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Semi-structured Data Model

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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"

LCDTV

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

Projector

- **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

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>
```
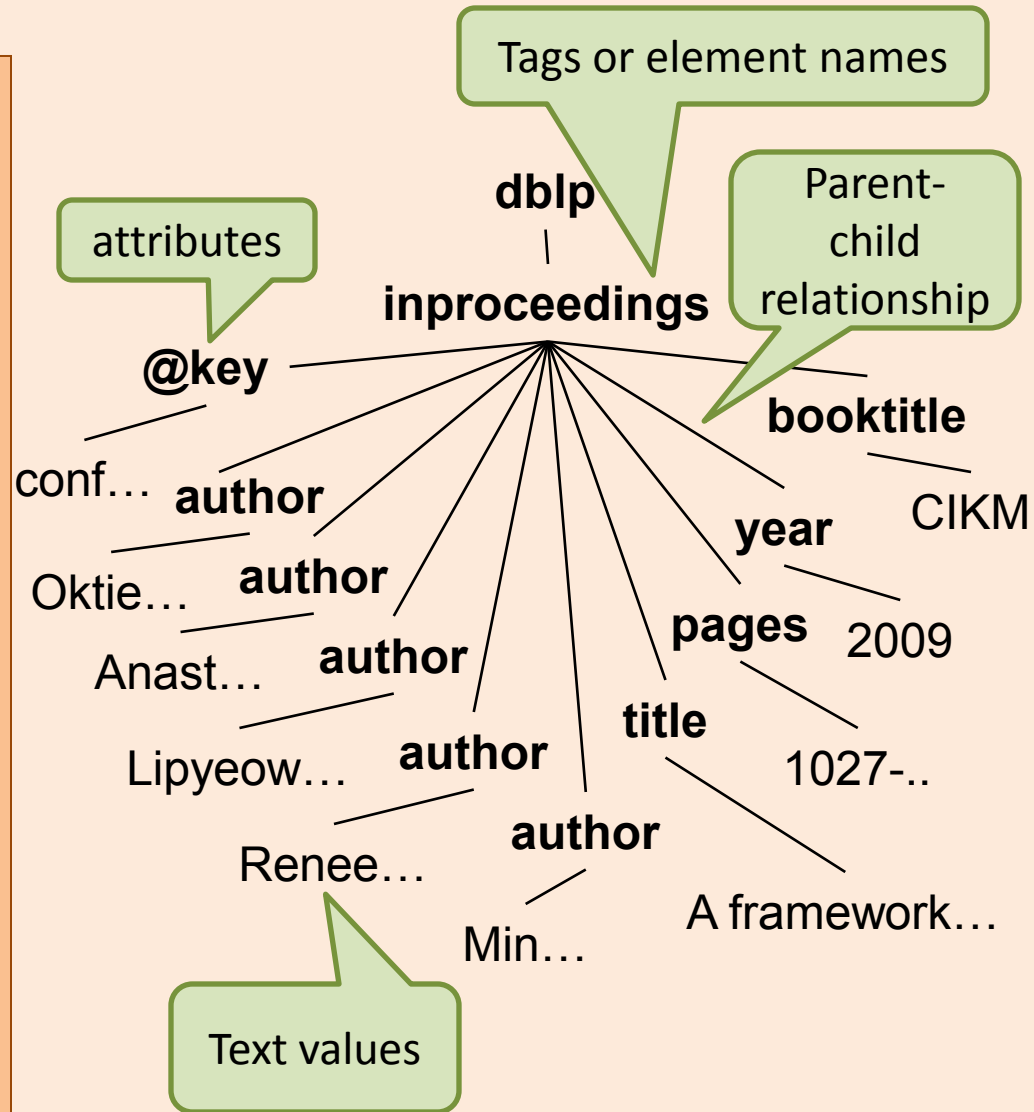
Examples

- 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/HassanzadehKLMW0
    9" >
  <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>
```

Tags or element names

attributes

Parent-child relationship

dblp
|
inproceedings

@key

booktitle

conf… **author**

author CIKM

Oktie… **author** **year**

Anast… **author** **pages** 2009

Lipyeow… **author** **title** 1027-..

Renee… **author**

Min… A framework…

Text values

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.
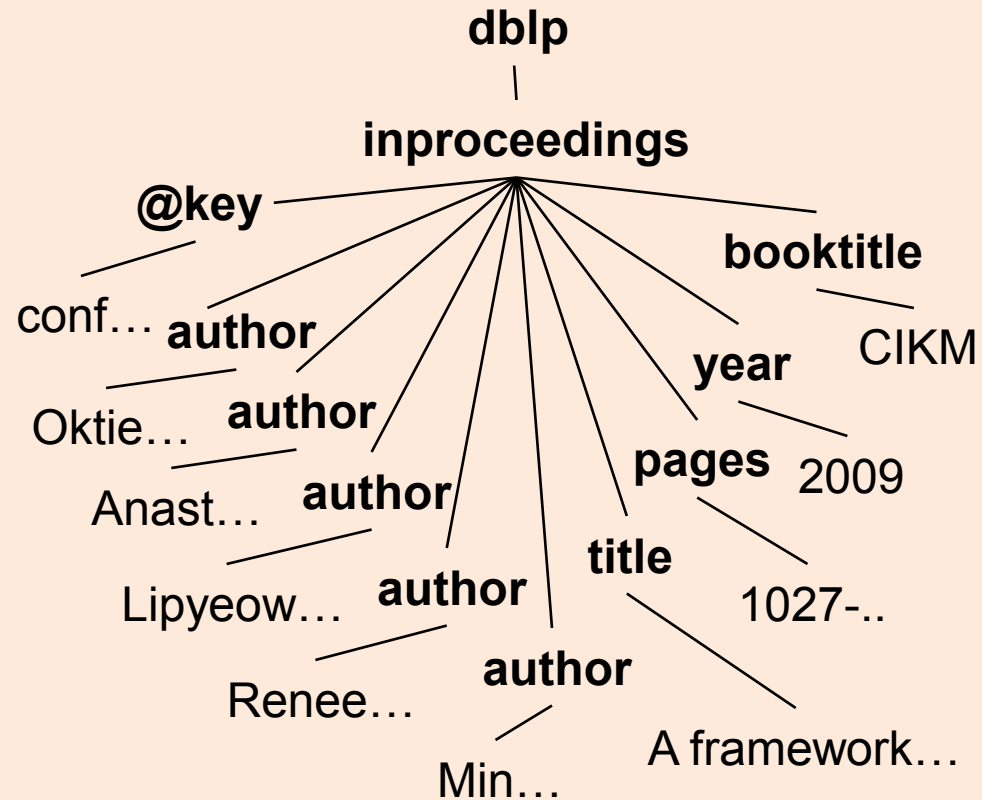- Think of a **node** as the XML fragment for the subtree rooted at that node.

dblp
|
inproceedings

@key — conf…

author — Oktie…

author — Anast…

author — Lipyeow…

author — Renee…

author — Min…

title — A framework…

pages — 1027-..

year — 2009

booktitle — CIKM

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"]

dblp

inproceedings

@key

conf…

author

Oktie…

author

Anast…

author

Lipyeow…

author

Renee…

author

Min…

title

pages

1027-..

year

2009

booktitle

CIKM

A framework…

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>
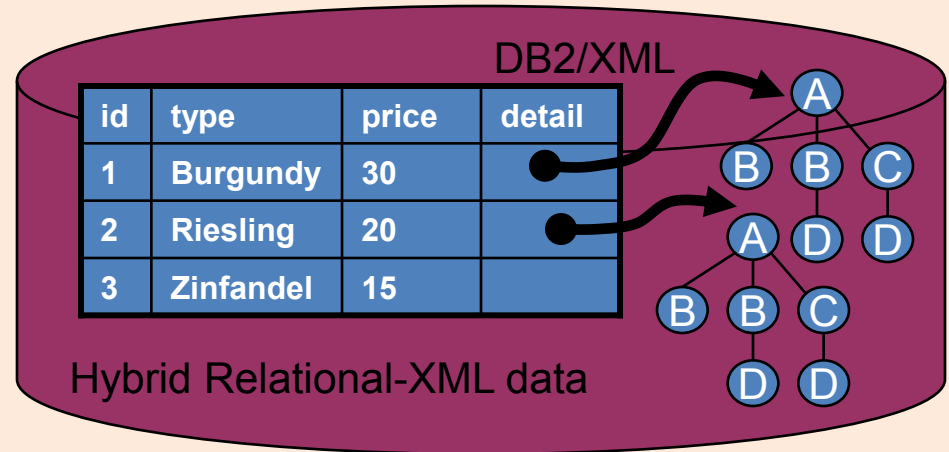 <title>$auth/../title/text()</title>
<author>

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>')
  );

DB2/XML

id	type	price	detail
1	Burgundy	30	
2	Riesling	20	
3	Zinfandel	15	

Hybrid Relational-XML data

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

Document tree delivered by the XML parser gets broken into regions

Regions index

page

page

page
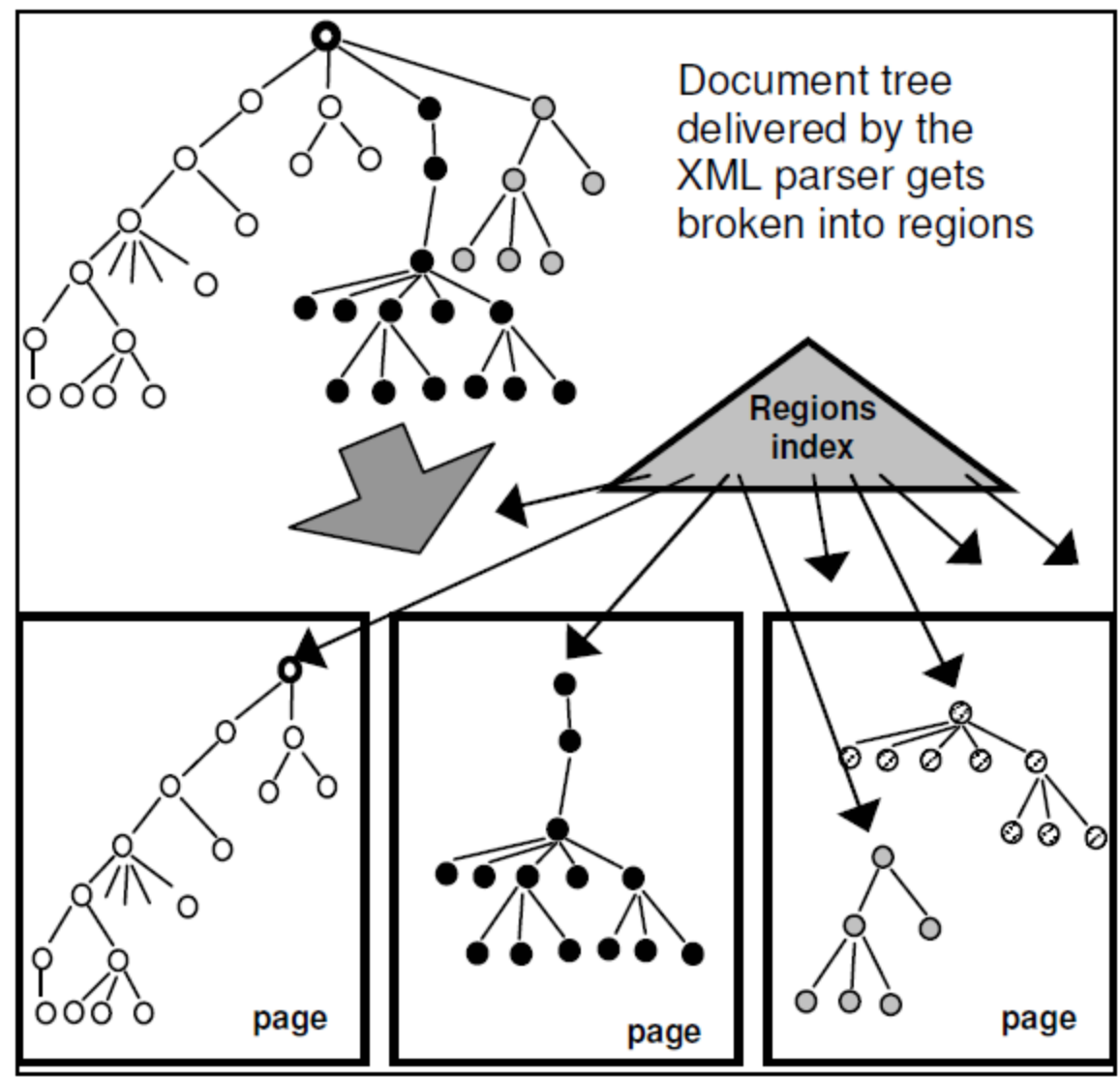
XML Indexing

- 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

Non-leaf Pages

Leaf Pages
(Sorted by search key)
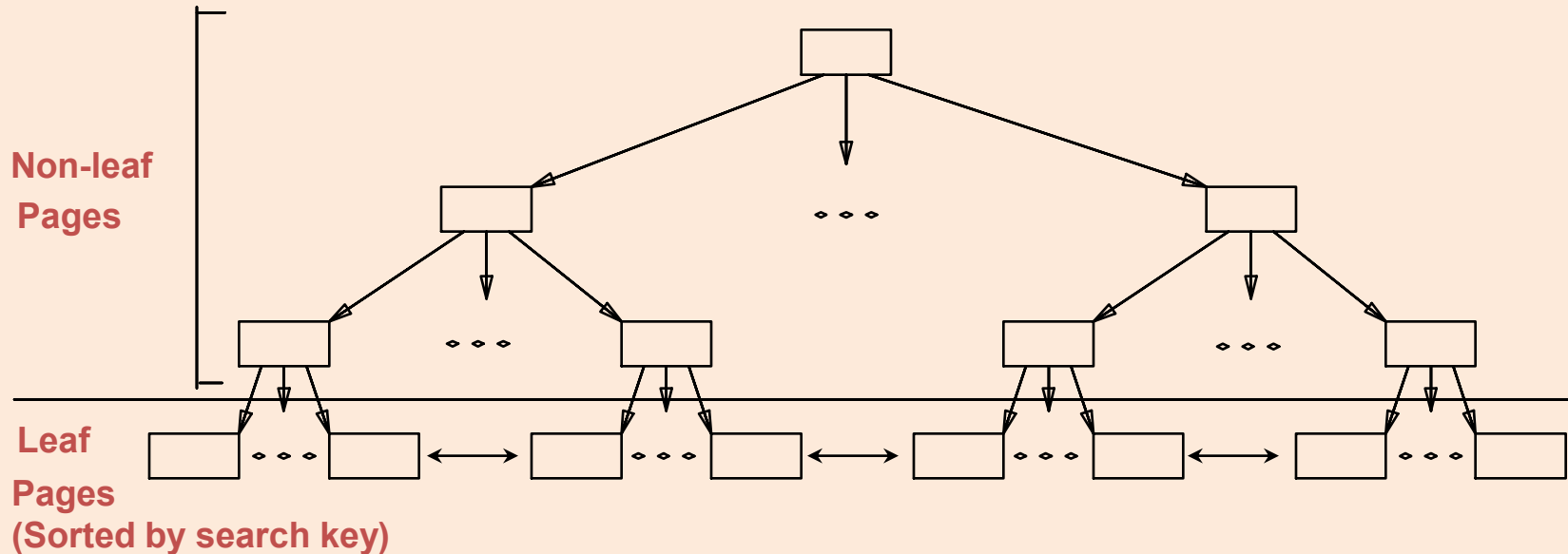
- For XML value indexes we want to map the value associated with an XML pattern to nodes in the XML data tree
- Key part of index entry is the "value"
- Instead of a rid, an index entry stores the (region ID, node ID)