Enterprise Application Integration

1. Basic XML

1.1. Introduction to XML

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Motivation

- Computers typically need to exchange information between **incompatible systems**
  - **Hardware Incompatibility**
    e.g. PC vs. MAC: different representations for integer and floating point numbers
  - **Data Incompatibility**
    e.g. MS Word vs. Adobe PDF (the information is stored using a proprietary format. This implies that there must exist converters between different formats and that the formats are actually documented.)

Java is not the solution...

- Java and simple agnostic formats are not a solution
  - E.g. Java Serialization Format, Sun XDR, CORBA CDR

- When Java serializes an object to disk, it's stored in a hardware-independent format
  - But, how to use that data in… C++, MS Word, etc?
  - Applications don't understand Java's native formats!

- Sun XDR, CORBA CDR are hardware independent formats but…
  - They were thought for transmitting data through the network, not to store data in disk
  - In 100 years, how can I be sure to be able to access the data?
  - Dichotomy between **storing data** and **transmitting data**

- Databases have the same problem
  - Data is stored on proprietary formats

Business Perspective

- Business Systems need documents that can be read and understood by **people** and **machines**
  - Well… it's possible to read ASCII from any application. That's one of the reasons it has been chosen for HTML and web pages.

- Documents need to be sufficiently structured so that its information and data can be **automatically processed**
  - Well.. HTML can be seen and edited using many different applications. Tags guaranty some structure.

- **So: Why isn't HTML the solution?**

Why to go beyond HTML

- HTML is only a standard for how to render **textual information** that must be shown **visually**
  - T*ags* only define visual appearance. E.g: bold (<b>), itálico (<i>)
  - We need something for the data, not how the data is shown.
  - Some data does not have an immediate visual representation (e.g. sound)

- HTML lacks the capability of saying what the data means (lack of meta-information)
  - In data-bases that's achieve by using a BD *schema*
  - It's necessary to know what each data item represents
  - It's necessary to know the relationship between data items

EDI

- **EDI** = **E**lectronic **D**ata **I**nterchange
- Used for may years and standardized as ANSI X12. (Still quite used!)
- Explicitly thought for commercial data interchange between different business partners
- Complex and Specific
  - "For example an EDI 940 ship-from-warehouse order is used by a manufacturer to tell a warehouse to ship product to a retailer. It typically has a ship to address, bill to address, a list of product numbers (usually a UPC code) and quantities. It may have other information if the parties agree to include it."

And example of an EDI document

```
ISA*00*          *00*          *01*123454321      *01(Continued)
*012341234      *031016*2359*U*00401*987600111*0*P*:
\GS*RA*123454321*012341234*031016*2359*987600111*X*004010
\ST*820*987600111
\BPR*C*77.77*C*ACH*CTX*01*234056789*DA*0099109999*(Continued)
*123454321*01*045678099*DA*1008973899*031016
\TRN*1*0310162359
\REF*AA*EDI6
\N1*PR*WHIZCO OF AMERICA INC
\N3*55 MEGAPLEASANT ROAD*SUITE 999
\N4*SUPERVILLE*NY*10954
\N1*PE*YOWZACO
\ENT*1
\RMR*AP*1111111111111111*PO*11.11
\RMR*AP*2222222222222222*PO*22.22
\RMR*AP*4444444444444444*PO*44.44
\DTM*055*031016
\SE*000000014*987600111
\GE*1*987600111
\IEA*1*987600111\
```

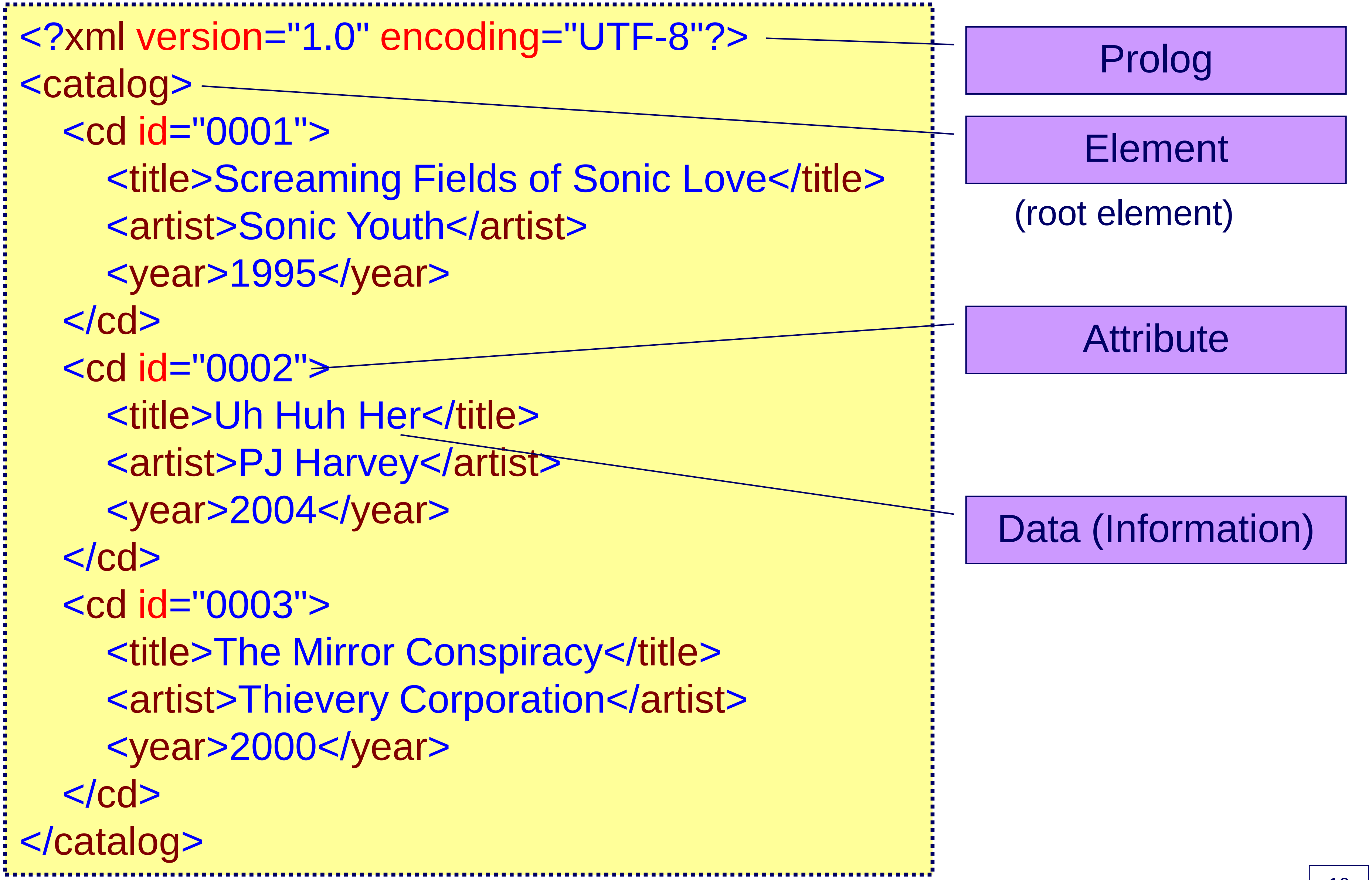
XML = e**X**tensible **M**arkup **L**anguage

- Substitutes EDI solving many of its problems
- Subset of SGML (*Standard Generalized Markup Language*)
  - Tag-based
  - Structured (documents are seen as a tree)
  - Extensible (the tags are not pre-defined and fixed)
  - Covers both **Data** and **Meta-information**
- Independent of storage and transmission mechanisms
  - e.g. you can sent it by email, ftp, you can archive it on a database or a text-file.
  - Data is encoded in ASCII/UNICODE (e.g. UTF-8)
- Readable by humans and editable in any tool
- Can be automatically validated
  - Note: only syntax and structure

Small example...

```xml
<?xml version="1.0" encoding="UTF-8"?>
<catalog>
   <cd id="0001">
      <title>Screaming Fields of Sonic Love</title>
      <artist>Sonic Youth</artist>
      <year>1995</year>
   </cd>
   <cd id="0002">
      <title>Uh Huh Her</title>
      <artist>PJ Harvey</artist>
      <year>2004</year>
   </cd>
   <cd id="0003">
      <title>The Mirror Conspiracy</title>
      <artist>Thievery Corporation</artist>
      <year>2000</year>
   </cd>
</catalog>
```

Small example...



```
<?xml version="1.0" encoding="UTF-8"?>
<catalog>
   <cd id="0001">
      <title>Screaming Fields of Sonic Love</title>
      <artist>Sonic Youth</artist>
      <year>1995</year>
   </cd>
   <cd id="0002">
      <title>Uh Huh Her</title>
      <artist>PJ Harvey</artist>
      <year>2004</year>
   </cd>
   <cd id="0003">
      <title>The Mirror Conspiracy</title>
      <artist>Thievery Corporation</artist>
      <year>2000</year>
   </cd>
</catalog>
```

Prolog

Element

(root element)

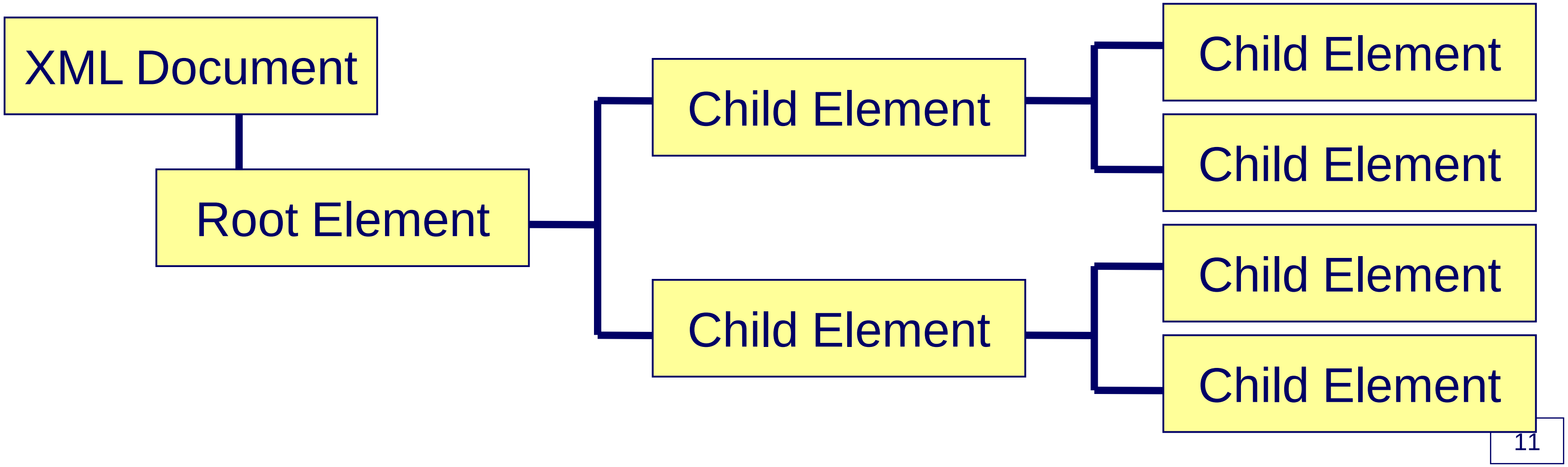
Attribute

Data (Information)

Structure of an XML file

- **Prolog:** File line of the XML file. Specifiy that's XML!
  - <?xml version="1.0" encoding="UTF-8"?>
  - Contains definitions that apply to all the document (e.g. version, encoding, DTD)

- There's a single **root element** that encapsulates all others. The elements bellow are called *nodes* or *child nodes*.
- It's **necessarily hierarchical**.



Well-formed documents

- The prolog is compulsory
- All elements must have an opening tag and closing tag
  - <title>Screaming Fields of Sonic Love</title>
  - Elements without data (e.g. <OutOfStock></OutOfStock>) can be represented by a single tag (e.g. <OutOfStock/>)
  - XML is case-sensitive. E.g. <title> é diferente de <TITLE>
  - Attributed must be between quotes. E.g. <cd id="0002">
  - Elements which name starts with "?" represent special processing instructions which are application specific.

- Elements must have a correct sequencing following an tree structure
  - <cd><title></cd></title> is incorrect!
  - There must be a root element

- XML Identifiers
  - Cannot start by numbers or punctuation signs
  - Can contains letters and numbers but not spaces
  - Cannot start by "XML", "xml", etc.
  - ":" is reserved for namespaces

Elements vs. Attributes

- In many cases information can be represented either as elements or attributes
  - There isn’t a clear rule on when to use each

- Rules of thumb
  - Elements can have hierarchy, attributes cannot
  - Elements can store multiple values, attributes cannot
  - Identifiers are normally attributes

```
<cd id="0002">
   <title>Uh Huh Her</title>
   <artist>PJ Harvey</artist>
   <year>2004</year>
</cd>
```

vs.

```
<cd>
   <id>0002</id>
   <title>Uh Huh Her</title>
   <artist>PJ Harvey</artist>
   <year>2004</year>
</cd>
```

XML Namespaces

- Imagine that you have to create a single XML file from two different sources. E.g. create a single unified catalog of products

cd_catalog.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<catalog>
    <cd id="0001">
        <title>Screaming Fields of Sonic Love</title>
        <artist>Sonic Youth</artist>
        <year>1995</year>
    </cd>
</catalog>
```

book_catalog.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<catalog>
    <book id="0001">
        <title>1984</title>
        <author>George Orwell</author>
        <year>1949</year>
    </book>
</catalog>
```

Problem: The same elements are used to identify data with different semantics.

XML Namespaces (2)

- Imagine that you have to create a single XML file from two different sources. E.g. create a single unified catalog of products

cd_catalog.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<cdns:catalog xmlns:cdns=“http://cdstore.com/cd_catalog”>
    <cdns:cd id="0001">
        <cdns:title>Screaming Fields of Sonic Love</cdns:title>
        <cdns:artist>Sonic Youth</cdns:artist>
        <cdns:year>1995</cdns:year>
    </cdns:cd>
</cdns:catalog>
```

book_catalog.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<bns:catalog xmlns:bns=“http://bookstore.com/book_catalog”>
    <bns:book id="0001">
        <bns:title>1984 </bns:title>
        <bns:author>George Orwell</bns:author>
        < bns:year>1949</bns:year>
    </bns:book>
</bns:author>
```

XML Namespaces (3)

- It’s not necessary to prefix all elements
  - Child elements inherit from their parents

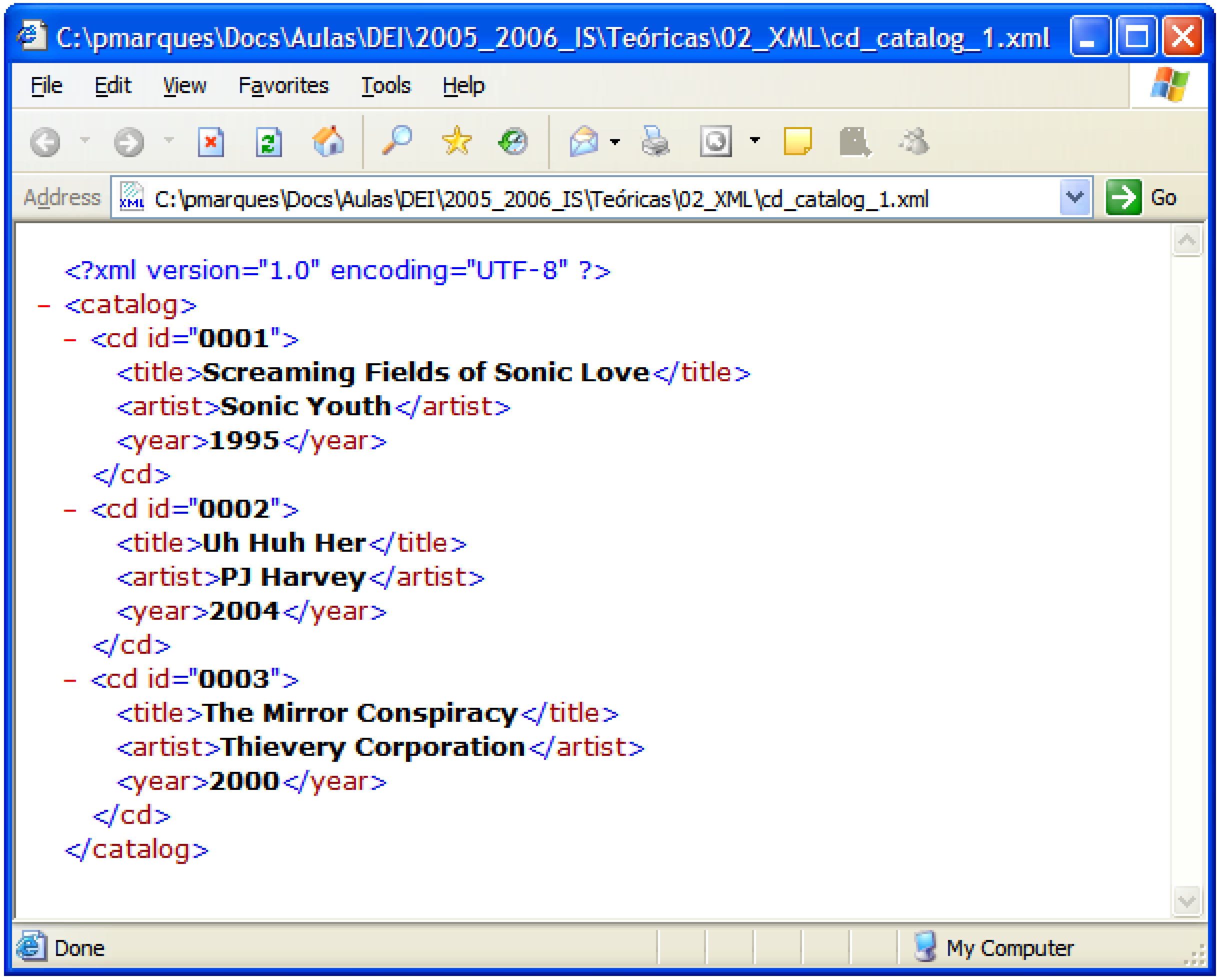
```
<?xml version="1.0" encoding="UTF-8"?>
<cdns:catalog xmlns:cdns=“http://cdstore.com/cd_catalog”>
    <cd id="0001">
        <title>Screaming Fields of Sonic Love</title>
        <artist>Sonic Youth</artist>
        <year>1995</year>
    </cd>
</catalog>
```

- The URI specified using xmlns does not have to contain anything valid. It’s only used as identifier (key).
  - Even so, it’s common that it points to a real web page.
- **One important aspect** of all this is that different organizations standardize different XML formats for different domain applications (XML Schemas).
  - XML Schemas ←→ XML Namespaces
  - E.g. XSD, XSL, MathML, BEPL4WS, etc.

Example of XML and Namespaces

```xml
<?xml version="1.0" encoding="UTF-8"?>
<catalog>
    <cd id="0001">
        <title>Screaming Fields of Sonic Love</title>
        <artist>Sonic Youth</artist>
        <year>1995</year>
    </cd>
    <cd id="0002">
        <title>Uh Huh Her</title>
        <artist>PJ Harvey</artist>
        <year>2004</year>
    </cd>
    <cd id="0003">
        <title>The Mirror Conspiracy</title>
        <artist>Thievery Corporation</artist>
        <year>2000</year>
    </cd>
</catalog>
```

Example of XML and Namespaces (2)



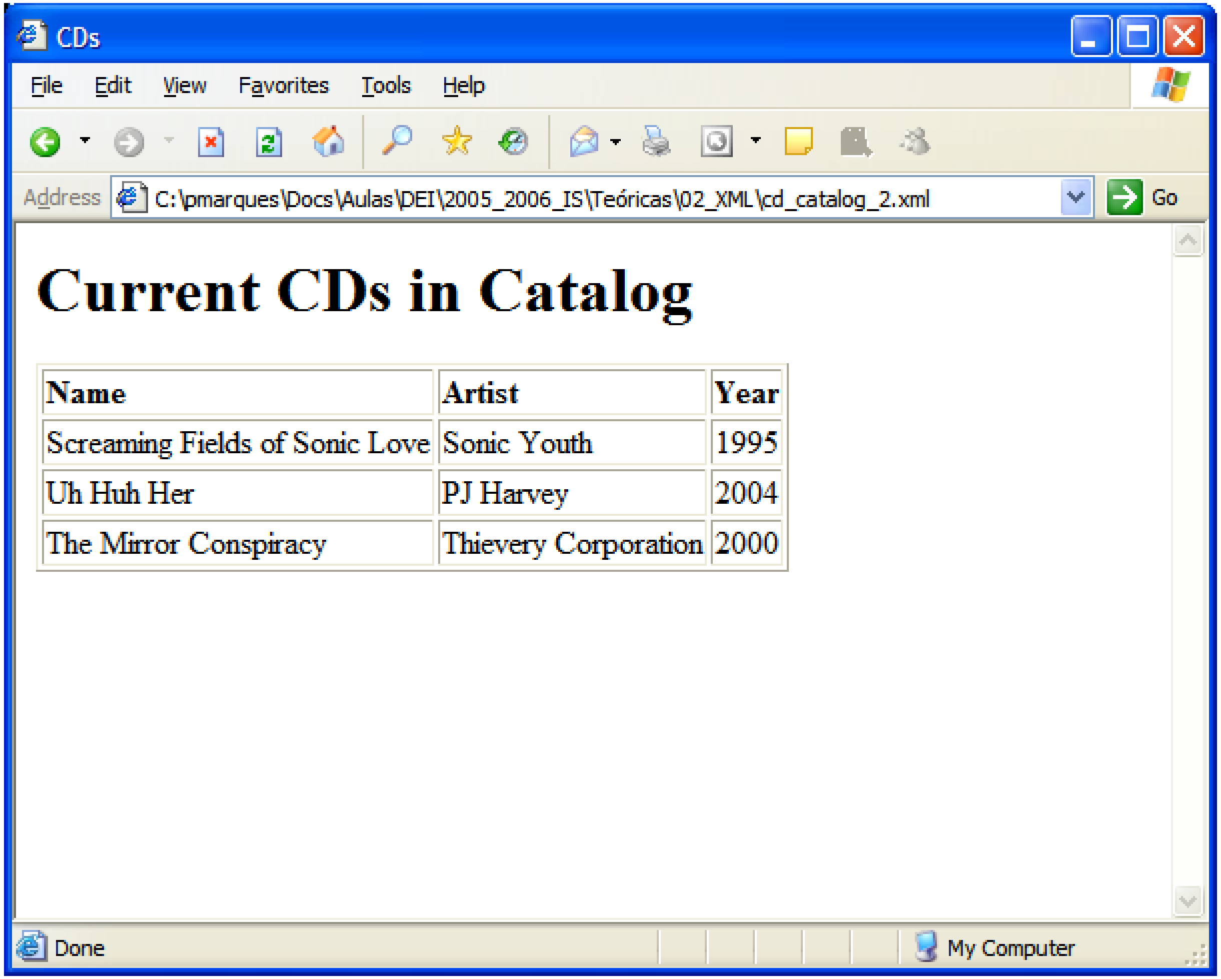
C:\pmarques\Docs\Aulas\DEI\2005_2006_IS\Teóricas\02_XML\cd_catalog_1.xml
File Edit View Favorites Tools Help
Address C:\pmarques\Docs\Aulas\DEI\2005_2006_IS\Teóricas\02_XML\cd_catalog_1.xml
Go
Done
My Computer

```
  <?xml version="1.0" encoding="UTF-8" ?>
- <catalog>
  - <cd id="0001">
      <title>Screaming Fields of Sonic Love</title>
      <artist>Sonic Youth</artist>
      <year>1995</year>
    </cd>
  - <cd id="0002">
      <title>Uh Huh Her</title>
      <artist>PJ Harvey</artist>
      <year>2004</year>
    </cd>
  - <cd id="0003">
      <title>The Mirror Conspiracy</title>
      <artist>Thievery Corporation</artist>
      <year>2000</year>
    </cd>
  </catalog>
```

Example of XML and Namespaces (3)

```xml
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="catalog_to_html.xsl"?>
<catalog>
    <cd id="0001">
        <title>Screaming Fields of Sonic Love</title>
        <artist>Sonic Youth</artist>
        <year>1995</year>
    </cd>
    <cd id="0002">
        <title>Uh Huh Her</title>
        <artist>PJ Harvey</artist>
        <year>2004</year>
    </cd>
    <cd id="0003">
        <title>The Mirror Conspiracy</title>
        <artist>Thievery Corporation</artist>
        <year>2000</year>
    </cd>
</catalog>
```

Example of XML and Namespaces (4)



C:\pmarques\Docs\Aulas\DEI\2005_2006_IS\Teóricas\02_XML\cd_catalog_2.xml

Current CDs in Catalog

Name	Artist	Year
Screaming Fields of Sonic Love	Sonic Youth	1995
Uh Huh Her	PJ Harvey	2004
The Mirror Conspiracy	Thievery Corporation	2000

catalog_to_html.xsl

```
<?xml version="1.0" encoding="UTF-8"?>
<html xmlns:xsl="http://www.w3.org/1999/XSL/Transform" xsl:version="1.0">
   <head><title> CDs </title></head> <body>
         <h1> Current CDs in Catalog</h1>
            <table border="1">
                 <tr>
                    <td><b> Name </b></td>
                    <td><b> Artist  </b></td>
                    <td><b> Year   </b></td>
                 <tr>

                 <xsl:for-each select="//cd">
                    <tr>
                       <td> <xsl:value-of select="title"/>    </td>
                       <td> <xsl:value-of select="artist"/> </td>
                       <td> <xsl:value-of select="year"/>  </td>
                    </tr>
                 </xsl:for-each>
            </table>
  </body>
</html>
```

Other relevant issues

- White space is preserved
  - Even so, when processing XML there are several ways of treating white space (normalization, canonical forms)
- CR/LF is converted into LF
- Comments:
  - <!-- This is comment -->
- **Entities**
  - Certain characters are reserved (e.g. "<")
  - To include them use "&name;". This type of construction is called an entity and it has to be previously defined. E.g:

    &lt; = "<"
    &gt; = ">"
    &copy; = "©"
  - In reality, you can pre-define any string

Enterprise Application Integration

1. Basic XML

1.2. Validation – DTD and XSD

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Validation

- Having a well-formed document does not mean it’s valid.
  - How can you tell if a certain element (tag) can be present?
  - How can you tell if a certain element can have a certain attribute?
  - How can you tell if a certain element cannot occur more than once?

- **DTD** = **D**ocument **T**ype **D**efinition
  - Original specification which states which elements and attributes a certain XML file can have, their order and number of times they can appear
  - DTD: Specifies if documents are structurally valid
  - The DTD specification is not XML!
  - Does not support datatypes!

- **XML Schema (XSD)**
  - Similar objective to DTDs, but using XML
  - Supports datatypes and advanced validation
  - Currently, the most widely used approach

A simple DTD specification

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE catalog [
        <!ELEMENT catalog         (cd*)>
        <!ELEMENT cd              (title, artist, year?)>
        <!ATTLIST cd              id CDATA #REQUIRED>
        <!ELEMENT title           (#PCDATA)>
        <!ELEMENT artist          (#PCDATA)>
        <!ELEMENT year            (#PCDATA)>
]>

<catalog>
  <cd id="0001">
    <title>Screaming Fields of Sonic Love</title>
    <artist>Sonic Youth</artist>
    <year>1995</year>
  </cd>
  <cd id="0002">
    <title>Uh Huh Her</title>
    <artist>PJ Harvey</artist>
    <year>2004</year>
  </cd>
  <cd id="0003">
    <title>The Mirror Conspiracy</title>
    <artist>Thievery Corporation</artist>
    <year>2000</year>
  </cd>
</catalog>
```

Separation between information and meta-information

- Although DTDs can be directly embedded in XML doing so is not a good idea
  - It’s important to have a clear separation between information (XML) and meta-information (DTD, XSD)

cd_catalog.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE catalog SYSTEM “book_catalog.dtd”>

<catalog>
   ...
</catalog>
```

cd_catalog.dtd

```
<!DOCTYPE catalog [
            <!ELEMENT catalog          (cd*)>
            <!ELEMENT cd               (title, artist, year?)>
            <!ATTLIST cd               id CDATA #REQUIRED>
            <!ELEMENT title            (#PCDATA)>
            <!ELEMENT artist           (#PCDATA)>
            <!ELEMENT year             (#PCDATA)>
]>
```

DTD Definition – Elements

- A DTD defines a grammar for what definitions are valid in a XML file
- Definitions are naturally recursive.

- Each element is specified using the notation **!ELEMENT**
  - Each element can be simple text (#PCDATA – *Parsed Character Data*) or other elements
  - If an element is composed of other elements, you may specify how many times each can appear:
    - ? = 0 or 1 time
    - + = 1 or more times
    - * = 0 or more times
    - If you want a specific number of times, you have to do it manualy, as a sequence

  - Sequences of elements are defined by name being separated by commas “,”

Going back to the example...

```
<!DOCTYPE catalog [
          <!ELEMENT catalog          (cd*)>
          <!ELEMENT cd               (title, artist, year?)>
          <!ATTLIST cd               id CDATA #REQUIRED>
          <!ELEMENT title            (#PCDATA)>
          <!ELEMENT artist           (#PCDATA)>
          <!ELEMENT year             (#PCDATA)>
]>
```

- “**catalog**” is the **root element**
- “**catalog**” has **0 or more** “**cd**”
- Each “**cd**” **has, in sequence**:
  - **ONE** entity “**title**”
  - **ONE** entity “**artist**”
  - **ZERO OR ONE** entities “**year**”
- A “**title**” is simple **text** (#PCDATA)
- An “**artist**” is simple **text** (#PCDATA)
- A “**year**” is simple **text** (#PCDATA)

Elements (2)

- Defining elements
  - Empty elements (e.g. <in_stock/>) are specified by using EMPTY (e.g. <!ELEMENT in_stock EMPTY>)
  - Elements containing any type of information are specified by using ANY (in general, you should not use them...)
  - Alternatives while defining content are specified using commas. For instance:

    <!ELEMENT contact (email|phone|fax)+ >

    «Each element "contact" has one or more "email", "phone" or "fax"»
  - It's also possible to specify sequences with alternatives:

    <!ELEMENT contact (email, (phone|fax)*) >

    «Each element "contact" has to have an "email" where this email can be followed, optionally, by one or more occurences of "phone" and "fax"»

Defining Attributes

- Each attribute of an element is specified using !ATTLIST

```
<!ATTLIST   cd   id   CDATA   #REQUIRED>
            1    2      3          4
```

1. Name of the entity
2. Name of the attribute
3. Data type
4. Parameterization

- «Each entity “cd” has necessarily to have (#REQUIRED) an attribute called “id”, which value is text (#CDATA)»

Defining Attributes (2)

- General format while defining an attribute:

  <!ATTLIST element_name attribute_name attribute_type parameterization>

- E.g. DTD: <!ATTLIST cd is_available CDATA “yes”>
  XML: <cd id=“0001” is_available=“no”>

- Typically, the parameterization of an attribute represents a default value (in this case, “yes”). Nevertheless, other keywords can be used (e.g. #REQUIRED)

Attribute Parameterization

Value	Explanation
“value”	The default value of the attribute
#REQUIRED	The attribute value must be included in the element
#IMPLIED	The attribute does not have to be included
#FIXED value	The attribute value is fixed

Examples at:
http://www.w3schools.com/dtd

Some examples...

- **Default attribute value**
  - DTD: <!ELEMENT square EMPTY>
    <!ATTLIST square width CDATA "0">
  - Valid XML: <square width="100" />
- **#IMPLIED**
  - DTD: <!ATTLIST contact fax CDATA #IMPLIED>
  - Valid XML: <contact fax="555-667788" /> or <contact/>
- **#REQUIRED**
  - DTD: <!ATTLIST person number CDATA #REQUIRED>
  - Valid XML: <person number="5677" />
- **#FIXED**
  - DTD: <!ATTLIST sender company CDATA #FIXED "Microsoft">
  - Valid XML: <sender company="Microsoft" />
  - Invalid XML: <sender company="W3Schools" />
- **Enumerated attribute values**
  - DTD: <!ATTLIST payment type (check|cash) "cash">
  - Valid XML: <payment type="check" />

Attribute Types (attribute_type)

Value	Explanation
CDATA	The value is character data
(en1|en2|..)	The value must be one from an enumerated list
ID	The value is a unique id
IDREF	The value is the id of another element
IDREFS	The value is a list of other ids
NMTOKEN	The value is a valid XML name
NMTOKENS	The value is a list of valid XML names
ENTITY	The value is an entity
ENTITIES	The value is a list of entities
NOTATION	The value is a name of a notation
xml:	The value is a predefined xml value

Complete definition and examples at:
http://infohost.nmt.edu/tcc/help/pubs/dtd/attr-decl.html

Entity Definition

- Entities correspond to text abreviations
  - DTD: <!ENTITY copyright "(c) Copyright, 2005 – DEI">
    XML: <direitos> &copyright; </direitos>
  - ... in reality: "&lt;", "&gt;" are predefined entities in XML

- Entities can either be internal or external
  - Internal entities are defined directly on the current file

    <!ENTITY copyright "(c) Copyright, 2005 – DEI">

  - External entities are defined in some other file or URI/URL

    <!ENTITY copyright SYSTEM "system.dtd">

But…

- DTDs are not something specified in XML
  - Being XML a specified on how to store data, one would expect that the format of an explicit XML file (DTD) would be an XML file in itself

- A XML Schema corresponds to a specific set of tags that are used to describe metadata (i.e. DTDs)

- The functionality associated to XML Schema (XSD) is similar to the one of DTDs but… in XML!
  - In terms of added-value, the major improvement is the usage of data-types (pre-defined or user-defined) and allowing for a stricter data validation.
  - Most important problem: COMPLEXITY. People normally use tools to write it.

Example of an XSD file (cd_catalog.xsd)

```
<?xml version="1.0" encoding="utf-8"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
    <xsd:element name="catalog">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element minOccurs="0" maxOccurs="unbounded" ref="cd" />
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>
    <xsd:element name="cd">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element ref="title" />
                <xsd:element ref="artist" />
                <xsd:element minOccurs="0" maxOccurs="1" ref="year" />
            </xsd:sequence>
            <xsd:attribute name="id" type="xsd:string" use="required" />
        </xsd:complexType>
    </xsd:element>
    <xsd:element name="title" type="xsd:string" />
    <xsd:element name="artist" type="xsd:string" />
    <xsd:element name="year" type="xsd:string" />
</xsd:schema>
```

Example of an XSD file (cd_catalog.xsd)

```xml
<?xml version="1.0" encoding="utf-8"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
    <xsd:element name="catalog">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element minOccurs="0" maxOccurs="unbounded" ref="cd" />
            </xsd:sequence>
        </xsd:complexType>
    </xsd:element>
    <xsd:element name="cd">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element ref="title" />
                <xsd:element ref="artist" />
                <xsd:element minOccurs="0" maxOccurs="1" ref="year" />
            </xsd:sequence>
            <xsd:attribute name="id" type="xsd:string" use="required" />
        </xsd:complexType>
    </xsd:element>
    <xsd:element name="title" type="xsd:string" />
    <xsd:element name="artist" type="xsd:string" />
    <xsd:element name="year" type="xsd:string" />
</xsd:schema>
```

How to specify and XSD file?

```
<?xml version="1.0" encoding="UTF-8"?>
<catalog xmlns="http://cdstore.com"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://cdstore.com cd_catalog.xsd">

    <cd id="0001">
      <title>Screaming Fields of Sonic Love</title>
      <artist>Sonic Youth</artist>
      <year>1995</year>
   </cd>
   <cd id="0002">
      <title>Uh Huh Her</title>
      <artist>PJ Harvey</artist>
      <year>2004</year>
   </cd>
   <cd id="0003">
      <title>The Mirror Conspiracy</title>
      <artist>Thievery Corporation</artist>
      <year>2000</year>
   </cd>
</catalog>
```

Another (simple) example: book.dtd conversion

```
<!DOCTYPE book [
    <!ELEMENT book        (title,author)>
    <!ATTLIST book        category (Fiction|Non-Fiction) #REQUIRED>
    <!ELEMENT title       (#PCDATA)>
    <!ELEMENT author      (#PCDATA)>
]>
```

```
<?xml version="1.0" encoding="UTF-8"?>
<book category=“Non-Fiction”>
    <title>C# -- Curso Completo</title>
    <author>Paulo Marques</author>
</book>
```

The corresponding Schema

```
<?xml version="1.0" encoding="utf-8"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">

  <xsd:element name="book">
    <xsd:complexType>

      <xsd:sequence>
        <xsd:element name="title" type="xsd:string"/>
        <xsd:element name="author" type="xsd:string"/>
      </xsd:sequence>

      <xsd:attribute name="category" use="required">
        <xsd:simpleType>
          <xsd:restriction base="xsd:string">
            <xsd:enumeration value="Fiction" />
            <xsd:enumeration value="Non-Fiction" />
          </xsd:restriction>
        </xsd:simpleType>
      </xsd:attribute>

    </xsd:complexType>
  </xsd:element>
</xsd:schema>
```

Some important points...

- Each element can be:
  - Simple: It only has text (No children or attributes)

    `<xsd:element name="title" type="xsd:string"/>`
  - Complex: Has children and/or attributes

    `<xsd:element name="book"> <xsd:complexType>     (...)`
    `</xsd:complexType>  </xsd:element>`
- Standard data types are defined at:

  xmlns:xsd=“http://www.w3.org/2001/XMLSchema”
  - String, Decimal, Integer, Boolean, Date, Time, ...
- It fully supports everything you can do on a DTD. E.g:
  - `<xsd:element name="color" type="xsd:string" default="red"/>`
  - `<xsd:element name="color" type="xsd:string" fixed="red"/>`
  - ...
  - The same applies to attributes...

But XSD allow for more powerful validations

```
<xsd:element name="age">
  <xsd:simpleType>
    <xsd:restriction base="xsd:integer">
      <xsd:minInclusive value="0"/>
      <xsd:maxInclusive value="100"/>
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

Wrong!

```
<age>120</age>
```

```
<xsd:element name=“car">
  <xsd:simpleType>
    <xsd:restriction base="xsd:string">
      <xsd:enumeration value=“BMW">
      <xsd:enumeration value=“Audi">
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

Wrong!

```
<car>Mini</car>
```

```
<xsd:element name=“phone">
  <xsd:simpleType>
    <xsd:restriction base="xsd:integer">
      <xsd:pattern value=“[0-9]{9}">
    </xsd:restriction>
  </xsd:simpleType>
</xsd:element>
```

Wrong!

```
<phone>123</phone>
```

Possible restrictions

Constraint	Description
enumeration	Defines a list of acceptable values
fractionDigits	Specifies the maximum number of decimal places allowed. Must be equal to or greater than zero
length	Specifies the exact number of characters or list items allowed. Must be equal to or greater than zero
maxExclusive	Specifies the upper bounds for numeric values (the value must be less than this value)
maxInclusive	Specifies the upper bounds for numeric values (the value must be less than or equal to this value)
maxLength	Specifies the maximum number of characters or list items allowed. Must be equal to or greater than zero
minExclusive	Specifies the lower bounds for numeric values (the value must be greater than this value)
minInclusive	Specifies the lower bounds for numeric values (the value must be greater than or equal to this value)
minLength	Specifies the minimum number of characters or list items allowed. Must be equal to or greater than zero
pattern	Defines the exact sequence of characters that are acceptable
totalDigits	Specifies the exact number of digits allowed. Must be greater than zero
whiteSpace	Specifies how white space (line feeds, tabs, spaces, and carriage returns) is handled

It also allows to do advanced data modeling

```
<xsd:element name="employee" type="fullpersoninfo"/>

<xsd:complexType name="personinfo">
  <xsd:sequence>
    <xsd:element name="firstname" type="xsd:string"/>
    <xsd:element name="lastname" type="xsd:string"/>
  </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="fullpersoninfo">
  <xsd:complexContent>
    <xsd:extension base="personinfo">
      <xsd:sequence>
        <xsd:element name="address" type="xsd:string"/>
        <xsd:element name="city" type="xsd:string"/>
        <xsd:element name="country" type="xsd:string"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>
```

(In fact, there are even tools to map from DB schemas into XML!)

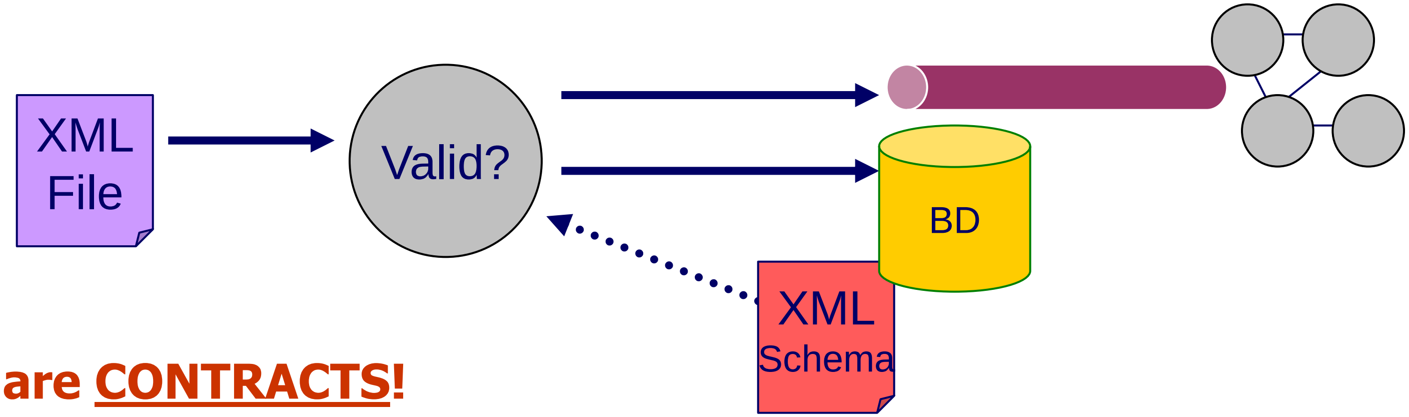
Key points regarding XSD

- Defined in XML (meta-circularity)
- Supports general data-types
- Supports advanced validation
- It’s possible to map relational models using restrictions, references and keys
- Modular and with support for namespaces

- ... Steep learning curve
- ... Slow when compared to DTDs

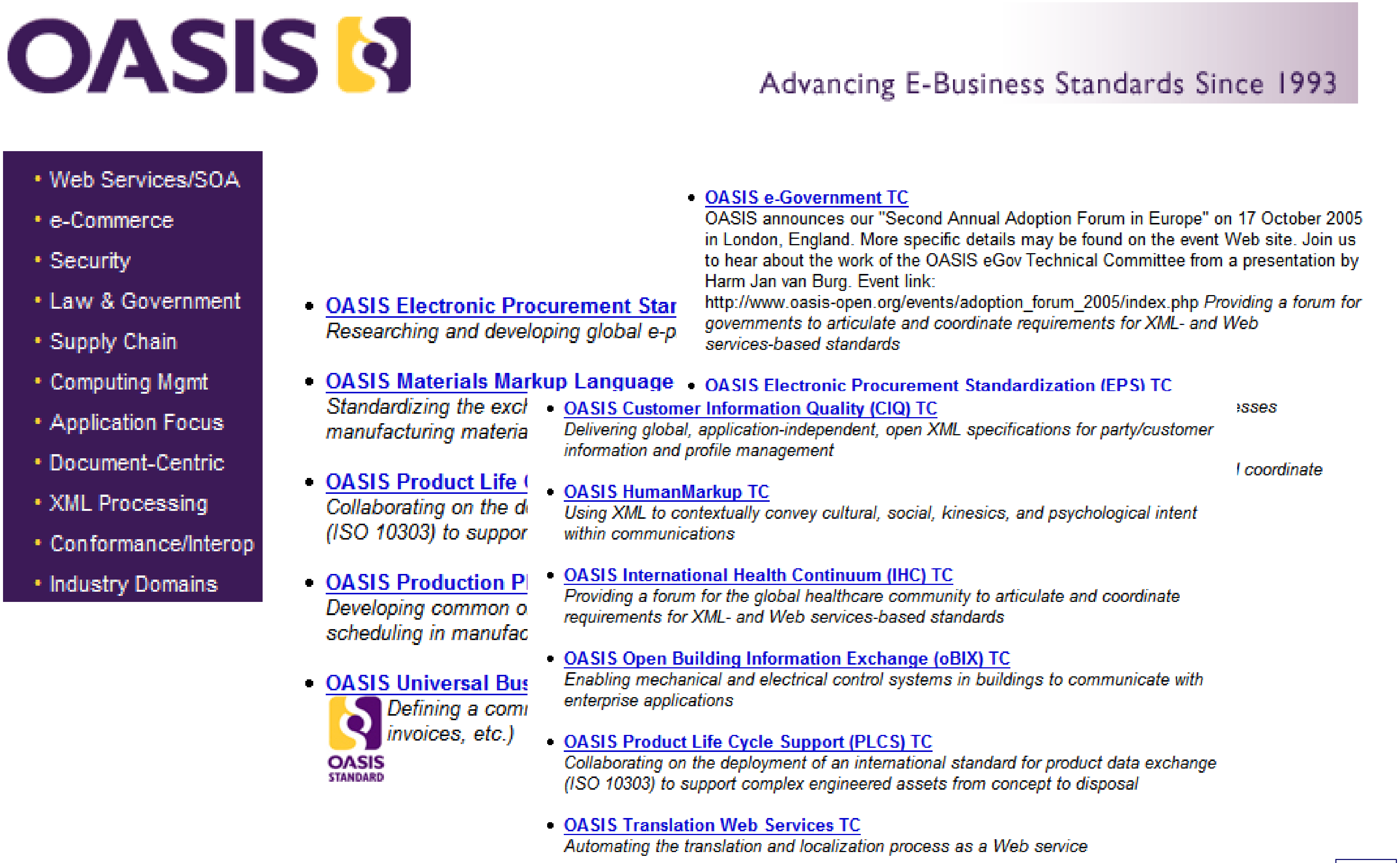
Validation in the “real world”…

- Consider an application which is processing an XML file:
  - Either it is thrown an exception because it finds something that is not expecting (e.g. a certain tag is not present)
  - Or everything processes ok
  - But doing validation with XSD/DTD is SLOW!
- Why use validation with DTD or XSD?
  - In reality, many times applications don’t do it.
  - Exceptions and validation are only done at the frontier of systems and at the entrance of databases



- **DTD and XSD are CONTRACTS!**
  - “What is the format of the XML file I need to process?”
  - It’s a **formal specification** of the data to process
  - Organizations create standards which specify the schemas used in certain business areas (e.g. OASIS)

OASIS – http://www.oasis-open.org



OASIS

Advancing E-Business Standards Since 1993

- Web Services/SOA
- e-Commerce
- Security
- Law & Government
- Supply Chain
- Computing Mgmt
- Application Focus
- Document-Centric
- XML Processing
- Conformance/Interop
- Industry Domains

- OASIS Electronic Procurement Star
  Researching and developing global e-p
- OASIS Materials Markup Language
  Standardizing the exch
  manufacturing materia
- OASIS Product Life (
  Collaborating on the d
  (ISO 10303) to suppor
- OASIS Production Pl
  Developing common o
  scheduling in manufac
- OASIS Universal Bus
  Defining a comı
  invoices, etc.)

OASIS STANDARD

- OASIS e-Government TC
  OASIS announces our "Second Annual Adoption Forum in Europe" on 17 October 2005 in London, England. More specific details may be found on the event Web site. Join us to hear about the work of the OASIS eGov Technical Committee from a presentation by Harm Jan van Burg. Event link: http://www.oasis-open.org/events/adoption_forum_2005/index.php *Providing a forum for governments to articulate and coordinate requirements for XML- and Web services-based standards*

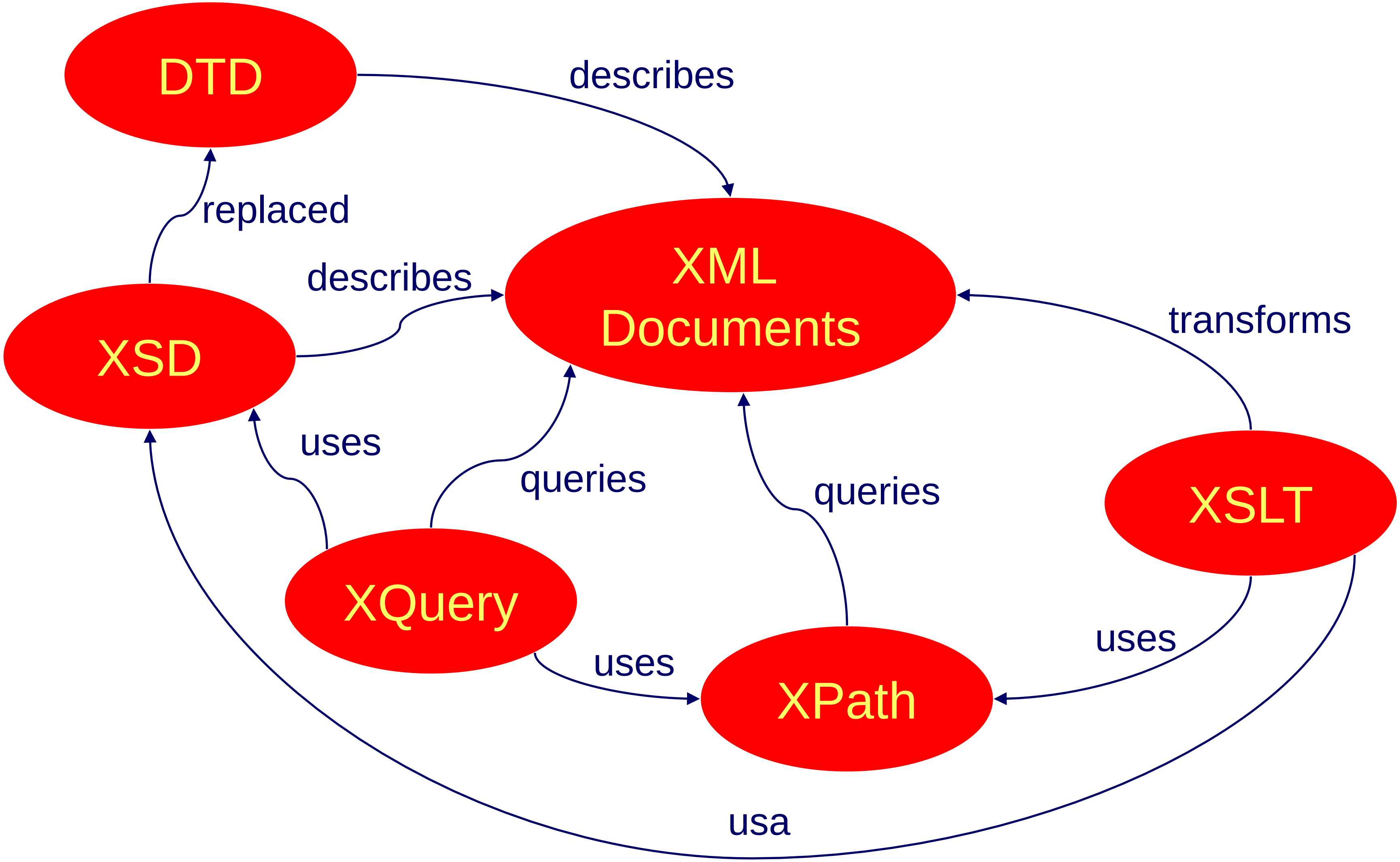
- OASIS Electronic Procurement Standardization (EPS) TC

esses

l coordinate

- OASIS Customer Information Quality (CIQ) TC
  Delivering global, application-independent, open XML specifications for party/customer information and profile management
- OASIS HumanMarkup TC
  Using XML to contextually convey cultural, social, kinesics, and psychological intent within communications
- OASIS International Health Continuum (IHC) TC
  Providing a forum for the global healthcare community to articulate and coordinate requirements for XML- and Web services-based standards
- OASIS Open Building Information Exchange (oBIX) TC
  Enabling mechanical and electrical control systems in buildings to communicate with enterprise applications
- OASIS Product Life Cycle Support (PLCS) TC
  Collaborating on the deployment of an international standard for product data exchange (ISO 10303) to support complex engineered assets from concept to disposal
- OASIS Translation Web Services TC
  Automating the translation and localization process as a Web service

What have we seen so far?



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Enterprise Application Integration

1. Basic XML

1.3. XML-based Programming

2009/2010

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XML Programming Models

- There are three models for XML development
  - Two of them are W3C recommendations

- **DOM** = **D**ocument **O**bject **M**odel

- **SAX** = **S**imple **A**PI for **X**ML (processing)

- XML Data Binding

  (non-standard)

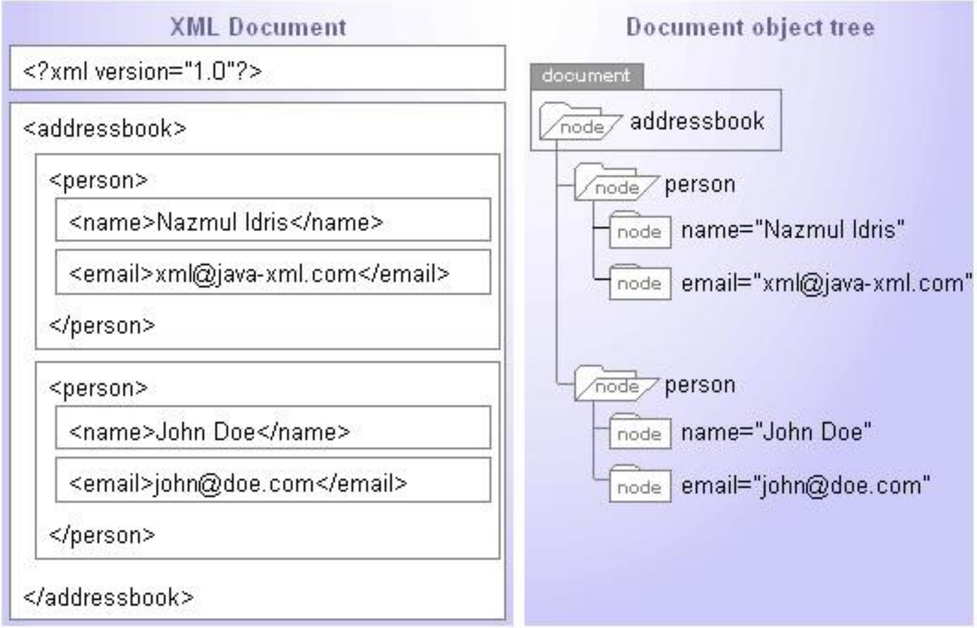
Java APIs for XML

- **JAXP: Java API for XML Processing**
  - *"This API provides a common interface for creating and using the standard SAX, DOM, and XSLT APIs in Java, regardless of which vendor's implementation is actually being used.."*
  - O J2SE 6.0 includes a **DOM** API and a **SAX** API (part of JAXP)
  - The biggest problem of those APIs is that there were originally though for C++. This means they are completely generic and not very friendly for the normal data types and structures available in Java (e.g. Collections)
  - **JDOM** is a nice friendly API for Java

- **JAXB: Java Architecture for XML Binding**
  - "This standard defines a mechanism for writing out Java objects as XML (marshalling) and for creating Java objects from such structures (unmarshalling). (You compile a class description to create the Java classes, and use those classes in your application.)"
  - Not covered in this course, although it's fairly useful

DOM = Document Object Model

- Idea:
  - XML documents are fully read into an object three which represents the document.
  - Quite heavy in terms of processing and memory
  - Only adequate for small and medium size documents
  - Useful when it is necessary to have random access to all the nodes of a document or if it is necessary to modify the document “in place”.
  - Simple programming model (+-)
  - In its normal format, it’s hard to use in Java ☹



XML Document

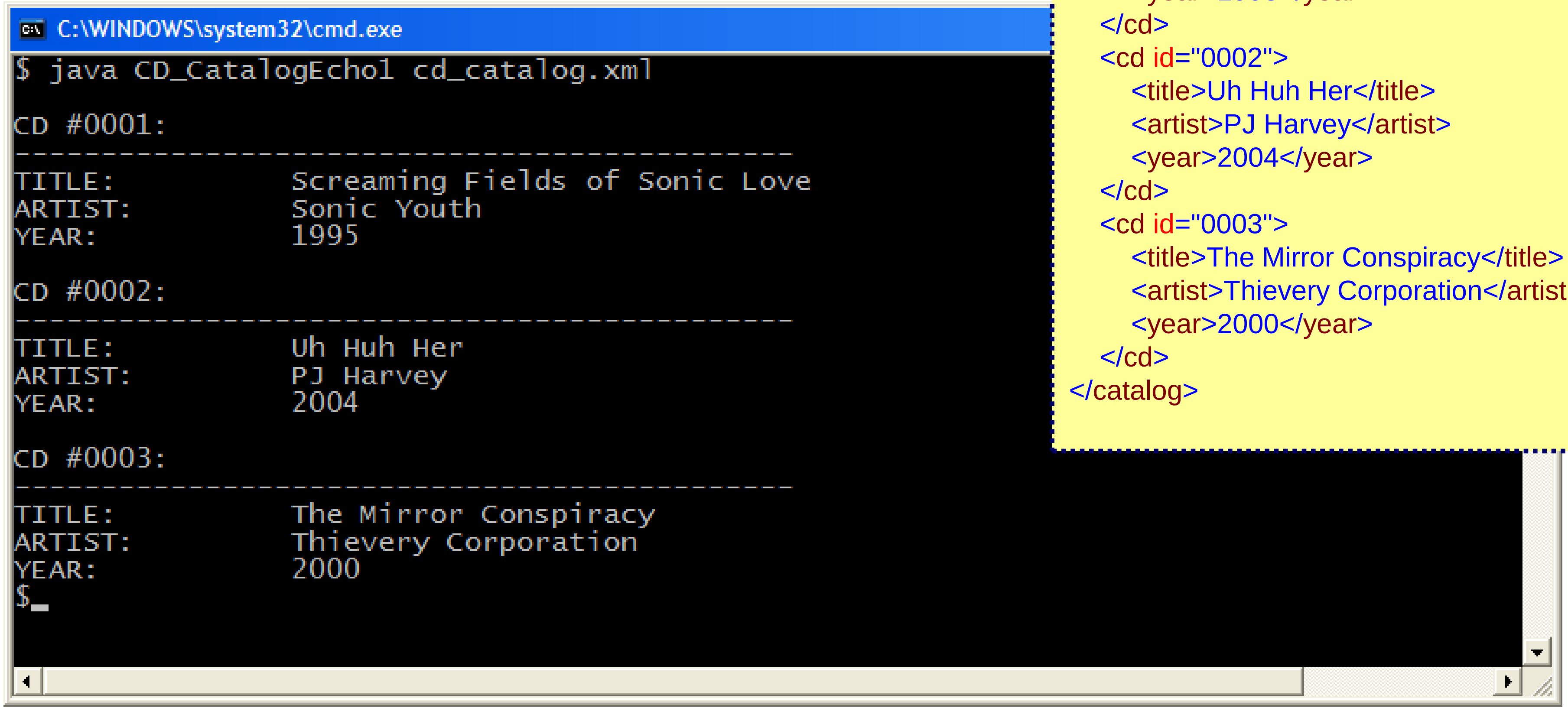
```
<?xml version="1.0"?>
<addressbook>
  <person>
    <name>Nazmul Idris</name>
    <email>xml@java-xml.com</email>
  </person>
  <person>
    <name>John Doe</name>
    <email>john@doe.com</email>
  </person>
</addressbook>
```

Document object tree

Let’s build a program...

cd_catalog.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<catalog>
   <cd id="0001">
      <title>Screaming Fields of Sonic
Love</title>
      <artist>Sonic Youth</artist>
      <year>1995</year>
   </cd>
   <cd id="0002">
      <title>Uh Huh Her</title>
      <artist>PJ Harvey</artist>
      <year>2004</year>
   </cd>
   <cd id="0003">
      <title>The Mirror Conspiracy</title>
      <artist>Thievery Corporation</artist>
      <year>2000</year>
   </cd>
</catalog>
```



```
$ java CD_CatalogEcho1 cd_catalog.xml

CD #0001:
---------------------------------------------
TITLE:          Screaming Fields of Sonic Love
ARTIST:         Sonic Youth
YEAR:           1995

CD #0002:
---------------------------------------------
TITLE:          Uh Huh Her
ARTIST:         PJ Harvey
YEAR:           2004

CD #0003:
---------------------------------------------
TITLE:          The Mirror Conspiracy
ARTIST:         Thievery Corporation
YEAR:           2000
$_
```

Reading cd_catalog.xml using Java’s DOM

```
import javax.xml.parsers.*;
import org.w3c.dom.*;

public class CatalogEcho1
{
    public static void processDocument() { // ... Next slide ... }

    public static void main(String[] args)     {
        try
        {
            // Parse our XML file into a Document object
            DocumentBuilderFactory factory = DocumentBuilderFactory.newInstance();
            DocumentBuilder builder = factory.newDocumentBuilder();
            Document myXML = builder.parse(args[0]);

            processDocument(myXML);
        }
        catch (Exception e)
        {
            e.printStackTrace();
        }
    }
}
```

Reading cd_catalog.xml using Java’s DOM (2)

```
public static void processDocument(Document myXML) {
    // Get a list of all nodes named "cd" and iterate along them
    NodeList theCDs = myXML.getElementsByTagName("cd");
    for (int i=0; i<theCDs.getLength(); i++) {
                Node cd = theCDs.item(i);

                // Get the ID of the current CD and print it out
                String id = cd.getAttributes().getNamedItem("id").getTextContent();
                System.out.println(“\nCD #" + id + ":");
                System.out.println("-----------------------------------------");

                // Get the details of the current CD (title, artist, year) and print them out
                NodeList details = cd.getChildNodes();
                for (int j=0; j<details.getLength(); j++)
                {
                    Node detail = details.item(j);
                    if (detail.getNodeName() == "title")
                        System.out.println("TITLE:  \t" + detail.getTextContent());
                    else if (detail.getNodeName() == "artist")
                        System.out.println("ARTIST: \t" + detail.getTextContent());
                    else if (detail.getNodeName() == "year")
                        System.out.println("YEAR:   \t" + detail.getTextContent());
                }
 }}
```

Now using JDOM – Much simpler ☺

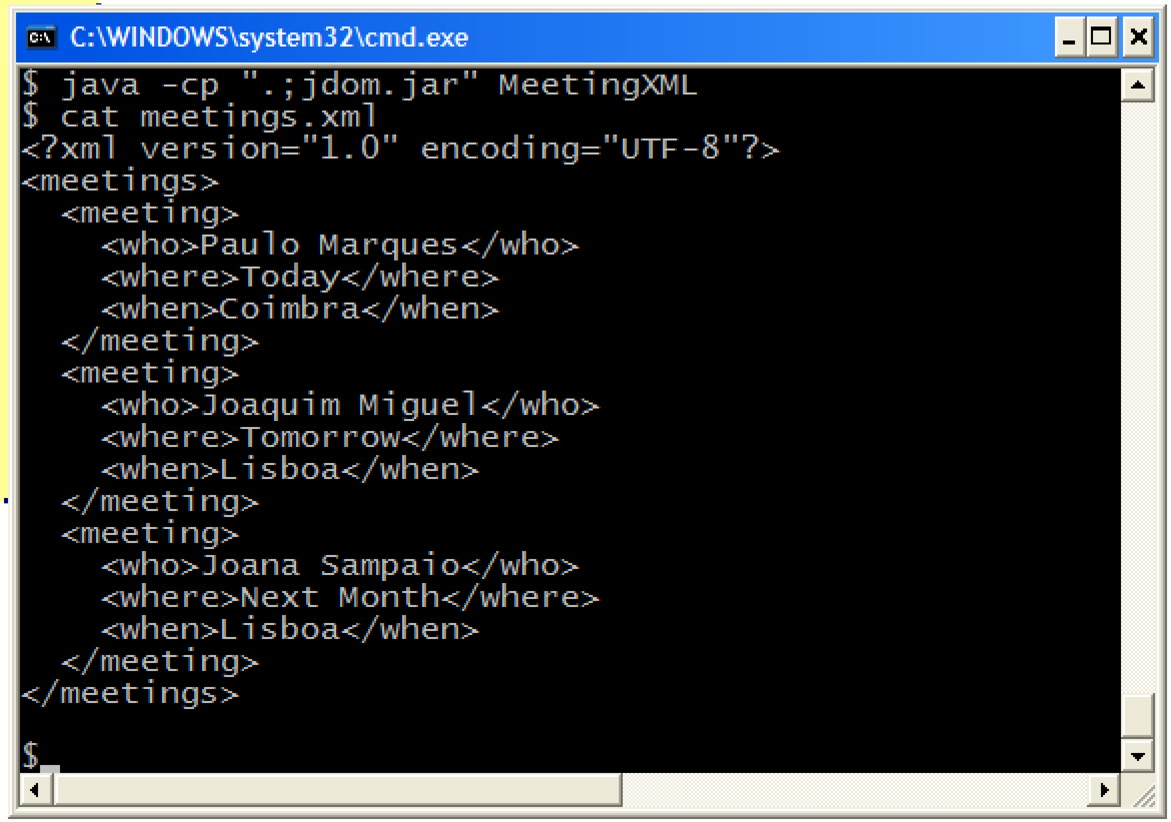
```
import org.jdom.input.*;
import org.jdom.*;
import java.util.*;

public class CD_CatalogEcho2 {
    public static void main(String[] args) {
        try {
            /// Parse our XML file into a Document object (uses SAX)
            SAXBuilder builder = new SAXBuilder();
            Document myXML = builder.build(args[0]);

            processDocument(myXML);
        }
        catch (Exception e) {
            e.printStackTrace();
        }
    }
}
```

Now using JDOM – Much simpler (2)

```
public static void processDocument(Document myXML) {
            // Get a list of all nodes named "cd" and iterate along them
            Element catalog = myXML.getRootElement();
            Iterator cdIterator = catalog.getChildren("cd").iterator();
            while (cdIterator.hasNext())
            {
                // Get the details of the current CD and print them out
                Element cd = (Element) cdIterator.next();

                String id = cd.getAttributeValue("id");
                String title = cd.getChild("title").getValue();
                String artist = cd.getChild("artist").getValue();
                String year = cd.getChild("year").getValue();

                System.out.println();
                System.out.println("CD #" + id + ":");
                System.out.println("----------------------------------------");
                System.out.println("TITLE:  \t" + title);
                System.out.println("ARTIST: \t" + artist);
                System.out.println("YEAR:   \t" + year);
            }
}
```

Writing a document in XML (JDOM)

```
<?xml version="1.0" encoding="UTF-8"?>
<meetings>
  <meeting>
    <who>Paulo Marques</who>
    <where>Today</where>
    <when>Coimbra</when>
  </meeting>
  <meeting>
    <who>Joaquim Miguel</who>
    <where>Tomorrow</where>
    <when>Lisboa</when>
  </meeting>
  <meeting>
    <who>Joana Sampaio</who>
    <where>Next Month</where>
    <when>Lisboa</when>
  </meeting>
</meetings>
```



```
$ java -cp ".;jdom.jar" MeetingXML
$ cat meetings.xml
<?xml version="1.0" encoding="UTF-8"?>
<meetings>
  <meeting>
    <who>Paulo Marques</who>
    <where>Today</where>
    <when>Coimbra</when>
  </meeting>
  <meeting>
    <who>Joaquim Miguel</who>
    <where>Tomorrow</where>
    <when>Lisboa</when>
  </meeting>
  <meeting>
    <who>Joana Sampaio</who>
    <where>Next Month</where>
    <when>Lisboa</when>
  </meeting>
</meetings>

$
```

Writing a document in XML (JDOM) (2)

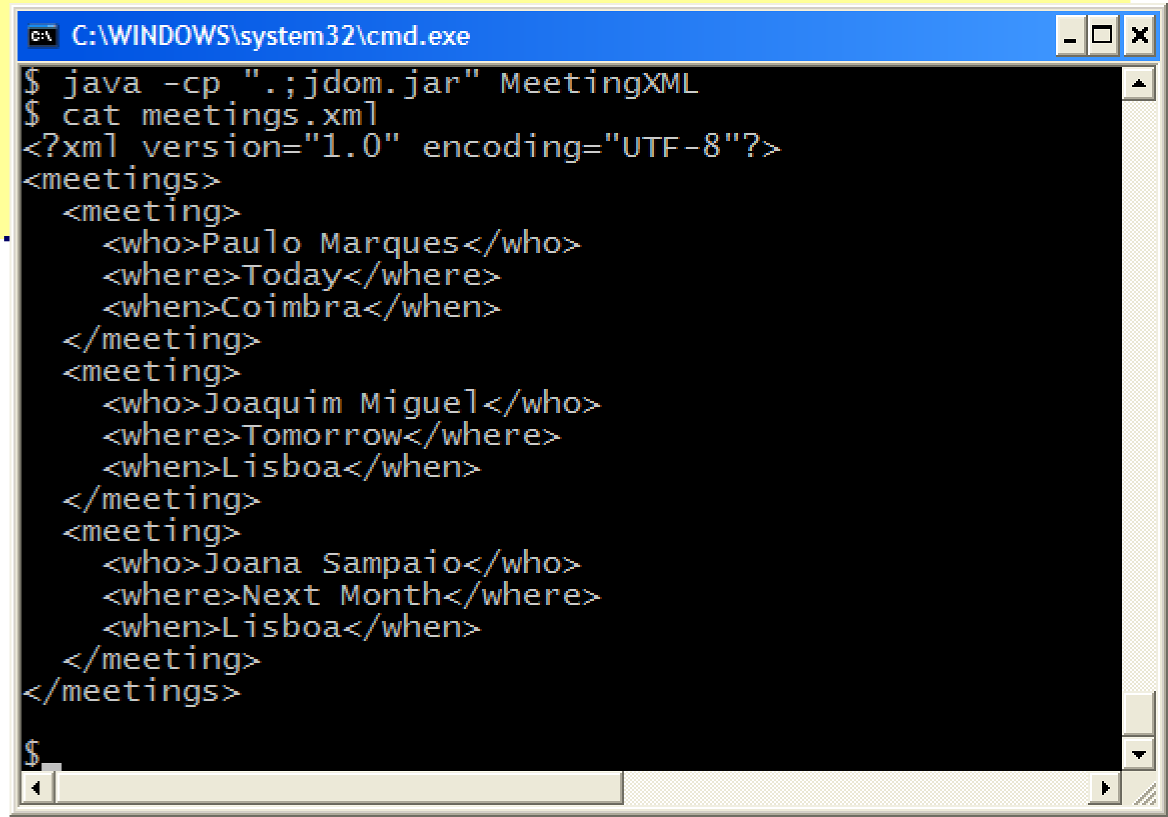
```
import (...)

// Meeting structure (not a real class)
class Meeting {
    public String who;
    public String where;
    public String when;

    public Meeting(String who, String when, String where)  {
        this.who    = who;
        this.where = where;
        this.when  = when;
    }
}

public class MeetingXML {
    public static void main(String[] args)     {
        // The meetings that we want out output to XML
        Meeting[] meetingsData = new Meeting[] {
                new Meeting("Paulo Marques", "Coimbra", "Today"),
                new Meeting("Joaquim Miguel", "Lisboa", "Tomorrow"),
                new Meeting("Joana Sampaio", "Lisboa", "Next Month")
        };
```

Writing a document in XML (JDOM) (3)

```
// Create a document an its root node
Document doc = new Document();
Element meetings = new Element("meetings");
doc.setRootElement(meetings);

// For each meeting, create a node for it with all the details
for (int i=0; i<meetingsData.length; i++)
{
    Element meeting = new Element("meeting");

    Element who = new Element("who");
    who.setText(meetingsData[i].who);
    Element where = new Element("where");
    where.setText(meetingsData[i].where);
    Element when = new Element("when");
    when.setText(meetingsData[i].when);

    meeting.addContent(who);
    meeting.addContent(where);
    meeting.addContent(when);

    meetings.addContent(meeting);
}
```

Writing a document in XML (JDOM) (4)

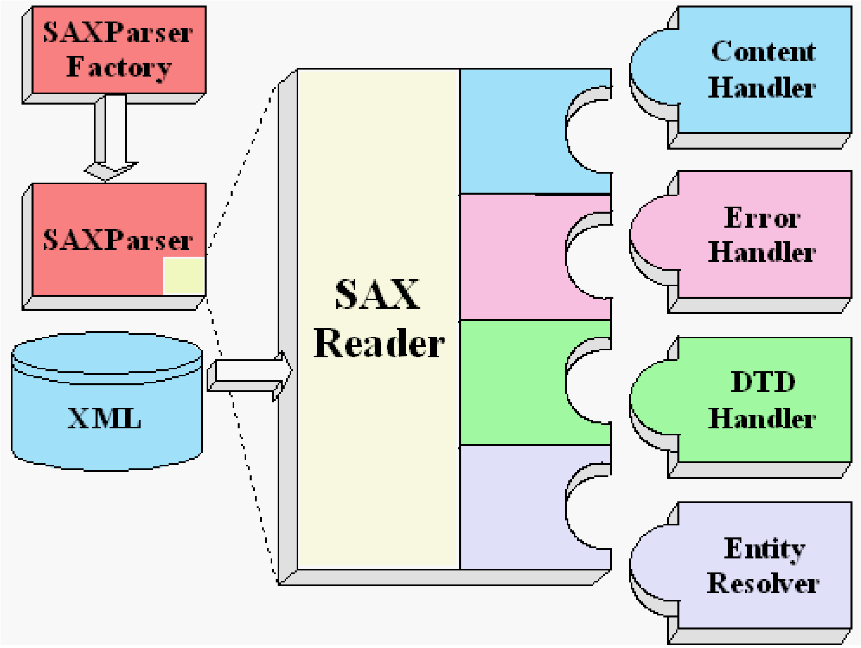
```
        // Finally, output the resulting document to disk (meetings.xml)
        try
        {
            XMLOutputter writer = new XMLOutputter(Format.getPrettyFormat());
            writer.output(doc, new FileWriter("meetings.xml"));
        }
        catch (Exception e)
        {
            e.printStackTrace();
        }
    }
}
```



```
$ java -cp ".;jdom.jar" MeetingXML
$ cat meetings.xml
<?xml version="1.0" encoding="UTF-8"?>
<meetings>
  <meeting>
    <who>Paulo Marques</who>
    <where>Today</where>
    <when>Coimbra</when>
  </meeting>
  <meeting>
    <who>Joaquim Miguel</who>
    <where>Tomorrow</where>
    <when>Lisboa</when>
  </meeting>
  <meeting>
    <who>Joana Sampaio</who>
    <where>Next Month</where>
    <when>Lisboa</when>
  </meeting>
</meetings>

$
```

SAX = Simple API for XML (processing)

- Principles…
  - Each node of a document is visited only once, top to bottom
  - An event is raised each time a node is visited
  - The programmer writes callback routines associated to these events
  - It's very lightweight in terms of processing and memory
  - Adequate for large documents
  - The programming model is not "as simple" as the same seems to imply



Reading cd_catalog.xml using SAX (Java)

```
public class CD_CatalogEcho3
{
    public static void main(String args[])
    {
        // Setup our SAX Event handler and a default parser
        DefaultHandler handler = new CD_Handler();
        SAXParserFactory factory = SAXParserFactory.newInstance();

        // Parse the input file
        try
        {
            SAXParser saxParser = factory.newSAXParser();
            saxParser.parse(new File(args[0]), handler);
        }
        catch (Exception e)
        {
            e.printStackTrace();
        }
    }
}
```

Reading cd_catalog.xml using SAX (2)

```
class CD_Handler extends DefaultHandler {
    // We will have to process 4 kinds of tags: "cd", "title", "artist" and "year"
    // thus, we can be in any of these states
    enum TagState {  STATE_IGNORE, STATE_CD,
                     STATE_TITLE, STATE_ARTIST, STATE_YEAR };

    private TagState currentState = TagState.STATE_IGNORE;

    //////////////////////////

    // Invoked when a new element is found -- state must be made up to date
    public void startElement(String namespace, String simpleName,
                             String qualifiedName, Attributes attrs) throws SAXException   { ... }

    // Invoked when a tag is closed, the new state is "ignoring"
    public void endElement(String namespace, String simpleName, String qualifiedName)
        throws SAXException { ... }

    // Called whenever actual text is seen. Should only process if inside "title", "artist" or "year"
    public void characters(char[] buf, int start, int length) throws SAXException { ... }
}
```

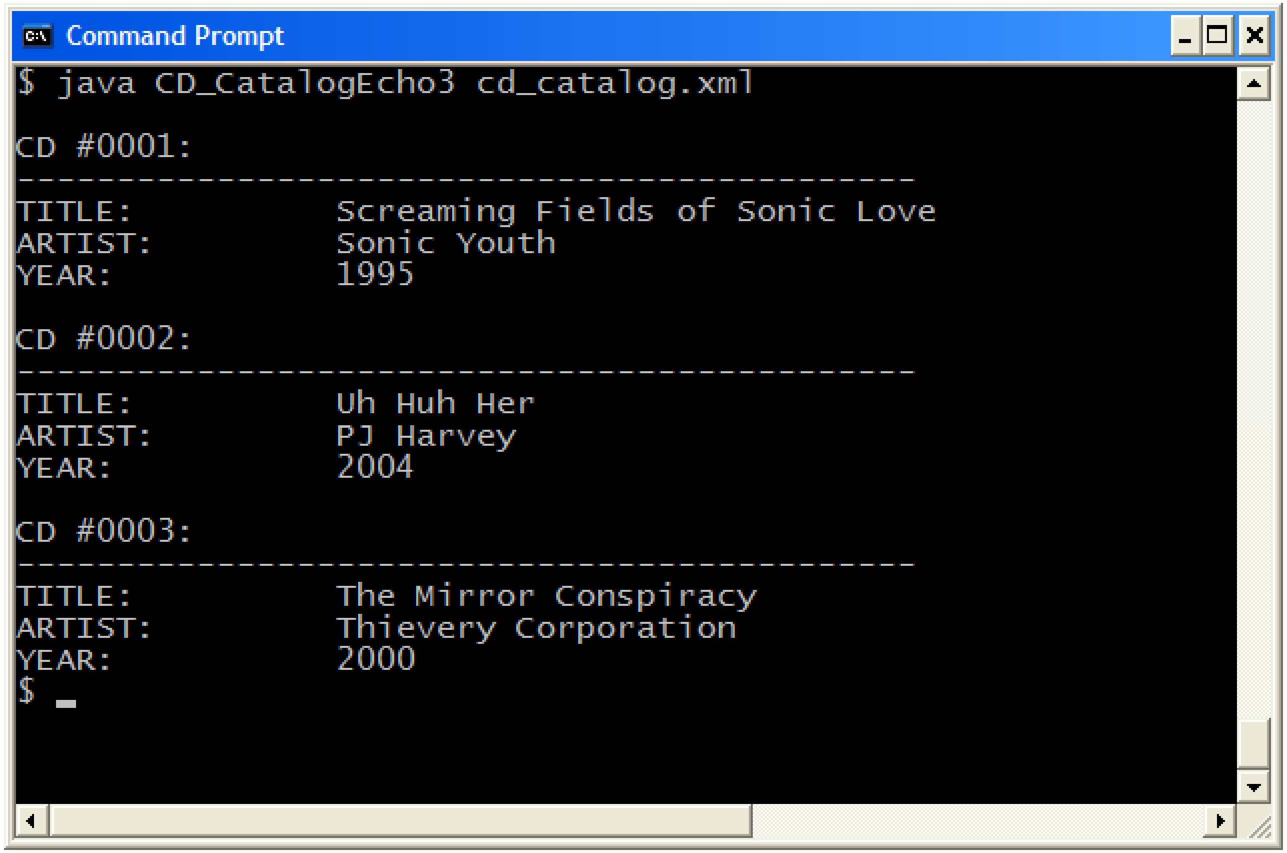
Reading cd_catalog.xml using SAX (3)

```
public void startElement(String namespace, String simpleName,
                                        String qualifiedName, Attributes attrs)  throws SAXException
    {
        // If the current element is a CD, find out its ID and print it out
        // Else, just make sure that the rest of this class knows what's the current state
        if (qualifiedName == "cd")
        {
            String id = attrs.getValue("id");
            System.out.println();
            System.out.println("CD #" + id + ":");
            System.out.println("------------------------------------------");

            currentState = TagState.STATE_CD;
        }
        else if (qualifiedName == "title")
            currentState = TagState.STATE_TITLE;
        else if (qualifiedName == "artist")
            currentState = TagState.STATE_ARTIST;
        else if (qualifiedName == "year")
            currentState = TagState.STATE_YEAR;
        else
            currentState = TagState.STATE_IGNORE;
    }
```

Reading cd_catalog.xml using SAX (4)

```
// Invoked when a tag is closed, the new state is "ignoring"
public void endElement(String namespace, String simpleName, String qualifiedName)
    throws SAXException
{
    currentState = TagState.STATE_IGNORE;
}

// Called whenever actual text is seen. Should only process if inside
// "title", "artist" or "year"
public void characters(char[] buf, int start, int length)
    throws SAXException
{
    String text = new String(buf, start, length);

    if (currentState == TagState.STATE_TITLE)
        System.out.println("TITLE:  \t" + text);
    else if (currentState == TagState.STATE_ARTIST)
        System.out.println("ARTIST: \t" + text);
    else if (currentState == TagState.STATE_YEAR)
        System.out.println("YEAR:   \t" + text);
}
```

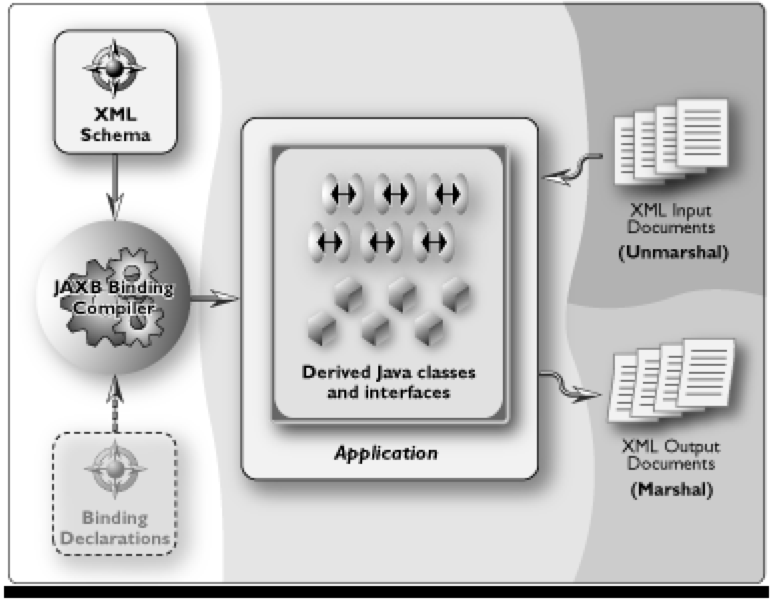
Reading cd_catalog.xml using SAX (5)

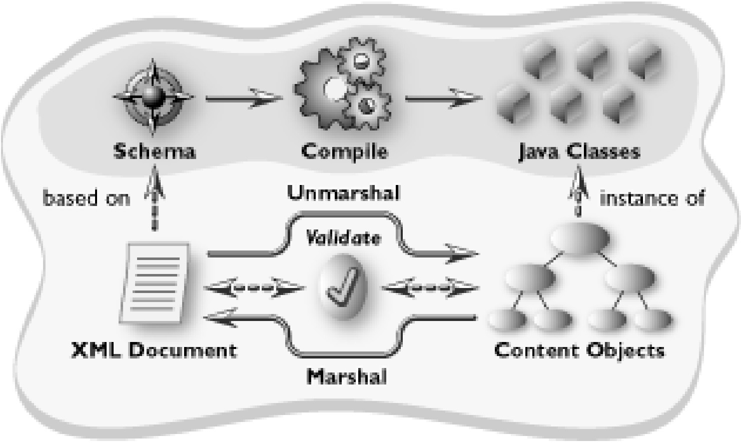


```
$ java CD_CatalogEcho3 cd_catalog.xml

CD #0001:
---------------------------------------------
TITLE:          Screaming Fields of Sonic Love
ARTIST:         Sonic Youth
YEAR:           1995

CD #0002:
---------------------------------------------
TITLE:          Uh Huh Her
ARTIST:         PJ Harvey
YEAR:           2004

CD #0003:
---------------------------------------------
TITLE:          The Mirror Conspiracy
ARTIST:         Thievery Corporation
YEAR:           2000
$ _
```

XML Data Binding

- Principles
  - Starting from an XML schema file, a compiler generates a set of classes which represents the XML data when instantiated.
  - There's also a StreamReader and StreamWriter for serializing and de-serializing between XML files and objects
  - **Easy to program** – the programmer only sees normal object
  - Typically suffers from the same problems as DOM





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  - "Chapter 4: Java API for XML Processing", in J2EE 1.4 Tutorial
  - "Chapter 5: Simple API for XML", in J2EE 1.4 Tutorial
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IMPORTANT NOTICE