDL.. Etc.
- Use well defined, standard design patterns to save time

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OMG MDA Technologies

Submissions

EJB

Java

SPE

UML Profile for EDOC...

Evaluating

UML

MOF

CORBA Med

Manufacturing

Life Sciences

EC
EAI
CCM
CWM
UML

CWM

EC
EAI
CCM
CWM
UML

Electronic Commerce

CIAS

Enterprise App Integration

Document Management

Etc.

Standards

MOF

UML

CCM

IDL
UML4CORBA

CWM

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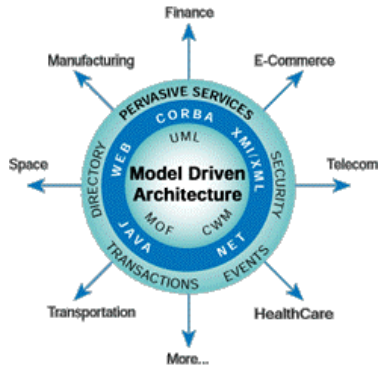

Integrating MDA and Web Services Architecture

We finally apply the MDA principles - Modeling the Web Services Architecture (and its components) so we can formally define web service models with rich semantics (remember the ‘semantic web’) so we can manage the full application life cycle

How to apply MDA principles to Web Services

- Of course we start by modeling the various parts of the web services architecture
- The key components of the architecture to model are
  - XML itself
  - UDDI
  - WSDL
  - Transformations from UML/MOF to these technologies
- These models of models are called ‘Metamodels’ in OMG parlance
- Having these metamodels and transformation models assists semantic integration of applications and data

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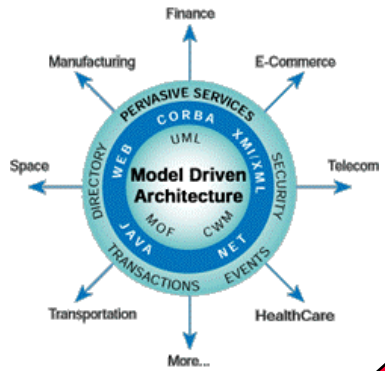
Mapping Platform Independent Models to Specific Platforms

PIM
Service Registry
Model



PSM
OMA - IR

UML

UML4CORBA

OMA

WSA

PIM to PSM
Transformation
Model

PSM
WSA - WSDL

UML4WSDL

UML

UML4UDDI

PIM
Service Definition
Model

PSM
WSA - UDDI

WSA: Web Services Architecture
OMA: Object Management Architecture
IR: Interface Repository

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Metamodels of XML and XML Schema itself

- XML and XML Schema Model
  - Defined in the OMG XML Production for XML Schemas proposal
  - OMG Document # : ad/01-06-12,13
  - A complete MOF model using UML notation of XML and XML Schema is available
  - Forward and reverse mappings from UML/MOF to XML and XML Schema have been specified
- Goal is to over time unify multiple schema models such as XML Schema, XMI, RDF etc using MOF
- See also UML profile for XML at xmlmodeling.com

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Fragment of XML Schema Model

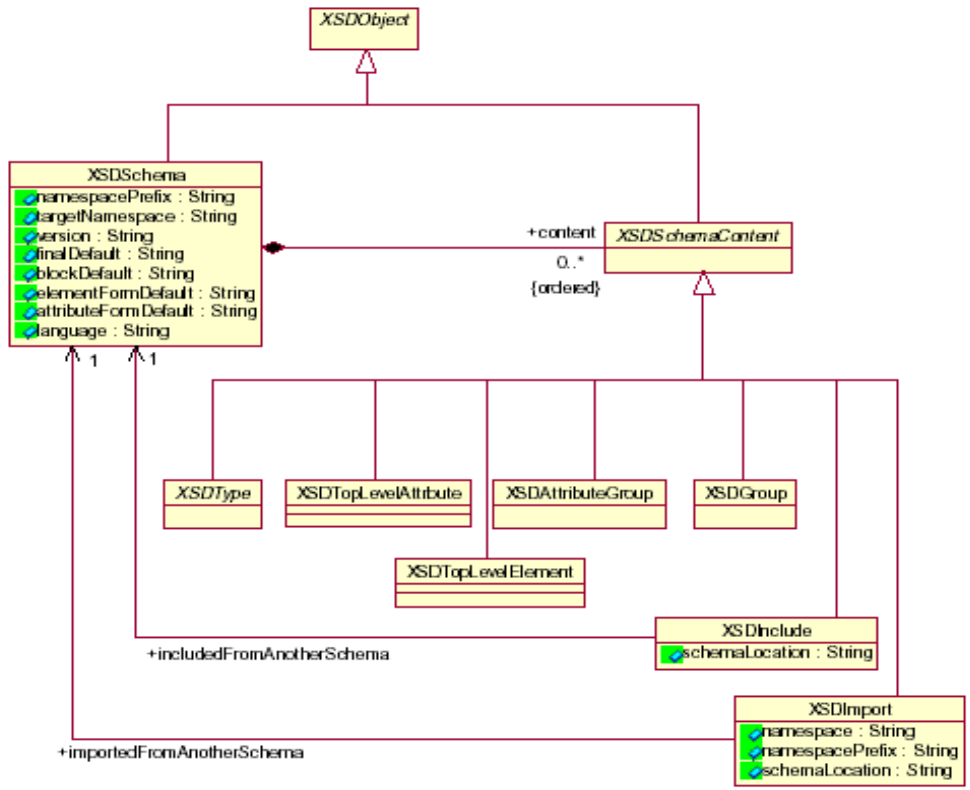


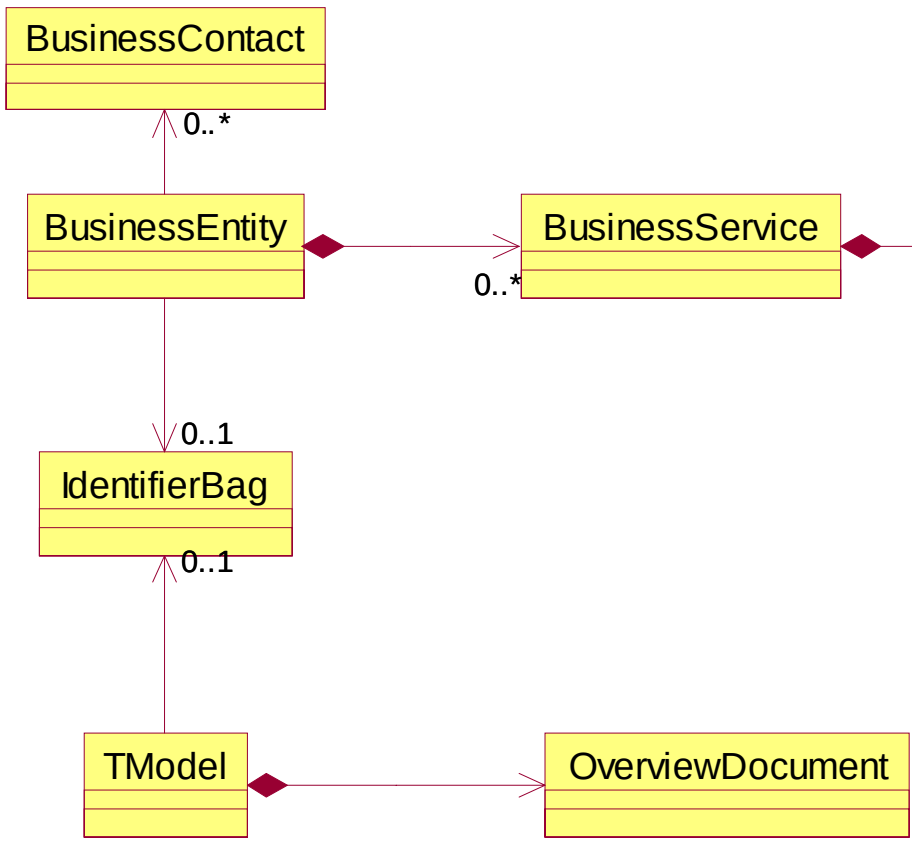
Figure 8-1 XML Schema top level declarations

The top level XML SChema declarations consist of the desciption of the schema itself (namespace prefix, tagert namespace, etc.) and the delcarations within the schema. These declarations include global scope Attributes, global scope Elements, attribute

Metamodel of UDDI

- Formally defining a metamodel for UDDI will make it more easy to integrate the structure and semantics of other directories and registries
- An alternative approach is to define a generic interface (JAXR - Java API for XML Registries) - but this is not likely to capture the richer semantics in models
- Models of UDDI are being developed at IBM, Unisys and Microsoft (among other vendors)

Metamodel of UDDI - Subset



This is only a subset of the UDDI metamodel. A complete model will be in an upcoming OMG Proposal.

See xmlmodeling.com for a

Metamodel of WSDL

- Formally defining a metamodel for WSDL will make it more easy to integrate the structure and semantics of other interface definition languages (IDL, Java…)
- A formal model (MOF metamodel) of WSDL is being defined by IBM and Unisys for an OMG submission
  - The CWM Web Services RFP - so that it becomes easier to integrate analytical web services with the rest of the database/data warehouse integration infrastrcucture
- This model can be integrated with additional metamodels of Java and IDL that have already proposed in OMG specifications

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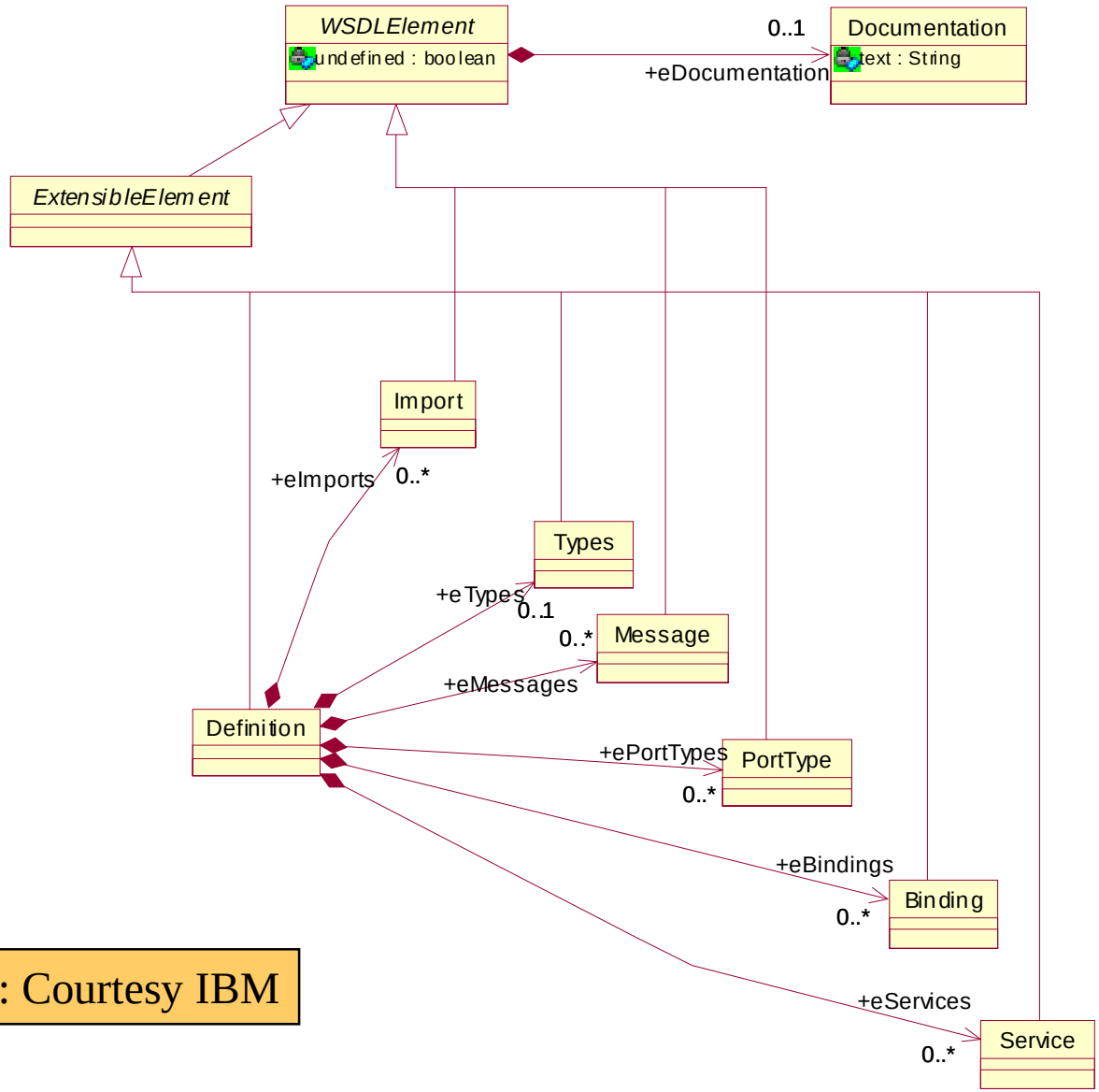
WSDL Metamodel Fragment



Metamodel : Courtesy IBM

How do we use these metamodels of WSDL, UDDI and XML!

- With in the OMG suite of metamodels, UML is the most well known and used to integrate application development and deployment tools
- CWM - Common Warehouse Metamodel is more recent, but is a landmark model that addresses the integration requirement of various types of databases (network, relational, XML, multidimensional etc,)
- The OMG is now in the process of integrating these suite of metamodels and the information they represent into the world of web services.
- A quick peek at CWM will show us the way!

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OMG Common Warehouse Metamodel (CWM)

- Scope
  - Data Warehouse lifecycle metadata interchange and management
- Initial submission : IBM, Unisys, NCR, Hyperion, Oracle, Genesis, UBS, Dimension EDI...
  - Metamodel - Single logical & physical!
  - Generated XML DTDs
  - Generated MOF - IDL mappings
  - Generated XML document
- Approved by OMG Board in June 2000
- CWM 1.1 Revision is being now worked on

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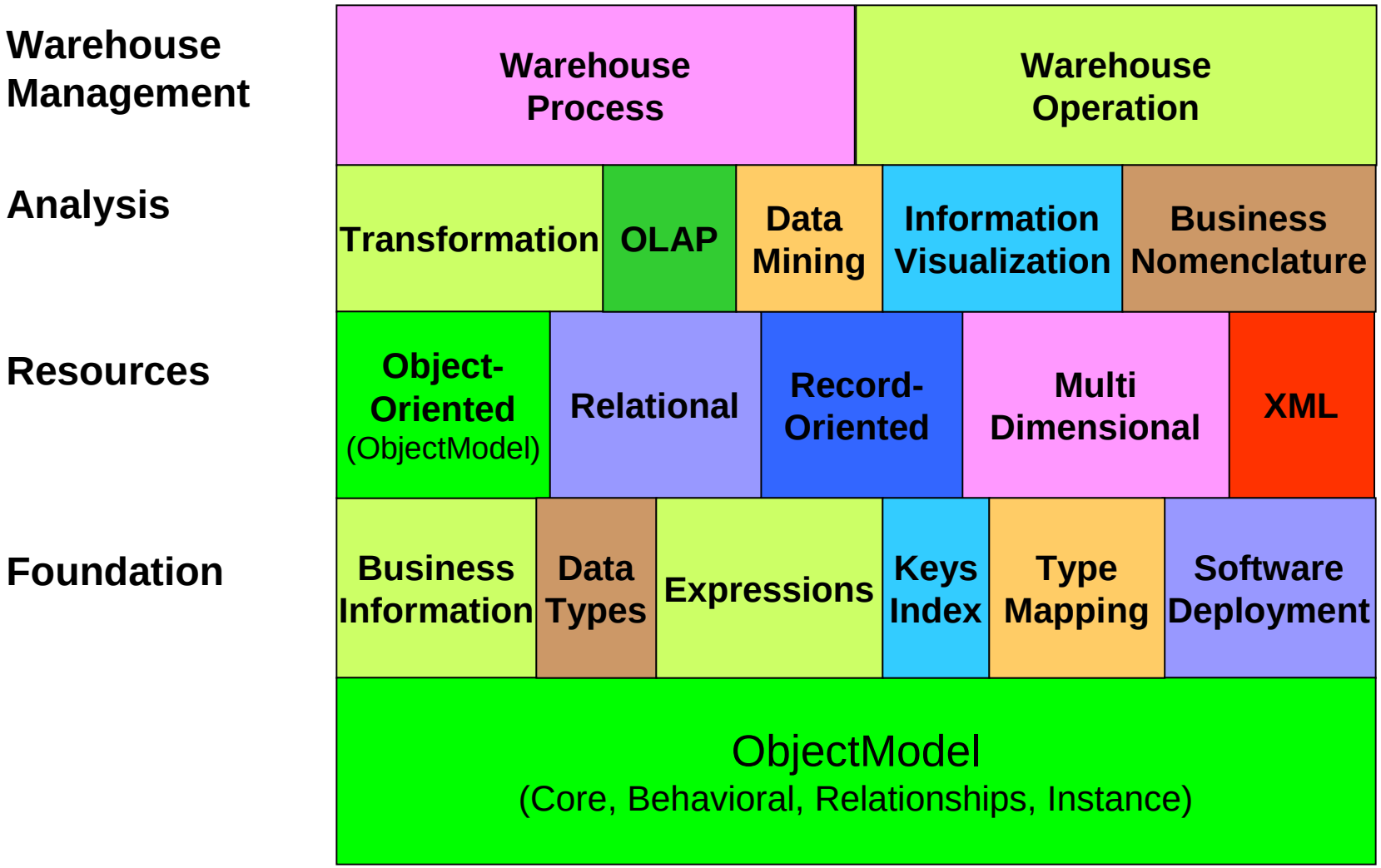
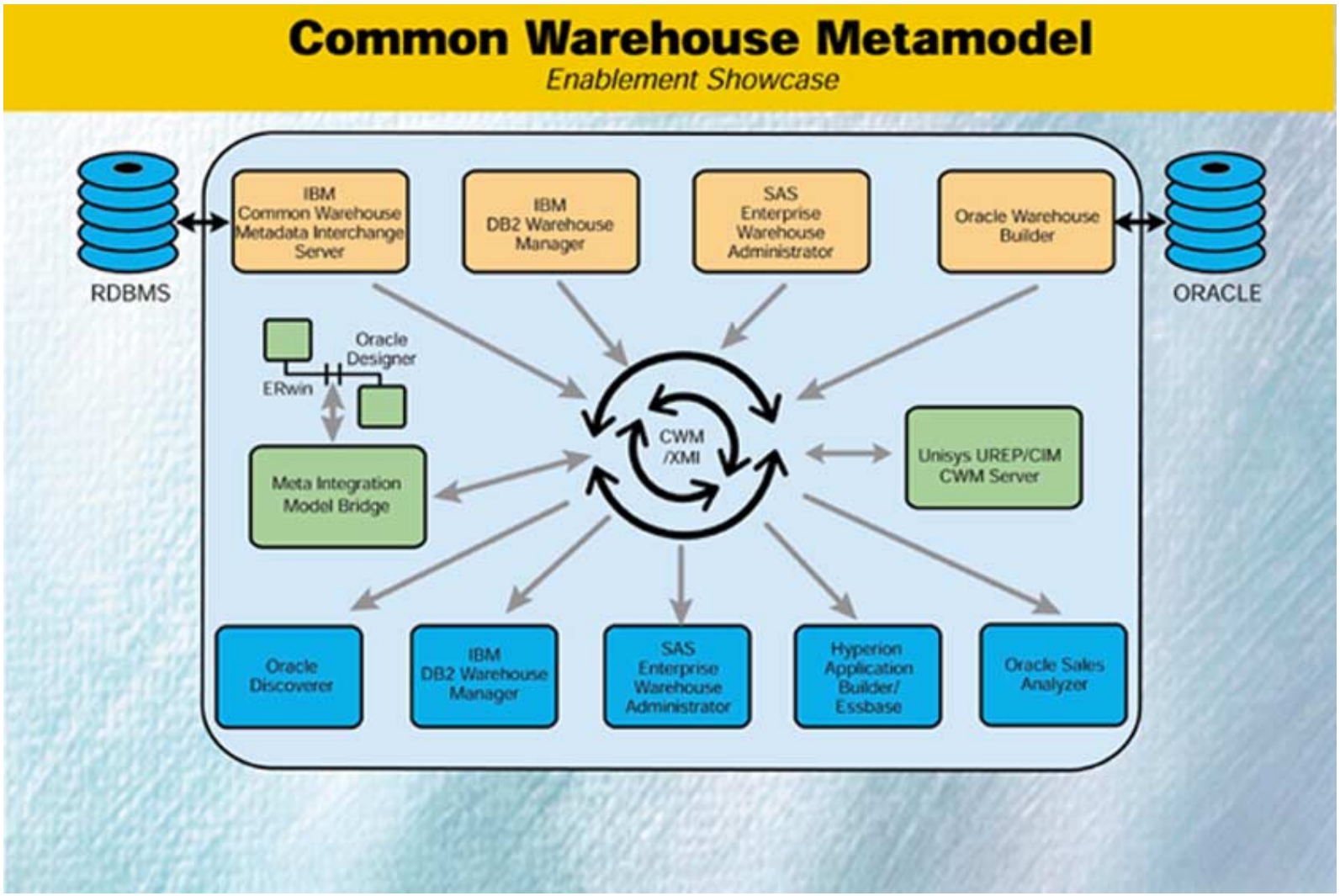
CWM 1.0 Overview {02/2001}
Common Warehouse Metamodel



MDA for Data Warehouse Integration using CWM



What next for CWM : CWM Web Services

- CWM is now being used by IBM, Oracle, Unisys, Hyperion and many others for integrating enterprise data, metadata and content
- However this interchange even though it uses XML (CWM is XMI compliant and uses XML for its interchange) has the following problems
  - The interchange patterns are too fine grained
  - The interchange patterns need to be formalized between the integration partners
  - The interchange protocol does not support web services
- To address these needs OMG is standarding ‘CWM for Web Services’

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CWM Web Services RFP

- Requires Integration of
  - CWM Metamodel
  - XMI - The XML DTDs and Schemas that conform to CWM
  - WSDL
  - SOAP
  - UDDI
- A key principle of OMG MDA is define formal models (platform independent and platform specific) of these technologies and their transformations
- The suite of metamodels and transformations being proposed will integrate MDA and Web Services

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CWM Web Services RFP - A Potential Solution

- The specific interchange patterns model will be specified using UML and MOF and this metadata interchanged using XMI
- Mappings from UML/MOF to WSDL and UDDI will make it possible to
  - Design web services applications and components using UML
  - Manage all related metadata using MOF/XMI and XML
  - Automatically publish the interfaces/service definitions in CORBA IR, UDDI registry and JNDI/LDAP servers!
  - Maintain traceability across the life cycle (try this today!)

Please note that the final adopted proposal may be different - Too early to tell!

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MDA meets Web Services bringing some order to the web services Chaos!

PIM
Service Registry
Model

UML

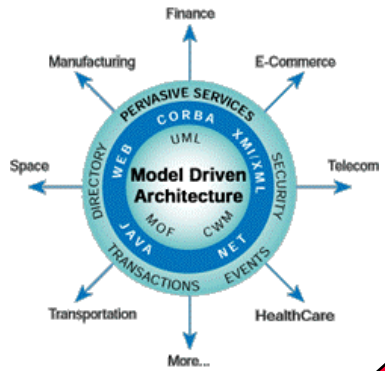
UML

UML 1.4
App Design

UML

UML

PIM
Service Definition
Model



OMA

WSA

PIM to PSM
Transformation
Model

UML4CORBA

UML4WSDL

UML4UDDI

PSM
OMA - IR

PSM
WSA - WSDL

PSM
WSA - UDDI

WSA: Web Services Architecture
OMA: Object Management Architecture
IR: Interface Repository

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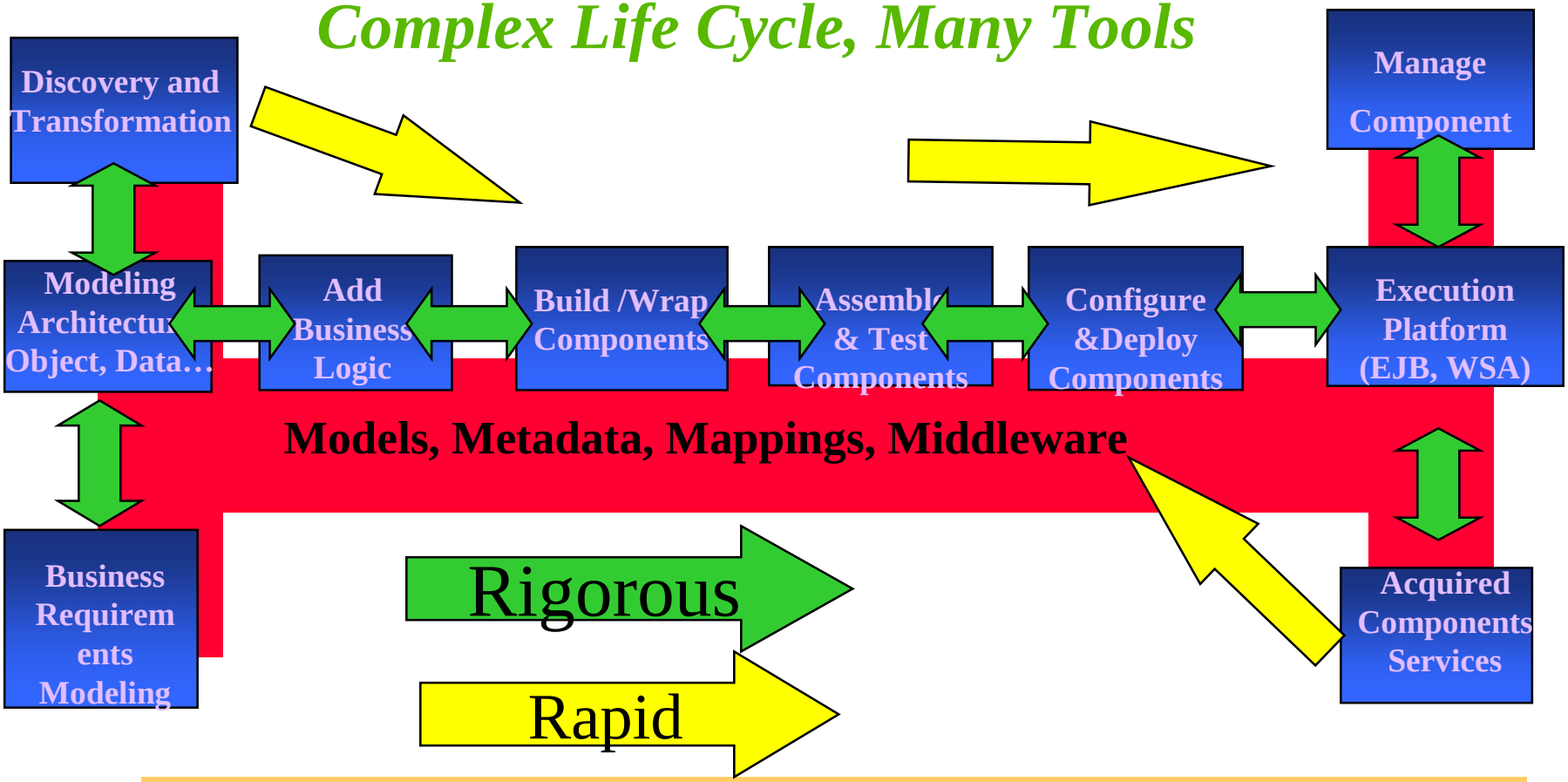
The Enterprise Application Life Cycle

Architecture Centric, Business driven, Complex Life Cycle, Many Tools



Needs to work for Web Services too - MDA Enables this!

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Who is Implementing key MDA standards ?

- IBM VisualAge for Java, WebSphere, Rose tool kit
- IBM VisualWarehouse, Hyperion, Oracle, SAS
- Rational Software (Unisys XMI for Rose); SUN Forte
- Microsoft VisualStudio.Net
- DSTC, OMEX, Hyperion
- Oracle Designer, Meta Integration, Together/J, Objecteering, ObjectsByDesign, Unisys, Aonix, Webgain
- OMG standard metamodels and DTDs (MOF, UML, CCM, CWM*, Java*, EJB*…)
- Metadata Coalition voted overwhelmingly to build on OMG specifications for metadata (September 2000)
- Java Community Process JSR-40 : Java Metadata Interface*
- Java Community Process JSR-69 : Java for OLAP*

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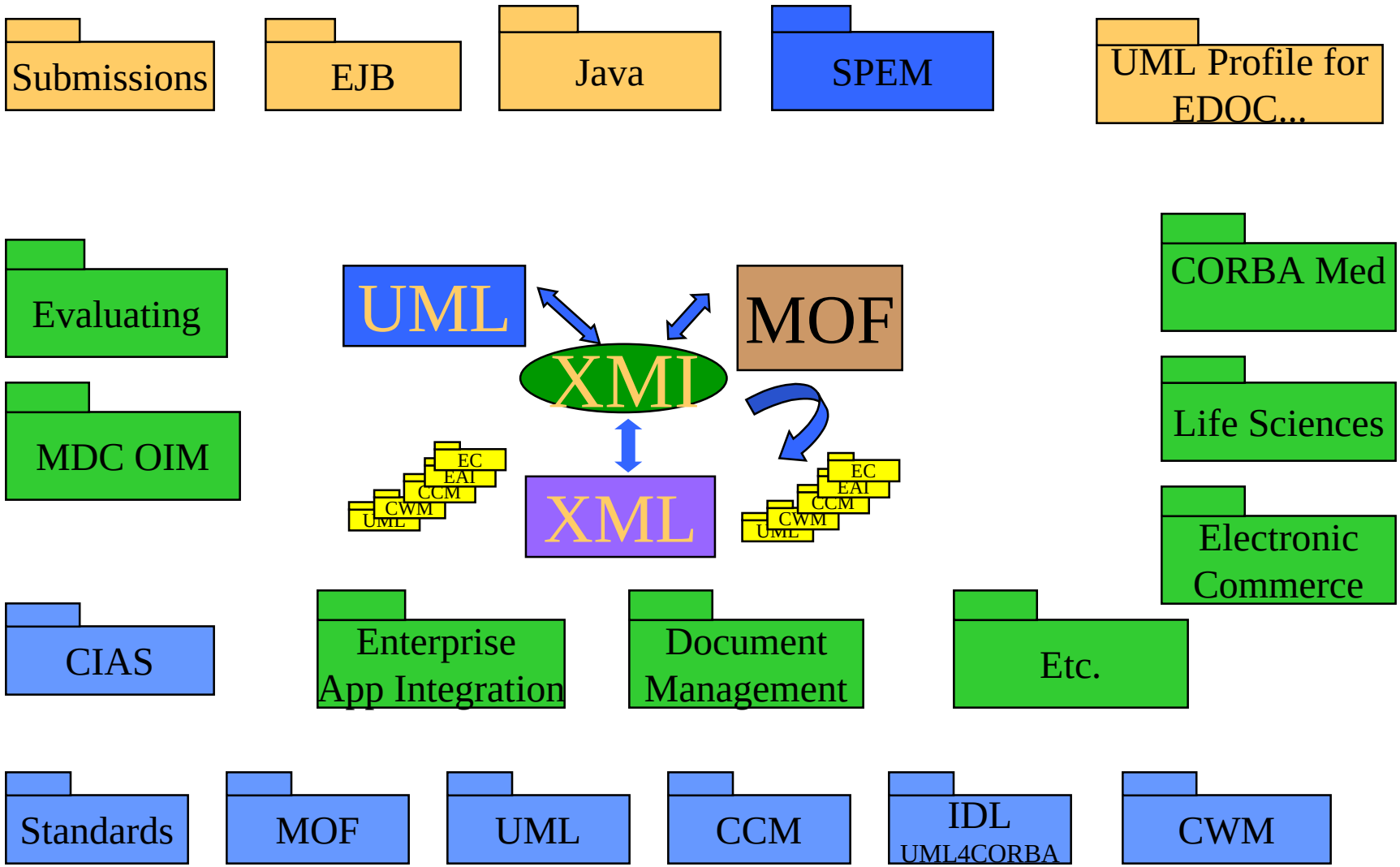
* In progress

OMG UML/XMI/MOF Usage



Concluding Thoughts

- Ensuring a *unified model and metadata driven architecture* is key to solving the heterogeneous integration problem
  - Use models and metadata to enable transformation
  - Use MDA principles through out the life cycle
  - OMG MDA is the realization of this vision
- Most customers have and will continue to have components and information/data from multiple sources and formats that need integration
- XML/HTTP, CORBA/EJB, DCOM/ActiveX, MOF/XMI (Metadata), UML (Modeling) and CWM (Data Warehousing) need to work together with the content (business models, BODS, HL7 RIM…)
- As new platforms arrive, MDA can map to them, so your investment is protected. MDA is being mapped to Web Services

For More Information

- OMG : www.omg.org, www.omg.org/cwm
- MDA : www.omg.org/mda
- Unisys : www.unisys.com
- UML : www.omg.org/uml, www.rational.com
- CWM : www.cwmforum.org, www.omg.org/uml
- W3C : www.w3c.org
- DSTC : www.dstc.edu.au
- Sridhar : sridhar.iyengar2@unisys.com
- UML RTF : uml-rtf@omg.org
- MOF RTF : mof-rtf@omg.org
- XMI RTF : xmi-rtf@omg.org
- CWM RTF : cwm-rtf@omg.org
- JMI : http://java.sun.com/aboutJava/communityprocess/jsr

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