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Agent and **O**bject **T**echnology **Lab**
Dipartimento di Ingegneria dell'Informazione
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Eclipse Modelling Framework (EMF)

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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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Who is Using EMF Today?

- Eclipse projects
  - Foundation for the Modeling Project: Graphical Modeling Framework (GMF), EMF Ontology Definition Metamodel (EODM), UML2…
  - Other uses: Web Tools Platform (WTP), Test and Performance Tools Platform (TPTP), Business Intelligence and Reporting Tools (BIRT), Data Tools Platform (DTP), Visual Editor (VE)…
- 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 1,000,000 download requests in 2006

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

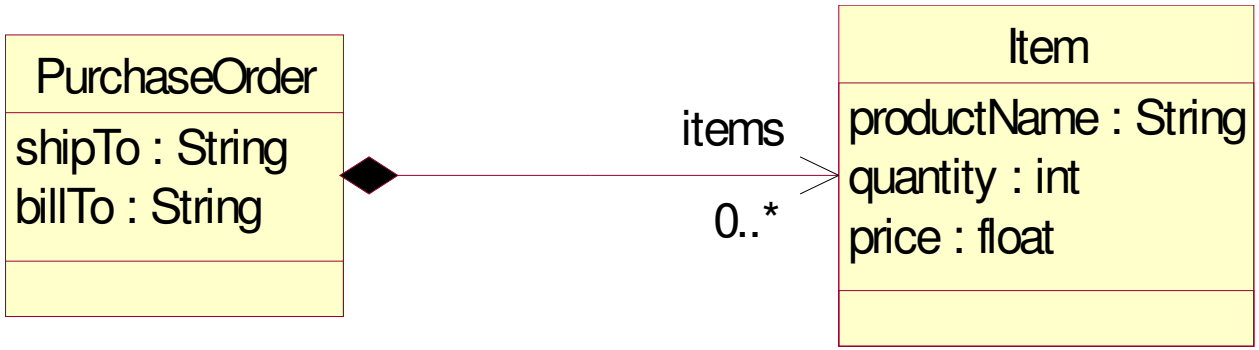
- Java Interfaces

```
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



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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

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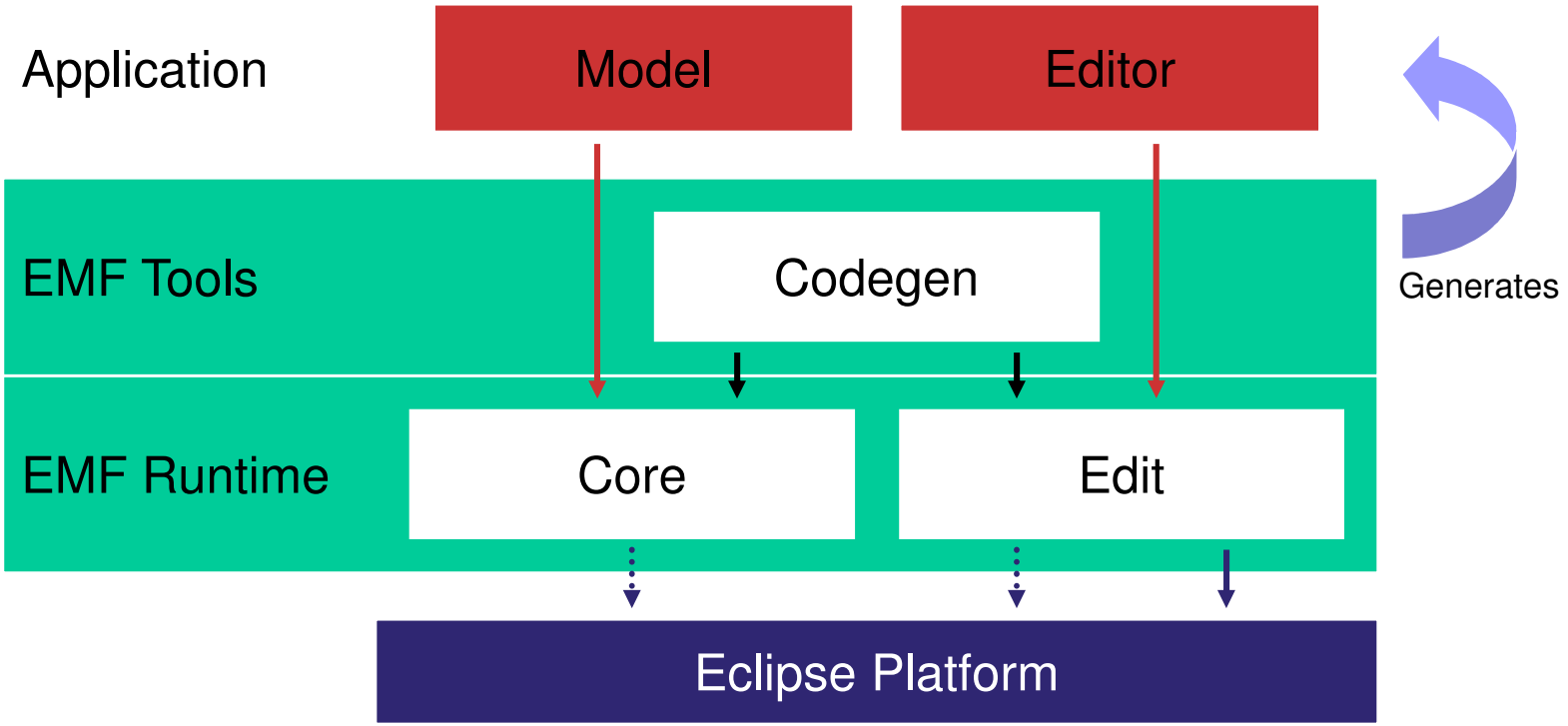
Typical EMF Usage Scenario

- 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

EMF Architecture



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

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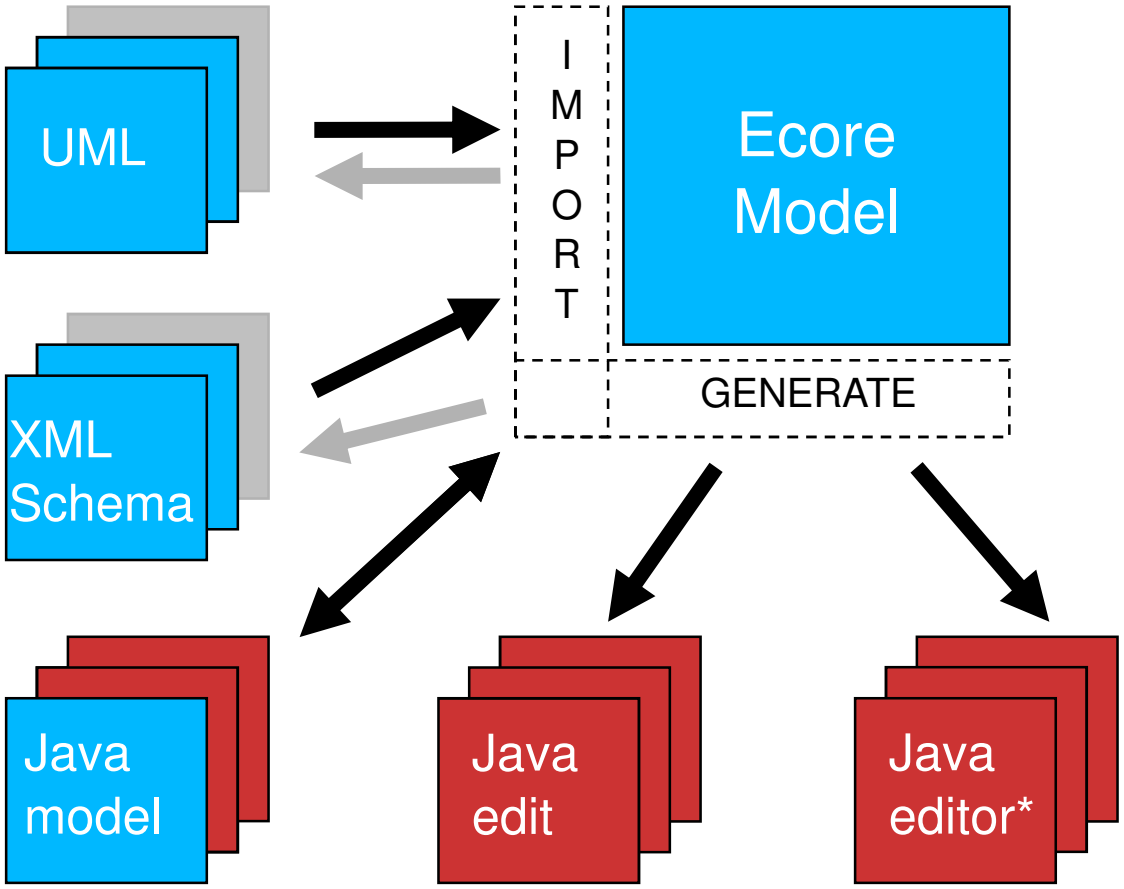
EMF Tools: Model Import and Generation



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)

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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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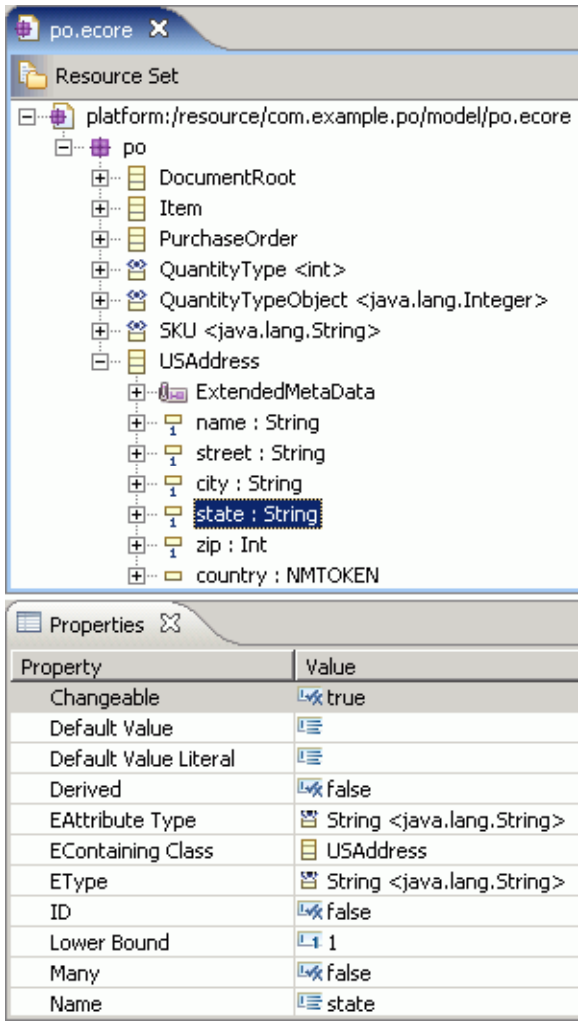
Ecore Model Editor

- 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



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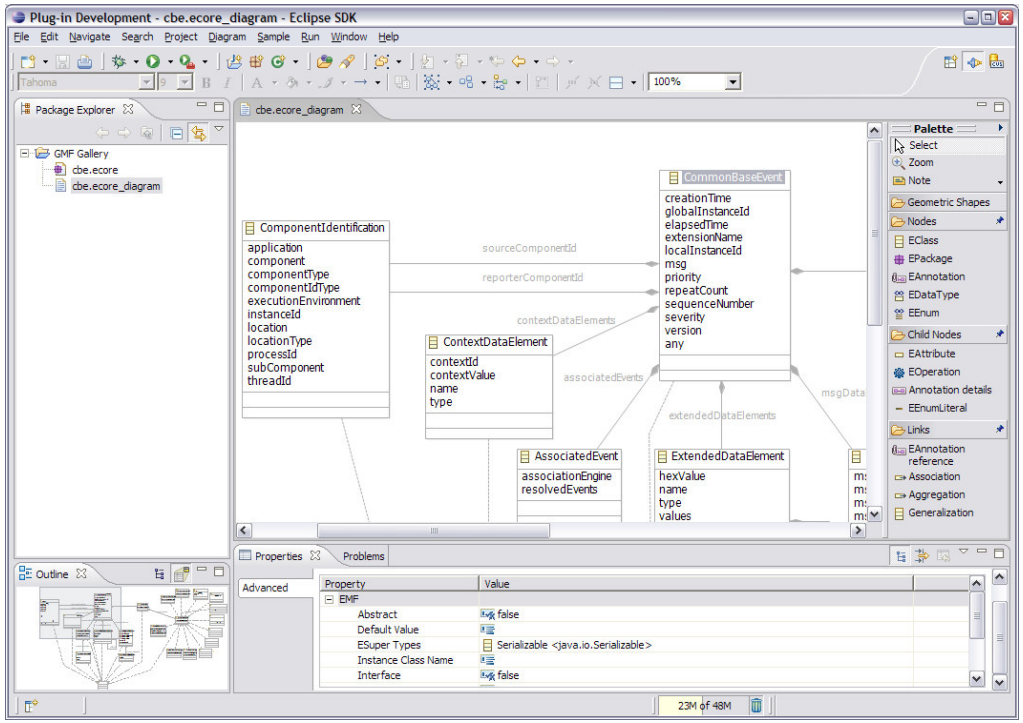
Ecore Model Editor

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



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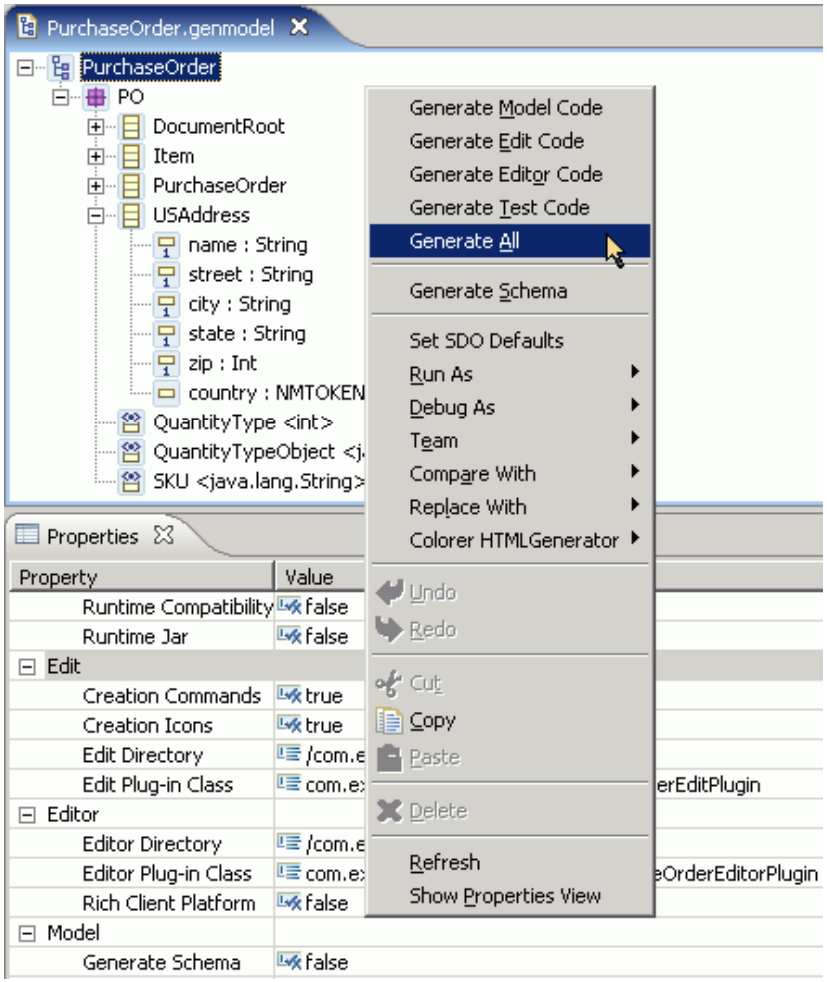
EMF Generator

- 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



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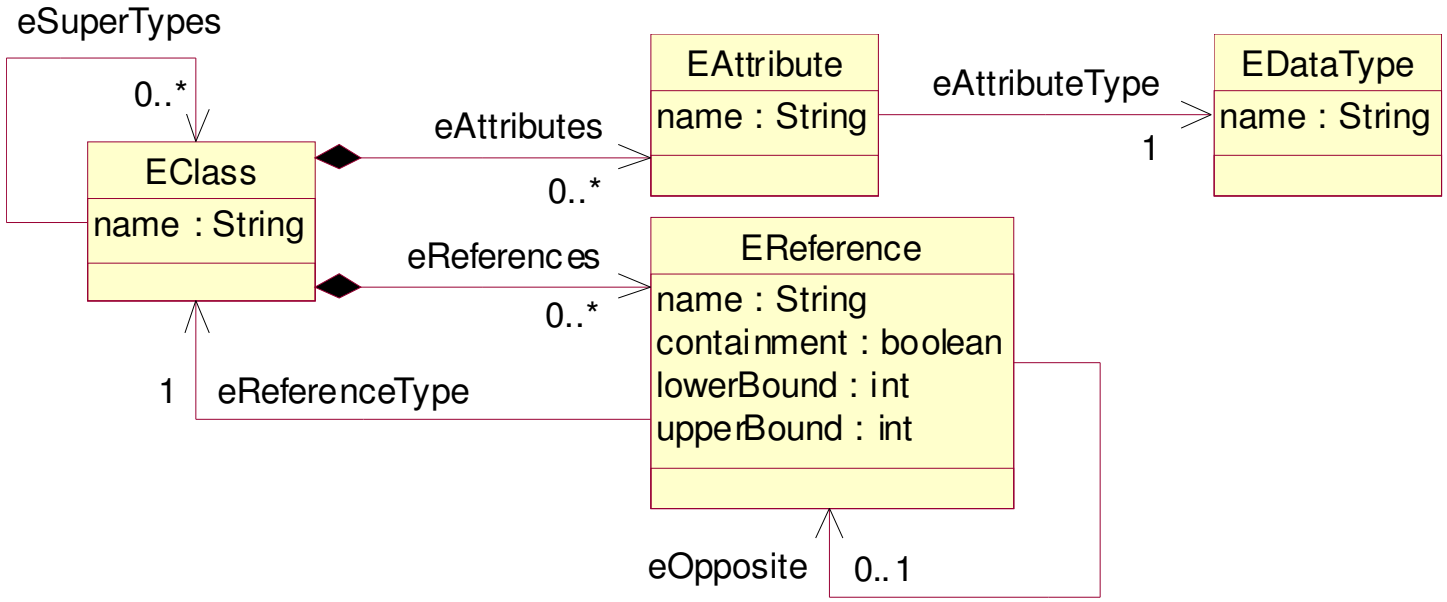
Summary of Generated Artifacts

- 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...

The Ecore (Meta) Model

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



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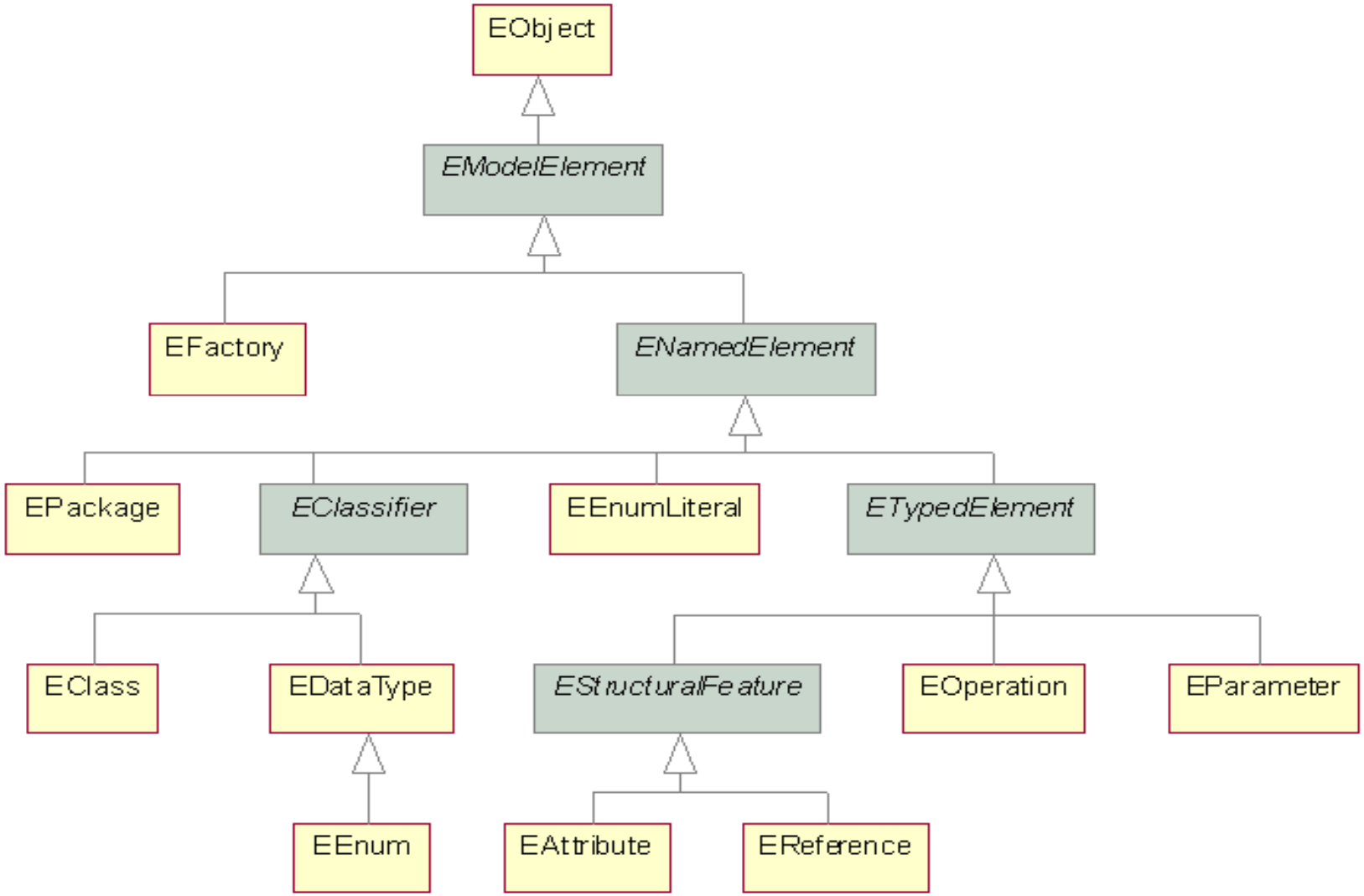
The Ecore Metamodel



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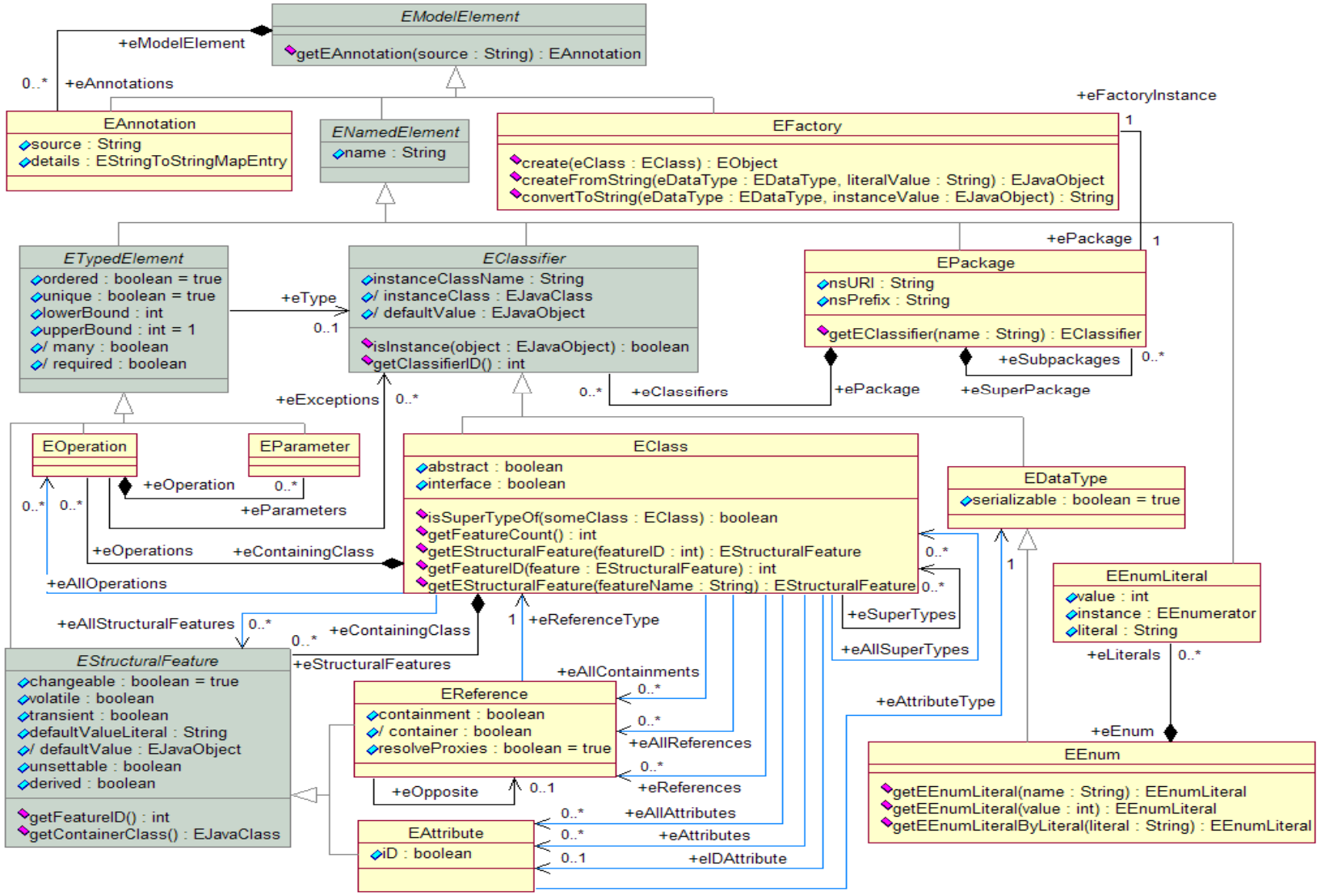
The Ecore Metamodel



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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

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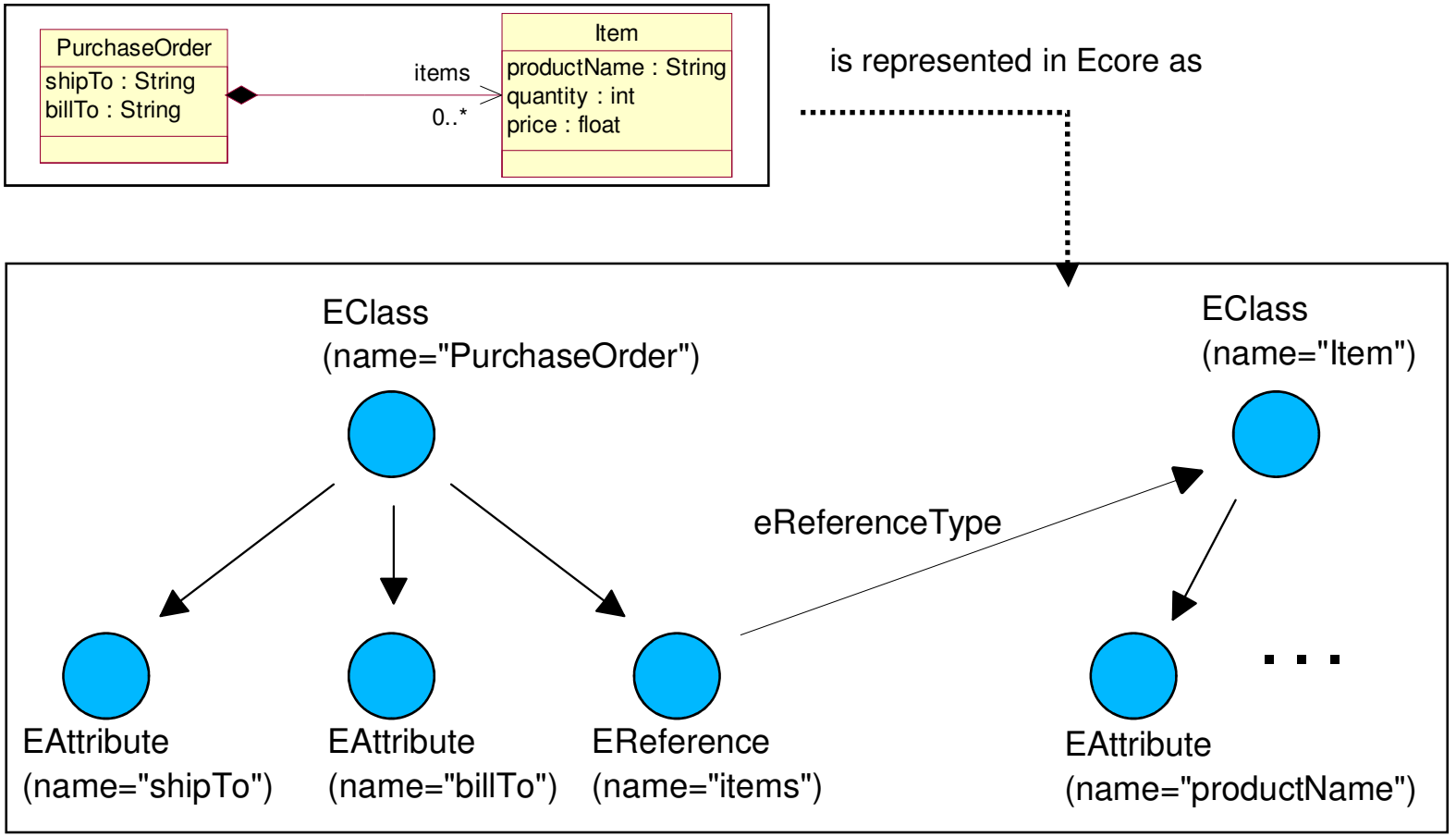
Ecore Model for Purchase Orders



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)

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.

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<Item> 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();
  //or POPackage.Literals.ITEM

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

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.");
```

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