ICS 321 Data Storage & Retrieval

Semi-structured Data Model

Asst. Prof. Lipyeow Lim

Information & Computer Science Department

University of Hawaii at Manoa

Schema Variability

- Structured data conforms to rigid schemas.
  - Relational data
- Unstructured data – the other extreme.
  - Eg. Free text
- Certain types of data are inbetween
  - Semi-structured
  - Schema variability across instances as well as time.
  - Eg. E-catalogs
- XML supports a very flexible "schema"

- **Model**
  - Brand = TOSHIBA
  - Series = REGZA
  - Model = 52HL167
  - Cabinet Color = Black
- **Display**
  - Screen Size = 52"
  - Recommended Resolution = 1920 x 1080
  - Aspect Ratio =16:9
  - …

LCDTV

- **Model**
  - Brand = ViewSonic
  - Model = PJ551D
  - Cabinet Color = Black
  - Type = DLP
- **Display**
  - Panel = 0.55" DMD
  - Lens = Manual zoom/focus
  - Lamp =180W, 3,500 hours normal, up to 4,000 eco mode
  - Aspect Ratio = 4:3 (native), 16:9

Projector

eXtended Markup Language (XML)

- Design goals:
  - straightforwardly usable over the Internet.
  - support a wide variety of applications.
  - compatible with SGML.
  - easy to write programs which process XML docs.
  - optional features in XML kept to the absolute minimum.
  - human-legible and reasonably clear.
  - easy to create.
  - Terseness in XML markup is of minimal importance.

```
<item rdf:about="http://news.slashdot.org/story/
      09/11/17/2245241/Hackers-Broke-Into-Brazil-Grid-Last-
      Thursday?from=rss">
  <title>Hackers Broke Into Brazil Grid Last Thursday</title>
  <link> http://rss.slashdot.org/~r/Slashdot/slashdot/~3/
      JcTR_BoVsgI/Hackers-Broke-Into-Brazil-Grid-Last-
      Thursday</link>
  <description>An anonymous reader writes "A week ago, 60
      Minutes had a story (we picked it up too) claiming that
      hackers had caused power outages in Brazil. While this
      assertion is now believed to be in error, hackers were
      inspired by the story actually to do what was claimed.…"
  </description>
  <dc:creator>kdawson</dc:creator>
  <dc:date>2009-11-17T23:41:00+00:00</dc:date>
  <dc:subject>security</dc:subject>
  <slash:department>wolf-no-really-this-time-i-mean-it</
      slash:department>
  <slash:section>news</slash:section>
  <slash:comments>38</slash:comments>
  <slash:hit_parade>38,37,32,22,9,2,0</slash:hit_parade>
  <feedburner:origLink> http://news.slashdot.org/story/
      09/11/17/2245241/Hackers-Broke-Into-Brazil-Grid-Last-
      Thursday?from=rss</feedburner:origLink>
</item>
```

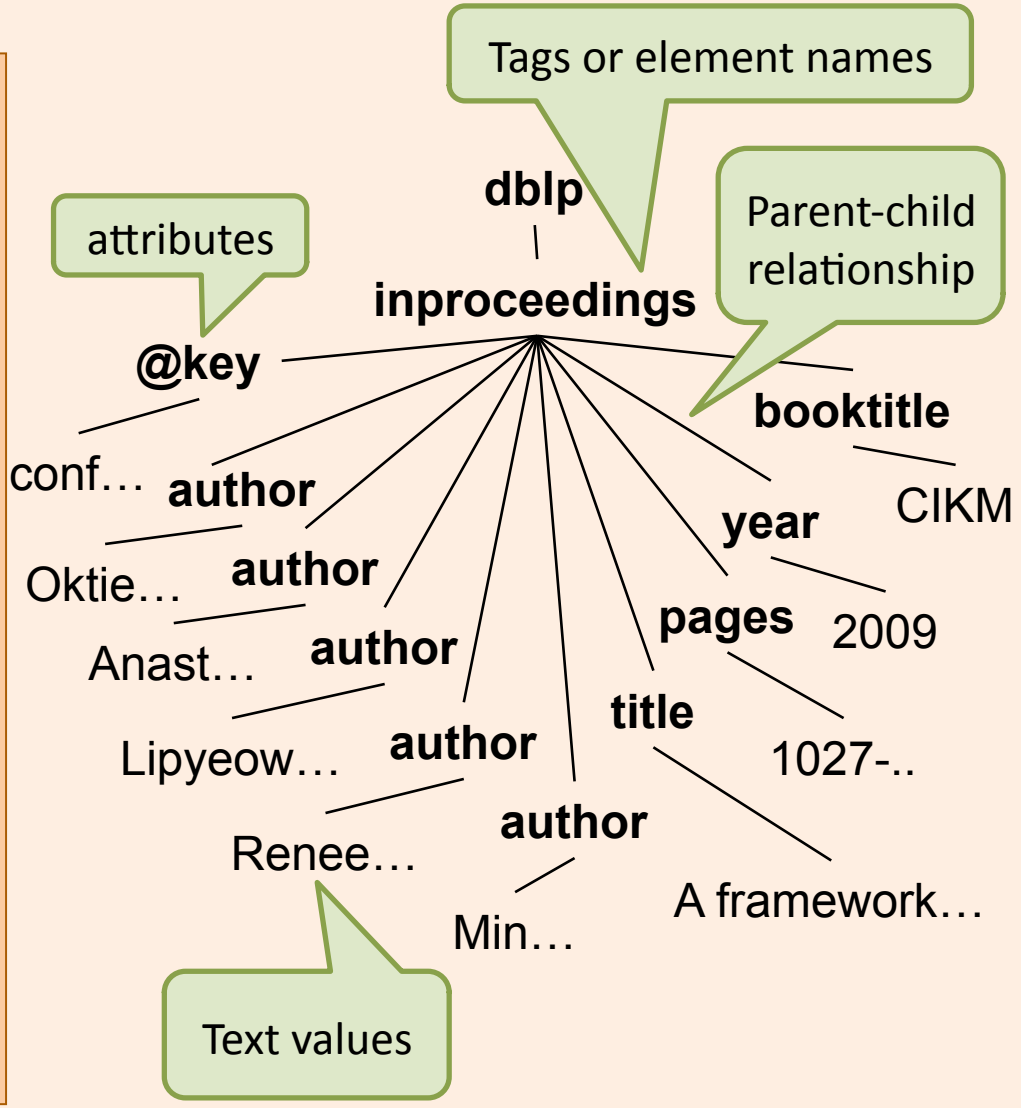
Examples

- Internet:
  - RSS, Atom
  - XHTML
  - Webservice formats: SOAP, WSDL
- File formats:
  - Microsoft Office, Open Office, Apple's iWork
- Industrial
  - Insurance: ACORD
  - Clinical trials: cdisc
  - Financial: FIX, FpML
  - Mortgages: MISMO
- Many applications use XML as a data format for persistence or for data exchange

XML Data Model

XML Document

```
<dblp>
  <inproceedings key="conf/cikm/
      HassanzadehKLMW09" >
    <author>Oktie Hassanzadeh</author>
    <author>Anastasios Kementsietsidis</
      author>
    <author>Lipyeow Lim</author>
    <author>Renée J. Miller</author>
    <author>Min Wang</author>
    <title>
      A framework for semantic link
      discovery over relational data.</title>
    <pages>1027-1036</pages>
    <year>2009</year>
    <booktitle>CIKM</booktitle>
  </inproceedings>
</dblp>
```



Processing XML

- Parsing
  - Event-based
    - Simple API for XML (SAX) : programmers write callback functions for parsing events eg. when an opening "<author>" is encountered.
    - The XML tree is never materialized
  - Document Object Model (DOM)
    - The XML tree is materialized in memory
- XML Query Languages
  - XPath : path navigation language
  - XQuery
  - XSLT : transformation language (often used in CSS)

XPath

- Looks like **paths** used in Filesystem directories.
  - Relative vs absolute
- Examples:
  - /dblp/inproceedings/author
  - //author
  - //inproceedings[year=2009 and booktitle=CIKM]/title
- Results are **sequences** of nodes.
- Think of a **node** as the XML fragment for the subtree rooted at that node.

XPath Axes

- An XPath is a sequence of location steps separated by "/" of the form
  - **Axisname::nodetest[predicate]**
- An **axis** defines a node-set relative to the current node:
  - self, parent, child, attribute
  - following, following-sibling
  - descendent, descendent-or-self
  - ancestor, ancestor-or-self
  - namespace
  - preceding, preceding-sibling
- Examples
  - /child::dblp/child::inproceedings/attribute::author
    - /dblp/inproceedings/@key
  - /descendent-or-self::author
    - //author

XPath Predicates

- An XPath is a sequence of location steps separated by "/" of the form
  - Axisname::nodetest**[predicate]**
- Predicates can be comparisons of atomic values or path expressions
  - //inproceedings[year="2009" and booktitle="CIKM"]/title
- A predicate is true if there exists some nodes that satisfy the conditions
  - //inproceedings[author="Renee"]

XQuery

- For-Let-Where-Return expressions
- Examples:

```
FOR $auth in doc(dblp.xml)//author
LET $title=$auth/../title
WHERE $author/../year=2009
RETURN
<author>
  <name>$auth/text()</name>
  <title>$title/text()</title>
<author>
```

```
FOR $auth in doc(dblp.xml)//author[../
    year=2009]
RETURN
<author>
  <name>$auth/text()</name>
  <title>$auth/../title/text()</title>
<author>
```

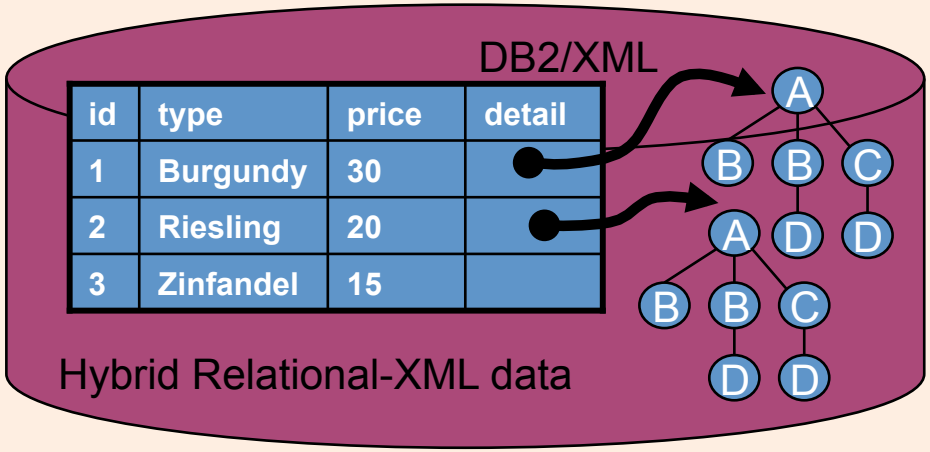
XML & RDBMS

- How do we store XML in DBMS ?
- Inherent mismatch between relational model and XML data model
- Approach #1: BLOBs
  - Parse on demand
- Approach #2: shredding
  - Decompose XML data to multiple tables
  - Translate XML queries to SQL on those tables
- Approach #3: Native XML store
  - Hybrid storage & query engine
  - Columns of type XML

DB2's Hybrid Relational-XML Engine

```
CREATE TABLE Product( id INTEGER, Specs XML );
```

```
INSERT INTO Product VALUES(1,
  XMLParse(  DOCUMENT
'<?xml version='1.0'>
      <ProductInfo>
        <Model>
          <Brand>Panasonic</Brand>
          <ModelID>
             TH-58PH10UK
          </ModelID>
        </Model>
        <Display>
          <ScreenSize>58in
          </ScreenSize>
          <AspectRatio>16:9
          </AspectRatio>
          <Resolution>1366 x 768
          </Resolution>
            …
      </ProductInfo>')
   );
```




```
SELECT id
FROM Product AS P
WHERE XMLExists('$t/ProductInfo/
Model/Brand/Panasonic' PASSING BY
REF P.Specs AS "t")
```

SQL/XML

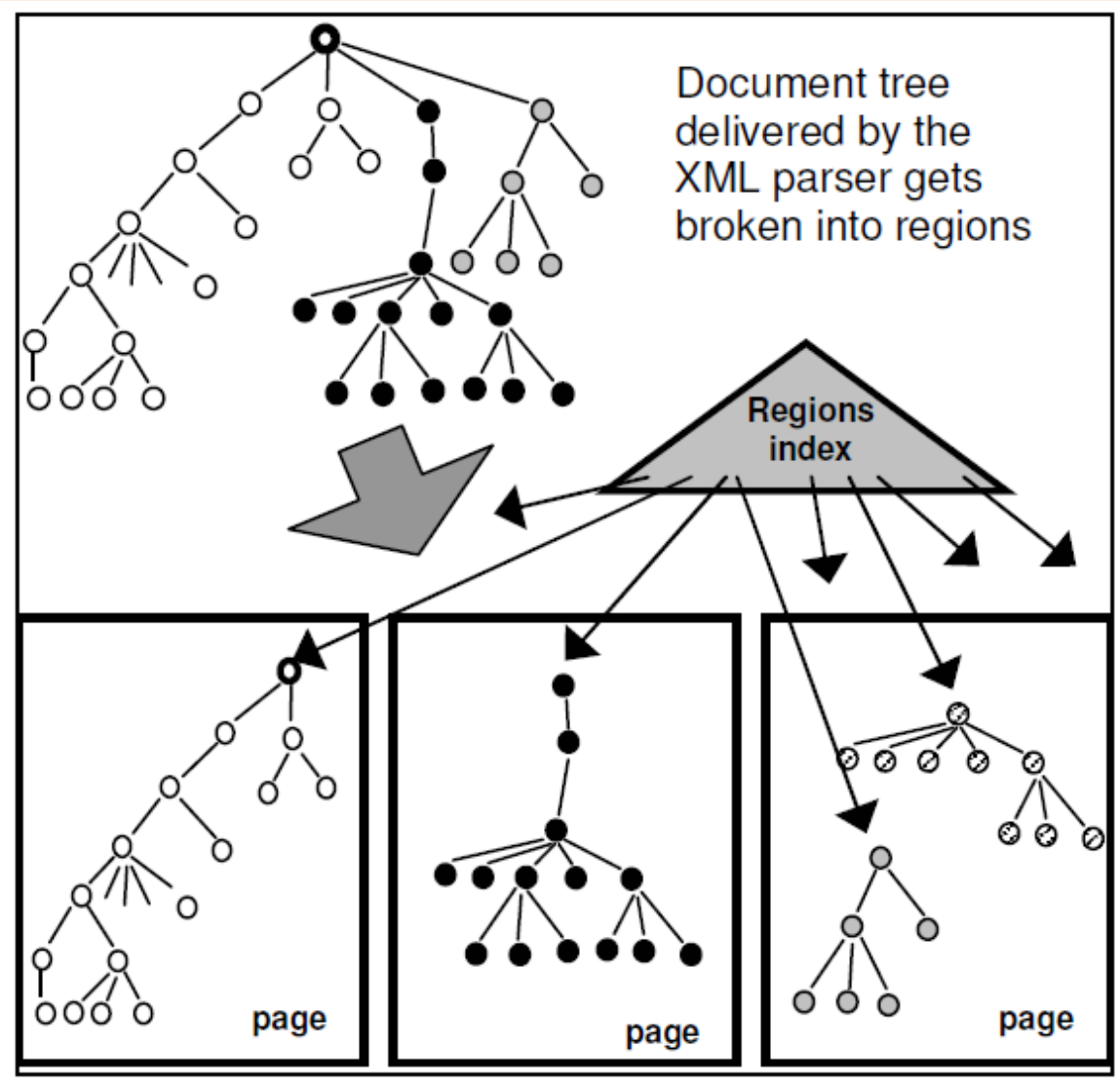
- **XMLParse** – parses an XML document
- **XMLexists** – checks if an XPath expression matches anything
- **XMLTable** – converts XML into one table
- **XMLQuery** – executes XML query

```
SELECT X.*
FROM emp, XMLTABLE ('$d/dept/employee'
passing doc as "d"
COLUMNS
  empID INTEGER PATH '@id',
  firstname VARCHAR(20) PATH 'name/first',
  lastname VARCHAR(25) PATH 'name/last')
AS X
```

```
SELECT XMLQUERY(
  '$doc//item[productName="iPod"]'
  PASSING PO.Porder as "doc")
  AS "Result"
FROM PurchaseOrders PO;
```

XML Storage (DB2 pureXML)

- **String IDs** for Namespace, Tag names
- **Path IDs** for paths
- XML tree partitioned into regions & packed into pages.
- **Regions index** track the pages associated with the XML structure



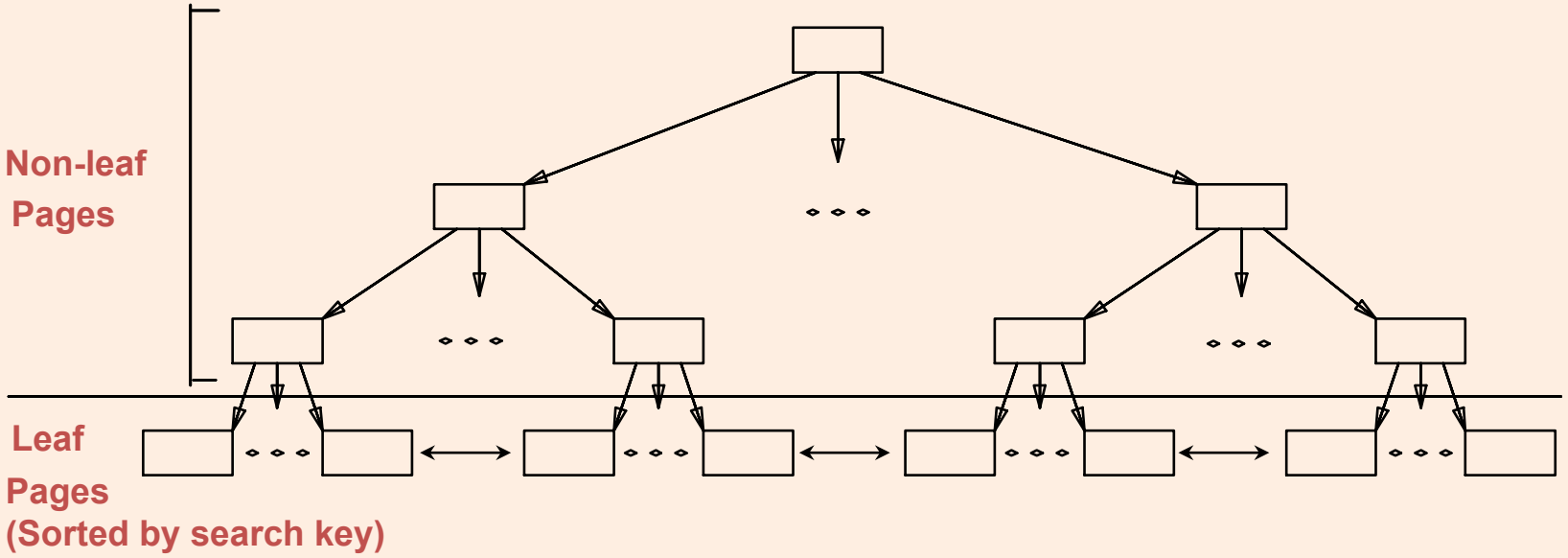
XML Indexing

- Users create specific ***value indexes*** associated with specific XPaths.

CREATE INDEX idx1 **ON** dept(deptdoc)
GENERATE KEY USING XMLPATTERN '/dept/employee/name' **AS SQL VARCHAR**(35)

- Index matching requires both the path and the type to match.
  - Queries involving /dept/employee/name and explicitly uses varchar or string for the type associated with the element can exploit the valued index

B+ Trees for XML Indexing



- For XML value indexes we want to map the value associated with an XML pattern to nodes in the XML data tree
- Key part of index entry is the “value”
- Instead of a rid, an index entry stores the (region ID, node ID)