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DEVELOP

OCTOBER 11-13, 2009 / HILTON / SAN FRANCISCO

Oracle Database 11g Release 2
Dive into Semantic Technologies: Security, Document Index, and Change Management

Aravind Yalamanchi, Consultant Member of Technical Staff
Bill Beauregard, Senior Principal Product Manager

Semantics at OOW 2009 - Sessions

Date/Time	Title	Location
Sunday, Oct. 11		
10:30 a.m.	Build Better SQL and Document Queries with Oracle Semantic Technologies, Part 1	Hilton Hotel Continental Parlor 1/2/3
11:45 a.m.	Build Better SQL and Document Queries with Oracle Semantic Technologies, Part 2	Hilton Hotel Continental Parlor 1/2/3
2:30 p.m.	Dive into Semantic Technologies: Security, Document Index, and Change Management	Hilton Hotel Golden Gate 2
3:45 p.m.	Put SPARQL in Your Code: Building Applications with Oracle Semantic Technologies	Hilton Hotel Golden Gate 2
Tuesday, Oct. 13		
4:00 p.m.	Turning the Database Inside-Out with Complex Event Processing	Hilton Hotel Golden Gate 1

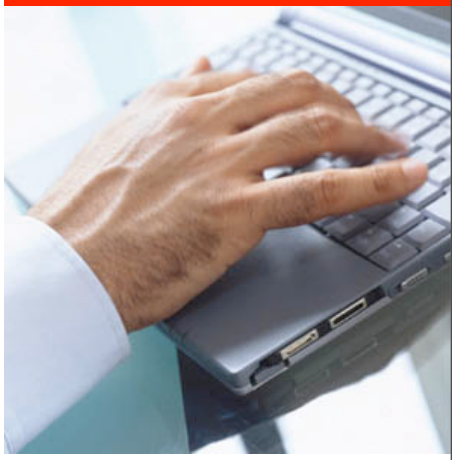
Semantics at OOW 2009 - Sessions

Date/Time	Title	Location
Wednesday, Oct. 14		
10:15 a.m.	Who's Who and What's What with Oracle Database Semantic Technologies	Moscone South Room 270

- DEMOgrounds
  - Oracle Database Semantic Technologies - *Moscone West, W-018*

The following is intended to outline our general product direction. It is intended for information purposes only, and may not be incorporated into any contract. It is not a commitment to deliver any material, code, or functionality, and should not be relied upon in making purchasing decisions.
The development, release, and timing of any features or functionality described for Oracle's products remains at the sole discretion of Oracle.

Agenda



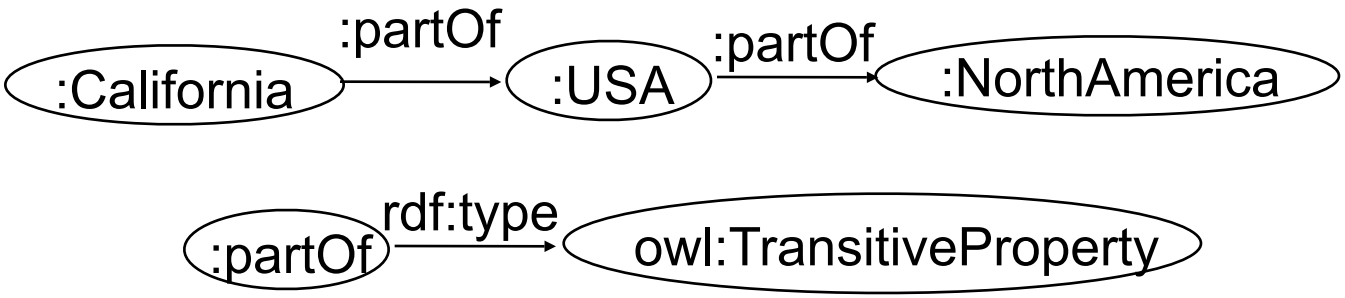
- Overview of Oracle Database Semantic Technologies
- Strong security
- Semantic indexing of documents
- Change management for collaboration

Semantic Data Mgt. Characteristics

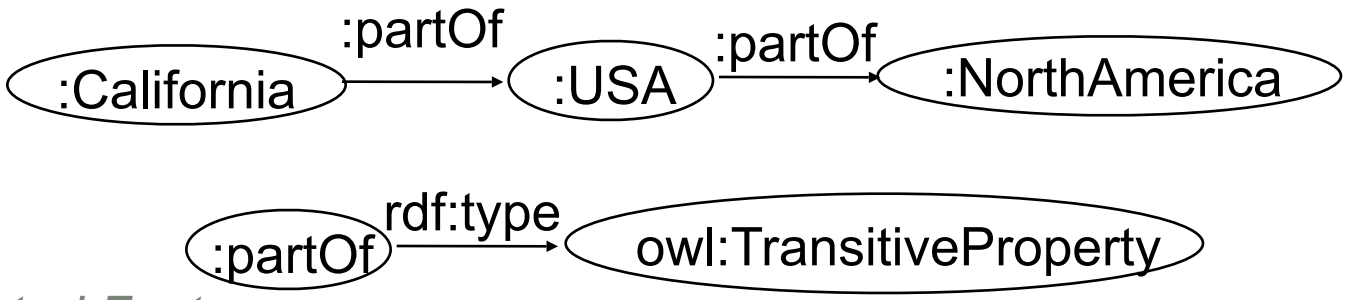
- Discovery of data relationships across…
  - Structured data (database, apps, web services)
  - Unstructured data (email, office documents) Multi-data types (graphs, spatial, text, sensors)
- Text Mining & Web Mining infrastructure
  - Terabytes of structured & unstructured data
- Queries are not defined in advance
- Schemas are continuously evolving
- Associate more meaning (context) to enterprise data to enable its (re)use across applications
- Allow sharing and reuse of enterprise and web data.
- Built on open, industry W3C standards:
  - SQL, XML, RDF, OWL, SPARQL

Semantic Database: Store, Infer, Query

Semantic Database: Store, Infer, Query



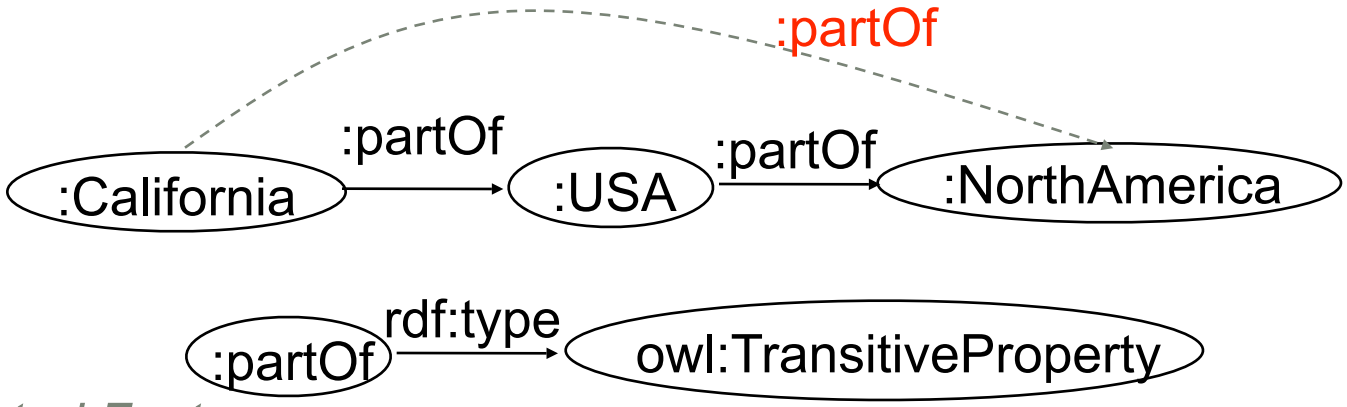
Semantic Database: Store, Infer, Query



Asserted Facts

:partOf	rdf:type	owl:TransitiveProperty
:California	:partOf	:USA
:USA	:partOf	:NorthAmerica

Semantic Database: Store, Infer, Query



Asserted Facts

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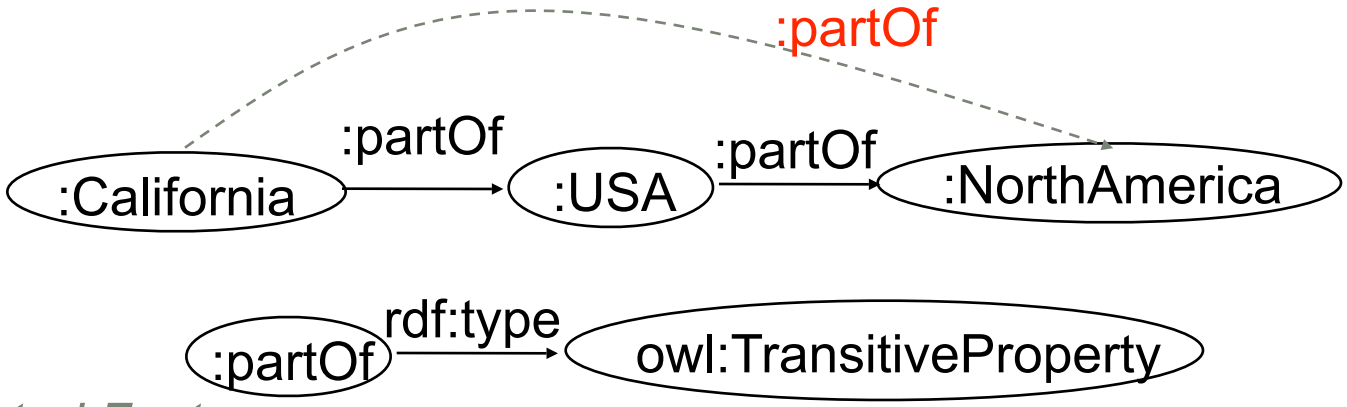
Semantic Database: Store, Infer, Query



Asserted Facts

:partOf	rdf:type	owl:TransitiveProperty
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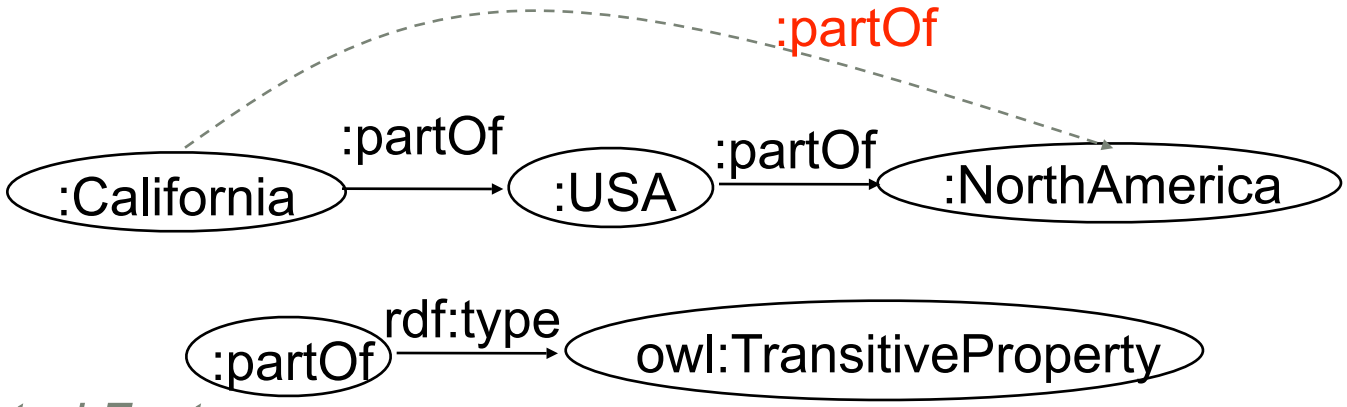
:USA	:partOf	:NorthAmerica

Derived Facts

:California	:partOf	:NorthAmerica

Semantic Database: Store, Infer, Query



Asserted Facts

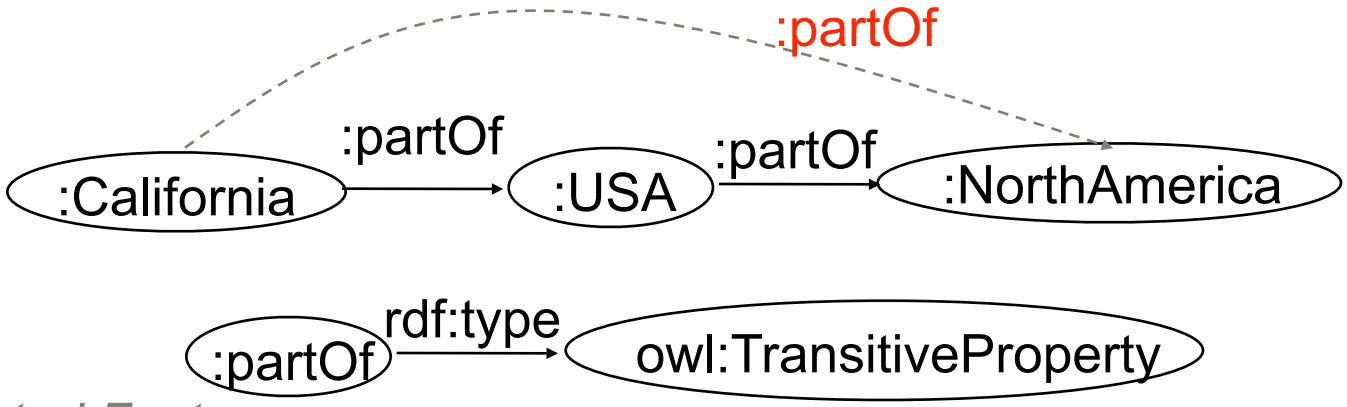
:partOf	rdf:type	owl:TransitiveProperty
:California	:partOf	:USA
:USA	:partOf	:NorthAmerica

Derived Facts

:California	:partOf	:NorthAmerica

```
Query:   SELECT ?x ?y
           FROM …
         WHERE {  ?x :partOf ?y }
```

Semantic Database: Store, Infer, Query



Asserted Facts

:partOf	rdf:type	owl:TransitiveProperty
:California	:partOf	:USA
:USA	:partOf	:NorthAmerica

Derived Facts

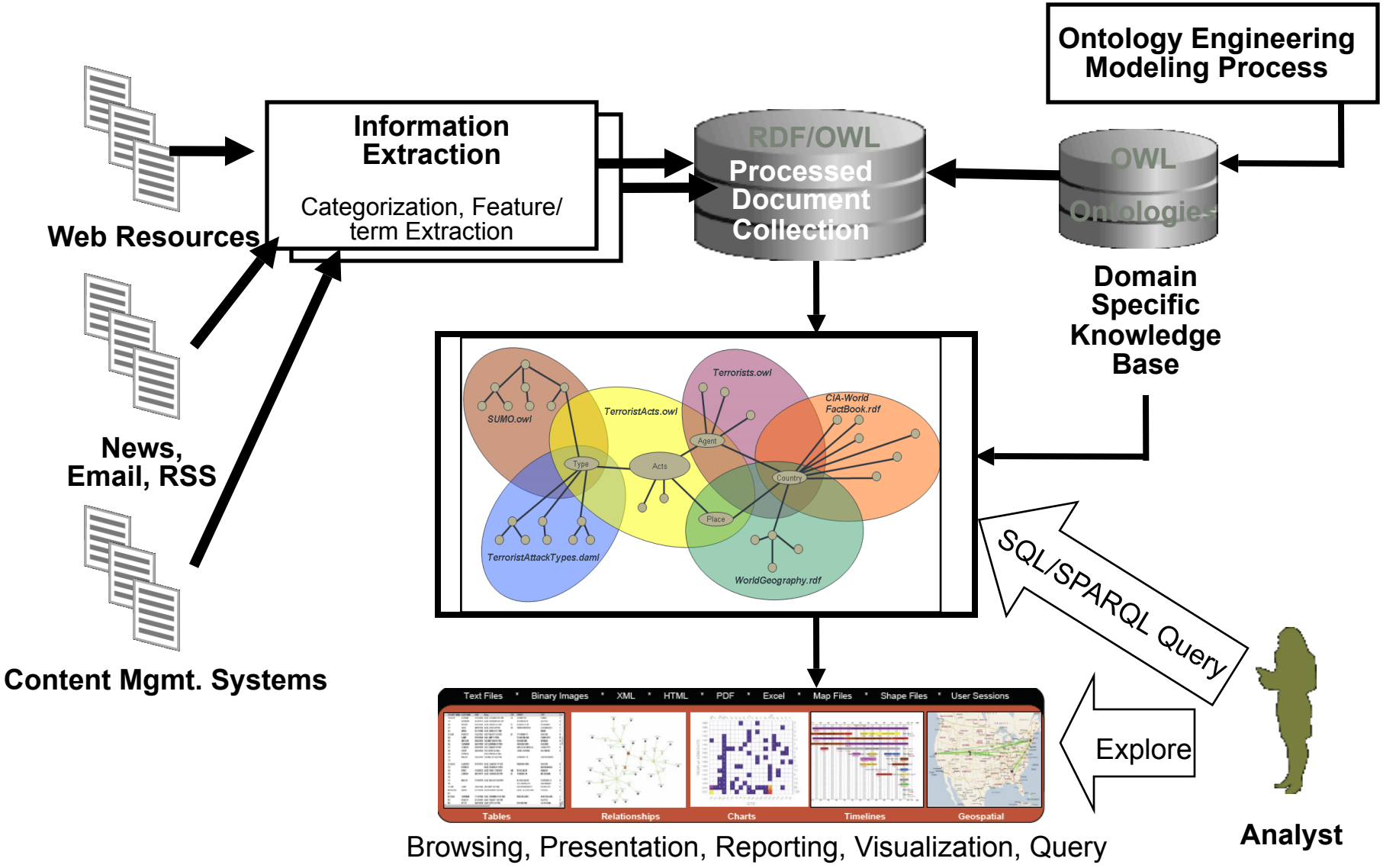
:California	:partOf	:NorthAmerica

Query:
```
SELECT ?x ?y
  FROM …
 WHERE { ?x :partOf ?y }
```

Result:

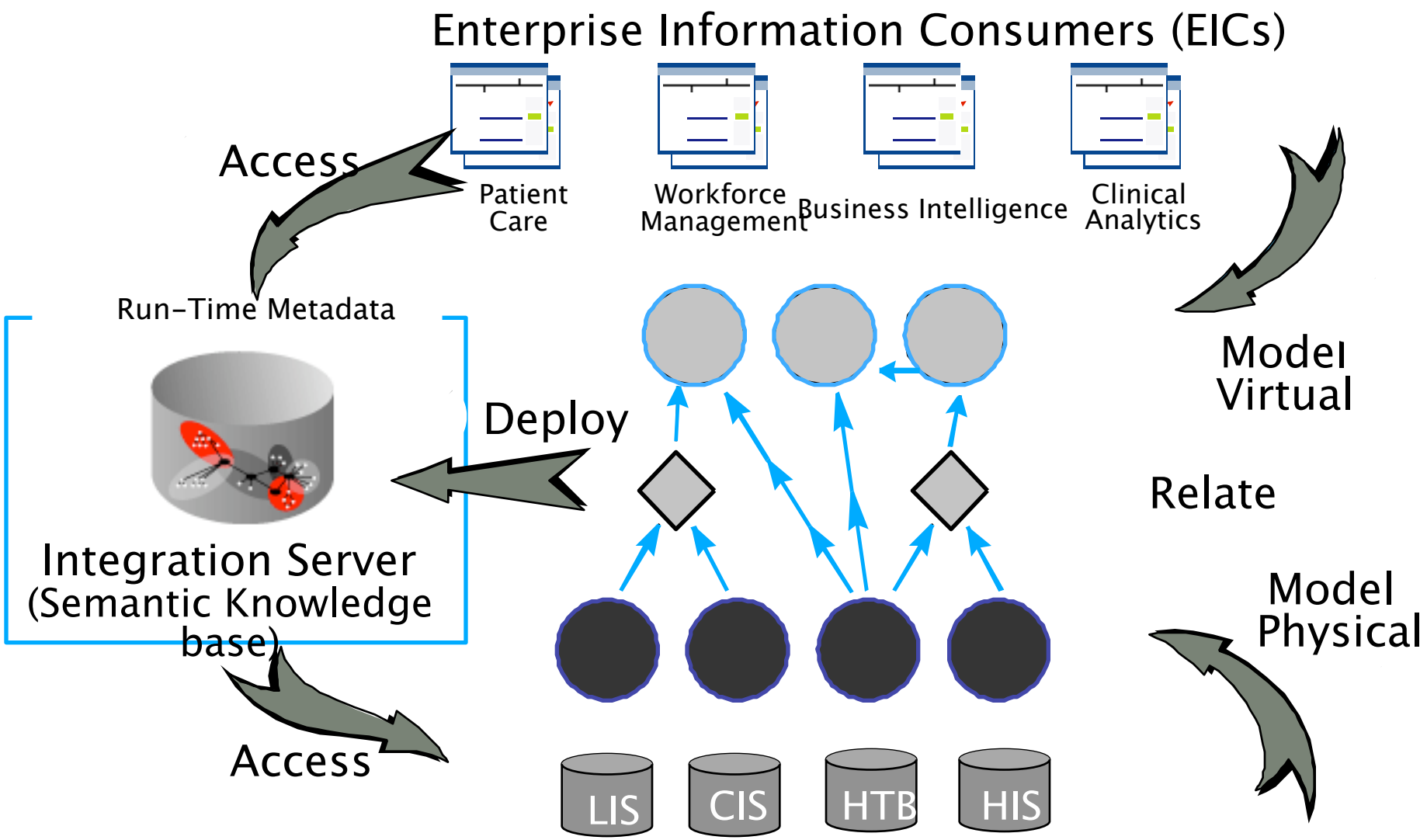
?x	?y
:California	:USA
:California	:NorthAmerica
:USA	:NorthAmerica

Text Mining: National Intelligence

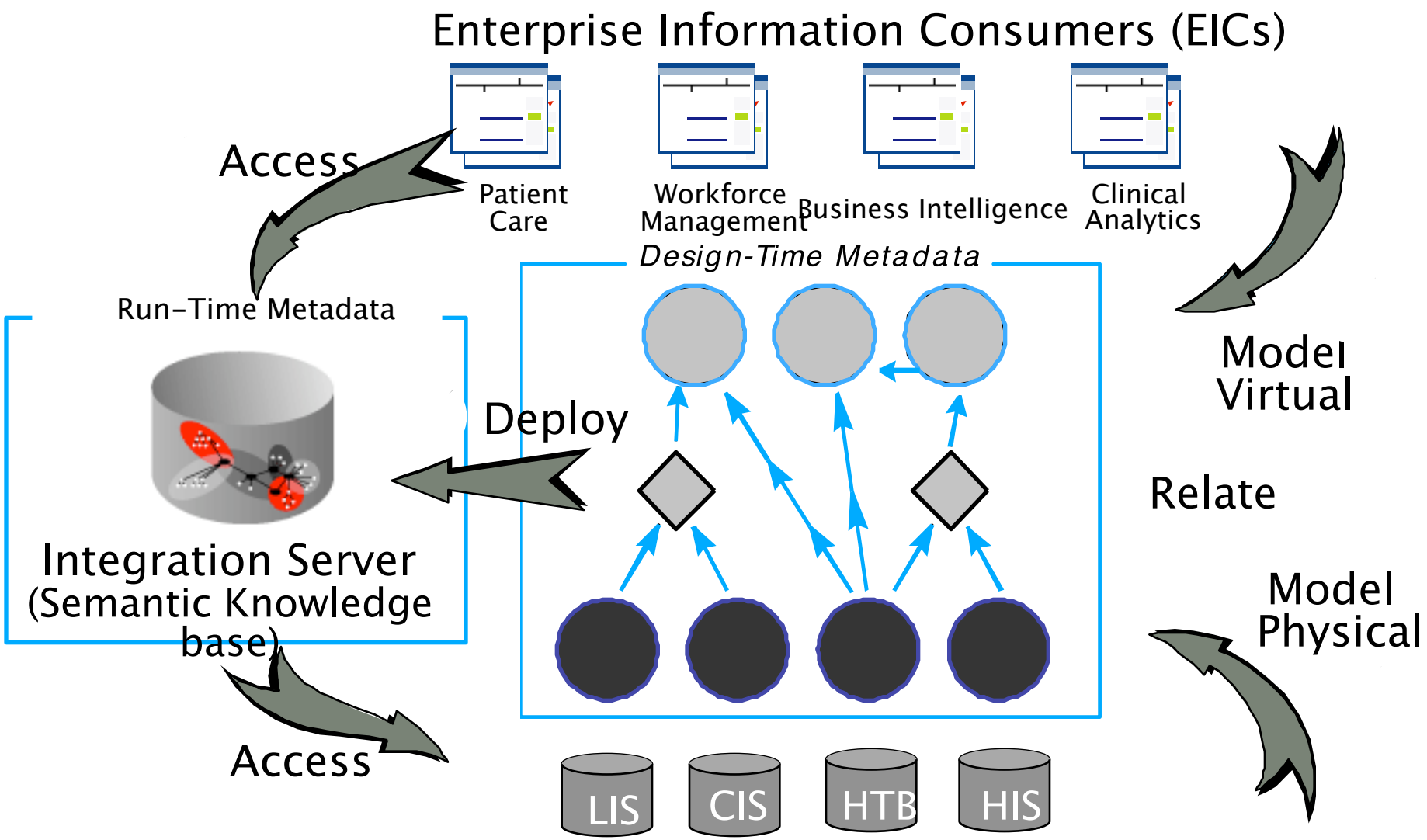


Browsing, Presentation, Reporting, Visualization, Query

Data Integration Platform in Health Informatics



Data Integration Platform in Health Informatics



Oracle Database 11G RDF/OWL Graph Data Management

- Oracle database 11g is the leading commercial database with native RDF/ OWL data management
- Scalable & secure platform for wide-range of semantic applications
- Readily scales to ultra-large repositories (+1 billion)
- Choice of SQL or SPARQL query
- Leverages Oracle Partitioning, RAC supported
- Growing ecosystem of 3rd party tools partners

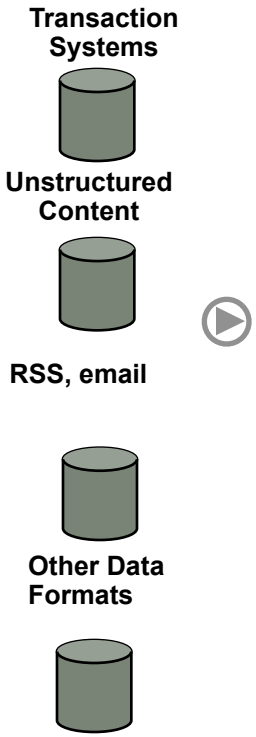
Key Capabilities:

Load / Storage
- Native RDF graph data store
- Manages billions of triples
- Fast batch, bulk and incremental load

Query
- SQL: SEM_Match
- SPARQL: via Jena plug-in
- Ontology assisted query of RDBMS data

Reasoning
- Forward chaining model
- RDFS++ OWL, OWL Prime
- User defined rule base

Semantic Data Management Workflow



Data Sources

Edit & Transform

- Entity Extraction & Transform
- Ontology Engineering
- Categorization
- Custom Scripting

Partners

Load, Query & Inference

- RDF/OWL Data Management
- SQL & SPARQL Query
- Inferencing
- Semantic Rules
- Scalability & Security

ORACLE SPATIAL

Applications & Analysis

- Graph Visualization
- Link Analysis
- Statistical Analysis
- Faceted Search
- Pattern Discovery
- Text Mining

Partners

Semantic Technology Partners

Integrated Tools and Solution Providers:

TopQuadrant

protégé

BOEING

Raytheon

metatomix

MONDECA

accenture

NORTHROP GRUMMAN

CollabRx

Cognia

SIDEREAN
Navigation for the Digital Universe

MedTrust

McDONALD BRADLEY

FRANZ INC.
"Web 3.0's Database"

ontoprise
know how to use Know-how

TERANODE

Saltlux

semantic web framework
Jena

orbis
TECHNOLOGIES, INC.

Release 11.1 Semantic Technologies

- W3C standards: RDF, RDFS, OWL, SPARQL
- SQL & DML access to RDF/OWL data and ontologies
  - Querying in SQL w/ SPARQL-like graph patterns
  - Querying w/ SPARQL in Java through Jena adaptor
  - Ontology-assisted querying of relational data
- Native Inferencing: RDFS/OWL & user-defined rules
  - Persistent, scalable, ahead of queries, plugable reasoners
- Model level security
- Bulk and incremental loading of triples
  - Up to 8 exabytes,1 million graphs w/ multi-graph querying
  - Integral Oracle Partitioning

Release 11.2 Semantic Technologies

- Strong security for Semantic Technologies
  - Security policies and data classification for RDF data
- Semantic indexing of documents
  - Semantic indexing of documents based on popular natural language tools
- Faster, more efficient reasoning to find new relationships
  - Parallel and incremental inference, owl:sameAs optimization
- Change management for collaboration
- Standards & open source support
  - SPARQL query support for Filter, Union in SEM_MATCH table function
  - OWL: union, intersection, OWL 2 property chains, disjoint properties
  - Pellet OWL DL reasoner Integration
  - Jena V2.5
  - Java SDK for SPARQL for 3rd party integration e.g., Sesame
  - W3C Simple Knowledge Organization System (SKOS) & SNOMED ontology
  - Utility to swap, rename, and merge model, rename entailment, remove duplicates

ORACLE OPEN WORLD

XML

JSF

EJB 3.0

Java

DBA

JPA

BPEL

ASP

Forms

Strong Security

ORACLE

Fine-Grained Access Control for RDF

- Fine-Grained Access Control mechanisms restrict access to data *within* the most critical database objects.
- Intercept and rewrite the user query to restrict the result set using additional predicates.
- Restricted result set only includes the rows the user "needed to know".
- Offers triple-level security for RDF data for defense, intelligence, and commercial regulatory environments.

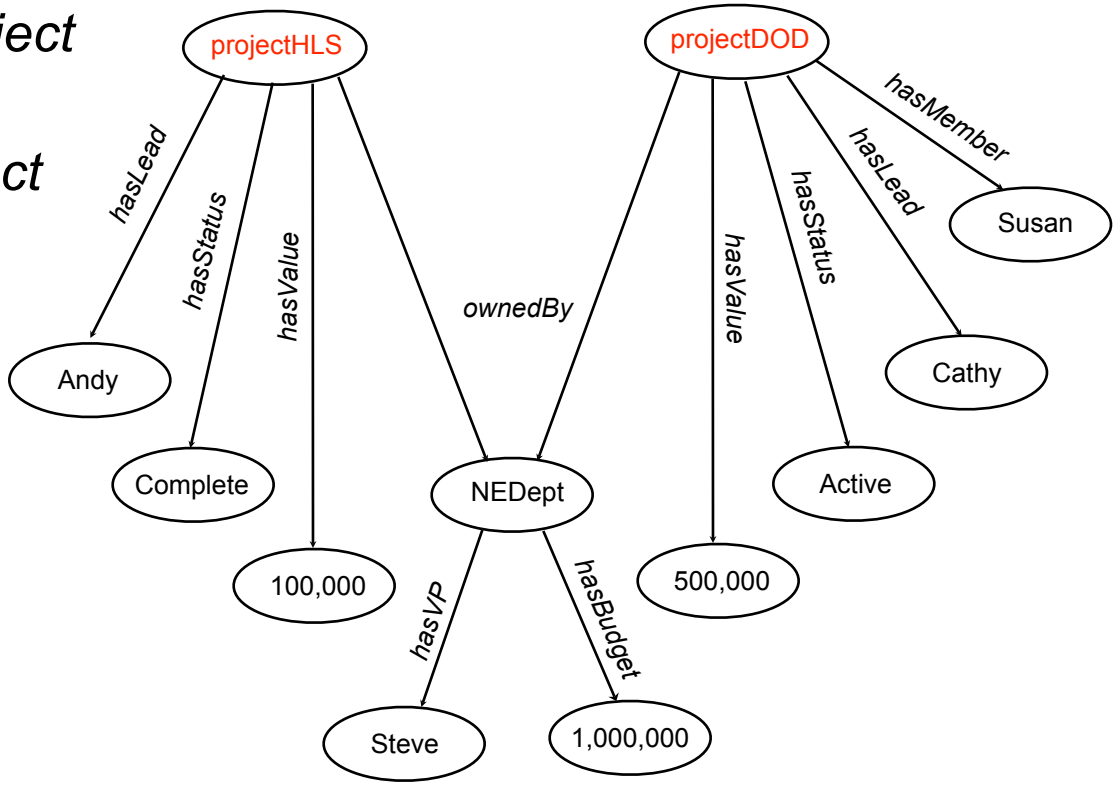
Enterprise Security for Semantic Data

- Access control policies on semantic data
  - Uses Virtual Private Database feature of Oracle Database
  - Applies declarative constraints to RDF classes and properties
  - Restricts access to parts of the RDF graph based on certain characteristics of the instance data and application/user context
  - E.g: *Only a manager of a contract can access its monetary value.*
- Data classification labels for semantic data
  - Uses Oracle Label Security option of Oracle Database
  - Assigns sensitivity labels to users and RDF data.
  - Restricts access to users having compatible access labels.
  - E.g: *A triple marked as "Sensitive" is only accessible to the users with clearance for "Sensitive" or "Highly Sensitive" information.*

Virtual Private Database for RDF Data

Ability to restrict access to parts of the RDF graph based on the application/user context.

- *An individual can only access information about the project he works on.*
- *Monetary value of a project can only be accessed by the project lead or the VP of the department.*
- *Only a department VP can access information about the department's budget.*



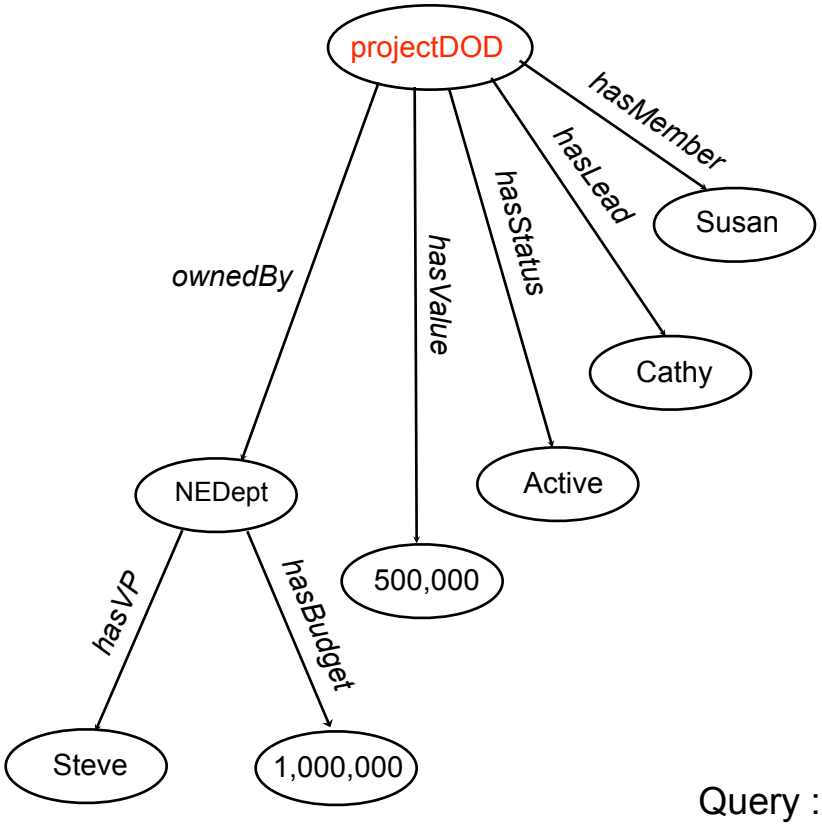
VPD Constraints for RDF

- The security conditions or the data access constraints are associated with RDF Classes and Properties.
  - An instance of **`Project`** class can only be accessed by an individual with **`hasMember`** relationship with the instance.
  - The **`hasValue`** property for a **`Project`** instance can be accessed by an individual recognized as the project lead (**`hasLead`** property).
- Declarative constraints restrict access to parts of the RDF graph.
  - E.g: *A user only has access to projects that are Active.*

```
{ ?project  rdf:type  :Project } →
                    { ?project  :hasStatus  :Active }
```

- SPARQL queries on a VPD-enabled graph are automatically rewritten to include *appropriate* constraints.

Compile-time Analysis of Queries with VPD

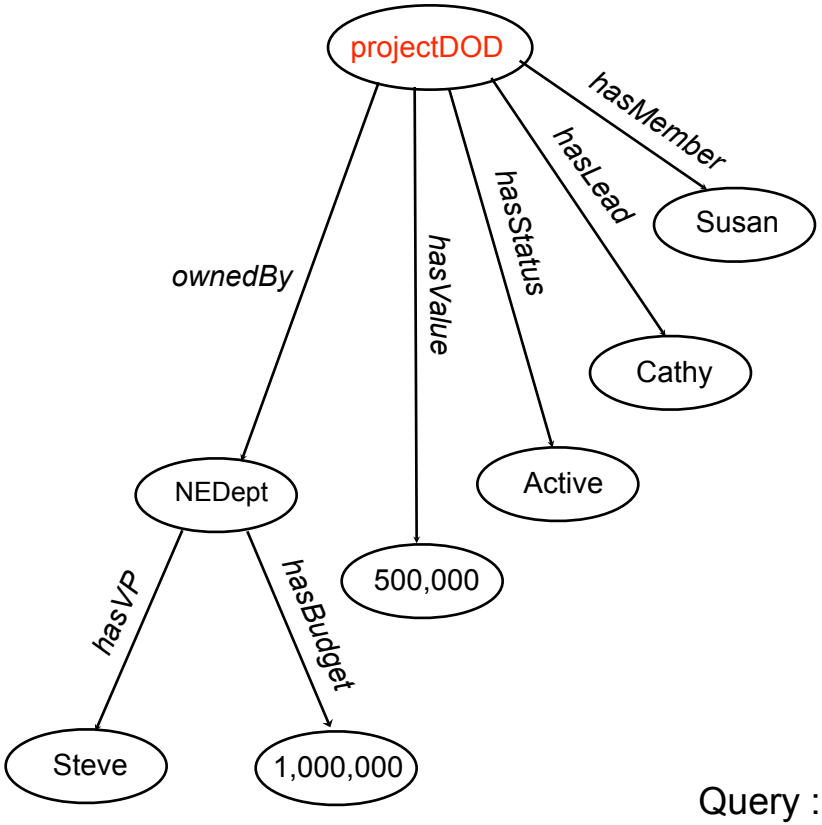


:Contract	rdfs:subClassOf	:Project
:GovtProject	rdfs:subClassOf	:Project
…		
:hasLead	rdfs:domain	:Project
:hasLead	rdfs:range	:Employee
:hasStatus	rdfs:domain	:Project
:hasValue	rdfs:domain	:Contract
:ownedBy	rdfs:domain	:Project
:ownedBy	rdfs:range	:Department
…		
:hasVP	rdfs:domain	:Department
:hasVP	rdfs:range	:Employee
:hasBudget	rdfs:domain	:Department

Query : Get the list of projects and their values

```
SELECT   ?proj   ?val
FROM     ProjectsGraph
WHERE    { ?proj    :hasValue   ?val }
```

Compile-time Analysis of Queries with VPD

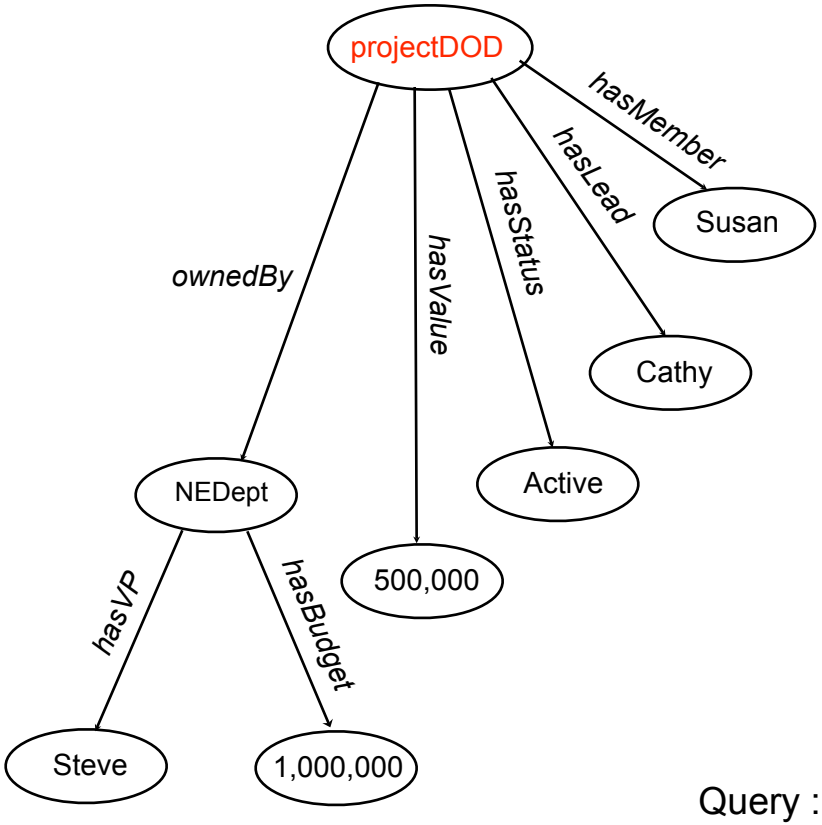


:Contract	rdfs:subClassOf	:Project
:GovtProject	rdfs:subClassOf	:Project
…		
:hasLead	rdfs:domain	:Project
:hasLead	rdfs:range	:Employee
:hasStatus	rdfs:domain	:Project
:hasValue	rdfs:domain	:Contract
:ownedBy	rdfs:domain	:Project
:ownedBy	rdfs:range	:Department
…		
:hasVP	rdfs:domain	:Department
:hasVP	rdfs:range	:Employee
:hasBudget	rdfs:domain	:Department

Query : Get the list of projects and their values

```
SELECT   ?proj   ?val
FROM     ProjectsGraph
WHERE    { ?proj   :hasValue   ?val }
```

Compile-time Analysis of Queries with VPD

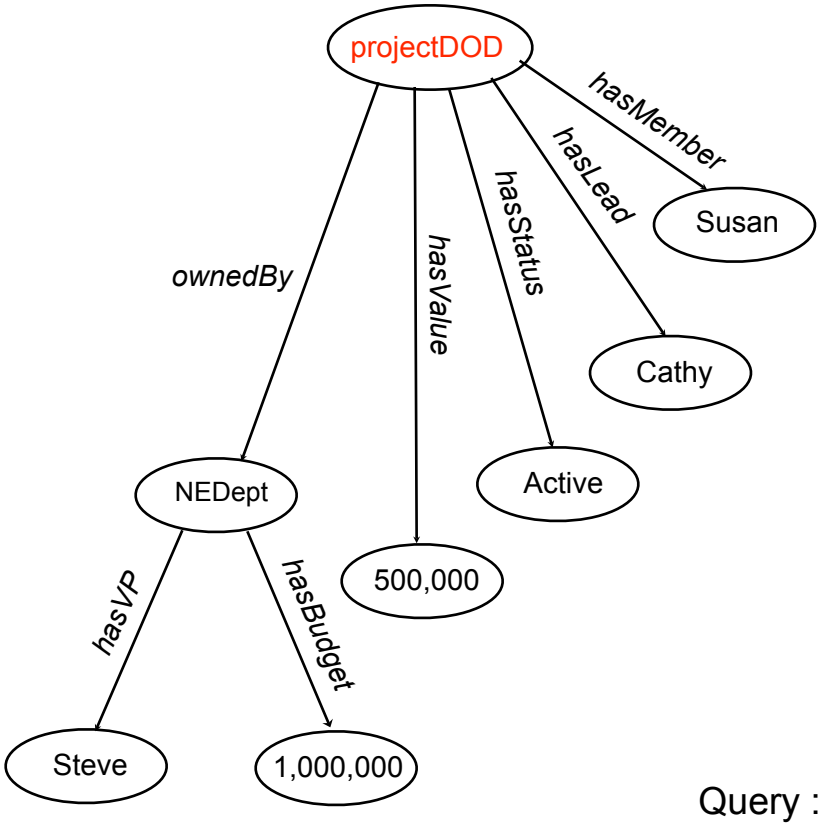


:Contract	rdfs:subClassOf	:Project
:GovtProject	rdfs:subClassOf	:Project
…		
:hasLead	rdfs:domain	:Project
:hasLead	rdfs:range	:Employee
:hasStatus	rdfs:domain	:Project
:hasValue	rdfs:domain	:Contract
:ownedBy	rdfs:domain	:Project
:ownedBy	rdfs:range	:Department
…		
:hasVP	rdfs:domain	:Department
:hasVP	rdfs:range	:Employee
:hasBudget	rdfs:domain	:Department

Query : Get the list of projects and their values

```
SELECT   ?proj   ?val
FROM     ProjectsGraph
WHERE    { ?proj   :hasValue   ?val }
```

Compile-time Analysis of Queries with VPD

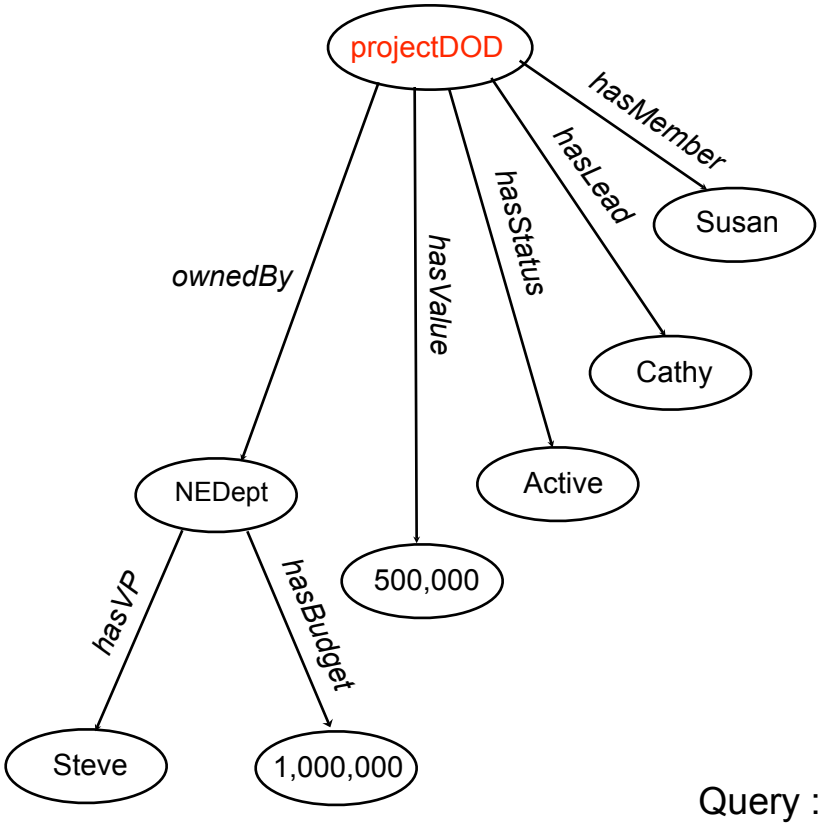


:Contract	rdfs:subClassOf	:Project
:GovtProject	rdfs:subClassOf	:Project
…		
:hasLead	rdfs:domain	:Project
:hasLead	rdfs:range	:Employee
:hasStatus	rdfs:domain	:Project
:hasValue	rdfs:domain	:Contract
:ownedBy	rdfs:domain	:Project
:ownedBy	rdfs:range	:Department
…		
:hasVP	rdfs:domain	:Department
:hasVP	rdfs:range	:Employee
:hasBudget	rdfs:domain	:Department

Query : Get the list of projects and their values

```
SELECT   ?proj   ?val
FROM     ProjectsGraph
WHERE    { ?proj   :hasValue   ?val   .
           ?proj   :hasStatus  :Active   }
```

Compile-time Analysis of Queries with VPD



:Contract	rdfs:subClassOf	:Project
:GovtProject	rdfs:subClassOf	:Project
…		
:hasLead	rdfs:domain	:Project
:hasLead	rdfs:range	:Employee
:hasStatus	rdfs:domain	:Project
:hasValue	rdfs:domain	:Contract
:ownedBy	rdfs:domain	:Project
:ownedBy	rdfs:range	:Department
…		
:hasVP	rdfs:domain	:Department
:hasVP	rdfs:range	:Employee
:hasBudget	rdfs:domain	:Department

To facilitate compile-time analysis, queries may not use unbound variables in the predicate position.

Query : Get the list of projects and their values

```
SELECT   ?proj   ?val
FROM     ProjectsGraph
WHERE    { ?proj   :hasValue   ?val   .
           ?proj   :hasStatus  :Active  }
```

VPD Constraints for RDF

- A VPD Constraint is used to enforce access restrictions on parts of the RDF graph, identified using its metadata.
- One or more constraints are grouped into a VPD policy that is applied to an RDF Graph.
- Each VPD constraint has a *match* pattern and an *apply* pattern, which are expressed as SPARQL graph patterns.
  - The *match* pattern identifies parts of the RDF graph being accessed by a user query.

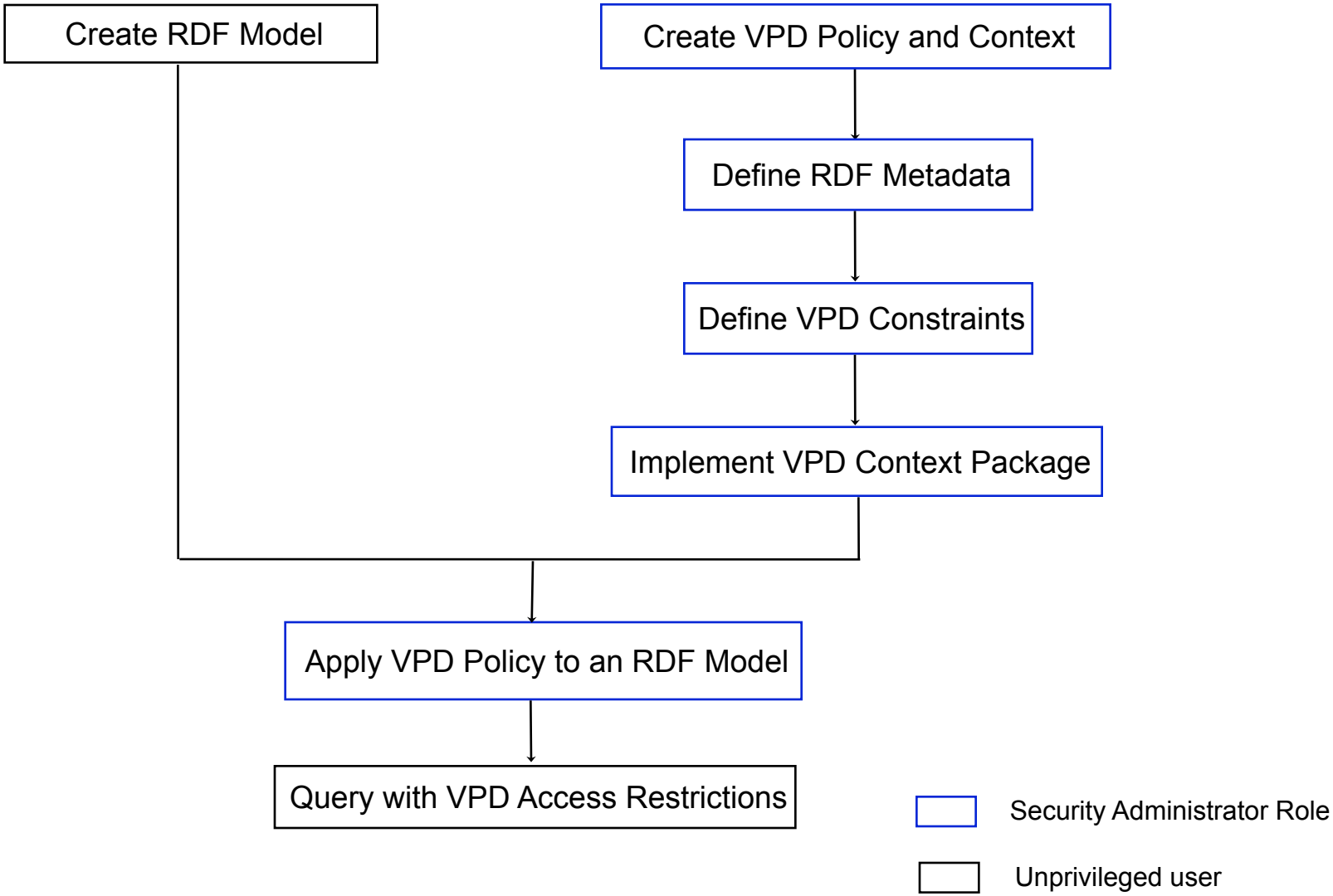
```
?project  :hasValue  ?val
```

  - The *apply* pattern defines additional graph patterns to be applied on the sub-graph before it can be used to construct the query results.

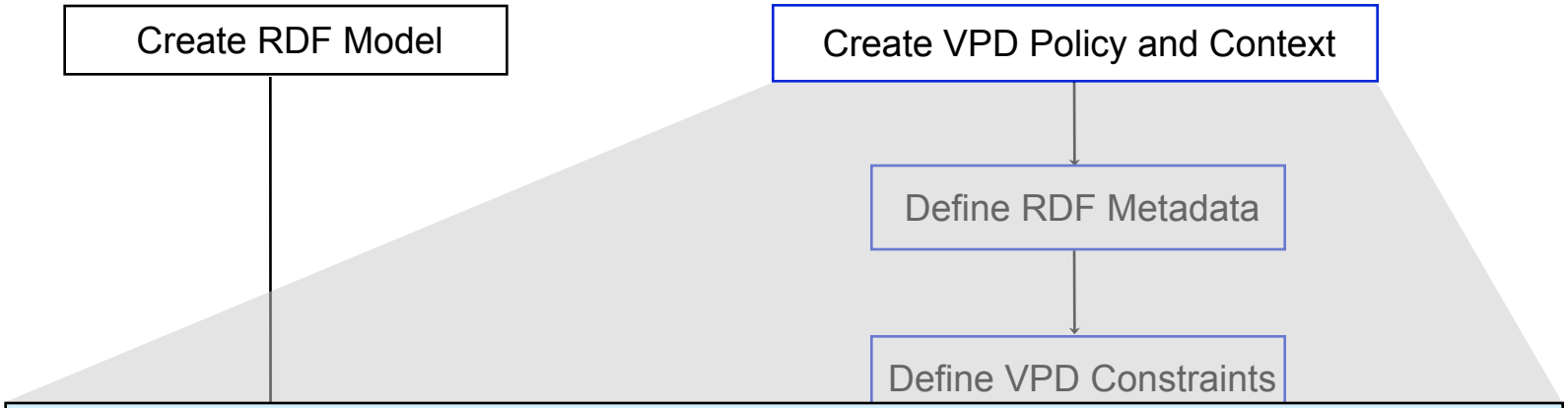
```
?project :ownedBy  ?dept .
?dept    :hasVP   "sys_context('sa
$env','user')"^^orardf:instruction
```

- Context-dependent VPD constraints may be defined using Secure Application context.

VPD enabled RDF



VPD enabled RDF

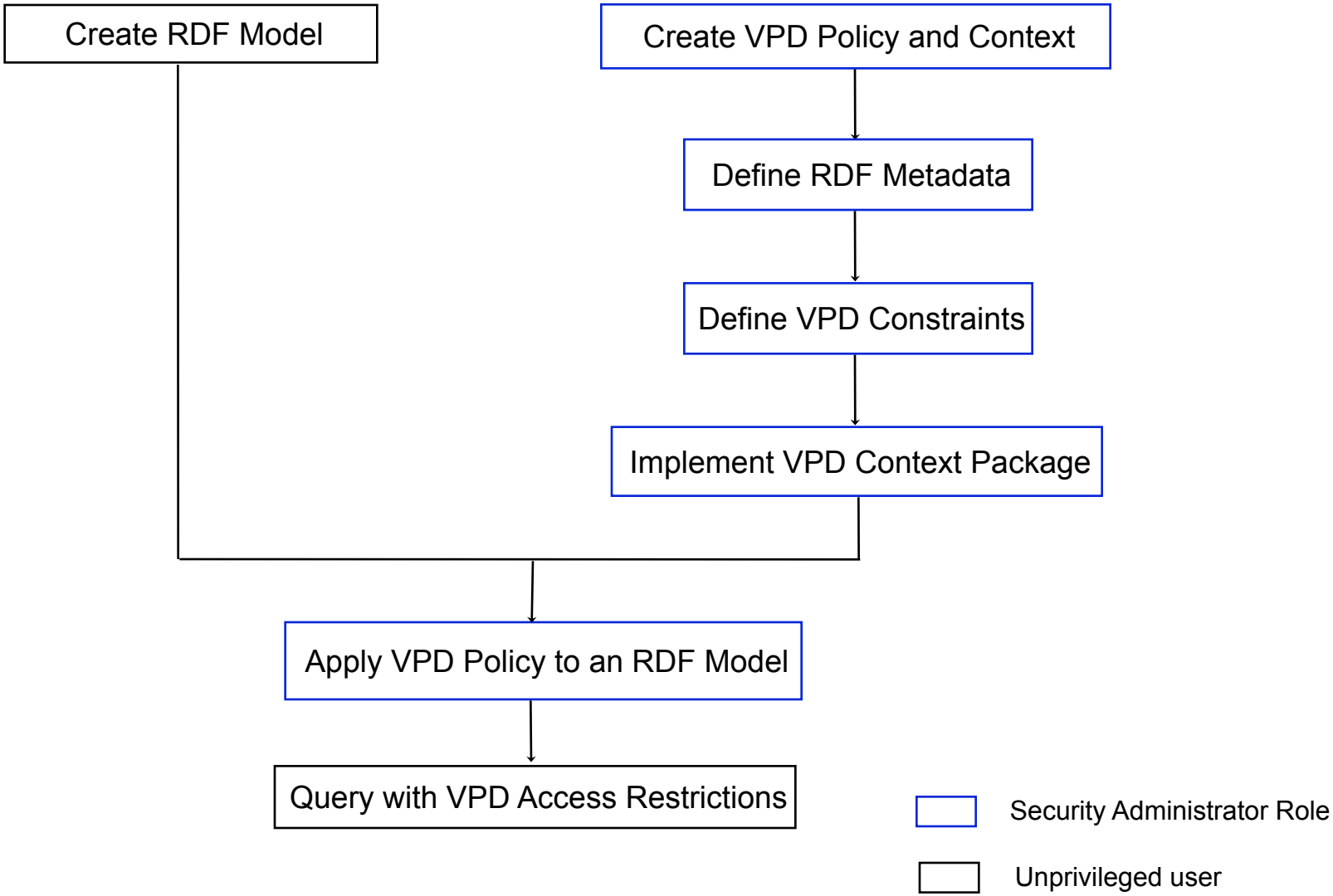



```
SQL> -- create a context to conditionally enable/disable constraints
SQL> create context contracts_appctx using sec_admin.contracts_ctxpack;


Context Created.

SQL>
SQL> -- Create a VPD policy with optional Namespace mapping and policy function.
SQL> begin
  2    sem_rdfsa.create_vpd_policy(
  3      policy_name   => 'contracts_policy',
  4      namespace_map => mdsys.rdf_aliases(
  5                       mdsys.rdf_alias('','http://www.myorg.com/contract/classes/'),
  6                       mdsys.rdf_alias('prjp','http://www.myorg.com/contract/properties/')),
  7      context_name  => 'contracts_appctx');
  8  end;
  9  /
```

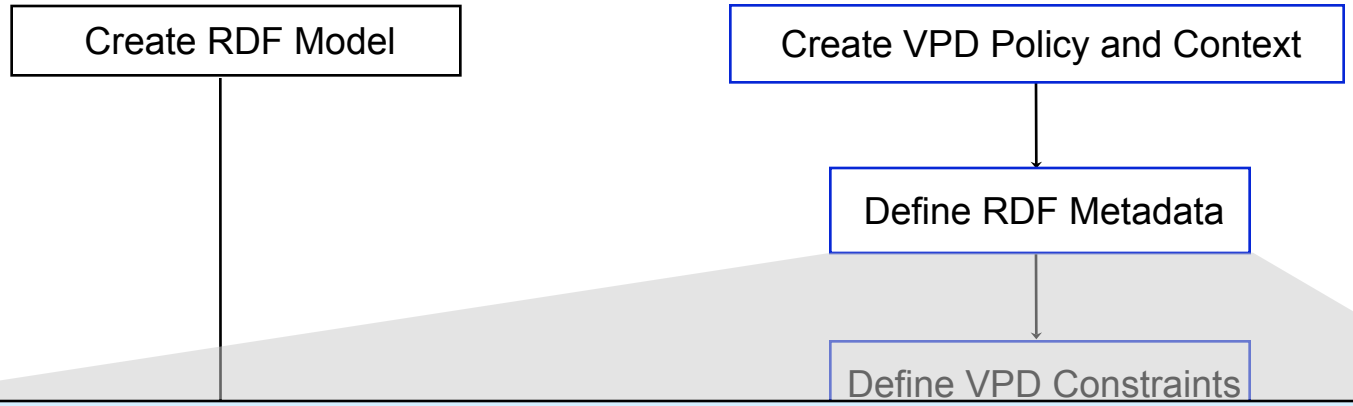
Role

Unprivileged user

VPD enabled RDF



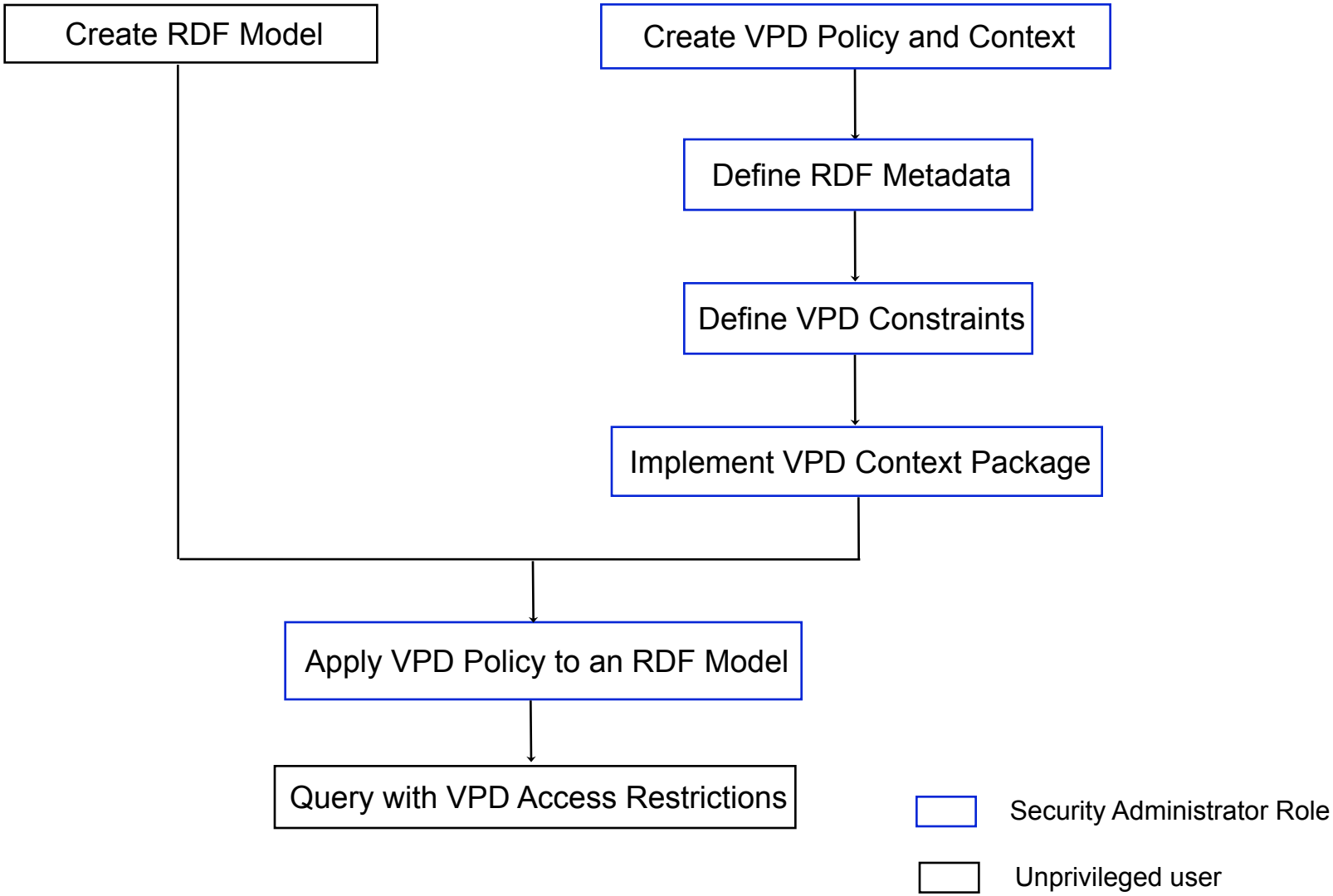
VPD enabled RDF



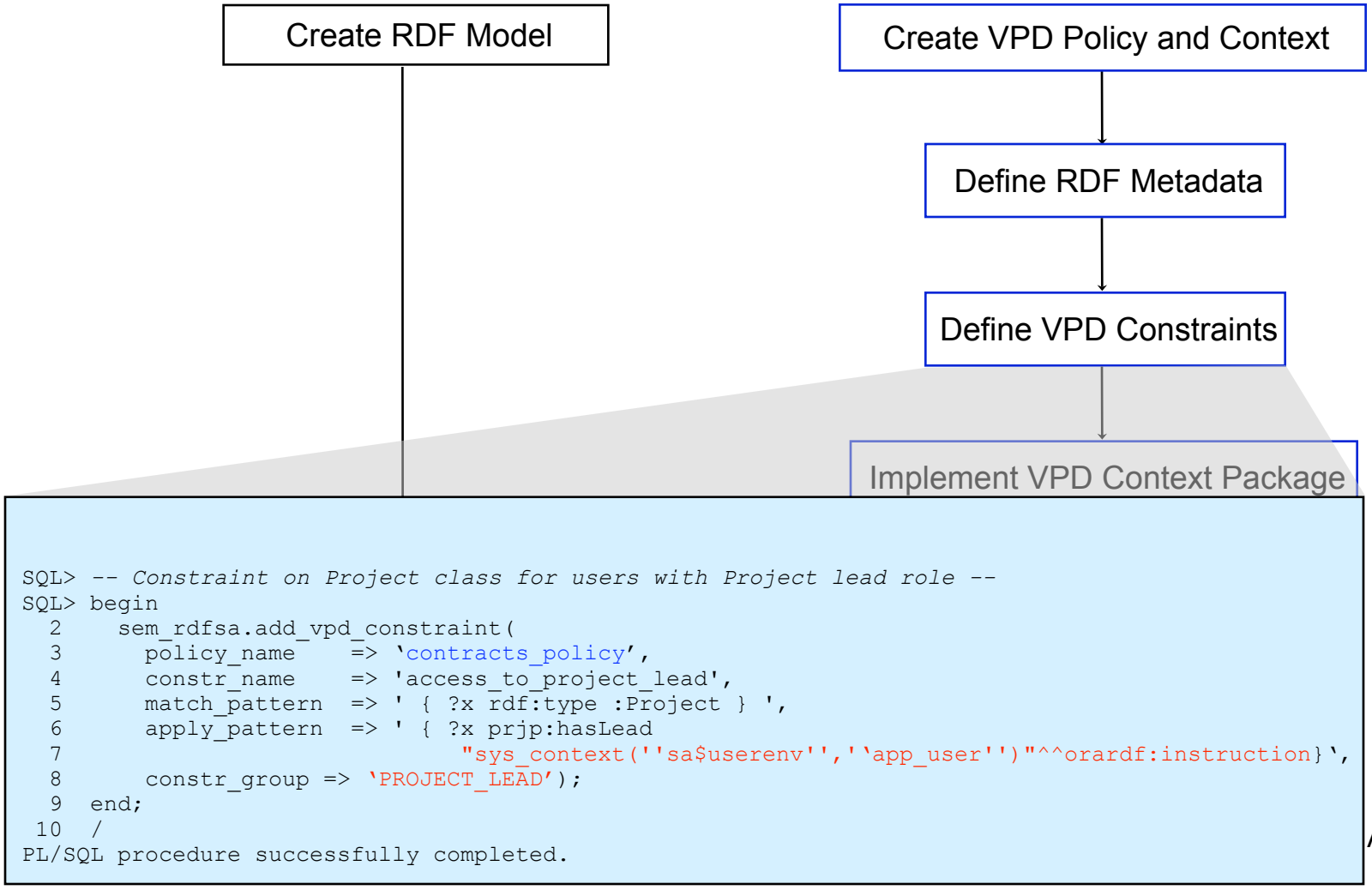

```
SQL> -- Define RDF Metadata pertaining to a given model. This includes
SQL> -- Domain/Range subClassof and subPropertyOf relationships
SQL> begin
  2    sem_rdfsa.maint_vpd_metadata(
  3      policy_name => 'contracts_policy',
  4      t_subject   => '<http://www.myorg.com/contract/classes/Contract>',
  5      t_predicate => '<http://www.w3.org/2000/01/rdf-schema#subClassOf>',
  6      t_object    => '<http://www.myorg.com/contract/classes/Project>');
  7  end;
  8  /
PL/SQL procedure successfully completed.


SQL>
SQL> begin
  2    sem_rdfsa.maint_vpd_metadata(
  3      policy_name => 'contracts_policy',
  4      t_subject   => '<http://www.myorg.com/contract/properties/hasValue>',
  5      t_predicate => '<http://www.w3.org/2000/01/rdf-schema#domain>',
  6      t_object    => '<http://www.myorg.com/contract/classes/Contract>');
  7  end;
  8  /
PL/SQL procedure successfully completed.
```

or Role

VPD enabled RDF



VPD enabled RDF

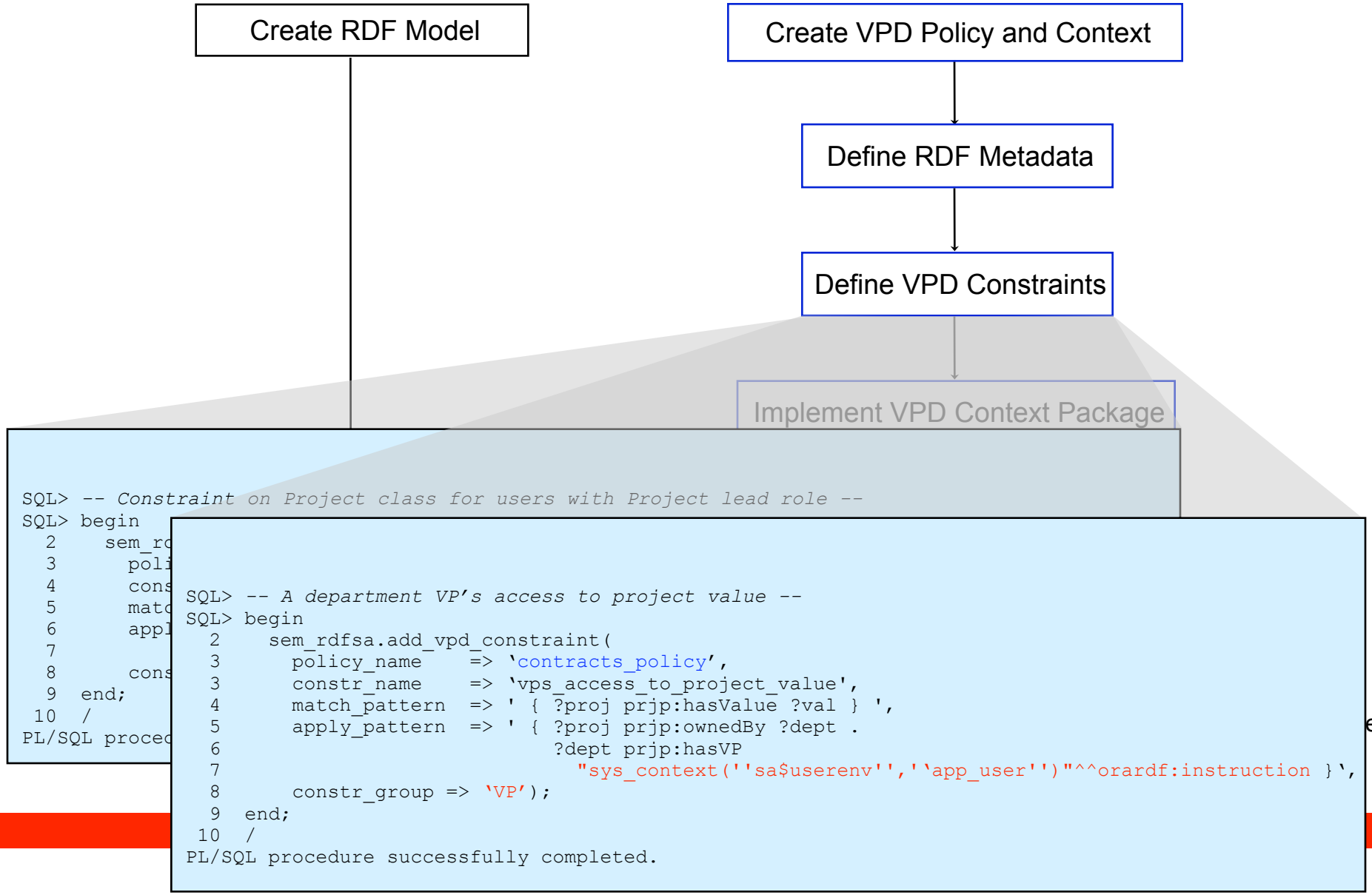



```
SQL> -- Constraint on Project class for users with Project lead role --
SQL> begin
  2    sem_rdfsa.add_vpd_constraint(
  3      policy_name    => 'contracts_policy',
  4      constr_name    => 'access_to_project_lead',
  5      match_pattern  => ' { ?x rdf:type :Project } ',
  6      apply_pattern  => ' { ?x prjp:hasLead
  7                          "sys_context(''sa$userenv'',''app_user'')"^^orardf:instruction}',
  8      constr_group => 'PROJECT_LEAD');
  9  end;
 10  /
PL/SQL procedure successfully completed.
```

Administrator Role

Unprivileged user

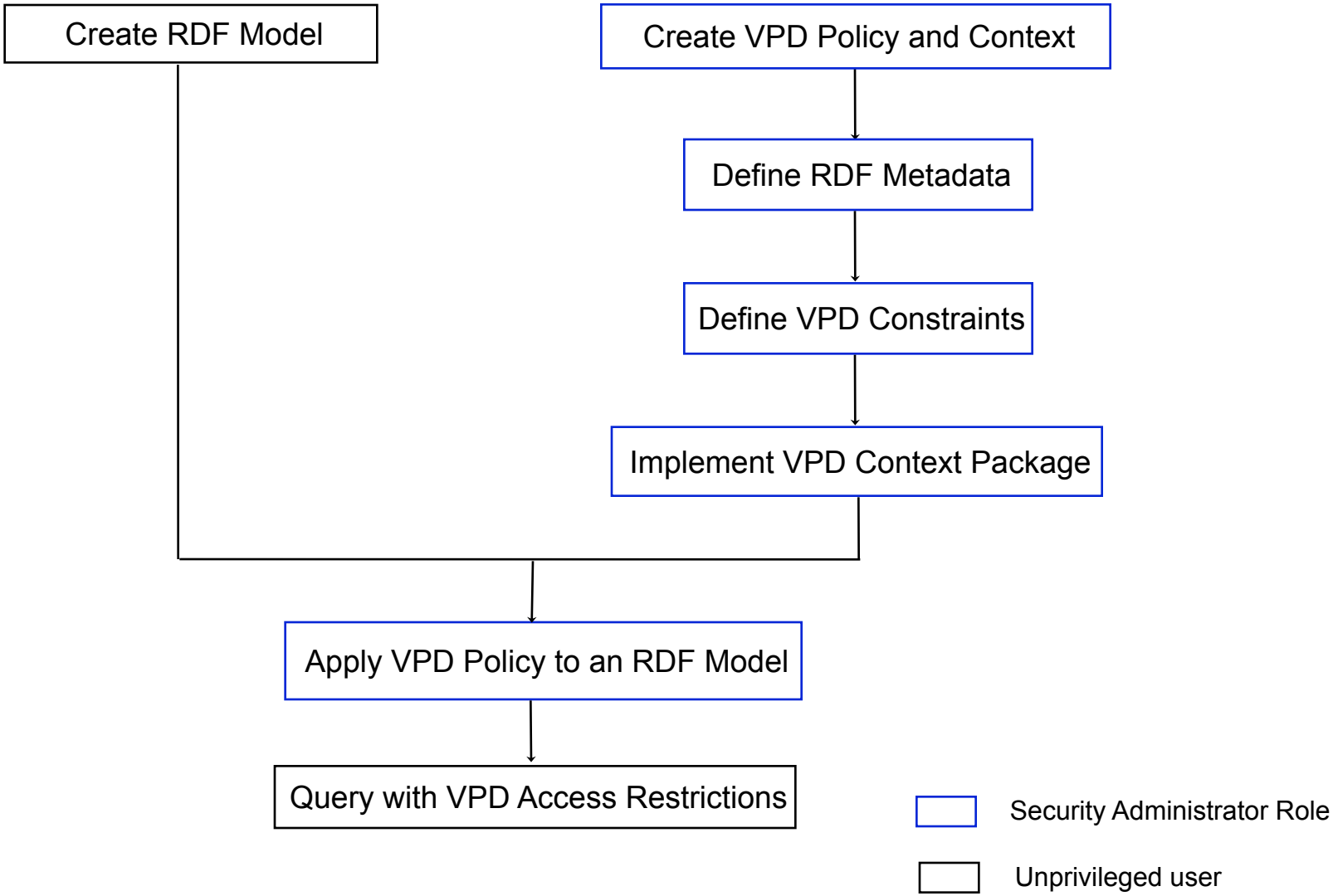
VPD enabled RDF



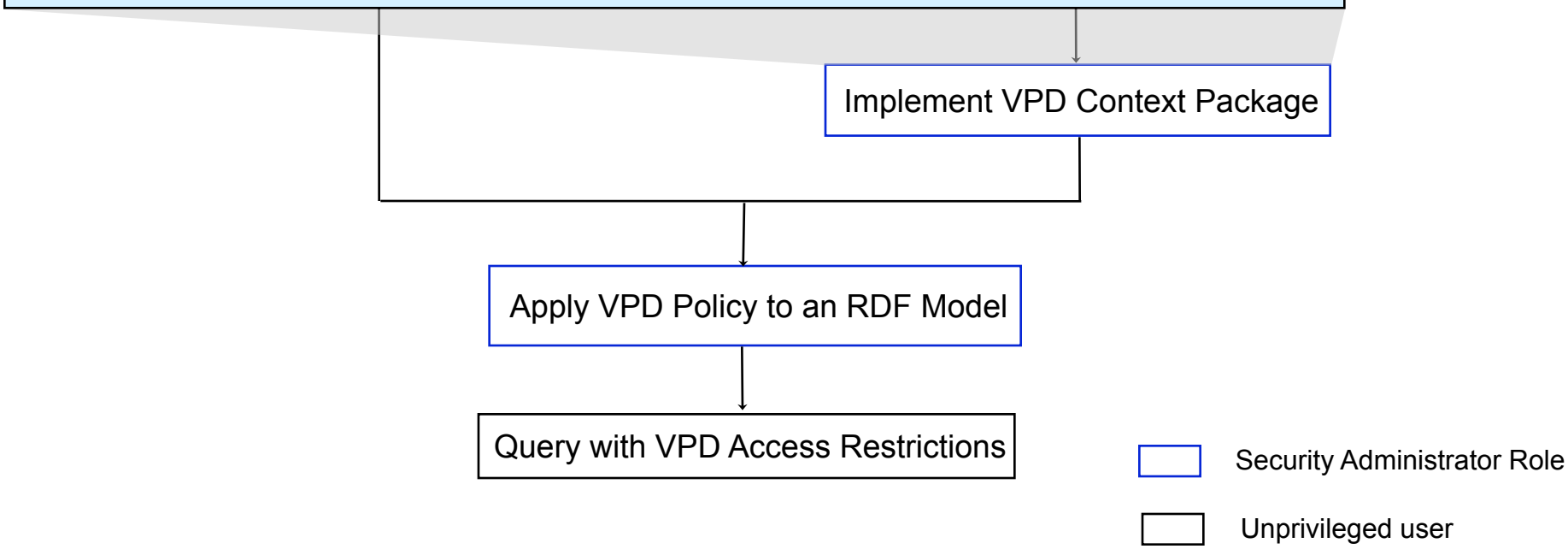

```
SQL> -- Constraint on Project class for users with Project lead role --
SQL> begin
  2     sem_rd
  3       poli
  4       cons
  5       matc
  6       appl
  7
  8       cons
  9   end;
 10   /
PL/SQL proced
```

```
SQL> -- A department VP's access to project value --
SQL> begin
  2     sem_rdfsa.add_vpd_constraint(
  3       policy_name     => 'contracts_policy',
  3       constr_name     => 'vps_access_to_project_value',
  4       match_pattern   => ' { ?proj prjp:hasValue ?val } ',
  5       apply_pattern   => ' { ?proj prjp:ownedBy ?dept .
  6                           ?dept prjp:hasVP
  7                             "sys_context(''sa$userenv'',''app_user'')"^^orardf:instruction }',
  8       constr_group => 'VP');
  9   end;
 10   /
PL/SQL procedure successfully completed.
```

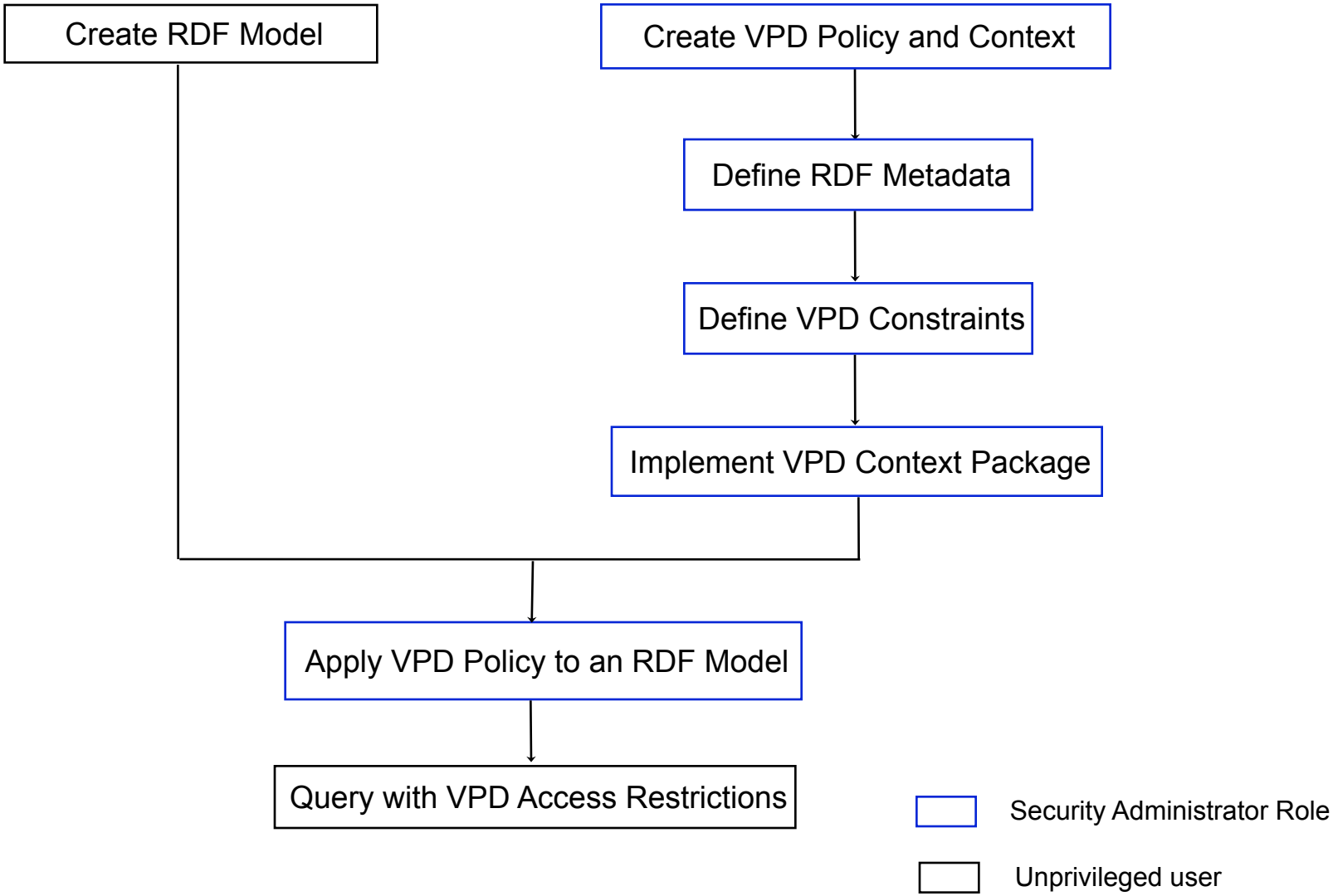
VPD enabled RDF



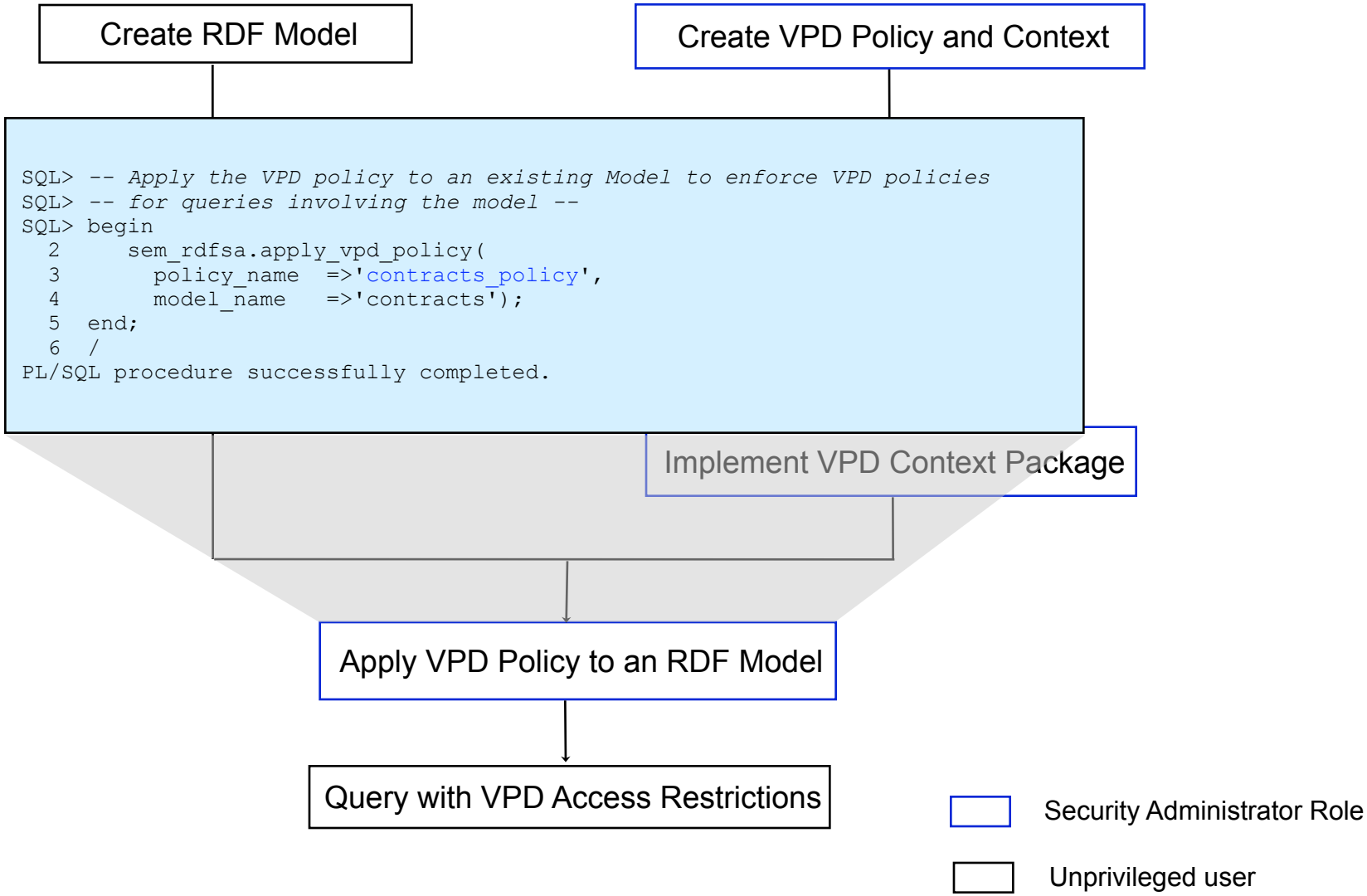
```
SQL> -- Implement the VPD policy context package to activate appropriate constraint groups
SQL> -- based on the application context
SQL> CREATE OR REPLACE PACKAGE BODY contracts_ctxpack
  2    PROCEDURE set_ctx_at_logon
  3      hrdata  HrTable%ROWTYPE;
  3    BEGIN
  4      SELECT * into hrdata FROM HrTable WHERE guid = sys_context('userenv','current_user');
  5      dbms_session.set_context('contracts_appctx', sem_rdfsa.VPD_DEF_CONSTR_ENFORCE, '0');
  5      if (hrdata.emprole = 'VP') then
  6        dbms_session.set_context('contracts_appctx', 'VP', '1');
  7      elsif (hrdata.emprole = 'PROJECT_LEAD') then
  8        dbms_session.set_context('contracts_appctx', 'PROJECT_LEAD','1');
  9      elsif
 ..        ..
 15      else
 16       dbms_session.set_context('contracts_appctx', sem_rdfsa.VPD_DEF_CONSTR_ENFORCE, '1');
 18      end if;
 19   END;
 ..   ..
```



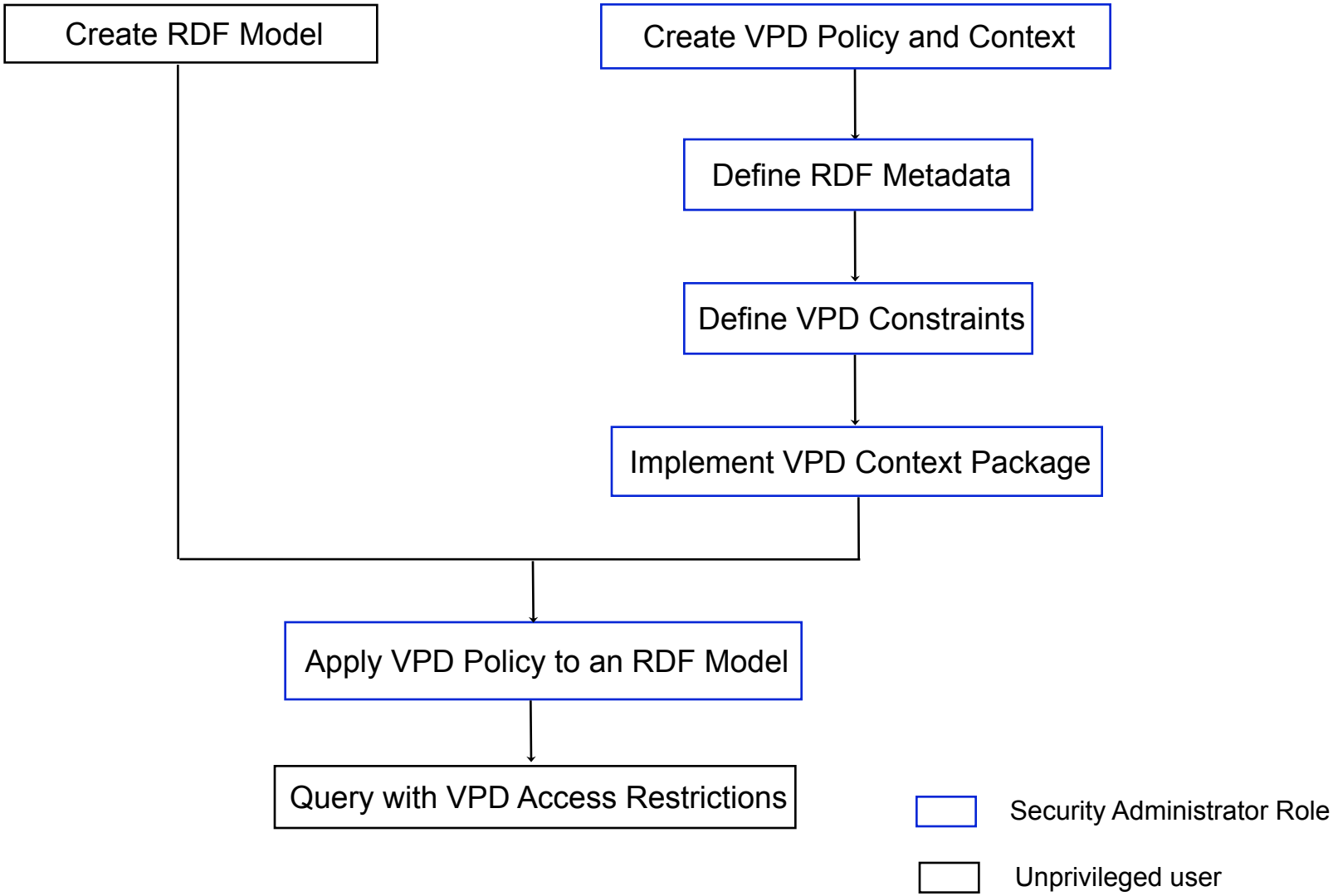
VPD enabled RDF



VPD enabled RDF



VPD enabled RDF



```
SQL> -- set some dummy context based on the user logged in --
SQL> connect susan/i_am_a_vp
Connected.
SQL> select prj, status, val
  2  from table(sem_match('sparql{ ?prj pred:hasStatus ?status . OPTIONAL { ?prj pred:hasValue ?val } }',
  3             sem_models('contracts'),null, ...));
PRJ                                        STATUS                                            VAL
------------------------------------------ ------------------------------------------------ ------------
http://www.myorg.com/contract/projectHLS   http://www.myorg.com/contract/status/Complete   100000
http://www.myorg.com/contract/projectDMV   http://www.myorg.com/contract/status/Active     150000

SQL> connect andy/i_am_a_project_lead
Connected.
SQL> select prj, status, val
  2  from table(sem_match('sparql{ ?prj pred:hasStatus ?status . OPTIONAL { ?prj pred:hasValue ?val } }',
  3             sem_models('contracts'),null, ... ));

PRJ                                        STATUS                                            VAL
------------------------------------------ ------------------------------------------------ -------------
http://www.myorg.com/contract/projectDMV   http://www.myorg.com/contract/status/Active     150000

SQL> connect bob/i_am_a_team_member
Connected.
SQL> select prj, status, val
  2  from table(sem_match('sparql{ ?prj pred:hasStatus ?status . OPTIONAL { ?prj pred:hasValue ?val } }',
  3             sem_models('contracts'),null, ... ));

PRJ                                        STATUS                                            VAL
------------------------------------------ ------------------------------------------------ -------------
http://www.myorg.com/contract/projectDMV   http://www.myorg.com/contract/status/Active
```

Query with VPD Access Restrictions

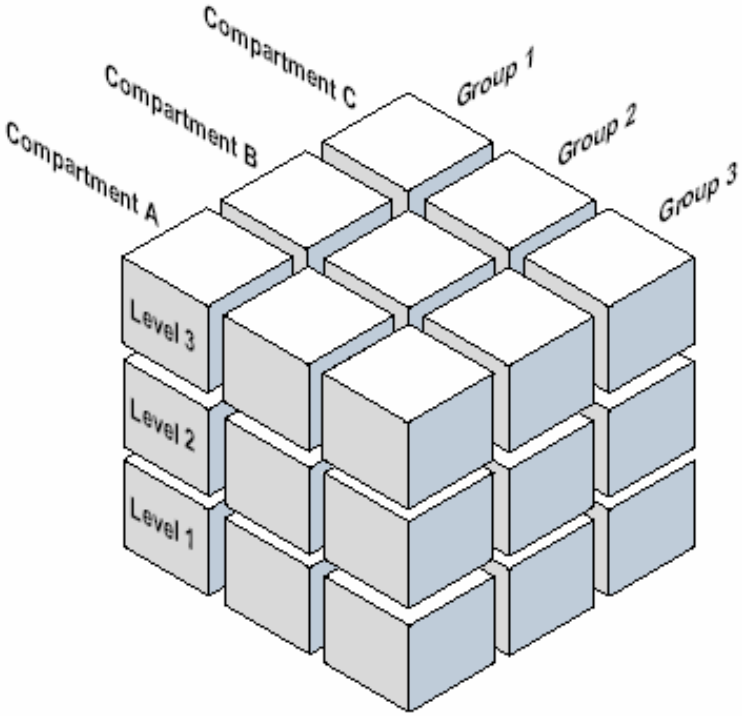
Security Administrator Role

Unprivileged user

Data Classification Labels for Access Control

Label Components:

- Levels – Determine the vertical sensitivity of data and the highest classification level a user can access.
- Compartments – Facilitate compartmentalization of data. Users need exclusive membership to a compartment to access its data.
- Groups – Allow hierarchical categorization of data. A user with authorization to a parent group can access data in any of its child groups.



CONF : NAVY,MILITARY : NY,ON → *Data Label matches User Access Label* ↓

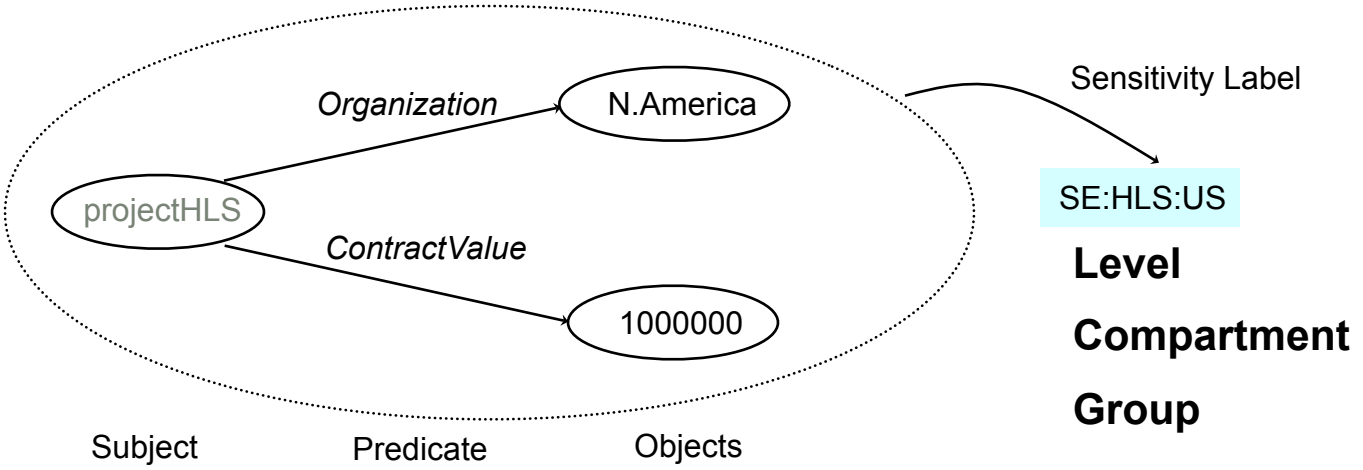
HIGHCONF : MILITARY,NAVY,SPCLOPS : US,UK

Oracle Label Security for RDF Data

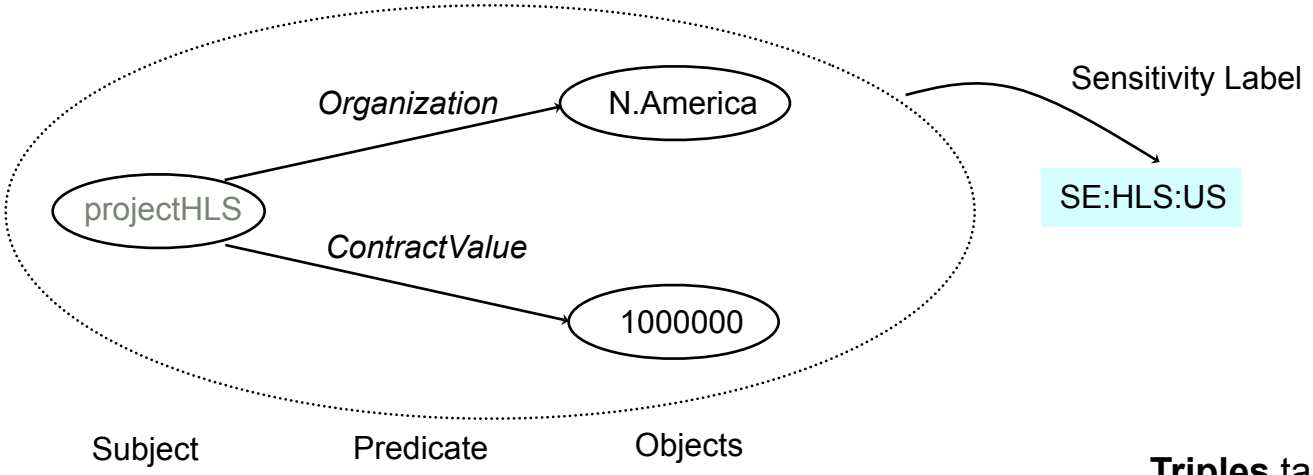
- Oracle Label Security enforces security at the “row” level.
  - Attempts to access key or non-key columns of a *specific row* are validated using row/data sensitivity labels.

ContractID	Organization	ContractValue	RowLabel
ProjectHLS	N. America	1000000	SE:HLS:US

- Notion of “row” does not exist for RDF data
  - Conceptually, a relational table row maps to a set of triples and the sensitivity label applies to the complete set.



Securing triples with sensitivity labels

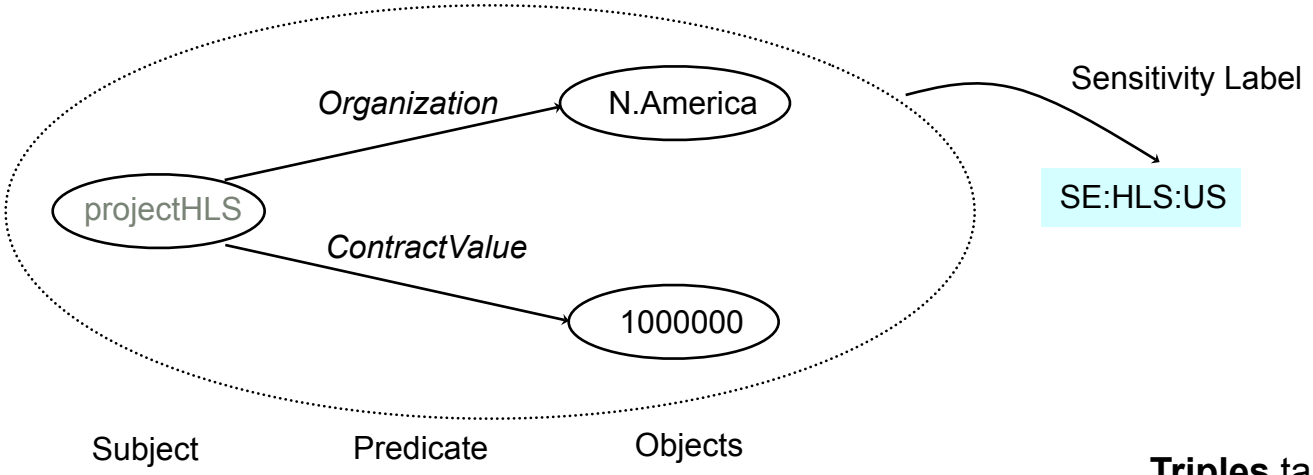


Triples table

Subject	Predicate	Object	RowLabel
projectHLS	Organization	N.America	SE:HLS:US
projectHLS	ContractValue	1000000	SE:HLS:US

- The user's read access label must cover (= or >) the triple's sensitivity label for the user to read the triple.
- Triples describing a single resource may employ different sensitivity labels for greater control.

Securing triples with sensitivity labels



Triples table

Subject	Predicate	Object	RowLabel
projectHLS	Organization	N.America	SE:HLS:US
projectHLS	ContractValue	1000000	SE:HLS,FIN:US

- The user's read access label must cover (= or >) the triple's sensitivity label for the user to read the triple.
- Triples describing a single resource may employ different sensitivity labels for greater control.

Securing RDF Data – Write Access

- Securing Subjects : Sensitivity label associated with a *Subject* determines the minimum access label for all the triples with the subject.

```
Subject: <http://../contract/projectHLS>        SE:HLS:US
```

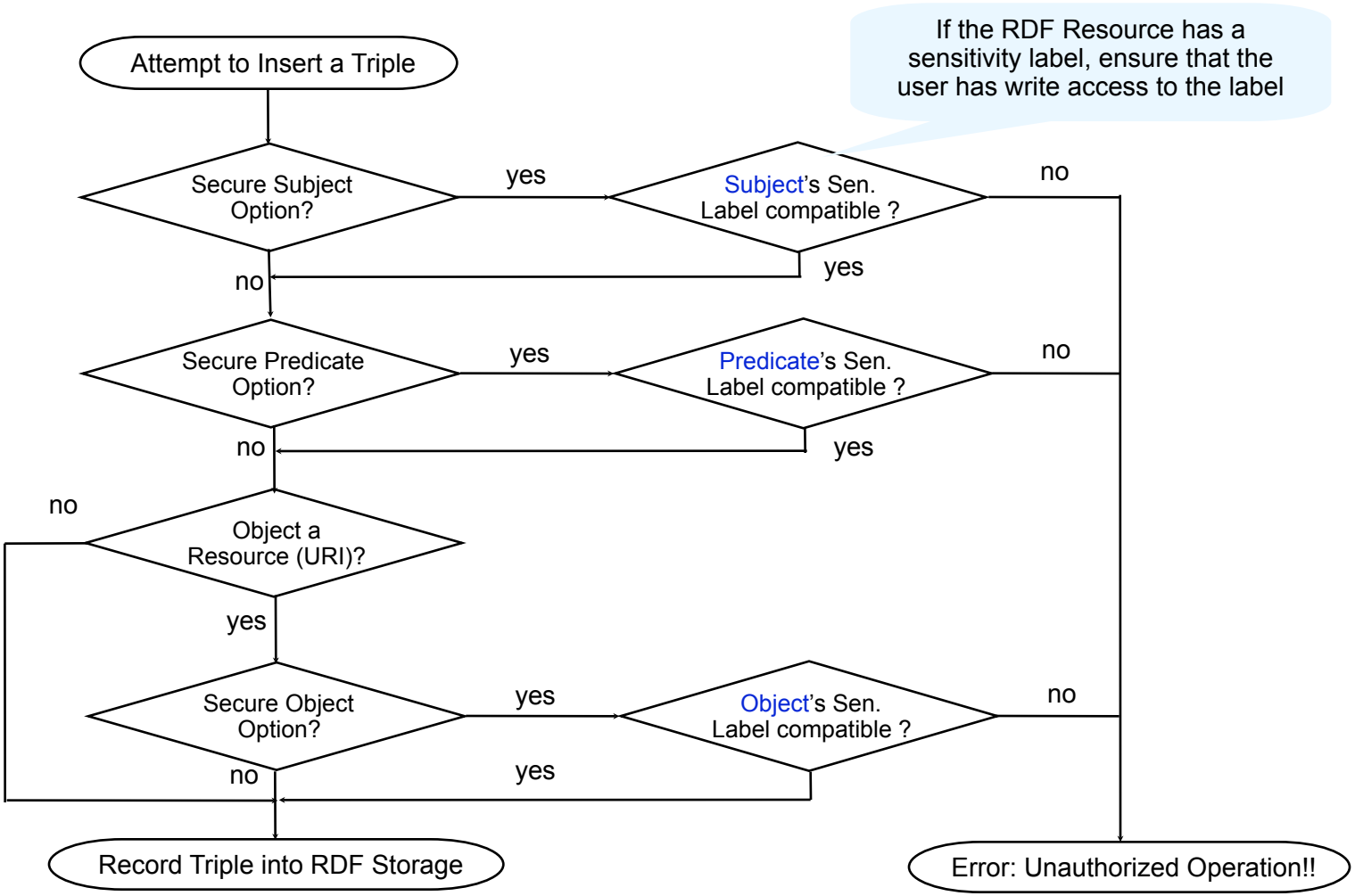
- Securing Predicates : Sensitivity label associated with a *Predicate* determines the minimum access label for the triples involving the predicate type

```
Predicate: hasContractValue                     TS:FIN:
```

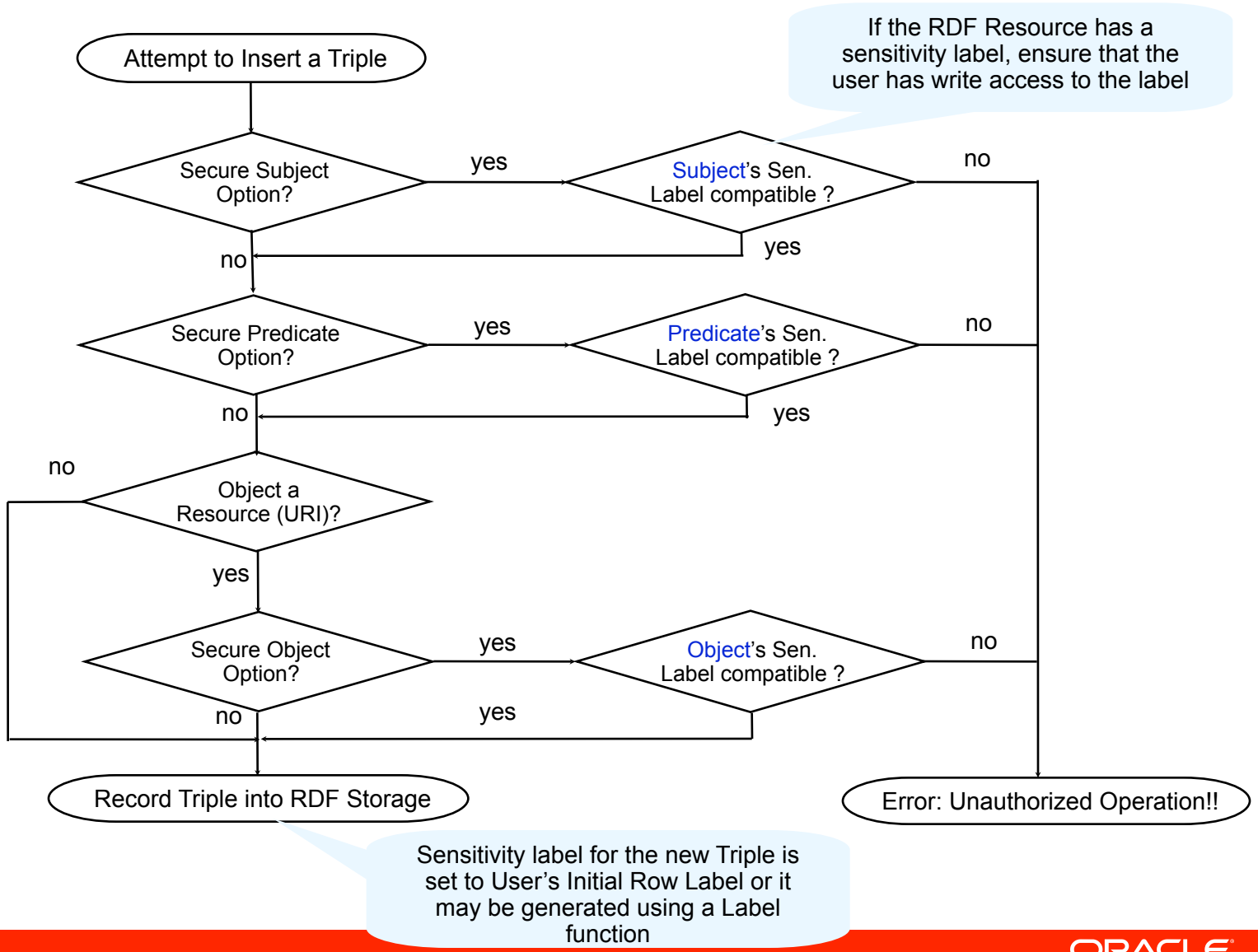
- Securing Objects: Sensitivity label associated with a resource (URI) determines the minimum access label for the triples using this resource as *Object*.

```
Resource: <http://../contractType/Govt>         SE::
Triple: <.../projectHLS> isA
                        <../contractType/Govt>
```

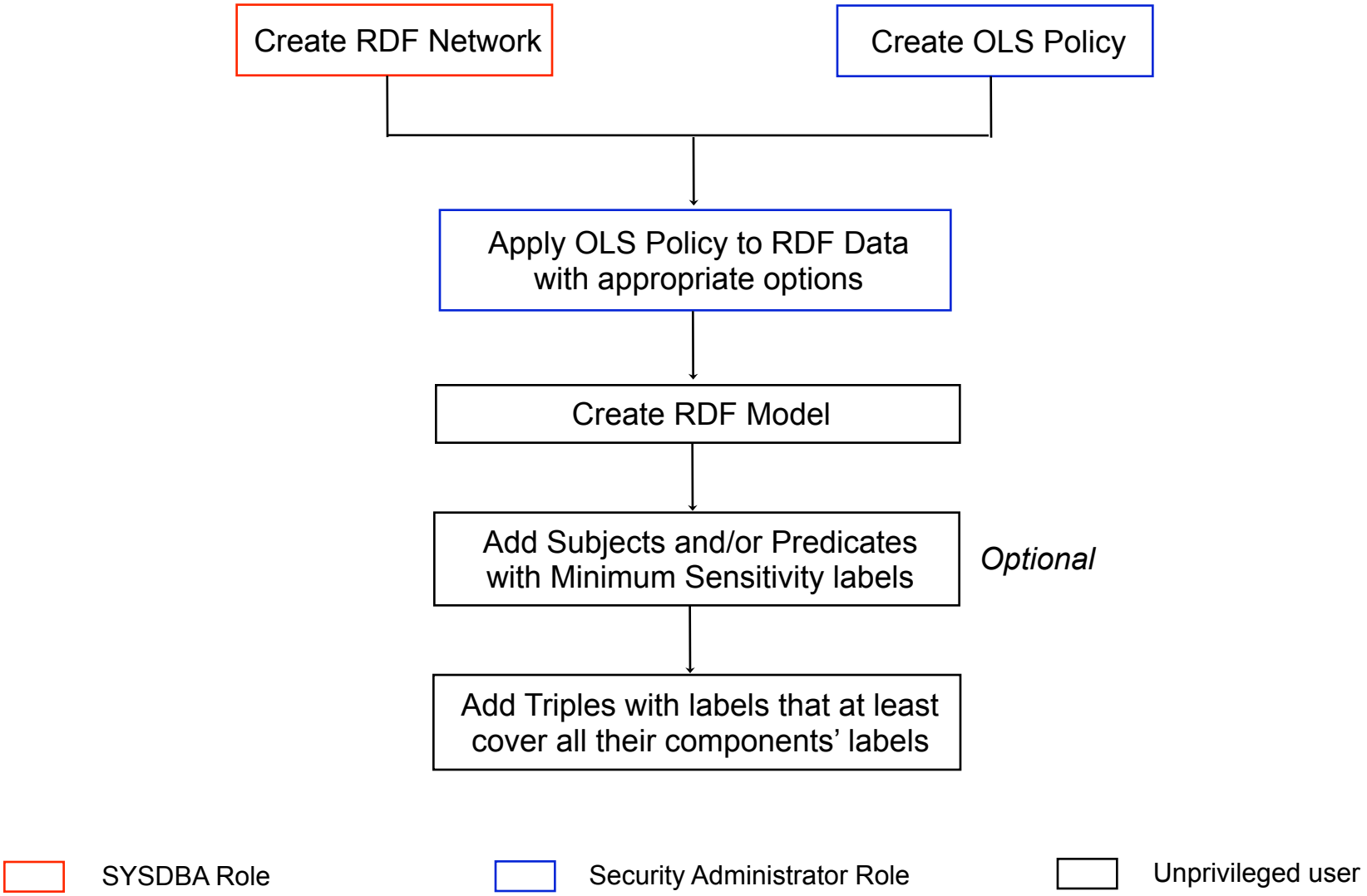
Policy enforcement for Insert operations



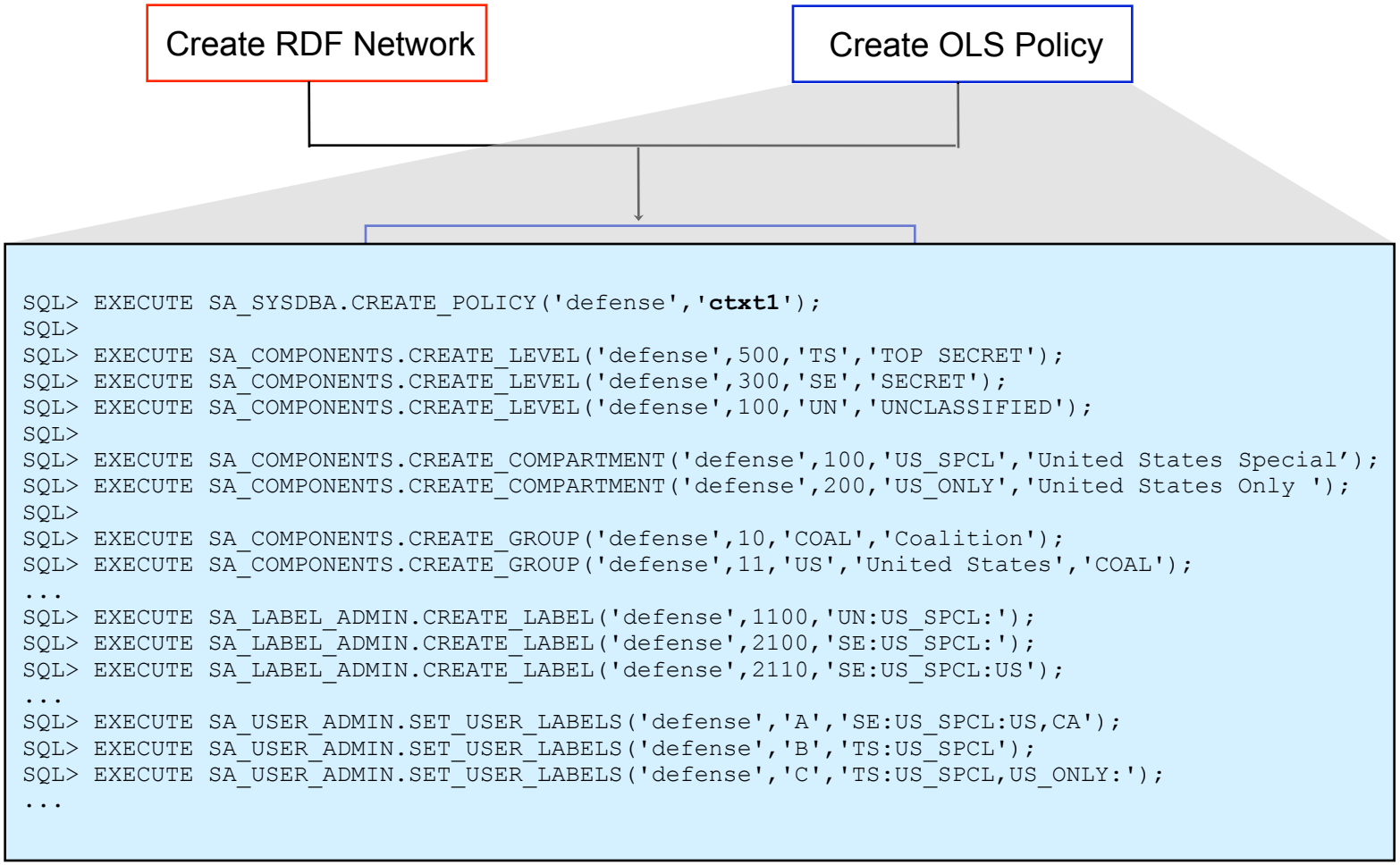
Policy enforcement for Insert operations



OLS enabled RDF



OLS enabled RDF

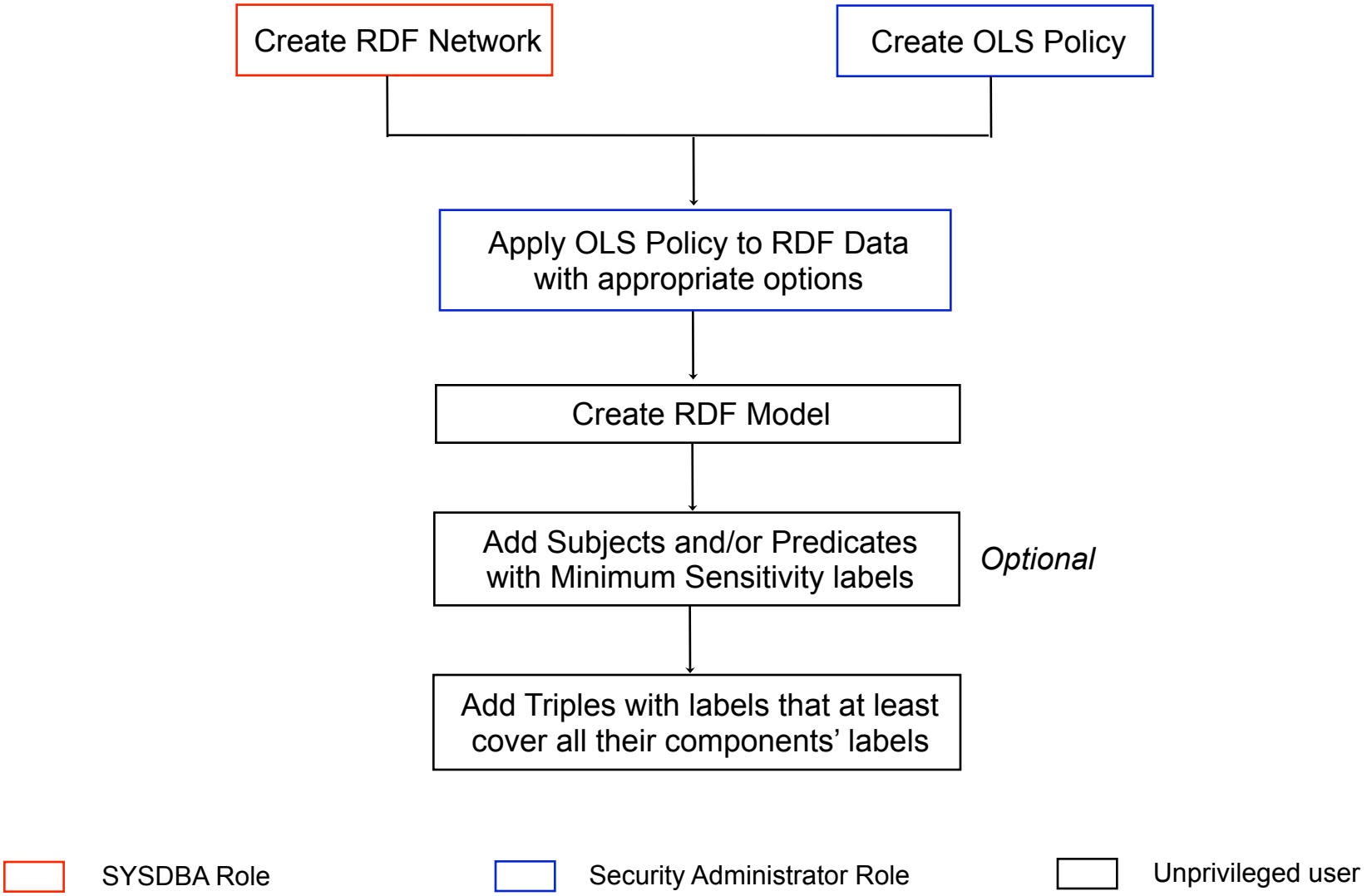


SYSDBA Role

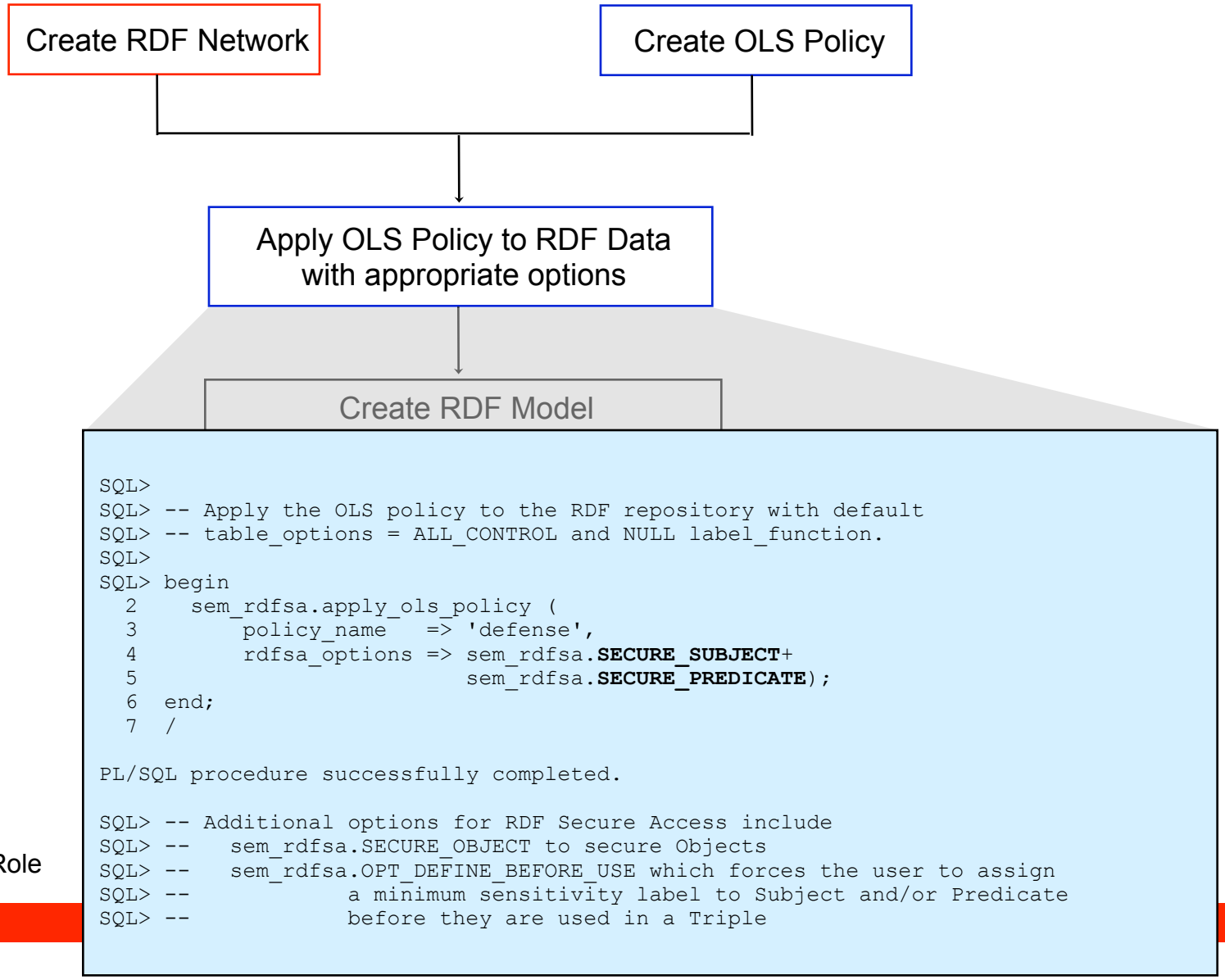
Security Administrator Role

Unprivileged user

OLS enabled RDF



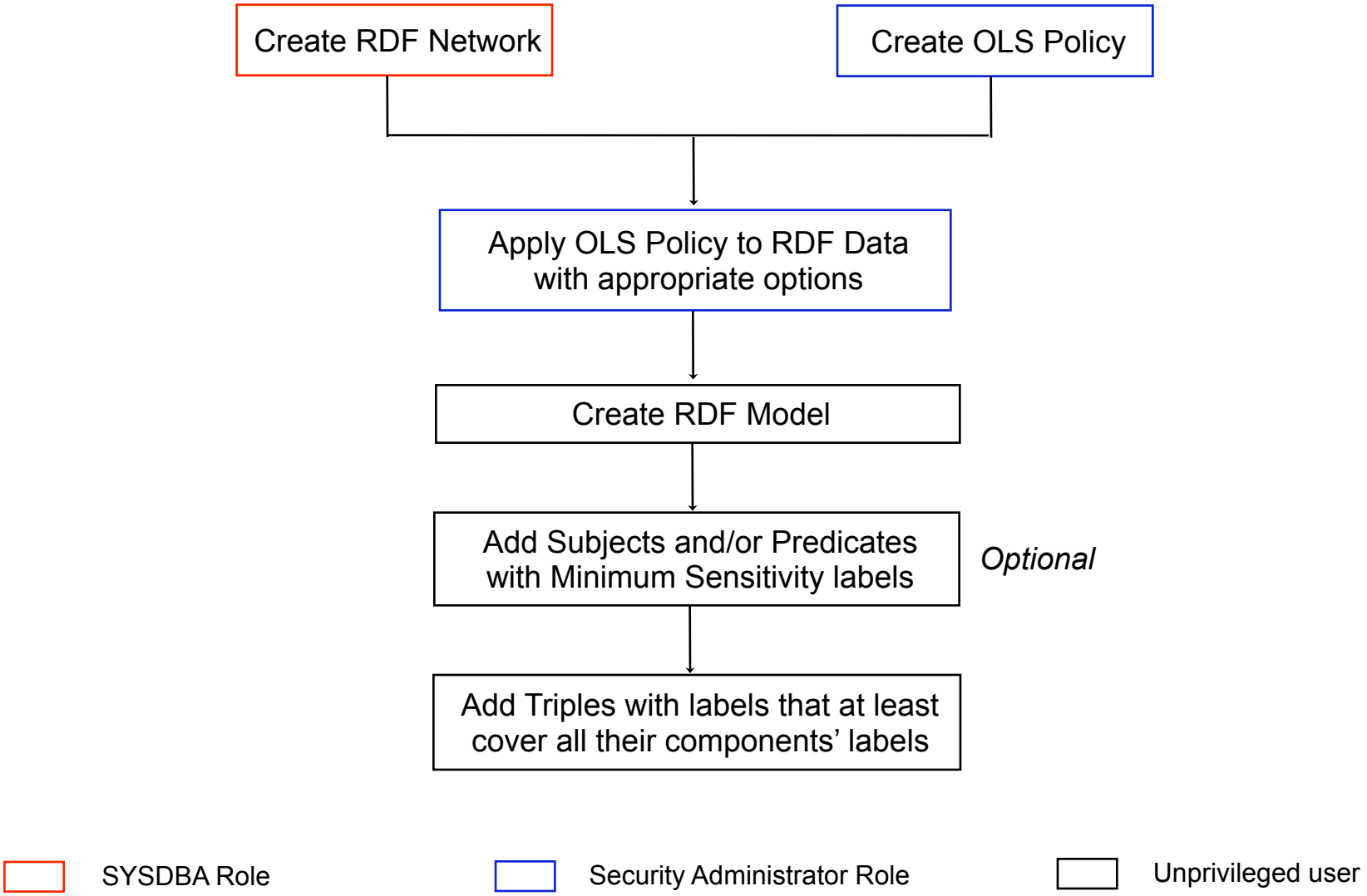
OLS enabled RDF



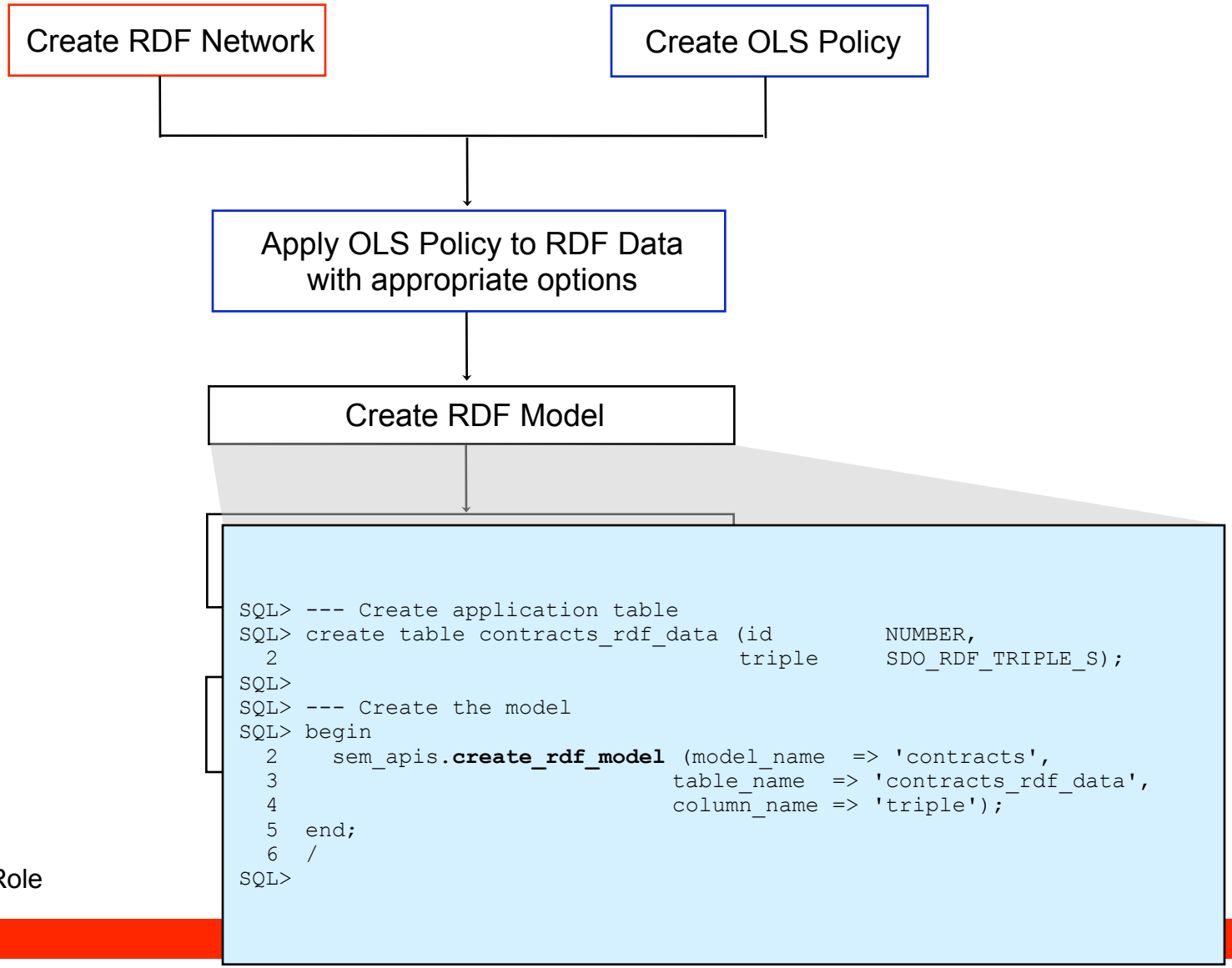

```
SQL>
SQL> -- Apply the OLS policy to the RDF repository with default
SQL> -- table_options = ALL_CONTROL and NULL label_function.
SQL>
SQL> begin
  2    sem_rdfsa.apply_ols_policy (
  3        policy_name   => 'defense',
  4        rdfsa_options => sem_rdfsa.SECURE_SUBJECT+
  5                         sem_rdfsa.SECURE_PREDICATE);
  6  end;
  7  /

PL/SQL procedure successfully completed.

SQL> -- Additional options for RDF Secure Access include
SQL> --   sem_rdfsa.SECURE_OBJECT to secure Objects
SQL> --   sem_rdfsa.OPT_DEFINE_BEFORE_USE which forces the user to assign
SQL> --            a minimum sensitivity label to Subject and/or Predicate
SQL> --            before they are used in a Triple
```

SYSDBA Role

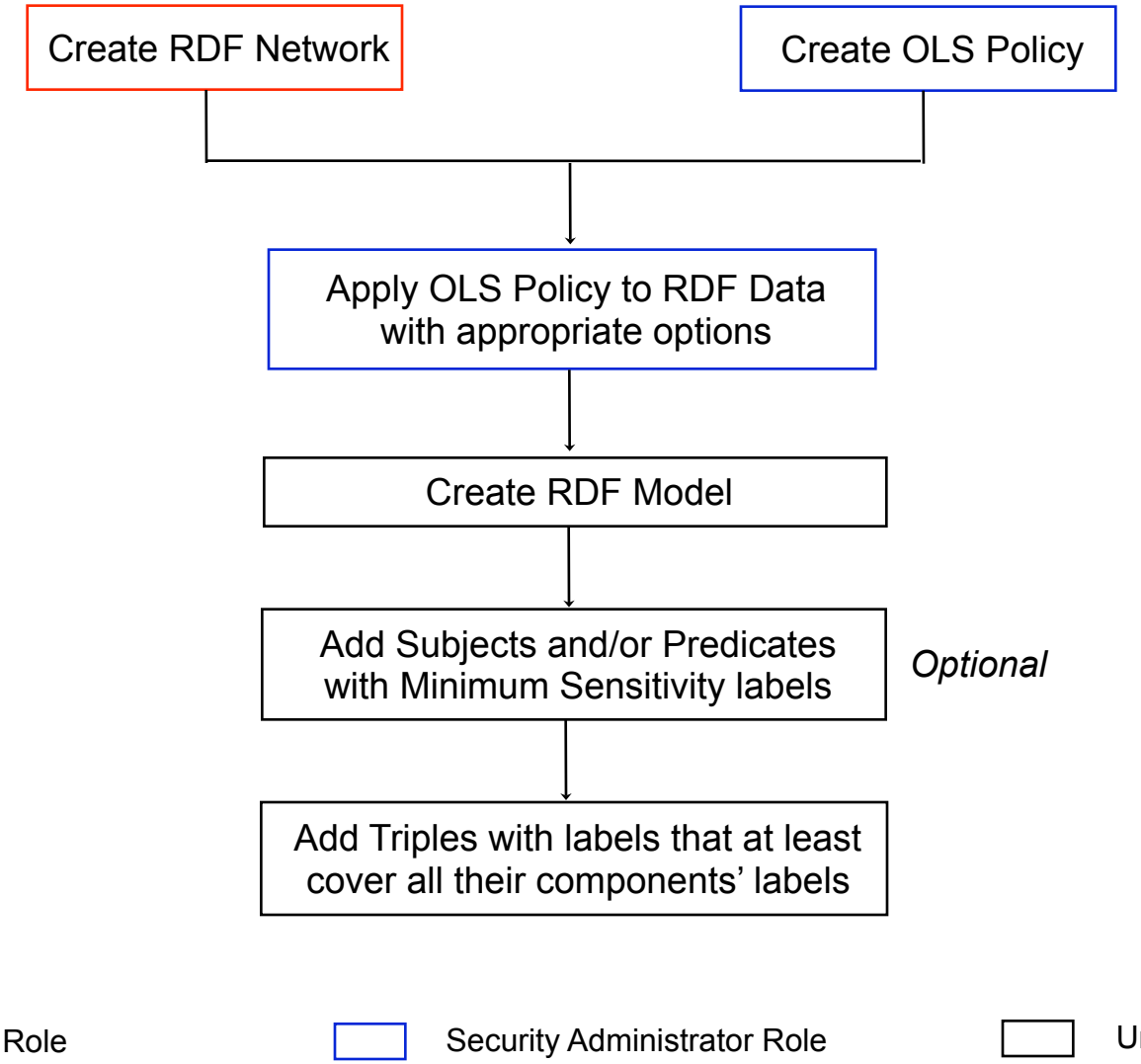
OLS enabled RDF



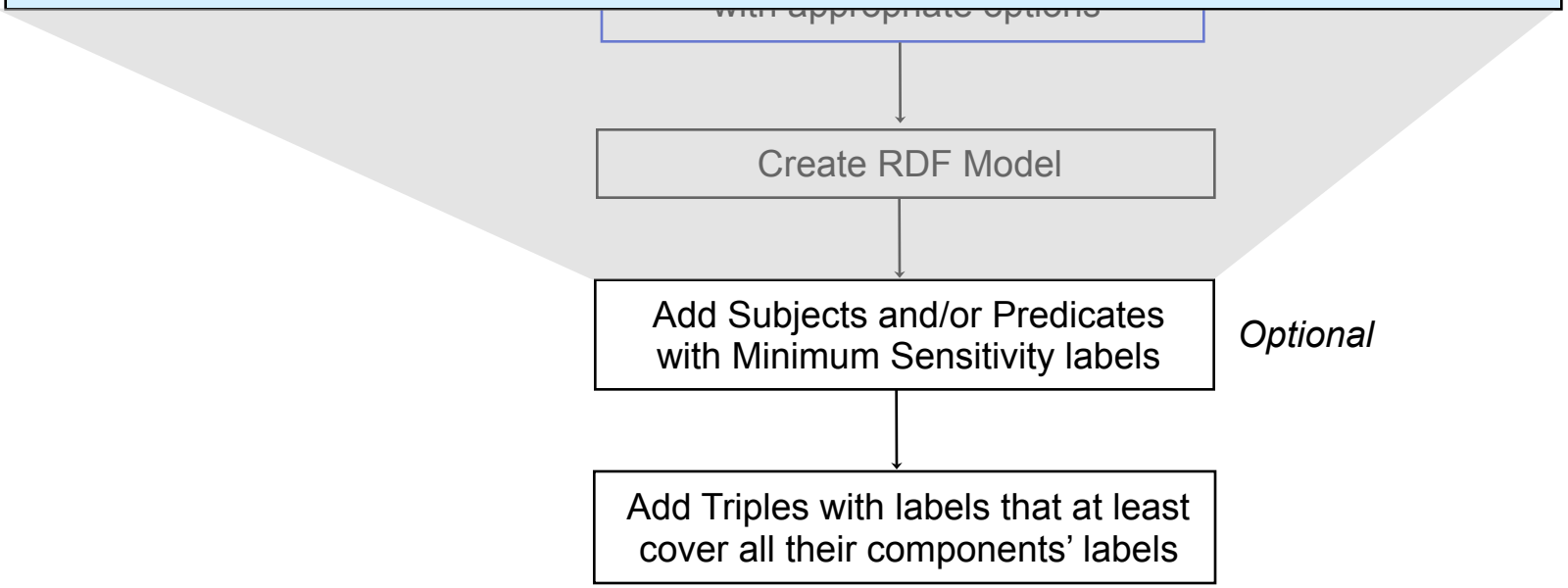
OLS enabled RDF



OLS enabled RDF



```
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label from dual;

INITIAL_LABEL
-------------------------
SE:US_SPCL:US,CA
SQL>
SQL> begin
  2    sem_rdfsa.set_resource_label(
  3              model_name   => 'contracts',
  4              subject      => 'http://www.myorg.com/contract/projectHLS',
  5              label_string => 'SE:US_SPCL:US');
  6  end;
  7  /
SQL>
```



SYSDBA Role

Security Administrator Role

Unprivileged user

```
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label from dual;

INITIAL_LABEL
-------------------
SE:US_SPCL:US,CA
SQL>
SQL> begin
  2     sem_rdfsa.se
  3                m
  4                s
  5                l
  6   end;
  7   /
SQL>
```

```
SQL> -- user's MIN Write and MAX Write are enforced
SQL> begin
  2     sem_rdfsa.set_predicate_label(
  3                model_name   => 'contracts',
  4                predicate    => 'http://www.myorg.com/pred/hasValue',
  5                label_string => 'TS:US_SPCL');
  6   end;
  7   /
begin
*
ERROR at line 1:
ORA-55359: unauthorized operation with policy DEFENSE - 28115
```

Create RDF Model

Add Subjects and/or Predicates with Minimum Sensitivity labels

Optional

Add Triples with labels that at least cover all their components' labels

SYSDBA Role

Security Administrator Role

Unprivileged user

```
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label from dual;

INITIAL_LABEL
-------------------
SE:US_SPCL:US,CA
SQL>
SQL> begin
  2    sem_rdfsa.se
  3                m
  4                s
  5                l
  6  end;
  7  /
SQL>
```

```
SQL
SQL
  2
  3
  4
  5
  6
  7
beg
*
ERR
ORA
```

```
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label ..

INITIAL_LABEL
-------------------------
TS:US_SPCL:US,CA
SQL>
SQL> begin
  2    sem_rdfsa.set_predicate_label(
  3                model_name   => 'contracts',
  4                predicate    => 'http://www.myorg.com/pred/hasValue',
  5                label_string => 'TS:US_SPCL');
  6  end;
  7  /
SQL>
```

Add Subjects and/or Predicates with Minimum Sensitivity labels

Optional

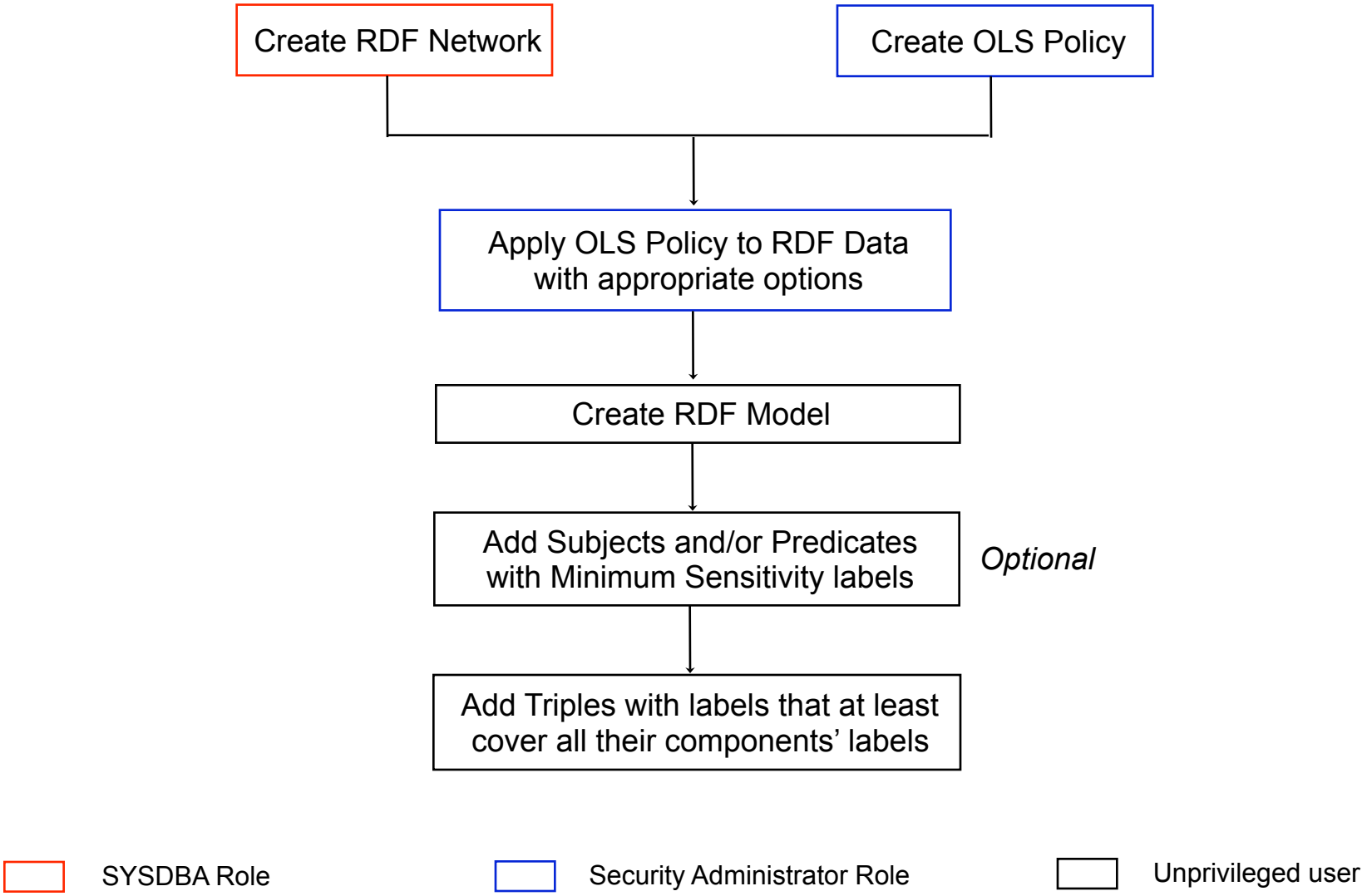
Add Triples with labels that at least cover all their components' labels

SYSDBA Role

Security Administrator Role

Unprivileged user

OLS enabled RDF



OLS enabled R

Create R

```
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label ..

INITIAL_LABEL
-------------------------
SE:US_SPCL:US,CA
SQL>
SQL> insert into a.contracts_rdf_data values (1,
  2    sdo_rdf_triple_s ('contracts','http://www.myorg.com/contract/projectHLS',
  3                                  'http://www.myorg.com/pred/drivenBy',
  4                                  'http://www.myorg.com/department/Dept1'));
SQL>
SQL> insert into a.contracts_rdf_data values (2,
  2    sdo_rdf_triple_s ('contracts','http://www.myorg.com/contract/projectHLS',
  3                                  'http://www.myorg.com/pred/hasValue',
  4                                  '"100000"^^xsd:integer'));
  sdo_rdf_triple_s ('contracts','http://www.myorg.com/contract/projectHLS',
  *
ERROR at line 2:
ORA-55359: unauthorized operation with policy DEFENSE
```

Add Subjects and/or Predicates with Minimum Sensitivity labels

Optional

Add Triples with labels that at least cover all their components' labels

SYSDBA Role

Security Administrator Role

Unprivileged user

OLS enabled R

```
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label ..

INITIAL_LABEL
-------------------------
```

```
myorg.com/contract/projectHLS',
yorg.com/pred/drivenBy',
yorg.com/department/Dept1'));

myorg.com/contract/projectHLS',
yorg.com/pred/hasValue',
d:integer'));
.com/contract/projectHLS',

ENSE
```

```
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label ..

INITIAL_LABEL
-------------------------
TS:US_SPCL:US,CA
SQL>
SQL>
SQL> insert into a.contracts_rdf_data values (3,
  2    sdo_rdf_triple_s ('contracts','http://www.myorg.com/contract/projectHLS',
  3                                  'http://www.myorg.com/pred/hasValue',
  4                                  '"100000"^^xsd:integer'));
SQL> commit;
```

Add Subjects and/or Predicates with Minimum Sensitivity labels

Optional

Add Triples with labels that at least cover all their components' labels

SYSDBA Role

Security Administrator Role

Unprivileged user

OLS enabled R

```
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label ..

INITIAL_LABEL
-------------------------
```

```
myorg.com/contract/projectHLS',
yorg.com/pred/drivenBy',
yorg.com/department/Dept1'));

myorg.com/contract/projectHLS',
yorg.com/pred/hasValue',
d:integer'));
.com/contract/projectHLS',

ENSE
```

```
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label ..

INITIAL_LABEL
-------------------------
TS:US_SPCL:US,CA
SQL>
SQL>
SQL> insert into a.contracts_rdf_data values (3,
  2    sdo_rdf_triple_s ('contracts','http://www.myorg.com/contract/projectHLS',
  3                                  'http://www.myorg.com/pred/hasValue',
  4                                  '"100000"^^xsd:integer'));
SQL> commit;
```

Add Subjects and/or Predicates with Minimum Sensitivity labels

Optional

Add Triples with labels that at least cover all their components' labels

SYSDBA Role

Security Administrator Role

Unprivileged user

RDF and OLS : Query

```
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label from dual;

INITIAL_LABEL
-------------------------
SE:US_SPCL:US,CA
SQL>
SQL> select s, p from TABLE(SEM_MATCH('{ ?s ?p ?o }',
  2                          SEM_Models('Contracts'), null, null, null));

S                                          P
------------------------------------------ ------------------------------------------
http://www.myorg.com/contract/projectHLS http://www.myorg.com/pred/drivenBy
SQL>
SQL> connect e/e
Connected.
SQL> select sys_context('sa$defense_x','initial_row_label') as initial_label from dual;
INITIAL_LABEL
-------------------------
TS:US_SPCL,FIN:US,CA
SQL>
SQL> select s, p from TABLE(SEM_MATCH(' { ?s ?p ?o }',
  2                          SEM_Models('Contracts'), null, null, null));

S                                           P
------------------------------------------ ------------------------------------------
http://www.myorg.com/contract/projectHLS http://www.myorg.com/pred/hasValue
http://www.myorg.com/contract/projectHLS http://www.myorg.com/pred/drivenBy
SQL>
```

Label Generation for Inferred Triple

- Predefined Label Generators:
  - Use Subject Label: Use *subject's* label as the label for the triple.
  - Use Predicate Label: Use *predicate's* label as the label for the triple.
  - Use Object Label: Use the label associated with the resource in the *object* position as the label for the inferred triple.
  - Use Rule Label: Use the label associated with the (last) *rule* inferring the triple as the label for the triple.
  - Use Dominating Label: Use all available component labels to determine the dominating one and assign it as the label for the triple.
- Custom Label Generators using Extensibility:
  - Use Component & Rule Labels: Use *custom* logic with Subject, Predicate, Object, and Rule labels to generate a label for the triple.
  - Use Antecedents' Labels: Conflict resolution based on the labels for antecedent triples generating the current triple.

ORACLE OPEN WORLD

Semantic Indexing for Documents

Semantic Indexing for Documents

- Links people – places – things – events to documents stored in Oracle Database through a semantic index
- Supports popular natural language processing tools that extract semantic metadata from documents, such as OpenCalais from Thomson Reuters and GATE.
- Provides a SQL interface for SPARQL queries to find documents of interest
- Ability to combine Domain Ontologies with extracted metadata to facilitate Ontology-Assisted searches
- Extends the power of Oracle Database to include semantic matching in cross-domain queries.

Semantic Indexing for Documents

- Create a semantic index on documents stored in Oracle Database using third-party entity extractors.
  - Out-of-the box support for OpenCalais from Thomson Reuters & General Architecture for Text Engineering (GATE).
  - Extensible framework to plug-in any information extractor.
- Embed SPARQL graph pattern queries in SQL to find documents of interest and return relevant information

  E.g., Find documents that refer to some financial business organizations in the context of Bailout.

```
SELECT docId, SEM_CONTAINS_SELECT(1) result FROM Newsfeed
WHERE SEM_CONTAINS (article,
    '{ ?org     rdf:type            c:Organization .
       ?org     pred:categoryName   c:BusinessFinance .
       ?event   pred:event          c:Bailout' ) = 1
```

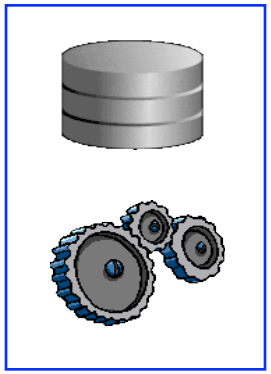
Semantic Search - Key Components

- Extensible Information Extractor
  - Programmable API to plug-in 3rd party extractors into the database.
- SEM_CONTAINS Operator
  - To identify documents of interest based on their extracted metadata, using standard SQL queries.
- SEM_CONTAINS_SELECT Ancillary Operator
  - To return relevant information about the documents matched using SEM_CONTAINS operator.
- SemContext Index type
  - Index type that interacts with the extractor to manage the metadata extracted from the documents efficiently and facilitates semantic search.

Extracting RDF from Documents

Indiana authorities filed felony charges and a court issued an arrest warrant for a financial manager who apparently tried to fake his death by crashing his airplane in a Florida swamp. Marcus, 38, remained on the lam Tuesday afternoon, two days after authorities say he staged his disappearance and then rode out of a small Alabama town on a red motorcycle under cover of darkness.

Input Document



Domain Ontologies

Document Processor

Information Extractor

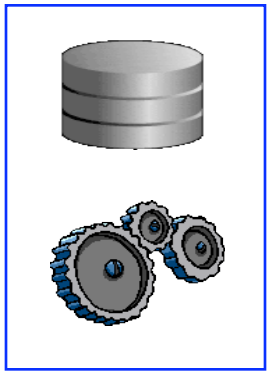
```
<rdf:RDF>
  <rdf:Description  rdf:about="http://../Marcus">
    <rdf:type rdf:resource="http://../Person"/>
    <p:hasName .. >Marcus</c:name>
    <p:hasAge .. >38</c:age>
    <p:hasGender .. >Male</c:gender>
  </rdf:Description>
  <rdf:Description rdf:about="http://../FloridaSwamp">
   <rdf:type rdf:resource="http://../NaturalFeature"/>
   <c:hasLocation>Florida</c:location> …
  </rdf:Description>
  …
</rdf:RDF>
```

RDF/XML Output

Extracting RDF from Documents

Indiana authorities filed felony charges and a court issued an arrest warrant for a financial manager who apparently tried to fake his death by crashing his airplane in a Florida swamp. Marcus, 38, remained on the lam Tuesday afternoon, two days after authorities say he staged his disappearance and then rode out of a small Alabama town on a red motorcycle under cover of darkness.

Input Document



Information Extractor

Domain Ontologies

Document Processor

```
<rdf:RDF>
  <rdf:Description  rdf:about="http://../Marcus">
    <rdf:type rdf:resource="http://../Person"/>
    <p:hasName .. >Marcus</c:name>
    <p:hasAge .. >38</c:age>
    <p:hasGender .. >Male</c:gender>
  </rdf:Description>
  <rdf:Description rdf:about="http://../FloridaSwamp">
   <rdf:type rdf:resource="http://../NaturalFeature"/>
   <c:hasLocation>Florida</c:location> …
  </rdf:Description>
  …
</rdf:RDF>
```

RDF/XML Output

	DocId	Article
r1	1	Indiana authorities filed felony charges and a court issued an arrest warrant for a financial manager who apparently tried to fake his death …
r2	2	Major dealers and investors in over-the-counter derivatives agreed to report all credit ..
	..	

Newsfeed *table*

RDF/XML for each document

NG	Subject	Property	Object
r1	p:Marcus	rdf:type	rc:Person
r1	p:Marcus	pred:hasName	"Marcus"^^xsd:string
r1	p:Marcus	pred:hasAge	"38"^^xsd:integer
..	..	..	..
r2	c:AcmeCorp	rdf:type	rc:Organization

Triples *table*

Matching Documents with SPARQL

DocId	Article
1	Indiana authorities filed felony charges and a court issued an arrest warrant for a financial manager who apparently tried to fake his death by crashing his airplane in a Florida swamp. Marcus Schrenker, 38 remained on the lam …
2	Major dealers and investors in over-the-counter derivatives agreed to report all credit-default swap trades not cleared through a central counterparty to a central trade repository, the New York Federal ReserveThe New York Fed, which hosted ..
..	

Newsfeed *table*

RDF/XML for each document

NG	Subject	Property	Object
r1	p:Marcus	rdf:type	rc::Person
r1	p:Marcus	pred:hasName	“Marcus”^^xsd:..
r1	p:Marcus	pred:hasAge	“38”^^xsd:integer
..	..	..	..
r2	c:AcmeCorp	rdf:type	rc:Organization
r2	c:AcmeCorp	pred:hasName	“Acme Corp”^^xsd:..
r2	c:AcmeCorp	pred:categoryName	rc:BusinessFinance
..	..	..	..

Triples *table*

Find all articles that match the SPARQL pattern

```
SELECT docId FROM Newsfeed
WHERE  SEM_CONTAINS (Articles,
       { ?org  rdf:type            c:Organization .
         ?org  pred:hasName        “Acme Corp”^^xsd:string .
         ?org  pred:categoryName    c:BusinessFinance
         ... }
```

Matching Documents with SPARQL

DocId	Article
1	Indiana authorities filed felony charges and a court issued an arrest warrant for a financial manager who apparently tried to fake his death by crashing his airplane in a Florida swamp. Marcus Schrenker, 38 remained on the lam …
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..	

Newsfeed *table*

RDF/XML for each document

NG	Subject	Property	Object
r1	p:Marcus	rdf:type	rc::Person
r1	p:Marcus	pred:hasName	“Marcus”^^xsd:..
r1	p:Marcus	pred:hasAge	“38”^^xsd:integer
..	..	..	..
r2	c:AcmeCorp	rdf:type	rc:Organization
r2	c:AcmeCorp	pred:hasName	“Acme Corp”^^xsd:..
r2	c:AcmeCorp	pred:categoryName	rc:BusinessFinance
..	..	..	..

Triples *table*

Find all articles that match the SPARQL pattern

```
SELECT docId FROM Newsfeed
WHERE  SEM_CONTAINS (Articles,
       { ?org  rdf:type            c:Organization .
         ?org  pred:hasName        “Acme Corp”^^xsd:string .
         ?org  pred:categoryName    c:BusinessFinance
         ... }
```

Returning bindings for matched documents

- Information returned about each matching document can be used to rank the results.

```
SELECT docId, SEM_CONTAINS_SELECT(1) FROM Newsfeed
WHERE  SEM_CONTAINS (Articles,
       'SELECT ?org  ?score
        WHERE { ?org  rdf:type            c:Organization .
                ?org  pred:categoryName   c:BusinessFinance .
                OPTIONAL { ?comp  p:score  ?score } }', 1) = 1
```

- Bindings from the matching documents are returned in SPARQL Query result XML format.

```
<result>
  <binding name="ORG">
    <uri>http://newscorp.com/Organization/AcmeCorp</uri>
  </binding>
  <binding name="SCORE">
    <literal>0.952</literal>
  </binding>
</result>
```

SemContext Index

SemContext index on ***Article*** *column*

Subject	Property	Object	rid
p:Marcus	rdf:type	rc::Person	r1
p:Marcus	:hasName	“Marcus”^^..	r1
p:Marcus	:hasAge	“38”^^xsd:..	r1
..	..	..	..

Triples *table with rowid references*

```
CREATE INDEX ArticleIndex
 ON NewsFeed (Article)
  INDEXTYPE IS SemContext
   PARAMETERS ('gate_nlp')
```

DocId	Article	Source
1	Indiana authorities filed felony charges and a court issued an arrest warrant for a financial …	CNN
2	Major dealers and investors in over-the-counter derivatives agreed to report all credit-default …	NW
..		..

Newsfeed *table*

```
SELECT docId FROM Newsfeed
WHERE  SEM_CONTAINS (Articles,
          '{ ?s ?p "Acme.." }') = 1
```

SemContext Index

SemContext index on ***Article*** *column*

Subject	Property	Object	rid
p:Marcus	rdf:type	rc::Person	r1
p:Marcus	:hasName	“Marcus”^^..	r1
p:Marcus	:hasAge	“38”^^xsd:..	r1
..	..	..	..

Triples *table with rowid references*

```
CREATE INDEX ArticleIndex
 ON NewsFeed (Article)
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```

DocId	Article	Source
1	Indiana authorities filed felony charges and a court issued an arrest warrant for a financial …	CNN
2	Major dealers and investors in over-the-counter derivatives agreed to report all credit-default …	NW
..		..

Newsfeed *table*

```
SELECT docId FROM Newsfeed
WHERE  SEM_CONTAINS (Articles,
          '{ ?s ?p "Acme.." }') = 1

       AND Source = 'CNN'
```

SemContext Index

SemContext index on ***Article*** *column*

Analytical Queries On Graph Data

Subject	Property	Object	rid
p:Marcus	rdf:type	rc::Person	r1
p:Marcus	:hasName	“Marcus”^^..	r1
p:Marcus	:hasAge	“38”^^xsd:..	r1
..	..	..	..

Triples *table with rowid references*

```
CREATE INDEX ArticleIndex
 ON NewsFeed (Article)
  INDEXTYPE IS SemContext
   PARAMETERS ('gate_nlp')
```

DocId	Article	Source
1	Indiana authorities filed felony charges and a court issued an arrest warrant for a financial …	CNN
2	Major dealers and investors in over-the-counter derivatives agreed to report all credit-default …	NW
..		..

Newsfeed *table*

```
SELECT docId FROM Newsfeed
WHERE  SEM_CONTAINS (Articles,
          '{ ?s ?p "Acme.." }') = 1

       AND Source = 'CNN'
```

SemContext Index – Additional Capabilities

- Ability to combine Domain Ontologies with extracted metadata to facilitate Ontology-Assisted document search.

```
SELECT docId FROM Newsfeed
WHERE  SEM_CONTAINS (Articles,
        ' { ?comp  rdf:type            c:Organization .
            ?comp  pred:categoryName   c:BusinessFinance .
            ?comp  pred:location       ?city .
            ?city  geo:state           "NY"^^xsd:string}') = 1
```

- Ability to edit extracted metadata for improved search results.
  - Allows combining triples extracted by multiple extraction tools.
  - Allows extension of the knowledge base with community feedback.
- Ability to infer additional information from the extracted metadata through Inference.*

* Only Cross-Document Inference supported in 11.2

Choosing an Extractor at Query time

- The SemContext index can be created with multiple Extractor policies so that a specific extractor can be chosen at query time.

```
CREATE INDEX ArticleIndex  ON Newsfeed (Article)
  INDEXTYPE IS mdsys.SemContext
    PARAMETERS ('gatenlp_policy iKnow_policy Calais_plus_geo')
```

- The exact policy to be used for a query is specified as an optional argument to the SEM_CONTAINS operator.

```
SELECT docId FROM Newsfeed
WHERE  SEM_CONTAINS (Articles,
          ' { ?comp  rdf:type          c:Company .
              ?comp  p:categoryName    c:BusinessFinance }',
          'iKnow_policy') = 1
```

ORACLE OPEN WORLD

Change Management for Collaboration

ORACLE

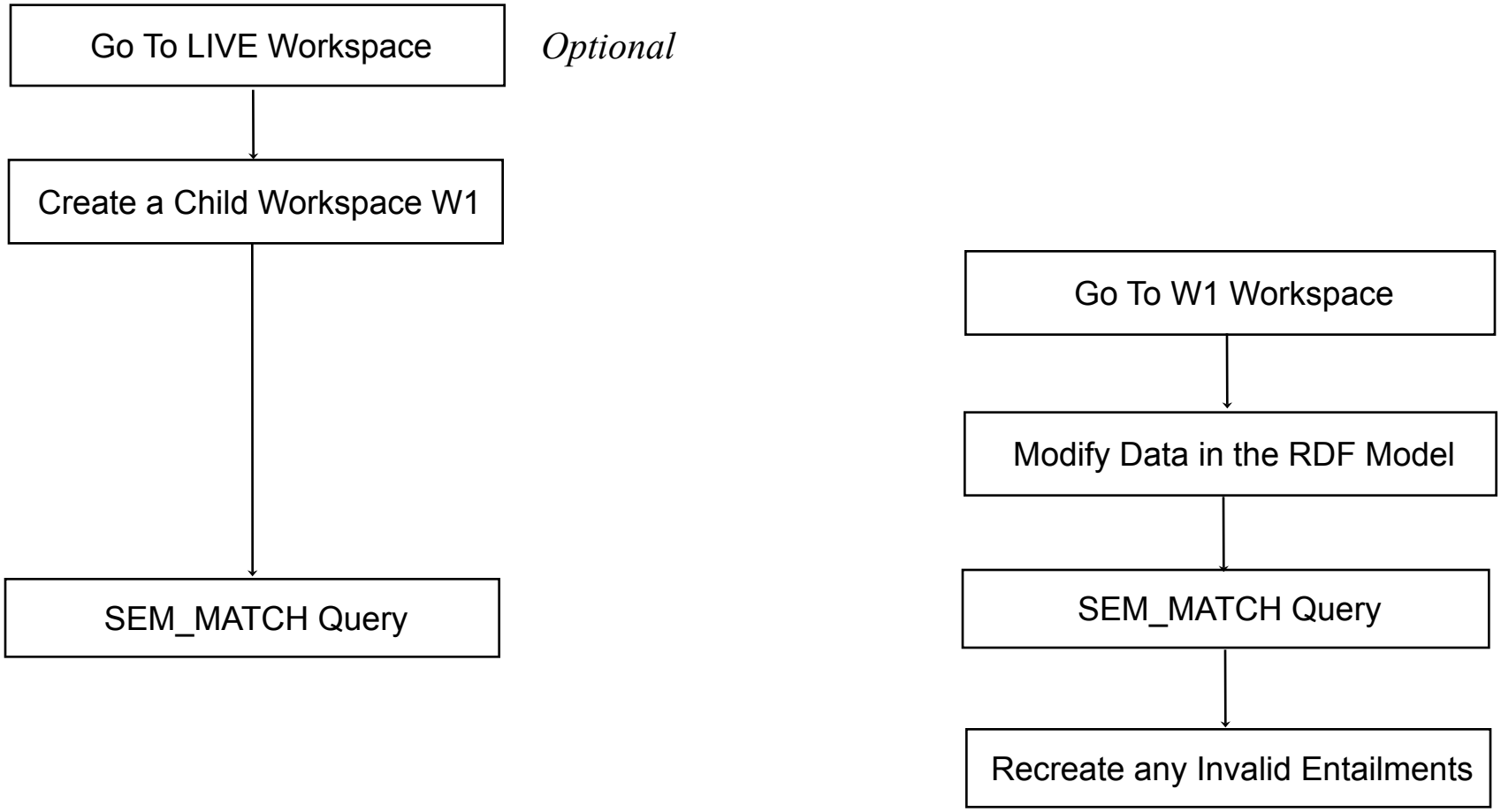
Change Management for Semantic Data

- Manage public and private versions of semantic data in database workspaces
- Collaborate with multi-user workspaces
- Isolate a group of changes in a workspace
  - Data in multiple valid states: e.g., Current – Planned - History
  - Publish all, some or none of the changes made in a workspace
- Create multiple scenarios in different workspaces
  - “What if” analysis
  - Allow multiple application testers to use the same data set
- Provides efficient data storage and querying
  - New versions created only for changed data
  - Queries are workspace-specific
  - Uses the Workspace Manager feature of Oracle Database

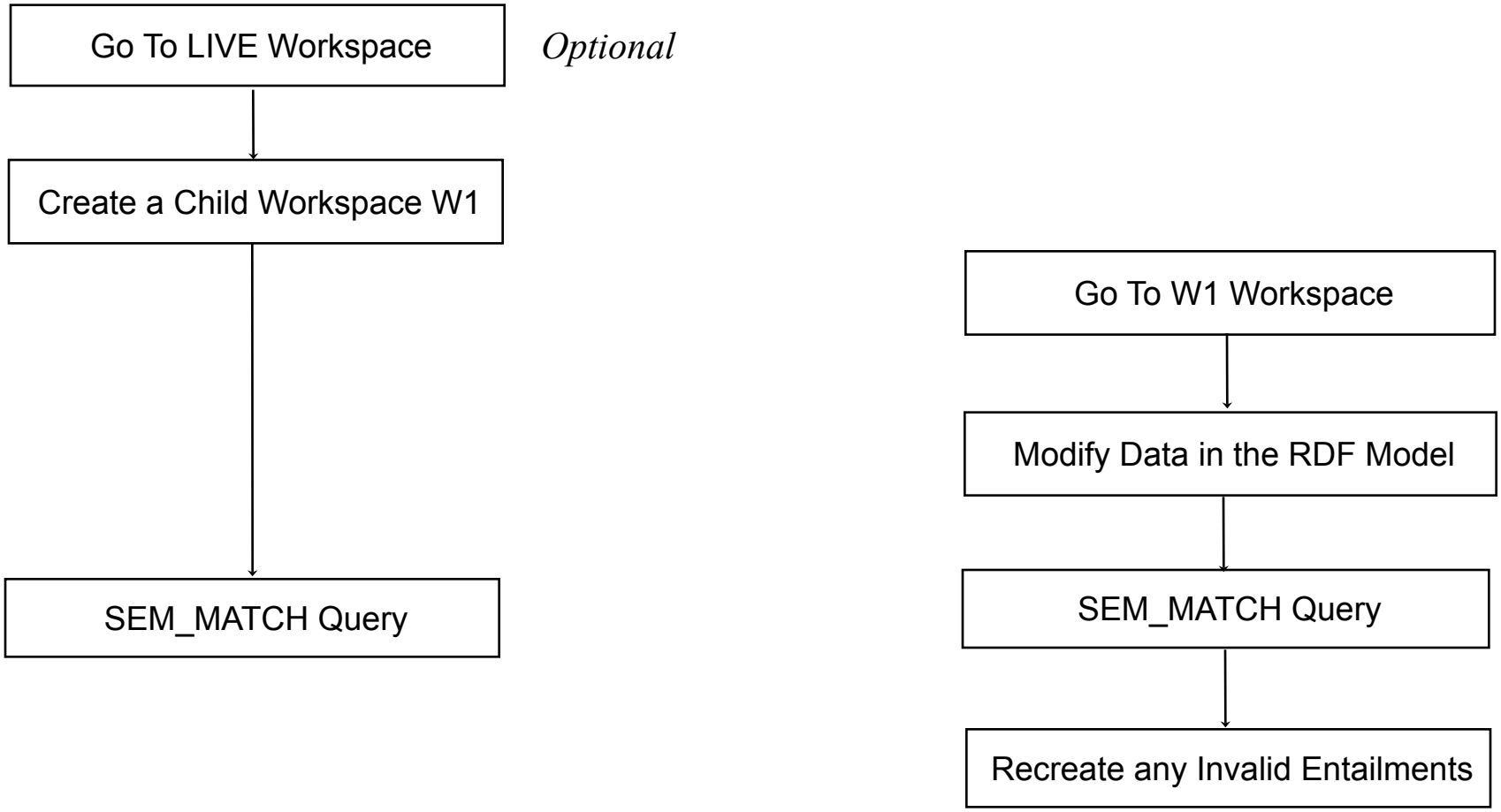
Oracle Semantic Technologies Versioning

- An RDF graph may be logically versioned.
  - No duplication of data and all versions of data use a common physical storage.
  - Triples added/deleted in a workspace are private to the workspace until the workspace is merged.
  - Ability to detect conflicts with application logic.
- Physically versioned inferred data
  - Each workspace shares the inferred data with its child workspace until some data modifications are made in the child workspace.
  - Each workspace with some workspace-private changes maintains a private copy of the inferred data.
- SEM_MATCH queries on version-enabled RDF graphs are version aware.

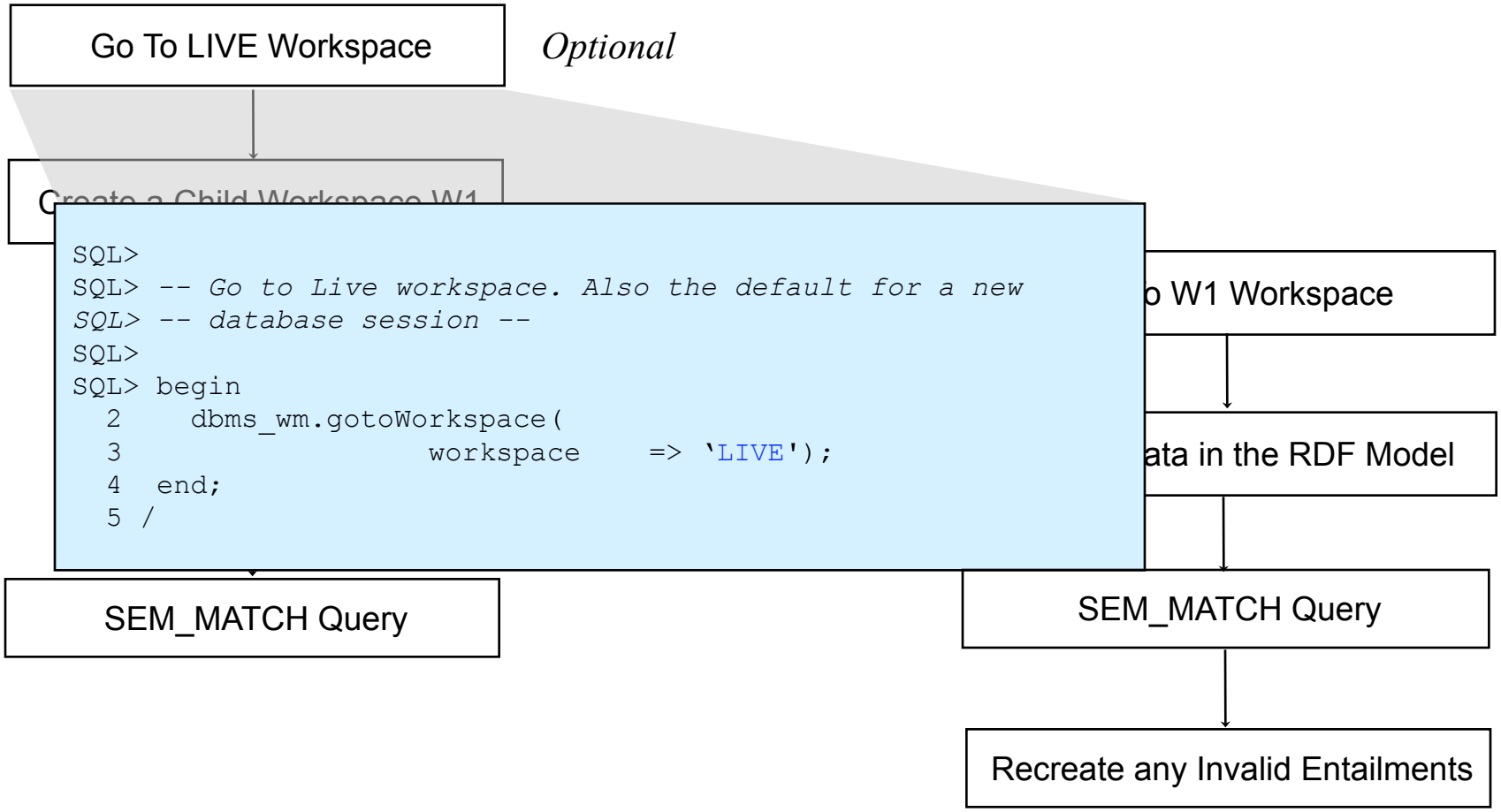
Versioning RDF Data



Versioning RDF Data

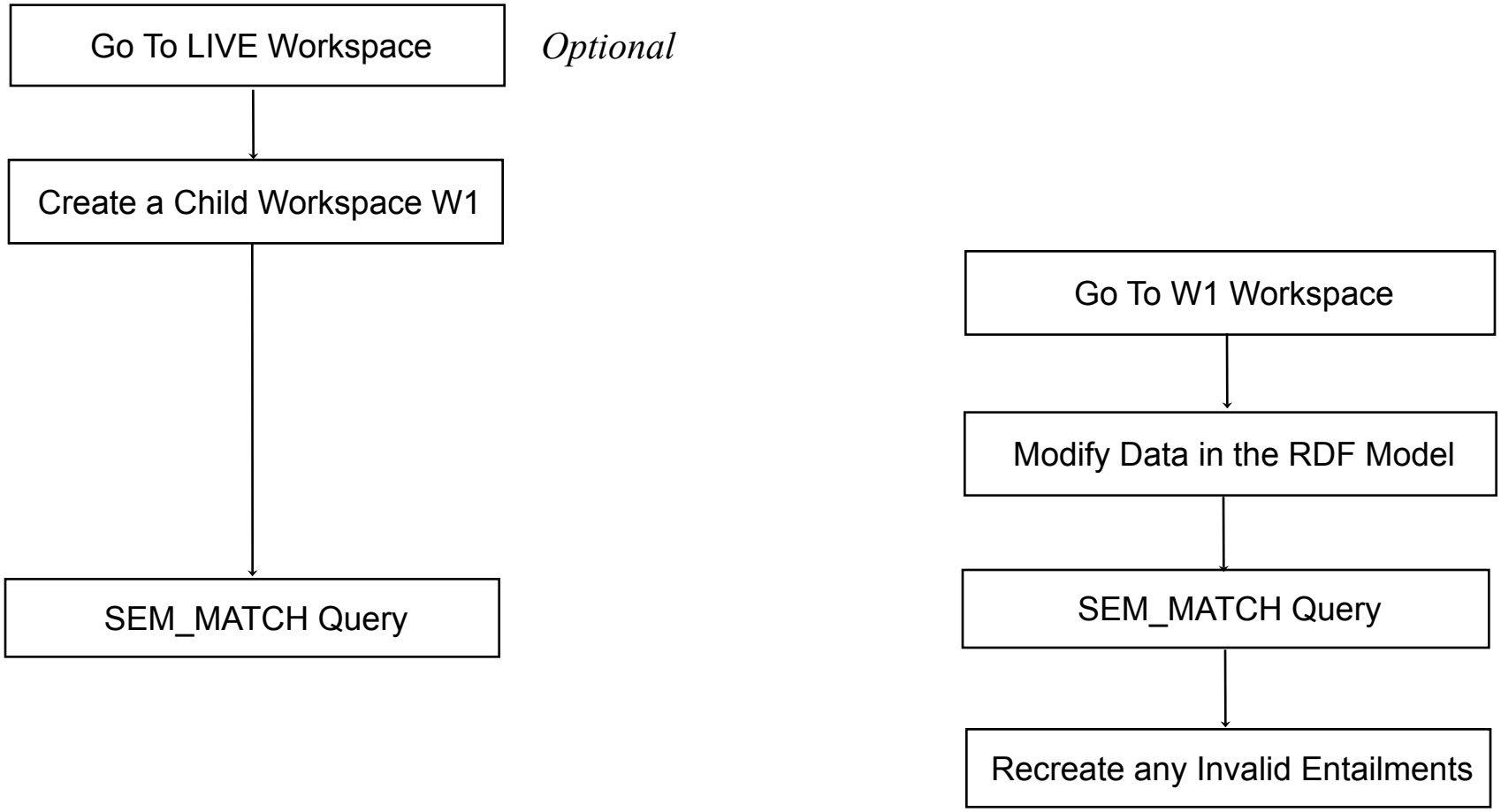


Versioning RDF Data

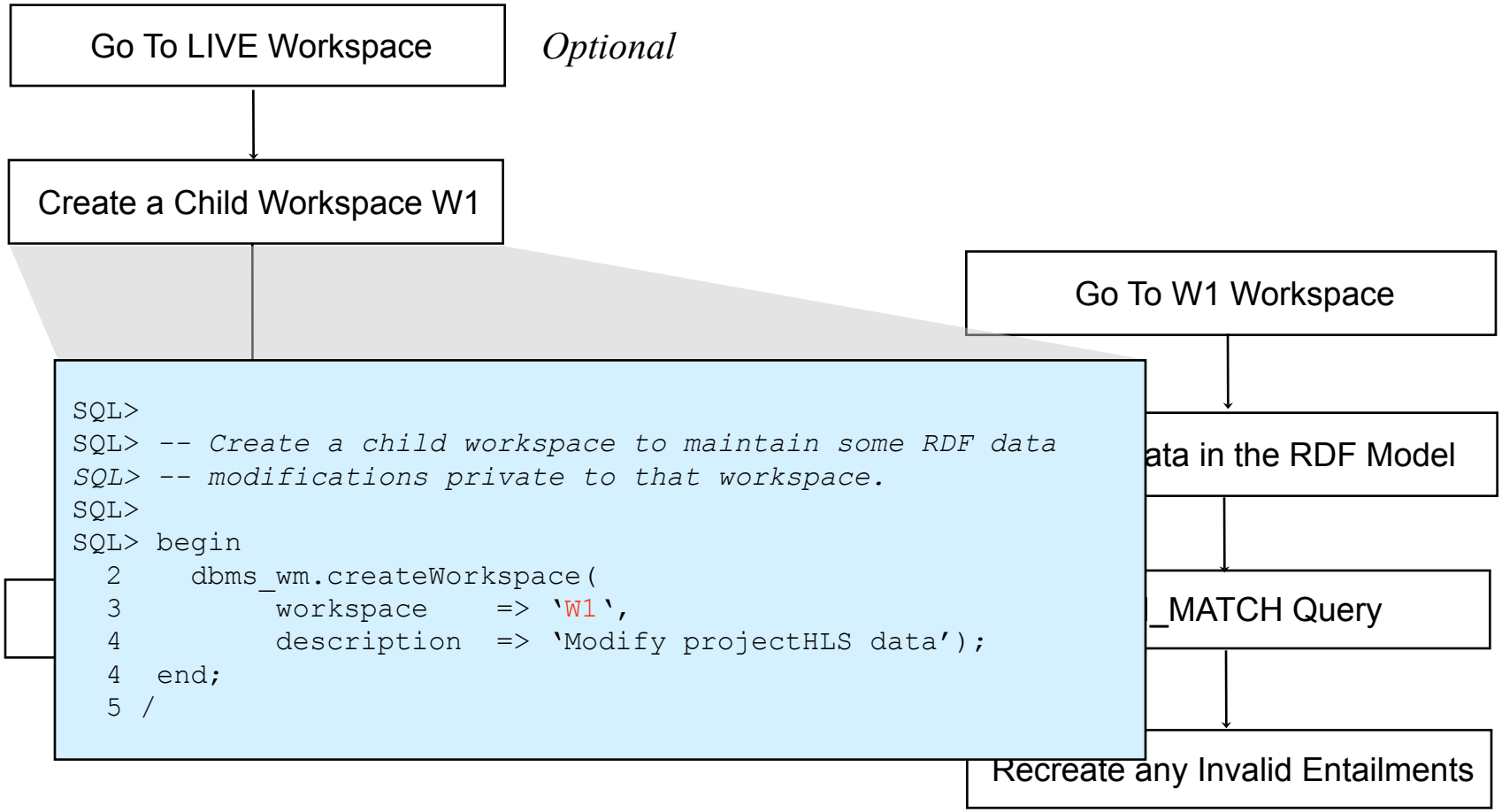



```
SQL>
SQL> -- Go to Live workspace. Also the default for a new
SQL> -- database session --
SQL>
SQL> begin
  2    dbms_wm.gotoWorkspace(
  3                    workspace    => 'LIVE');
  4  end;
  5 /
```

Versioning RDF Data

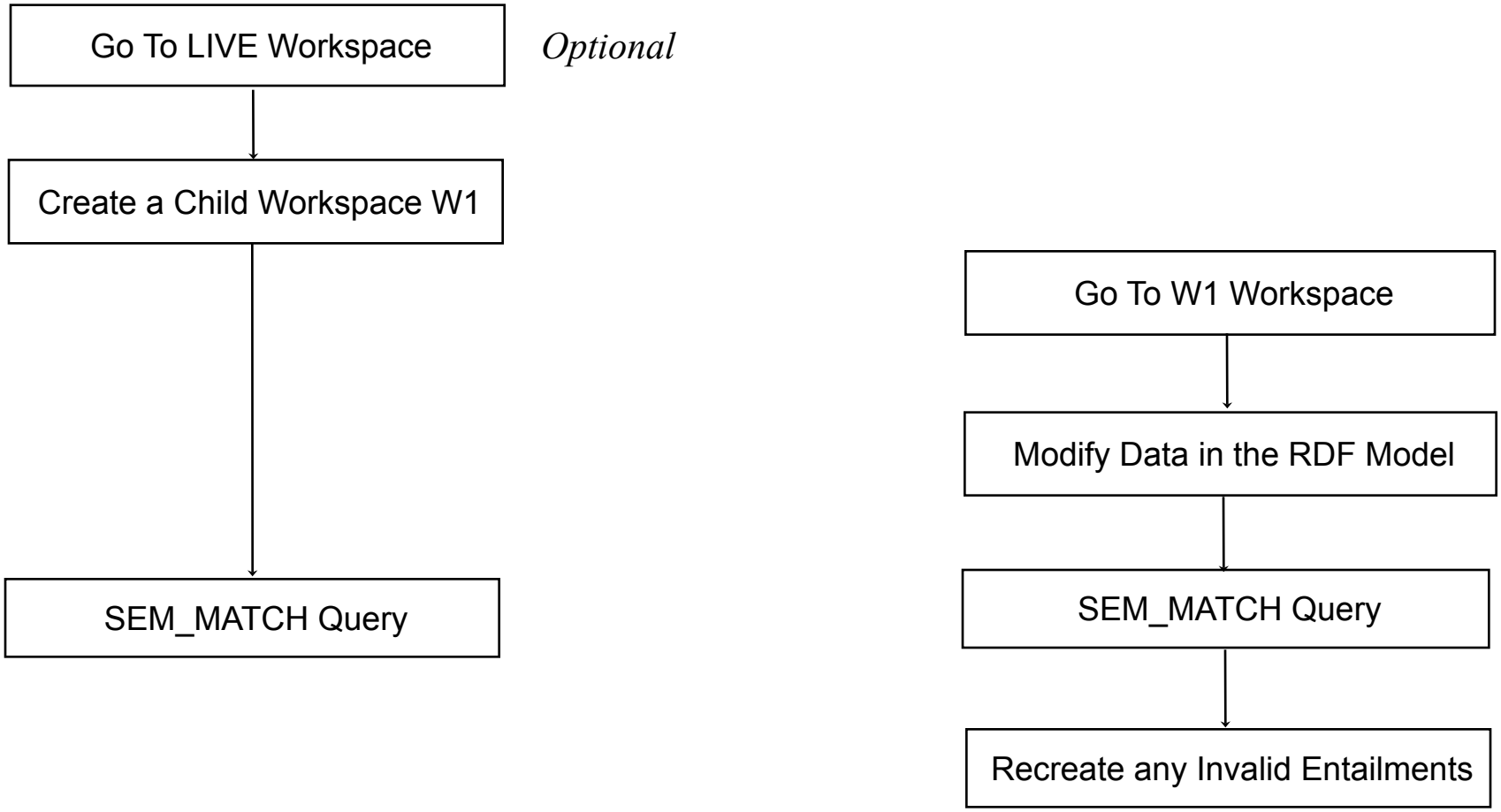


Versioning RDF Data

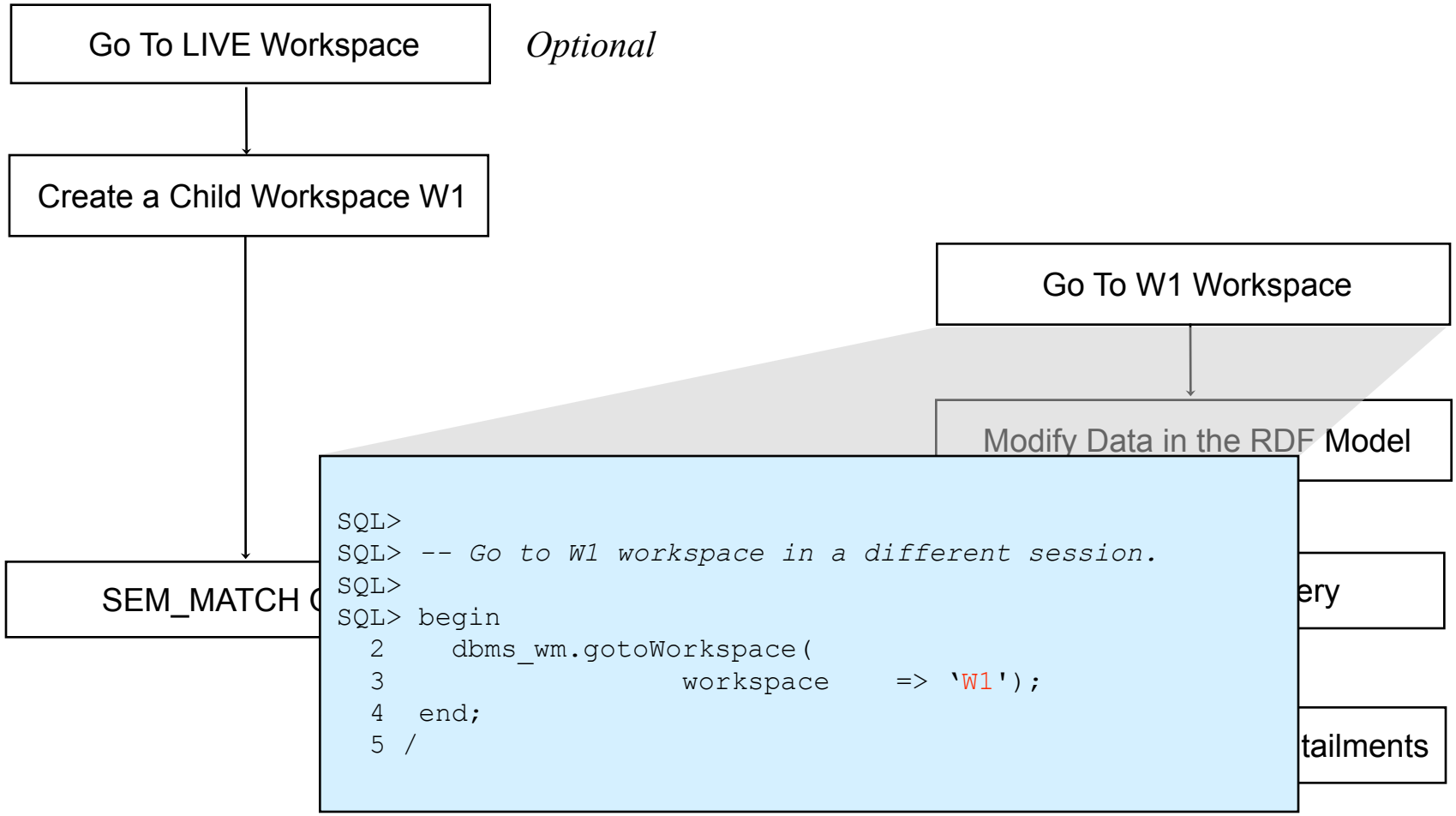



```
SQL>
SQL> -- Create a child workspace to maintain some RDF data
SQL> -- modifications private to that workspace.
SQL>
SQL> begin
  2    dbms_wm.createWorkspace(
  3         workspace    => 'W1',
  4         description  => 'Modify projectHLS data');
  4  end;
  5 /
```

Versioning RDF Data

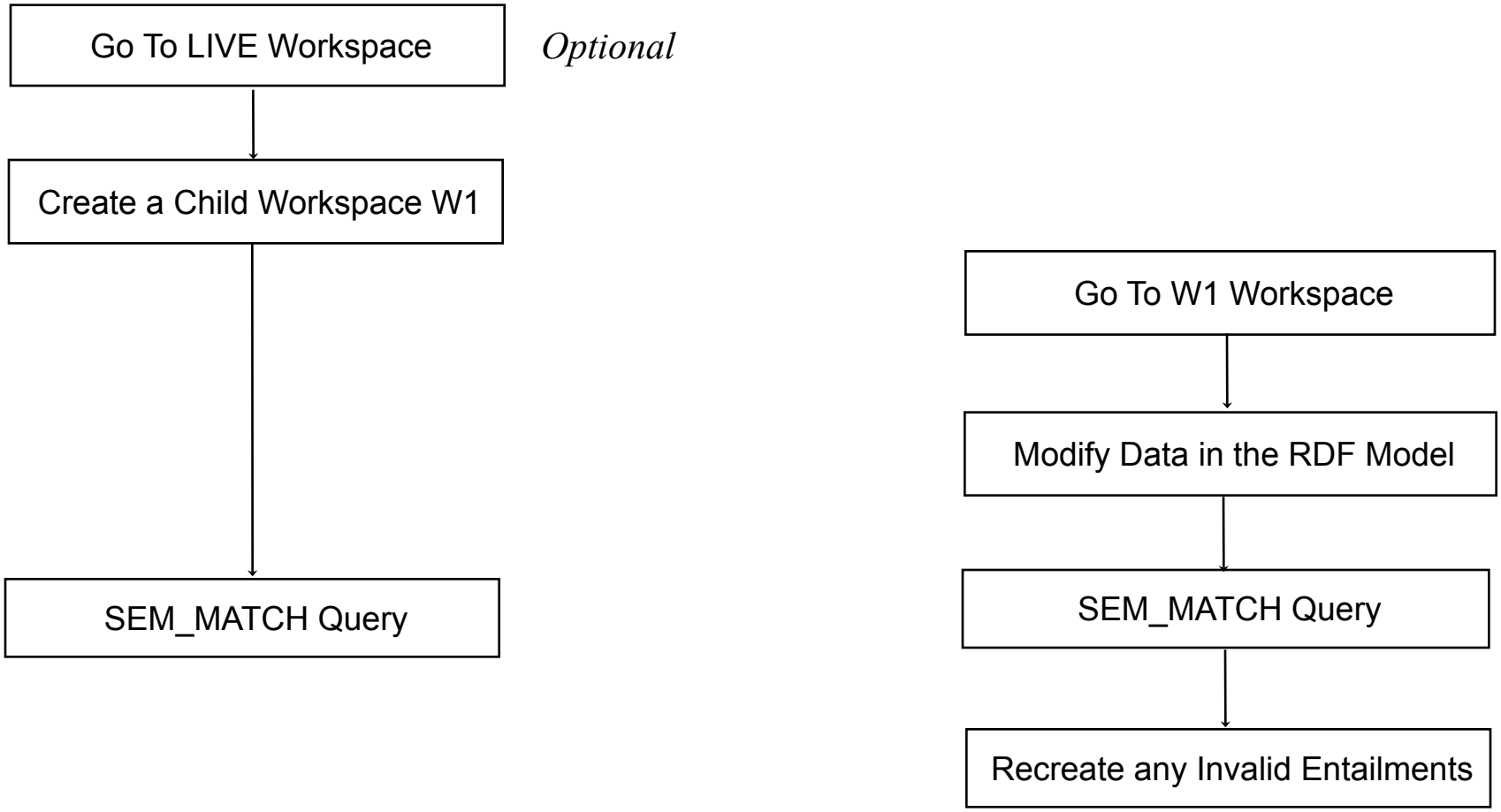


Versioning RDF Data




```
SQL>
SQL> -- Go to W1 workspace in a different session.
SQL>
SQL> begin
  2    dbms_wm.gotoWorkspace(
  3                    workspace    => 'W1');
  4  end;
  5 /
```

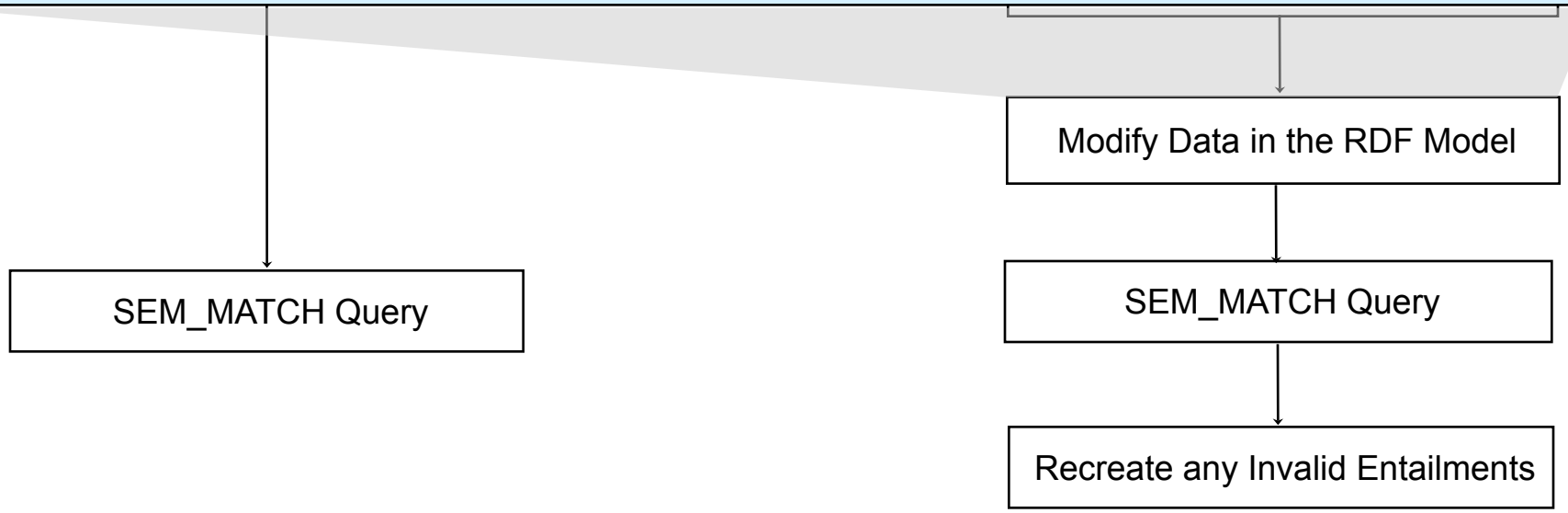
Versioning RDF Data



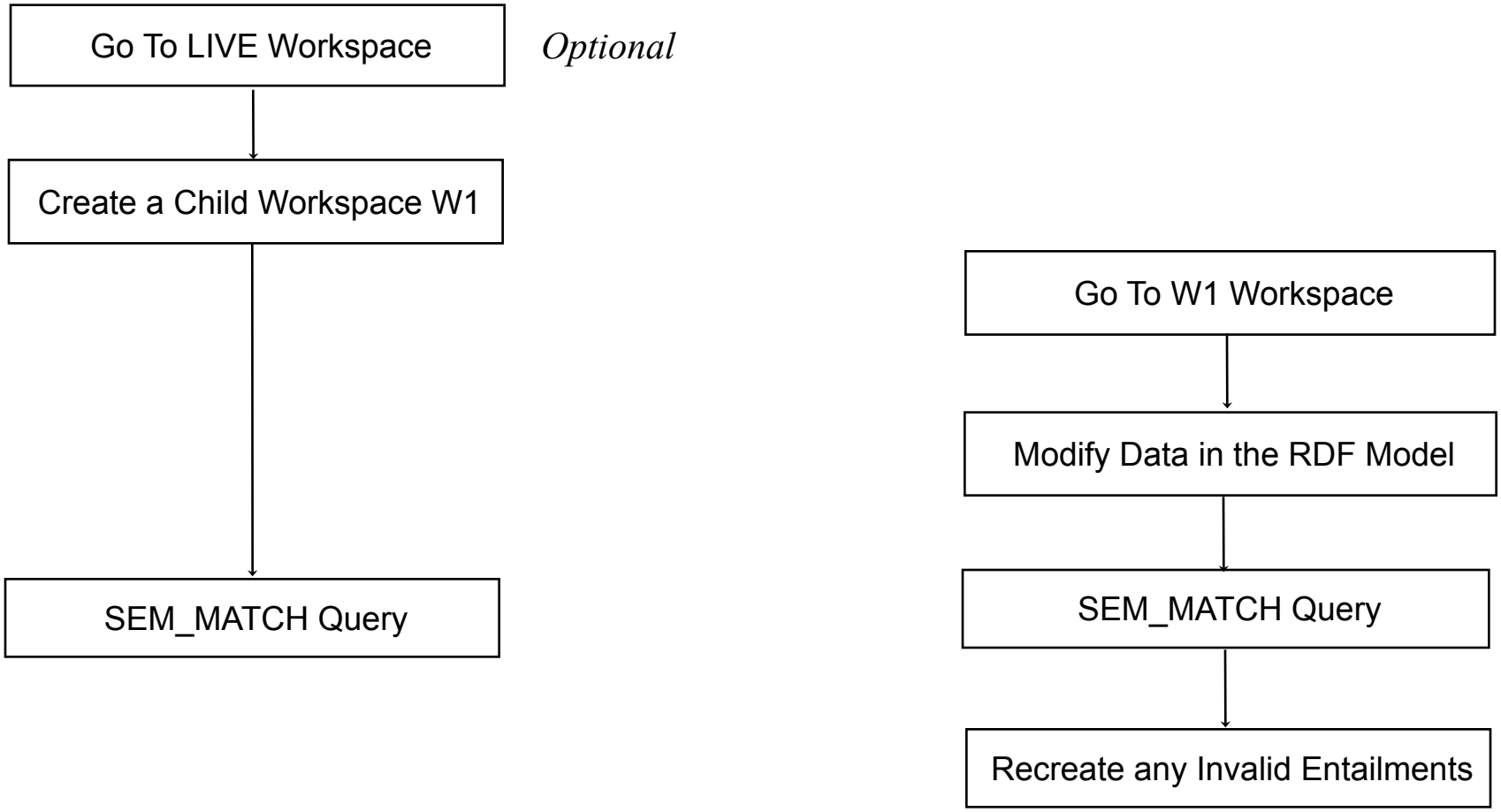
```
SQL> select proj, dept from TABLE(SEM_MATCH( {?proj ctr:drivenBy ?dept}, ...));

PROJ                                          DEPT
--------------------------------------------- ---------------------------------------------
http://www.myorg.com/contract/projectHLS      http://www.myorg.com/department/Dept1
...

SQL> -- Update a triple to re-assign the project to a different department
SQL> update contracts_rdf_data set triple = sdo_rdf_triple_s ('contracts',
  2            '<http://www.myorg.com/contract/projectHLS>',
  3            '<http://www.myorg.com/contract/properties/drivenBy>',
  4            '<http://www.myorg.com/department/Dept9>')) where id = 1;
```



Versioning RDF Data



Versioning RDF Data

```
SQL> -- Live workspace does not show the effects of workspace W1 --
SQL> select proj, dept
  2    from TABLE(SEM_MATCH( {?proj ctr:drivenBy ?dept},
  3                SDO_RDF_Models('Contracts'), null, null, null));

PROJ                                          DEPT
--------------------------------------------- ------------------------------------------
http://www.myorg.com/contract/projectHLS      http://www.myorg.com/department/Dept1
...
```

Modify Data in the RDF Model

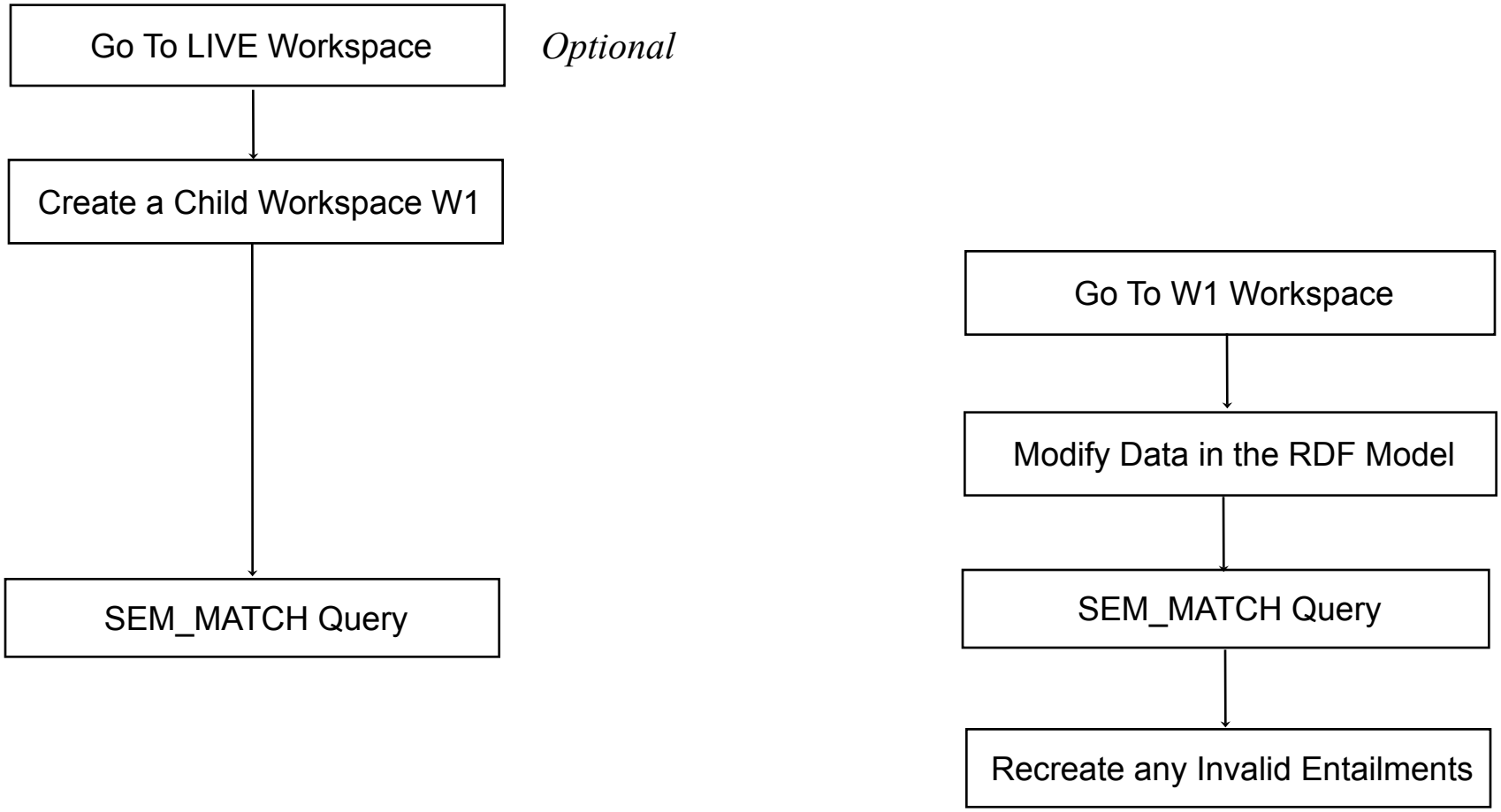
SEM_MATCH Query

SEM_MATCH Query

```
SQL> -- Workspace W1 maintains the updated version --
SQL> select proj, dept
  2    from TABLE(SEM_MATCH( {?proj ctr:drivenBy ?dept}, ...);

PROJ                                          DEPT
--------------------------------------------- ------------------------------------------
http://www.myorg.com/contract/projectHLS      http://www.myorg.com/department/Dept9
```

Versioning RDF Data



```
SQL> -- Data modifications within a workspace leave the index segment invalid/incomplete
SQL> -- while the same index segment in other workspaces may be valid.
SQL>
SQL> select index_name, index_view_name, status from mdsys.RDF_RULES_INDEX_INFO;

INDEX_NAME           INDEX_VIEW_NAME                STATUS
-------------------- ------------------------------ ------------------------------
CONTRACTS_RDFS       RDFI_CONTRACTS_RDFS            INVALID

SQL> begin                        -- recreate the index with workspace private data --
  2    sem_apis.create_entailment(
  3         index_name_in   => 'contracts_rdfs',
  4         models_in       => SDO_RDF_Models('contracts'),
  5         rulebases_in    => SDO_RDF_Rulebases('RDFS'));
  6  end;
  7  /

SQL> select index_name, index_view_name, status from mdsys.RDF_RULES_INDEX_INFO;

INDEX_NAME           INDEX_VIEW_NAME                STATUS
-------------------- ------------------------------ ------------------------------
CONTRACTS_RDFS       RDFI_CONTRACTS_RDFS            VALID
```

Recreate any Invalid Entailments

Workspace Manager Operations for RDF

- **Application Table/Model**: EnableVersioning, DisableVersioning, merge, refresh, rollback
- **Workspace**: create, goto, refresh, merge, rollback, remove, compress, alter, events
- **Savepoints**: create, alter, goto, rollback
- **Privileges**: access, create, delete, rollback, merge
- **Access Modes**: read, 1 writer, WS operations, none
- **Locks**: exclusive and shared on the application table rows
- **Differences**: compares savepoints and workspaces
- **Detect / Resolve Conflicts** : Conflicts detected based on application table primary keys with the ability to choose the version to merge

Summary

- Requirement to search and and derive greater business knowledge from enterprise databases and applications
- Oracle database 11g is the leading commercial database with native RDF/OWL data management
- Scalable & secure platform for wide-range of semantic applications
- Readily scales to ultra-large repositories (+10 billion)
- Choice of SQL or SPARQL query
- Leverages Oracle Partitioning, RAC supported
- Growing ecosystem of 3rd party tools partners

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