Semantic Web

Using Oracle Semantic Graph in a scientific knowledge portal for the pharmaceutical industry

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Date: 05/02/2013
AGENDA

1. Oracle RDF Triple Store
2. Pharma Ontology search tool at Novartis
3. Questions and answers
Introduction

1. Oracle Semantic Graph is a way to store and maintain Ontology oriented data in the Oracle relational database

2. Our case study is a semantic data integration platform for the biomedical domain using Oracle Semantic Graph
Oracle RDF Triple Store

- Oracle Semantic Graph is an add-on to Oracle Spatial.
  - Spatial allows geoTemporal search and inferencing on semantic data
- Supports most of the W3C rules
- Use of named graphs (quad) since 11.2.0.3
- Scales up to 100’s billions of triples
- Oracle specific adapters available for JENA, SESAME, TopBraid, Cytoscape and Protege
ORACLE Database RDF Query engine

SEM_MATCH: Adding SPARQL to SQL

**SPARQL**

```sparql
PREFIX foaf: <http://...>
SELECT ?n1 ?n2
FROM <http://g1>
WHERE
  {?p foaf:name ?n1}
  OPTIONAL {?p foaf:knows ?f .
    ?f foaf:name ?n2 }
  FILTER (REGEX(?n1, "^A"))
```

**SQL**

```sql
SELECT n1, n2
FROM TABLE(SEM_MATCH(`
  {?p foaf:name ?n1}
  OPTIONAL {?p foaf:knows ?f .
    ?f foaf:name ?n2 }
  FILTER (REGEX(?n1, "^A")) `,
  SEM_MODELS(`g1`), ...,
  SEM_ALIASES(
    SEM_ALIAS(`foaf`, `http://...`), ...))
```
SPARQL Query

- SQL query on a relational table

```sql
SQL> SELECT ename from EMP where JOB='CLERK';
```

- SPARQL in the `SEM_MATCH` function

```sparql
{?s ?p ?o FILTER(sameTerm(?p,:ENAME)) .
 ?s :hasJob :Clerk}
```
Physical implementation of Oracle Semantics

1. A good understanding of the physical implementation is necessary

Models owned by Metastore

- **Model**
  - **M1**
  - **M2**

- **Meta-model**

- **MDSYS.RDF_LINK$**
  - Partitions of other owners
    - **Partition M1**
    - **Partition M2**
    - **Partition Meta-Model**
      - **Partition M1+M2+Metamodel inferenced**

- **MDSYS.RDF_VALUE$**
  - **used**
  - **Unused**

- **Indexes GPSCM,**

- **MDSYS Views**
  - **M1, M2**
  - **M1_IDX, M2_IDX**

- **Staging Table**
  - Partitioned

- **VIRTUAL MODEL**
  - **VIRTUAL MODEL without Infer.**

- **Object tables**
  - Model M1 Table
  - Model M2 Table
  - Meta-model Table
Live demo Oracle Semantic Graph

1. SPARQL Queries using Joseki
2. SPARQL Queries using the SEM_MATCH function
3. Virtua Model implementation
4. SQL join Triple Store with RDF Tables
5. Inferencing
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Project Overview

Metastore Fundamentals

1. Consists of a semantic data federation layer based on controlled terminologies extracted from scientific data repositories

2. Organized around scientific concepts: Genes, Proteins, Indications, Anatomy, diseases, taxonomy etc...;
   - some hierarchically organized and classified

3. Complemented by referential knowledge (cross references to internal and external knowledge repositories)

4. Ontological relations between concepts materializing semantic network of scientific concepts

5. Content is monthly updated (concept type centric updates) during dedicated loading exercises
Project Overview

Workflow Loading Exercise (1)

Loading Exercise
Contains one to many RDF/XML files to be uploaded

There is one file per concept type
• Each file is checked first against an XML Schema

Import with Jena into the staging Table

Pre-validate  Bulk Load  Post-Validate  Materialize in tables  Swap model Live and Work
Project Overview

Workflow Loading Exercise (2)

Staging Table

RDF Triple store WORK

RDF Triple store LIVE

Materialized Views

SPARQL end Point Joseki

Query SQL and PL/SQL APIs

Relational Tables
- Pointers
- History
- Versions
- Logs
- Reference tables

Jena

DATA-Services
Technical Implementation

Staging table and Model implementation

1. A Partitioned staging table stores the uploaded triples
   - The RDF/XML files read by Jena can be up to 1.2 Gigabytes in size
     - This is not a problem for the load into the staging table
   - The validation process checks for inconsistencies (dangling references, missing mandatory properties, ...) before bulk loading into the semantic Model

2. The Metastore RDF Model has been duplicated into MS3_LIVE and MS3_WORK
   - Separates the productive Data from the work-in-progress Data
   - Note: Versioning using Oracle Workspace Management did not work
Special requirements: Versioning

1. Concepts are versioned
   - Each concept has an history and its content can be compared between versions
   - Only modified or new concepts should get a new version ID
     - Verified during the validation process on the staging table
     - the old triples related to this modified concept are deleted and replaced by the latest version of the concept
Special requirements: Security

1. We need a security concept on triple level
   - The default control of access to the Oracle Database semantic data store is at the model level.
   - Oracle does not recommend to use Virtual Private Database in the triple store.
   - We use instead the new 11gR2 feature Oracle Label Security for Triples.
Special requirements: Reification

1. Support for annotation on triple level: reification

- Problem: complex, slows down query performances
- We decided to make it only visible in SQL
  - PL/SQL to transform reified triples into standard triples, the annotation are stored as column in the Semantic Object table
Technical Implementation

Data volume

1. Each model contains **1,001,544 concepts / 22 concept types**

2. Stored **74,000,000 triples + 35,000,000 inferred triples for each Model**
   - *RDF_LINK*$ table size 183,000,000 rows; 19,237 Mb
   - *RDF_VALUE*$ table size 137,000,000 rows; 23,314 Mb
   - Only 34,000,000 rows are actually used in our Models → will be fixed
   - We use Keep Pool to cache the partition Model LIVE on *RDF_LINK*$ + Keep Pool on *RDF_VALUE*$
     - Required an alter table storage (Buffer pool keep)

3. Expected growth: **100% more by the end of the year**
Technical Implementation

Use of Named Graphs

1. For better performance we switched to named graph
   - one for the semantic model, one for each concept
   - Every triple is now associated to a named graph
   - Inferred triples can also be associated with named graphs

2. Issues with blank nodes getting larger and larger ..... 

3. \textit{SEM\_MATCH} Query using name graphs :

   \begin{verbatim}
   SELECT * FROM TABLE(SEM_MATCH(
   'select ?rep ?obj
   { GRAPH :gNVMTAX9606 {
   :NVMTAX9606 :CONCEPT_isRepresentedBy  ?rep .
   OPTIONAL{?rep :REPRESENTATION_hasSource ?obj . }}},
   sem_models('MS3\_LIVE'),SEM_RULEBASES(''), SEM_ALIASES(SEM_ALIAS(null,'http://www.novartis.com/metastore#')),null,null,
   ' GRAPH\_MATCH\_UNNAMED=F PLUS_RDFT=T
   ',null,SEM_GRAPHS(':gNVMTAX9606')));
   \end{verbatim}
1. We decided to rewrite the SPARQL end point to have a better control on what end users can do and to support:

- Session Kills
- Timeouts
- Oracle Hints
- Named Graphs
- List of predefined queries

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX ORACLE_SEM_ES_NS: <http://oracle.com/semtech#timeout=100,qid=123>
PREFIX :<http://www.novartis.com/metastore#>

SELECT *
WHERE { GRAPH ?g { :NVMTAX9606 :CONCEPT_isRepresentedBy ?rep .
} }
```

Submit
Technical Implementation
PL/SQL implementation

1. The REST Webservice calls PL/SQL functions to retrieve the triples in a nt triple format

- Example using our function `nt_describe`

```
SELECT ms3_util.nt_describe('NVMTAX9606',0,0,1) FROM DUAL;
```

- Returns triples in a CLOB

- This way, we can optimize the `SEM_MATCH` queries but we still have sometimes performance issues (more than 5 sec. waiting time)
Next Step: Virtual Model

• Splitting the current triple store into multiple triple stores
  ▪ One Model per concept type
  ▪ A copy of each model for the working environment
    - If 22 concept types, then Metastore owns 44 models + 2 models for the metamodel

• Remove the “swap model” process and replace it by a drop and recreate Virtual Model

• Replace all blank nodes by a URI to solve the problem of Blank Nodes getting larger and larger
  ▪ This will reduce also the size of RDF_VALUE$

• Performance should stay the same, maybe better because of the partitioning of RDF_LINK$
Core messages

- Oracle 11gR2 implementation of RDF Web semantics is a powerful new way of storing data in a database

- The advantage of using the Oracle Triple store are multiple
  - SPARQL and SQL interaction with relationally stored data
  - Use of SQL Hints, indexes and caching to increase performances
  - Standard DB Administration : Backup/recovery/replication, etc...
  - PL/SQL or Java programming
  - Supports large volumes of data
  - Good integration with standard RDF client tools such as Jena and Sesame

- Newcomers to RDF Web Semantics will need some time to get used to the various modeling concepts and to the SPARQL syntax

- Newcomers to Oracle Semantic Graph will need some time to fine tune the Oracle specific features but the effort is worthwhile!
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THANK YOU.

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