XML and Databases

Chapter 1: XML Syntax

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Objectives

After completing this chapter, you should be able to:

- write syntactically correct XML.
- check given XML documents for syntax errors.
- explain the tree-structure of XML data.
- read XML Document Type Definitions (DTDs).
- validate an XML document against a given DTD.

Inhalt

Introduction (1)

- XML ("eXtensible Markup Language") is basically a simplification (subset) of SGML ("Standard Generalized Markup Language").

  SGML is an ISO-Standard since 1986. XML was developed mainly 1996, and became an W3C Recommendation on February 10, 1998.

- HTML was too restricted for exchanging semantic data over the internet (not only text documents): User-defined tags are needed.

  E.g., there is no tag "`<price>`" in HTML.

- The browser vendors complained that SGML was too complex.

Introduction (2)

- The current version is XML 1.1 (2nd Ed.) from August 2006.

  The standard is freely available: [https://www.w3.org/TR/xml11/]

  There is also a fifth edition of the XML 1.0 standard from November 2008 (editions add clarifications): [https://www.w3.org/TR/xml/].

- XML/SGML has two levels:
  - It is a syntax formalism, in which (X)HTML and similar markup languages can be defined.
  - For a given DTD (grammar), XML/SGML documents contain the data or the text.

Introduction (3)

- XML/SGML is only a data format (syntax).
- It says nothing about the semantics of the data that are coded in XML/SGML.
- In contrast to SGML, where a DTD is required, XML can also be used without DTD:
  - "Well-formed XML": Basic syntax rules (proper nesting of tags) are satisfied. No DTD is needed.
  - "Valid XML": In addition, only tags defined in a DTD are used, and the content of each "tag" (element) satisfies the constraints of the DTD.

XHTML Example

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!DOCTYPE html PUBLIC
  "-//W3C//DTD XHTML 1.0 Strict//EN"
  "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
    <head>
        <title>My first XHTML document</title>
    </head>
    <body>
        <h1>Greeting</h1>
        <p>Hello, world!</p>
    </body>
</html>
```

Database Example (1)

STUDENTS

SID	FIRST	LAST	EMAIL
101	Ann	Smith	...
102	David	Jones	NULL
103	Paul	Miller	...
104	Maria	Brown	...

RESULTS

SID	CAT	ENO	POINTS
101	H	1	10
101	H	2	8
101	M	1	12
102	H	1	9
102	H	2	9
102	M	1	10
103	H	1	5
103	M	1	7

EXERCISES

CAT	ENO	TOPIC	MAXPT
H	1	ER	10
H	2	SQL	10
M	1	SQL	14

Database Example (2)

- Table rows can be directly translated to XML:

```
<?xml version='1.0' encoding='ISO-8859-1'?>
<GRADES-DB>
  <STUDENT SID='101' FIRST='Ann' LAST='Smith'/>
  <STUDENT SID='102' FIRST='David' LAST='Jones'/>
  ...
  <EXERCISE CAT='H' ENO='1' TOPIC='ER'/>
  ...
  <RESULT SID='101' CAT='H' ENO='1' POINTS='10'/>
  ...
</GRADES-DB>
```

Database Example (3)

- One can also use nested elements for table entries:

```
<?xml version='1.0' encoding='ISO-8859-1'?>
<GRADES-DB>
  <STUDENTS>
    <STUDENT>
      <SID>101</SID>
      <FIRST>Ann</FIRST>
      <LAST>Smith</LAST>
    </STUDENT>
    ...
  </STUDENTS>
  ...
</GRADES-DB>
```

DB Example with Nesting

```
<?xml version='1.0' encoding='ISO-8859-1'?>
<COURSE-DB>
    <PROFESSOR NAME='Brass' PHONE='55-24740'>
        <COURSE TERM='Summer 2004'
                TITLE='Database Design'>
            <CLASS DAY='MON' FROM='10' TO='12'/>
            <CLASS DAY='THU' FROM='16' TO='18'/>
        </COURSE>
        <COURSE TERM='Winter 2004'
                TITLE='Foundations of the WWW'>
            <CLASS DAY='WED' FROM='14' TO='16'/>
        </COURSE>
    </PROFESSOR>
    ...
```

Inhalt

Elements (1)

- An XML/SGML document is a text, in which words, phrases, or sections are marked with "tags", e.g.

  ```
  <title>My first XHTML document</title>
  ```

- "`<title>`" is an example for a start-tag.
- "`</title>`" is an example for an end-tag.
- Specialized editors also use other symbols on the screen, e.g.

  title〉My first XHTML document〈title

Elements (2)

- The text part from the begin of a start tag to the end of the corresponding end tag is called an element.
- The name in start tag and end tag (e.g., "`title`") is called the element name (or element type).

  Note that there can be several elements with the same name, so the name is a kind of "type". However, in XML Schema, elements have types, which are something different. The XML standard talks about "element type declaration", the XML schema standard calls basically the same thing an "element declaration" (it avoids "element type"). That is confusing. In the same way, the concrete instance is called "element" in the XML standard, and "element information item" in the XML Schema standard.

Elements (3)

- Quite often, “tag” is used when “element” would be formally right:
  - A tag is the string from “<” to “>” (inclusive).
  - “The `title` tag” is not quite correct.

    Unless you refer to a specific occurrence in the text, but there are always two `title` tags, the start tag and the end tag.
  - Better say “The `title` element of the document” or something similar.

    No points will be taken off because this confusion is so common.

Elements (4)

- Element types/names are declared in a DTD.

  E.g. the "XHTML 1.0 strict" DTD declares a certain set of element types for HTML documents that includes e.g. "`title`".

- Names (identifiers, used e.g. as element types) can contain letters, digits, periods "`.`", hyphens "`-`", underscores "`_`", and colons "`:`".

  Plus certain extended characters from the Unicode set. They must start with a letter, an underscore "`_`", or a colon "`:`". The colon should only be used in accordance with the namespace specification. All names starting with "`xml`" are reserved.

- Names are case-sensitive.

  In SGML, this can be selected in an SGML declaration.

Elements (5)

- The contents of an element is the text between start-tag and end-tag. E.g. the contents of the example element (Slide 13) is

  `My first XHTML document`

- For each element type, one can define in the DTD what exactly is allowed as contents of these elements ("Content Model").
- E.g. elements of the type `title` can contain only pure text in XHTML (one cannot nest any other elements inside).

Elements (6)

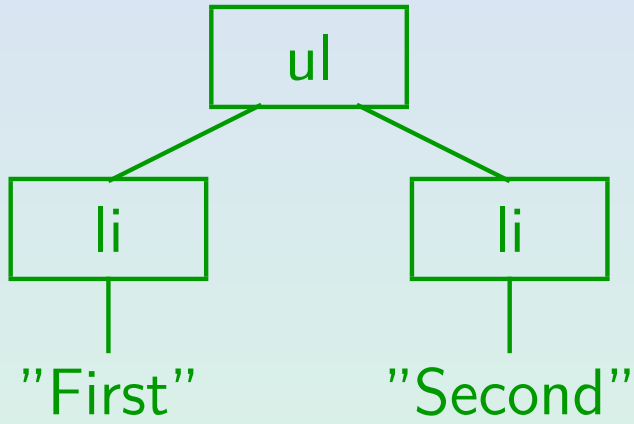
- The element type "ul" (unordered list) contains a sequence of elements of the type "li" (list item):

```
<ul><li>First</li><li>Second</li></ul>
```

- Since elements can contain themselves elements, one can understand an SGML document as a tree:
  - Inner nodes are labelled with elements.
  - Leaf nodes are labelled with text or with elements (which have empty contents in this case).

Elements (7)

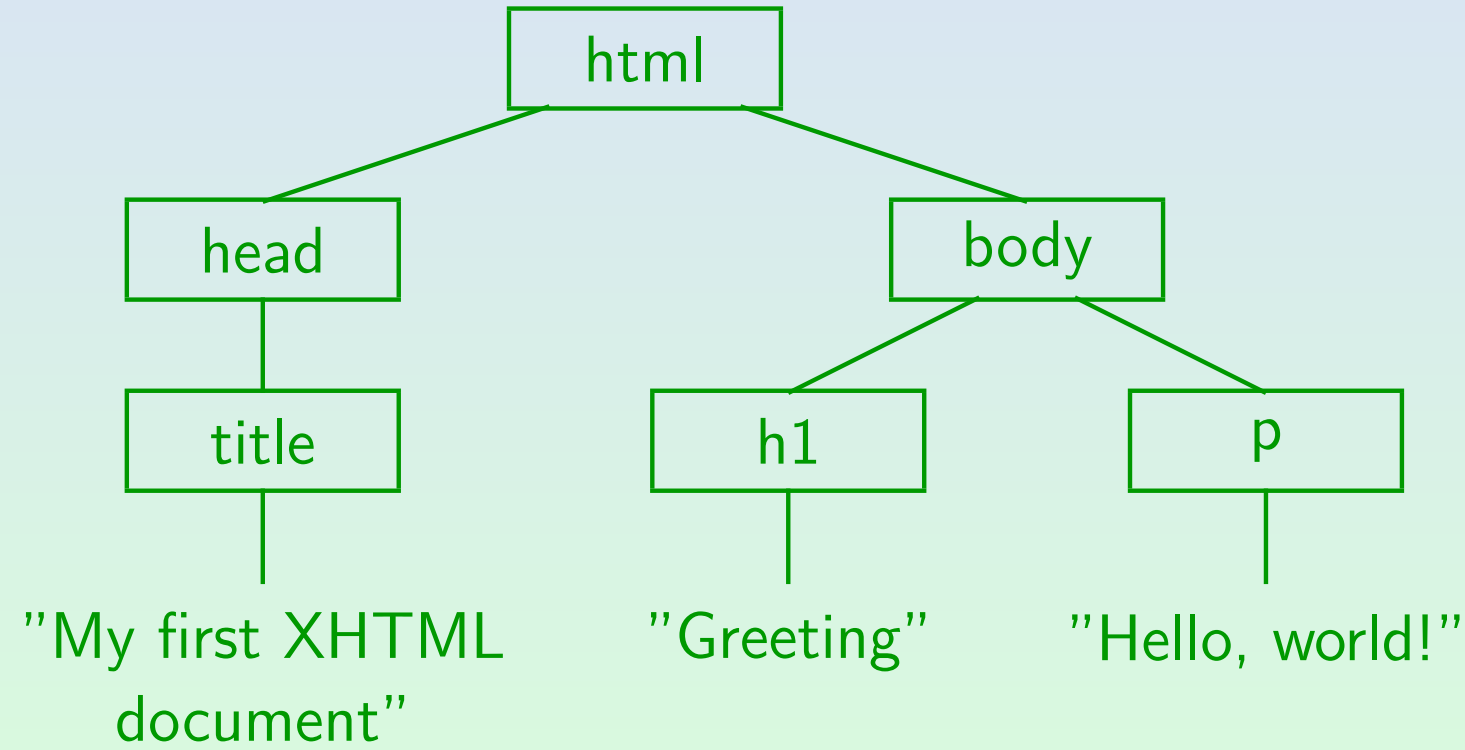
- E.g. the unordered list above has this structure:



It is called "unordered list" because bullets are used for the list items, not numbers, so presumably the exact sequence is not very important. However, in SGML and XML, the child nodes of a node always have a sequence from left to right (as given in the document). This is a difference to relational databases, where the rows in a table have no sequence.

Elements (8)

- Structure of the XHTML example (Slide 7):



Elements (9)

- Elements cannot overlap only partially.

  For each two elements A and B, either A is completely contained in B, or B completely in A, or the two do not overlap at all.

- This means that opening and closing tags must be nested correctly: E.g. the following is legal:

  ```
  <h1><code>...</code></h1>
  ```

  However, this is a syntax error:

  ```
  <h1><code>...</h1></code>
  ```

- Begin and end tags work like parentheses of different types: ([ ]) is legal, but [( ]) is not.

Elements (10)

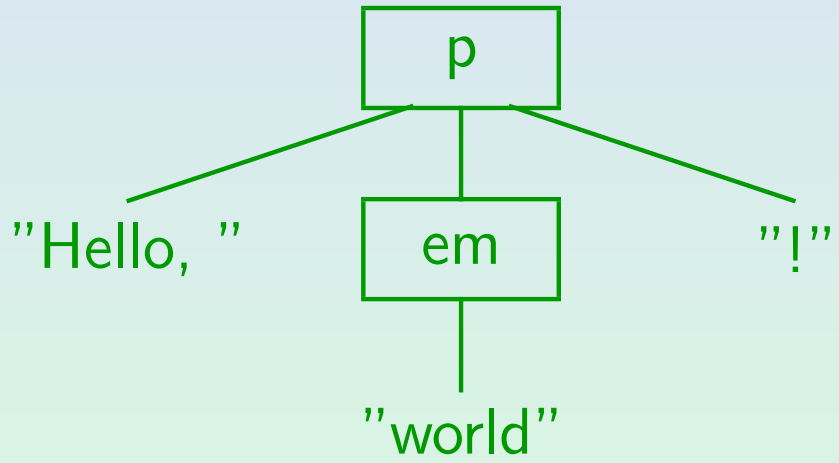
- Four kinds of element types can be distinguished:
  - Element types that can only contain text.
  - Element types that can only contain other element types.

    Of course, these other elements might contain text. The DTD defines which element types are exactly valid inside the given element type and in which sequence they must appear.
  - Element types that can contain a mixture of text and other elements ("mixed content model"):

    ```
    <p>Hello, <em>world</em>!</p>
    ```
  - Element types that always have empty contents.

Elements (11)

- The tree representation of an element with mixed content looks as follows:



- Elements with empty contents work as markers.
  E.g. "`br`" (break) does a line break in XHTML.

Empty Elements

- In XML, for every opening tag there must be a corresponding closing tag.

  In contrast, SGML has "tag minimization" rules that permit to leave out tags that can be uniquely reconstructed by the SGML parser.

- Since `<br></br>` does not look very nice, and the closing tag contains no additional information, empty element tags were introduced in XML: "`<br/>`" is equivalent to "`<br></br>`".

  This was one of the few points were XML was not a subset of SGML at the beginning. Of course, SGML was/will be extended to permit this syntax, too.

Line Ends

- In SGML, line ends (record boundaries) directly after a start tag or directly before an end tag are ignored (i.e. at the start or end of the content).
- In XML, line ends or empty space is not ignored.

  The parser passes it to the application, which can of course ignore it. E.g. a validating parser, which knows that an element contains pure element content (not mixed content) will ignore whitespace between the elements.
- In XML, line ends are normalized to a line feed.

  Even on a Windows system (which uses CR, LF for line ends), the XML application receives LF (ASCII 10) from the parser.

Attributes (1)

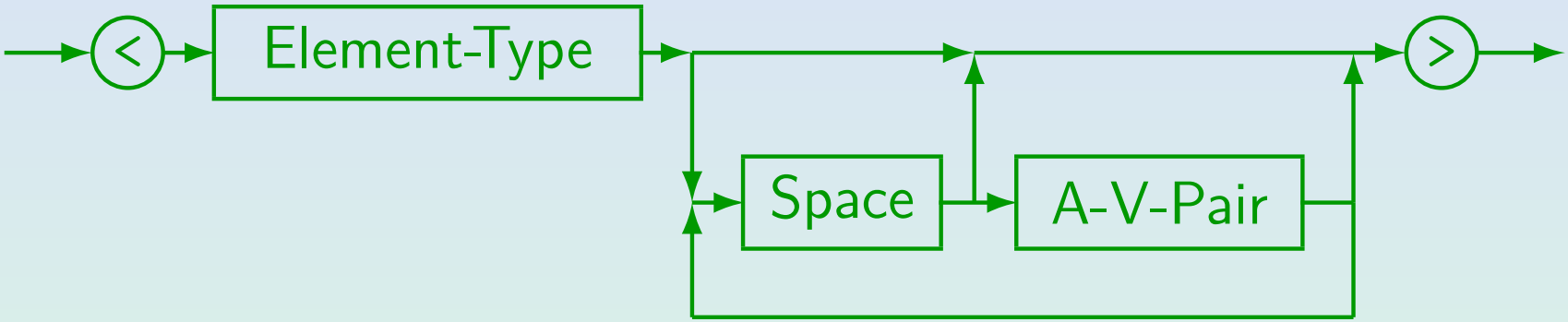
- In the start tag, attribute-value pairs can be optionally specified.
- E.g. in XHTML, links to other documents are marked with the element `a` (“anchor”):

```
XML was developed by the
<a href="http://www.w3.org">W3C</a>.
```

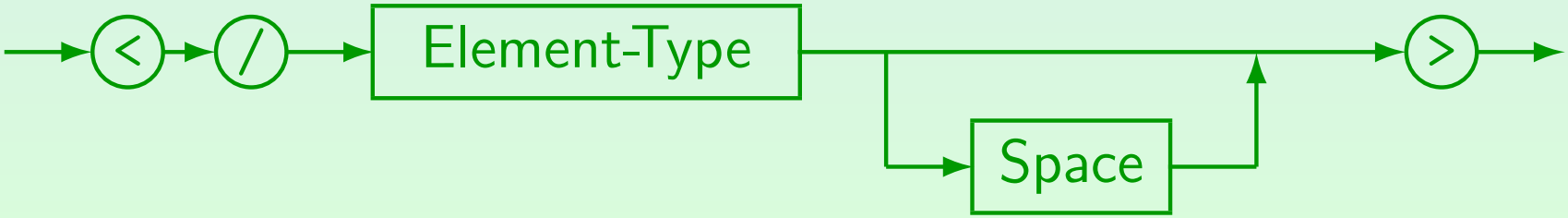
- The text of the reference is given in the element content, the URI of the referenced web page is specified in the attribute “`href`”.

Attributes (2)

Start-Tag:

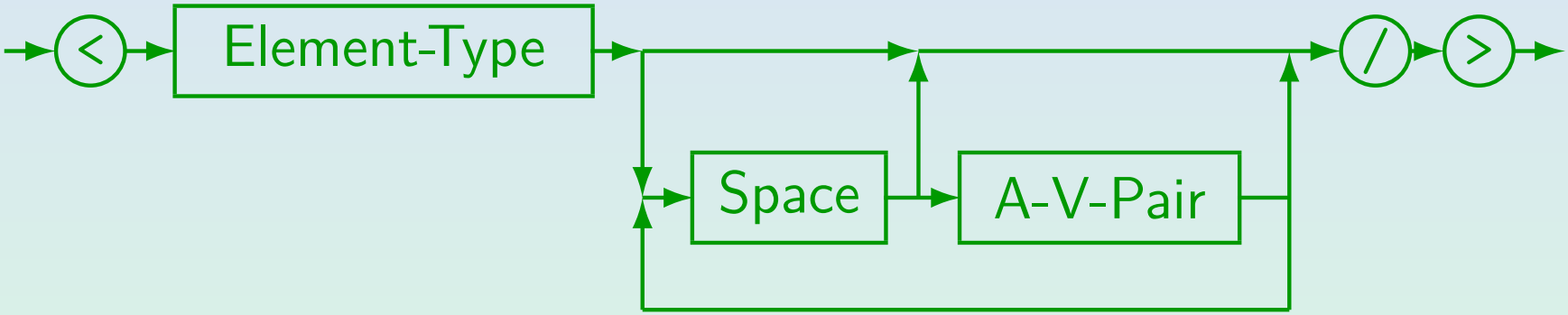


End-Tag:



Attributes (3)

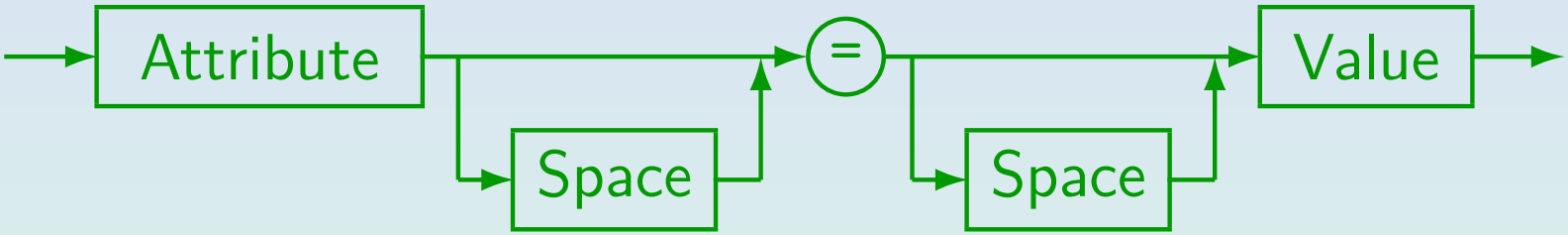
Empty Element Tag:



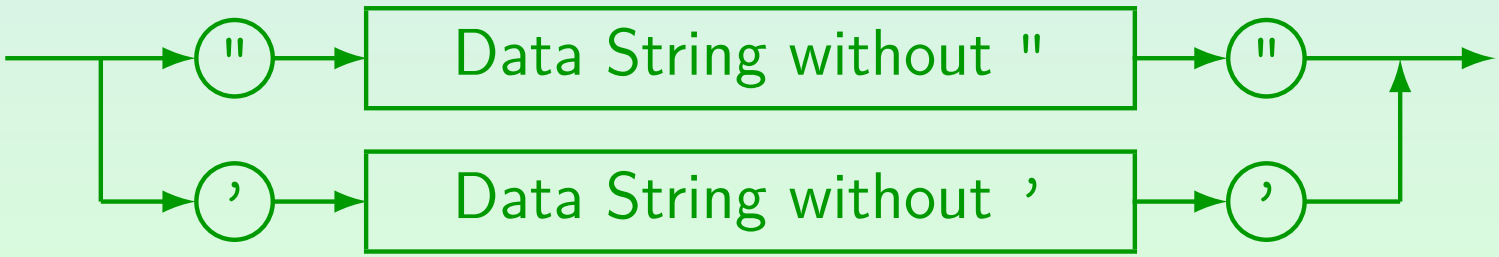
- "Space" (white space) consists of one or more space characters, carriage returns, line feeds, and tabs (ASCII 32, 13, 10, 9).

Attributes (4)

A-V-Pair:



Value:



Attributes (5)

- Attribute values can be enclosed in " or '.
  The other sign can appear inside the string.

  If one needs both quotation marks, one must use an entity or character reference (see below).

- Attribute values cannot contain elements.

- The character "<" is forbidden in attribute values.

  If necessary, one can include it with a character reference or an entity reference. Excluding "<" in attribute values helps to detect errors earlier (such as a missing quote). To make this clear: "<" ist not forbidden in the internal value of an attribute (which an XML parser can pass to the application), it is only forbidden in the external representation. But it never creates elements in attribute values.

Attributes (6)

- The character "&" is treated special in attribute values (character/entity reference, see below).
- Attribute values can extend over multiple lines. The parser replaces tabs and line ends in the attribute value by a space.

  Depending on the type of the attribute, white space may be normalized: It is then removed at the beginning and at the end of the attribute value, and several consecutive spaces are merged into one. However, this does not happen for normal "CDATA" attributes.
- The sequence in which several attribute-value-pairs are listed in a tag is not important.

Character References (1)

- One must distinguish between
  - the repertoire of characters used internally (e.g. data passed from XML parser to application)
  - the encoding of these characters in bytes for exchanging documents (external representation).
- Internally, XML uses the Unicode character set.
- For exchanging documents, one can e.g. use the ISO 8859-1 (ISO Latin 1) character codes, which contains only a subset of all Unicode characters.

  Other encodings contain e.g. cyrillic or japanese characters.

Character References (2)

- The XML declaration at the beginning of the XML file defines the encoding (see below).

  The encoding can also be specified in the HTTP protocol.

- The characters in the ISO Latin 1 character set are also contained in the Unicode character set and have the same numeric codes in both character sets.

  I.e. Unicode is upward compatible to ISO Latin 1. However, the encoding as sequence of bytes is different. At the beginning, Unicode character numbers had 16 Bit, now there are 17 planes of 16 Bit each. With the UTF-8 encoding of Unicode, at least the 7-bit ASCII characters have the same encoding in ASCII, ISO Latin 1, and Unicode. However, for German national characters (ä, ö, ü, etc.) this is no longer true: UTF-8 uses two bytes for them. See Slide 36.

Character References (3)

- Characters that cannot be directly entered, can be written as a "character reference" using their numeric code:

  `&#228;`

  is an "ä". Hexadecimal notation can also be used:

  `&#xE4;`

- The numbers refer to the repertoire (i.e. Unicode), not to the encoding for exchange.

  ASCII and ISO Latin 1 codes can be used since Unicode is upward compatible.

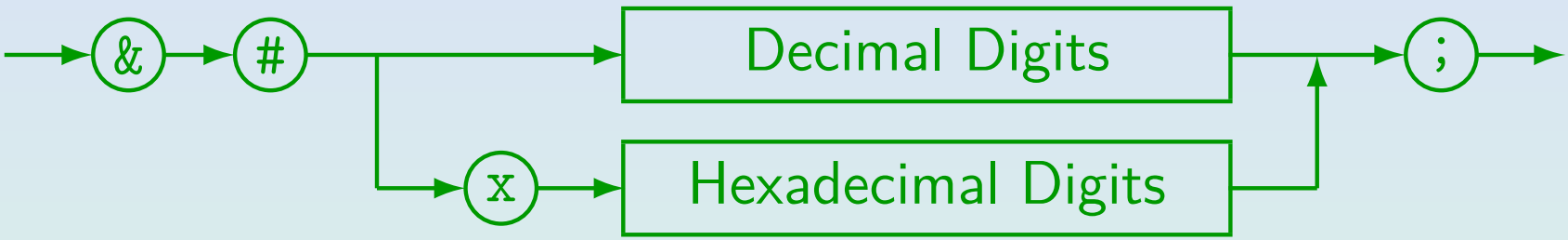
- Character references can also be used to "escape" characters that otherwise would have special meaning in SGML/XML.

  The result of a character reference is always treated as data.

  E.g. if a double quote (ASCII 34) needs to be included in an attribute value that is enclosed in double quotes, one can write it as "`&#34;`".

Character References (4)

Character Reference:



- In DTDs, abbreviations/macros ("entities") can be defined (see appendix).
- In this way, one does not have to remember character codes.

  E.g. in HTML, one would write "`&auml;`" for an "ä" (if one wants to stick to pure ASCII). In XML, this is not predefined.

Short Digression: UTF-8 (1)

- The character "ä" has the number ("code point") U+00E4 (228) in Unicode.
- It has the same number in ISO Latin 1, and this encoding uses one byte per character, therefore it is represented by the byte 0xE4.
- UTF-8 uses one byte per character only for characters with codes up to U+007F (127).

  I.e. when the first bit of a byte is 0, this byte encodes a character by itself.

  This ensures that UTF-8 is upwards compatible to ASCII.

Short Digression: UTF-8 (2)

- For characters with code point above U+007F (including ä), multi-byte sequences are needed in UTF-8:
  - For *n*-byte sequences, the first byte starts with *n* 1-bits followed by a 0-bit.

    E.g. the prefix 110 in the first byte means that this byte sequence consists of two bytes.
  - All other bytes start with 10.

    If one jumps somewhere into an UTF-8 byte stream, one can detect the start of character encodings (bytes starting not with 10).
- Unicode reserves 17 planes of 16 bit each (up to U+10FFFF), which requires max. 4 bytes in UTF-8.

Short Digression: UTF-8 (3)

- A two byte sequence consists of bytes `110xxxxx` and `10yyyyyy`, representing the code point `xxxxxyyyyyy` and is used for the range `U+0080` to `U+7FF`.
- The character "ä" with code `U+00E4` (`11100100`) is encoded as `11000011` (`0xC3`) and `10100100` (`0xA4`).
- If an editor assumes that the text is encoded in ISO Latin 1, it will display the two characters `Ã ¤`.

  The second is a "general currency symbol": `U+00A4` (= 164).
- Each code point must be encoded in the shortest byte sequence (e.g. ASCII characters as one byte).

Comments (1)

- Comments can be used to enter notes or explanations for a reader of the SGML/XML source file into the document.
- Comments are ignored by programs that process an SGML/XML file. E.g. they might not appear in the formatted output.

  The XML standard permits that an XML parser passes comments to the application program, but it does not require this.

- A comment in SGML/XML has the form

```
<!-- This is a comment -->
```

Comments (2)

- Comments can extend over several lines.

  I.e. they do not have to be closed on the same line.

- Within a comment, it is forbidden to write two consecutive hyphens "--".

  In SGML, the comment actually extends from "--" to "--". However, it can only be used in a markup declaration, which starts with "<!" and ends with ">".

- Tags within a comment are permitted, but confuse many browsers.

  Browsers try to correct syntax errors. When they see a tag, they might assume that the author forgot the "end of comment" mark.

Comments (3)

- Comments can be used anywhere in the document outside other markup.
- They cannot be used within tags.
- In SGML (but not in XML), comments "`-- ... --`" can appear in markup declarations at places permitted by the grammar.

  In modern programming languages, whitespace including comments is allowed between tokens. SGML/XML are different: maybe because they are languages for writing documents, not programs, maybe they are a bit outdated in this aspect.

- XML supports only "`<!-- ... -->`".

Exercise

Please find syntax errors:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<GradesDB3>
    <student sid='101' first='Ann' last="Smith"
        <result cat='H' eno = 1  points=10>
        <result cat='H' eno ='1' points='8'>
        <result cat='M" eno ="1" points='12'
            >
    </ student >
    <!------------ Exercises ------------>
    <ex cat='H' eno='1' note='<em>difficult</em>'>
        Rel&#97 tional Algebra</ex>
</Grades-DB>
```

Software (1)

- Although browsers are very generous with syntax errors in HTML documents, they show all errors in XML documents.

  E.g. Internet Explorer, Firefox.

- They check only the syntax of well-formed XML, they do not validate documents against a DTD.

- If no style sheet is given, the document tree is displayed (child nodes are indented under the parent).

  It is possible to collapse/expand subtrees by clicking on the -/+ in front of the elements.

Software (2)

- Xerces from the Apache Software Foundation is an example for a validating parser for XML (supporting DTDs and XML Schema).

  See [http://xerces.apache.org/]. It has a DOM and a SAX interface for accessing the parsed data. It comes with a test program domprint, which can be used for checking the syntax (it is an unparser, i.e. it outputs the result of parsing again as XML, but probably differently formatted). There is a C++ and a Java version, and a Perl interface to the C++ version.

- There are also validation services on the web, e.g.
  - [http://www.xmlvalidation.com/]
  - [https://www.w3schools.com/xml/xml_validator.asp]

Inhalt

Example

Simple DTD for a HTML-Subset:

```
<!ELEMENT html  (head, body)>
<!ELEMENT head  (title)>
<!ELEMENT title (#PCDATA)>
<!ELEMENT body  ((#PCDATA|p|em|ul)*)>
<!ELEMENT p     ((#PCDATA|em|br)*)>
<!ELEMENT em    (#PCDATA)>
<!ELEMENT br    EMPTY>
<!ELEMENT ul    (li+)>
<!ELEMENT li    ((#PCDATA|p|em|ul|br)*)>
```

Element-Type Declarations (1)

An Element-Type Declaration consists of:

- "<!" followed by the keyword "ELEMENT".

  In SGML, one could define a different string instead of "<!". This is the parameter MDO ("Markup Deklaration Open Delimiter") in the SGML declaration. Correspondingly, ">" is called MDC ("Markup Declaration Close Delimiter"). XML is based on a fixed SGML declaration, so one cannot change these delimiters.

- Name of the element type to be declared.

  Such names are officially called "Generic Identifiers".

- Then one specifies what is permitted as content of this type of elements ("content model").

- ">".

Element-Type Declarations (2)

Element-Type Declaration:

White space is required between "<!ELEMENT" and the name, and between the name and the content specification. It is permitted but not required between content specification and the ">".

Names in XML must start with a letter, an underscore "_" or a colon ":", and can otherwise contain letters, digits, periods ".", hyphens "-", underscores "_", colons ":", or certain special Unicode characters. Names starting with "xml" in any capitalization are reserved, the colon is treated specially by the XML namespace standard.

The element type declaration is SGML is more complicated: There, also specifications for markup minimization are required (if the markup minimization parameter OMITTAG is set), "exclusions" and "inclusions" are possible, several element types can be declared together, etc.

Content Specifications (1)

- The building blocks of content specifications are
  - Names X of element types: This pattern matches exactly one element of type X, i.e. basically <X>...</X>.
  - The keyword #PCDATA: Pure textual data without tags (but possibly character/entity references).

    #PCDATA stands for "Parsed Character Data" (it is checked that there are no nested tags). SGML (not XML) has also CDATA (treats < as text).
- One can specify the optionality/multiplicity of elements and groups by attaching occurrence indicators:
  - $A?$: Optional, non repeatable (0 or 1 time).
  - $A*$: Optional, repeatable (0 or more times).
  - $A+$: Required, repeatable (1 or more times).

Content Specifications (2)

- Content specifications can be connected with
  - $(A_1 | \ldots | A_n)$: "Alternative"/"Choice" (one of the A_i).

    E.g. (A | B): "A or B". The content must match A or match B.
  - $(A_1, \ldots, A_n)$: "Sequence" (all A_i in the given sequence).

    E.g. (A, B): "First A, then B" ("A followed by B"). A prefix of the content must match A, the rest B.

    SGML (not XML) has also (A & B): "A and B". A and B must both appear, but in arbitrary sequence. This is equivalent to ((A,B)|(B,A)).
- The A_i are
  - An element type (possibly with ?/*/+).
  - #PCDATA (in XML with restrictions, see below).
  - A nested model group (possibly with ?, *, +).

Content Specifications (3)

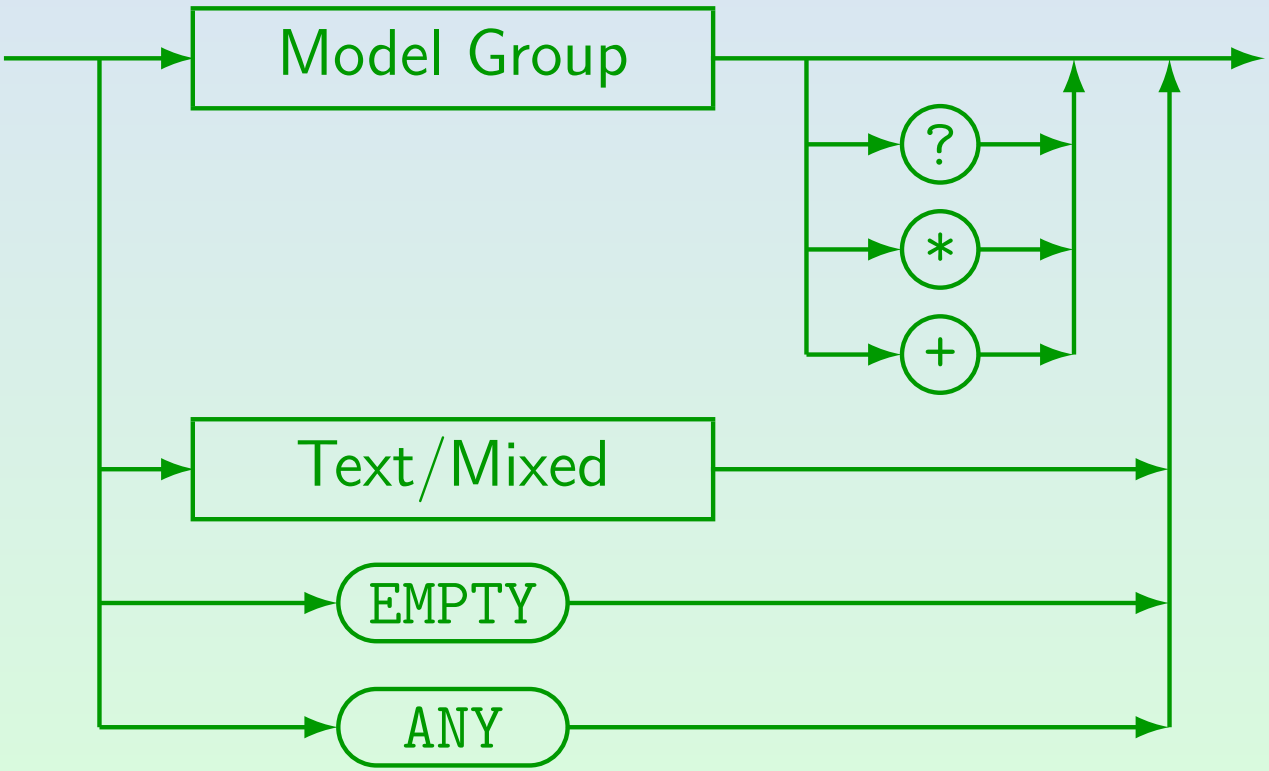
- A content specification ("content model") is
  - A model group (possibly only of one element),

    Element types must always be specified within parentheses.

    XML has special restrictions for mixed content, see below.
  - the keyword `EMPTY`: No content permitted.
  - The keyword `ANY`: Character data and elements of arbitrary type.

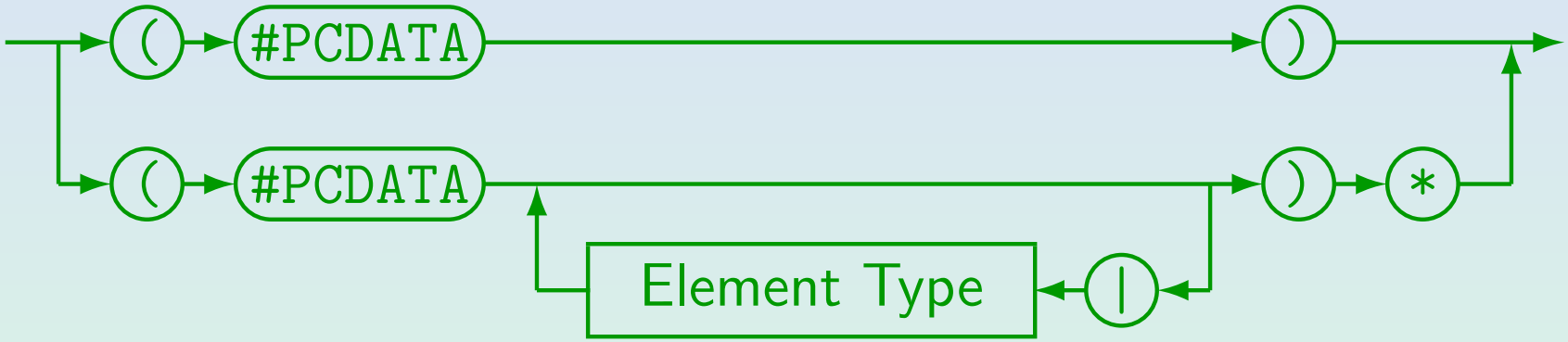
Content Specifications (4)

Content:



Content Specifications (5)

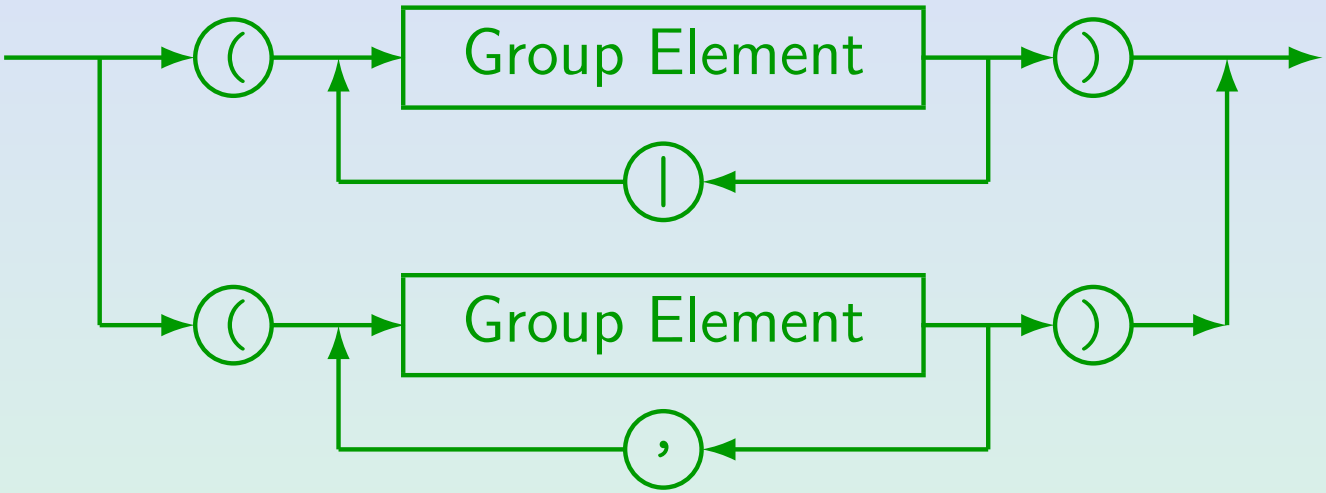
Text/Mixed:



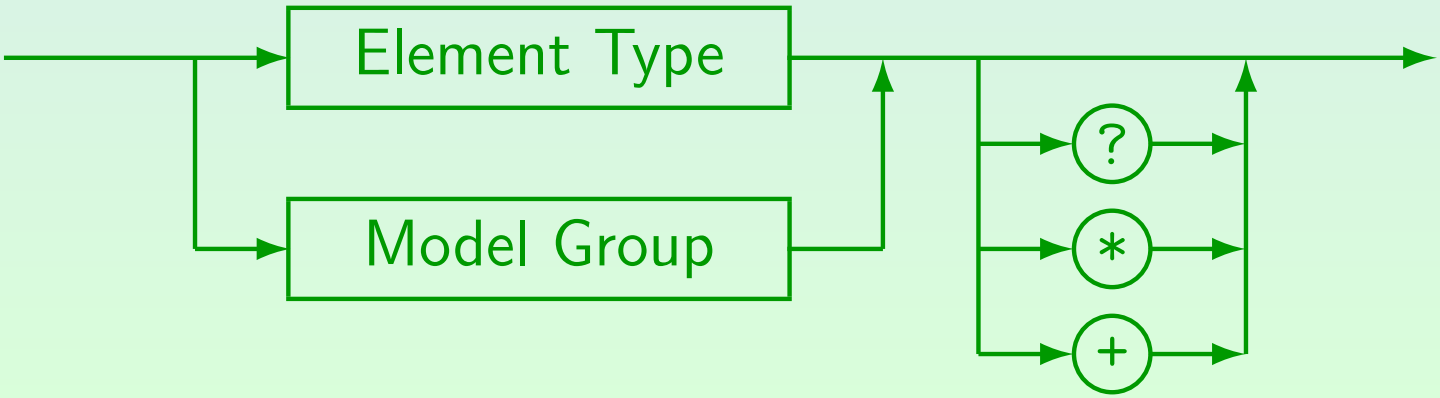
- In XML, the only content models that can contain `#PCDATA` are (SGML has no such restriction):
  - `(#PCDATA)`
  - `(#PCDATA | Element-Type | ... | Element-Type)*`

Content Specifications (6)

Model Group:



Group Element:



Content Specifications (7)

- In SGML and XML, the possible occurrence of white space is defined by the grammar.
- It is permitted but not required between each two tokens ("word symbols") in content models, except before the occurrence indicators "?", *", "+".
- The keyword "#PCDATA" requires the symbol "#" (RNI, "Reserved Name Indicator") in order to distinguish it from an element type named "PCDATA".

  Other keywords like "EMPTY" do not use it, since in the element type declaration, they appear outside of parentheses, while user-defined names must appear inside parentheses.

Content Specifications (8)

- In SGML and in XML, content models must be not ambiguous. E.g. the following is forbidden:

```
<!ELEMENT E ((A, B?), B)>
```

  When the parser has read an `A` and sees a `B`, it is not clear whether this is the optional `B` in the middle or already the required `B` at the end.

- Another example for an ambiguous content model:

```
<!ELEMENT E ((A, B) | (A, C))>
```

  When the parser sees the element `A`, it does not know which path to follow.

- This requirement simplifies the task of checking the input with respect to a given DTD.

  There are standard techniques for generating a nondeterministic finite automaton for a given regular expression. SGML and XML are restricted in such a way that the constructed automaton is already deterministic.
  Some XML Parsers accept nondeterministic content models.

Attribute Declarations (1)

- Example (symbol used for marking list items):

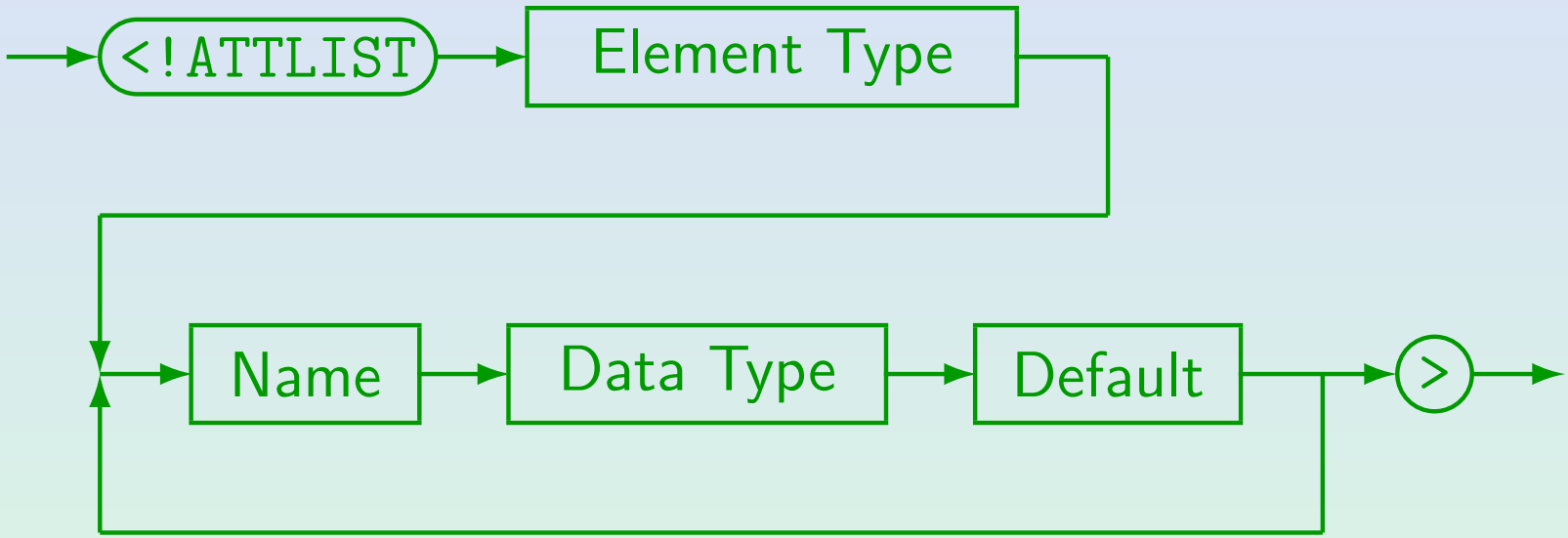
```
<!ATTLIST UL type (disc|square|circle) #IMPLIED>
```

  In HTML 4.01 Strict this attribute was removed.

- Several attributes (of one element type) can be declared in a single `ATTLIST` command.
- E.g. some attributes of images in HTML:

```
<!ATTLIST IMG src CDATA #REQUIRED
              alt CDATA #REQUIRED
              width CDATA #IMPLIED
              height CDATA #IMPLIED>
```

Attribute Declarations (2)



- For each attribute, three things are defined:
  Name, data type, and default value.

  White space is required between each two components of the `ATTLIST` command, except before the final "`>`", where it is optional.

Attribute Declarations (3)

- The same attribute name can appear in an `ATTLIST` declaration only once.

  This is clear: There cannot be conflicting definitions for an attribute in the same declaration.

- If there are several `ATTLIST` declarations for the same element type, they are merged. The first declaration for an attribute becomes effective, all other declarations for the same attribute are ignored.

  This might be useful if a DTD is constructed in several pieces. It is however recommended (required in SGML?) that for every element type, there is only one `ATTLIST` declaration which defines all its attributes.

Attribute Data Types (1)

- E.g. `(yes|no)`: Enumeration type.

  The attribute value must be one of the listed values. Each value is a "name token" (NMTOKEN), i.e. a sequence of characters that can appear anywhere in identifiers (letters, digits, and certain special characters). E.g. a sequence of digits would be valid. In SGML, it is forbidden that same enumeration type value is used for two attributes of the same element type. In XML, this is recommended "for interoperability".

- `CDATA`: Sequence of arbitrary characters.

  The character "`&`" is interpreted, i.e. one can use character and entity references in the attribute values. In XML, "`<`" is forbidden in attribute values (so that missing quotes are easier found), and "`>`" is not interpreted (treated as data). In SGML, "`<`" and "`>`" are valid, but not interpreted. Thus, attribute values still cannot contain elements.

Attribute Data Types (2)

- `ID`: A name that uniquely identifies this element (within the entire document).

  The syntax is the same as for element type names (sequence of letters and digits plus `_`, `:`, `.`, `-`, starting with letter or `_`, `:`, `.`). Two elements must not have the same value for an attribute of type `ID`. This even holds for elements of different type. The same element type cannot have two attributes of type `ID`. One should use the same name for all attributes of type `ID`, and the attribute name "`ID`" is very common.

- `IDREF`: A name that appears as value of an `ID`-attribute somewhere in the document.

- `IDREFS`: List of `IDREF`-values.

  The single values are separated by white space.

Attribute Data Types (3)

- `NMTOKEN`: Sequence of name characters.

  An arbitrary sequence of letters, digits, "`_`", "`-`", "`.`", and "`:`".

  This is the most restricted type one can use for numbers. There is no numeric type in XML.

- `NMTOKENS`: List of `NMTOKEN`-values.

- `ENTITY`: Name of an entity (not in exam).

  Entities are a kind of macros or include files (see appendix). An attribute of type `ENTITY` takes as value the name of a declared unparsed entity.

- `ENTITIES`: List of `ENTITY`-values (not in exam).

- `NOTATION (`N_1`|...|`N_m`)`: One of the notations N_i.

  (Not in exam.) The N_i must be declared as notations (data formats). Only one attribute of an element type can have the type `NOTATION`. This attribute defines the format of the content of the element.

Default Values (1)

- One must specify what should happen if an element of the type has not defined a value for the attribute.
- One possibility is to specify a default value:

```
<!ATTLIST UL type (disc|square|circle) "disc">
```

The quotation marks around the default value are not required in SGML, but they are required in XML. This is a bit inconsistent, since in accordance with SGML, there are no quotation marks in the enumeration of possible values. In SGML, attribute values that are NMTOKENS do not need quotes.

- Then the tag `<UL>` in the document is equivalent to

```
<UL type="disc">.
```

Default Values (2)

- Instead of a default value, one can also specify:
  - `#IMPLIED`: The attribute is optional.

    I.e. the default value is a "null value" different from all possible normal values. The name for the keyword was chosen because it is assumed that the application program can compute a value for the attribute. E.g. a chapter number is usually the number of the last chapter plus 1.
  - `#REQUIRED`: An attribute value must be specified.
  - `#FIXED "Value"`: The attribute can have only this single value that is specified in the DTD.

    This is e.g. used when many/all element types have an attribute with the same name, and for each element type a (possibly different) value is declared in the DTD.

Exercise (1)

Please find syntax errors:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<!DOCTYPE GradesDB4 [
    <!-- contains syntax errors -->
    <!ELEMENT GradesDB4 (STUDENT, RESULT)*>
    <!ELEMENT STUDENT RESULT+>
    <!ATTLIST STUDENT FIRST CDATA #REQUIRED
                      LAST  CDATA #REQUIRED>
    <!ELEMENT RESULT #EMPTY>
    <!ATTLIST RESULT EX_ID  IDREF   #REQUIRED
                     POINTS NMTOKEN #OPTIONAL>
    <!ELEMENT EXERCISE #PCDATA>
    <!ATTLIST EXERCISE ID ID #REQUIRED>
]> <!-- continued on next slide -->
```

Exercise (2)

Please validate against DTD on last slide:

```
<GradesDB4>
    <student sid='101' first='Ann' last='Smith'>
        <email>smith@acm.org</email>
        <result ex_id='H1' points='A+'/>
        <result ex_id='2' points='8'/>
        <result ex_id='M1' points='12 points'/>
    </student>
    <student first='Maria' last='Brown'/>
    <exercise id='H1'>ER</exercise>
    <exercise id='2'>SQL</exercise>
</GradesDB4>
```

Exercise (3)

Please develop a DTD for this document:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<smallbusiness>
    <product id='P01' name='Apple' price='0.40'>
        Really <em>delicious</em>Apples!</product>
    <product id='P02' name='Banana' price='0.50'>
        The best bananas!</product>
    <order id='R100' customer='Ann Smith'>
        <item prodid='P01'/>
        <item prodid='P02' quantity='5'/> </order>
    <order id='R100' customer='Maria Brown'>
        <item prodid='P01' quantity='3'/> </order>
</smallbusiness>
```

Inhalt

Well-Formed vs. Valid (1)

- In XML, the document type definition is optional.

  In SGML, a DTD is required for every document. An SGML document can normally not be parsed without knowing the DTD because of markup minimization (optional start and end tags).

- There are two classes of XML documents:
  - Well-formed documents satisfy the general rules of the XML syntax (e.g. that tags must be properly nested).
  - Well-formed documents may in addition be valid if they have an associated DTD and satisfy the syntax rules of this DTD.

Well-Formed vs. Valid (2)

- Checking the syntax of a document with respect to a DTD is called "to validate" the document.
- Even if there is a DTD, not every XML processor is required to read it and to validate the document.

  Correspondingly, the XML specification distinguishes "validating" and "non-validating XML processors".
- Web browsers (e.g. Internet Explorer, Firefox) typically do not validate the displayed XML documents.

  However, they do report an error if already the well-formed syntax rules are not satisfied.

System/Public Identifiers (1)

- In SGML/XML DTDs and other objects (e.g. entities, notations, see appendix) can be identified by system and public identifiers.
- In XML, the system identifier is more important.
- In XML, the system identifier must be a URI/URL (without fragment identifier, i.e. without #).
- Local file names are relative URIs and are therefore permitted.

  In SGML, the system identifier typically was a local file name. Since the directory structure can be different on different computers, the system identifier was system dependent.

System/Public Identifiers (2)

- Public identifiers are system-independent and very stable.

  They were especially important in SGML: Otherwise it was quite likely that documents had to be changed when they were moved from one system to another. For XML, this problem is much smaller, because a URI is typically "global" and relatively stable (at least URIs for globally used DTDs).

- However, public identifiers must be translated into system identifiers.

  In the end, there must be the possibility to retrieve the file with the DTD (unless the DTD is built into the software, e.g. a web browser does not need to read the HTML DTD). Normally, an SGML system contains a configuration file that maps public IDs into system IDs.

System/Public Identifiers (3)

- An advantage of public identifiers even in the Web age is that the contents of the URI does not have to be retrieved if there is a local copy and the public identifier is mapped to that copy.

  Otherwise one (probably) must retrieve the DTD via the URI each time a document is validated against that URI (there is no guarantee that the DTD stored under the URI does not change).

- In XML, a public ID can only be used in combination with a system ID. Thus, if an XML system does not know the public identifier, it can use the URI.

  SGML permits to specify only a public identifier.

System/Public Identifiers (4)

- Public identifiers can be any string of letters, digits, certain special characters, spaces and line breaks (enclosed in single or double quotes: ' or ").

  Allowed special characters in XML: '()+,-./:=?;!*#@$_%. Sequences of line breaks and spaces are replaced by a single space, and ignored at the very beginning or end.

- Example: "-//W3C//DTD HTML 4.01//EN"

  A subset of public identifiers are called "formal public identifiers". They have more structure and must be composed from an owner identifier, a double slash "//", and a text identifier. The owner identifier starts with "ISO" for ISO publications, "+//" for registered owners, and "-//" for unregistered owners. The text identifier starts with the public text class, followed by a space, a description, a double slash "//", and the language of the text. Public text classes are, e.g., DTD and NOTATION.

DOCTYPE Declaration (1)

- One usually refers at the beginning of the document to the corresponding DTD:

```
<?xml version="1.0"?>
<!DOCTYPE EMAIL SYSTEM "mail.dtd">
<EMAIL>
    ...
</EMAIL>
```

- The file "mail.dtd" contains the declaration of elements, attributes, and entities as described above.

```
<!ELEMENT EMAIL (TO, FROM, DATE, SUBJECT?,
                 CONTENTS)>
...
```

DOCTYPE Declaration (2)

- One can also specify public and system identifier:

```
<!DOCTYPE html PUBLIC
    "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html>
    ...
</html>
```

- The name of the DTD must always be identical to the name of the outermost element (document element, root of the element tree).

  The DTD itself does not specify what is the root element.

DOCTYPE Declaration (3)

- It is possible to declare the DTD in the document itself:

```
<!DOCTYPE EMAIL [
    <!ELEMENT EMAIL ...>
    ...
]>
<EMAIL> ... </EMAIL>
```

- Also a mixture of both is possible:

```
<!DOCTYPE EMAIL SYSTEM "mail.dtd" [...]>
```

DOCTYPE Declaration (4)

- The part in the document itself ("[...], "internal DTD subset") is processed before the DTD file ("external subset").

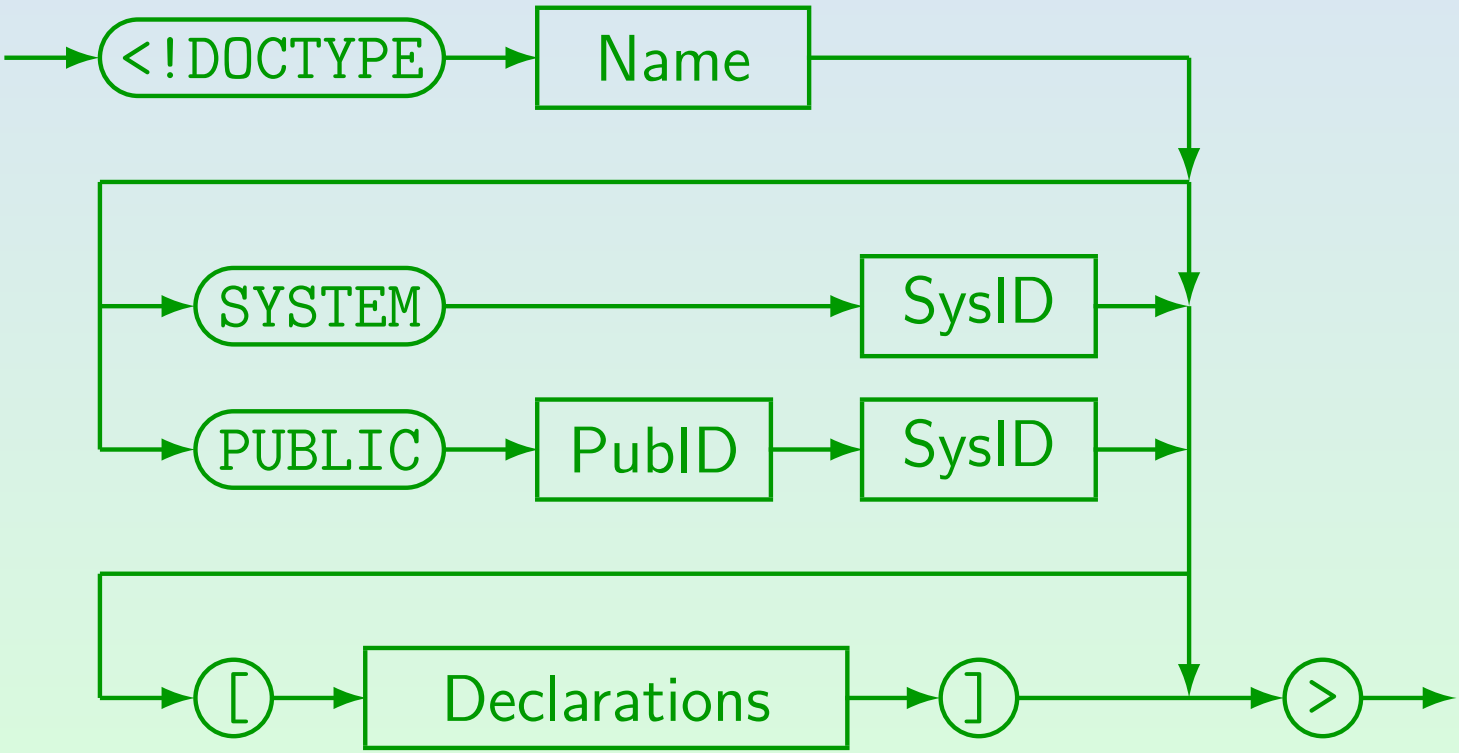
  The same entity (a kind of macro, see below) can be declared several times. Then the first declaration counts, all following declarations are ignored. In this way, the external subset can declare a default value for the entity, which can be overridden in the document.

- In XML, the constructs used in the internal subset of the DTD are somewhat restricted, such that a non-validating XML processor can easily skip it.

  See parameter entity references, marked sections.

DOCTYPE Declaration (5)

DOCTYPE Declaration:



Processing Instructions (1)

- Processing instructions are instructions for the application program that processes the XML/SGML data.
- E.g. they are used to add a link to an XSLT stylesheet to the document.
- Processing instructions can appear more or less anywhere in the document (in the same places as comments).
- Processing instructions start with "<?" and end with "?>".
- Processing instructions can contain any text, and are system- and application-dependent.

Processing Instructions (2)

- Processing instructions must start with a name that is the "target" for this instruction.

  In this way, on can have processing instructions for different applications in the file. Applications should ignore processing instructions that are not intended for them. In SGML, a processing instruction can be any string, but processing instructions must normally be exchanged when the file is processed with a different application. In SGML, processing declarations by default end with ">", not "?>". But of course, SGML is so parameterized that the XML end marker can also be selected.

- The special target "xml" (in any capitalization) is reserved (see XML Declaration below).

- One can e.g. use the attribute-value syntax in a processing instruction, but this is not required.

XML Declaration (1)

- XML documents should start with an XML declaration that specifies at least the XML version:

```
<?xml version="1.0"?>
```

  For SGML processors, the XML declaration is simply a processing instruction.

- Version "1.0" is still the most widely used version, but there is now also a version "1.1".

  There are new editions of the W3C recommendation for XML 1.0. but they only clarify/correct a few points. The W3C recommendation for XML 1.0 was published on February 10, 1998. The second edition was published on October 6, 2000. The third edition of XML 1.0 was published on February 4, 2004, together with the first edition of XML 1.1. The current, fourth edition of XML 1.0 was published together with the second edition of XML 1.1 on August 16, 2006, both were edited in place on September 29, 2006. [http://www.w3.org/XML/].

XML Declaration (2)

- The changes from version 1.0 to 1.1 are small:
  - More characters are allowed in names.

    In XML 1.0, the valid characters in names were specified.
    In XML 1.1, the forbidden characters are specified (and characters are forbidden only if there is a specific reason). This makes a difference because the Unicode standard is developed further and some new languages were discriminated by the old XML standard.
  - Line ends in IBM mainframes are now permitted.
  - The rules for control characters change a bit.

    Character references to control characters in the range `x01` to `x1F` are now permitted, control characters in the range `x7F` to `x9F` (except whitespace) must now be written as character references.
  - Normalization rules permit binary comparison.

XML Declaration (3)

- The XML declaration is optional, but it can be only the first command in an XML document.

  Even comments and white space is not allowed in front of it.

- The reason for this is that it can help to automatically detect the encoding used in the file.

  XML processors must at least be able to read at least the UTF-8 and UTF-16 encodings of Unicode. UTF-16 encoded files must start with the "Byte Order Mark" (`#xFeFF`).

- If one uses a different encoding (not Unicode), the XML declaration at the begin of the document is required, and must specify the encoding:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
```

XML Declaration (4)

- The XML declaration can also specify whether markup declarations that are not contained in the same file (entity) may influence the information returned from the parser to the application program.

```
<?xml version="1.0" encoding="ISO-8859-1"
                    standalone="yes"?>
```

- The default is “no” (if there are external markup declarations), and this is normally correct.

  E.g. default values for attributes, entities used in the document, even element types with element content where white space is inserted in the document would all require “no”.

Summary: XML Document

- In summary, an XML document consists of:
  - An XML declaration (optional, recommended).
  - Comments, processing instructions, white space (optional).
  - A document type declaration (optional).
  - Comments etc. (optional).
  - An element (the document element, required).
  - Comments etc. (optional).

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