Comp-4150: Advanced and Practical Database Systems

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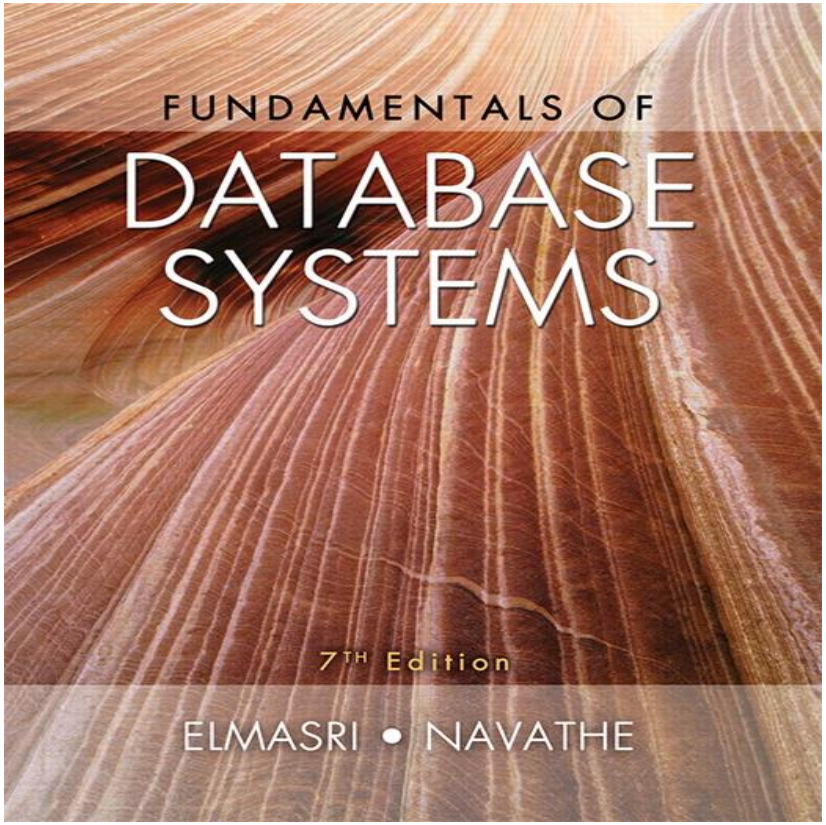
CHAPTER 13

XML: Extensible Markup Language



Chapter 13: XML Extensible Markup Language Outline

- 1. Structured, Semistructured, and Unstructured Data
- 2. XML Hierarchical (Tree) Data Model
- 3. XML Documents, DTD, and XML Schema
- 4. Storing and Extracting XML Documents
- 5. XML Languages
- 6. Extracting XML Documents from Relational Databases
- 7. XML/SQL: SQL Functions for Creating XML Data

Chapter 13: Introduction

- Databases function as data sources for Web applications
- Common method to specify contents of a web page is the use of a hypertext document in languages as:
  - HTML (Hypertext Markup Language)
    - Used in static Web pages (with fixed text and other objects)
  - XML (Extensible Markup Language), JSON (Java Script Object Notation)
    - Self-describing documents (providing data attributes and values)
    - Dynamic Web pages (with different data based on user input)
- Chapter focus: XML data model and languages

13.1 Structured, Semistructured, and Unstructured Data

- 1. Structured data with strict scema (eg. Company database)
  - Stored in relational database
- 2. Semistructured data
  - Not all data has identical structure
  - Schema information mixed in with data values
    - Self-describing model (e.g., XML, NOSQL data models)
  - Directed graph model (another example)
- 3. Unstructured data
  - Limited data type indication
  - Example: Web pages in HTML

13.1. Directed Graph Model for Semistructured Data

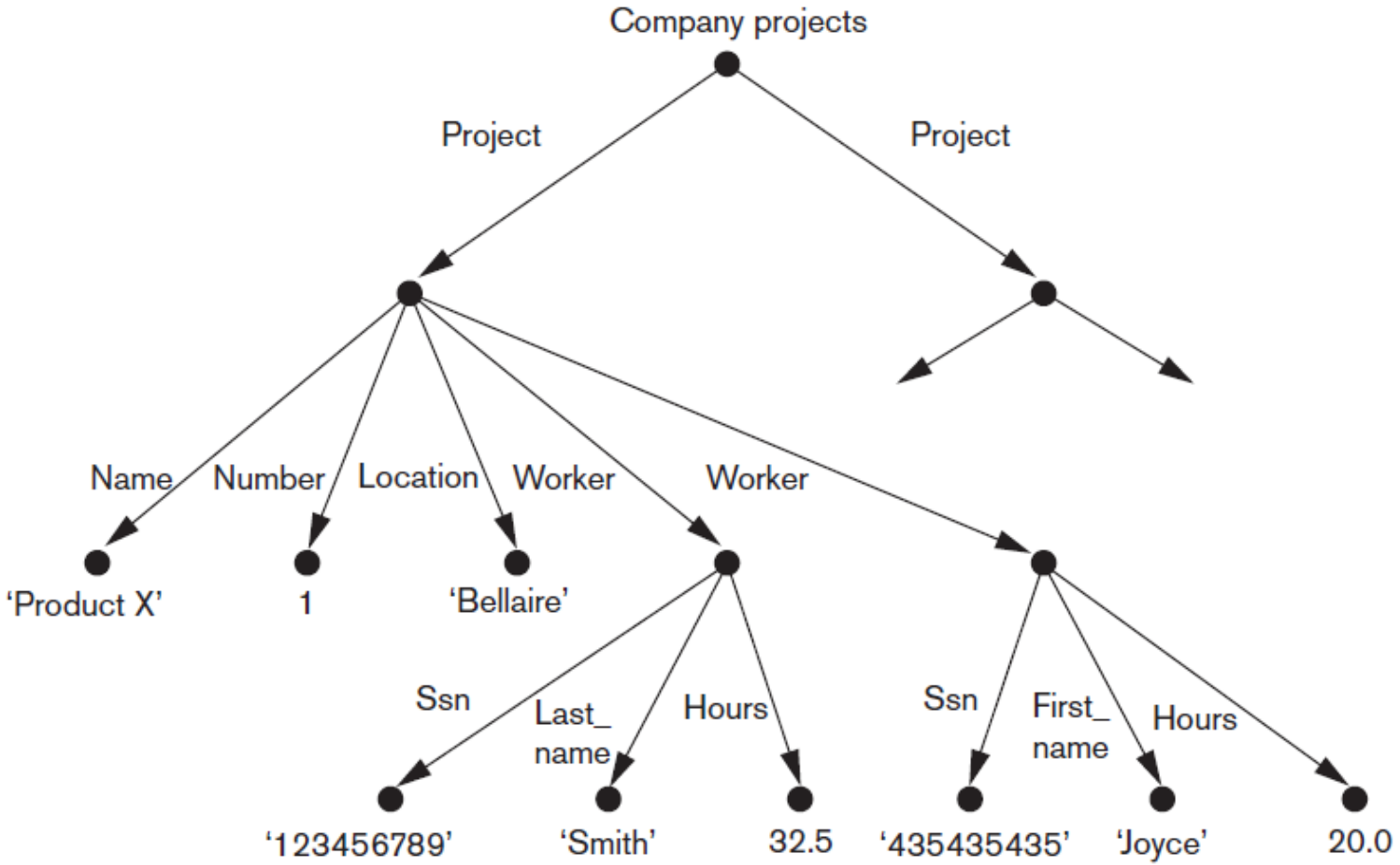


Figure 13.1 Representing semistructured data as a graph

13.1. Structured, Semistructured, and Unstructured Data (cont'd.)

- HTML uses predefined tags with start (e.g., <HTML>) and closing matching end tag with a forward slash (eg. </HTML>)
  - Document header (<HEAD> …</HEAD>)
    - Specifies various Script functions, formatting styles (eg. Fonts, paragraph styles, header styles, etc.) for the document.
  - Body (<BODY> … </BODY>)
  - Table tags (<TABLE> … (</TABLE>)
    - Each table row is enclosed in a <<TR> .. </TR> tag and each table data elements in a row are within <TD> .. </TD> tags.
  - Attributes. Some tags may have attributes for properties of the tag.
  - Large number of predefined tags
- XHTML
  - Extends tags for different applications

13.2 XML Hierarchical (Tree) Data Model

- Basic object: XML document and has
  - 1. Element (of the following 3 types)
    - Simple (contain data values)
    - Complex (formed from other elements hierarchically)
    - Schema document defines element names
  - 2. Attribute (for describing the elements)
- XML Three Document types are:
  - 1. Data-centric (follow a pre-defined schema with tag names)
  - 2. Document-centric (large unstructured text with few data elements)
  - 3. Hybrid (structured data and unstructured text content)
  - Fig. 13.3 has an example Complex XML element

13.3. XML Documents, DTD, and XML Schema

- Conditions for an XML document to be well-formed are:
  - 1. Begins with XML declaration (as in Fig 13.3 line 1 to declare version of XML in use and other attributes)
  - 2. Syntactically correct tree data model with one root and matching pairs of open and end tags.
  - 3. To be Valid, which means
    - Must follow a particular schema because the element names used in the start and end tag pairs must follow the structure specified in a separate XML DTD (Document Type Definition) file or XML Schema file.
    - Fig 13.4 shows a simple XML DTD file. DTD has its own special syntax for specification.
    - Fig. 13.5 shows an XML schema file

13.3. XML Documents, DTD, and XML Schema (cont'd.)

- Notation for specifying elements
  - elementname* indicates optional multivalued (repeating) element
  - elementname+ indicates required multivalued (repeating) element
  - elementname? indicates optional single-valued (non-repeating) element
  - elementname indicates required single-valued (non-repeating) element

13.3. XML Documents, DTD, and XML Schema (cont'd.)

- Notation for specifying elements (cont'd.)
  - Type specified by parentheses following the element name
  - !ATTLIST used to specify attributes within the element
  - Parentheses can be nested when specifying elements
  - Bar symbol ($e_1|e_2$) indicates either e_1 or e_2 can appear in the document

13.3. XML Documents, DTD, and XML Schema (cont'd.)

(a)
```
<!DOCTYPE Projects [
    <!ELEMENT Projects (Project+)>
    <!ELEMENT Project (Name, Number, Location, Dept_no?, Workers)>
        <!ATTLIST Project
            ProjId ID #REQUIRED>
    <!ELEMENT Name (#PCDATA)>
    <!ELEMENT Number (#PCDATA)
    <!ELEMENT Location (#PCDATA)>
    <!ELEMENT Dept_no (#PCDATA)>
    <!ELEMENT Workers (Worker*)>
    <!ELEMENT Worker (Ssn, Last_name?, First_name?, Hours)>
    <!ELEMENT Ssn (#PCDATA)>
    <!ELEMENT Last_name (#PCDATA)>
    <!ELEMENT First_name (#PCDATA)>
    <!ELEMENT Hours (#PCDATA)>
]>
```

Figure 13.4(a) An XML DTD file called 'Projects'

13.3. XML Schema

- XML schema language
  - Specifies document structure
  - Same syntax rules as XML documents
  - Elements, attributes, keys, references, and identifiers
  - Example: Figure 13.5 in the text

13.3. XML Schema (cont'd.)

- XML namespace
  - Defines set of commands that can be used
- Annotations, documentation, and language used
- Elements and types
  - Root element
  - First-level elements
  - Specifying element type and min and max occurrences

13.3. XML Schema (cont'd.)

- Keys
  - Constraints that correspond to relational database
  - Primary key
  - Foreign key
- Complex elements
  - xsd:complexType
- Composite (compound) attributes

13.4 Storing and Extracting XML Documents from Databases

- Use file system or DBMS to store documents as text
- Use DBMS to store document contents as data elements
- Design specialized system to store XML data
- Create or publish custom XML documents from preexisting relational databases
  - This approach explored further in 13.6

13.5 XML Languages

- Query language standards for XML include:
  - XPath
  - XQuery
- Specifying XPath expressions in XML
  - Returns sequence of items satisfying certain pattern
    - Values, elements, or attributes
  - Qualifier conditions
  - Separators
    - Single slash / or double slash //

13.5.1. XPath (cont'd.)

- Example
  - For COMPANY.XML document stored at location www.company.com/info.XML
  - doc(www.company.com/infor.XML)/company returns company root node and all descendant nodes

13.5.1. XPath (cont'd.)

1. /company
2. /company/department
3. //employee [employeeSalary gt 70000]/employeeName
4. /company/employee [employeeSalary gt 70000]/employeeName
5. /company/project/projectWorker [hours ge 20.0]

Figure 13.6 Some examples of XPath expressions on XML documents that follow the XML schema file company in Figure13.5.

13.5.2. XQuery: Specifying Queries in XML

- FLWOR expression

  FOR <variable bindings to individual nodes (elements)>
  LET <variable bindings to collections of nodes (elements)>
  WHERE <qualifier conditions>
  ORDER BY <ordering specifications>
  RETURN <query result specification>

- Variables preceded with $
- For assigns variable to a range
- Where specifies additional conditions
- Order by specifies order of result elements
- Return specifies elements for retrieval

13.5.2. XQuery: Specifying Queries in XML

- Example

```
LET $d : = doc(www.company.com/info.xml)
FOR $x IN $d/company/project[projectNumber = 5]/projectWorker,
        $y IN $d/company/employee
WHERE $x/hours gt 20.0 AND $y.ssn = $x.ssn
ORDER BY $x/hours
RETURN <res> $y/employeeName/firstName, $y/employeeName/lastName,
                    $x/hours </res>
```

13.5.3. Other Languages and Protocols Related to XML

- Extensible Stylesheet Language (XSL)
- Extensible Stylesheet Language for Transformations (XSLT)
- Web Services Description Language (WSDL)
- Simple Object Access Protocol (SOAP)
- Resource Description Framework (RDF)

13.6 Extracting XML Documents from Relational Databases

- XML uses hierarchical (tree) model
- Common database model is flat relational database
- Conceptually represented using ER schema
- University example (follows)
  - Choices for root: course, student, section

13.6.1. University Example

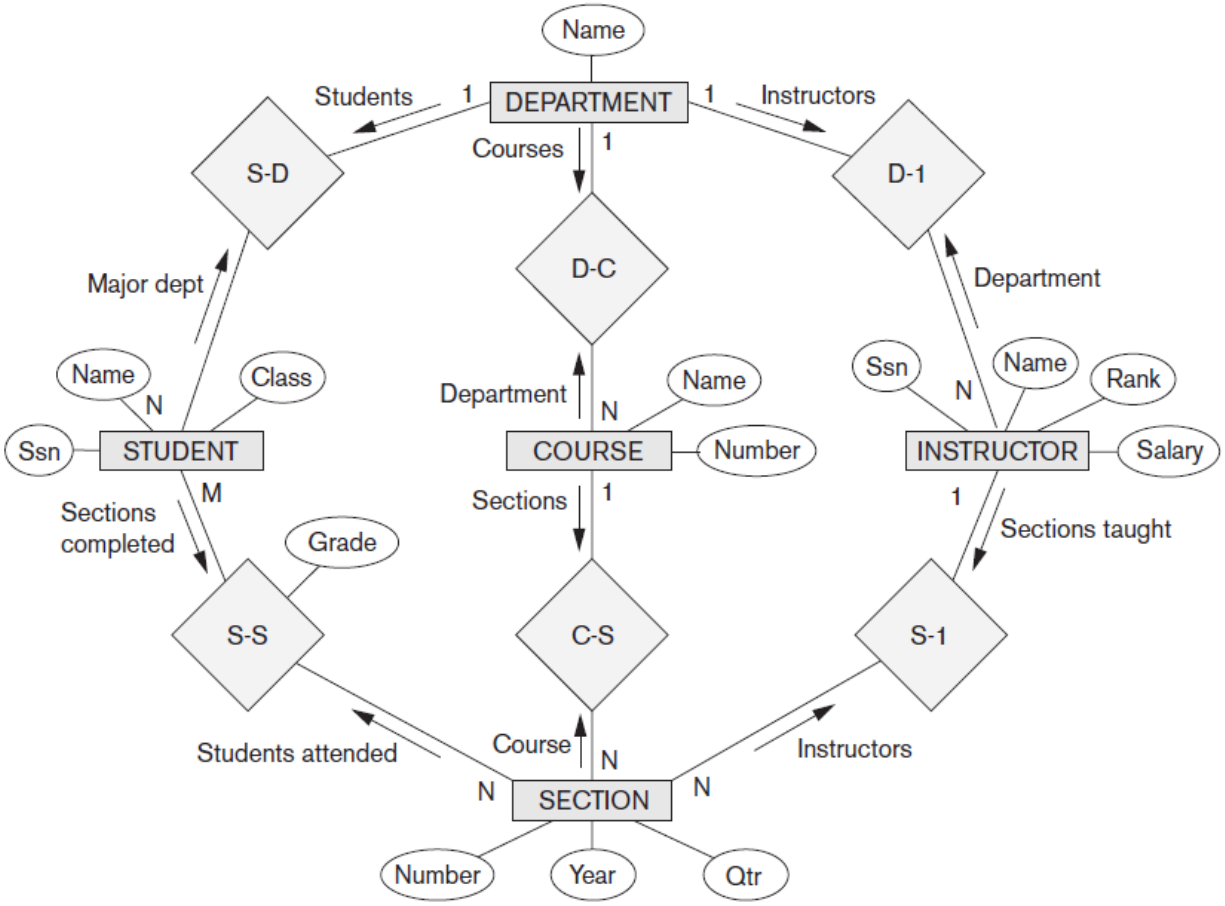


Figure 13.8 An ER schema diagram for a simplified UNIVERSITY database

13.6.1. University Example (cont'd.)

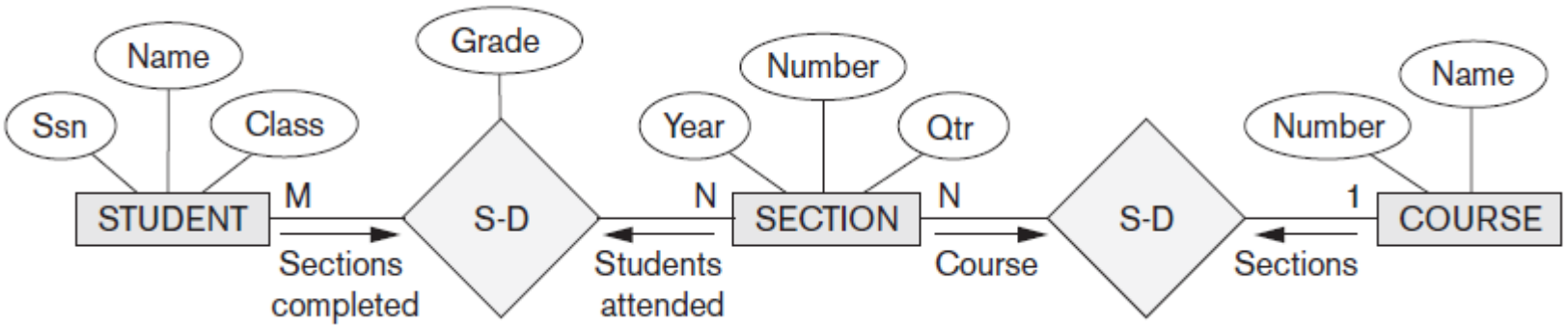


Figure 13.9 Subset of the UNIVERSITY database schema needed for XML document extraction

13.6.1. University Example (cont'd.)

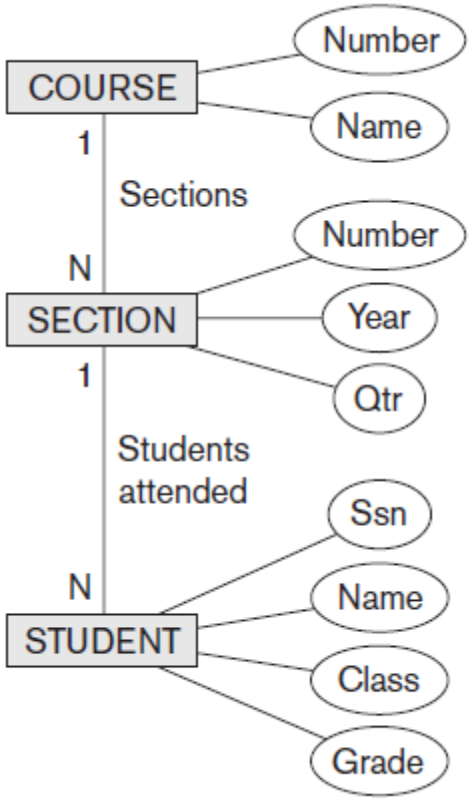


Figure 13.10 Hierarchical (tree) view with 'COURSE' as the root

13.6.1. University Example (cont'd.)

```
<xsd:element name="root">
    <xsd:sequence>
    <xsd:element name="course" minOccurs="0" maxOccurs="unbounded">
        <xsd:sequence>
            <xsd:element name="cname" type="xsd:string" />
            <xsd:element name="cnumber" type="xsd:unsignedInt" />
            <xsd:element name="section" minOccurs="0" maxOccurs="unbounded">
                <xsd:sequence>
                    <xsd:element name="secnumber" type="xsd:unsignedInt" />
                    <xsd:element name="year" type="xsd:string" />
                    <xsd:element name="quarter" type="xsd:string" />
                    <xsd:element name="student" minOccurs="0" maxOccurs="unbounded">
                        <xsd:sequence>
                            <xsd:element name="ssn" type="xsd:string" />
                            <xsd:element name="sname" type="xsd:string" />
                            <xsd:element name="class" type="xsd:string" />
                            <xsd:element name="grade" type="xsd:string" />
                        </xsd:sequence>
                    </xsd:element>
                </xsd:sequence>
            </xsd:element>
        </xsd:sequence>
    </xsd:element>
    </xsd:sequence>
    </xsd:element>
```

Figure 13.11 XML schema with 'COURSE' as the root

13.6.1. University Example (cont'd.)

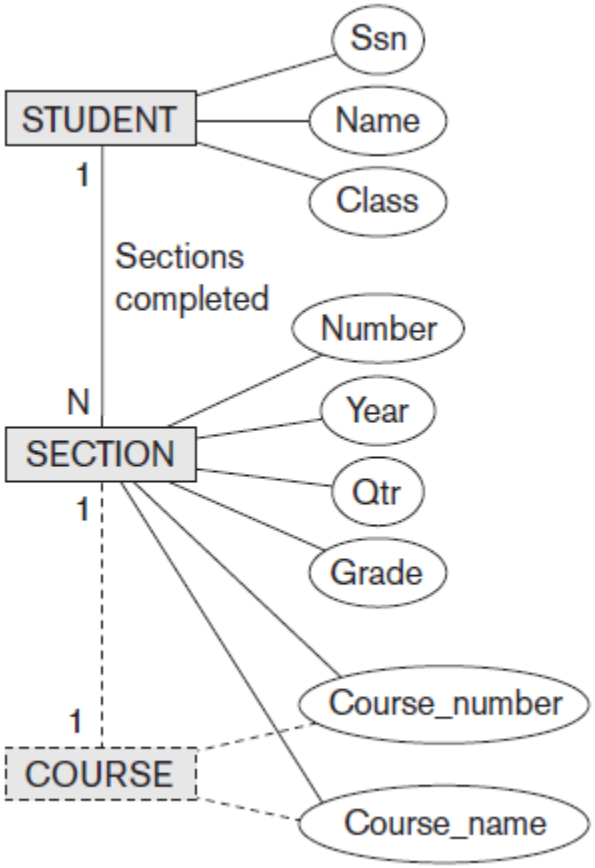


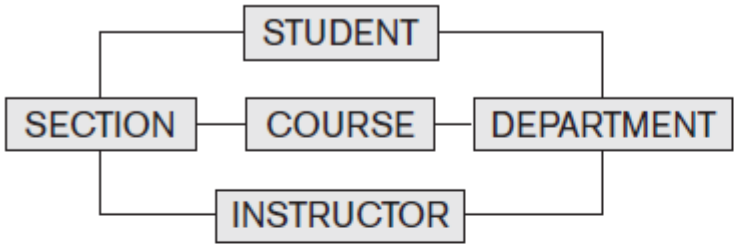
Figure 13.12 Hierarchical (tree) view with 'STUDENT' as the root

13.6.1. University Example (cont'd.)

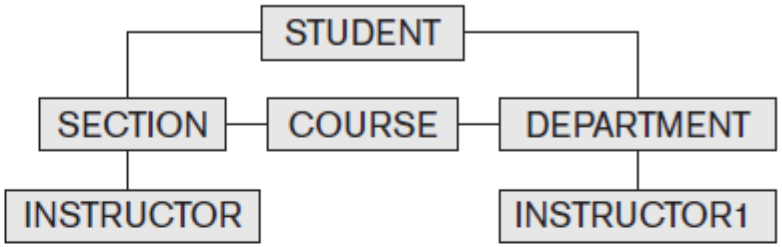
```
<xsd:element name="root">
<xsd:sequence>
<xsd:element name="student" minOccurs="0" maxOccurs="unbounded">
    <xsd:sequence>
        <xsd:element name="ssn" type="xsd:string" />
        <xsd:element name="sname" type="xsd:string" />
        <xsd:element name="class" type="xsd:string" />
        <xsd:element name="section" minOccurs="0" maxOccurs="unbounded">
            <xsd:sequence>
                <xsd:element name="secnumber" type="xsd:unsignedInt" />
                <xsd:element name="year" type="xsd:string" />
                <xsd:element name="quarter" type="xsd:string" />
                <xsd:element name="cnumber" type="xsd:unsignedInt" />
                <xsd:element name="cname" type="xsd:string" />
                <xsd:element name="grade" type="xsd:string" />
            </xsd:sequence>
        </xsd:element>
    </xsd:sequence>
</xsd:element>
</xsd:sequence>
</xsd:element>
```

Figure 13.13 XML schema document with 'STUDENT' as the root

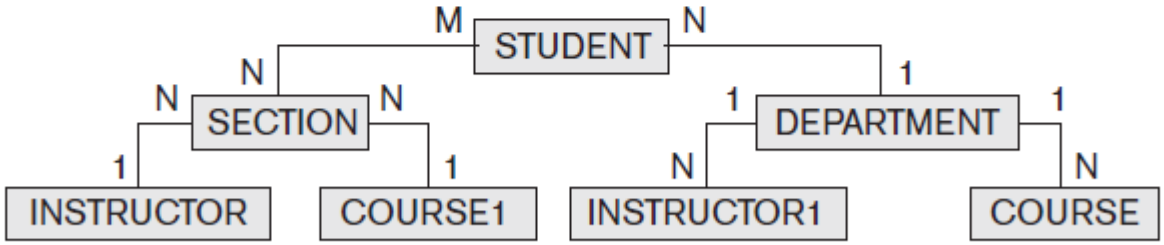
13.6.2. Breaking Cycles to Convert Graphs into Trees



(a)



(b)



(c)

13.6.2. Other Steps for Extracting XML Documents from Databases

- Create SQL query to extract desired information
- Execute the query
- Restructure from flat to tree structure
- Customize query to select single or multiple objects into the document

13.7 XML/SQL: SQL Functions for Creating XML Data

- XMLELEMENT
  - Specifies tag (element) name that will appear in XML result
- XMLFOREST
  - Specifies multiple element names
- XMLAGG
  - Aggregate several elements
- XMLROOT
  - Selected elements formatted as XML document with single root element

13.7 XML/SQL: SQL Functions for Creating XML Data (cont'd.)

- XMLATTRIBUTES
  - Creates attributes for the elements of the XML result
- Example: create XML element containing the EMPLOYEE lastname for the employee with SSN 123456789

```
X1: SELECT    XMLELEMENT (NAME "lastname", E.LName)
    FROM      EMPLOYEE E
    WHERE     E.Ssn = "123456789" ;
```

  - Result: <lastname>Smith</lastname>

13.7 Employee Example (Query 2)

- To retrieve multiple columns for a single row:

```
X2: SELECT    XMLELEMENT (NAME "employee",
                  XMLFOREST (
                      E.Lname AS "ln",
                      E.Fname AS "fn",
                      E.Salary AS "sal" ) )
    FROM      EMPLOYEE AS E
    WHERE     E.Ssn = "123456789" ;
```

- Result:

```
<employee><ln>Smith</ln><fn>John</fn><sal>30000</sal></employee>
```

13.7 Employee Example (Query 3)

- To create XML document with last name, first name, and salary of employees from Dept. 4:

```
X3: SELECT    XMLROOT (
              XMLELEMENT (NAME "dept4emps",

              XMLAGG (
                   XMLELEMENT (NAME "emp"
                   XMLFOREST (Lname, Fname, Salary)
                   ORDER BY Lname ) ) )

    FROM      EMPLOYEE
    WHERE     Dno = 4 ;
```

13.7 Employee Example (Query 3 cont'd.)

- Result:

```
<dept4emps>
<emp><Lname>Jabbar</Lname><Fname>Ahmad</Fname><Salary>25000
   </Salary></emp>
<emp><Lname>Wallace</Lname><Fname>Jennifer
   </Fname><Salary>43000</Salary></emp>
<emp><Lname>Zelaya</Lname><Fname>Alicia</Fname><Salary>25000
   </Salary></emp>
</dept4emps>
```

13.8 Summary

- Structured, semistructured, and unstructured data
- Hierarchical data model of XML standard
- Languages for specifying structure
  - XML DTD and XML schema
- Approaches for storing XML documents
- XPath and XQuery languages
- Mapping issues
- SQL/XML allows formatting query results as XML data