B0B36DBS: **Database Systems**

http://www.ksi.mff.cuni.cz/~svoboda/courses/202-B0B36DBS/

Lecture 5

SQL: Advanced Constructs

Martin Svoboda
martin.svoboda@fel.cvut.cz

16. 3. 2021

Czech Technical University in Prague, Faculty of Electrical Engineering

Outline

- **SQL**
  - **Views**
  - Embedded SQL
    - **Functions** (stored procedures)
    - **Cursors**
    - **Triggers**
  - **SQL/XML**
    - Manipulation with XML data

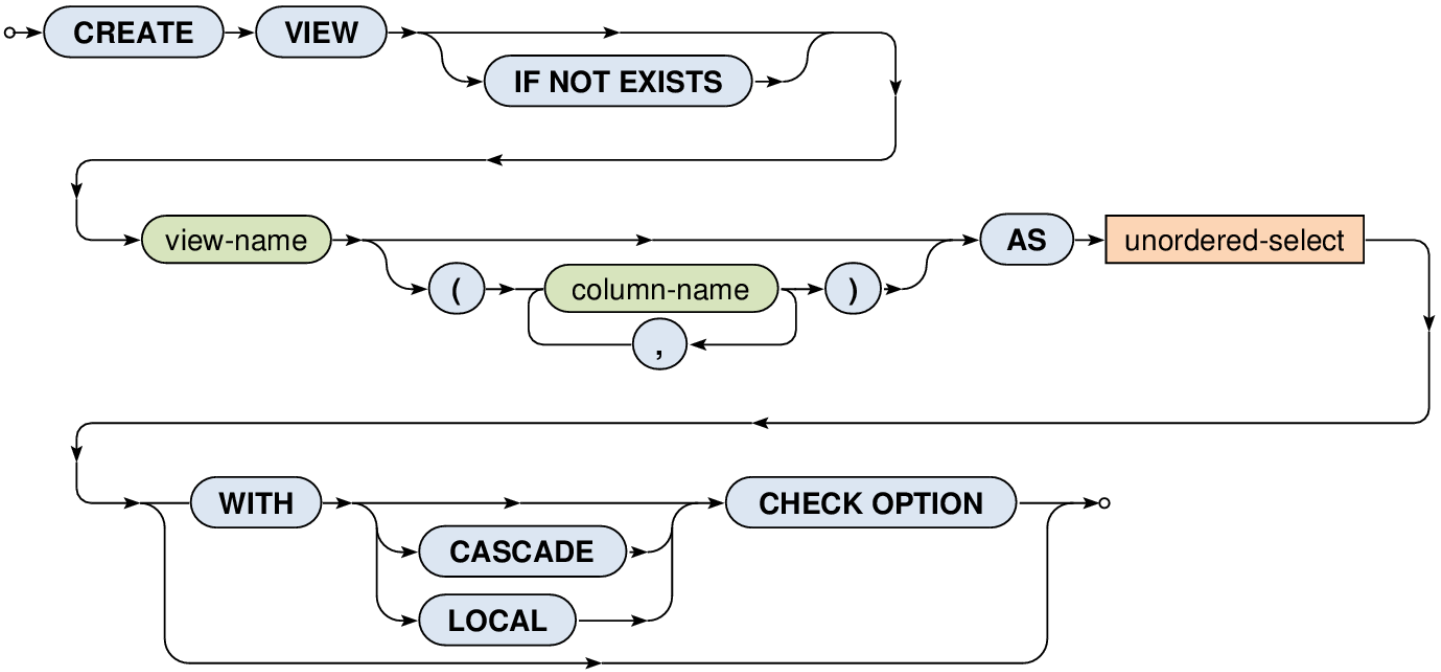
Views

Database Views

- **What are views?**
  - **Named SELECT queries**
    - They can be used similarly as tables
      - E.g. in the FROM clause of the SELECT statements
    - **Evaluated dynamically**
  - Motivation for views
    - Creation of virtual tables, security reasons (hiding tables and their content from particular users), repeated usage of the same complicated statements, …
  - Content of views can be updatable
    - But only only sometimes!

Database Views

- **CREATE VIEW**
  - View name and optionally names of its columns
  - Select query and check option



Database Views

- **View updatability**
  - I.e. can rows be inserted / updated in a view?
  - Yes, but only when…
    - It makes sense…
      - I.e. the given view is based on a **simple SELECT query** (without aggregations, subqueries, …) with only projections (without derived values, …) and selections **over right one table** (without joins, …)
      - I.e. we are deterministically able to reconstruct the entire tuples to be inserted / updated in the original table(s)
    - And, moreover, …

Database Views

- **View updatability**
  - …
  - When **WITH CHECK OPTION** is specified
    - Then the newly inserted / updated tuples must be visible…
      - **LOCAL** – in the given view
      - **CASCADE** (default) – in the given view as well as all the other views this given one is derived from (depends on)

Database Views

- **Examples**
  - View creation

```
CREATE VIEW BigPlanes AS
SELECT * FROM Aircrafts WHERE (Capacity > 200)
WITH LOCAL CHECK OPTION
```

  - Successful insertion

```
INSERT INTO BigPlanes
VALUES ('Boeing 737', 'CSA', 201);
```

  - Denied insertion

```
INSERT INTO BigPlanes
VALUES ('Boeing 727', 'CSA', 100);
```

    - This aircraft is only too small (will not be visible in the view)

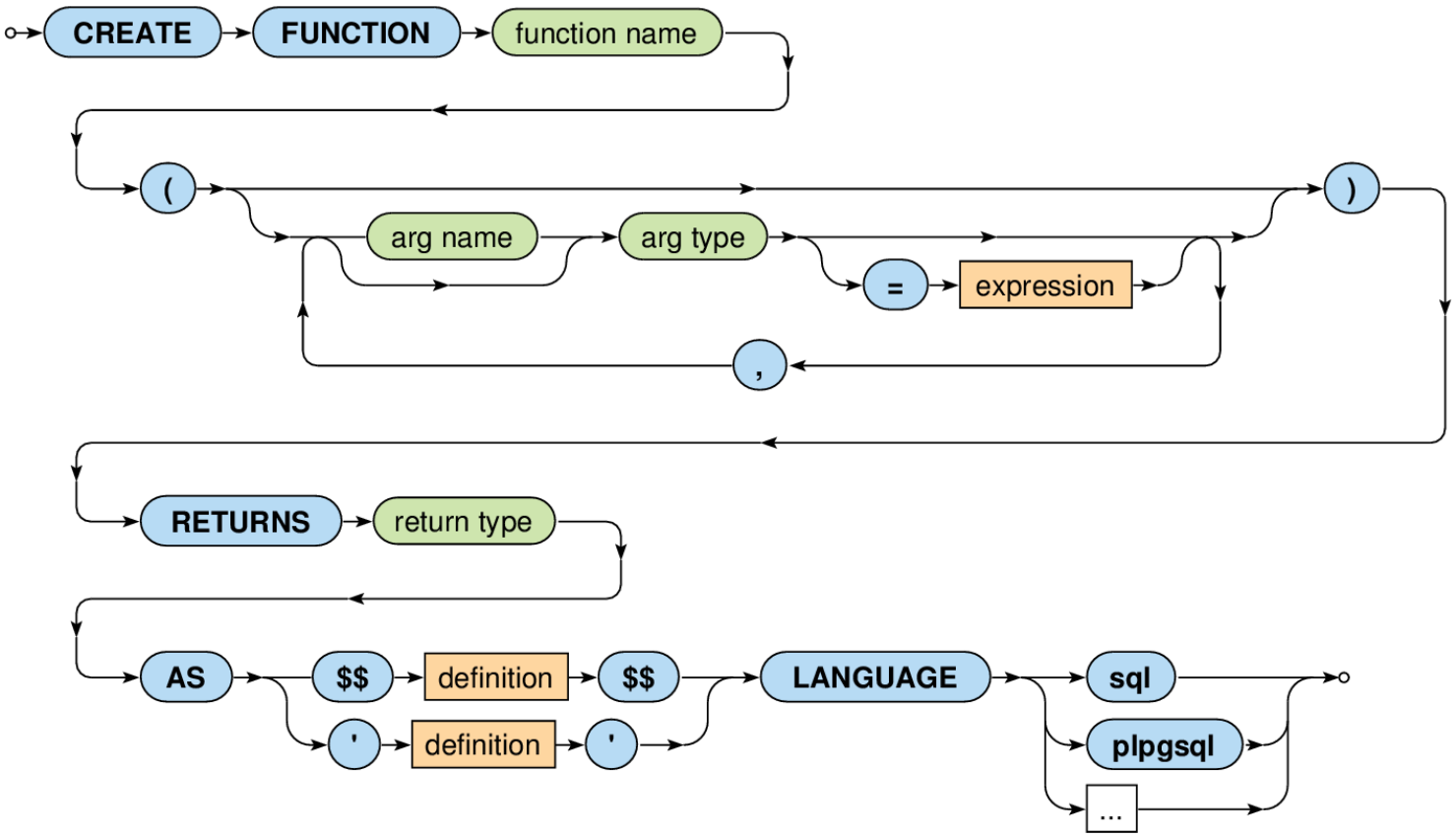
Embedded SQL

Embedded SQL

- **Internal database applications**
  - Proprietary procedural extensions of SQL
    - Transact SQL (T-SQL) – Microsoft SQL Server
    - PL/SQL – Oracle Database
    - **PL/pgSQL – PostgreSQL**
  - Available constructs
    - Control statements: **if then else, for, while, switch**
    - **Stored procedures**
    - **Cursors** – iterative scanning of tables
    - **Triggers** – general integrity constraints
    - …

Stored Procedures

- **CREATE FUNCTION** – defines a new function



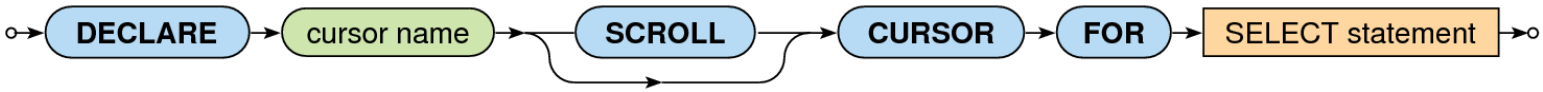
Stored Procedures: Example

```
CREATE FUNCTION inc(x INT)
RETURNS INT
AS
$$
  BEGIN
    RETURN x + 1;
  END;
$$
LANGUAGE plpgsql;

SELECT inc(5);
```

Cursors

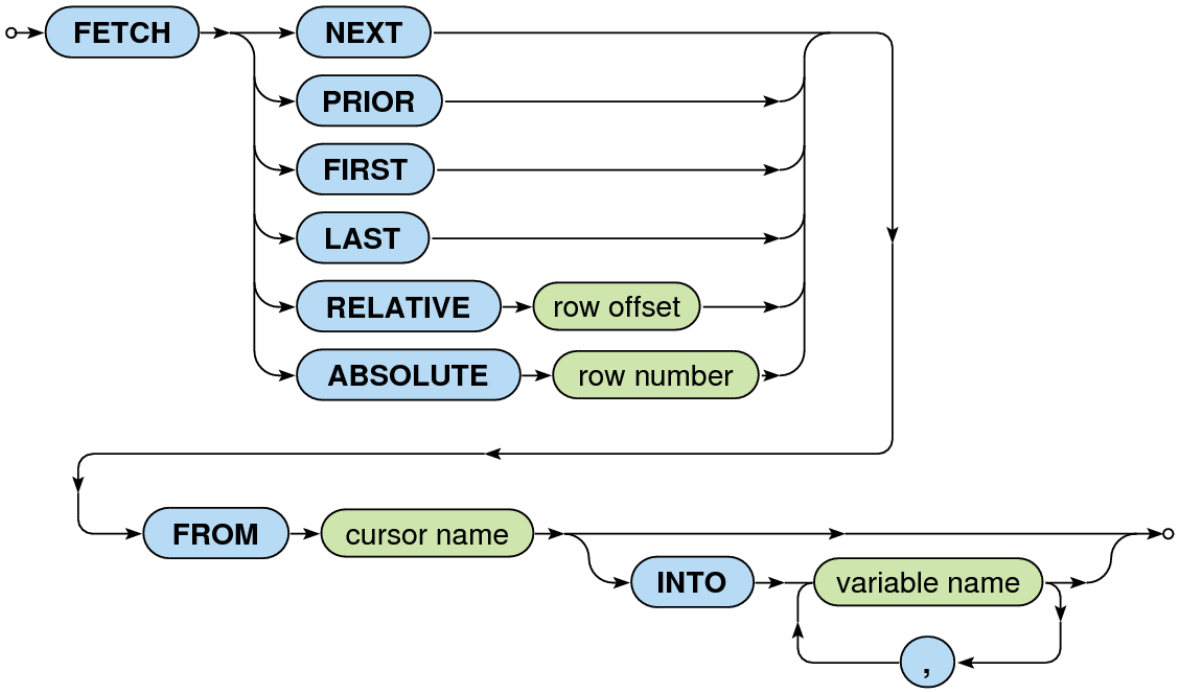
- **Cursor declaration**
  - Database cursor is a control structure that allows us to traverse the rows of a selected table



  - **SCROLL** option
    - When specified, even **backward fetches** are permitted
    - Otherwise only **forward fetches** are allowed

Cursors

- **Data retrieval**



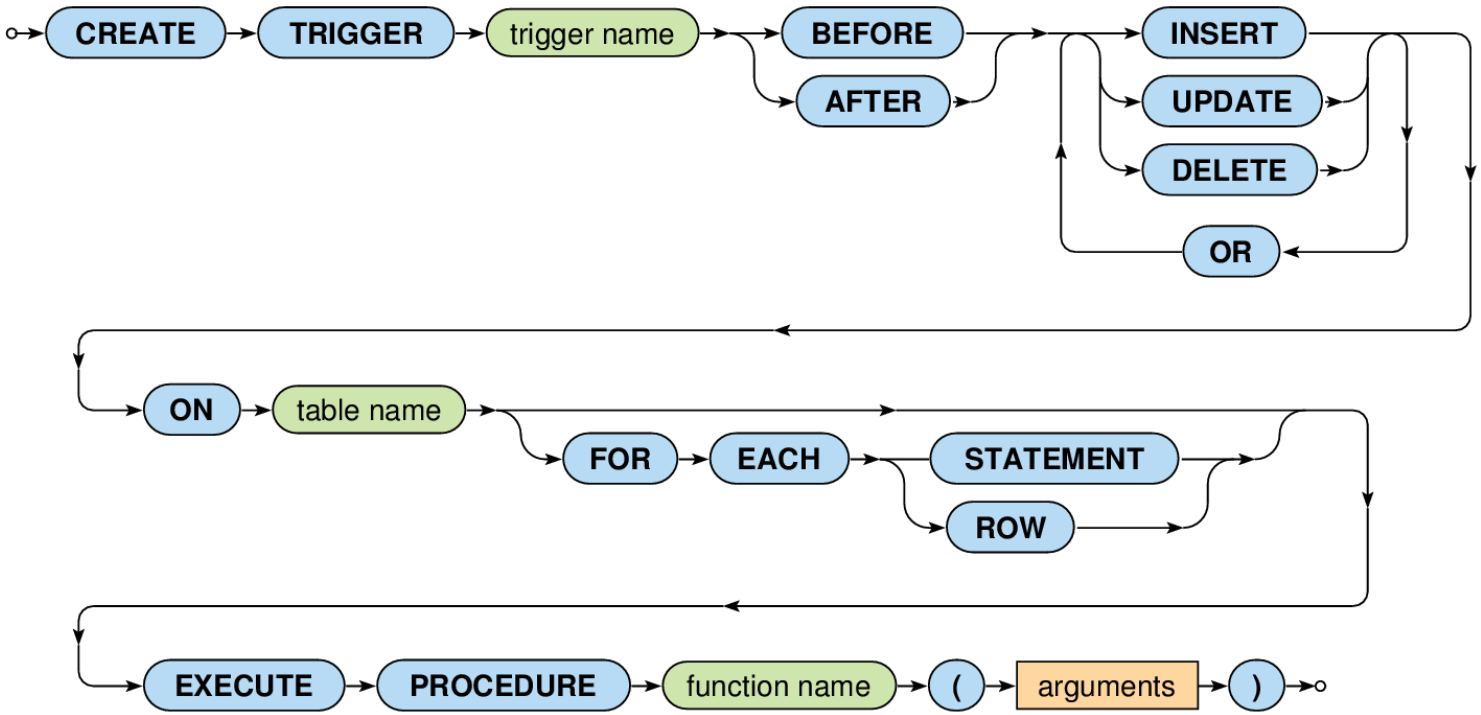
  - **INTO** clause
    - Local variables into which a given row will be stored
    - NULL values are returned when there is no additional row

Triggers

- **CREATE TRIGGER**
  - Trigger is a procedure that is automatically executed as a response to certain events (INSERT, UPDATE, DELETE)
    - Used for maintaining complex integrity constraints
  - Modes
    - FOR EACH **STATEMENT** (default mode)
      - Trigger will be invoked only once for all the rows involved in a given query
    - FOR EACH **ROW**
  - Procedure
    - Return type must be TRIGGER

Triggers

- **CREATE TRIGGER**



SQL/XML

XML Documents: Example

```
<?xml version="1.0"?>
<library>
   <book id="1" catalogue="c1" language="en">
      <title>Red</title>
      <author>John</author>
      <author>Peter</author>
   </book>
   <book id="2" catalogue="c1">
      <title>Green</title>
      <price>25</price>
   </book>
   <book id="3" catalogue="c2" language="en">
      <title>Blue</title>
      <author>John</author>
   </book>
</library>
```

Introduction

- **SQL/XML**
  - **Extension to SQL for XML data**
    - XML Datatype
    - Constructs
      - Functions, constructors, mappings, XQuery embedding, …
- Standards
  - **SQL:2011-14** (ISO/IEC 9075-14:2011)
    - Older versions 2003, 2006, 2008

Example

- **Table**: books

id	catalogue	title	details	language
1	c1	Red	<author>John</author> <author>Peter</author>	en
2	c1	Green	<price>25</price>	NULL
3	c2	Blue	<author>John</author>	en

- **Table**: languages

code	name
en	English
cs	Czech

Example

- **Query**

```
SELECT
   id,
   XMLELEMENT(
      NAME "book",
      XMLELEMENT(NAME "title", title),
      details
   ) AS book
FROM books
WHERE (language = "en")
ORDER BY title DESC
```

Example

- **Result**

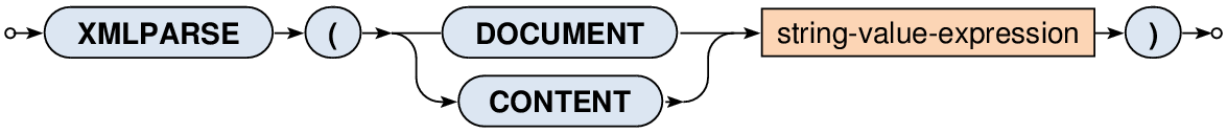
id	book
3	<book> <title>Blue</title> <author>John</author> </book>
1	<book> <title>Red</title> <author>John</author> <author>Peter</author> </book>

XML Datatype

- Traditional types
  - BLOB, CLOB, VARCHAR, …
- **Native XML type**
  - Collection of information items
    - Based on XML Information Set (**XML Infoset**)
      - Elements, attributes, processing instructions, …
      - But we also allow fragments without exactly one root element
        - » This means that XML values may not be XML documents
  - NULL

Parsing XML Values

- XMLPARSE
  - **Creates an XML value from a string**
    - DOCUMENT – well-formed document with exactly one root
    - CONTENT – well-formed fragment

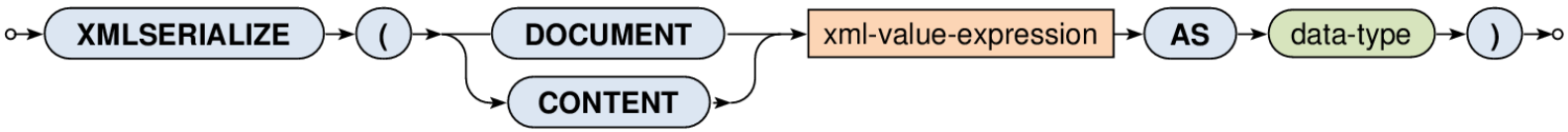



```
SELECT XMLPARSE (
   DOCUMENT "<book><title>Red</title></book>"
) AS result
```

result
<book> <title>Red</title> </book>

Serializing XML Values

- XMLSERIALIZE
  - **Exports an XML value to a string**




```
SELECT
   id, title,
   XMLSERIALIZE(CONTENT details AS VARCHAR(100)) AS export
FROM books
```

id	title	export
1	Red	<author>John</author><author>Peter</author>
...	...	...

Well-Formedness Predicate

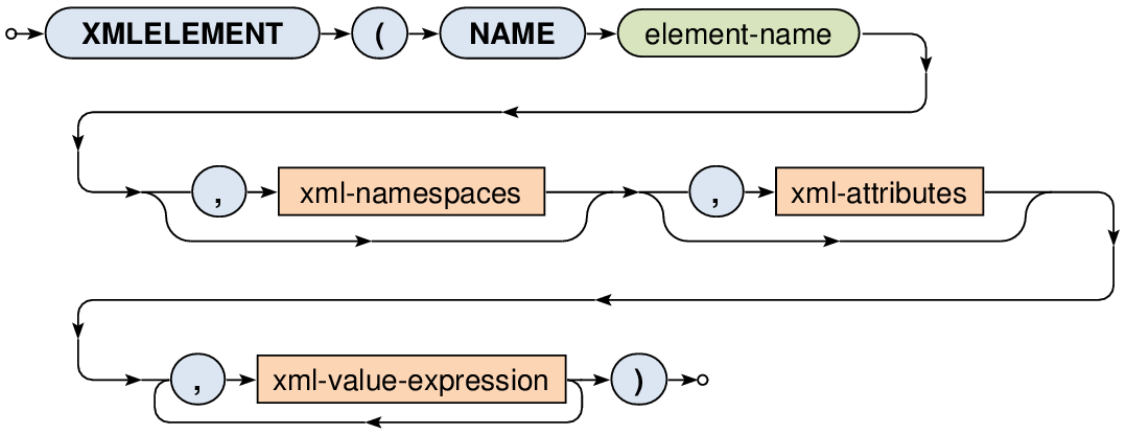
- IS DOCUMENT
  - **Tests whether an XML value is an XML document**
    - Returns `TRUE` if there is right one root element
    - Otherwise `FALSE`

Constructors

- Functions for construction of XML values…
  - **XMLELEMENT** – elements
  - **XMLNAMESPACES** – namespace declarations
  - **XMLATTRIBUTES** – attributes
  - **XMLCOMMENT** – comments
  - **XMLPI** – processing instructions
  - **XMLFOREST** – sequences of elements
  - **XMLCONCAT** – concatenations of values
  - **XMLAGG** – aggregates

Elements

- XMLELEMENT
  - **Creates an XML element** with a given name and…
    - optional **namespace declarations**
    - optional **attributes**
    - optional **element content**



Elements: Example 1

```
SELECT
   id,
   XMLELEMENT(NAME "book", title) AS result
FROM books
ORDER BY id
```

id	result
1	<book>Red</book>
2	<book>Green</book>
3	<book>Blue</book>

Elements: Example 2: Subelements

```
SELECT
   id,
   XMLELEMENT(
      NAME "book",
      XMLELEMENT(NAME "title", title),
      XMLELEMENT(NAME "language", language)
   ) AS records
FROM books
```

id	records
1	<book> **<title>Red</title>** **<language>en<language>** </book>
…	…

Elements: Example 3: Mixed Content

```
SELECT
   id,
   XMLELEMENT(
      NAME "info",
      "Book ", XMLELEMENT(NAME "title", title),
      " with identifier equal to", id, "."
   ) AS description
FROM books
```

id	description
1	<info> **Book <title>Red</title> with identifier equal to 1.** </info>
…	…

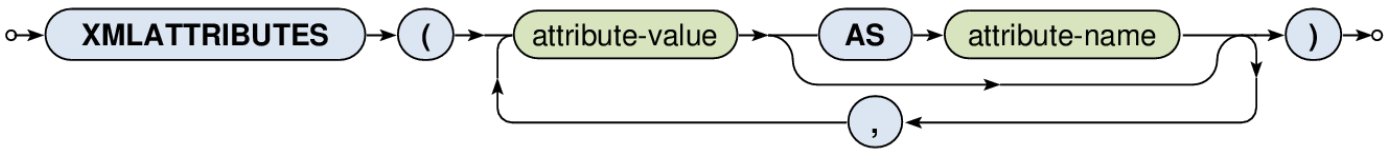
Elements: Example 4: Subqueries

```
SELECT
   id,
   XMLELEMENT(NAME "title", title) AS book,
   XMLELEMENT(
      NAME "language",
      (SELECT name FROM languages WHERE (code = language))
   ) AS description
FROM books
```

id	book	description
1	<title>Red</title>	<language>**English**</language>
…	…	…

Attributes

- XMLATTRIBUTES
  - **Creates a set of attributes**
  - Input: list of values
    - Each value must have an **explicit / implicit name**
      - It is used as a name for the given attribute
      - Implicit names can be derived, e.g., from column names
  - Output: XML value with a set of attributes



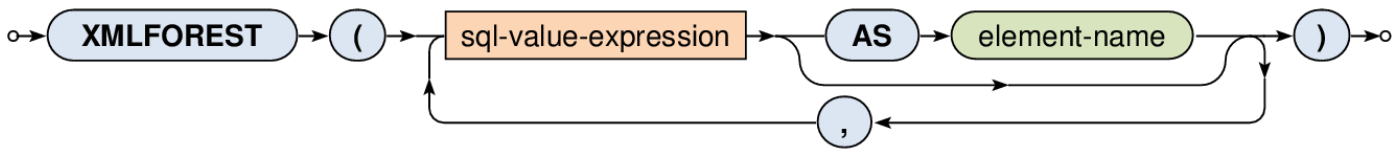
Attributes: Example

```
SELECT
   id,
   XMLELEMENT(NAME "book",
      XMLATTRIBUTES(
         language, catalogue AS "location"
      ),
      XMLELEMENT(NAME "title", title)
   ) AS book
FROM books
```

id	book
1	<book **language="en" location="c1"**> <title>Red</title> </book>
…	…

Element Sequences

- XMLFOREST
  - **Creates a sequence of XML elements**
  - Input: list of SQL values
    - Individual content expressions evaluated to `NULL` are ignored
    - If all the expressions are evaluated to `NULL`, then `NULL` is returned
  - Each content value must have an **explicit / implicit name**
    - It is used as a name for the given element
  - Output: XML value with a sequence elements



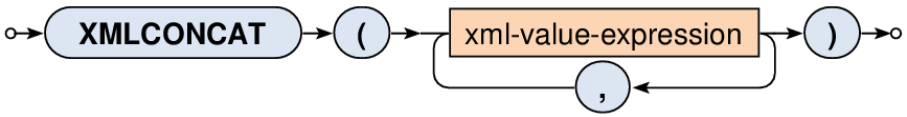
Element Sequences: Example

```
SELECT
   id,
   XMLFOREST(
      title, language, catalogue AS location
   ) AS book
FROM books
```

id	book
1	<title>Red</title> <language>en</language> <location>c1</location>
2	<title>Green</title> <location>c1</location>
…	…

Concatenation

- XMLCONCAT
  - **Creates a sequence from a list of values**
  - Input: list of XML values
    - Individual content expressions evaluated to `NULL` are ignored
    - If all the expressions are evaluated to `NULL`, then `NULL` is returned
  - Output: XML value with a sequence of values



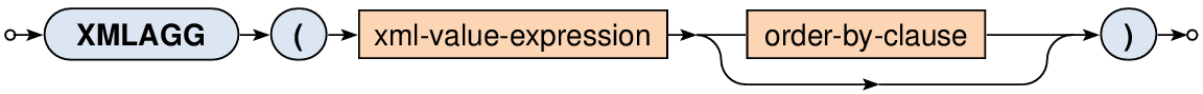
Concatenation: Example

```
SELECT
   id,
   XMLCONCAT(
      XMLELEMENT(NAME "book", title),
      details
   ) AS description
FROM books
```

id	description
1	<book>Red</book> <author>John</author> <author>Peter</author>
…	…

XML Aggregation

- XMLAGG
  - **Aggregates rows within a given super row**
    - I.e. acts as a standard aggregate function (like SUM, AVG, …)
  - Input: rows within a given super row
    - These rows can first be optionally sorted (**ORDER BY**)
    - For each row an XML value is generated as described
      - Individual rows evaluated to `NULL` values are ignored
    - All the generated XML values are then concatenated
      - If all the rows are evaluated to `NULL`, then `NULL` is returned
  - Output: XML value with a sequence of items



XML Aggregation: Example

```
SELECT
   catalogue,
   XMLAGG(
      XMLELEMENT(NAME "book", XMLATTRIBUTES(id),
         title)
      ORDER BY id
   ) AS list
FROM books
GROUP BY catalogue
```

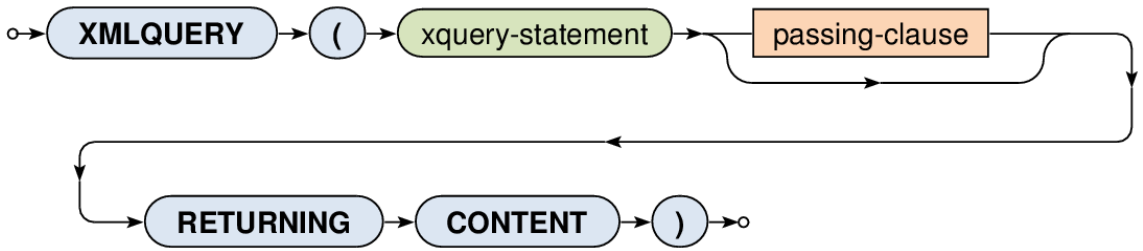
catalogue	list
c1	<book id="1">Red</book> <book id="2">Green</book>
c2	<book id="3">Blue</book>

Querying

- Query constructs
  - Based on XQuery language
  - **XMLQUERY** – returns query result
    - Usually in SELECT clauses
  - **XMLTABLE** – decomposes query result into a table
    - Usually in FROM clauses
  - **XMLEXISTS** – tests query result non-emptiness
    - Usually in WHERE clauses

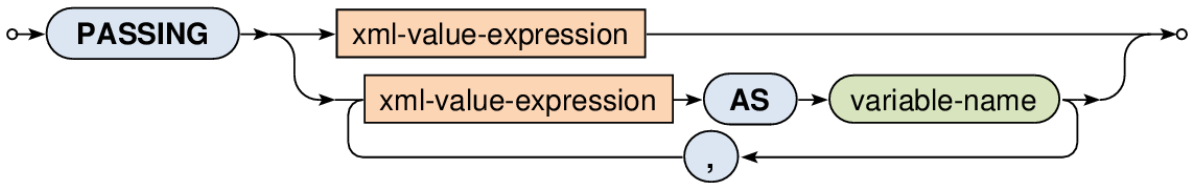
XQuery Statements

- XMLQUERY
  - **Evaluates an XQuery statement and returns its result**
  - Input:
    - XML values declared in an optional **PASSING** clause
  - Output: XML value



XQuery Statements

- XMLQUERY
  - Input data
    - When **only one input value** is specified…
      - its content is accessible via `/` inside the XQuery statement
    - When **one or more named variables** are specified…
      - their content is accessible via `$variable-name/`



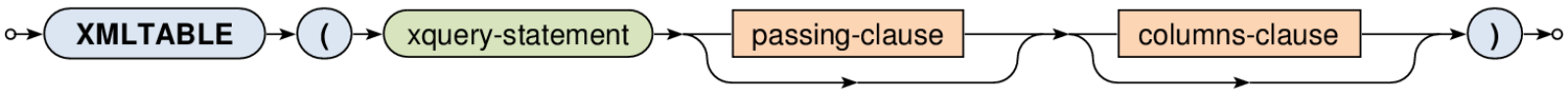
XQuery Statements: Example

```
SELECT
   id, title,
   XMLQUERY(
      "<authors>{ count($data/author) }</authors>"
      PASSING details AS data
      RETURNING CONTENT
   ) AS description
FROM books
```

id	title	description
1	Red	<authors>2</authors>
…	…	…

XML Tables

- XMLTABLE
  - **Decomposes an XQuery result into a virtual table**
  - Output:
    - When **COLUMNS** clause is specified…
      - Table containing the XQuery result being shredded into individual rows and columns according to the description
    - Otherwise…
      - Table with one row and one column with the XQuery result represented as an XML value



XML Tables: Example 1

```
SELECT
   id, title, result.*
FROM
   books,
   XMLTABLE(
      "<authors>{ count($data/author) }</authors>"
      PASSING books.details AS data
   ) AS result
```

id	title	result
1	Red	<authors>2</authors>
…	…	…

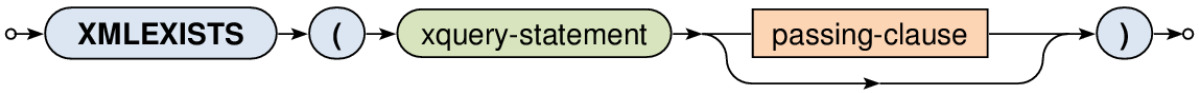
XML Tables: Example 2

```
SELECT
   id, title, result.count
FROM
   books,
   XMLTABLE(
      "<authors>{ count($data/author) }</authors>"
      PASSING books.details AS data
      COLUMNS
         count INTEGER PATH "authors/text()"
   ) AS result
```

id	title	count
1	Red	**2**
...	...	...

Exists Predicate

- XMLEXISTS
  - **Tests an XQuery statement result for non-emptiness**
  - Output: Boolean value
    - Returns `TRUE` for result sequences that are not empty
    - Otherwise `FALSE`



Exists Predicate: Example

```
SELECT books.*
FROM books
WHERE
   XMLEXISTS(
      "/author"
      PASSING details
   )
```

id	catalogue	title	details	language
1	c1	Red	<author>John</author> <author>Peter</author>	en
3	c2	Blue	<author>John</author>	en