The Road to the XML Type

Current and Future Developments

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Outline

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1. Past Developments
2. Current Developments
3. Future Developments
4. Use Cases
5. Conclusion

Past Developments

- contrib/xml2 by J. Gray et al.
- Initial patch for SQL/XML publishing functions by Pavel Stehule
- Google Summer of Code 2006 - Nikolay Samokhvalov
- Initial version of export functions by Peter Eisentraut

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New Features

Target for PostgreSQL 8.3:

- XML Data Type
- XML Publishing
- XML Export
- SQL:2003 conformance
- XPath

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XML Data Type

```
CREATE TABLE test (
    ...,
    data xml,
    ...
);
```

Features:

- Input checking
- Support functions

Issues:

- Internal storage format (plain text)
- Encoding handling

Using the XML Type

Bizarre SQL way:

```
INSERT INTO test VALUES (
    ...,
    XMLPARSE (DOCUMENT '<foo>...</foo>'),
    ...
);

SELECT XMLSERIALIZE (DOCUMENT data AS varchar)
    FROM test;
```

Simple PostgreSQL way:

```
INSERT INTO test VALUES (... , '<foo>...</foo>', ...);

SELECT data FROM test;
```

XML Type Oddities

- No comparison operators
- To retrieve, use:
  - Cast to text, or
  - XPath, or
  - Other key column
- To index, use:
  - Cast to text, or
  - XPath

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Producing XML Content

The old way?

```
SELECT '<record id="' || id || '"><value>'
       || ad_hoc_escape_func(value)
       || '</value></record>'
    FROM tab;
```

The new way:

```
SELECT XMLELEMENT(NAME record,
                  XMLATTRIBUTES(id),
                  XMLELEMENT(NAME value, value))
    FROM tab;
```

XMLELEMENT Example

SQL:

```
XMLROOT (
  XMLELEMENT (
    NAME 'gazonk',
    XMLATTRIBUTES (
      'val' AS 'name',
      1 + 1 AS 'num'
    ),
    XMLELEMENT (
      NAME 'qux',
      'foo'
    )
  ),
  VERSION '1.0',
  STANDALONE YES
)
```

Result:

```
<?xml version='1.0'
      standalone='yes' ?>
<gazonk name='val'
        num='2'>
  <qux>foo</qux>
</gazonk>
```

XMLFOREST Example

```
SELECT xmlforest (
  "FirstName" as "FName", "LastName" as "LName",
  'string' as "str", "Title", "Region" )
FROM "Demo"."demo"."Employees";
```

might result in

```
<FName>Nancy</FName>
<LName>Davolio</LName>
<str>string</str>
<Title>Sales Representative</Title>
<Region>WA</Region>
. . .
<FName>Anne</FName>
<LName>Dodsworth</LName>
<str>string</str>
<Title>Sales Representative</Title>
```

(1 row per record)

XMLAGG Example

```
SELECT xmlelement ('Emp',
  xmlattributes ('Sales Representative' as "Title"),
  xmlagg (xmlelement ('Name', "FirstName", ' ', "LastName")))
  FROM "Demo"."demo"."Employees"
  WHERE "Title" = 'Sales Representative';
```

might result in

```
<Emp Title="Sales Representative">
  <Name>Nancy Davolio</Name>
  <Name>Janet Leverling</Name>
  <Name>Margaret Peacock</Name>
  <Name>Michael Suyama</Name>
  <Name>Robert King</Name>
  <Name>Anne Dodsworth</Name>
</Emp>
```

(1 row)

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XML Export

- Map table/schema/database contents to XML document
- Map table/schema/database schema to XML Schema

Useful for:

- Downstream processing (e.g., SOAP, web services)
- Postprocessing using XSLT
- Backup???
- Display formats (alternative to psql's HTML mode)

XML Export Functions

Data export:

```
table_to_xml(tbl regclass, nulls boolean,
             tableforest boolean, targetns text)
query_to_xml(query text, nulls boolean,
             tableforest boolean, targetns text)
cursor_to_xml(cursor refcursor, count int, nulls boolean,
              tableforest boolean, targetns text)
```

Schema export:

```
table_to_xmlschema(tbl regclass, nulls boolean,
                   tableforest boolean, targetns text)
query_to_xmlschema(query text, nulls boolean,
                   tableforest boolean, targetns text)
cursor_to_xmlschema(cursor refcursor, nulls boolean,
                    tableforest boolean, targetns text)
```

XML Schema Mapping Example

```
CREATE TABLE test (a int PRIMARY KEY, b varchar(200));
```

is mapped to

```
<xsd:complexType name="RowType.catalog.schema.test">
  <xsd:sequence>
    <xsd:element name="a" type="INTEGER"></xsd:element>
    <xsd:element name="b" type="VARCHAR_200_200" minOccurs="0"></xsd:element>
  </xsd:sequence>
</xsd:complexType>

<xsd:complexType name="TableType.catalog.schema.test">
  <xsd:sequence>
    <xsd:element name="row"
        type="RowType.catalog.schema.test"
        minOccurs="0"
        maxOccurs="unbounded" />
  </xsd:sequence>
</xsd:complexType>
```

XML Export Format Example

```
<catalogname>
  <schemaname>
    <tablename>
      <row>
        <colname1>value</colname1>
        <colname2 xsi:nil='true'/>
        ...
      </row>
      ...
    </tablename>
    ...
  </schemaname>
  ...
</catalogname>
```

Outline

XPath example

The table for further examples:

```
CREATE TABLE table1(
  id INTEGER PRIMARY KEY,
  created TIMESTAMP NOT NULL
      DEFAULT CURRENT_TIMESTAMP,
  xdata XML
);
```

XPath Example

Sample data:

```
INSERT INTO
  table1(id, xdata)
  VALUES(
  1,
  '<dept xmlns:smpl="http://example.com" smpl:did="DPT011-IT">
    <name>IT</name>
    <persons>
      <person smpl:pid="111">
        <name>John Smith</name>
        <age>24</age>
        </person>
        <person smpl:pid="112">
          <name>Michael Black</name>
          <age>28</age>
        </person>
    </persons>
  </dept>'
);
```

XPath Example

Simple example:

```
SELECT *
FROM table1
WHERE (xpath('//person/name/text()',
             xdata))[1]::text = 'John Smith';
```

And using namespaces:

```
xmltest=# SELECT *
FROM table1
WHERE (xpath('//person/@smpl:pid', xdata,
  ARRAY[ARRAY['smpl', 'http://example.com']]))::text = '111'
FROM table1;
```

XPath: Indexes

Use functional indexes to avoid XPath evaluation at runtime:

```
CREATE INDEX i_table1_xdata ON table1 USING btree(
  xpath('//person/@name', xdata)
);
```

External Dependencies

- Uses libxml (MIT License) for XML publishing and XPath
- Enable with `configure --with-libxml`
- Not necessary for XML export

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Future Developments

- DTD and XML Schema validation
- Annotated schema decomposition
- XSLT
- Performance issues
- Full-Text Search
- Advanced Indexing (XLABEL)
- More, More, More

DTD and XML Schema validation

DTD validation:

- Implemented for 8.3, DTD is passed by URI
- Should be extended to allow passing DTD as text

XML Schema (XSD) validation (XMLVALIDATE per SQL:2006):

```
INSERT INTO messages(msg)
SELECT xmlvalidate(
  DOCUMENT '<?xml ...'
  ACCORDING TO XMLSCHEMA NO NAMESPACE
  LOCATION 'http://mycompany.com/msg-schema'
);
```

The result of XMLVALIDATE is new XML value!

Annotated schema decomposition

In some cases decomposition is better (no needs in storing XML data, XML serves as transport only):

- When we need to store only small parts of the XML data
- Already developed tools might be designed only for relational data

During decomposition following capabilities could be used:

- Data normalization
- Foreign keys creation
- Conditional insertion of data chunks
- Insert parts of initial XML document as XML values

XSLT

The easiest way: adapt and expand `contrib/xml2`'s capabilities. We should choose one of two:

- Move XSLT functionality to the core (and use `--with-libxslt`)
- Separate `contrib/xslt`

Performance issues

Ideas:

- Cache intermediate results to avoid redundant parsing and XPath evaluation
- Advanced physical storage to speedup access to arbitrary node in XML data
- Use PostgreSQL existing capabilities for full-text search
- Use additional structures/tables/indexes to avoid XPath evaluation at runtime
- Use slices (similar to `array_extract_slice()`) to avoid dealing with entire values (both in SELECTs and UPDATEs)

Full-Text Search

Simple way to create FTS index (available in 8.3):

```
CREATE INDEX i_table1_fts ON table1
USING gist(
  to_tsvector(
    'default',
    array_to_string(xpath('//text()', xdata), ' ')
  )
);
```

Full-Text Search

Proposal for overloading of built-in `to_tsvector()`:

```
CREATE OR REPLACE FUNCTION to_tsvector(text, xml)
RETURNS tsearch2.tsvector
AS $BODY$
  SELECT to_tsvector(
    $1,
    array_to_string(xpath('//text()', $2), ' ')
  );
$BODY$ LANGUAGE sql IMMUTABLE;

CREATE INDEX i_table1_fts
ON table1
USING gist(to_tsvector('default', xdata));
```

Full-Text Search

Further ideas for full-text search:

- Indexing parts of documents (available in 8.3, in some way)
- Element names in `tsvector`
- Relevance Scoring (ranking)
- FTS parser for XML

XLABEL

Idea:

- Enumerate all XML node names in one database-wide table (`xnames`)
- Store shredded data in additional table (`columnname_xlabel`)
- Use numbering scheme (in prototype it's `ltree`, then SLS) encode nodes
- Use GiST/GIN indexes for numbering scheme column
- Rewrite XPath expression to plain SQL statement
- Implement partial updates support to avoid massive index rebuilding

XLABEL

Enumerate all XML node names in the database:

Table: `xnames`

xname_id	**xname_name**
1	person
2	dept
3	name
4	did
5	persons
...	...

XLABEL

For an XML column implicitly create additional table (using `xlabel.register_column()` function):

Table: `table1_xdata`

tid	xlabel	node_type	xname_id	value
1	a	1 (elem.)	2	NULL
1	a.b	2 (attr.)	4	DPT011-IT
1	a.c	1 (elem.)	3	NULL
1	a.c.a	NULL	NULL	IT
...	...	...	...	...
1	a.d.a.b	1 (elem.)	3	NULL
1	a.d.a.b.a	NULL	NULL	John Smith
...	...	...	...	...

```
CREATE INDEX i_table1_xdata_xlabel
ON table1_xdata
USING gist(xlabel);
```

XLABEL

Rewrite XPath expression to plain SQL statement:

```
SELECT *
FROM table1
WHERE array_dims(xpath('//person/name', xdata)) IS NOT NULL;
```

... becomes ...

```
SELECT *
FROM table1
WHERE EXISTS(
  SELECT 1
  FROM table1_xdata AS t1, table1_xdata AS t2
  WHERE t1.xname_id = 1 AND t2.xname_id = 3
        AND t3.xlabel <@ t1.xlabel
);
```

... where <@ means "is a child of"

XLABEL

Current thoughts:

- Separate table is not good (*deja vu*: `fti` VS `tsearch2`)
- It would be great if one structure solves 2 problems at once:
    - access to arbitrary node
    - SELECTs with XPath

More, more, more

- Inline ORDER BY for XMLAGG (SQL:2003)
  `... XMLAGG(XMLELEMENT(...) ORDER BY col1) ...`
- XMLCAST (SQL:2006)
- XML Canonical
- Pretty-printing XML
- Registered XML Schemas (SQL:2006)
- Schema evolution
- Improve Data Model (XDM)
- XQuery Support (SQL:2006)
- Updatable XML views (over relational data)
- RelaxNG validation

And even more!

- Bulk loader for XML data (parallelize the XML parsing)
- XML-awareness in APIs and PLs
- Additional contribs/projects (web services, ODF, DocBook utils, etc)
- New tools and applications, integration with existing ones

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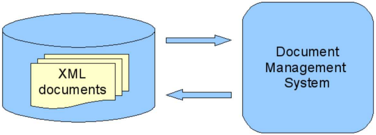
Use Cases

- Use Case 1: Document Management System
- Use Case 2: Store Logs in the Database
- Use Case 3: Heterogeneous Catalog

Use Case 1: Document Management System



The primary goal: to store documents in the RDBMS *as is*

Use Case 2: Store Logs in the Database

Table: action

action_id	SERIAL
action_type_id	INT4
action_status_id	INT4
action_person_id	INT4
action_data	XML

The primary goal: to achieve flexibility, avoid DB schema changes (schema evolution)

Use Case 3: Heterogeneous Catalog

Task: to build heterogeneous catalog (items of different types, a lot of properties)

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How?

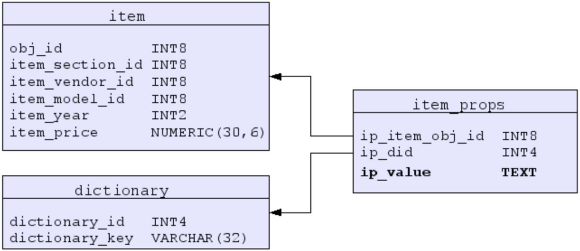
Use Case 3: Heterogeneous Catalog

Ugly way

item	
obj_id	INT8
item_section_id	INT8
item_vendor_id	INT8
item_model_id	INT8
item_year	INT2
item_price	NUMERIC(30,6)
item_prop1	**INT4**
item_prop2	**INT4**
item_prop3	**INT4**
item_prop4	**INT4**
...	
item_prop21	**TEXT**
item_prop22	**TEXT**
item_prop23	**TEXT**
...	
item_prop41	**BOOLEAN**
...	

Use Case 3: Heterogeneous Catalog

Entity-Attribute-Value model



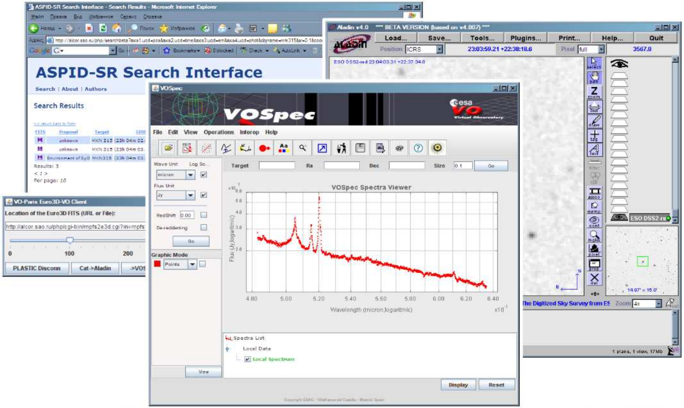
Use Case 3: Heterogeneous Catalog

Semi-structured data approach

item	
obj_id	INT8
item_section_id	INT8
item_vendor_id	INT8
item_model_id	INT8
item_year	INT2
item_price	NUMERIC(30,6)
item_props	**XML**

Use Case 3: Heterogeneous Catalog

Metadata Query Interface for Heterogeneous Data Archives (International Virtual Observatory): `http://alcor.sao.ru/php/search/`



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More Information

- SQL:2006, Part 14: XML-Related Specifications.

  http://wiscorp.com/sql200n.zip
- PostgreSQL documentation.

  http://momjian.us/main/writings/pgsql/sgml/
- XML Development Wiki Page.

  http://developer.postgresql.org/index.php/XML_Support
- N. Samokhvalov. XML Support in PostgreSQL. *In Proceedings of SYRCoDIS.* Moscow, Russia, 2007.

  http://samokhvalov.com/syrcodis2007.ps