SDXML VT2024
Models and languages for semi-structured data and XML

Product-specific techniques
IBM DB2

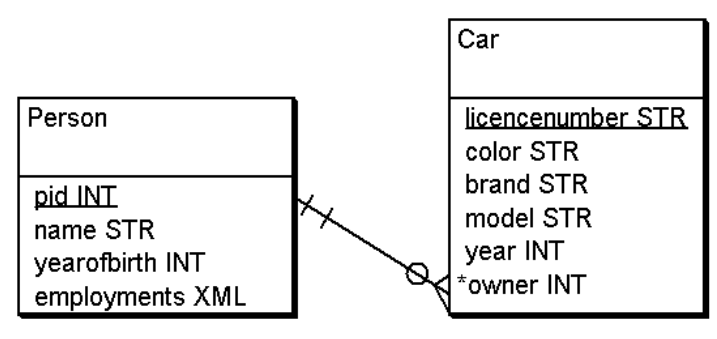
nikos dimitrakas
nikos@dsv.su.se
08-161295

Corresponding reading
Product documentation
Compendium with introduction to IBM DB2
Section 13.3 of the course book

IBM DB2 11.5

- **Support for SQL/XML according to SQL:2006 with some exceptions**
  - **No support for XML data types associated to schemas**
  - **Partial support for XPath and XQuery**
- **Custom additions**
  - **XMLGROUP, XMLROW, XSLTRANSFORM** XMLGROUP,XMLROW,XSLTRANSFORM
  - **XQUERY, extra XQuery functions**
- **Support in earlier versions**
  - **Data types XMLVARCHAR, XMLCLOB, XMLFILE**
  - **DTD validation**
  - **Composition and shredding according to templates (DAD files)**
  - **Modifying data inside XML**
    - » **update function** extractInteger,extractDate,extractVarchar,extractCLOB
  - **Extracting data from XML with XPath (functions)**
    - » **extractInteger, extractDate, extractVarchar, extractCLOB, etc.**
    - » **extractIntegers, extractDates, extractVarchars, etc.**

Sample data



PERSON

pid	name	yearofbirth
1	John Higgins	1975
2	Steven Hendry	1973
3	Matthew Stevens	1982
4	Ronnie O´Sullivan	1980
5	Ken Doherty	1974
6	Steve Davis	1960
7	Paul Hunter	1983
8	Neil Robertson	1982

CAR

licencenumber	color	brand	model	year	owner
ABC123	black	NISSAN	Cherry	1995	1
CCD457	blue	FIAT	Forza	2001	2
DKL998	green	SAAB	9000C	1998	3
RSQ199	black	NISSAN	Micra	1999	4
WID387	red	FIAT	Nova	2003	5
ROO197	blue	SAAB	900i	1982	3
TYD226	black	NISSAN	Cherry	1990	1
PTF357	red	VOLVO	V70	2001	6
DAVIS1	red	VOLVO	V90	2007	6

Sample data

Person - pid,name,yearofbirth and employments

pid	employments
1	<root><employment startdate="2001-08-20" enddate="2009-02-28" employer="ABB"/> <employment startdate="2009-04-15" employer="UPC"/></root>
2	<root><employment startdate="2002-08-20" enddate="2003-06-30" employer="ABB"/> <employment startdate="2003-08-01" employer="UPC"/> <employment startdate="2006-11-01" employer="ABB"/></root>
3	<root><employment startdate="2003-01-10" employer="UPC"/> </root>
4	<root><employment startdate="2002-03-10" enddate="2010-05-22" employer="LKP"/> <employment startdate="2010-08-15" employer="STG"/></root>
5	<root><employment startdate="2002-02-12" enddate="2003-05-11" employer="LKP"/> <employment startdate="2003-05-12" enddate="2003-12-02" employer="ABB"/> <employment startdate="2003-12-06" enddate="2005-02-17" employer="LKP"/> <employment startdate="2005-02-18" enddate="2008-05-16" employer="FFD"/> <employment startdate="2008-06-02" employer="STG"/></root>
6	<root><employment startdate="2001-01-05" enddate="2005-12-31" employer="ABB"/> <employment startdate="2006-01-15" enddate="2009-01-22" employer="LKP"/> <employment startdate="2009-02-01" employer="FFD"/> <employment startdate="2009-02-01" employer="XAB"/></root>
7	<root><employment startdate="2004-01-10" enddate="2008-09-29" employer="FFD"/> <employment startdate="2008-10-01" enddate="2010-11-20" employer="LKP"/></root>
8	<root><employment startdate="2006-02-03" enddate="2008-10-30" employer="UPC"/> <employment startdate="2008-11-20" employer="ABB"/></root>

DB2 - data type

- XML
  - No support for explicit association to XML Schema or DTD
  - Accepts well-formed XML documents and XML fragments
- Validation
  - Support for XML Schema
  - No support for DTD
  - Function XMLVALIDATE
    - » explicit schema
    - » implicit schema
  - Registration of XML Schema
- VALIDATED constraint
  - Checks that an XML value is validated
    - » in general
    - » according to specific XML Schema

DB2 - XML Schema Repository

- Support for XML Schema and DTD
- REGISTER XMLSCHEMA
- ADD XMLSCHEMA
- COMPLETE XMLSCHEMA
- UPDATE XMLSCHEMA
- REGISTER XSROBJECT

DB2 - SQL/XML

- Supports the following functions
  - XMLELEMENT
  - XMLATTRIBUTES
  - XMLFOREST
  - XMLCONCAT
  - XMLCOMMENT
  - XMLPI
  - XMLNAMESPACES
  - XMLAGG
  - XMLTEXT
  - XMLDOCUMENT
  - XMLQUERY (only SEQUENCE)
  - XMLTABLE
  - XMLEXISTS (classified as a predicate, not as a function)
  - XMLSERIALIZE
  - XMLCAST (classified as an expression, not as a function)
  - XMLPARSE
  - XMLVALIDATE

DB2 - XMLROW

- Returns one XML document per row

```
SELECT XMLROW(name, yearofbirth, pid)
FROM Person
```

```
<row><NAME>John Higgins</NAME><YEAROFBIRTH>1975</YEAROFBIRTH><PID>1</PID></row>
<row><NAME>Stephen Hendry</NAME><YEAROFBIRTH>1973</YEAROFBIRTH><PID>2</PID></row>
<row><NAME>Matthew Stevens</NAME><YEAROFBIRTH>1982</YEAROFBIRTH><PID>3</PID></row>
<row><NAME>Ronnie O'Sullivan</NAME><YEAROFBIRTH>1980</YEAROFBIRTH><PID>4</PID></row>
<row><NAME>Ken Doherty</NAME><YEAROFBIRTH>1974</YEAROFBIRTH><PID>5</PID></row>
<row><NAME>Steve Davis</NAME><YEAROFBIRTH>1960</YEAROFBIRTH><PID>6</PID></row>
<row><NAME>Paul Hunter</NAME><YEAROFBIRTH>1983</YEAROFBIRTH><PID>7</PID></row>
<row><NAME>Neil Robertson</NAME><YEAROFBIRTH>1982</YEAROFBIRTH><PID>8</PID></row>
```

DB2 - XMLROW - element names

- **Offers configuration of element names**

```
SELECT XMLROW(name AS "FullName",
       yearofbirth AS "YoB",
       pid AS ID
       OPTION ROW "Someone")
FROM Person
```

```
SELECT XMLROW(name AS "FullName",
yearofbirth as "YoB"
pid AS ID
OPTION ROW "Someone")
FROM Person
```

```
<Someone><FullName>John Higgins</FullName><YoB>1975</YoB><ID>1</ID></Someone>
<Someone><FullName>Stephen Hendry</FullName><YoB>1973</YoB><ID>2</ID></Someone>
<Someone><FullName>Matthew Stevens</FullName><YoB>1982</YoB><ID>3</ID></Someone>
<Someone><FullName>Ronnie O'Sullivan</FullName><YoB>1980</YoB><ID>4</ID></Someone>
<Someone><FullName>Ken Doherty</FullName><YoB>1974</YoB><ID>5</ID></Someone>
<Someone><FullName>Steve Davis</FullName><YoB>1960</YoB><ID>6</ID></Someone>
<Someone><FullName>Paul Hunter</FullName><YoB>1983</YoB><ID>7</ID></Someone>
<Someone><FullName>Neil Robertson</FullName><YoB>1982</YoB><ID>8</ID></Someone>
```

```
SELECT XMLELEMENT(NAME "Someone",
       XMLFOREST(name AS "FullName",
                 yearofbirth AS "YoB", pid AS ID))
FROM Person
```

```
SELECT XMLELEMENT(NAME "Someone",
XMLFOREST(name AS "FullName",
yearofbirth AS "YoB",pid as "ID"))
```


DB2 - XMLROW - attributes

- **Possible to request attributes instead of elements**

```
SELECT XMLROW(name AS "FullName",
       yearofbirth AS "YoB",
       pid AS ID
       OPTION ROW "Someone" AS ATTRIBUTES)
FROM Person
```

```
<Someone FullName="John Higgins" YoB="1975" ID="1"/>
<Someone FullName="Stephen Hendry" YoB="1973" ID="2"/>
<Someone FullName="Matthew Stevens" YoB="1982" ID="3"/>
<Someone FullName="Ronnie O'Sullivan" YoB="1980" ID="4"/>
<Someone FullName="Ken Doherty" YoB="1974" ID="5"/>
<Someone FullName="Steve Davis" YoB="1960" ID="6"/>
<Someone FullName="Paul Hunter" YoB="1983" ID="7"/>
<Someone FullName="Neil Robertson" YoB="1982" ID="8"/>
```

```
SELECT XMLELEMENT(NAME "Someone",
       XMLATTRIBUTES(name AS "FullName",
                 yearofbirth AS "YoB", pid AS ID))
FROM Person
```

DB2 - XMLGROUP

- Returns many rows as one XML document
  - Aggregate function

```
SELECT XMLGROUP(name, yearofbirth, pid)
FROM Person
```

```
<rowset>
  <row>
    <NAME>John Higgins</NAME>
    <YEAROFBIRTH>1975</YEAROFBIRTH>
    <PID>1</PID>
  </row>
  <row>
    <NAME>Stephen Hendry</NAME>
    <YEAROFBIRTH>1973</YEAROFBIRTH>
    <PID>2</PID>
  </row>
  <row>
    <NAME>Matthew Stevens</NAME>
    <YEAROFBIRTH>1982</YEAROFBIRTH>
    <PID>3</PID>
  </row>
  …
</rowset>
```


DB2 - XMLGROUP - element names

- Offers configuration of element names

```
SELECT XMLGROUP(name AS "FullName", yearofbirth AS "YoB",
                pid AS ID OPTION ROOT "Everyone" ROW "Someone")
FROM Person
```

```
<Everyone>
  <Someone>
    <FullName>John Higgins</FullName>
    <YoB>1975</YoB>
    <ID>1</ID>
  </Someone>
  <Someone>
    <FullName>Stephen Hendry</FullName>
    <YoB>1973</YoB>
    <ID>2</ID>
  </Someone>
  <Someone>
    <FullName>Matthew Stevens</FullName>
    <YoB>1982</YoB>
    <ID>3</ID>
  </Someone>
  …
</Everyone>
```

DB2 - XMLGROUP - attributes

- Possible to request attributes instead of elements

```
SELECT XMLGROUP(name AS "FullName", yearofbirth AS "YoB",
                pid AS ID OPTION AS ATTRIBUTES
                ROOT "Everyone" ROW "Someone")
FROM Person
```

```
<Everyone>
  <Someone FullName="John Higgins" ID="1" YoB="1975"/>
  <Someone FullName="Stephen Hendry" ID="2" YoB="1973"/>
  <Someone FullName="Matthew Stevens" ID="3" YoB="1982"/>
  <Someone FullName="Ronnie O'Sullivan" ID="4" YoB="1980"/>
  <Someone FullName="Ken Doherty" ID="5" YoB="1974"/>
  <Someone FullName="Steve Davis" ID="6" YoB="1960"/>
  <Someone FullName="Paul Hunter" ID="7" YoB="1983"/>
  <Someone FullName="Neil Robertson" ID="8" YoB="1982"/>
</Everyone>
```

```
SELECT XMLELEMENT(NAME "Everyone",
          XMLAGG(XMLROW(name AS "FullName", yearofbirth AS "YoB",
                        pid AS ID OPTION ROW "Someone" AS ATTRIBUTES)))
FROM Person
```


DB2 - XSLTRANSFORM

- Transforms an XML document according to an XSLT document (XSLT 1.0)
  - XSLTRANSFORM(XML-value USING XSLT-value)

```
<xsl:transform version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
    <xsl:output method="xml" />
    <xsl:template match="/">
        <xsl:element name="Employers">
            <xsl:apply-templates select="//@employer"  />
        </xsl:element>
    </xsl:template>
    <xsl:template match="@employer">
        <xsl:element name="Employer">
            <xsl:value-of select="."/>
        </xsl:element>
    </xsl:template>
</xsl:transform>
```

DB2 - XSLTRANSFORM

```
SELECT XSLTRANSFORM(employments USING
'<xsl:transform version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
    <xsl:output method="xml"/>
    <xsl:template match="/">
        <xsl:element name="Employers">
            <xsl:apply-templates select="//@employer"/>
        </xsl:element>
    </xsl:template>
    <xsl:template match="@employer">
        <xsl:element name="Employer">
            <xsl:value-of select="."/>
        </xsl:element>
    </xsl:template>
</xsl:transform>')
FROM Person
WHERE name = 'Stephen Hendry'
```

```
<Employers>
    <Employer>ABB</Employer>
    <Employer>UPC</Employer>
    <Employer>ABB</Employer>
</Employers>
```


DB2 - XSLTRANSFORM

```
CREATE TABLE xslt (name VARCHAR(15) NOT NULL PRIMARY KEY,
                   value XML NOT NULL)

INSERT INTO xslt VALUES
('employers',
'<xsl:transform version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform">
    <xsl:output method="xml"/>
    <xsl:template match="/">
        <xsl:element name="Employers">
            <xsl:apply-templates select="//@employer"/>
        </xsl:element>
    </xsl:template>
    <xsl:template match="@employer">
        <xsl:element name="Employer">
            <xsl:value-of select="."/>
        </xsl:element>
    </xsl:template>
</xsl:transform>')

SELECT XSLTRANSFORM(employments USING xslt.value)
FROM Person, xslt
WHERE Person.name = 'Stephen Hendry' AND xslt.name = 'employers'
```

DB2 - XMLCAST

- Converts between XML and other data types
- Requires a value or a node

```
SELECT name, XMLCAST(XMLQUERY('count( $EMPLOYMENTS//employment)') AS INT)
FROM Person

SELECT name, XMLCAST(
XMLQUERY('($EMPLOYMENTS//@employer[not(../@enddate)])[1]') AS VARCHAR(50))
FROM Person

SELECT name, XMLCAST(XMLQUERY(
'string-join($EMPLOYMENTS//@employer[not(../@enddate)], '', '')') AS VARCHAR(50))
FROM Person

SELECT XMLCAST(name AS XML)
FROM Person
```

May behave weirdly when converting sequences from XML to something else.

DB2 - XQUERY

- Support for XQuery
  - XQuery statements after the keyword XQUERY

```
XQUERY
for $a in (1,2,3)
return element Number {$a}
```

Three rows in the result:

```
<Number>1</Number>
<Number>2</Number>
<Number>3</Number>
```

```
XQUERY
element Result  {for $a in (1,2,3)
                 return element Number {$a}}
```

```
<Result>
  <Number>1</Number><Number>2</Number><Number>3</Number>
</Result>
```

DB2 - XQUERY - sqlquery

- XQuery function for SQL inside XQuery
  - db2-fn:sqlquery
    - » supports parameters
  - The result is a sequence in the XQuery context
  - The SELECT statement must return one XML column

```
XQUERY
for $a in distinct-values(db2-fn:sqlquery("SELECT
employments FROM Person")//@employer)
return element Company {$a}
```

```
<Company>ABB</Company>
<Company>UPC</Company>
<Company>LKP</Company>
<Company>STG</Company>
<Company>FFD</Company>
<Company>XAB</Company>
```


DB2 - XQUERY - sqlquery

- Parameters

```
XQUERY
for $a in distinct-values(db2-fn:sqlquery("SELECT
employments FROM Person WHERE yearofbirth >
parameter(1)", 1980)//@employer)
return element Company {$a}
```

```
<Company>UPC</Company>
<Company>FFD</Company>
<Company>LKP</Company>
<Company>ABB</Company>
```

DB2 - XQUERY - sqlquery

```
XQUERY
let $a := db2-fn:sqlquery('SELECT XMLELEMENT(NAME
"Person", name) FROM Person WHERE yearofbirth < 1975')
return element People {$a}
```

```
<People>
        <Person>Stephen Hendry</Person>
        <Person>Ken Doherty</Person>
        <Person>Steve Davis</Person>
</People>
```


DB2 - XQUERY - xmlcolumn

- XQuery function to get data from an XML column
  - db2-fn:xmlcolumn
  - Table name and column name are case-sensitive

```
XQUERY
for $a in distinct-values(db2-
fn:xmlcolumn('PERSON.EMPLOYMENTS')//@employer)
return element Company {$a}
```

```
<Company>ABB</Company>
<Company>UPC</Company>
<Company>LKP</Company>
<Company>STG</Company>
<Company>FFD</Company>
<Company>XAB</Company>
```

DB2 - XML DML

- XQuery Update Facility
  - some syntax differences
- transform statements
  - (transform clause)
  - copy clause
  - modify clause
    - » do delete
    - » do insert
    - » do rename
    - » do replace
  - return clause
  - keywords for do insert
    - » before
    - » after
    - » as first into
    - » as last into
    - » into
  - keywords for do replace
    - » (value of) … with …
  - keywords for do rename
    - » as

DB2 - XML DML

- The whole XML value in a cell must be replaced

```
UPDATE Person
SET employments = XMLQUERY('transform statement'
                           PASSING employments)
WHERE …
```

DB2 - transform - insert

```
XQUERY
transform
copy $x := <root><a>456</a><a>789</a></root>
modify do insert <a>123</a> as first into $x
return $x
```

```
<root>
        <a>123</a>
        <a>456</a>
        <a>789</a>
</root>
```


DB2 - transform - insert

```
XQUERY
transform
copy $x := <root><a>456</a><a>789</a></root>
modify do insert <a>123</a> before $x/a[text() = 789]
return $x
```

```
<root>
        <a>456</a>
        <a>123</a>
        <a>789</a>
</root>
```

DB2 - transform - insert

```
XQUERY
transform
copy $x := <root><a>456</a><a>789</a></root>
modify do insert attribute c {5} into $x/a[text() = 789]
return $x
```

```
<root>
        <a>456</a>
        <a c="5">789</a>
</root>
```


DB2 - transform - insert

```
UPDATE Person
SET employments =  XMLQUERY('
        transform
        copy $ne := $e
        modify do insert element employment {
                        attribute startdate {"2011-09-01"},
                        attribute employer {"LBM"}} as last into $ne/root
        return $ne' PASSING employments AS "e")
WHERE pid = 3
```

```
SELECT employments FROM Person WHERE pid = 3
```

```
<root>
    <employment startdate="2003-01-10" employer="UPC"/>
    <employment startdate="2011-09-01" employer="LBM"/>
</root>
```

DB2 - transform - delete

```
XQUERY
transform
copy $x := <root><a>456</a><a>789</a></root>
modify do delete $x/a[text() = 789]
return $x
```

```
<root>
        <a>456</a>
</root>
```


DB2 - transform - delete

```
SELECT XMLQUERY('transform
                copy $ne := $e
                modify do delete $ne//employment[2]
                return $ne' PASSING employments AS "e")
FROM Person
WHERE pid = 3
```

```
<root>
    <employment startdate="2003-01-10" employer="UPC"/>
</root>
```

```
SELECT employments FROM person WHERE pid = 3
```

```
<root>
    <employment startdate="2003-01-10" employer="UPC"/>
    <employment startdate="2011-09-01" employer="LBM"/>
</root>
```

DB2 - transform - delete

```
UPDATE Person
SET employments = XMLQUERY('transform
                            copy $ne := $e
                            modify do delete $ne//employment[2]
                            return $ne' PASSING employments AS "e")
WHERE pid = 3
```

```
SELECT employments FROM Person WHERE pid = 3
```

```
<root>
    <employment startdate="2003-01-10" employer="UPC"/>
</root>
```


DB2 - transform - replace

```
XQUERY
transform
copy $x := <root><a>456</a><a>789</a></root>
modify do replace $x/a[text() = 789] with <b>123</b>
return $x
```

```
<root>
        <a>456</a>
        <b>123</b>
</root>
```

DB2 - transform - replace

```
XQUERY
transform
copy $x := <root><a>456</a><a>789</a></root>
modify do replace value of $x/a[text() = 789] with 123
return $x
```

```
<root>
        <a>456</a>
        <a>123</a>
</root>
```


DB2 - transform - replace

```
XQUERY
transform
copy $x := <root><a b="ccc">456</a><a>789</a></root>
modify do replace $x/a[1]/@b with attribute f {"ddd"}
return $x
```

```
<root>
        <a f="ddd">456</a>
        <a>789</a>
</root>
```

DB2 - transform - rename

```
XQUERY
transform
copy $x := <root><a>456</a><a>789</a></root>
modify do rename $x/a[2] as "b"
return $x
```

```
<root>
        <a>456</a>
        <b>789</b>
</root>
```


DB2 - transform – many, loop

```
XQUERY
transform
copy $x := <root><a>456</a><a>789</a></root>
modify for $a in $x/a
        return do rename $a as "b"
return $x
```

```
<root>
        <b>456</b>
        <b>789</b>
</root>
```

DB2 - transform - many, list

```
XQUERY
transform
copy $x := <root><a>456</a><a>789</a></root>
modify (do replace value of $x/a[text() = 789] with 123,
        do rename $x/a[2] as "b",
        do insert attribute c {5} into $x/a[text() = 789])
return $x
```

```
<root>
        <a>456</a>
        <b c="5">123</b>
</root>
```


DB2 & JSON

- Functions (SQL/JSON)
  - JSON_VALUE, JSON_QUERY, JSON_OBJECT, JSON_ARRAY
  - More functions coming in the next version

Summary

- DB2 follows the SQL standard quite well
- No XQuery 3
- No dynamic node names
- Few supported XPath axes:
  - child, parent, self, attribute, descendant, and descendant-or-self
- Use of standard SQL makes migration easier
  - Avoid product specific solutions when possible
  - Avoid deprecated solutions when possible

What to do next

- Introduction to DB2 & XML (compendium)
  - Introduction to DB2 and IBM Data Studio
  - Examples
- Assignment 6 (DB2 & XML)