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ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΡΗΤΗΣ

Εισαγωγή στην Επιστήμη και Τεχνολογία των Υπηρεσιών

Ενότητα 4: Document Type Definitions (DTDs) - 1

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Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

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ΕΥΡΩΠΑΪΚΟ ΚΟΙΝΩΝΙΚΟ ΤΑΜΕΙΟ

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

XML
Document Type Definitions (DTDs)
605.444 / 635.444

David Silberberg

Lecture 3

What are Document Type Definitions (DTDs)?

- A mechanism for describing the rules of forming a set of documents
  - Description of the syntactic (and some semantic) rules of an XML document
  - Akin to structure definitions in programming languages
  - Description of the configuration of elements and attributes for a document set
- Enable validating XML documents for syntactic correctness
  - Useful for document exchange
  - Useful for business to business applications
  - Useful for ensuring correctness of single document
- Provides a mechanism for documenting XML files

Why Create DTDs?

- Portability
  - All applications know the correct structure of documents
  - Reduce the need for “paper” documentation
  - Can be parsed by a program
  - Structure definition independent of platform
- Reduce code size
  - Constraints of data not coded in application
  - Can rely on tools to determine validity of document structure
- Reduce maintenance
  - Changes in structure require only corresponding changes in a single DTD
  - No need to update validation software of multiple applications

Why DTDs? (cont.)

- What is wrong with just ensuring that a document is well formed?
  - Well-formed documents are syntactically correct
  - However, their structures may not make sense from a semantic perspective
  - A mechanism is needed to ensure that documents make sense

An Example Document that is Well-Formed

```
<?xml version="1.0"?>
<course_list>
    <course internal_id="I-02237">
        <name>XML: Technology and Application</name>
        <number>635.781</number>
        <number>605.741</number>
        <instructor>Silberberg</instructor>
    </course>
    <course internal_id="I-20087">
        <name>User Interfaces</name>
        <number>635.721</number>
        <number>605.766</number>
        <instructor>Gersh</instructor>
    </course>
</course_list>
```

Another Well-Formed Document

```
<?xml version="1.0"?>
<name>
    <instructor internal_id="I-02237">
        <course>XML: Technology and Application</course>
        <number>635.781</number>
        <number>605.741</number>
        <course_list>Silberberg</course_list>
    </instructor>
    <instructor internal_id="I-20087">
        <course>User Interfaces</course>
        <number>635.721</number>
        <number>605.766</number>
        <course_list>Gersh</ course_list>
    </instructor>
</name>
```

Well-formed, but does not make sense (semantically incorrect).

DTD Benefits

- Describes document structure
- Shares document structure definition with other applications
- Enables software to verify and validate document structure correctness
  - Are the right elements (and attributes) there?
  - Are the wrong elements (and attributes) not there?
- Ensures data types are correct
- Provides default values

- DTDs enable automated software to check these

More on DTDs

- A DTD describes an *XML vocabulary*
  - A cooperating set of documents
  - A cooperating set of applications that share the documents
- A group of XML documents that share the same vocabulary is known as a *document type*
- An individual XML document that conforms to a document type is a *document instance*
- A Document Type Definition (DTD) is a formal description of the syntax (and some of the semantics) of an XML document

DTD Locations

- DTDs can be defined in
  - A single document that is external to XML files.
  - Internally, within an XML document
  - A combination of both
  - Internal definitions override external definitions
- The DTD specification provides a standard syntax for describing document types
- Validating parsers can examine DTDs to determine the validity of XML documents

Common Scenario

- Multiple applications that share XML documents
  - Some applications create documents
  - Some read documents
  - Some modify documents
- Applications need to verify that the documents are structured according to a predefined semantics
  - Content verification
    - Ensure all required elements are present
    - Ensure disallowed elements are not present
  - Semantic interpretation - structure & data
  - Provide default values
  - Error handling

Alternative Approaches to XML Validation

- Special software to perform application-specific checking
  - Could streamline performance
  - However, each application would require a customer parser to perform checks
    - Error-prone
    - Difficult to maintain - especially across organizations
    - Code duplication
- External custom syntax checker
  - Eliminates problem with code duplication
  - Reduces, but does not eliminate, errors
  - Easier to maintain
  - However, a new syntax checker must be created and maintained for each document type

The DTD Approach

- Standard specification and syntax for defining document types
- Standard validating parsers can be built in accordance with the specification
- Semantics are declarative, rather than procedural
  - Changes are introduced by changing file specifications
  - Software never needs modification for verification
  - Application software
    - Needs to change in either case
    - However, with DTDs, changes are only required for operations on XML documents that are specific to the applications themselves

Validating Parsers

- Simple XML parsers to ensure that XML documents are well formed
  - Validates the syntax
  - Internet Explorer and Netscape
- Validating parsers check the XML documents for adherence to DTD descriptions
  - Validates the semantics, as well
  - Ensures that XML documents conform to the rules of the XML vocabulary
  - Compares XML document to associated DTD

Example

```
<?xml version="1.0" standalone="no"?>
<!DOCTYPE store SYSTEM "file:/C:/My Documents/APL/XML/DTD/store.dtd">
<store>
    <cust_list>
        <customer cid="C-1" >
            <name title="Mr.">
                <first>Sam</first>
                <middle>Ta</middle>
                <middle>Chuan</middle>
                <last>Chu</last>
            </name>
            <address>
                <street>123-A Kensington Circle</street>
                <city>London</city><country>England</country>
            </address>
            <purchase date="2002-01-12" items="I-34 I-62 I-15" qty="3 1 1" />
            <purchase date="2002-01-13" items="I-15" qty="2" />
        </customer>
```

Example (2)

```
        <customer cid="C-2" ctype="bad">
            <name title="Dr.">
                <first>Darsana</first>
                <last>Sudarsen</last>
            </name>
            <address>
                <street>11100 Johns Hopkins</street>
                <city>Baltimore</city><state>MD</state>
                <zip>21207</zip>
            </address>
            <purchase date="2002-02-02" items="I-62 I-5" qty="2 1" />
        </customer>
    </cust_list>
    <inventory_list>
        <item item_no="I-5" supplier_id="S-1">
            <description>Ivory Soap</description>
            <in_stock>50</in_stock>
            <price>1.09</price>
            <cost>.28</cost>
        </item>
```

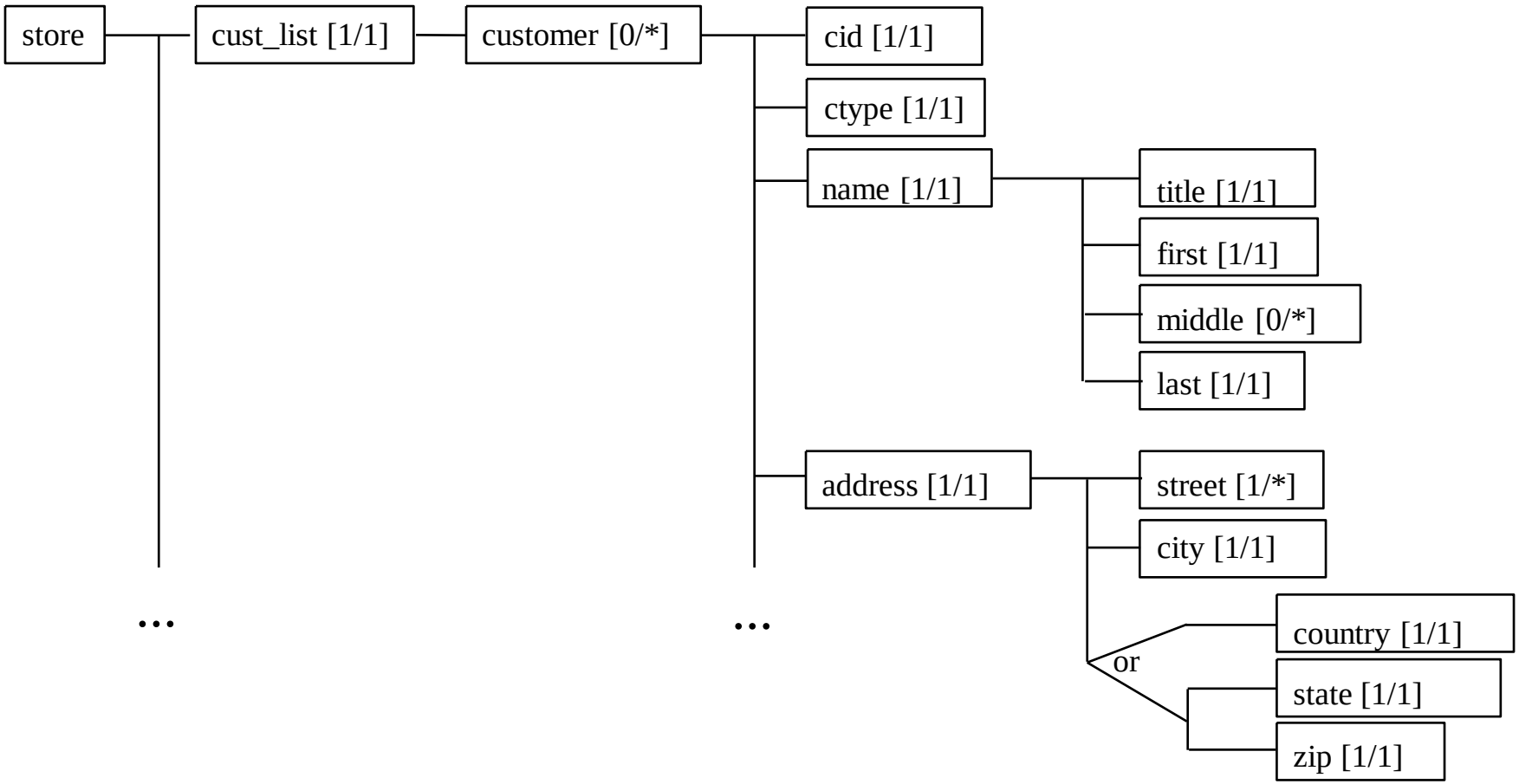
Example (3)

```
<item item_no="I-15" supplier_id="S-1">
    <description>Cheer Detergent</description>
    <in_stock>37</in_stock>
    <price>5.98</price>
    <cost>2.10</cost>
</item>
<item item_no="I-34" supplier_id="S-1">
    <description>Bounty Paper Towels</description>
    <in_stock>112</in_stock>
    <price>1.48</price>
    <cost>.57</cost>
</item>
<item item_no="I-62" supplier_id="S-2">
    <description>Sunshine Tissues</description>
    <in_stock>320</in_stock>
    <price>1.65</price>
    <cost>.98</cost>
</item>
</inventory_list>
```

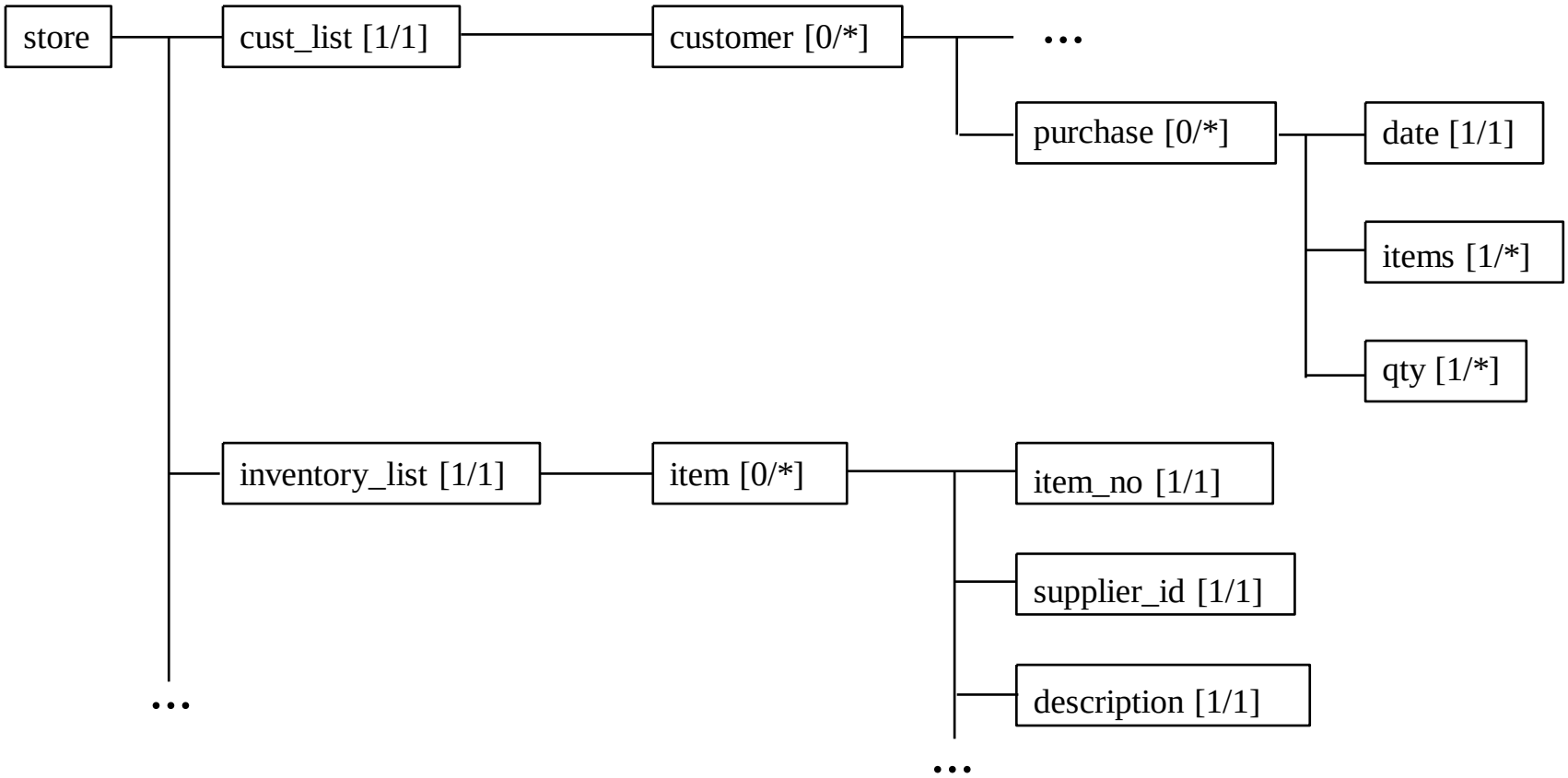
Example (4)

```
        <supplier_list>
                <supplier sid =“S-1”>
                        <company>Proctor and Gamble</company>
                        <telephone>1-800-PAMPERS</telephone>
                </supplier>
                <supplier sid =“S-2”>
                        <company>Sunshine Products</company>
                        <telephone>1-888-344-9881</telephone>
                </supplier>
        </supplier_list>
</store>
```

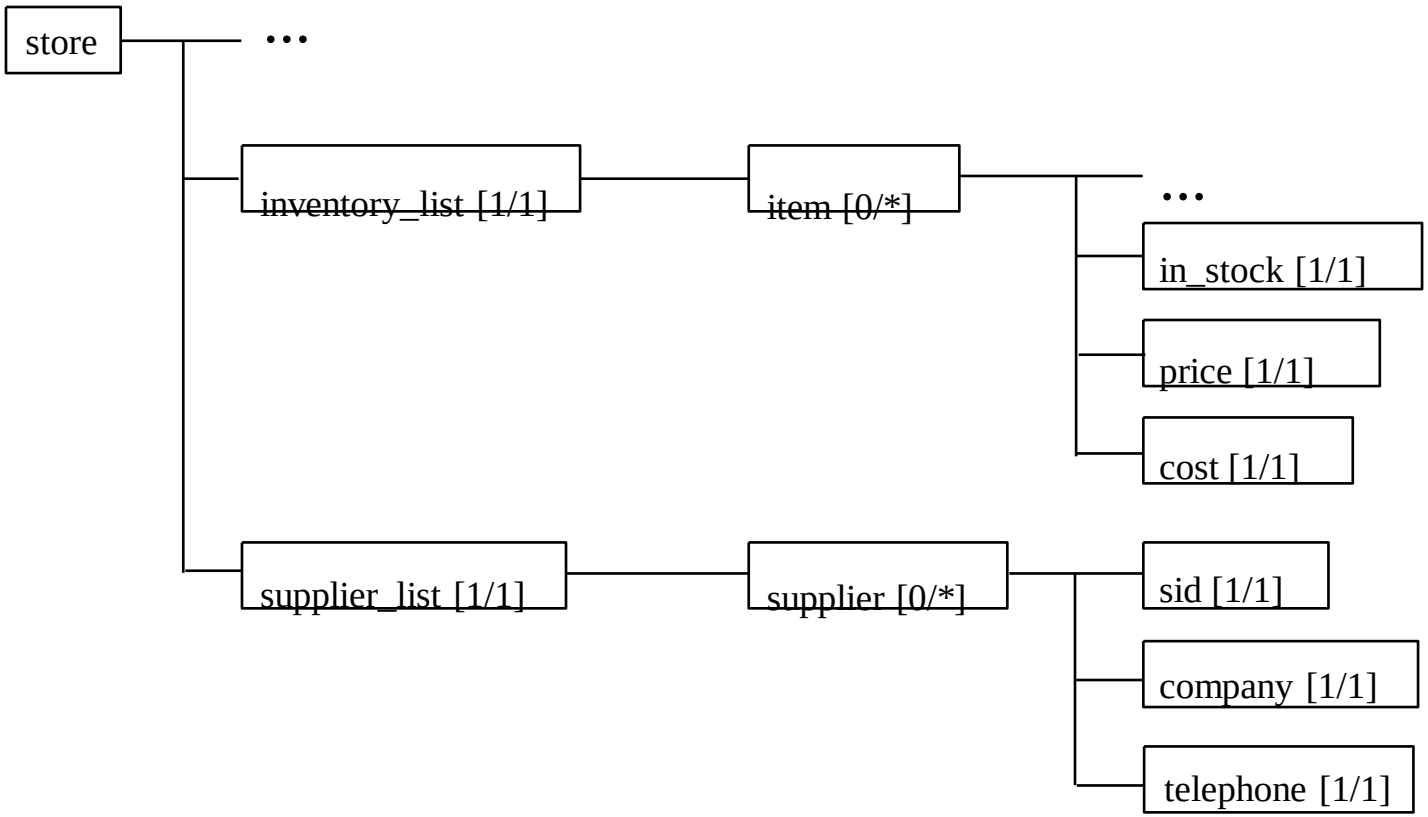
Data Model


store
cust_list [1/1]
customer [0/*]
cid [1/1]
ctype [1/1]
name [1/1]
title [1/1]
first [1/1]
middle [0/*]
last [1/1]
address [1/1]
street [1/*]
city [1/1]
country [1/1]
or
state [1/1]
zip [1/1]
...
...

Data Model (2)


store
cust_list [1/1]
customer [0/*]
...
purchase [0/*]
date [1/1]
items [1/*]
qty [1/*]
inventory_list [1/1]
item [0/*]
item_no [1/1]
supplier_id [1/1]
description [1/1]
...
...

Data Model (3)


store
...
inventory_list [1/1]
item [0/*]
...
in_stock [1/1]
price [1/1]
cost [1/1]
supplier_list [1/1]
supplier [0/*]
sid [1/1]
company [1/1]
telephone [1/1]

Internal vs. External DTDs

- DTDs can be divided into two parts
  - Internal subset (included in the document)
  - External subset (external to the document)
- Can combine internal and external subsets within a single document
- Internal declarations override the external declarations
- Use of DTDs
  - Generally, one should use external DTDs!
  - Changes are made to one document
  - Maintenance nightmare if DTDs are in document instances

Associating DTDs with an XML Document

- Need a Document Type Declaration (DOCTYPE - not DTD!)
- Specifies the document(s) to search for the associated DTD
  - At most, two places will be searched
  - Only one of the two documents is used for the DTD
    - If the first matches, it will be used
    - If there is no document at the first location, the second will be used
    - More on this later
- The use of only one DTD is very limiting
  - Cannot build up a larger vocabularies from smaller subsets
  - Cannot merge vocabularies

XML Declaration

- Standard declarations
  - <?xml version="1.0" encoding="…" standalone="yes"?>
  - <?xml version="1.0" encoding="…" standalone="no"?>
- Standalone attribute
  - yes - document is self-contained
    - No need for external DTD
    - If there is a DTD, it is internal
  - no - document refers to external DTD

DOCTYPE Declaration

<!DOCTYPE document_root_element source location1 location2 [internal subset of DTD] >

- Must follow the <?xml …?> declaration
- Must precede all element and character data
  - Comments can precede a DOCTYPE statement
  - Processing Instructions (PIs) can precede a DOCTYPE statement
- XML documents do not need to be validated
- If one wants a document to be validated, one must use a DOCTYPE command
- Only one DOCTYPE per XML document
  - Can be divided into internal and external definitions

DOCTYPE syntax

Example: <!DOCTYPE store SYSTEM
“file:/C:/My Documents/APL/XML/DTD/store.dtd”>

Example: <!DOCTYPE store SYSTEM “store.dtd”>

- < > delimiters
- **!** - special XML declaration
- **DOCTYPE** keyword
- **document_element** - name of the top-level (root) element name
  - **store** - example for this document
  - Must be a single set of <store> ... </store> tags at the top level of an associated document

DOCTYPE syntax (2)

- DTD source
  - Only two options - **SYSTEM** or **PUBLIC**
  - Must declare at least **location1**
  - If **PUBLIC** is used, **location2** may be declared
- **SYSTEM**
  - **location1** must be a Uniform Resource Locator (URL) or more general Uniform Resource Identifier (URI)
  - Parser attempts to retrieve DTD from URI
  - If not found, an error is reported
  - URIs with URL fragment identifiers (#) should not be used
    - "file:/C:/My Documents/APL/XML/DTD/store.dtd#section_1"

DOCTYPE syntax (3)

- **PUBLIC**
  - Useful when applications are spread out
  - Each application requires quick access to the DTDs
  - Rather than having the DTD at one location, make copies and place them local to the applications
  - If local copy not available use master copy
    - **SYSTEM** keyword is implied

Example: <!DOCTYPE store PUBLIC

“store.dtd” “http://www.store.com/store.dtd”>

DTD Markup

- DTDs define the elements of a document and their structure
- Syntax
  - <!keyword parameter1 parameter2 … paramenterN>
  - <!keyword
    parameter1
    parameter2
    …
    parameterN>
  - Whitespace and carriage returns are permitted

Keywords

- ELEMENT
  - Declares XML element name
  - Declares permitted children of the element
  - <!ELEMENT …>
- ATTRIBUTE
  - Declares XML attribute names
  - Declares permitted attribute values
  - <!ATTRIBUTE …>

Keywords (cont.)

- ENTITY
  - Declares special character references, text macros, and other content from external sources
  - <!ENTITY …>
- NOTATION
  - Declares external non-XML content (e.g., images, etc.)
  - Declares applications that handle them
  - <!NOTATION …>

ELEMENT Declarations

- All XML documents use at least one element (the document root element)
- Almost all XML documents contain sets of nested elements
- Two types of ELEMENT declarations
  - <!ELEMENT name category >
  - <!ELEMENT name (content_model) >
- Name is the actual element name
- Category and content model parameters describe the content that ELEMENTs may contain

ELEMENT Names

- ELEMENT name rules
  - Must use XML NameChar characters
  - Unicode letters
  - Numbers
  - “_”, “:”, “-”, “.”
  - Must start with Unicode character, “_” or “:”
  - Colons are not recommended because they can be confused with namespace delimiters

Content Categories - ANY

- ANY
  - Element type can contain any well-formed XML data
  - Character data
  - Other elements
  - Comments
  - Processing Instructions (PIs)
  - Character Data (CDATA) sections
  - <!ELEMENT someEltName ANY>
- Disadvantage
  - Since anything can go in this element, no real checking is done
  - Parsers just ensure that the element and its sub-hierarchy is well-formed

Content Categories - EMPTY

- EMPTY
  - Can only contain ATTRIBUTES
  - DTD specifications
    - <!ELEMENT purchase EMPTY>
    - <!ELEMENT BR EMPTY>
  - XML document example
    - <purchase date="02-02-2002" items="I-62 I-5" qty="2 1"/>
    -
 or
 </BR>

Content Models

- <!ELEMENT element_name (content_model)>
- Content_model can be:
  - **PCDATA**
    - Parsed character data
  - **element**
    - One ore more child elements
  - **mixed**
    - Combination of PCDATA and elements

PCDATA Content

- Parsed character data
- DTD specifications
  - <!ELEMENT city (#PCDATA)>
  - <!ELEMENT description (#PCDATA)>
- XML examples
  - <city>Baltimore</city>
  - <description>Ivory Soap</description>

Τέλος Ενότητας