Analysis & Design of XML Vocabularies with UML

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Agenda

- Conceptual analysis of XML vocabularies
- Designing XML schemas with UML
- UML Profile for XML schemas
- Supporting alternative XML schemas:
  - W3C XML Schema, RELAX NG, SOX, DTD, ...
- Case studies and lessons learned
  - FpML financial products schema
  - xCBL e-commerce vocabulary
  - XMI 2.0 schema reverse-engineered to UML
  - TREX schema grammar

Mapping UML to XML

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- Forward and Reverse engineering UML models to and from XML schemas
- Basic mapping rules

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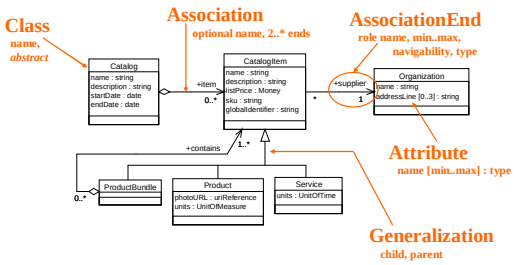
UML Class Diagram for CatML



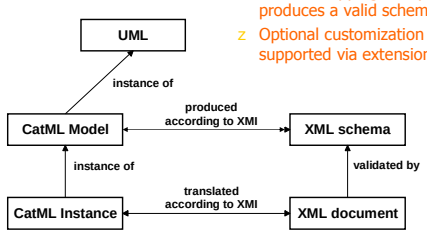
CatML as Portal Content Language

- This demo portal uses the Apache Jetspeed server
- Product Detail portlet is based on this simple CatML model
- Other portlets for price discounts and categories are from an extended model

Goals of Mapping

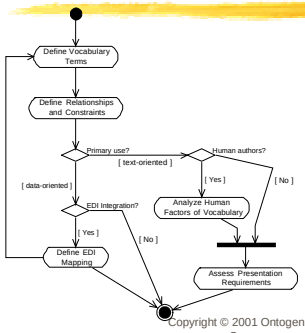
- Produce a usable XML schema from any UML class diagram, without use of extension stereotypes
- Customize schema specification by using UML profile extensions (required for most reverse-engineering)
- Start with XMI 1.1 specification as default, baseline production rules
- Possible to automate both schema generation and reverse-engineering
- UML packages should be mapped to XML namespaces and modular schema design

Mapping UML to Schemas & Instance



- Default mapping always produces a valid schema.
- Optional customization is supported via extensions

Forward Engineering Schemas



- Analysis of business vocabulary guides the development of new XML schemas.
- Requirements for data-oriented or text-oriented use determine the final design.
- This is a UML Activity diagram, often used for business process diagramming.

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Reverse Engineering Schemas

- Integrate existing XML schema assets into UML software engineering tools and repositories
- Use the same mapping rules as forward engineering
- Support round-trip development process
- Unless the schema was written with strict adherence to XMI production rules, then UML modeling extensions are probably required
- Use reverse-engineered schemas a part of a larger new development project
  - Examples: UDDI, WSDL, XHTML, NewsML, FpML, xCBL, DocBook, xlang, TREX grammar

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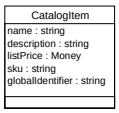
UML Class and Attributes




```
<xs:element name="CatalogItem" type="cml:CatalogItem"/>

<xs:complexType name="CatalogItem">
  <xs:all>
    <xs:element name="name" type="xs:string"/>
    <xs:element name="description" type="xs:string"/>
    <xs:element name="listPrice">
      <xs:complexType>
        <xs:sequence>
          <xs:element ref="cml:Money"/>
        </xs:sequence>
      </xs:complexType>
    </xs:element>
    <xs:element name="sku" type="xs:string"/>
    <xs:element name="globalIdentifier" type="xs:string"/>
  </xs:all>
</xs:complexType>
```

Allows unordered element content, but still enforces min/maxOccurs

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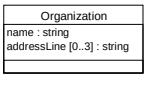
UML Attribute




```
<xs:element name="Organization"
            type="cml:Organization"/>

<xs:complexType name="Organization">
  <xs:sequence>
    <xs:element name="name" type="xs:string"/>
    <xs:element name="addressLine" type="xs:string"
                minOccurs="0" maxOccurs="3" />
  </xs:sequence>
</xs:complexType>
```

- All UML attributes are mapped to XML elements in these examples, but you can control this via UML extensions.
- UML attributes are [1..1] multiplicity by default (i.e. required)

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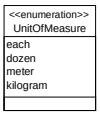
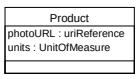
Enumerated Datatypes






```
<xs:simpleType name="UnitOfMeasure">
  <xs:restriction base="xs:string">
    <xs:enumeration value="each"/>
    <xs:enumeration value="dozen"/>
    <xs:enumeration value="meter"/>
    <xs:enumeration value="kilogram"/>
  </xs:restriction>
</xs:simpleType>

<Product>
  <units>each</units>
</Product>

<Product units="each">
  ...
</Product>
```

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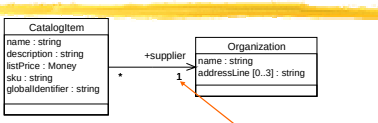
UML Association




```
<xs:complexType name="CatalogItem" >
 <xs:all>
  . . .
  <xs:element name="supplier">
   <xs:complexType>
    <xs:sequence>
     <xs:element ref="cml:Organization"/>
    </xs:sequence>
   </xs:complexType>
  </xs:element>
 </xs:all>
</xs:complexType>
```

Enforces association multiplicity (1..1 in this example)

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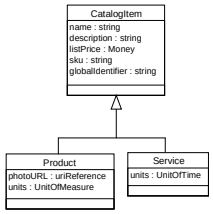
UML Class Inheritance




```
<xs:element name="Product" type="cml:Product"
            substitutionGroup="cml:CatalogItem" />

<xs:complexType name="Product">
 <xs:complexContent>
  <xs:extension base="cml:CatalogItem">
   <xs:all>
    <xs:element name="photoURL"
                type="xs:uriReference"/>
    <xs:element name="units"
                type="cml:UnitOfMeasure"/>
   </xs:all>
  </xs:extension>
 </xs:complexContent>
</xs:complexType>
```

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Schema Generation

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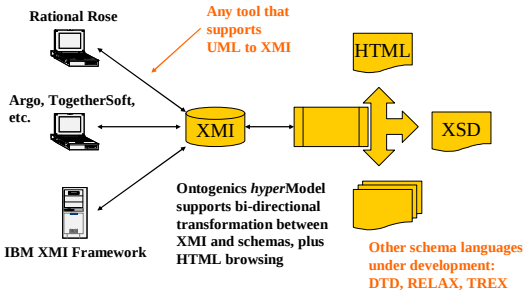
UML Model Transformation



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XML Metadata Interchange (XMI)

- Standard XML interchange format for UML
  - adopted by the Object Management Group (OMG)
  - gaining widespread acceptance
- But, XMI is more general than this…
  - create a DTD/schema for any MOF metamodel
  - serialize XML document for metamodel instance
  - UML is only one of several metamodels using XMI
    - Common Warehouse Metamodel (CWM)
    - CORBA Component Model

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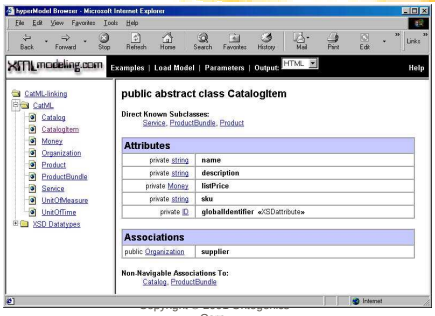
*hyper*Model UML Model Browsing



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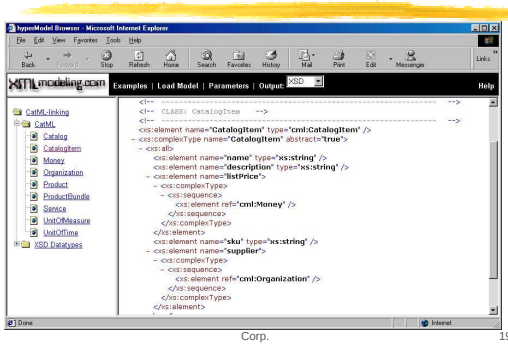
*hyper*Model XML Schema Generation



Customized Mapping

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UML Profile for XML

- Stereotypes
  - An extension to the UML language itself. A stereotype allows a modeler to attach a new meaning to one of the UML foundational elements, e.g. Class, Attribute, Association, Package, etc. A stereotype is usually represented on a diagram as the name surrounded by guillements << >>. Alternatively, a stereotyped element can be shown as an icon on the UML diagram.
- Tagged Value
  - An extension to the attributes of a UML model element. Each model element has a standard set of attributes; for example, each UML Class has a name, visibility, etc. A tagged value defines a new attribute that is associated with a stereotyped model element. A tagged value is shown on the diagram as a name/value string: {tagName=value}.

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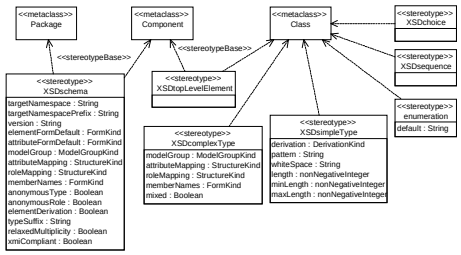
UML Profile for XML (part 1)



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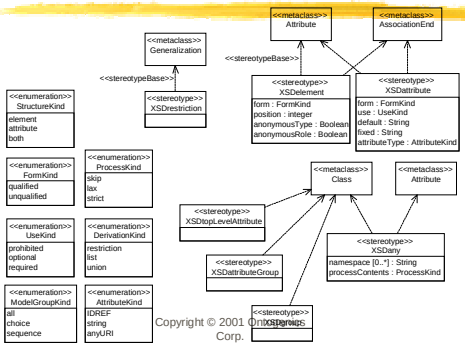
UML Profile for XML (part 2)



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<<XSDattribute>>

UML Construct	Attribute AssociationEnd
Description	This stereotype may be assigned to either a UML Attribute or an AssociationEnd to indicate that the corresponding UML construct should be generated as an *attribute* definition within the parent complexType, and not generated as an *element* definition.
Tagged Values	form (qualified | unqualified) – overrides the attributeFormDefault selection set for the <<XSDschema>> containing this definition. use (prohibited | optional | required) – As defined by the XML Schema specification. default – string containing attribute default value fixed – string containing attribute fixed value

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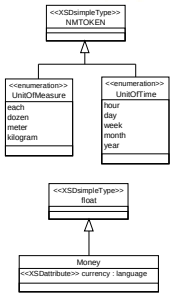
<<XSDsimpleType>>



UML Construct	Class
Description	Define a new XML Schema simpleType. The UML class with this stereotype is usually a specialization of another simpleType, possibly owned by the XML Schema Datatypes namespace. If no superclass is specified, then derive this simpleType from 'string'.
Tagged Values	derivation (restriction | list | union) – select one of the three kinds of derivation, as defined by the XML Schema Datatypes specification. pattern – as defined by the XML Schema Datatypes specification. length – as defined by the XML Schema Datatypes specification. minLength – maxLength – and others…

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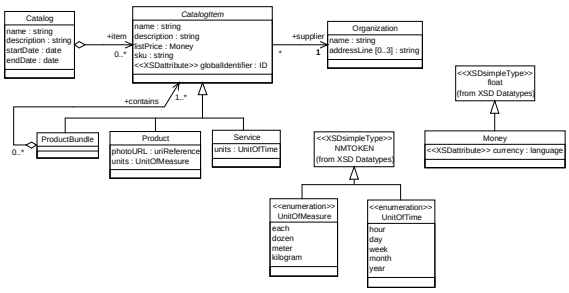
UML Diagram with Stereotypes



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Customized CatML Schema

```
<xs:complexType name="CatalogItem" abstract="true">
  <xs:all>
    <xs:element name="name" type="xs:string"/>
    ...
  </xs:all>
  <xs:attribute name="globalIdentifier" type="xs:ID" use="required"/>
</xs:complexType>

<xs:complexType name="Money">
  <xs:simpleContent>
    <xs:extension base="xs:float">
      <xs:attribute name="currency" type="xs:language" use="required"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
```


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Reverse Engineering

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- **Manual**
  - XHTML (represent DTD modularity)
- **Automated**
  - NewsML, FpML, xCBL, UDDI, WSDL, xlang, DocBook, TREX grammar, XMI 2.0

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Reverse Engineering XHTML

- Divide a large schema into reusable parts
  - "modularization" in the XHTML specification
- Explore the ability to map text-oriented DTDs into UML, then into an W3C Schema
- The modularization is defined by content group parameter entities in the DTD. How well do these map to generalization and inheritance in the UML model?

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Goals of XHTML Specification

- XHTML represents the essential core of elements required for presentation of hypertext documents
  - omit the embedded presentation tags and attributes from HTML 4.0
- XHTML Basic was designed for simple devices such as mobile phones, PDAs, pagers, etc.
- XHTML Basic modules may also be included in other vocabularies
  - e.g., allow HTML text in a product description element content, but without allowing <table>

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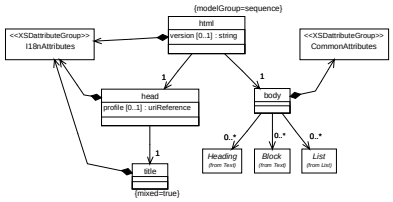
Structure Module



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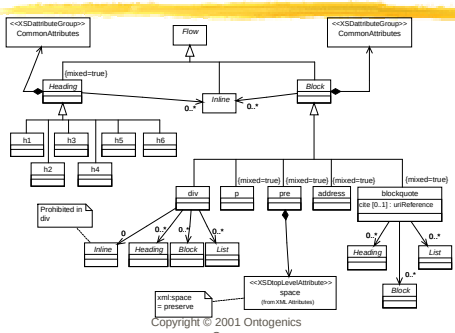
Text Module



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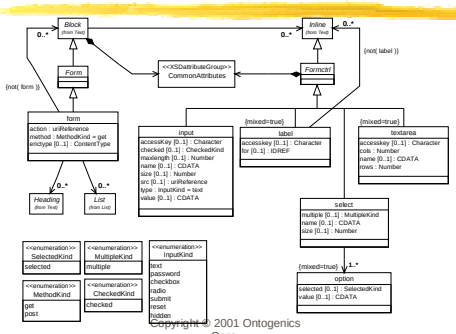
Basic Forms Module



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Lessons Learned from XHTML

- Generalization in UML provides a very effective way to represent reusable content groups in XML Schema
  - Association to an abstract superclass allows all subclasses to be included in that relationship
- Shared attribute collections are sometimes difficult to represent without excessive duplication
  - However, generalization hierarchy helps to keep attributeGroup associations from cluttering the model
- It's difficult to capture all constraints in the UML model structure (e.g. cannot contain *Inline*)
  - Schema languages like Schematron (based on constraint rules) may be complementary to W3C Schema

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Reverse Engineering XMI 2.0

- UML model was reverse engineered from the XMI 2.0 schema included in the June 2001 spec
- Comparable with the original UML model includes in Chapter 4, except <<XSDany>> classes replace MOF RefBaseObject
- This model was generated on the airplane ride to Boston...

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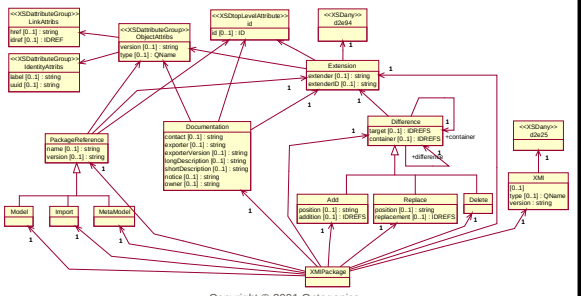
XMI 2.0 imported from XML Schema



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FpML Vocabulary

- Financial Products Markup Language (FpML)
- FpML Architecture document is based on object-oriented design practices, mapped into guidelines for manually authoring DTD/XSD
- Lessons:
  - manual division of model into readable diagrams
  - enhance reverse engineering stylesheet to recognize plain associations, aggregations, and composition

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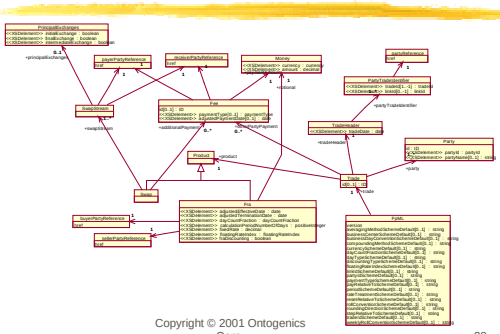
FpML Model (*small* excerpt)



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xCBL from SOX to UML to XSD

- Automated reverse engineering from SOX schema to UML model
  - (SOX is an OO schema language developed by CommerceOne, to be replaced by XML Schema)
- Then, generated XSD schema from the UML model which successfully validates original XML document instances for auction messages.
- This UML model was produced from SOX

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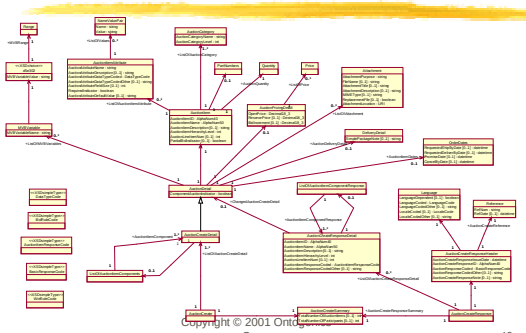
xCBL AuctionCreateDetail



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Reverse Engineering RELAX NG

- Preliminary work-in-progress to reverse/forward engineer TREX schemas
  - (TREX & RELAX now combined and renamed to RELAX NG, moving toward ISO standard via OASIS)

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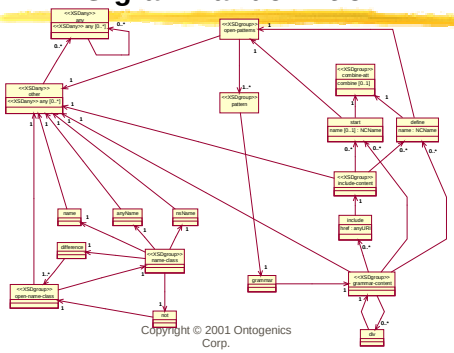
RELAX NG grammar definition



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Challenges to Resolve

- Reverse engineering schemas into a good platform independent conceptual model
- Automated class diagram layout is pretty bad…
- Many UML tools do not allow display of tagged values (e.g. position & modelGroup)
- Some schema constraints don't map well to UML
- We need to separate UML model structure definition from design profile values