CASCON'06
Introduction to the Eclipse Modeling Framework

http://www.eclipse.org/emf/docs.php#presentations

Nick Boldt and Marcelo Paternostro
IBM Rational Software
Toronto, Canada
EMF Project

Agenda

- Introduction
  - ***EMF in a Nutshell***
  - EMF Components
  - The Ecore Metamodel

- Exercise 1: Code Generation, Regeneration and Merge
- Exercise 2: EMF Runtime
- Exercise 3: Recording Changes
- Exercise 4: Validation
- Exercise 5: Reflection, Dynamic EMF and XML Processor

- What's New in EMF 2.2
- Summary

What is EMF?

- A modeling & data integration framework
- Exploits the facilities offered in Eclipse to...
  - Generate code without losing user customizations (merge)
  - Automate important tasks (such as registering the runtime information)
  - Improve extensibility
  - Provide a UI layer
- What is an EMF “model”?
  - Specification of your application’s data
    - Object attributes
    - Relationships (associations) between objects
    - Operations available on each object
    - Simple constraints (eg. cardinality) on objects and relationships
  - Essentially it represents the class diagram of the application

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What does EMF Provide?

- From a model specification, EMF can generate efficient, correct, and easily customizable implementation code
- Out of the box, EMF provides support for
  - Java™ interfaces
  - UML
  - XML Schema
- EMF converts your models to Ecore (EMF metamodel)
- Tooling support within the Eclipse framework (UI, headless mode, Ant and standalone), including support for generating Eclipse-based and RCP editors
- Reflective API and dynamic model definition
- Persistence API with out of box support for XML/XMI (de)serialization of instances of a model
- And much more….

Why EMF?

- EMF is middle ground in the modeling vs. programming worlds
  - Focus is on class diagram subset of UML modeling (object model)
  - Transforms models into Java code
  - Provides the infrastructure to use models effectively in your application
- Very low cost of entry
  - EMF is free and open source
  - Full scale graphical modeling tool not required
  - Reuses your knowledge of UML, XML Schema, or Java
- It's real, proven technology (since 2002)

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EMF History

- First version was released in June, 2002
- Originally based on MOF (Meta Object Facility)
  - From OMG (Object Management Group)
  - Abstract language and framework for specifying, constructing, and managing technology neutral metamodels
- EMF evolved based on experience supporting a large set of tools
  - Efficient Java implementation of a practical subset of the MOF API
- 2003: EMOF defined (Essential MOF)
  - Part of OMG's MOF 2 specification; UML2 based
  - EMF is approximately the same functionality
    - Significant contributor to the spec; adapting to it

Who is Using EMF Today?

- Eclipse projects
  - UML2
  - Graphical Modeling Framework (GMF)
  - EMF Technologies (EMFT): OCL, Validation, Query, Transaction, EODM, and Database Persistence
  - Visual Editor (VE)
  - Data Tools Platform (DTP)
  - Web Tools Platform (WTP)
  - Test and Performance Tools Platform (TPTP)
  - Business Intelligence and Reporting Tools (BIRT)

  … to name but a few
- Commercial offerings
  - IBM, Borland, Oracle, Omondo, Versata, MetaMatrix, Bosch, Ensemble, ...
- Applied sciences
  - Darmstadt University of Technology, Mayo Clinic College of Medicine, European Space Agency, …
- Large open source community
  - Over 770,000 download requests from January to July 2006
  - In first month of its release, over 100,000 download requests for EMF 2.2.0!

EMF at IBM

- Pervasive usage across product lines
  - IBM® Rational® Software Architect
  - IBM Rational Application Developer for WebSphere Software
  - IBM WebSphere® Integration Developer
  - IBM WebSphere Application Server
  - IBM Lotus® Workplace
- Emerging technology projects: alphaWorks
  - Emfatic Language for EMF Development (http://www.alphaworks.ibm.com/tech/emfatic)
  - Model Transformation Framework (http://www.alphaworks.ibm.com/tech/mtf)
  - XML Forms Generator (http://www.alphaworks.ibm.com/tech/xfg)

What Have People Said About EMF?

- EMF represents the ***core subset*** that's left when the non-essentials are eliminated. It represents a ***rock solid foundation*** upon which the more ambitious extensions of UML and MDA can be built.
  - *Vlad Varnica, OMONDO Business Development Director, 2002*

- EMF ***provides the glue between the modeling and programming worlds***, offering an infrastructure to use models effectively in code by integrating UML, XML and Java. EMF thus fits well into [the] Model-Driven Development approach, and is ***critically important for Model-Driven Architecture***, which underpins service-oriented architectures [SOA].
  - *– Jason Bloomberg, Senior analyst for XML & Web services, ZapThink, 2003*

- *EMF is capable of **creating sophisticated editors** from abstract business models. … EMF creates feature complete implementations including persistence, **business model implementation**, editing framework and editors. … At InferData, we have been using EMF [to] create **persistence** implementation for various in-house products, … **standalone products** for the Eclipse platform, [and] quick prototypes to validate complex business models. Business models remain technology independent; code generation is performed for all that can be code generated and kept separate from the manually developed code.*
  - *– Petter Graff, SYS-CON Media, 2004*

- *EMF was chosen because it (a) provides a **lightweight, pragmatic approach to modeling** with very **low entry cost** and is thus suitable for rapid prototyping, (b) unifies key technologies such as Java and XML, and (c) integrates well into Eclipse.*
  - *Bruch, Bockisch, Schäfer, Mezini, Darmstadt Univ. of Technology, Germany, 2005*

- [As] a consultant with fiduciary responsibility to my customers, [...] given the ***enormous traction*** that Eclipse has gathered, we have to view the EMF metadata management framework as the ***de facto standard***.
  - *– David Frankel, as seen in Business Process Trends, March 2005*

Creating the Ecore Model

- Representing the modeled domain in Ecore is the first step in using EMF
- Ecore can be created
  - Directly using the EMF editors
  - Through a graphical UI provided by external contributions
  - By converting a model specification for which a Model Importer is available
- Model Importers available in EMF
  - Java Interfaces
  - UML models expressed in Rational Rose® files
  - XML Schema
- Choose the one matching your perspective or skills

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Model Importers Available in EMF

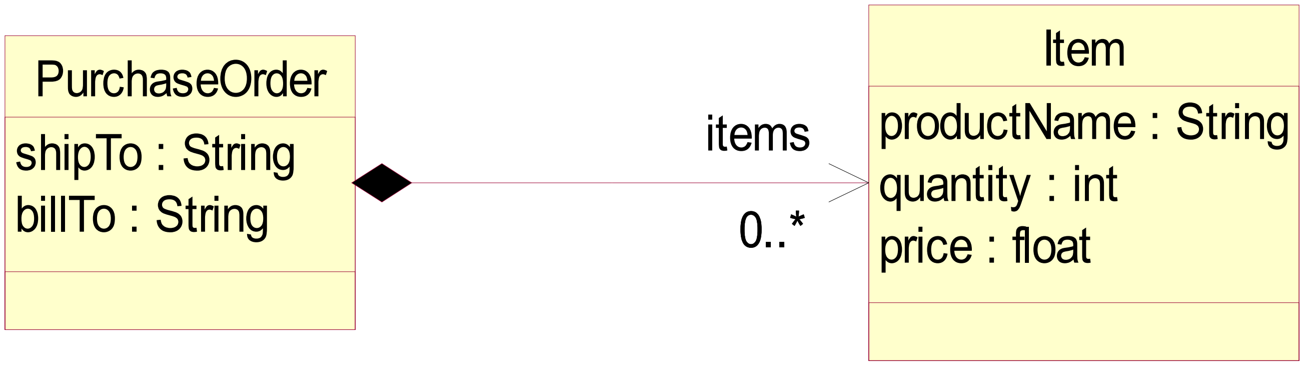
- Java Interfaces

```
public interface PurchaseOrder
{
  String getShipTo();
  void setShipTo(String value);
  String getBillTo();
  void setBillTo(String value);
  List getItems(); // List of Item
}
```

```
public interface Item
{
  String getProductName();
  void setProductName(String value);
  int getQuantity();
  void setQuantity(int value)
  float getPrice();
  void setPrice(float value);
}
```

Model Importers Available in EMF

- UML Class Diagram



Model Importers Available in EMF

- XML Schema

```
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema"
            targetNamespace="http://www.example.com/SimplePO"
            xmlns:PO="http://www.example.com/SimplePO">
  <xsd:complexType name="PurchaseOrder">
    <xsd:sequence>
      <xsd:element name="shipTo" type="xsd:string"/>
      <xsd:element name="billTo" type="xsd:string"/>
      <xsd:element name="items"  type="PO:Item"
                   minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
  </xsd:complexType>
  <xsd:complexType name="Item">
    <xsd:sequence>
      <xsd:element name="productName" type="xsd:string"/>
      <xsd:element name="quantity" type="xsd:int"/>
      <xsd:element name="price" type="xsd:float"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:schema>
```

Unifying Java, XML and UML Technologies

- The Model Importers available in EMF were carefully chosen to integrate today's most important technologies
- All three forms provide the same information
  - Different visualization/representation
  - The application's "model" of the structure
- From a model definition, EMF can generate
  - Java implementation code, including UI
  - XML Schemas
  - Eclipse projects and plug-in

Typical EMF Usage Scenario

- Create an Ecore model that represents the domain you are working on
  - Import UML (e.g. Rose .mdl file)
  - Import XML Schema
  - Import annotated Java interfaces
  - Create Ecore model directly using EMF's Ecore editor or a graphical editor
- Generate Java code for model
- Prime the model with instance data using generated EMF model editor
- Iteratively refine model (and regenerate code) and develop Java application
  - You will use the EMF generated code to implement the use cases of your application
- Optionally, use EMF.Edit to build customized user interface

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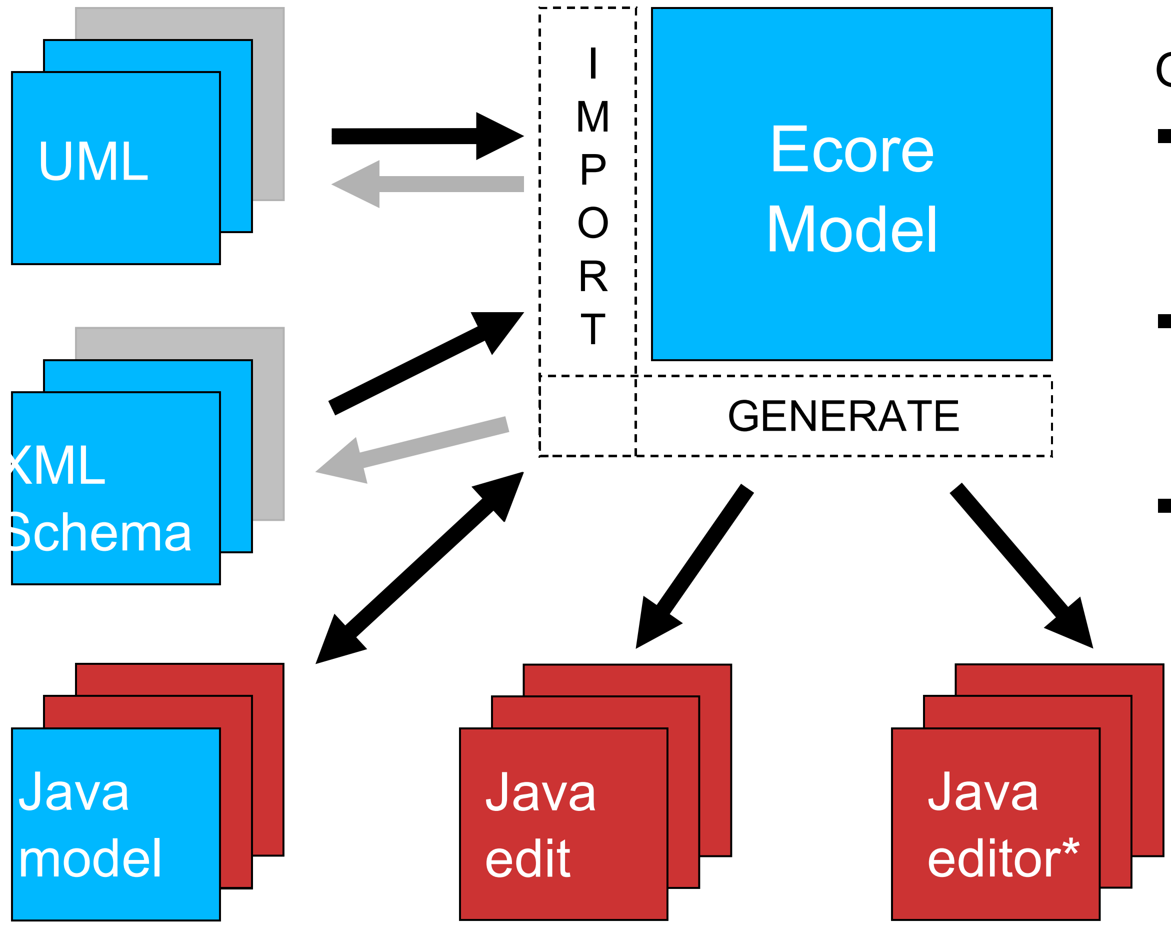
EMF Components

- EMF Core
  - Ecore metamodel
  - Model change notification & validation
  - Persistence and serialization
  - Reflection API
  - Runtime support for generated models
- EMF Edit
  - Helps integrate models with a rich user interface
  - Used to build editors and viewers for your model
  - Includes default reflective model editor
- EMF Codegen
  - Code generator for core and edit based components
  - Extensible model importer framework

EMF Tools: Model Import and Generation



Generator Features:

- Customizable JSP-like templates (JET)
- JDT-integrated, command-line, or Ant
- Fully supports regeneration and merge

* Eclipse IDE-integrated or RCP-based

EMF Model Importers

- UML
  - Rational Rose .mdl file
  - Eclipse UML2 project provides importer for .uml2
- Annotated Java
  - Java interfaces representing modeled classes
  - Javadoc annotations using @model tags to express model properties not captured by method declarations
  - Lowest cost approach
- XML Schema
  - Describes the data of the modeled domain
  - Provides richer description of the data, which EMF exploits
- Ecore model (*.ecore file)
  - Just creates the generator model (discussed later)
  - Also handles EMOF (*.emof)

Ecore Model Creation

- An Ecore model is created within an Eclipse project via a wizard
- Input: one of the model specifications from the previous slide
- Output:
  - modelname.ecore
    - Ecore model file in XMI format
    - Canonical form of the model
  - modelname.genmodel
    - A “generator model” for specifying generator options
    - Decorates .ecore file
    - EMF code generator is an EMF .genmodel editor
    - Automatically kept in synch with .ecore file

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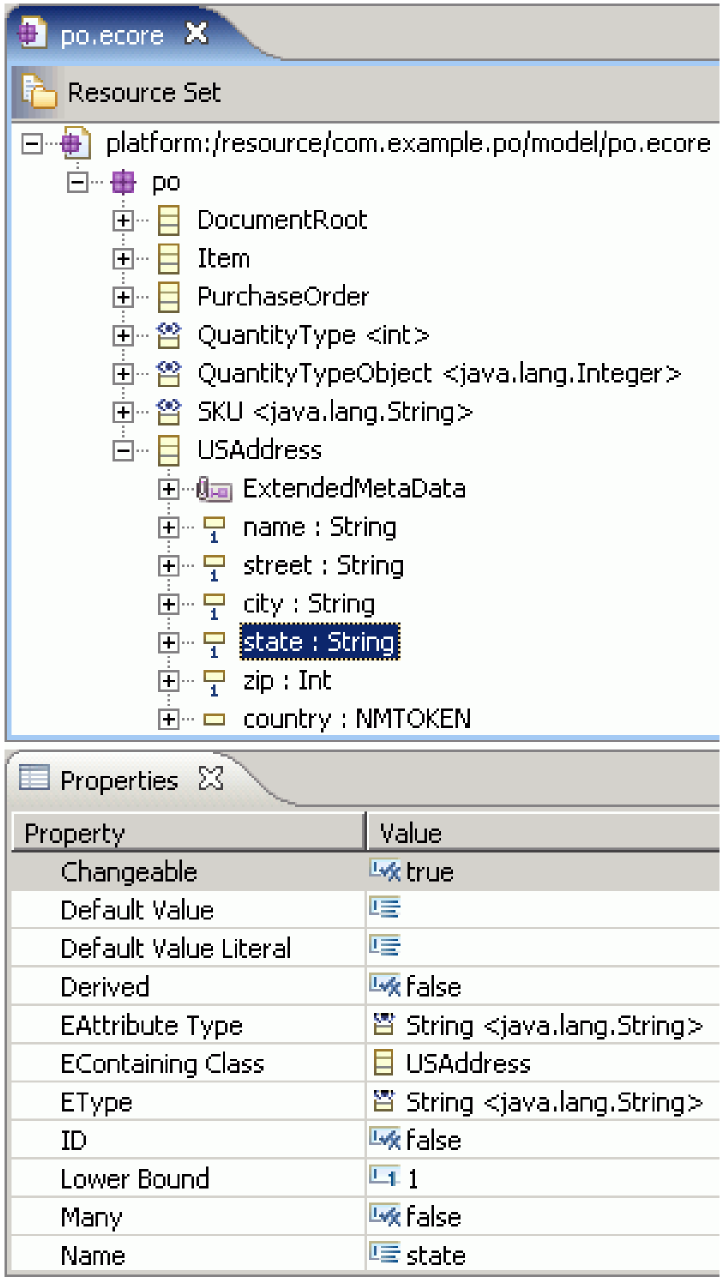
Ecore Model Editor

- A generated (and customized) EMF editor for the Ecore model
- Create, delete, etc. model elements (EClass, EAttribute, EReference, etc.) using pop-up actions in the editor's tree
- Set names, etc. in the Properties view


po.ecore

Resource Set

```
platform:/resource/com.example.po/model/po.ecore
  po
    DocumentRoot
    Item
    PurchaseOrder
    QuantityType <int>
    QuantityTypeObject <java.lang.Integer>
    SKU <java.lang.String>
    USAddress
      ExtendedMetaData
      name : String
      street : String
      city : String
      state : String
      zip : Int
      country : NMTOKEN
```

Properties

Property	Value
Changeable	true
Default Value	
Default Value Literal	
Derived	false
EAttribute Type	String <java.lang.String>
EContaining Class	USAddress
EType	String <java.lang.String>
ID	false
Lower Bound	1
Many	false
Name	state

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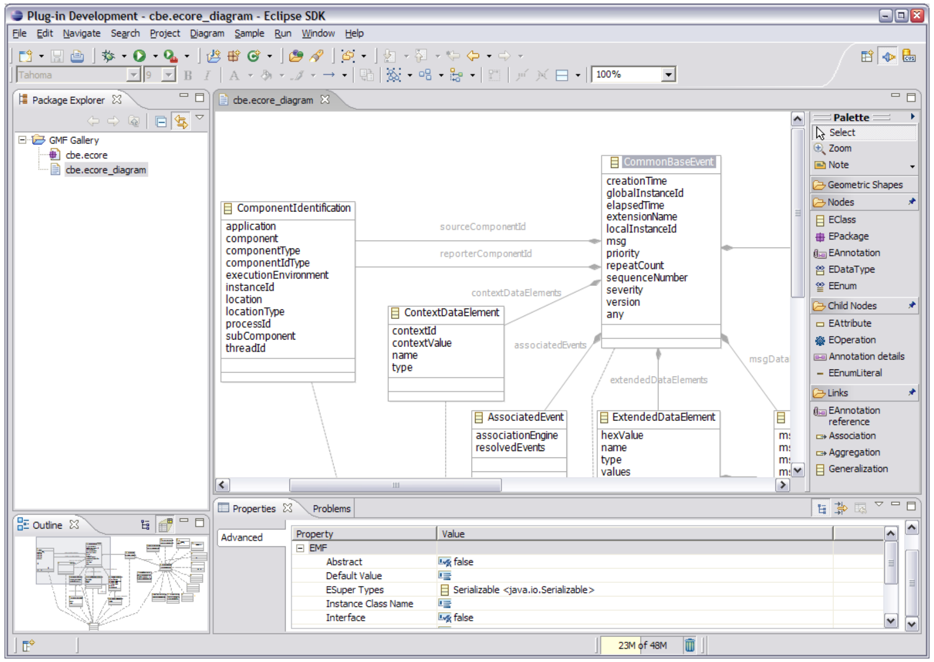
Ecore Model Editor

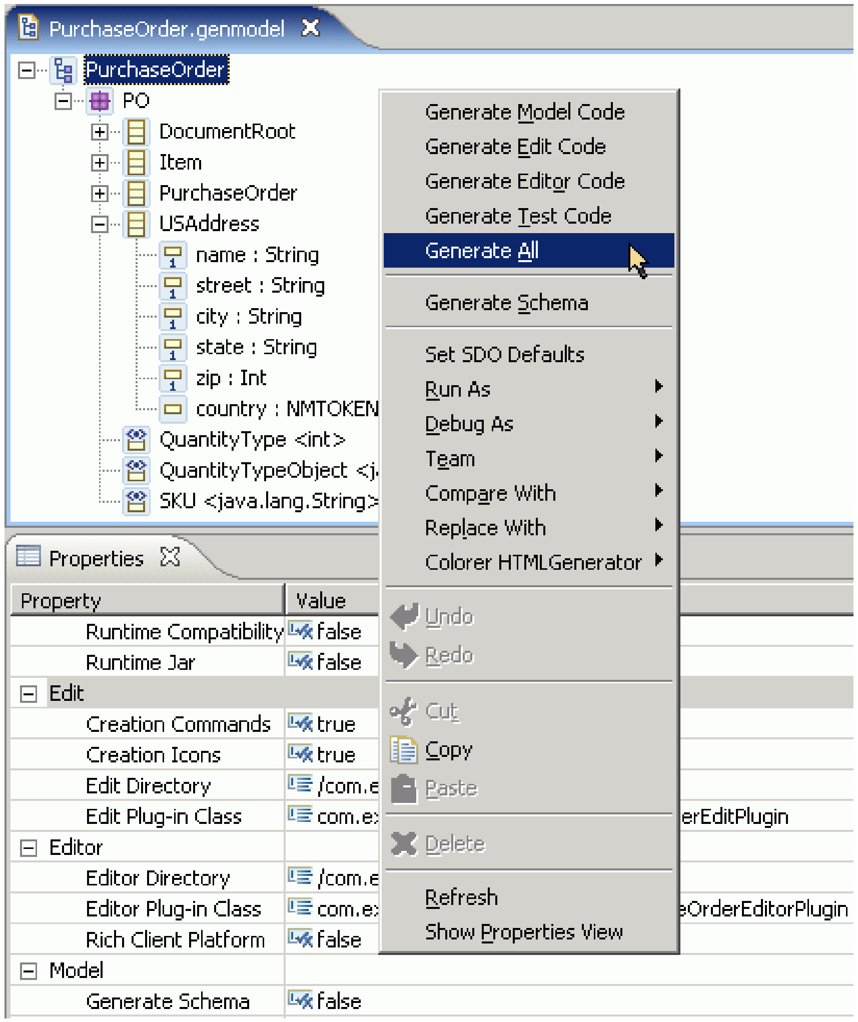
- A graphical editor is a better approach
  - GMF Ecore Diagram Example (http://www.eclipse.org/gmf/)
  - Omondo EclipseUML (http://www.omondo.com/)



Property	Value
EMF	
Abstract	false
Default Value	
ESuper Types	Serializable <java.io.Serializable>
Instance Class Name	
Interface	false

EMF Generator

- Similar layout to Ecore model editor
- Automatically keeps in synch with .ecore changes
- Generate code with pop-up menu actions
  - Generate Model Code
  - Generate Edit Code
  - Generate Editor Code
  - Generate Test Code
  - Generate All
- Code generation options in Properties view
- Generator > Reload to reload .genmodel and .ecore files from original model form



Property	Value
Runtime Compatibility	false
Runtime Jar	false
Edit	
Creation Commands	true
Creation Icons	true
Edit Directory	/com.e
Edit Plug-in Class	com.e erEditPlugin
Editor	
Editor Directory	/com.e
Editor Plug-in Class	com.e eOrderEditorPlugin
Rich Client Platform	false
Model	
Generate Schema	false

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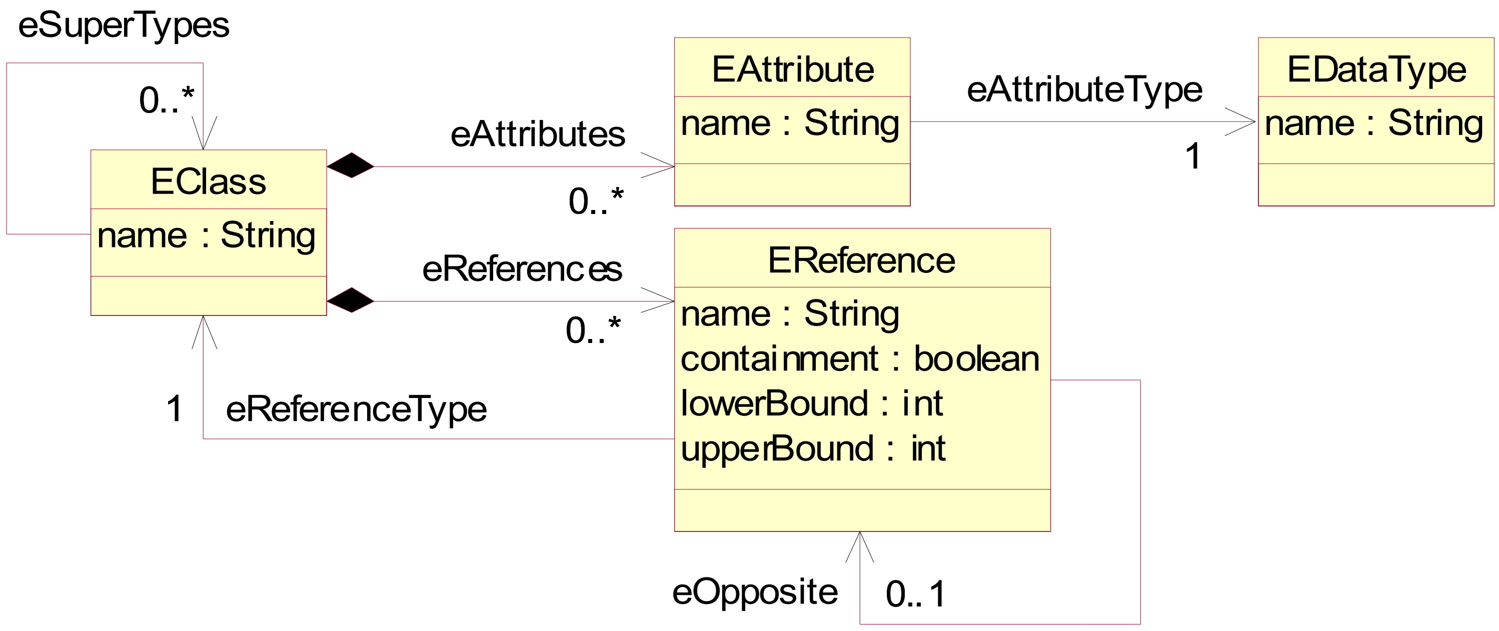
The Ecore (Meta) Model

- Ecore is EMF's model of a model
  - Also called a "metamodel"
  - Persistent representation is XMI



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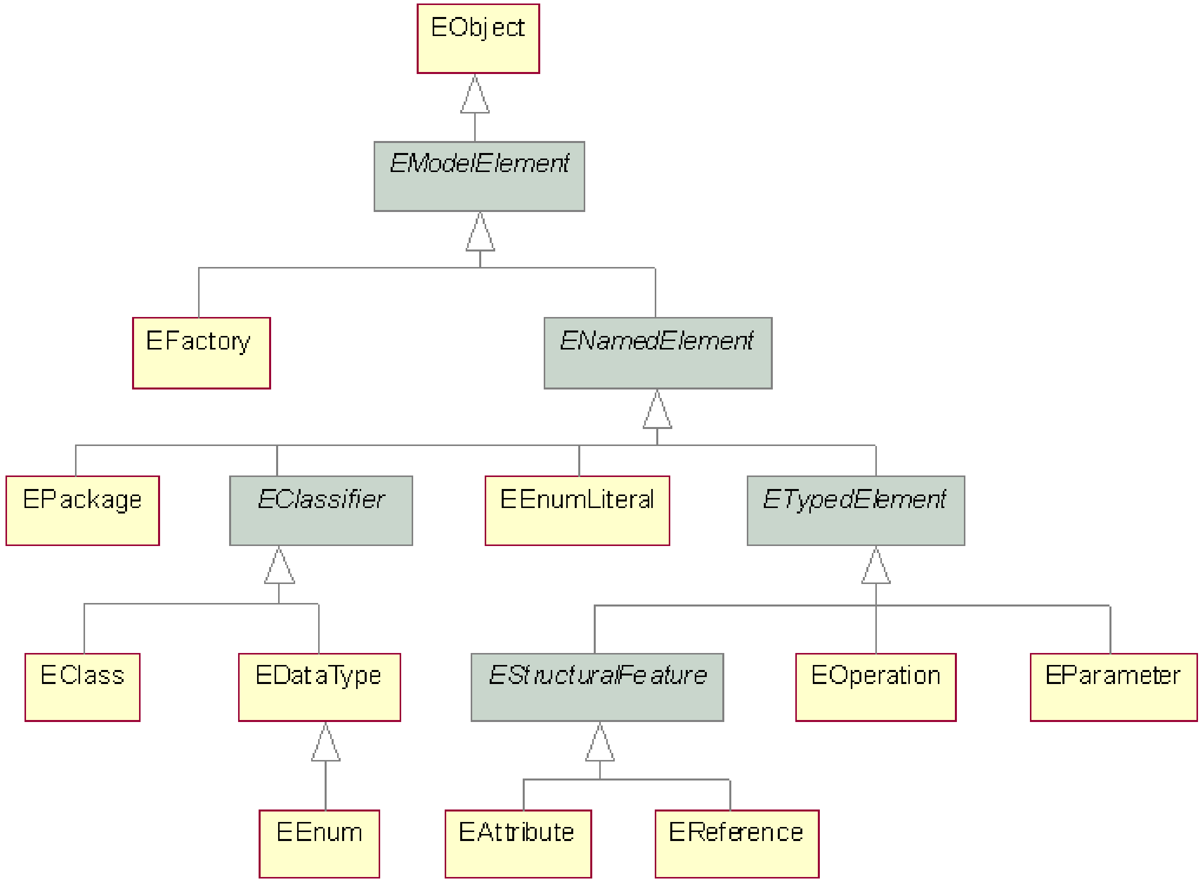
The Ecore Metamodel



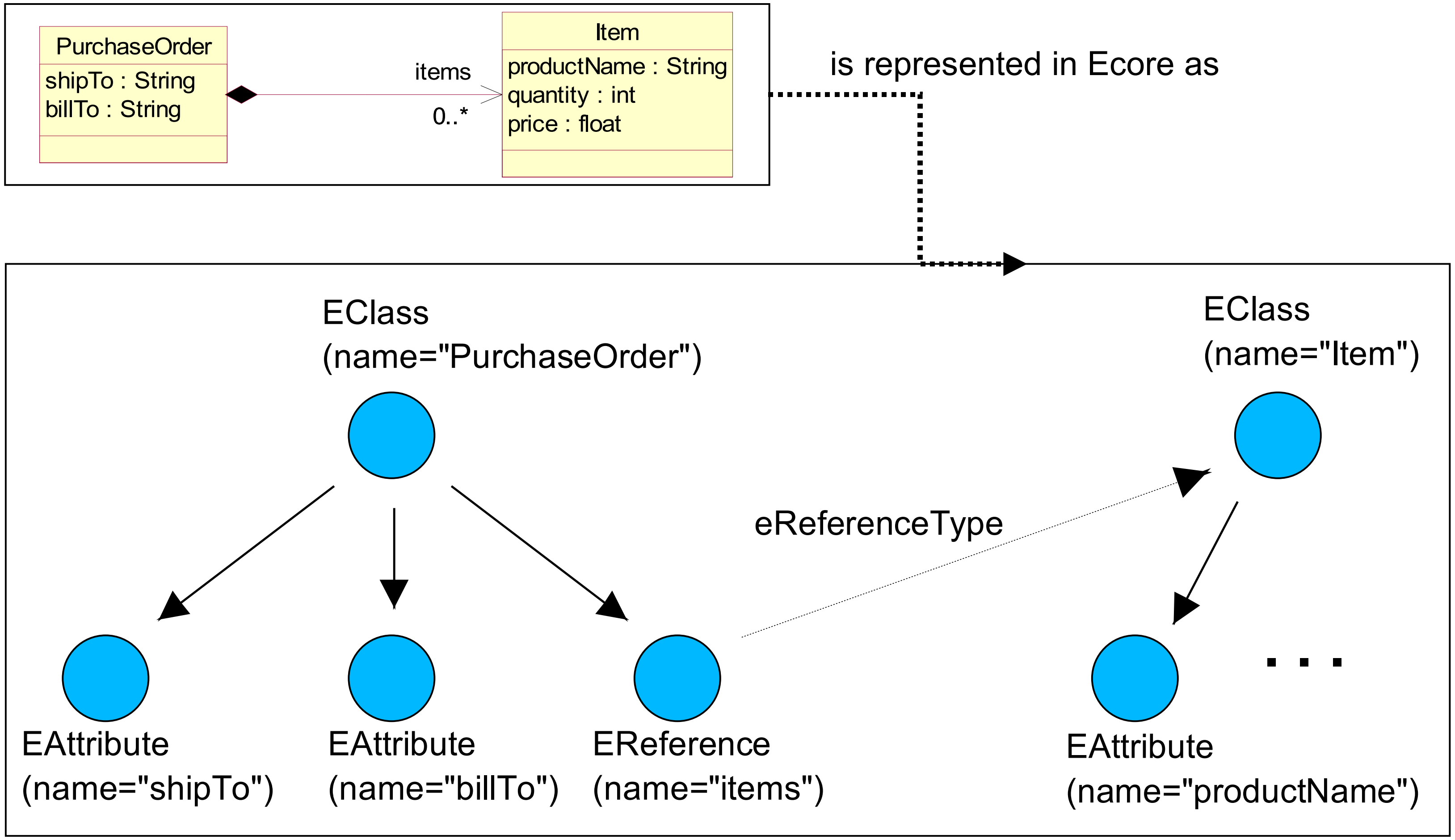
- EObject is the root of every model object – equivalent to java.lang.Object

Partial List of Ecore Data Types

Ecore Data Type	**Java Primitive Type or Class**
EBoolean	boolean
EChar	char
EFloat	float
EString	java.lang.String
EByteArray	byte[ ]
EBooleanObject	java.lang.Boolean
EFloatObject	java.lang.Float
EJavaObject	java.lang.Object

- Ecore data types are serializable and custom data types are supported

Ecore Model for Purchase Orders


PurchaseOrder
shipTo : String
billTo : String
items
0..*
Item
productName : String
quantity : int
price : float
is represented in Ecore as
EClass (name="PurchaseOrder")
EClass (name="Item")
eReferenceType
EAttribute (name="shipTo")
EAttribute (name="billTo")
EReference (name="items")
EAttribute (name="productName")
. . .

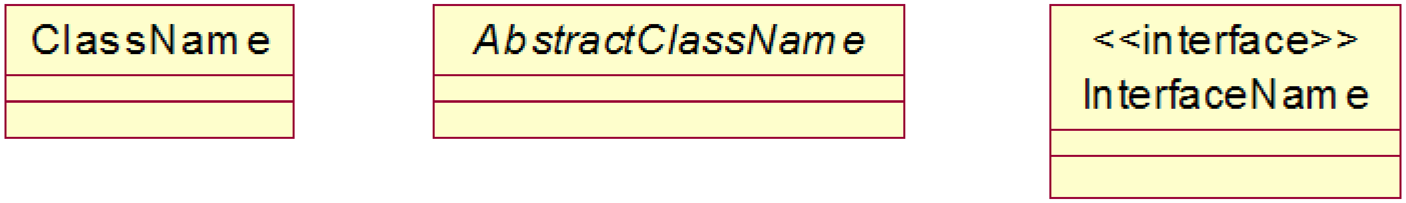
Purchase Order Ecore XMI

```
<eClassifiers xsi:type="ecore:EClass"
  name="PurchaseOrder">
 <eReferences name="items" eType="#//Item"
   upperBound="-1" containment="true"/>
 <eAttributes name="shipTo"
   eType="ecore:EDataType http:...Ecore#//EString"/>
 <eAttributes name="billTo"
   eType="ecore:EDataType http:...Ecore#//EString"/>
</eClassifiers>
```

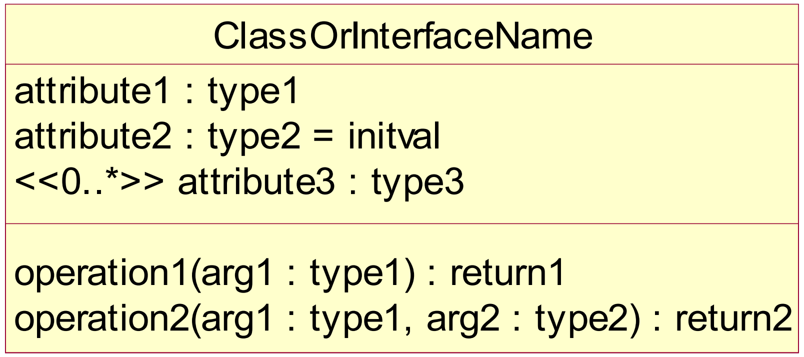
- Alternate serialization format is EMOF (Essential MOF) XMI
  - Part of OMG Meta Object Facility (MOF) 2.0 standard (http://www.omg.org/docs/ptc/04-10-15.pdf)

UML Constructs Available in Ecore

- Classes, Abstract Classes, and Interfaces

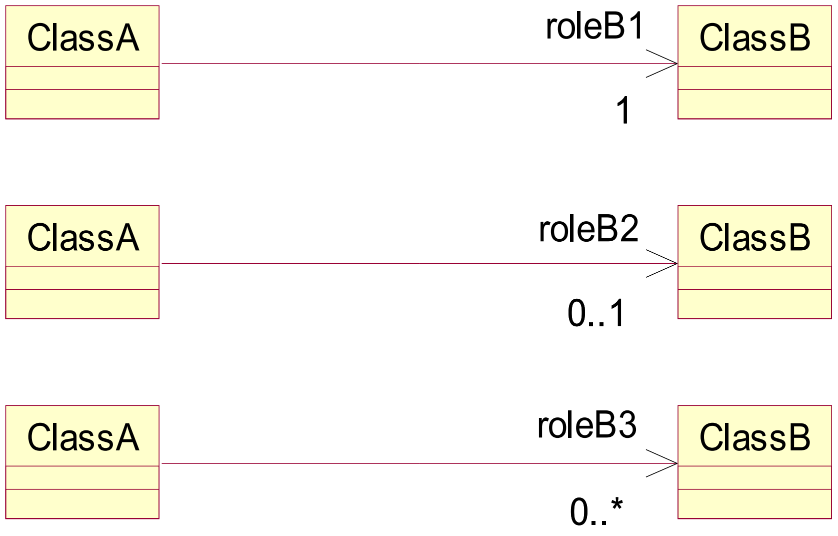


- Attributes and Operations


ClassOrInterfaceName
attribute1 : type1
attribute2 : type2 = initval
<<0..*>> attribute3 : type3
operation1(arg1 : type1) : return1
operation2(arg1 : type1, arg2 : type2) : return2

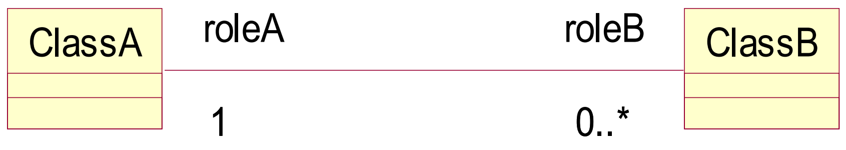
UML Constructs Available in Ecore

- References (Associations)
  - One-way

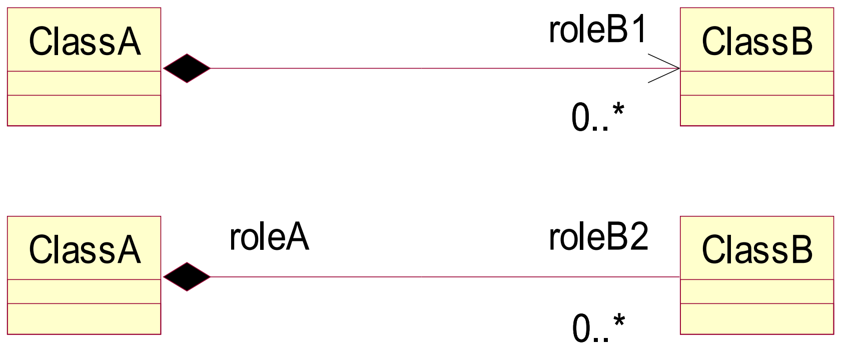


UML Constructs Available in Ecore

- References (Associations)
  - Bidirectional

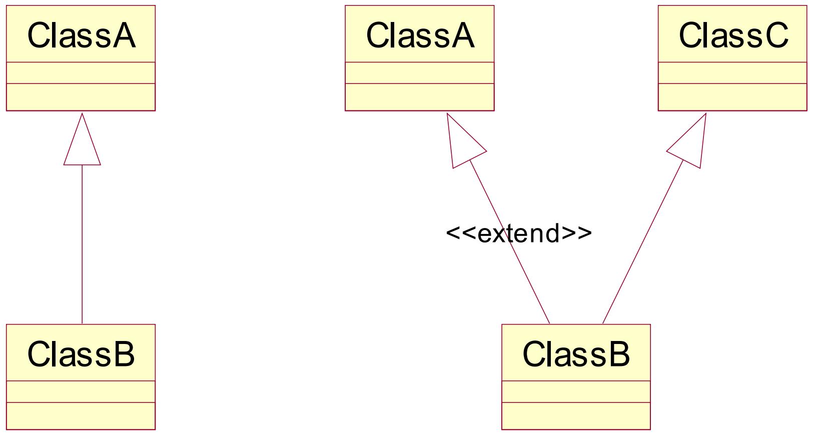


  - Containment

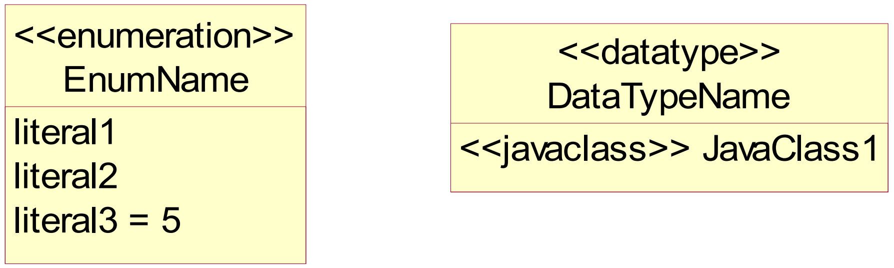


UML Constructs Available in Ecore

- Class Inheritance



- Enumerations and Data Types



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Code Generation

- EMF framework is lightweight
  - Generated code is clean, simple, efficient
- EMF can generate
  - Model implementation
  - UI-independent edit support
  - Editor and views for Eclipse IDE-integrated or RCP application
  - JUnit test skeletons
  - Manifests, plug-in classes, properties, icons, etc.

Modeling Framework

Generated Model Code

- Interface and implementation for each modeled class
  - Includes get/set accessors for attributes and references

```
public interface PurchaseOrder extends EObject
{
  String getShipTo();
  void setShipTo(String value);
  String getBillTo();
  void setBillTo(String value);
  EList getItems();
}
```

  - Usage example

```
order.getItems().add(item);
```

Generated Model Code

- Factory to create instances of model objects

```
POFactory factory = POFactory.eINSTANCE;
PurchaseOrder order = factory.createPurchaseOrder();
```

- Package class provides access to metadata

```
POPackage poPackage = POPackage.eINSTANCE;
EClass itemClass = poPackage.getItem();

EAttribute priceAttr = poPackage.getItem_Price();
  //or itemClass.getEStructuralFeature(POPackage.ITEM__PRICE)
```

- Also generated: switch utility, adapter factory base, validator, custom resource, XML processor

Generated Edit/Editor Code

- Viewing/editing code divided into two parts
  - UI-independent code
    - Item providers (adapters)
    - Item provider adapter factory
  - UI-dependent code
    - Model creation wizard
    - Editor
    - Action bar contributor
    - Advisor (RCP)
  - By default each part is placed in a separate Eclipse plug-in

Summary of Generated Artifacts

- Model
  - Interfaces and classes
  - Type-safe enumerations
  - Package (metadata)
  - Factory
  - Switch utility
  - Adapter factory base
  - Validator
  - Custom resource
  - XML Processor
- Edit (UI independent)
  - Item providers
  - Item provider adapter factory
- Editor
  - Model Wizard
  - Editor
  - Action bar contributor
  - Advisor (RCP)
- Tests
  - Test cases
  - Test suite
  - Stand-alone example
- Manifests, plug-in classes, properties, icons...

Regeneration and Merge

- Hand-written code can be added to generated code and preserved during regeneration
  - This merge capability has an Eclipse dependency, so is not available standalone
- All generated classes, interfaces, methods and fields include @generated marker in their Javadoc
- To replace generated code:
  - Remove @generated marker
  - Or include additional text, e.g.

    @generated NOT
- Methods without @generated marker are left alone during regeneration

Modeling Framework

Regeneration and Merge

- Extend (vs. replace) generated method through redirection
  - Append “Gen” suffix to the generated method's name

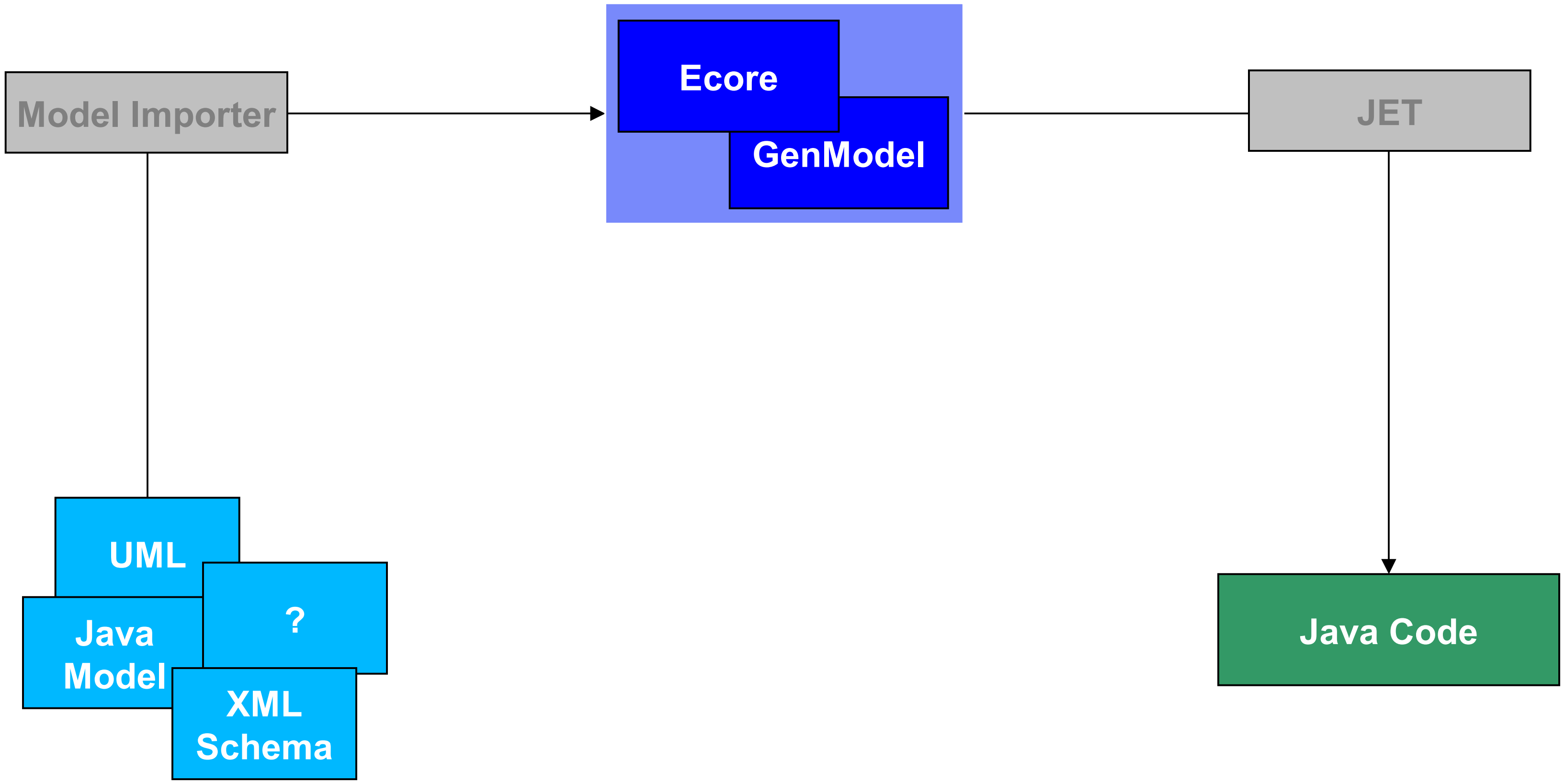
```
/**
 * <!-- begin-user-doc -->
 * <!-- end-user-doc -->
 * @generated
 */
public String getName()
{
  return name;
}
```

```
/**
 * <!-- begin-user-doc -->
 * <!-- end-user-doc -->
 * @generated
 */
public String getNameGen()
{
  return name;
}

public String getName()
{
  return format(getNameGen());
}
```

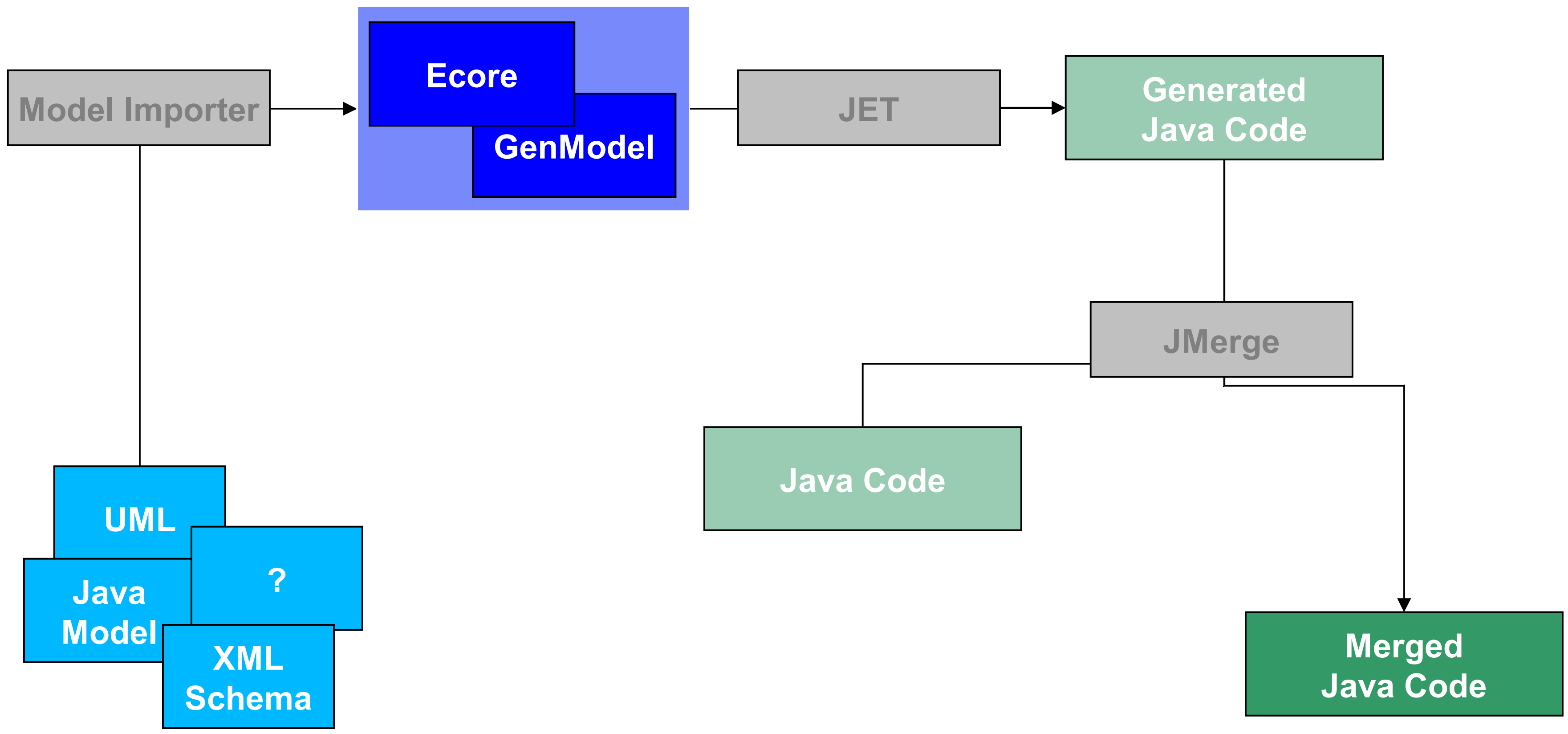
Eclipse Modeling Framework

Summarizing the Code Generation Process



Simplified version

Summarizing the Code Generation Process



Full version

Exercise 1:
Code Generation, Regeneration and Merge

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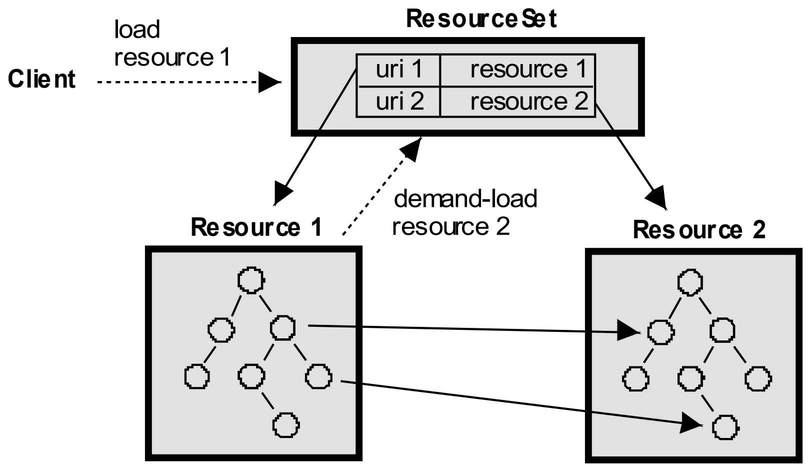
EMF Runtime

- Persistence and serialization of model data
  - Proxy resolution and demand load
- Automatic notification of model changes
- Bi-directional reference handshaking
- Dynamic object access through a reflective API
- Runtime environments
  - Eclipse
    - Full IDE
    - RCP
  - Standalone Java

Persistence and Serialization



- Serialized data is referred to as a resource
- Data can be spread out among a number of resources in a resource set
- One resource is loaded at a time, even if it has references to objects in other resources in the resource set
  - Proxies exist for objects in other resources
  - Lazy or demand loading of other resources as needed
  - A resource can be unloaded

Resource Set

- Context for multiple resources that may have references among them
- Usually just an instance of ResourceSetImpl, or a customized subclass
- Provides factory method for creating new resources in the set:

```
ResourceSet rs = new ResourceSetImpl();
URI uri = URI.createFileURI("C:/data/po.xml");
Resource resource = rs.createResource(uri);
```

- Also provides access to the registries, URI converter, and default load options for the set

Resource Factory Registry

- Returns a resource factory for a given type of resource
  - Based on the URI scheme or filename extension
  - Determines the type of resource, hence format for save/load

```
Resource.Factory.Registry reg = rs.getResourceFactoryRegistry();
reg.getExtensionToFactoryMap().put("xml", new
XMLResourceFactoryImpl());
```

- For models created from XML Schema, the generated custom resource factory implementation should be registered to ensure schema-conformant serialization
  - When running as a plug-in under Eclipse, EMF provides an extension point for registering resource factories
  - Generated plugin.xml registers generated resource factory against a package specific extension (e.g. “po”)
- Global registry: Resource.Factory.Registry.INSTANCE
  - Consulted if no registered resource factory found locally

Package Registry

- Returns the package identified by a given namespace URI
  - Used during loading to access the factory for creating instances

```
EPackage.Registry registry = rs.getPackageRegistry();
registry.put(POPackage.eNS_URI, POPackage.eINSTANCE);
```

- Global registry: EPackage.Registry.INSTANCE
  - Consulted if no registered package found locally
- Running in Eclipse, EMF provides an extension point for globally registering generated packages
- Even standalone, a package automatically registers itself when accessed:

```
POPackage poPackage = POPackage.eINSTANCE;
```

Resource

- Container for objects that are to be persisted together
  - Convert to and from persistent form via save() and load()
  - Access contents of resource via getContents()

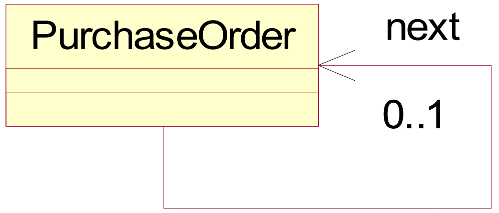
```
URI uri = URI.createFileURI("C:/data/po.xml");
Resource resource = rs.createResource(uri);
resource.getContents().add(p1);
resource.save(null);
```

- EMF provides XMLResource implementation

```
<PurchaseOrder>
  <shipTo>John Doe</shipTo>
  <next>p2.xml#p2</next>
</PurchaseOrder>
```

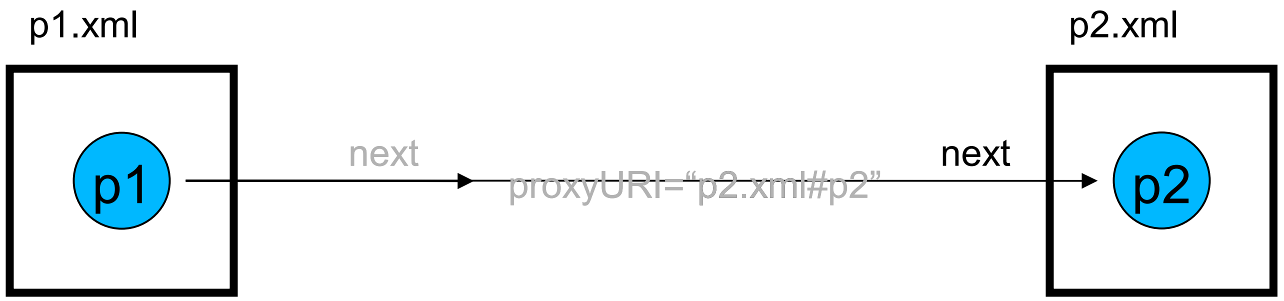
- Other, customized XML resource implementations, provided, too (e.g. XMI, Ecore, EMOF)

Proxy Resolution and Demand Load



p1.xml

```
<PurchaseOrder>
  <shipTo>John Doe</shipTo>
  <next>p2.xml#p2</next>
</PurchaseOrder>
```

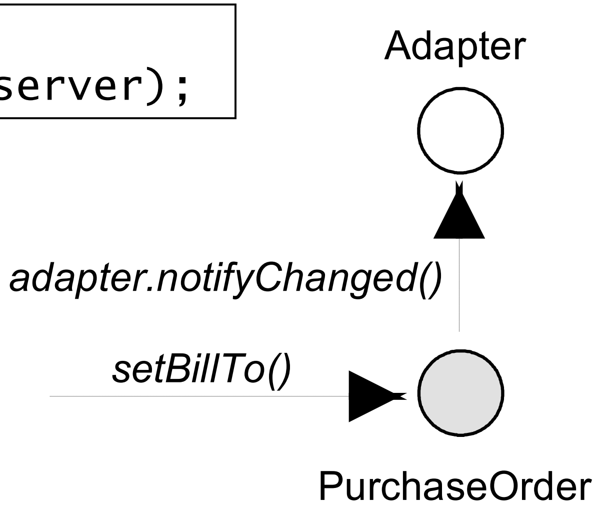


```
PurchaseOrder p2 = p1.getNext();
```

Model Change Notification

- Every EMF object is also a Notifier
  - Send notification whenever an attribute or reference is changed
  - EMF objects can be "observed" in order to update views and dependent objects

```
Adapter poObserver = ...
purchaseOrder.eAdapters().add(poObserver);
```



Model Change Notification

- Observers or listeners in EMF are called adapters
  - An adapter can also extend class behavior without subclassing
  - For this reason they are typically added using an AdapterFactory

```
PurchaseOrder purchaseOrder = ...
AdapterFactory somePOAdapterFactory = ...
Object poExtensionType = ...

if (somePOAdapterFactory.isFactoryForType(poExtensiontype))
{
  Adapter poAdapter = somePOAdapterFactory.adapt(purchaseOrder,
                                                 poExtensionType);
  ...
}
```

Eclipse Modeling Framework

Model Change Notification

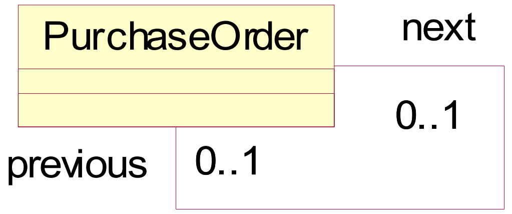
- Efficient notification in “set” methods
  - Checks for listeners before creating and sending notification

```
public String getShipTo()
{
  return shipTo;
}

public void setShipTo(String newShipTo)
{
  String oldShipTo = shipTo;
  shipTo = newShipTo;
  if (eNotificationRequired())
    eNotify(new ENotificationImpl(this, ... );
}
```

Eclipse Modeling Framework

Bidirectional Reference Handshaking

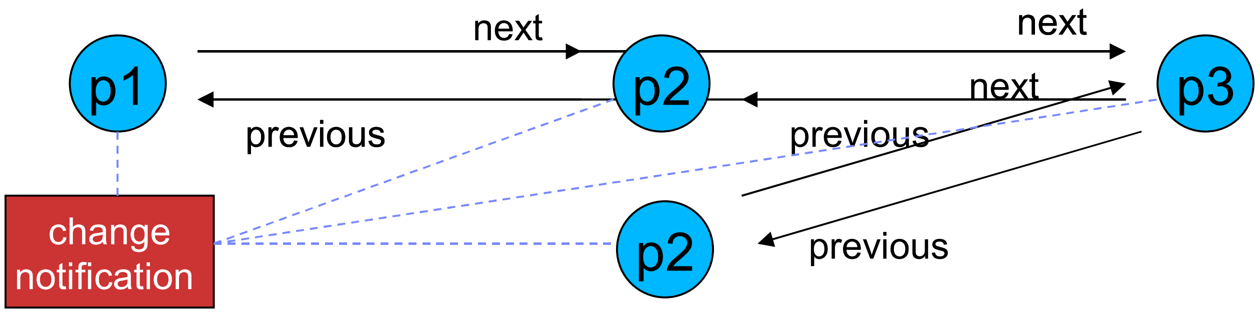


Invariant imposed by the bidirectional reference:

po.getNext().getPrevious() == po

```
public interface PurchaseOrder
{
  PurchaseOrder getNext();
  void setNext(PurchaseOrder value);
  PurchaseOrder getPrevious();
  void setPrevious(PurchaseOrder value);
}
```

Bidirectional Reference Handshaking



```
p1.setNext(p3);
```

Reflection

- All EMF classes implement interface EObject
- Provides an efficient API for manipulating objects reflectively
  - Used by the framework (e.g., serialization/deserialization, copy utility, generic editing commands, etc.)
  - Also key to integrating tools and applications built using EMF

```
public interface EObject
{
  EClass eClass();
  Object eGet(EStructuralFeature sf);
  void eSet(EStructuralFeature sf, Object val);
  ...
}
```

Reflection Example

- Setting an attribute using generated API:

```
PurchaseOrder po = ...
po.setBillTo("123 Elm St.");
```

- Using reflective API:

```
EObject po = ...
EClass poClass = po.eClass();
po.eSet(poClass.getEStructuralFeature("billTo"),
        "123 Elm St.");
```

Reflective Performance

- Efficient generated switch-based implementation of reflective methods

```
public Object eGet(int featureID, ...)
{
  switch (featureID)
  {
    case POPackage.PURCHASE_ORDER__SHIP_TO:
      return getShipTo();
    case POPackage.PURCHASE_ORDER__BILL_TO:
      return getBillTo();
    ...
  }
}
```

Reflection Benefits

- Reflection allows generic access to any EMF model
  - Similar to Java's introspection capability
  - Every EObject (that is, every EMF object) implements the reflection API
- An integrator need only know your model!
- A generic EMF model editor uses the reflection API
  - Can be used to edit any EMF model

Dynamic EMF

- Ecore models can be defined dynamically in memory
  - No generated code required
  - Dynamic implementation of reflective EObject API provides same runtime behavior as generated code
  - Also supports dynamic subclasses of generated classes
- All EMF model instances, whether generated or dynamic, are treated the same by the framework
- A dynamic Ecore model can be defined by
  - Instantiating model elements with the Ecore API
  - Loading from a .ecore file

Dynamic EMF Example

- Model definition using the Ecore API

```
EPackage poPackage = EcoreFactory.eINSTANCE.createEPackage();
poPackage.setName("po");
poPackage.setNsURI("http://www.example.com/PurchaseOrder");

EClass poClass = EcoreFactory.eINSTANCE.createEClass();
poClass.setName("PurchaseOrder");
poPackage.getEClassifiers().add(poClass);

EAttribute billTo = EcoreFactory.eINSTANCE.createEAttribute();
billTo.setName("billTo");
billTo.setEType(EcorePackage.eINSTANCE.getEString());
poClass.getEStructuralFeatures().add(billTo);
...

EObject po = EcoreUtil.create(poClass);
po.eSet(billTo,"123 Elm St.");
```

Exercise 2:
EMF Runtime and Static Model APIs

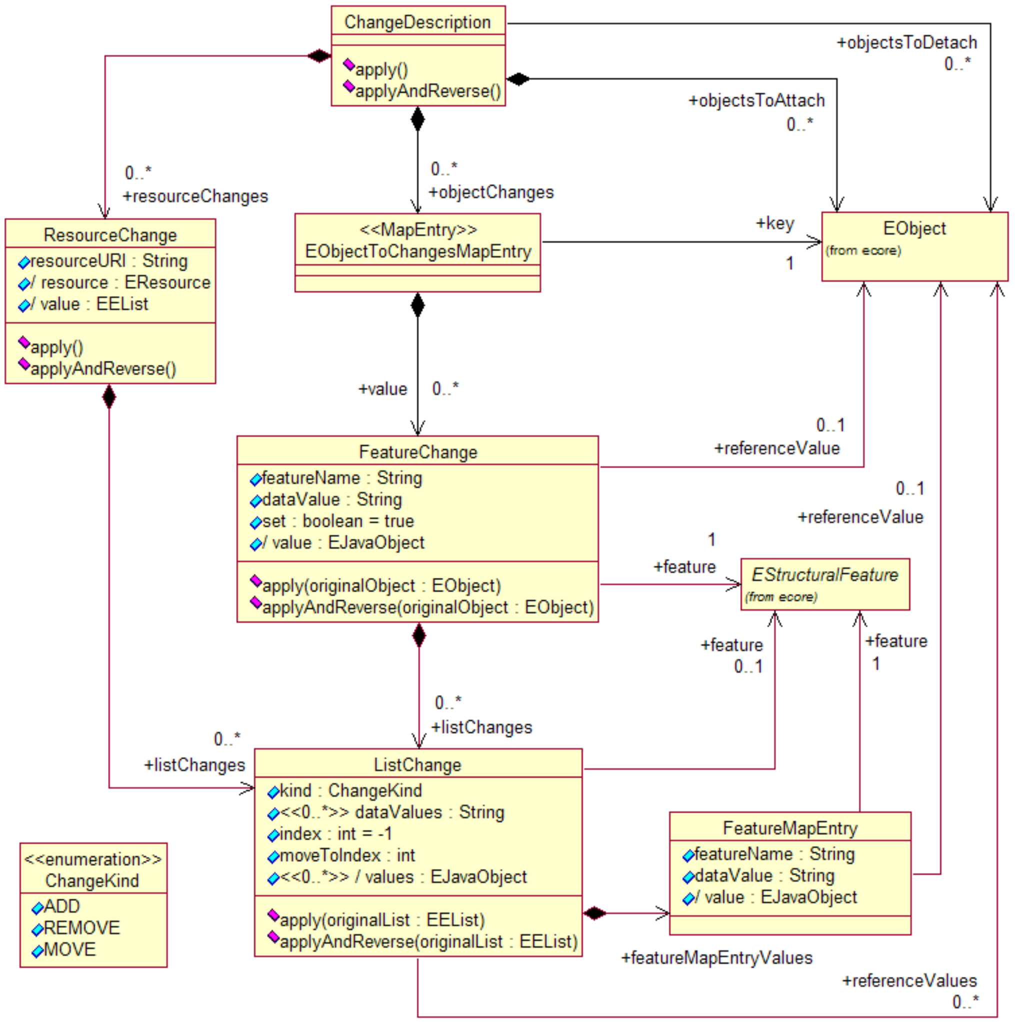
Agenda

- Introduction
  - EMF in a Nutshell
  - EMF Components
  - The Ecore Metamodel
- Exercise 1: Code Generation, Regeneration and Merge
- Exercise 2: EMF Runtime
- ***Exercise 3: Recording Changes***
- Exercise 4: Validation
- Exercise 5: Reflection, Dynamic EMF and XML Processor
- What's New in EMF 2.2
- Summary

Recording Changes

- EMF provides facilities for recording the changes made to instances of an Ecore model
- Change Model
  - An EMF model for representing changes to objects
  - Directly references affected objects
  - Includes “apply changes” capability
- Change Recorder
  - EMF adapter
  - Monitors objects to produce a change description (an instance of the change model)

Change Model



Change Recorder

- Can be attached to EObjects, Resources, and ResourceSets
  - Monitors changes to the objects and their contents trees
- Produces a description of the changes needed to return to the original state (a reverse delta)

```
PurchaseOrder order = ...
order.setBillTo("123 Elm St.");

ChangeRecorder recorder = new ChangeRecorder();
recorder.beginRecording(Collections.singleton(order));
order.setBillTo("456 Cherry St.");
ChangeDescription change = recorder.endRecording();
```

- Result: a change description with one change, setting billTo to “123 Elm St.”

Applying Changes

- Given a change description, the change can be applied:
  - ChangeDescription.apply()
    - consumes the changes, leaving the description empty
  - ChangeDescription.applyAndReverse()
    - reverses the changes, leaving a description of the changes originally made (the forward delta)

- The model is always left in an appropriate state for applying the resulting change description

Example: Transaction Capability

- If any part of the transaction fails, undo the changes

```
ChangeRecorder changeRecorder =
  new ChangeRecorder(resourceSet);

try
{
  // modifications within resource set
}
catch (Exception e)
{
  changeRecorder.endRecording().apply();
}
```

Exercise 3:
Recording Changes

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Validation Framework

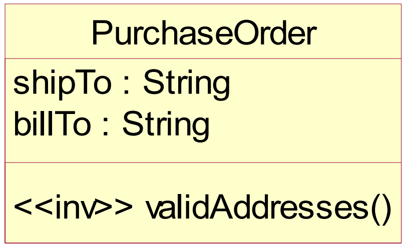
- Model objects validated by external EValidator

```
public interface Evalidator
{
  boolean validate(EObject eObject,
                   DiagnosticChain diagnostics, Map Context);
  boolean validate(EClass eClass, EOjbect eObject,
                   DiagnosticChain, diagnostics, Map context);
  boolean validate(EDataType eDataType, Object value,
                   DiagnosticChain diagnostics, Map context);
  ...
}
```

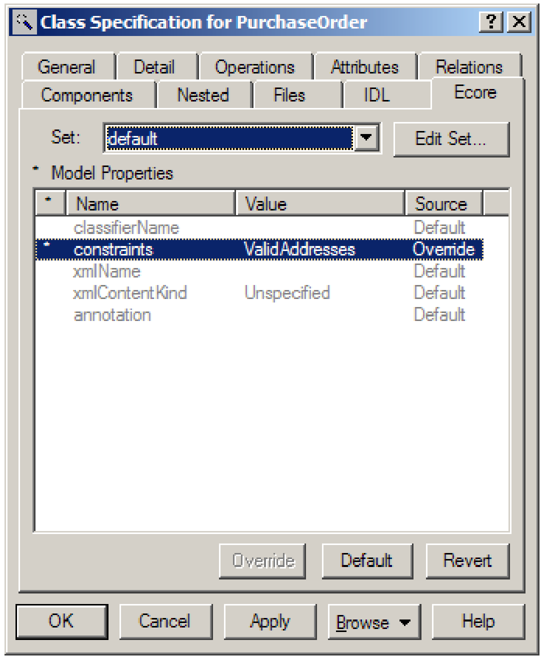
- Detailed results accumulated as Diagnostics
  - Essentially a non-Eclipse equivalent to IStatus
  - Records severity, source plug-in ID, status code, message, other arbitrary data, and nested children

Invariants and Constraints

- Invariant
  - Defined directly on the class, as an operation with <<inv>> stereotype
  - Stronger statement about validity than a constraint



- Constraint
  - Externally defined for the class via a method on the validator



Set: default

Model Properties

Name	Value	Source
classifierName		Default
constraints	ValidAddresses	Override
xmlName		Default
xmlContentKind	Unspecified	Default
annotation		Default

Generated EValidator Implementations

- Generated for each package that defines invariants or constraints
- Dispatches validation to type-specific methods
- For classes, a validate method is called for each invariant and constraint
  - Method body must be hand coded for invariants and named constraints

Schema-Based Constraints

- In XML Schema, named constraints are defined via annotations:

```
<xsd:annotation>
  <xsd:appinfo source="http://www.eclipse.org/emf/2002/Ecore"
    ecore:key="constraints">VolumeDiscount</xsd:appinfo>
</xsd:annotation>
```

- Also, constraints can be defined as facets on simple types, and no additional coding is required
  - Constraint method implementation generated

```
<xsd:simpleType name="SKU">
  <xsd:restriction base="xsd:string">
    <xsd:pattern value="\d{3}-[A-Z]{2}"/>
  </xsd:restriction>
</xsd:simpleType>
```

Framework EValidator Implementations

- EObjectValidator validates basic EObject constraints:
  - Multiplicities are respected
  - Proxies resolve
  - All referenced objects are contained in a resource
  - Data type values are valid
- Used as base of generated validators and directly for packages without additional constraints defined

Framework EValidator Implementations

- Diagnostician walks a containment tree of model objects, dispatching to package-specific validators
  - Diagnostician.validate() is the usual entry point
  - Obtains validators from its EValidator.Registry

```
Diagnostician validator = Diagnostician.INSTANCE;
Diagnostic diagnostic = validator.validate(order);

if (diagnostic.getSeverity() == Diagnostic.ERROR)
{
  // handle error
}

for (Iterator i = diagnostic.getChildren().iterator(); i.hasNext();)
{
  Diagnostic child = (Diagnostic)i.next();
  // handle child diagnostic
}
```

Exercise 4: Validation

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- ***Exercise 5: Reflection, Dynamic EMF and XML Processor***

- What's New in EMF 2.2
- Summary

XML Processor

- Simplified API for loading and saving XML
  - Handles resource set, registries, etc. under the covers
- Can automatically create a dynamic Ecore representation of a schema
  - Load/save instance documents without generating code
  - Manipulate the objects using reflective EObject API

```
URI schemaURI = ...
String instanceFileName = ...

XMLProcessor processor = new XMLProcessor(schemaURI);
Resource resource = processor.load(instanceFileName);

EObject documentRoot = (EObject)resource.getContents.get(0);
```

Exercise 5:
Reflection, Dynamic EMF and XML Processor

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- ***What's New in EMF 2.2***
- Summary

Important Changes in EMF 2.2

- Content adapter for managing reverse of 1-way references
- Cross-resource containment
- XMI 2.1 support
- Model exporter
- Improve XML Schema generation
- Improve code generation error reporting and handling

- Performance optimizations
- For more, see:
  - http://www.eclipse.org/emf/docs.php#plandocs
  - http://www.eclipse.org/emf/news/

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- ***Summary***

Summary

- EMF is low-cost modeling for the Java mainstream
- Boosts productivity and facilitates integration
- Mixes modeling with programming to maximize the effectiveness of both

Summary

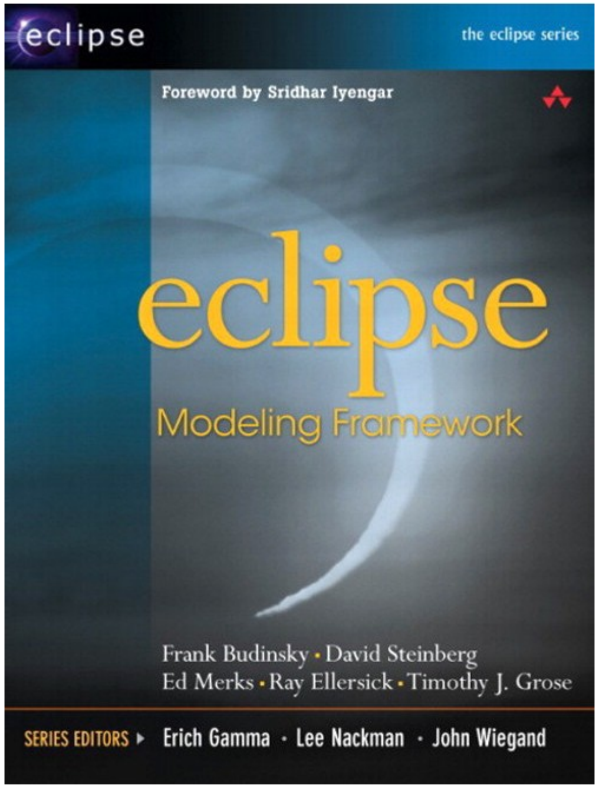
- EMF provides…
  - A metamodel (Ecore) with which your domain model can be specified
    - Your model can be created from UML, XML Schema or annotated Java interfaces
  - Generated Java code
    - Efficient and straightforward
    - Code customization preserved
  - Persistence and Serialization
    - Resource-based serialization
    - Proxy resolution and demand loading
    - Default resource implementation is XMI (XML metadata interchange), but can be overridden

Summary

- EMF provides…
  - Model change notification is built in
    - Just add adapters (observers) where needed
  - Reflection and dynamic EMF
    - Full introspection capability
  - Simple change recording and roll-back
  - Extensible validation framework
  - Standalone runtime support
  - A UI-independent layer for viewing and editing modeled data (EMF.Edit)

Resources

- EMF documentation in Eclipse Help
  - Overviews, tutorials, API reference
- EMF Project Web Site
  - http://www.eclipse.org/emf/
  - Overviews, tutorials, newsgroup, Bugzilla
- Eclipse Modeling Framework by Frank Budinsky et al.
  - Addison-Wesley; 1st edition (August 13, 2003)
  - ISBN: 0131425420.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