ADVANCED DATABASE

Semi-structured databases - XML

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Agenda

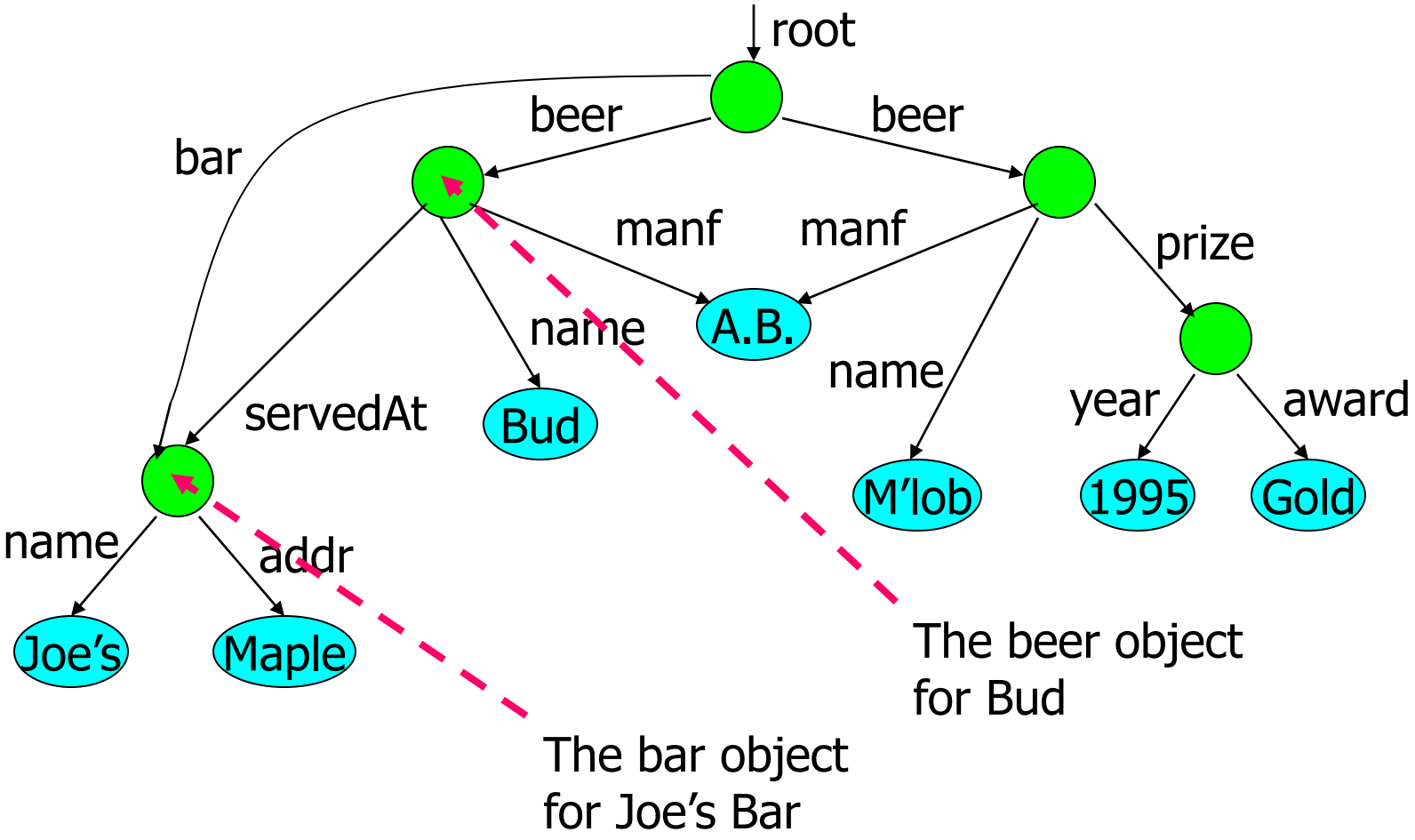
- Semis-structured Data
- Background of XML
- XML syntax
- XML validation
  - DTD
  - XSD
- XQuery

Semis-tructured Data

- Motivation:
  - Flexible representation of data: often, data comes from multiple sources with differences in notation, meaning, etc.
  - Sharing of documents among systems and databases.
- Semi-structured data
  - Not conform with formal structure (tables)
  - Another data model, based on trees.

3

Example: Data Graph



4

Semi-structured Data Representation

- Nodes = objects.
  - Atomic values at leaf nodes (nodes with no arc out).
  - Interior nodes have one or more arcs out
    - Labels on arcs (attributes, relationships).
- Flexibility: no restriction on:
  - Labels out of a node.
  - Number of successors with a given label.

5

History of Markup

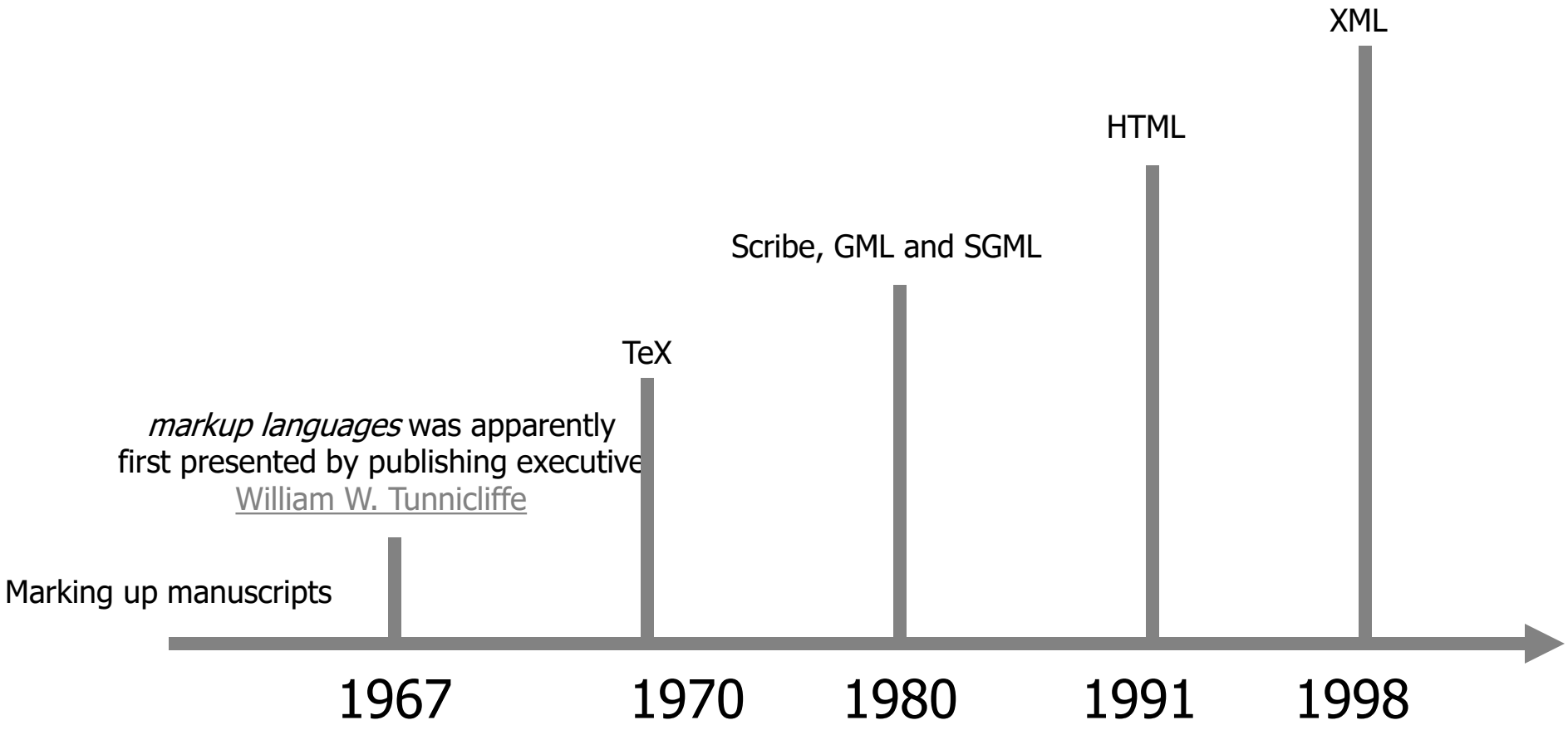
Documents recorded using paper and pen

Tools used by typesetters to format a document

Typesetters formatting documents

History of Markup

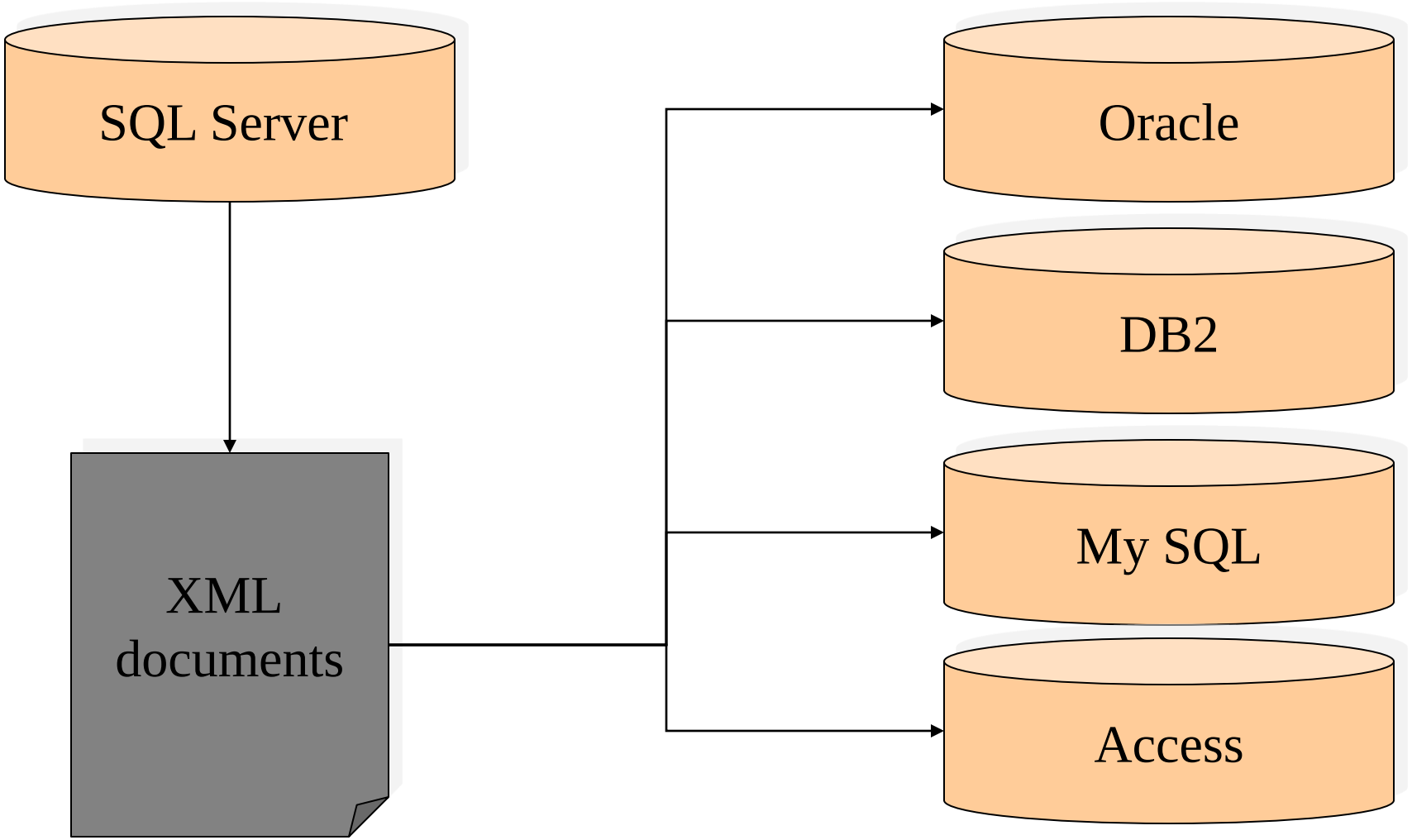
A Markup language defines the rules that help to add meaning to the content and structure of documents



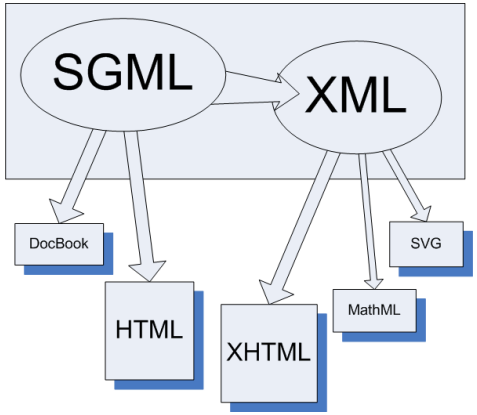
Extensible Markup Language - XML

- A smaller version of SGML.
- For data description, not for presentation like HTML
  - Data in XML can be displayed in different ways
- More flexible than HTML.
  - Users can define their tags understandable for others (people, programs)

XML as a data integration mean



Background for XML



- An Extensible Markup Language (XML) document describes the *structure of data*
- XML and HTML have a similar syntax … both derived from SGML
- XML has no mechanism to specify the format for presenting data to the user
- An XML document resides in its own file with an '.xml' extension

Example of XML

```
<?xml version="1.0" standalone = "yes" ?>
<BusinessCard>
    <Name>Joe Marini</Name>
    <phone type="mobile">(415) 555-4567</phone>
    <phone type="work">(800) 555-9876</phone>
    <phone type="fax">(510) 555-1234</phone>
    <email>joe@joe.com</email>
</BusinessCard>
```

XML syntax

XML declaration

```
<?xml version = "1.0" standalone= "no" encoding = "UTF-8"?>
```

- At very beginning, not even white space before
- XML declaration is optional
- <?xml?> must be in lower case
- Standalone: yes or no → whether this documents has rules (DTD, XSD)

Tags

- Tags (a.k.a elements) are nodes
- Format
  - Starting tag: <____>
  - Ending tag: </____>
- Starting and ending tags must match
- Tag name:
  - Case sensitive
  - Starts with underscore or letter
  - Followed by letters, digits, underscore, hyphens, dots
  - Cannot use "xml" in any combination
- Tag content: string between tags: <email>joe@joe.com</email>
- Short format for empty tag: <___/>. E.g: <email></email> ≈ </email>

Tags

- Every XML document has one root tag

<?xml version = "1.0" standalone= "no" encoding = "UTF-8"?>

<BusinessCard>

</BusinessCard>

- Nesting tag
  - Tag can contains child tags
  - Children must not overlap

```
<?xml version = "1.0"?>
<contact-info>
<company>TutorialsPoint
<contact-info>
</company>
```

```
<?xml version = "1.0"?>
<contact-info>
<company>TutorialsPoint
</company>
<contact-info>
```

Attribute

```
<phone type="mobile">(415) 555-4567</phone>
```

- Similar to Attribute of HTML
- Specify on opening only
- Name
  - Starts with underscore or letter
  - Followed by letters, digits, underscore, hyphens, dots
- Value
  - Between double quotes
  - Can be converted into appropriate data type in programming languages
- Not duplicate name

Namespace

- Motivation: same tag (attribute) name but with different meanings in different contexts

→ use namespace to uniquely identify them

- Syntax
  - The Namespace starts with the keyword **xmlns**.
  - The **URL** is the Namespace identifier.

```
<?xml version = "1.0" encoding = "UTF-8"?>
<cont:contact xmlns:cont = "www.usth.edu.vn">
 <cont:name>Tanmay Patil</cont:name> <cont:company>Adventure
Works</cont:company>
<cont:phone>(011) 123-4567</cont:phone>
</cont:contact>
```

Comments

- Comments embed human-readable infor
- Start with <!-- and end with -->
- Appear anywhere after declaration, but not nest to other comments

```
<?xml version = "1.0" standalone= "no" encoding = "UTF-8"?>
<!--- Business card information---->
<BusinessCard>
    <Name>Joe Marini</Name>
    <phone type="mobile">(415) 555-4567</phone>
    <phone type="work">(800) 555-9876</phone>
    <phone type="fax">(510) 555-1234</phone>
    <email>joe@joe.com</email>
</BusinessCard>
```

Character Data Section (CDATA)

- Used to contain data with special characters
  - <,>,&,
- Define a block ignored by XML parser
- <![CDATA[_____]]>

```
<script>
<![CDATA[ <message> Welcome to TutorialsPoint </message> ]] >
</script >
```

- Nesting is not allowed

Special Characters

- Some characters are reserved for XML syntax
- There are replacements

Not Allowed Character	Replacement	Character Description
<	<	less than
>	>	greater than
&	&	ampersand
'	'	apostrophe
"	"	quotation mark

The Basic Rules

- XML is case sensitive
- All start tags must have end tags
- Elements must be properly nested
- XML declaration is the first statement
- Every document must contain a root element
- Attribute values must have quotation marks
- Certain characters are reserved for parsing

XML formatting guidelines

- Add an indent for every new level of tags
- Tags do not contain other tags can have start and end tags on the same line
- Tags containing other tags should be on their own lines

Exercise: Convert a Table into XML

CONTACT								
ID	**Name**	**Company**	**Email**	**Phone**	**Street**	**City**	**State**	**ZIP**
100	TOM CRUISE	XYZ Corp.	tom@usa.net	3336767	25th St.	Toronto	Toronto	20056

```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
<CONTACT>
    <Id>        100      </Id>
    <Name> TOM CRUISE    </Name>
    <Company> XYZ Corp.  </Company>
    <Email>    tom@usa.net  </Email>
    <Phone>   3336767       </Phone>
    <Street>  25th St.    </Street>
    <City>    Toronto      </City>
    <State>   Toronto     </State>
    <ZIP>     20056       </ZIP>
</CONTACT>
```

XML VERIFICATION

Valid vs. Well Formed

- An XML document following XML syntax is called "Valid"
- A valid XML document conforming to structure rule is a "Well Formed" XML document
- 02 ways of structure rule definition:
  - DTD (Doctype definition)
    - Simple but not powerful
    - Written in a syntax different from XML
  - XML Schema
    - More powerful and flexible than DTD
    - Written in XML syntax

DTD example

```
<?xml version="1.0" standalone = "yes" ?>
<!DOCTYPE BusinessCard [
    <!ELEMENT BusinessCard (Name, phone+, email?)>
    <!ELEMENT Name (#PCDATA)>
    <!ELEMENT phone (#PCDATA)>
    <!ATTLIST phone type (mobile | fax | work | home) #REQUIRED>
    <!ELEMENT email (#PCDATA)>
]>
<BusinessCard>
    <Name>Joe Marini</Name>
    <phone type="mobile">(415) 555-4567</phone>
    <phone type="work">(800) 555-9876</phone>
    <phone type="fax">(510) 555-1234</phone>
    <email>joe@joe.com</email>
</BusinessCard>
```


Online Validator at http://xmlvalidator.new-studio.org/

DTD Structure

```
<!DOCTYPE <root tag> [
   <!ELEMENT  <name> (<components>) >
   . . . more elements . . .
]>
```

- The description of an element consists of its name (tag), and a parenthesized description of any nested tags.
  - Includes order of subtags and their cardinality.
- Leaves (text elements) have #PCDATA (*Parsed Character DATA*) in place of nested tags.

27

Element Descriptions

- Subtags must appear in order shown.
- A tag may be followed by a symbol to indicate its multiplicity.
  - * = zero or more.
  - + = one or more.
  - ? = zero or one.
- Symbol | can connect alternative sequences of tags.

28

Attributes

- Opening tags in XML can have *attributes*.
- In a DTD,

`<!ATTLIST` *E* `...>`

declares attributes for element *E*, along with its datatype.

Example

```
<!ATTLIST phone type (mobile | fax | work | home) #
  REQUIRED>
```

```
<phone type="mobile">(415) 555-4567</phone>
    <phone type="work">(800) 555-9876</phone>
    <phone type="fax">(510) 555-1234</phone>
```


29

The same data in different format

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

<!DOCTYPE BusinessCard [
        <!ATTLIST BusinessCard name CDATA #REQUIRED>
        <!ATTLIST BusinessCard email CDATA #REQUIRED>
        <!ELEMENT BusinessCard (phone+)>
        <!ELEMENT phone (#PCDATA)>
        <!ATTLIST phone type (mobile | fax | work | home) #REQUIRED>
        <!ELEMENT email (#PCDATA) >
]>

<BusinessCard name = "Joe Marini" email = "joe@joe.com">
        <phone type="mobile">(415) 555-4567</phone>
        <phone type="work">(800) 555-9876</phone>
        <phone type="fax">(510) 555-1234</phone>
        <phone type="home">(425) 555-8989</phone>
</BusinessCard>
```

Use of DTD's

1. Set standalone = "no".
2. Either:
   a) Include the DTD as a preamble of the XML document, or
   b) Follow DOCTYPE and the <root tag> by SYSTEM and a path to the file where the DTD can be found.

31

Outer DTD file

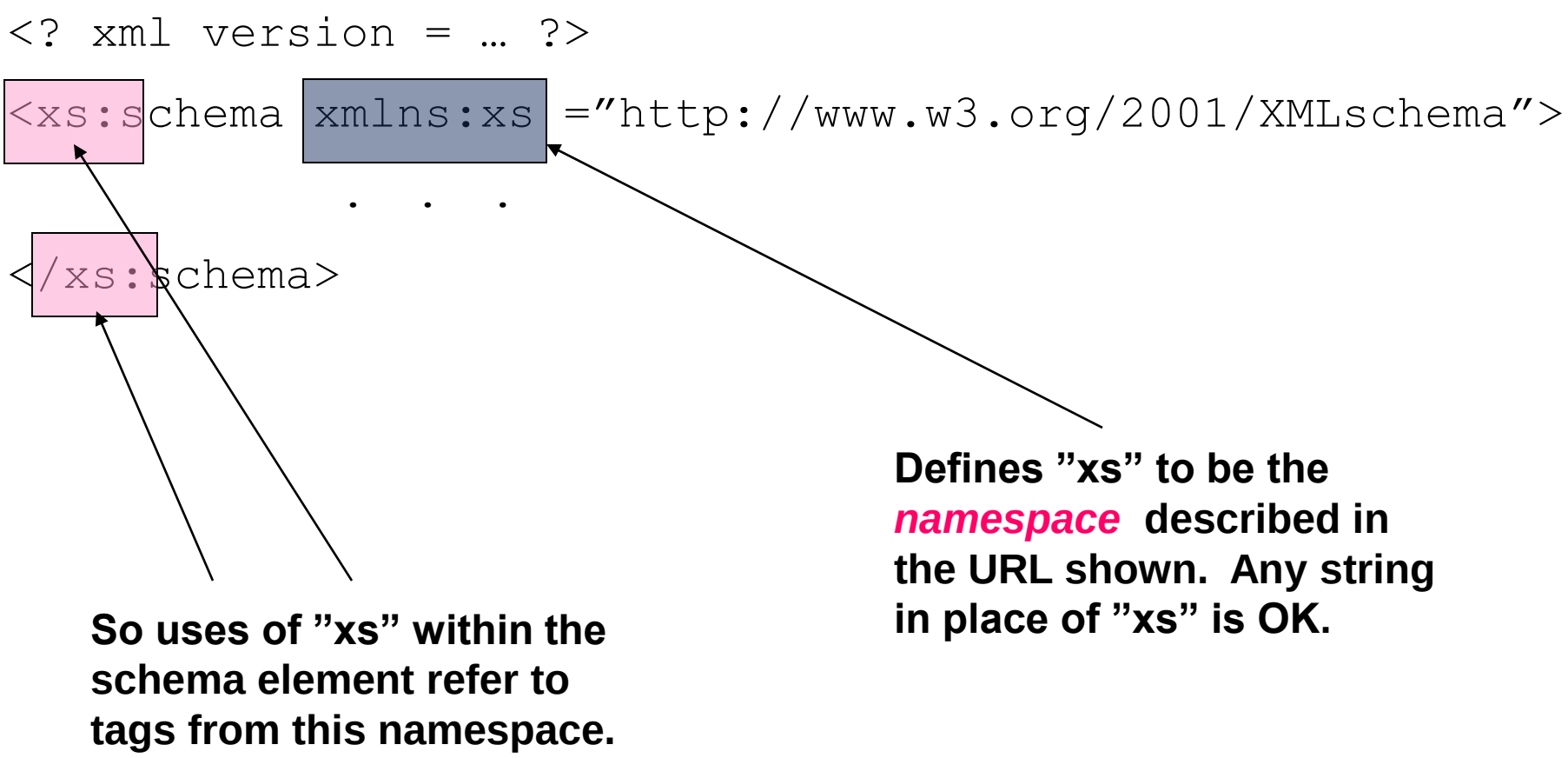
Assumse "BusinessCard.dtd" is the outer dtd file

```
<?xml version="1.0" standalone = "no" ?>
<!DOCTYPE BusinessCard SYSTEM "BusinessCard.dtd">
<BusinessCard>
    <Name>Joe Marini</Name>
    <phone type="mobile">(415) 555-4567</phone>
    <phone type="work">(800) 555-9876</phone>
    <phone type="fax">(510) 555-1234</phone>
    <email>joe@joe.com</email>
</BusinessCard>
```

```
<?xml version="1.0" encoding="utf-8" ?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <xsd:element name="BusinessCard">
    <xsd:complexType  mixed="true">
      <xsd:sequence>
        <xsd:element name="Name" type="xsd:string"/>
        <xsd:element name="phone" maxOccurs="unbounded">
          <xsd:complexType mixed="true">
            <xsd:attribute name="type" use="required">
              <xsd:simpleType>
                <xsd:restriction base="xsd:string">
                  <xsd:enumeration value="mobile"/>
                  <xsd:enumeration value="fax"/>
                  <xsd:enumeration value="work"/>
                  <xsd:enumeration value="home"/>
                </xsd:restriction>
              </xsd:simpleType>
            </xsd:attribute>
          </xsd:complexType>
        </xsd:element>
        <xsd:element name="email" type="xsd:string" minOccurs="0" />
      </xsd:sequence>
    </xsd:complexType>
  </xsd:element>
</xsd:schema>
```

https://www.liquid-technologies.com/online-xsd-validator

Structure of an XML-Schema Document



34

The xs:element Element

Has attributes:

- name = the tag-name of the element being defined.
- type = the data type of the element.
  - Could be an XML-Schema type, e.g., xs:string.
  - Or the name of a type defined in the document itself
- maxOccurs, minOccurs: restrict number of instances

Example

```
<xsd:element name="Name" type="xsd:string"/>
 </xsd:element>
```


35

Complex Types

- To describe elements that consist of sub elements, we use xs:complexType.
  - Attribute name gives a name to the type.
- Typical subelement of a complex type is xs:sequence, which itself has a sequence of xs:element subelements.
  - Use minOccurs and maxOccurs attributes to control the number of occurrences of an xs:element.

```
<xsd:element name="BusinessCard">
    <xsd:complexType>
```


36

xs:attribute

- xs:attribute elements can be used within a complex type to indicate attributes of elements of that type.
- attributes of xs:attribute:
  - name and type as for xs.element.
  - use = ”required” or ”optional”.

37

XQUERY

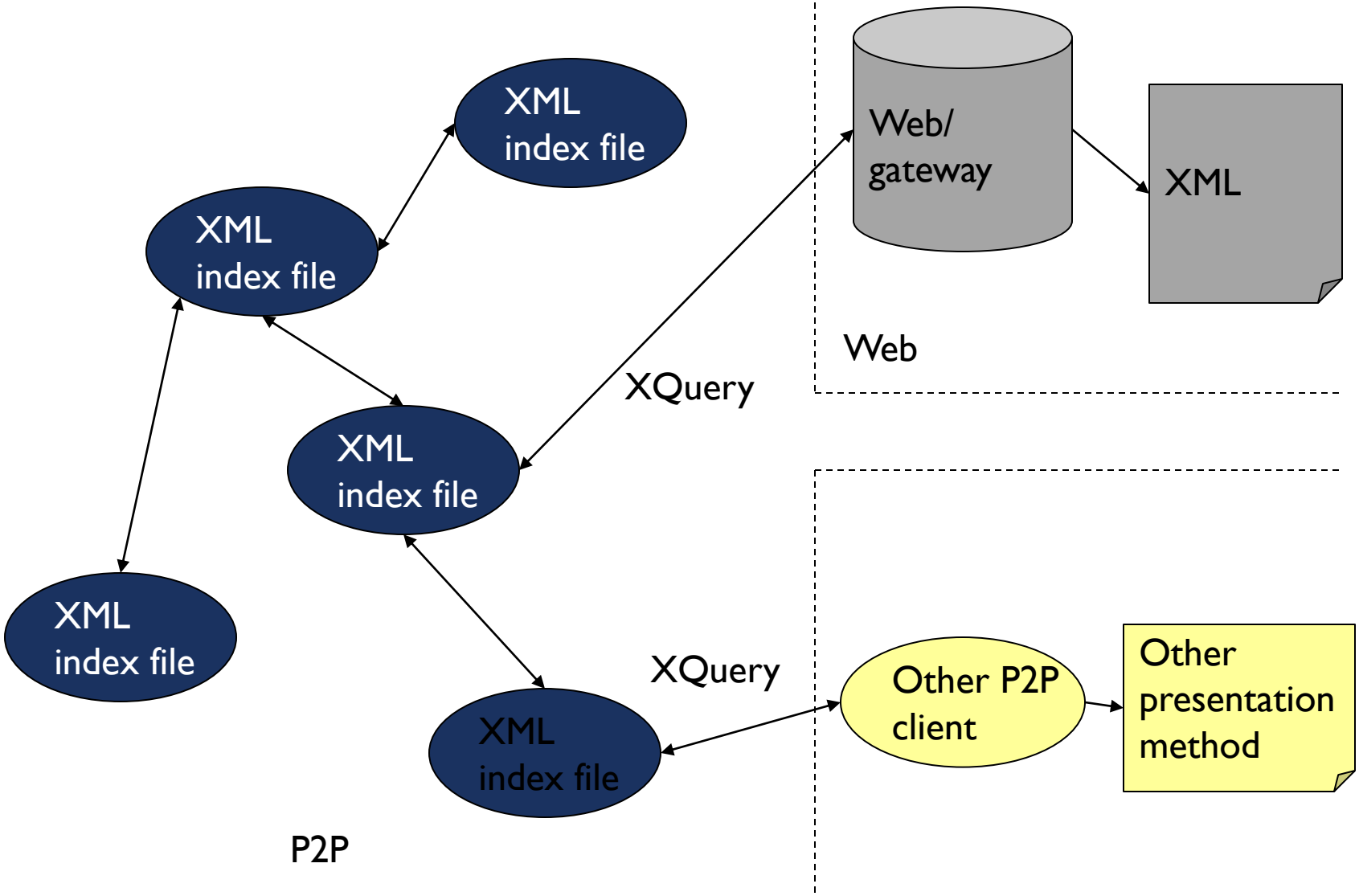
Querying XML Data

- XPath = simple navigation through the tree
- XQuery = the SQL of XML
  - FLWOR ("Flower") Expressions

```
FOR ...
LET...
WHERE...
ORDER BY …
RETURN...
```


Test XPath and Xquery at http://www.xpathtester.com/xquery

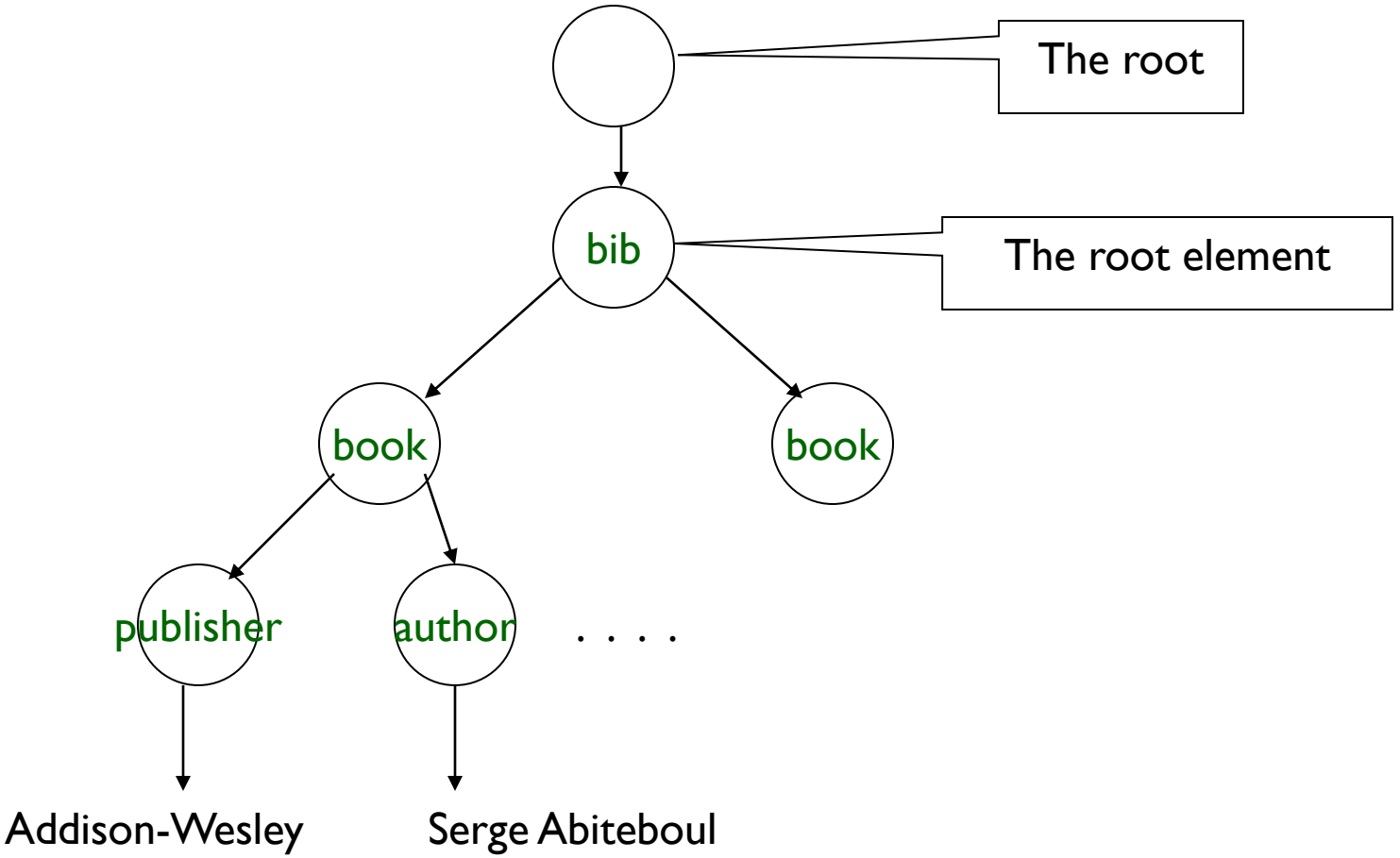
Possible Application



Sample for Xquery

```
<bib>
  <book>
    <publisher> Addison-Wesley </publisher>
    <author> Serge Abiteboul </author>
    <author>
      <first-name> Rick </first-name>
      <last-name> Hull </last-name>
    </author>
    <author> Victor Vianu </author>
    <title> Foundations of Databases </title>
    <year> 1995 </year>
  </book>
  <book price="55">
    <publisher> Freeman </publisher>
    <author> Jeffrey D. Ullman </author>
    <title> Principles of Database and Knowledge Base Systems </title>
    <year> 1998 </year>
  </book>
</bib>
```

Data Model for XPath



Selecting Nodes

Expression	Description
nodename	Get all nodes with nodename
/	Root node
//nodename	Get all nodes in document with nodename
.	Current node
..	Parent node
@attName	Get attribute names

XPath: Simple Expressions

/bib/book/author

```
<?xml version="1.0" encoding="UTF-8"?>
<author> Serge Abiteboul </author>
<author>
    <first-name> Rick </first-name>
    <last-name> Hull </last-name>
  </author>
<author> Victor Vianu </author>
<author> Jeffrey D. Ullman </author>
```

/bib/book[year<1996]

/bib/paper/year

Result: empty (there were no papers)

Xpath: Attribute Nodes

```
/bib/book/@price
```

Result: “55”

@price means that price is has to be an attribute

Xpath: Text Nodes

/bib/book/author/text()

Result: Serge Abiteboul
Jeffrey D. Ullman

Rick Hull doesn't appear because he has firstname, lastname

Functions in XPath:

- text() → text value
- node() → matches any node
- name() → returns the name of the current tag

XQuery

- **Syntax**
  - **For -** selects a sequence of nodes
  - **Let -** binds a sequence to a variable
  - **Where -** filters the nodes
  - **Order by -** sorts the nodes
  - **Return -** what to return (gets evaluated once for every node)
- Example: Find all book titles published after 1995:

```
FOR $x IN /bib/book
WHERE $x/year > 1995
RETURN { $x/title }
```

Result:

```
<title> abc </title>
<title> def </title>
<title> ghi </title>
```

XQuery

Same as before, but eliminate duplicates:

```
FOR $x IN bib/book[title/text() = "Database Theory"]/author
        $y IN distinct(bib/book[author/text() = $x/text()]/title)

RETURN <answer> { $y/text() } </answer>
```

distinct = a function
that eliminates duplicates

E.g. FLOWR query filtering by attribute

```
for $b in /bib/book
let $title := $b/title
where $b/@price < 100
order by $title
return $title
```

```
<?xml version="1.0" encoding="UTF-8"?>
<title> Foundations of Databases </title>
<title> Principles of Database and Knowledge Base Systems </title>
```