Module 10

XQuery Update, XQueryP

Disclaimer: Work in progress!!!

Summary of M1-M9

- XML and XML Schema
  - serialization of data (documents + structured data)
  - mixing data from different sources (namespaces)
  - validity data (constraints on structure)
- XQuery
  - extracting, aggregating, processing (parts of) data
  - constructing new data; transformation of data
  - full-text search
- Web Services and Mashups
  - remote procedure calls on the Web
    (message format, service interfaces, broker)
- **Next: Updates and Scripting**
  - **bringing it all togheter!**

XQuery Update Facility

XQuery Updates Overview

- Activity in W3C; work in progress (~two years)
  - requirements, use cases, specification documents
- Use as transformation + DB operation (side-effect)
  - Preserve Ids of affected nodes! (No Node Construction!)
- Updates are expressions!
  - return “()” as result
  - in addition, return a *Pending Update List*
- Updates are fully composable with other expr.
  - however, there are semantic restrictions!
  - e.g., no update in condition of an if-then-else allowed
- Primitive Updates: insert, delete, replace, rename
- Extensions to other expr: FLWOR, TypeSwitch, ...

Examples

- do delete //book[@year lt 1968]

- do insert <author/> into //book[@ISBN eq “34556”]

- for $x in //book
  where $x/year lt 2000 and $x/price gt 100
  return do replace value of $x/price
  with $x/price-0.3*$x/price

- if ($book/price gt 200) then
  do rename $book as “expensive-book”

- The „do“ needed in syntax! (Don‘t ask, just do it!)

Overview

- Insert: Insert new XML instances
- Delete: Delete nodes
- Replace, Renam: Replace/Rename nodes
- FLWOR Update: bulk update
- Conditional Updates:
  - if - then - else
  - typeswitch
- Comma Expression
- Updating Functions

INSERT - Variant 1

- Insert a new element into a document
  do insert InsertionSeq **into** TargetNode
- InsertionSeq: transform docs into their children
- TargetNode: Exactly one document or element
  - otherwise ERROR
- Specify whether to insert at the beginning or end
  - as last: InsertionSeq becomes first child of Target (default)
  - as first: InsertionSeq becomes last child of Target
- Nodes in InsertionSeq assume a new Id.
- Whitespace, Textconventions as in ElementConstruction of XQuery

INSERT Variant 1

- Insert new book at the end of the library

  do insert <book> <title>Snowcrash</title> </book>

  into document(„www.uni-bib.ch“)//bib

- Insert new book at the beginning of the library

  do insert <book> <title>Snowcrash</title> </book>

  as first into document(„www.uni-bib.ch“)//bib

- Insert new attribte into an element

  do insert (attribute age { 13 }, <parents xsi:nil = „true“/>)

  into document(„ewm.de“)//person[@name = „KD“]

INSERT - Variant 2

- Insert at a particular point in the document
  do insert InsertionSeq **(after | before)** TargetNode
- Subtleties in InsertionSeq
  - No attributes allowed after an element!
  - Document nodes are transformed into their children
- TargetNode: One Element, Comment or PI.
  - Otherwise ERROR
- Specify whether before or behind target
  - Before vs. After
- Nodes in InsertionSeq assume new Identity
- Whitespace, Text conventions as ElementConstructors of XQuery

Insert - Variant 2

- Add an author to a book

```
do insert <author>Florescu</author>
before //article[title = „XL“]/author[. eq „Grünhagen“]
```

INSERT - Open Questions

- Insert into schema-validated instances?
  - When and how to validate types?
  - What is the type of the updated instance?
- Insert (V2): TargetNode has no Parent?
  - Is that an error?
- TargetNode is empty?
  - Is that an error or a no-operation?

DELETE

- Delete nodes from an instance

  do delete TargetNodes

- TargetNodes: sequence of nodes (no values!)
- Delete XML papers.

  delete //article[header/keyword = „XML“]

- Deletes 2‘s from (1, 1, 2, 1, 2, 3) not possible
  - need to construct new seqeunce with FLWOR

REPLACE

- Variant 1: Replace a node

  do replace TargetNode **with** UpdateContent
- Variant 2: Replace the content of a node

  do replace value of TargetNode **with** UpdateContent
- TargetNode: One node (with Id)
- UpdateContent: Any sequence of items
- Whitespace and Text as with inserts.
- Many subtelties
  - in UpdateContent, replace document with its children
  - can only replace one node by another node (of similar kind)

RENAME

- Give a node a new name

  do rename Target as NewName

- Target must be attribute, element, or PI
- NewName must be an expression that evaluates to a qname (or castable)
- First author of a book is principle author:

  do rename //book[1]/author[1]

  as „principle-author“

Composability

- *Insert, delete, rename*, *replace, and calls to updating functions* are expressions
- They are *not* fully composable with the rest
  - Semantic, not syntactic restrictions
- Side-effecting expressions only allowed in
  - “return” clause of a FLWOR
  - “then” and “else” branches of a conditional
  - the body of a function
  - within a typeswitch or stand-alone
  - only in “control-flow” style expressions

Bulk Updates: FLWOR Update

- INSERT and REPLACE operate on ONE node!
- Idea: Adopt FLWOR Syntax from XQuery

  (ForClause | LetClause)+ WhereClause? OrderBy?
  return *SimpleUpdate*

  – *SimpleUpdate:* insert, delete, replace, or rename
- Semantics: Carry out *SimpleUpdate* for every node bound by FLW.

  – Quiz: Does an OrderBy make sense here?

FLWOR Update - Examples

- „Müller“ marries „Lüdenscheid“.

```
for $n in //article/author/lastname
where  $n/text() eq „Müller“ return do
replace  value of $n with „Müller-Lüdenscheid“
```

- Value-added tax of 19 percent.

```
for $n in //book return do
insert attribute vat { $n/@price * 0.19 } into $n
```

Snapshot Semantics

- Updates are applied at the very end
  - inserts are not visible during execution
  - avoids Halloween problem
  - allows optimizations (change order of updates)
- Three steps
  - evaluate expr; compose pending update list (PUL)
    - append „primitive“ to PUL in every iteration of FOR
  - conformance test of PUL
    - avoid duplicate updates to same node (complicated rule)
    - avoids indeterminism due to optimizations
  - apply PUL (update primitives one at a time)

Halloween Problem

```
for $x in $db/*
return do insert $x into $db
```

- Obviously, not a problem with snapshot semantics.
- (SQL does the same!)

Conditional Update

- Adopted from XQuery‘s if then else expr.

```
if (condition) then
    SimpleUpdate
else
    SimpleUpdate
```

Transformations

- Update streaming data - create new instances

```
transform copy Var := SExpr modify UExpr
   return RExpr
```

- Delete salary of Java programmers

```
for $e in //employee[skill = „Java“] return
transform copy $je := $e
modify   do delete $je/salary
return $je
```

- SExpr: Source expression - what to transform
- UExpr: Update expression - update
- RExpr: Return expression - result returned

Further Update Expressions

- Comma Expression
  - Compose several updates (sequence of updates)

```
for $x in //books
return do delete $x/price, do delete $x/currency
```

- Typeswitch Expression
  - Carry out updates depending on the type
- Function Declaration + Function Call
  - Declare functions with side-effects
  - Impacts optimization and exactly-once semantics

Implementations

- MXQuery (www.mxquery.org)
  - implements full XQuery Update Facility
  - but, limitations in how to bind data to update to variables
  - but, MXQuery only implements subset of XQuery
  - MXQuery is an α release; bleeding edge
- Most database vendors have a proprietary update language
  - developed before the working drafts were released
  - need time to adjust to W3C recommendation
  - need to guarantee compatibility for customers

XQueryP

Observation

- Despite of XQuery and XQuery Updates, we still need Java
  - implement user interfaces
  - call Web services; interact with other programs
  - expose functions as Web service
  - write complex applications
- Once you start using Java, you are tempted to do everything in Java (-> your projects :-))
- **Goal: Get rid of Java!!! All XQuery!**
  - XQueryP: Extension of XQuery for scripting

XQueryP Overview

- Sequential Mode: Visibility of Updates
  - define order in which expressions are evaluated
  - fine-graned snapshot (update primitive)
- New expressions
  - Assignment, Block, While, Break, Continue, Return
- Error handling (try-catch)
- Graphs: references and de-referencing
- Web Service Import, Call, and Export

Sequential evaluation order

- Slight modification to existing rules:
  - FLWOR: FLWO clauses are evaluated first; result in a tuple stream; then Return clause is evaluated in order for each tuple. Side-effects made by one row are visible to the subsequent rows.
  - COMMA: subexpressions are evaluated in order
  - (UPDATING) FUNCTION CALL: arguments are evaluated first before body gets evaluated

Required (only) if we add side-effects immediately visible to the program: e.g. variable assignments *or* single snapshot atomic updates; otherwise semantics not deterministic.

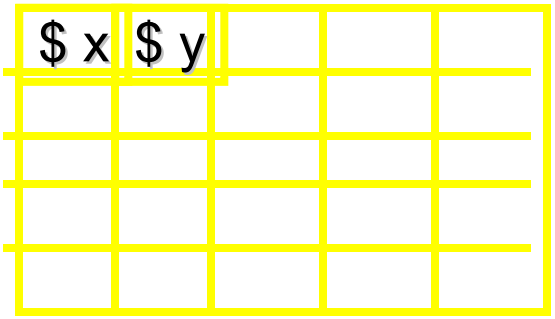
Reduce snapshot granularity

- Today update snapshot: entire query
- Change:
  - Every single atomic update expression (insert, delete, rename, replace) is executed and made effective immediately
  - The effects of side-effecting external functions are visible immediately
- Semantics is deterministic because of the sequential evaluation order (point1)

Sequential evaluation mode and the FLWOR

for $x in <*expression*/>
let $y := <*expression*/>
where <*expression*/>
order by <*expression*/>
return
    <*side-effecting expression*/>

No side-effects are visible until here.



Adding new expressions

- Assignment expressions
- Block expressions
- While expressions
- Break,Continue, Return

- Only under sequential evaluation mode

Assignment Expression

- Syntax:

  “set” $VarName “:=“ ExprSingle
- Semantics:
  - Change the value of the variable
  - Variable has to be external or declared in a block (no let, for, or typeswitch)
- Updating expression
- Semantics is deterministic because of the sequential evaluation order
  - restricted side-effects in ExprSingle: only one side-effecting expression (primitive) allowed!

Block expression

- Syntax:

  “{“ (BlockDecl “;”)* Expr (“;” Expr)* “}”

  BlockDecl :=

  (“declare” $VarName TypeDecl? (“:=“ ExprSingle) ?)?

  (“,” $VarName TypeDecl? (“:=“ ExprSingle) ?)*

- Semantics:
  - Declare a set of updatable variables, whose scope is only the block expression (in order)
  - Evaluate each expression (in order) and make the effects visible immediately
  - Return the value of the last expression
- Updating if body contains an updating expression
- Optional “atomic” makes updates in block all or nothing (nothing, if an error occurs)

Atomic Blocks

- Syntax:

  “atomic” “{“ . . . “}”
- Semantics:
  - If the evaluation of Expr does not raise errors, then result is returned
  - If the evaluation of Expr raises a dynamic error then no partial side-effects are performed (all are rolled back) and the result is the error
- Only the largest atomic scope is effective
- Note: XQuery! had a similar construct
  - Snap {…} vs. atomic {…}

Functions and blocks

- Blocks are the body of functions
- We relax the fact the a function cannot update some nodes *and* return a value

```
declare updating function local:prune($d as xs:integer) as
    xs:integer
{
    declare $count as xs:integer := 0;
    for $m in /mail/message[date lt $d]
    return {   do delete $m;
               set $count := $count + 1
           };
    $count
}
```

While expression

- Syntax:

  “while” “(“ *exprSingle* “)” “return” *expr*
- Semantics:
  - Evaluate the test condition
  - If “*true*” then evaluate the return clause; repeat
  - If “*false*” return the concatenation of the values returned by all previous evaluations of return
- Syntactic sugar, mostly for convenience
  - Could be written using recursive functions

Break, Continue, Return

- Traditional semantics, nothing surprising
- *Break* (or *continue*) the closest FLWOR or WHILE iteration
- *Return*: early exit from a function body
- Hard(er) to implement in a “database” style evaluation engine
  - Because of the lazy evaluation

Example

```
declare updating function myNs:cumCost($projects)
    as element( )*
{
    declare $total-cost as xs:decimal :=0;
    for $p in $projects[year eq 2005]
    return
        {set $total-cost := $total-cost+$p/cost;
         <project>
                <name>{$p/name}</name>
                <cost>{$p/cost}</cost>
                <cumCost>{$total-cost}</cumCost>
        <project>
        }
}
```

XQuery: self join or recursive function

Putting everything together: the sequential mode

- New setter in the prolog
- Syntax:

  “declare” “execution” “sequential”
- Granularity: query or module
- What does it mean:
  - Sequential evaluation mode for expressions
  - Single atomic update snapshot
  - Several new updating expressions (blocks, set, while, break, continue)
- If the query has no side-effects, sequential mode is irrelevant, and traditional optimizations are still applicable

Try-catch

- Errors in XQuery 1.0, Xpath 2.0, XSLT 2.0
  - *fn:error(err:USER0005, "Value out of range", $value)*
- Traditional design for try-catch

try (*target-expr*)
catch ($name as *QName1*, $desc, $obj)
    return *handler-expr1*
catch ($name as *QName2*, $desc, $obj)
    return *handler-expr2*. . .
default ($name, $desc, $obj)
    return *general-handler-expr*

- Example

```
let $x := expr
return
   try ( <a>{ $x }</a> )
   catch (err:XQTY0024)
   return  <a>
```

Web Services

- WS are the standard way of *sending* and *receiving* XML data
- XQuery are the standard way to *program* the XML processing
- We should design them *consistently,* natural fit

XQuery	Web Services
module	service
functions/operations	operations
arguments	ports
values for arguments and	value for input and output
Result: *XML*	messages: *XML*

- XQueryP proposes:
  - A standard way of importing a Web Service into an XQuery program
  - A standard way of invoking a WS operation as a normal function
  - A standard way of exporting an XQuery module as a Web Service
- Many XQuery implementations already support this. We have to agree on a standard.

Calling Google...

```
import service namespace ws=„urn:GoogleSearch“ from
                    "http://api.google.com/GoogleSearch.wsdl";

declare execution sequential;

declare variable $result;
declare variable $query;

set $query := mxq:readLine();
set $result :=
ws:doGoogleSearch("oIqddkdQFHIlwHMXPerc1KlNm+FDcPUf",
$query, 0,\10, fn:true(), "", fn:false(), "", "UTF-8", "UTF-8");

<results query="{$query}">
{
      for $url in $result/resultElements/item/URL
      return data($url)
}
</results>
```

Defining a Web Service

```
service namespace eth="www.ethz.ch" port:2001;
   declare execution sequential;
   declare function eth:mul($a,$b) {$a * $b};
   declare function eth:add($a,$b) {$a + $b};
   declare function eth:sub($a,$b) {$a - $b};
   declare function eth:div($a,$b) {$a div $b};
```

- Calling that Web Service...

```
import service namespace ab="www.ethz.ch" from "
   http://localhost:2001/wsdl";
ab:div(ab:sub(ab:mul(ab:add(1,2),ab:add(3,4)),1),5)
```

Bubblesort in XQueryP

```
declare execution sequential;
declare variable $data := (5,1,9,5,7,1,7,23,7,22,432,4,2,765,3);
declare variable $len := 15;
declare variable $changed := fn:true();
while($changed) return {
   declare $i := 1;
   set $changed := fn:false();
   while ($i < $len) return {
        if ($data[$i] > $data[$i + 1]) then {
                declare $cur := $data[$i];
                set $changed := fn:true();
                do replace $data[$i] with $data[$i+1];
                do replace $data[$i+1] with $cur }
        else();
   set $i := $i + 1 } };
```

Adding references to XML

- XML tree, not graph
- E/R model graph, not tree
- Inherent tension, XML Data Model is the source of the problem, not XQuery
- Example
  - let $x := <a><b/><a/> return <c>{$x/b)</c> */* copy of <b/>*/*
- Nodes in XDM have node identifiers
  - Lifetime and scope of nodeids, implementation defined
- XQueryP solution:
  - fn:ref($x as node()) as xs:anyURI
  - fn:deref($x as xs:anyURI) as node()
- Lifetime and scope of URIs, implementation defined
- Untyped references (URIs)
- No changes required to:
  - XML Schema, XDM Data Model, Xquery type system
- NOT YET IMPLEMENTED IN MXQuery!!!

XQueryP usage scenarios

- XQueryP programs in the browsers
  - We all love Ajax (the results). A pain to program. Really primitive as XML processing goes.
  - Embedding XQueryP in browsers
  - XQueryP code can take input data from WS, RSS streams, directly from databases
  - Automatically change the XHTML of the page
- XQueryP programs in the databases
  - Complex data manipulation executed directly inside the database
  - Takes advantage of the DB goodies, performance, scalability, security, etc
- XQueryP programs in application servers
  - Orchestration of WS calls, together with data extraction for a variety of data sources (applications, databases, files), and XML data transformations
  - XML data mashups

Related work

- Programming for XML:
  - Extensions to other programming languages
    - Xlinq, ECMAScript, PhP, XJ, etc
  - Extensions to XQuery
    - XL, XQuery!, MarkLogic's extension
  - Re-purposing other technologies: BPEL
- Long history of adding control flow logic to query languages
  - 15 years of success of PL /SQL and others
  - SQL might have failed otherwise !
- This is certainly not new research, but a natural evolution
- Florescu, Kossmann: SIGMOD 2006 Tutorial

XQueryP Implementations

- Prototype in Big OracleDB
  - Presented at Plan-X 2005
- Prototype in BerkeleyDB-XML
  - Might be open sourced (if interest)
- MXQuery
  - http://www.mxquery.org (Java)
  - Runs on mobile phones: Java CLDC1.1; some cuts even run CLDC 1.0
  - Eclipse Plugin available in March 2007
- Zorba C++ engine (FLWOR Foundation)
  - Small footprint, performance, extensibility, potentially embeddable in many contexts

XQueryP Pet Projects (at ETH)

- Airline Alliances
  - every student programs his/her own airline
  - form alliances
  - experiment: do this in Java/SQL first; then in XQueryP
- Public Transportation
  - mobile phone computes best route (S-Bahn)
  - integrate calendar, address book, ZVV, GPS
- Context-sensitive Remote Control
  - mote captures „clicks“ and movements
  - mobile phone determines context and action (TV, garage, ..)
- Lego Mindstorm
  - move to warmest place in a room
- *Less of a toy (Oracle*): XML Schema validator in XQueryP
- Your CS345b project goes here!

XQueryP Grammar (MXQuery)

- **Bold:** modifications to XQuery grammar rules
- *Italic:* new XQueryP grammar rules

LibraryModule::= (ModuleDecl | **ServiceDecl**) Prolog;

Setter ::= BoundarySpaceDecl | DefaultCollationDecl | BaseURIDecl | ConstructionDecl | OrderingModeDecl | EmptyOrderDecl | RevalidationDecl | CopyNamespacesDecl | **ExecutionDecl**;

ExecutionDecl ::= "declare" "execution" " sequential";

Import::= SchemaImport | ModuleImport | **ServiceImport;**

QueryBody ::= **SequentialExpr;** (=> rewritten)

SequentialExpr ::= Expr(";" Expr);*

PrimaryExpr ::= Literal | VarRef | ParenthesizedExpr | ContextItemExpr | FunctionCall | OrderedExpr | UnorderedExpr | Constructor | **Block**

FunctionDecl ::= "declare" "updating"? "function" QName "("
ParamList? ")" ("as" SequenceType)? (**Block** | "external");

ExprSingle ::= FLWORExpr | QuantifiedExpr |
TypeswitchExpr | IfExpr | InsertExpr | DeleteExpr |
RenameExpr | ReplaceExpr | TransformExpr | **AssignExpr** |
WhileExpr | **TryExpr** | OrExpr

Block ::= "atomic"? "{" (BlockDecl ";") SequentialExpr*
("return" ExprSingle| *"continue"|"break")?"}" ;*

BlockDecl ::= "declare" "$" VarName TypeDeclaration? ("="
ExprSingle)? ("," "$" *VarName TypeDeclaration? (":="*
ExprSingle)?);*

AssignExpr ::= "set" "$" VarName ":=" ExprSingle;

WhileExpr::= "while" "(" ExprSingle ")" "return" ExprSingle;

TryExpr ::= "try" "(" ExprSingle ")" CatchExpr (CatchExpr | DefaultCatchExpr);*

CatchExpr ::= "catch" "(" ("$" VarName ("as" NameTest)? ("," "$" VarName ("," "$" VarName)?)?)? ")" "return" ExprSingle;

DefaultCatchExpr ::= "default" "(" "$" VarName ("," "$" VarName ("," "$" VarName)?)?)? ")" "return" ExprSingle;

IfExpr ::= "if" "(" Expr ")" "then" (ExprSingle| **"return" ExprSingle|"break"|"continue"**) "else ExprSingle|**"return" ExprSingle|"break"|"continue"**;

TypeswitchExpr ::= "typeswitch" "(" Expr ")" CaseClause+ "default" ("$" VarName)? "return" (ExprSingle|**"return"ExprSingle|"break"|"continue"**);

CaseClause ::= "case" ("$" VarName "as")? SequenceType "return" (ExprSingle|**"return" ExprSingle|"break"|"continue"**);

- *ServiceImport ::= "import" "service" "namespace" NCName "=" URILiteral "from" URILiteral ("name" = NCName)?;*
- *ServiceDecl ::= "service" "namespace" NCName ="URILiteral" "port:" IntegerLiteral;*

Summary

- Side-effects
  - change data without re-creating the data
  - data keeps its identity (stays the „same“)
  - open questions concern „re-validation“ of data
- Add scripting capabilities
  - assignment, error handling, visibility of updates
  - Web Service calls; basic Mashups
- How does that impact your project?
  - Do you still need Java/PHP? Probably yes. :-(
  - Prediction: 1 year, can do projects without Java
  - Prediction: 10 years, XQuery(P) is the new Java
- Implementations: stay tuned :-)