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Complex XML Schemas

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What is an XML Schema ?

- W3C standard for defining the content of an XML document
  - Replaces the DTD format XML inherited from SGML
  - Strong data typing, 47 Scalar data types
  - Extensible type model
- An XML Schema is an XML document
  - Content is defined by W3C “Schema for Schemas”
- Typically authored using graphical tools such as Altova’s XMLSpy and Oracle’s Jdeveloper.

XML Schema Usage

- Primarily used for validation
  - An XML Schema validator can determine whether an XML document is a valid instance of an XML Schema.
- Explosion of XML schema based industry standards
  - Enable organizations to share information in common, well defined and verifiable formats
  - Financial Services : FpML, XBRL, SwiftML, FixML
  - Public Safety : NIEM
  - Authoring and Publishing : Dita, Docbook, Open XML
  - Geospatial : GML, KML
  - Healthcare : HL7
  - Oil and Gas : WitsML

XML Schema and Object Relational Storage

- Predicated on XML Schema
  - SQL Object model derived from the XML Schema
  - Lossless conversion between XML and SQL Objects
  - SQL Objects stored as XMLType and Nested tables
- XQuery operations compiled into the same relational algebra as SQL statements
  - Optimizer executes SQL and XQuery in the same way
- Light-Weight validation performed as part of the conversion to SQL object model
  - Full XML Schema validation via check constraint or trigger

XML Schema and Binary XML Storage

- XML stored in a post-parsed binary format in a secure file LOB.
- Optimized token management,
  - Set of tag names is known ipso facto
- Non-character data (Numbers, dates, etc) stored using native representations
- Query and update operations optimized based on knowledge of XML Schema
- Full Schema validation part of the Binary Encoding process

XML Schema Registration

- Must register XML schema with the database before using it for Binary or XML storage
- Compiled version of the XML Schema stored in the XML DB repository
  - Compiled version stored memory as an SGA object.
  - Shared by all database users

What makes schema registration complex?

- Mutually recursive dependencies (import/include) between multiple schemas
- Deep type hierarchy and/or large types
- Large number of subtypes for a particular complex type
- Cycles involving base and extension types
- Lot of substitution groups
- Large number of elements in a single substitution group

Complex Schema Examples

- NIEM: National Information Exchange Model
  - 115 base schemas and several extensions
  - Complex interdependencies between schemas
  - Over 2000 subtypes
  - Deep type hierarchy
- HL7 CDA: Healthcare - Clinical Doc Architecture
  - Over 100 schemas
  - Mutually recursive dependencies between schemas
  - Large number of substitution group elements
  - Large number of subtypes

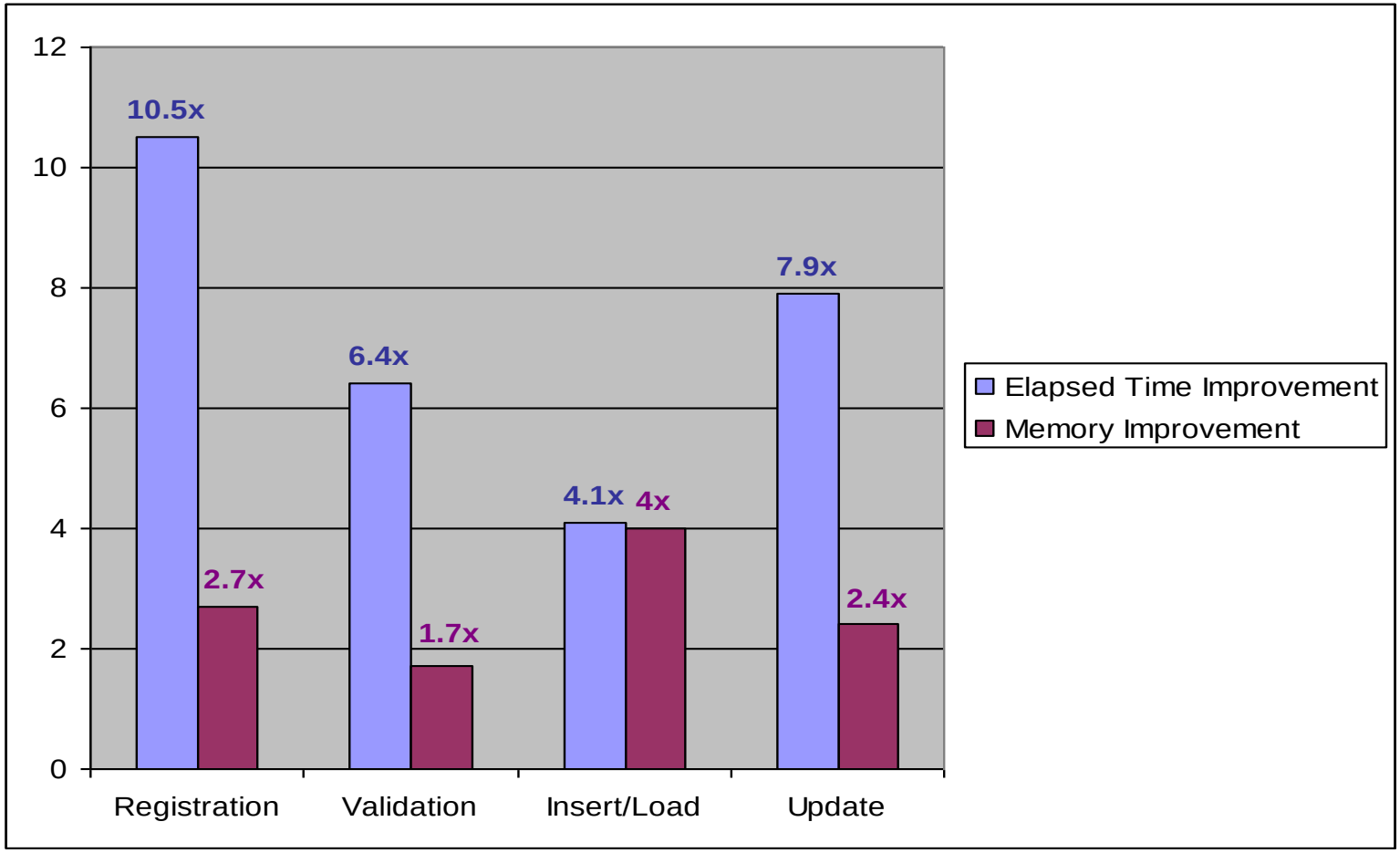
11gR2 Schema Enhancements

- Major improvements in both memory & time
- Much faster Registration and loading of Schemas
  - Speedup is higher for more complex schema sets
  - Upto 200x in some cases
- 2-3x reduction in shared memory usage
- Much less PGA usage during schema registration

11gR2 Schema Enhancements

- StoreVarrayAsTable annotation now honored when creating XMLType tables and columns manually
- Streaming Schema Validator Cache for Binary XML
  - Validation
  - DML: Insert & partial update
  - Significant improvements for small documents

11gR2 Performance



Schema Registration Tips

- Set aside sufficient shared_pool memory
  - Examples: NIEM needs about 1024M
- Register different schemas or sets of schemas in different PL/SQL blocks if possible
- If generating tables, set xdb:defaultTable="" as appropriate
- For O-R storage
  - Break up large types using xdb:SQLInline="false"
  - Use xdb:maintainDOM=false on appropriate elements to improve performance
    - No ordering, substitution groups etc

11.2.0.2.0 Enhancements

- Improvements in cycle detection with-in type hierarchy
  - Errors related to type cycles eliminated
  - Significant reductions in errors related to memory usage

11.2.0.2.0 Enhancements

- New package to manage schema annotation
  - DBMS_XMLSCHEMA_ANNOTATE*
  - Common annotations can be applied programmatically
  - Makes it easier to annotate XML Schemas
  - Makes it easier to manage annotations as schemas change
- New package to help manage object-relational storage
  - DBMS_XMLSTORAGE_MANAGE*
  - Simplifies renaming tables and creating indexes for object relational storage

* Packages need to installed manually

Object relational storage

- XML Schema simpleTypes map directly to SQL data types
  - Elements and attributes based on simple types become an attributes of a SQL object
  - Each simpleType requires a single column in the underlying storage table
  - XDB Annotation mechanism can be used to overide the default mapping between simple types and SQL Types
- SQL Object Types generated from XML Schema complexTypes
  - VARRAY Types generated for repeating elements
  - Elements based on complex types can require 100’s or 1000’s of columns in the underlying storage table

Object relational mapping

- SQL Object and Attribute names derived from XML names
- Name-mangling algorithm used to map from valid XML names to valid SQL names
  - Name mangling applies to SQL Attribute name, SQL Type names and Table names
  - XDB Schema annotation mechanism can be used to override name mangling.
- Annotations can be provided programmatically using

DBMS_XMLSCHEMA_ANNOTATE.setSQLName()

DBMS_XMLSCHEMA_ANNOTATE.setSQLType()

DBMS_XMLSCHEMA_ANNOTATE.setDefaultTable()

DOM Fidelity

- Content and order of the nodes for a document stored in XDB is identical to the content and order of the nodes in the original document
  - Does not preserve insignificant whitespace
- Dom Fidelity maintains instance meta data
  - Overhead when inserting and retrieving XML
  - Additional storage requirements
- Metadata is tracked for each element based on a complexType
  - Managed using a Positional Descriptor attribute

The Positional Descriptor

- The Positional Descriptor contains information relating to the use of
  - Comments and Processing Instructions
  - Mixed content text() nodes
  - Location and Prefix in Namespace declarations
  - Empty Vs Missing Nodes and xsi:nil usage
  - Substitutable elements
  - Ordering of elements for a repeating choice
- The Positional Descriptor is named SYS_XDB$PD
  - The format is not documented
  - Stored as a (in-line) LOB.

Disabling DOM Fidelity

- DOM Fidelity is typically not required for most ETL type use cases
- Documents will still be valid per the XML Schema
- Disabling DOM Fidelity improves performance
  - Eliminates overhead associated with maintaining instance level metadata
  - Reduces storage requirements
  - Improves elapsed time for insert and retrieval operations

Disabling DOM Fidelity

- Ordering of members of a collection is preserved when repetition is specified at element level. Eg

  <element name="Foo" type="FooType" maxOccurs="10"/>

- Ordering of members is not preserved when repetition is specified at the 'model' level. E.g.

  <choice maxOccurs="unbounded>…

  <element "Foo" type="FooType>

  <element "Baa" type="BaaType">

  </choice>

Disabling DOM Fidelity

- DOM Fidelity is disabled on a Type by Type basis
  - Add annotation xdb:maintainDOM="false“ on complexType definition
  - Removes the PD attribute from the SQLType.
  - Causes the information managed in the PD to be discarded when ingesting the XML document
- Can be done programmatically using

  DBMS_XMLSCHEMA_ANNOTATE. disableMaintainDOM()

Using DBMS_XMLSCHEMA_ANNOTATE

DEMO

Nested Table storage

- Normalized (Master-Detail) storage model for repeating elements
  - Repeating elements mapped to SQL VARRAY object types
  - VARRAY is stored as a nested table
  - Each member of the VARRAY becomes a row in the nested table
  - Relationships between parent and child tracked using system generated Primary Key / Foreign Key
- Improves performance
  - Operations executed as SQL on the nested table
  - Enables indexing of repeating elements and attributes
- Multiple levels of nesting supported

Nested Table Storage

Specifying Nested Table storage model

- Collection Storage controlled by schema level annotation “xdb:storeVarrayAsTable”
  - xdb:storeVarrayAsTable=“false” : Use Lob based storage
  - Xdb:storeVarrayAsTable=“true” : Use Nested Tables
- Default setting
  - Pre 11gR1 : “false”
  - 11gR1 : “true”
- Scope
  - Pre 11gR2 : Annotation applies to XMLType tables generated during call to dbms_xmlschema.registerSchema()
  - 11gR2 : Annotation applies all XMLType tables and columns bound to the XML Schema

Nested tables with manual DDL (Pre 11gR2)

- In 11gR1 and earlier manual DDL must explicitly specify nested table storage when using create table
  - STORE VARRAY AS TABLE clause required for each collection
  - Create Table statements becomes very complex for deeply nested collections
- In 11gR2 nested tables will automatically be generated when using create table.
  - No need to specify STORE VARRAY AS TABLE
  - Nested tables are given system generated names
  - Nested tables can be renamed programmatically using **DBMS_XMLSTORAGE_MANAGE. renameCollectionTable()**

Use of the “Default” table

- In 11gR1 and earlier many applications relied on the “default” table to manage XML
  - Used nested-table storage model by default
  - Default Table is meant to be used with XML DB repository.
- In 11gR2 there is no difference between tables or columns created using create table and default tables
  - Do not specify default tables in the XML schema unless intent is to use the XML DB Repository.
  - Register XML Schemas with genTables false unless Out-Of-Line storage model is required
  - Use Create Table statement to create tables or columns of XMLType after registering XML schema

Simplifying Nested Table usage in 11gR1

- If you need nested table storage in 11gR1 or earlier use 11gR2 and DBMS_METADATA package
  - Register the XML schema in 11gR2
  - Execute the create table statement in 11gR2
  - Capture the actual DDL for the table using DBMS_METADATA().
  - Edit to remove 11gR2 specific options
  - Register XML Schema in 11gR1
  - Execute DDL in 11gR1

B-Tree Indexing on Object-Relational Storage

- Indexing singletons is easy
  - Create an index using XMLCast(XMLQuery)
  - Confirm Index creation was re-written by checking that there is no entry for the index in user_ind_expressions
- Indexing collections is more complex
  - Collections are stored in nested tables
  - Indexes need to be created directly on the nested table
- Both types of Indexes can be created using xpath expressions using

  DBMS_XMLSTORAGE_MANAGE. xpath2TabColMapping()

Mapping non-repeating element

```
select  DBMS_XMLSTORAGE_MANAGE.XPATH2TABCOLMAPPING
        (
          USER,
          'PURCHASEORDER ',
          NULL,
          '/PurchaseOrder/Reference ',
          ' '
         ) from dual
```

```
<Result>
  <Mapping TableName="PURCHASEORDER" ColumnName="SYS_NC00008$"/>
</Result>
```

- Package returns the name of the collection table and the internal column name for the specified node specified by the XPath
- This name can be used in DDL operations such as create index.

Mapping repeating elements

```
select  DBMS_XMLSTORAGE_MANAGE.XPATH2TABCOLMAPPING
        (
          USER,
          'PURCHASEORDER ',
          NULL,
          '/PurchaseOrder/LineItems/LineItem/Part ',
          ' '
         ) from dual
```

```
<Result>
  <Mapping TableName="LINEITEMS_TABLE" ColumnName="SYS_NC00008$"/>
</Result>
```

- Package returns the name of the collection table and the internal column name for the specified node specified by the XPath
- This name can be used in DDL operations such as create index.

Using DBMS_XMLSTORAGE_MANAGE

DEMO

Schema Ordering

- Registration requires XML schema be valid
  - All external references (include / import) must be resolvable
  - Schemas must be registered in order
  - ‘Force’ mode used to manage cyclic dependencies
- Ordering is not always obvious
  - Need to traverse the set of include / import elements in all of the related XML schemas
  - Need to detect cyclic dependancies
- Common for include / import to use relative URLs

Calculating Schema Ordering

- Utility package XDB_ANALYZE_XMLSCHEMA can help with ordering schemas
  - Method schemaOrderingScript() will create a SQL script that will register a set of related XML schemas in the correct order.
  - Arguments
    - The path to an XML DB repository folder that contains the set of XML schemas to be registered
    - The relative path to the XML Schema that contains the definition of the root element
    - Any modifier which needs to be applied to the relative path to generate the correct value for the schema location hint
  - Minimizes the number of ‘force’ operations required to successfully register the set of XML schemas

Schema Ordering and Type Analysis

DEMO : FPML V5.0

Type Compilation and Analysis

- Complex complexTypes can result in SQL Objects that require 100's or 1000's of columns
- A table can only have 1000 column
- Need to break the SQL Objects into more manageable units
- Move elements out-of-line
  - Creates an XMLType table which contains a fragment
  - Enables a degree of normalization of the XML Schema
  - The number of columns required by the parent type is reduced by the number of columns moved out-of-line

Type analysis

- Needs to be looked at holistically
  - Cannot work on a schema by schema basis as types that extend types will change the number of columns required
  - Need to register all XML Schemas then perform compilation and analysis
  - Calculate the set of annotations required to register the XML schema.

Type analysis

- Generate a set of scripts that will register the set of XML Schemas
  - Uses DBMS_XMLSCHEMA_ANNOTATE package
  - May take a few minutes to execute all the scripts
- Script can be generated programmatically using package XDB_ANALYZE_XMLSCHEMA

Schema Registration

DEMO : FPML V5.0

Schema Evolution & Other Considerations

- Evolution: Changes in schema to which all documents (new & old) should conform
- Use InPlaceEvolve for most common backward compatible changes
- CopyEvolve for other changes
  - Involves data copy => time-consuming process
- When is schema-optimized persistence not useful?
  - Too many schema changes (especially backward-incompatible)
  - Insert & Full-retrieval overheads negate schema benefits
  - Alternative: Non-schema-based Binary XML storage & XML Index

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