MarkLogic Server

Semantics Developer's Guide

MarkLogic 7
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1.0 Introduction to Semantics in MarkLogic

Semantics enables the discovery of facts and relationships in data, and provides context for those facts. Semantic technologies refer to a family of specific W3C standards to allow the exchange of information about relationships in data, in machine readable form – whether it resides on the Web or within organizations. MarkLogic semantics, using RDF (Resource Description Framework), allows you to natively store, search, and manage RDF triples, using SPARQL query, XQuery, or REST.

Semantics requires a flexible data model (RDF), query tool (SPARQL), and a common markup language (for example RDFa, Turtle, N-Triples). MarkLogic allows you to natively store, manage, and search triples using SPARQL and XQuery or REST.

RDF is one of the core technologies of linked open data. The framework provides standards for disambiguating data, integrating, and interacting with data that may come from disparate sources, both machine-readable and human-readable. It makes use of W3C recommendations and formal, defined vocabularies for data to be published and shared. SPARQL (SPARQL Protocol and RDF Query Language) is used to query data in RDF serialization. You can enrich your data using Linked Open Data (or LOD), an extension of the World Wide Web created from the additional semantic metadata embedded in data.

For more information, see the following resources:

- http://www.w3.org/standards/semanticweb/
- http://www.w3.org/RDF/
- http://www.w3.org/TR/rdf-sparql-query/

This document describes how to load, query, and work with semantic data in MarkLogic Server. This chapter provides an overview of semantics in MarkLogic Server. This chapter includes the following sections:

- Terminology
- Linked Open Data
- RDF Implementation in MarkLogic
- Example Datasets

1.1 Terminology

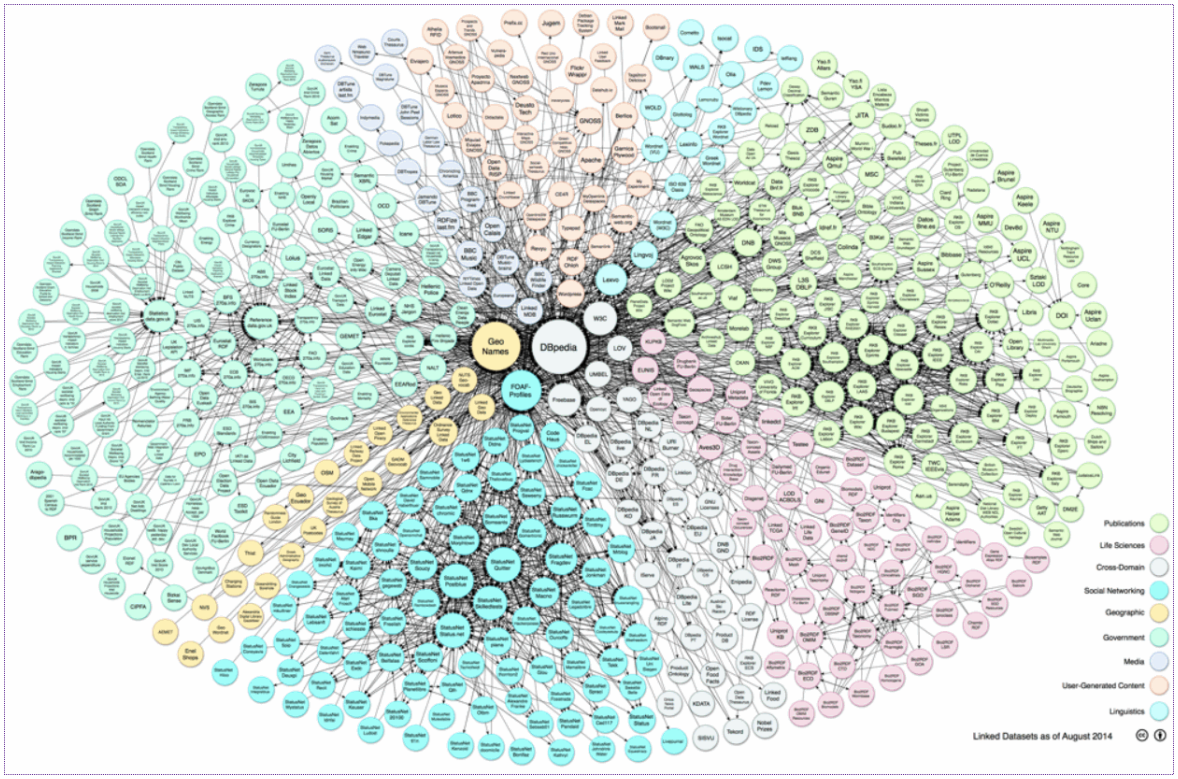
Terms used in this guide:

Term	Definition
RDF	Resource Description Format (or RDF) is a data model used to represent facts as a triple made up of a subject, predicate, and an object. The framework is W3C specification with a defined vocabulary.
RDF Triple	An RDF statement containing atomic values representing a subject, predicate, object, and optionally a graph. Each triple represents a single fact.
Subject	A representation of a resource such as a person or an entity. A node in an graph or triple.
Predicate	A representation of a property or characteristics of the subject or of the relationship between the subject and the object. The predicate is also known as an *arc* or *edge*.
Object	A node representing a property value, which in turn may be the subject in a triple or graph. An object may be a typed literal. See “RDF Datatypes” on page 16.
Graph	A set of RDF triple statements or patterns. In a graph-based RDF model, nodes represent subject or object resources, with the predicate providing the connection between those nodes. Graphs that are assigned a name are referred to as *named graphs*.
Quad	A representation of a subject, predicate, object, and an additional resource node for the context of the triple.
Vocabularies	A standard format for classifying terms. Vocabularies such as FOAF (Friend of a Friend) and Dublin Core (DC) define the concepts and relationships used to describe and represent facts. For example, OWL is a Web Ontology Language for publishing and sharing ontologies across the World Wide Web.
Triple Index	An index that indexes triples ingested into MarkLogic to facilitate the execution of SPARQL queries.
RDF Triple Store	A storage tool for the persistent storage, indexing, and query access to RDF graphs.

Term	Definition
IRI	An IRI (or International Resource Identifier) is a compact string that is used for uniquely identifying resources in an RDF triple. IRIs may contain characters from the Universal Character Set (Unicode/ISO 10646), including Chinese or Japanese Kanji, Korean, Cyrillic characters, and so on.
CURIE	Compact URI Expression.
SPARQL	A recursive acronym for SPARQL Protocol and RDF Query Language (SPARQL), a query language designed for querying data in RDF serialization. SPARQL 1.1 syntax and functions are available in MarkLogic.
SPARQL Protocol	A means of conveying SPARQL queries from query clients to query processors, consisting of an abstract interface with bindings to HTTP (Hypertext Transfer Protocol) and SOAP (Simple Object Access Protocol).
RDFa	Resource Description Framework in Attributes (RDFa) is a W3C Recommendation that adds a set of attribute-level extensions to HTML, XHTML, and various XML-based document types for embedding rich metadata within Web documents.
Blank node	A node in an RDF graph representing a resource for which a IRI or literal is not provided. The term *bnode* is used interchangeably with blank node.

1.2 Linked Open Data

Linked Open Data enables sharing of metadata and data across the Web. The World Wide Web provides access to resources of structured and unstructured data as human-readable web pages and hyperlinks. Linked Open Data extends this by inserting machine-readable metadata about pages and how they are related to each other, to present semantically structured knowledge. The Linked Open Data Cloud gives some sense of the variety of open data sets available on the Web.



For more about Linked Open Data, see http://linkeddata.org/

1.3 RDF Implementation in MarkLogic

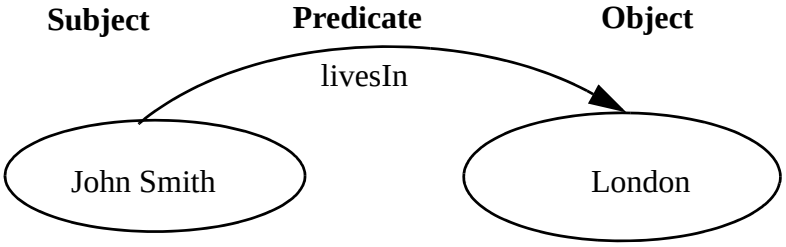
This section describes the semantic technologies using RDF that are implemented in MarkLogic Server and includes the following concepts:

- Using RDF in MarkLogic
- RDF Data Model
- RDF Datatypes
- RDF Vocabulary

1.3.1 Using RDF in MarkLogic

RDF is implemented in MarkLogic to store and search RDF triples. Specifically, each triple is an RDF triple statement containing a subject, predicate, object, and optionally a graph.

For example:

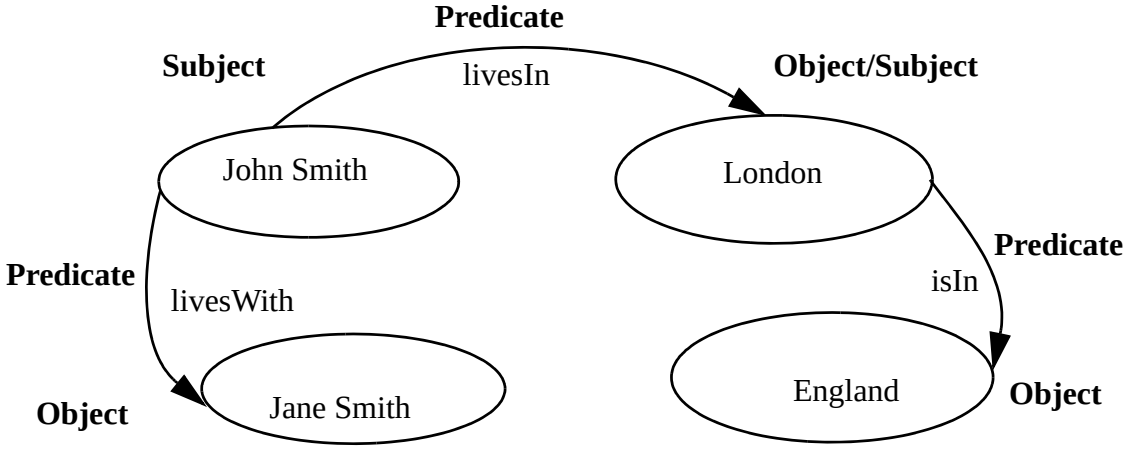


The subject node is a resource named John Smith, the object node is London, and the predicate, shown as an edge linking the two nodes, describes the relationship. From the example, the statement that "John Smith lives in London" is derived.

In XML, the triple looks like this:

```
<sem:triples xmlns:sem="http://marklogic.com/semantics">
  <sem:subject> http://xmlns.com/foaf/0.1/name/"John Smith"
  </sem:subject>
  <sem:predicate> http://example.org/livesIn
  </sem:predicate>
  <sem:object datatype="http://www.w3.org/2001/XMLSchema#string">
    "London"
  </sem:object>
</sem:triple>
```

Sets of triples are stored as RDF graphs. In MarkLogic, the graphs are stored as collections. The following image is an example of a simple RDF graph model that contains three triples. For more information about graphs, see "RDF Data Model" on page 15.



The object node of a triple can in turn be a subject node of another triple. In the example, the following facts are represented “John Smith lives with Jane Smith”, “John Smith lives in London” and “London is in England”.

The graph can be represented in tabular format:

Subject	Predicate	Object
John Smith	livesWith	Jane Smith
John Smith	livesIn	London
London	isIn	England

1.3.1.1 Storing RDF Triples in MarkLogic

When you load RDF triples into MarkLogic, the triples are stored in MarkLogic-managed XML documents. You can load triples from a document using an RDF serialization, such as Turtle or N-Triple. This is a triple representing “John Smith lives with Jane Smith”:

```
<http://example.org/dir/js> <http://xmlns.com/foaf/0.1/firstname>
"John" .
<http://example.org/dir/js> <http://xmlns.com/foaf/0.1/lastname>
"Smith" .
<http://example.org/dir/js> <http://xmlns.com/foaf/0.1/livesWith>
"Jane Smith" .
```

For more examples of RDF formats, see “Example RDF Serialization Syntax” on page 35.

The triples in this example are stored in MarkLogic as an XML document, with `sem:triples` as the document root. These are *managed* triples because they have a document root element of `sem:triples`.

```
<?xml version="1.0" encoding="UTF-8"?>
<sem:triples xmlns:sem="http://marklogic.com/semantics">
 <sem:triple>
  <sem:subject>http://example.org/dir/js
  </sem:subject>
  <sem:predicate>http://xmlns.com/foaf/0.1/firstname
  </sem:predicate>
  <sem:object datatype="http://www.w3.org/2001/XMLSchema#string">
      John
  </sem:object>
 </sem:triple>
 <sem:triple>
  <sem:subject>http://example.org/dir/js
  </sem:subject>
  <sem:predicate>http://xmlns.com/foaf/0.1/lastname
  </sem:predicate>
```

```
  <sem:object datatype="http://www.w3.org/2001/XMLSchema#string">
      Smith</sem:object>
 </sem:triple>
<sem:triple>
  <sem:subject>http://example.org/dir/js
  </sem:subject>
  <sem:predicate>http://xmlns.com/foaf/0.1/livesWith
  </sem:predicate>
  <sem:object datatype="http://www.w3.org/2001/XMLSchema#string">
      Jane Smith</sem:object>
 </sem:triple>
</sem:triples>
```

You can also embed triples within XML documents and load them into MarkLogic as-is. These are *unmanaged triples*, with an element node of `sem:triples`.

Here is an embedded triple, contained in an XML document:

```
<?xml version="1.0" encoding="UTF-8"?>
<article>
  <info>
    <title>News for April 9, 2013</title>
      <sem:triples xmlns:sem="http://marklogic.com/semantics>
        <sem:subject>http://example.org/article</sem:subject>
        <sem:predicate>http://example.org/mentions</sem:predicate>
        <sem:object>http://example.org/London</sem:object>
      </sem:triples>
    ...
  </info>
</article>
```

The triples loaded into MarkLogic are automatically indexed with a special-purpose triple index. The triple index allows you to immediately search the RDF data for which you have the required privileges.

1.3.1.2 Querying Triples

You can write native SPARQL queries in Query Console to retrieve information from RDF triples stored in MarkLogic or in memory. When queried with SPARQL, the question of “who lives in England?” is answered with “John and Jane Smith”. This is based on the assertion of facts from the above graph model. This is an example of a simple SPARQL `SELECT` query:

```
SELECT ?person ?place
WHERE
{
  ?person <http://example.org/LivesIn> ?place .
  ?place <http://example.org/IsIn> "England".
}
```

You can also use XQuery to execute SPARQL queries with `sem:sparql`.

For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

sem:sparql("

PREFIX kennedy:<http://example.org/kennedy#>
SELECT *
WHERE
{
?s ?p ?o .
FILTER (regex(?o, 'Joseph', 'i'))
}
")
```

For more information about using SPARQL and `sem:sparql` to query triples, see "Semantic Queries" on page 63.

Using XQuery, you can query across triples, documents, and values with `cts:triples` or `cts:triple-range-query`.

Here is an example using `cts:triples` query:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $r :=
  cts:triples(sem:iri("http://example.org/people/dir#"),
  sem:iri("http://xmlns.com/foaf/0.1/knows"),
  sem:iri("person1"))

return <result>{$r}</result>
```

The following is an example of a query that uses `cts:triple-range-query`:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $query := cts:triple-range-query(
sem:iri("http://example.org/people/dir#"),
sem:iri("http://xmlns.com/foaf/0.1/knows"),
("person2"), "sameTerm")

return cts:search(fn:collection()//sem:triple, $query)
```

You can create combination queries with `cts:query` functions such as `cts:or-query` or `cts:and-query`.

For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics" at
  "MarkLogic/semantics.xqy";

declare namespace dc = "http://purl.org/dc/elements/1.1/";
  cts:search(collection()//sem:triple, cts:or-query((
  cts:triple-range-query((), sem:curie-expand("foaf:name"),
  "Lamar Alexander", "="),
  cts:triple-range-query(sem:iri("http://www.rdfabout.com/rdf/usgov
  /congress/people/A000360"), sem:curie-expand("foaf:img"), (),
  "=")))
```

For more information about `cts:triples` and the `cts:triple-range-query` queries, see “Semantic Queries” on page 63.

You can also use the results of a SPARQL query with an XQuery search to create combination queries. For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

import module namespace semi = "http://marklogic.com/semantics/impl"
    at "/MarkLogic/semantics/sem-impl.xqy";

declare namespace sr = "http://www.w3.org/2005/sparql-results#";

let $results := sem:sparql( "prefix k: <http://example.org/kennedy/>
select * { ?s k:latitude ?lat . ?s k:longitude ?lon }" )
let $xml := semi:sparql-results-xml($results)

return
for $sol in $xml/sr:results/sr:result
let $point := cts:point(xs:float($sol/sr:binding[@name eq
'lat']/sr:literal), xs:float($sol/sr:binding[@name eq
'lon']/sr:literal))
return <place name="{$sol/sr:binding[@name eq 's']/*}"
point="{$point}"/>
```

For more information about combination queries, see “Querying Triples with XQuery” on page 95.

1.3.2 RDF Data Model

RDF triples are a convenient way to represent facts - facts about the world, facts about a domain, facts about a document. Each RDF triple is a fact (or assertion) represented by a subject, predicate, and object - “John livesIn London”. The subject and predicate of a triple must be an IRI (Internationalized Resource Identifier), which is a compact string used to uniquely identify resources. The object may be either an IRI or a literal, such as a number or string.

- Subjects and predicates are IRI references with an optional fragment identifier.
  For example:

  ```
  <http://xmlns.com/foaf/0.1/Person>
  foaf:person
  ```

- Literals are strings with an optional language tag or a number and are used as objects in RDF triples. For example:

  ```
  "Bob"
  "chat"@fr
  ```

- Typed literals may be strings, integers, dates and so on, that are assigned to a datatype. These literals are typed with a “^^” operator “”.
  For example:

  ```
  "Bob"^^xs:string
  "3"^^xs:integer
  "26.2"^^xs:decimal
  ```

In addition, a subject or object may be a blank node (*bnode* or anonymous node), which is a node in a graph without a name. A blank node is represented as an underscore, followed by a colon (:) and then an identifier. For example:

```
_:a
_:jane
```

For more information about IRIs, see “IRIs and Prefixes” on page 16.

Often the object of one triple is the subject of another, so a collection of triples forms a graph. In this document we represent graphs using these conventions:

- Subjects and objects are shown as ovals.
- Predicates are shown as edges (labeled arrows).
- Typed literals are shown as boxes.

1.3.3 Blank Node Identifiers

In MarkLogic, a blank node is assigned a blank node identifier. This internal identifier is maintained across multiple invocations. In a triple, a blank node is used for the subject or object and is specified by an underscore (_). For example:

```
_:jane <http://xmlns.com/foaf/0.1/name> "Jane Doe".
<http://example.org/people/about> <http://xmlns.com/foaf/0.1/knows>
_:jane
```

Given two blank nodes, you can determine whether or not they are the same. The first node "`_:jane`" will refer to the same node as the second invocation that also mentions `"_:jane"`. Blank nodes are represented as skolemized IRIs: blank nodes where existential variables are replaced with unique constants. Each blank node has a prefix of "`http://marklogic.com/semantics/blank/`".

1.3.4 RDF Datatypes

RDF uses the XML schema datatypes. These include `xs:string`, `xs:float`, `xs:double`, `xs:integer`, and `xs:date` and so on, as described in the specification, *XML Schema Part 2: Datatypes Second Edition*:

http://www.w3.org/TR/xmlschema-2/

All XML schema simple types are supported, along with all types derived from them, except for `xs:QName` and `xs:NOTATION`.

RDF can also contain custom datatypes that are named with an IRI. For example, a supported MarkLogic-specific datatype is `cts:point`.

Note: Use of an unsupported datatype such as `xs:QName`, `xs:NOTATION`, or types derived from these will generate an XDMP-BADRDFVAL exception.

If you omit a datatype declaration, it is considered to be of type `xs:string`. A typed literal is denoted by the presence of the `datatype` attribute, or by an `xml:lang` attribute to give the language encoding of the literal; for example, “en” for English.

Datatypes in the MarkLogic semantics data model allow for values with a datatype that has no schema. These are identified as `xs:untypedAtomic`.

1.3.5 IRIs and Prefixes

This section describes meaning and role of IRIs and prefixes, and includes the following concepts:

- IRIs
- Prefixes

1.3.5.1 IRIs

IRIs (Internationalized Resource Identifiers) are internationalized versions of URIs (Uniform Resource Identifiers). URIs use a subset of ASCII characters and are limited to this set. IRIs use characters beyond ASCII, making them more useful in an international context. IRIs (and URIs) are unique resource identifiers that enable you to fetch a resource. A URN (Uniform Resource Name) can also be used to uniquely identify a resource.

An IRI may appear similar a URL and may or may not be an actual website. For example:

```
<http://example.org/addressbook/d>
```

IRIs are used instead of URIs, where appropriate, to identify resources. Since SPARQL specifically refers to IRIs, later chapters in this guide reference IRIs and not URIs.

IRIs are required to eliminate ambiguity in facts, particularly if data is received from different data sources. For example, if you are receiving information about books from different sources, one publisher may refer to the name of the book as “title”, another source may refer to the position of the author as “title”. Similarly, one domain may refer to the writer of the book as the “author” and another as “creator”.

Presenting the information with IRIs (and URNs), we see a clearer presentation of what the facts mean. The following examples are three sets of N-Triples:

```
<http://example.org/people/title/sh1999>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#label>
"Lucasian Professor of Mathematics"

<urn:isbn:9780553380163>
<http://purl.org/dc/elements/1.1/title>
"A Brief History of Time"

<urn:isbn:9780553380163>
<http://purl.org/dc/elements/1.1/creator>
"Stephen Hawking"
```

Note: Line breaks have been inserted for the purposes of formatting, which make this RDF N-Triple syntax invalid. Each triple would normally be on one line. (Turtle syntax allows for single triples to wrap across multiple lines.)

The IRI is a key component of RDF, however IRIs are usually long and are difficult to maintain. Compact URI Expressions (CURIEs) are supported as a mechanism for abbreviating IRIs. These are specified in the CURIE Syntax Definition:

http://www.w3.org/TR/rdfa-syntax/#s_curies

1.3.5.2 Prefixes

Prefixes are identified by IRIs and often begin with the name of an organization or company. For example:

```
PREFIX js: <http://example.org/people/about/js>
```

A prefix is a shorthand string used to identify a name. The designated prefix binds a prefix IRI to the specified string. The prefix can then be used instead of writing the full IRI each time it is referenced. When you use prefixes to write RDF, the prefix is followed by a colon. You can choose any prefix for resources that you define. For example, here is a SPARQL declaration:

```
PREFIX dir: <http://example.org/people/about>
```

You can also use standard and agreed upon prefixes that are a part of a specification. This is a SPARQL declaration for rdf:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
```

The prefix format depends on the serialization format that you use. The Turtle prefix declaration would be:

```
@prefix dir: <http://example.org/people/about> .
```

1.3.6 RDF Vocabulary

RDF vocabularies are defined using RDF Schema (RDFS) or Web Ontology Language (OWL) to provide a standard format for classifying terms. The vocabulary is essentially the set of IRIs for the arcs that form RDF graphs. For example, the FOAF vocabulary describes people and relationships.

The existence of a shared standard vocabulary is helpful, but not essential since it is possible to combine vocabularies or create a new one. Use the following prefix lookup to help decide which vocabulary to use:

http://prefix.cc/about

There is an increasingly large number of vocabularies. Common RDF prefixes that are widely used and agreed upon include the following:

Prefix	Prefix IRIs	Description
cc	http://web.resource.org/cc/	Creative Commons
dc	http://purl.org/dc/elements/1.1/	Dublin Core vocabulary
dcterms	http://purl.org/dc/terms/	Dublin Core terms
rdfs	http://www.w3.org/2000/01/rdf-schema#	RDF schema
rdf	http://www.w3.org/1999/02/22-rdf-syntax-ns#	RDF vocabulary
owl	http://www.w3.org/2002/07/owl#	Web Ontology Language
foaf	http://xmlns.com/foaf/0.1/	FOAF (Friend of a Friend)
skos	http://www.w3.org/2004/02/skos/core#	SKOS (Simple Knowledge Organization System)
vcard	http://www.w3.org/2001/vcard-rdf/3.0	VCard vocabulary
void	http://rdfs.org/ns/void#	Vocabulary of Interlinked Datasets
xml	http://www.w3.org/XML/1998/namespace	XML namespace
xhtml	http://www.w3.org/1999/xhtml	XHTML namespace
xs	http://www.w3.org/2001/XMLSchema	XML Schema
fn	http://www.w3.org/2005/xpath-functions	XQuery function and operators

Note: For these vocabularies, the IRIs are also URLs.

1.4 Example Datasets

There is a growing body of data from domains such as Government and governing agencies, Healthcare, Finance, Social Media, and so on, available as triples, often accessible via SPARQL for the purpose of:

- Semantic search
- Dynamic Semantic Publishing
- Aggregating diverse datasets

There are a large number of datasets available for public consumption. For example:

- FOAF: http://www.foaf-project.org/ - a project that provides a standard RDF vocabulary for describing people, what they do, and relationships to other people or entities.
- DBPedia: http://dbpedia.org/Datasets - data derived from Wikipedia with many external links to RDF datasets.
- Semantic Web: http://data.semanticweb.org/ - a database of thousands of unique triples about conference data.

2.0 Semantics in MarkLogic Quick Start

This chapter includes the following sections:

- Setting up MarkLogic Server
- Loading Triples
- Querying Triples

2.1 Setting up MarkLogic Server

You can create and configure databases in MarkLogic Admin Interface, Admin API, or Information Studio. This section focuses on using Information Studio to set up MarkLogic Server to store triples.

> **Note:** You must have admin privileges for MarkLogic Server to complete the procedures described in this section.

Install MarkLogic Server on the database server, as described in the *Installation Guide for All Platforms*, and then perform the following tasks:

- Creating a Database
- Configuring a Database
- Creating a REST API Instance
- Creating an XDBC Server

2.1.1 Creating a Database

The process to create a database is described in detail in Creating a New Database in the *Information Studio Developer's Guide*.

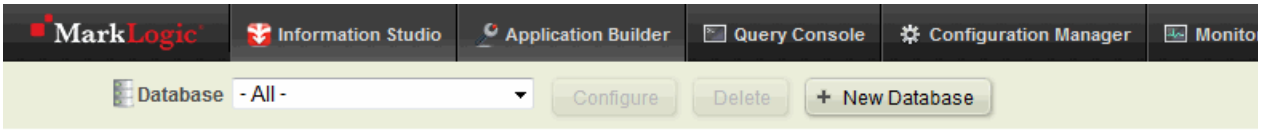
To create a database with Information Studio:

1. In a Web browser, navigate to Information Studio in Application Services:

   ```
   http://hostname:8000/appservices/
   ```

   where *hostname* is the name of your MarkLogic Server host machine.

2. At the top of the application services page, click New Database:



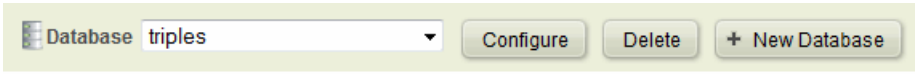
3. In the New Database dialog, type the name of the new database, for example “triples”.



Click Create Database. The database and its respective forest are created.

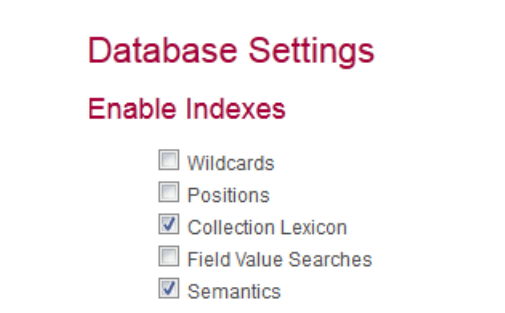
2.1.2 Configuring a Database

1. To configure the database, select it from the Database drop-down list.



Click Configure.

2. In Database Settings, select Collection Lexicon and Semantics indexes.



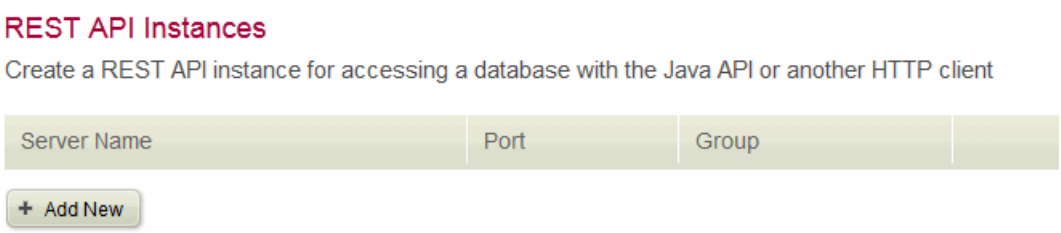
The Collection Lexicon index is required and used by the REST endpoint. The Semantics index is the Triple index shown in the Admin Interface and Information Studio.

2.1.3 Creating a REST API Instance

A REST API instance is an HTTP App Server configured to use the REST API against a particular database. The process to create a REST API Instance is described in detail in Creating a REST API Instance in the *Information Studio Developer's Guide*.

To create a REST API instance:

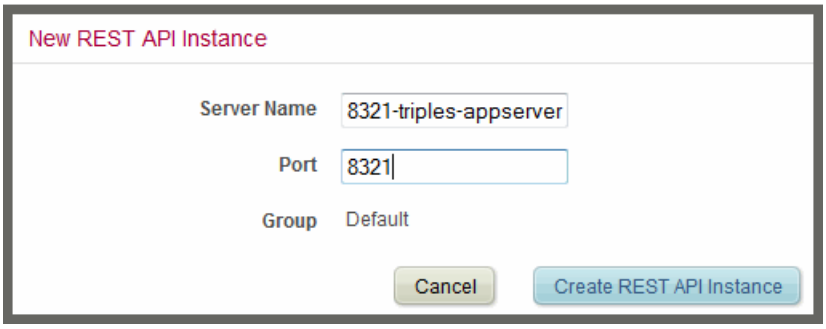
1. Find the REST API Instances section on the Database Configuration page.



   Click Add New.

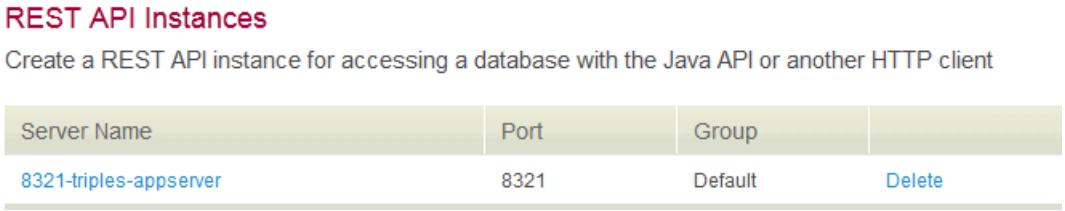
2. Type a server name and an unassigned port number in the New Rest API Instance dialog. For example:

   - Server Name: 8321-triples-appserver
   - Port: 8321



3. Click Create REST API Instance.

   The REST server is created.



2.1.4 Creating an XDBC Server

The process to create an XDBC server is described in detail in Creating a New XDBC Server in the *Administrator's Guide*. You will use the Admin Interface to create an XDBC server.

To create a new XDBC server:

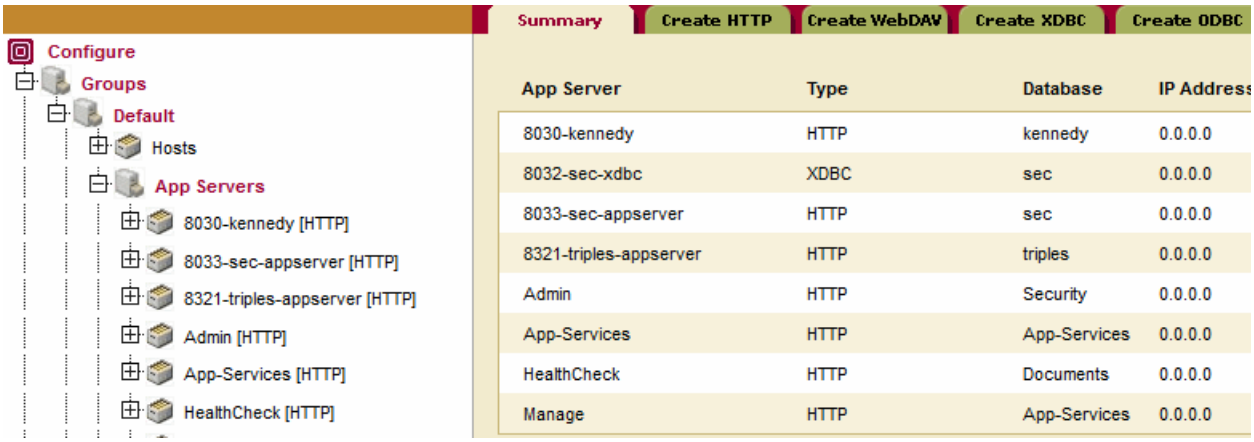
1. With a Web browser, navigate to the Admin Interface:

   ```
   http://hostname:8001
   ```

   where *hostname* is the name of your MarkLogic Server host machine.

2. Click Groups in the left navigation bar to expand the groups. Click Default and then click App Servers to expand the lists.

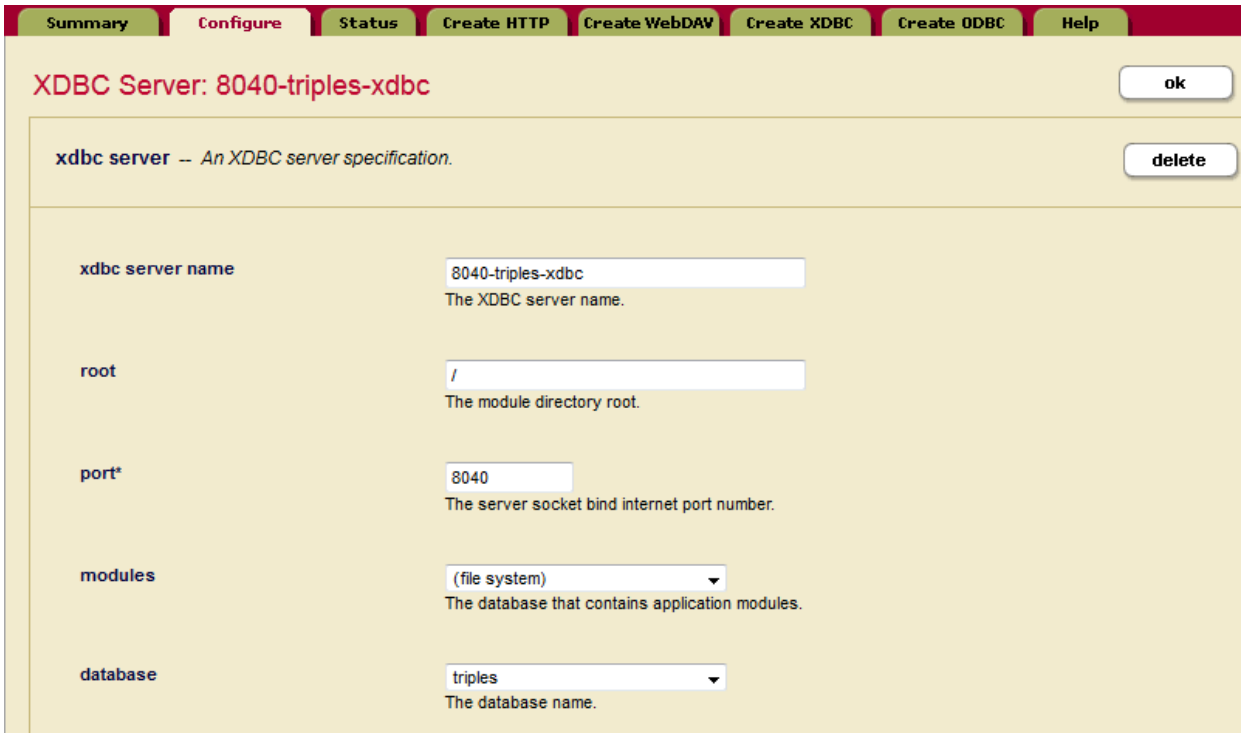
3. In the App Server group, click the Create XDBC tab at the top right of the panel:



4. In the Create XDBC Server panel, specify the following:

   - XDBC Server Name: "8040-triples-xdbc"
   - The root directory: "/"
   - Port number: "8040" (if this port is in use, enter an unused port number)
   - Modules: "(file system)" - the default
   - Database: select "triples" from the drop-down list

5. Click OK when you are done. The XDBC Server configure page is displayed.



This is all you need to do before loading triples into your new database ("triples").

2.1.5 Setting Up Additional Servers

In a production enviroment, you will want to create additional app servers, REST instances, and XDBC servers. Use these links to find out more:

- Application servers: The process to create additional app servers is described in Creating and Configuring App Servers in the *Administrator's Guide*.
- REST instances: To create a different REST instance on another port, see Administering MarkLogic REST API Instances in the *REST Application Developer's Guide*.
- XDBC servers: The process to create an XDBC server is described in detail in Creating a New XDBC Server in the *Administrator's Guide*.

2.2 Loading Triples

This section covers loading triples into the triples database. It includes the following topics:

- Downloading the Dataset
- Importing Triples with mlcp
- Verifying the Import

2.2.1 Downloading the Dataset

Use the full sample of Persondata from DBPedia (in English and Turtle format) for the examples. Or use a different subset of Persondata if you prefer.

1. Download the Persondata example dataset from http://wiki.dbpedia.org/Downloads38. Use this dataset for the steps in the rest of this chapter. Scroll down on the web page to find Persondata and select the "en" and "ttl" version (`persondata_en.ttl.b2zip`).

   Note: DBPedia datasets are licensed under the terms of the of the Creative Commons Attribution-ShareAlike License and the GNU Free Documentation License. The data is available in localized languages and in N-Triple and N-Quad serializations.

2. Extract the data from the compressed file to a local directory. For example, to `C:\space`.

2.2.2 Importing Triples with mlcp

There are a number of ways to load triples into MarkLogic, including MarkLogic Content Pump (mlcp), REST endpoints, and XQuery. The recommended way to bulk-load triples is with mlcp. These examples use mlcp on a stand-alone Windows environment.

1. Install and configure MarkLogic Pump as described in Downloading and Installing mlcp in the *Loading Content Into MarkLogic Server Guide*.

2. In a Windows command interpreter (cmd.exe) navigate to the mlcp bin directory for your mlcp installation. For example:

   ```
   cd C:\space\marklogic-contentpump-1.1\bin
   ```

3. Assuming that the Persondata content in saved locally under `C:\space`, enter the following as a single-line command at the prompt:

   ```
   mlcp.bat import -host localhost -port 8040 -username admin ^
   -password password -input_file_path c:\space\persondata_en.ttl ^
   -mode local -input_file_type RDF -output_uri_prefix /people/
   ```

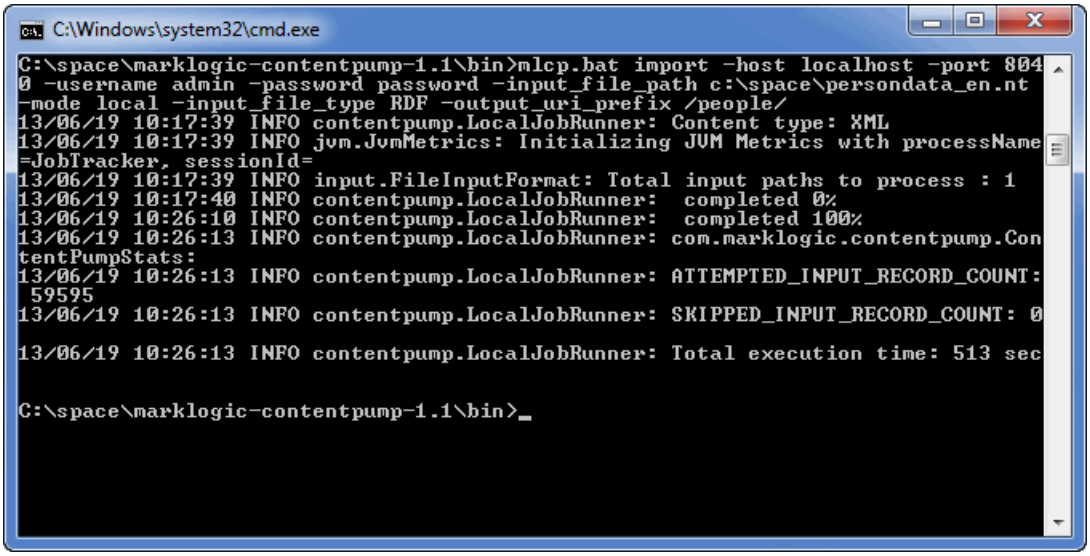
   For clarity the long command line is broken into multiple lines using the Windows line continuation character "^". Remove the line continuation characters to use the command.

- The modified command for Unix is:

```
mlcp.sh import -host localhost -port 8040 -username admin -password \
password -input_file_path /space/persondata_en.ttl -mode local \
-input_file_type RDF -output_uri_prefix /people/
```

For clarity, the long command line is broken into multiple lines using the Unix line continuation character "\". Remove the line continuation characters to use the command.

4. The successful triples data import looks like this when it is complete.



2.2.3 Verifying the Import

To verify that the RDF triples are successfully loaded into the triples database, do the following.

1. Navigate to the REST Server with a Web browser:

```
http://hostname:8321
```

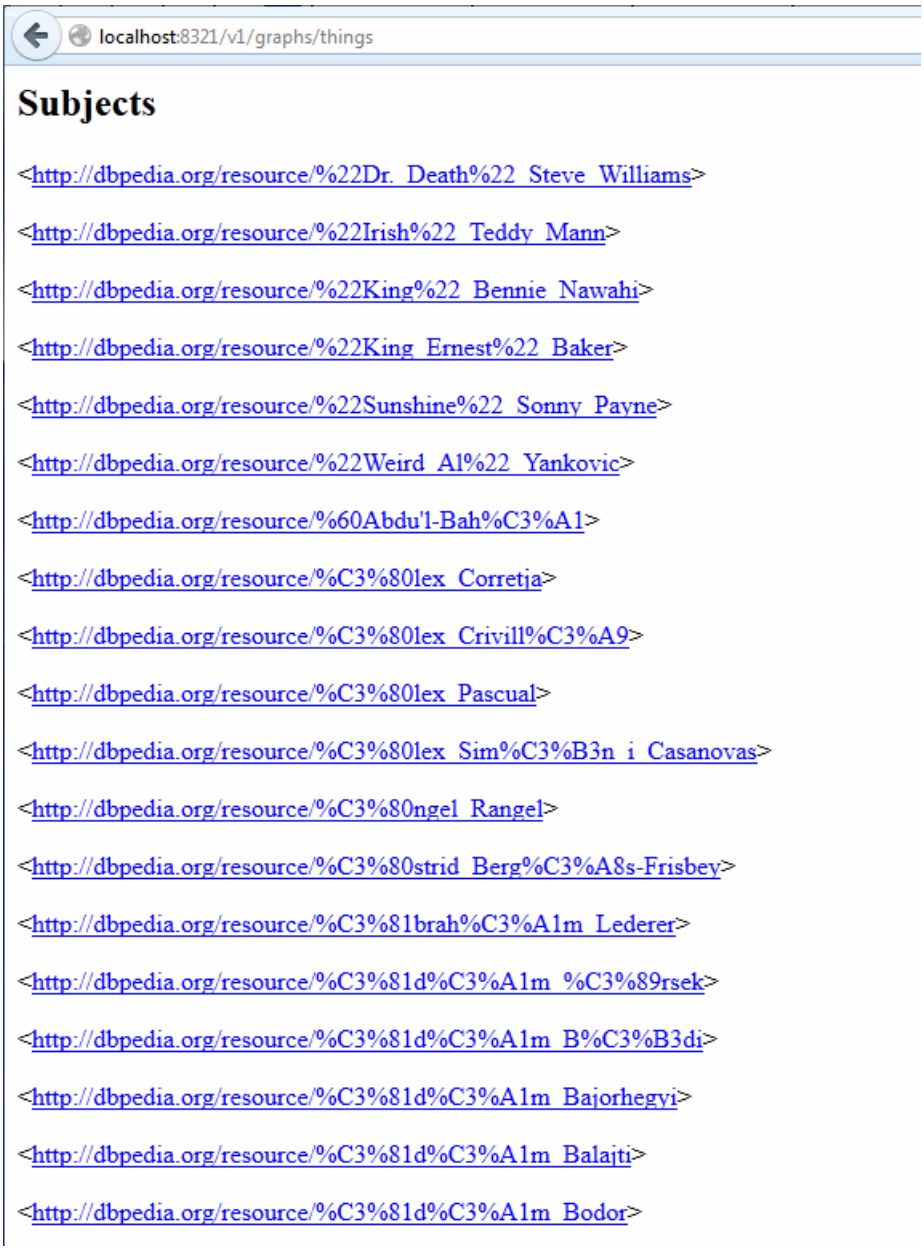
where *hostname* is the name of your MarkLogic Server host machine, and `8321` is the port number for the REST instance you created in "Creating a REST API Instance" on page 23.

2. Append "`/v1/graphs/things`" to the end of the web address URL.

   For example:

   ```
   http://hostname:8321/v1/graphs/things
   ```

   The first one thousand subjects are displayed:



3. Click on a subject link to view the triples. Subject and predicate IRIs are represented as links.

8 triples

<http://dbpedia.org/resource/%C3%80lex_Corretja> <http://dbpedia.org/ontology/birthPlace> <http://dbpedia.org/resource/Barcelona> .
<http://dbpedia.org/resource/%C3%80lex_Corretja> <http://dbpedia.org/ontology/birthPlace> <http://dbpedia.org/resource/Spain> .
<http://dbpedia.org/resource/%C3%80lex_Corretja> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://xmlns.com/foaf/0.1/Person> .
<http://dbpedia.org/resource/%C3%80lex_Corretja> <http://xmlns.com/foaf/0.1/givenName> "Alex" .
<http://dbpedia.org/resource/%C3%80lex_Corretja> <http://xmlns.com/foaf/0.1/name> "Alex Corretja" .
<http://dbpedia.org/resource/%C3%80lex_Corretja> <http://xmlns.com/foaf/0.1/surname> "Corretja" .
<http://dbpedia.org/resource/%C3%80lex_Corretja> <http://purl.org/dc/elements/1.1/description> "Tennis player" .
<http://dbpedia.org/resource/%C3%80lex_Corretja> <http://dbpedia.org/ontology/birthDate> "1974-04-11"^^xs:date .

2.3 Querying Triples

You can run SPARQL queries in Query Console or via an HTTP endpoint using the `/v1/graphs/sparql` endpoint (`GET:/v1/graphs/sparql` and `POST:/v1/graphs/sparql`). This section includes the following topics:

- Querying with Native SPARQL
- Querying with the sem:sparql Functions

Note: This section assumes you loaded the sample dataset as described in “Downloading the Dataset” on page 26.

2.3.1 Querying with Native SPARQL

You can run queries in Query Console using native SPARQL or the built-in function `sem:sparql`.

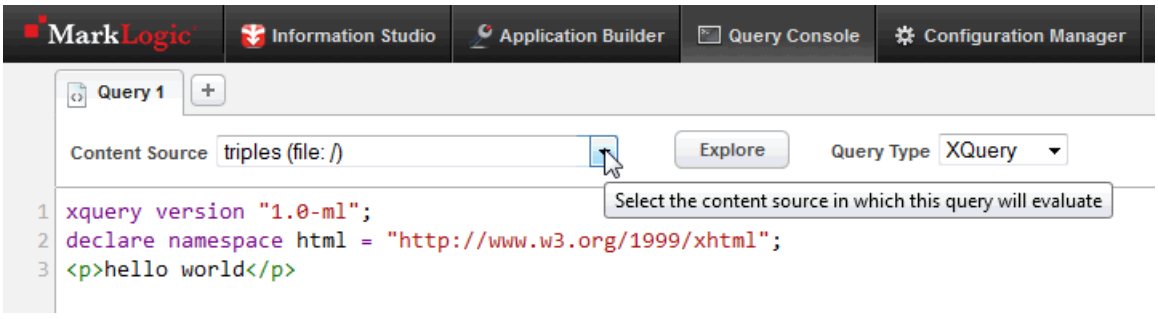
To run queries:

1. Navigate to Query Console with a Web browser:

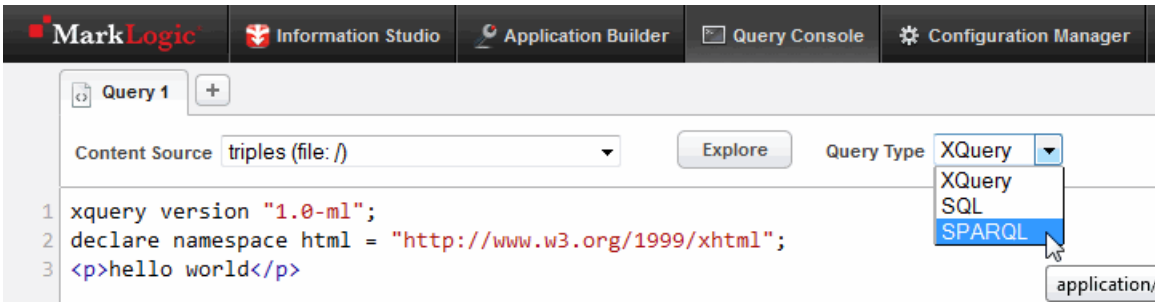
   ```
   http://hostname:8000/qconsole
   ```

   where *hostname* is the name of your MarkLogic Server host.

2. From the Content Source drop-down list, select the triples database.



3. From the Query Type drop-down list, select “SPARQL”.

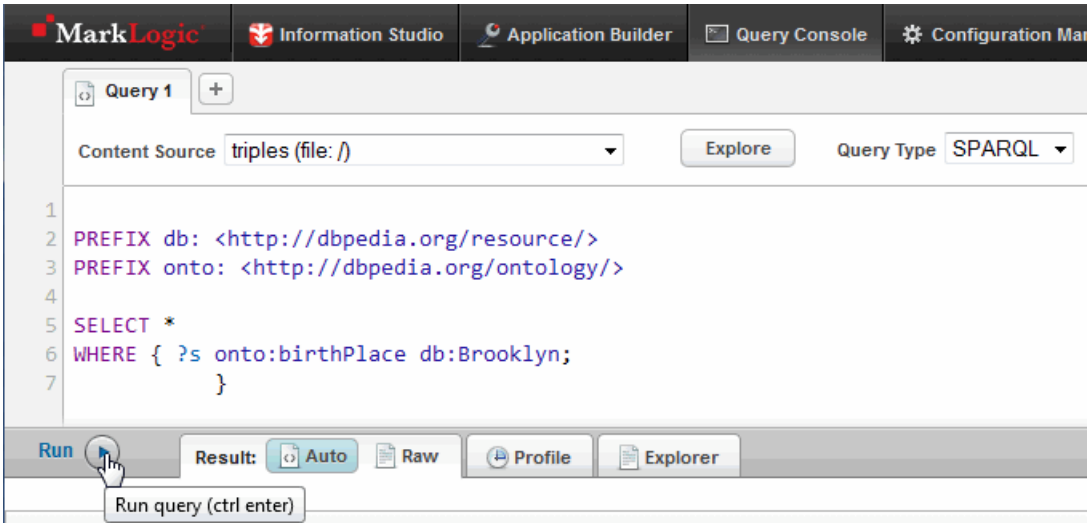


4. In the query window, replace the default query text with this SPARQL query:

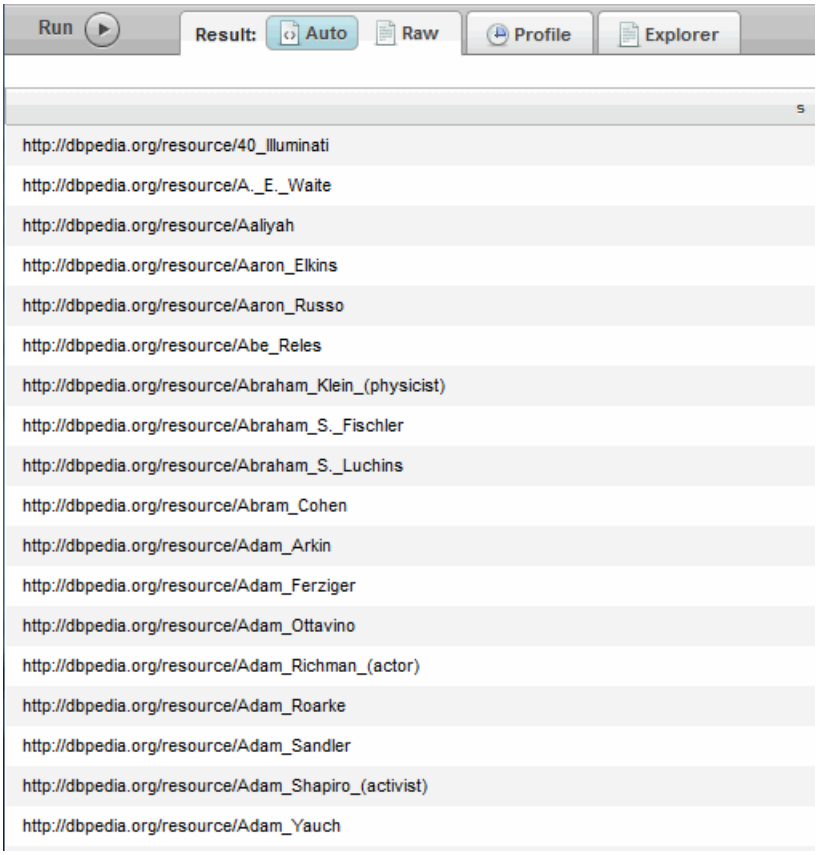
```
PREFIX db: <http://dbpedia.org/resource/>
PREFIX onto: <http://dbpedia.org/ontology/>

SELECT *
WHERE { ?s onto:birthPlace db:Brooklyn }
```

5. Click Run.



The results show people born in Brooklyn, as IRIs.



2.3.2 Querying with the sem:sparql Functions

Use the built-in XQuery function `sem:sparql` in Query Console to run the same query.

1. From the Content Source drop-down list, select the triples database.
2. From the Query Type drop-down list, select “XQuery”.
3. In the query window, enter this query:

```
xquery version "1.0-ml";

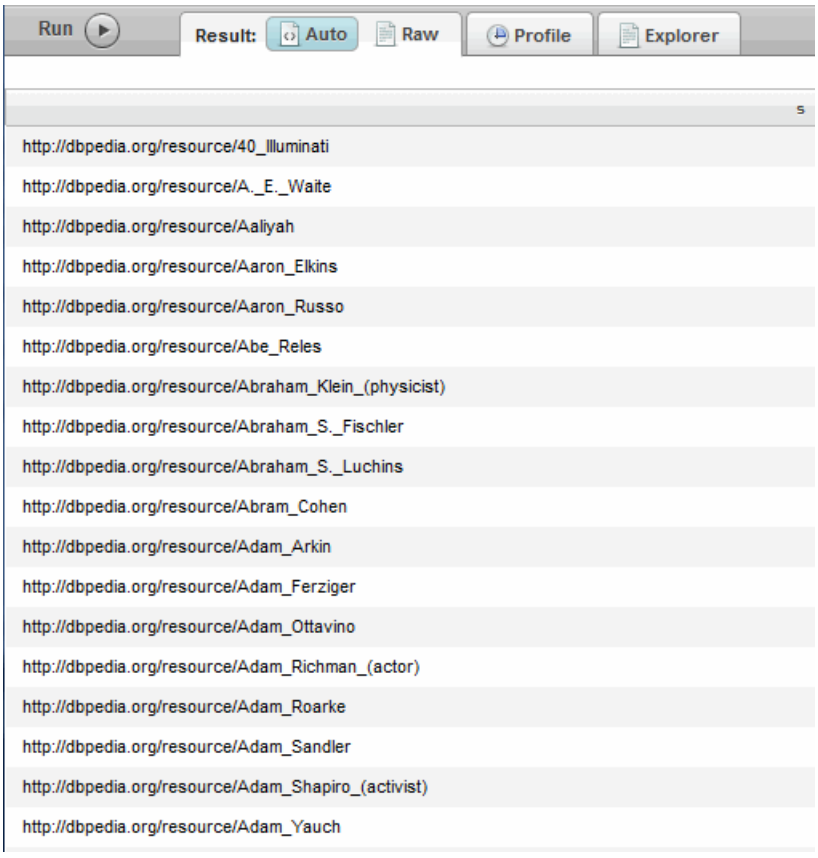
sem:sparql('
PREFIX db: <http://dbpedia.org/resource/>
PREFIX onto: <http://dbpedia.org/ontology/>

SELECT *
WHERE { ?s onto:birthPlace db:Brooklyn }
')
```

4. Click Run.



5. The results show people born in Brooklyn as IRIs, the same as in “Querying with Native SPARQL” on page 29.



For more information and examples of SPARQL queries, see “Semantic Queries” on page 63.

3.0 Loading Triples

You can load triples into a MarkLogic database from two sources; from an XML document that contains embedded triples elements, or from a triples files containing serialized RDF data. This chapter includes the following sections:

- Loading Embedded RDF Triples
- Loading Triples from Triples Files

3.1 Loading Embedded RDF Triples

You can load documents that contain embedded triples in XML documents with any of the ingestion tools described in Available Content Loading Interfaces in the *Loading Content Into MarkLogic Server Guide*.

> **Note:** The embedded triples must be in the MarkLogic XML format defined in the schema for `sem:triple` (`semantics.xsd`).

Triples ingested into a MarkLogic database are indexed by the triples index and stored for access and query by SPARQL. See “Storing RDF Triples in MarkLogic” on page 11 for details.

3.2 Loading Triples from Triples Files

There are a number of ways to load triples files–documents containing serialized triples in a supported RDF serialization–into MarkLogic. “Supported RDF Triple Serializations” on page 34 describes these RDF serializations.

When you load one or more triples files, they are parsed into generated XML documents. A unique IRI is generated for every XML document. Each document can contain multiple triples.

> **Note:** The setting for the number of triples stored in documents is defined by MarkLogic Server and is not a user configuration.

Ingested triples are indexed with the triples index to provide access and the ability to query the triples with SPARQL, XQuery, or a combination of both. You can also use a REST endpoint to execute SPARQL queries and return RDF data.

Triples are stored in a default graph that uses a MarkLogic Server feature called a *collection*. MarkLogic Server tracks the default graph with the collection IRI `http://marklogic.com/semantics#default-graph`. You can specify a different collection during the load process and load triples into a named graph. For more information about collections, see Collections in the *Search Developer’s Guide*.

The generated XML documents containing the triple data are loaded into a default directory named `/triplestore`. Some loading tools let you specify a different directory. For example, when you load triples using mlcp, you can specify the collection and the directory as part of the import options. For more information, see “Loading triples with mlcp” on page 39.

This section includes the following topics:

- Supported RDF Triple Serializations
- Example RDF Serialization Syntax
- Loading triples with mlcp
- Loading Triples with XQuery
- Loading Triples Using the REST API

3.2.1 Supported RDF Triple Serializations

MarkLogic Server supports loading these RDF data serializations:

Format	Description	File Type	MIME Type
RDF/XML	A syntax used to serialize an RDF graph as an XML document. For an example, see "RDF/XML" on page 35.	.rdf	application/rdf+xml
Turtle	Terse RDF Triple Language (Turtle) format is a simplified subset of Notation 3 (N3), used for expressing data in the lowest common denominator of serialization. For an example, see "Turtle" on page 36.	.ttl	text/turtle
RDF/JSON	A syntax used to serialize RDF data as JSON objects. For an example, see "RDF/JSON" on page 36.	.json	application/rdf+json
N3	Notation3 (N3) format is a non-XML syntax used to serialize RDF data. For an example, see "N3" on page 37.	.n3	text/n3
N-Triples	A plain text serialization format for RDF graphs. N-Triples is a subset of Turtle and Notation3 (N3). For an example, see "N-Triples" on page 37.	.nt	application/n-triples
N-Quads	A superset format that extends N-Triples with an optional context value. For an example, see "N-Quads" on page 38.	.nq	application/n-quads

Format	Description	File Type	MIME Type
TriG	A plain text serialization format for RDF-named graphs and RDF datasets. For an example, see “TriG” on page 39.	.trig	application/trig

3.2.2 Example RDF Serialization Syntax

This section includes examples for the following RDF serializations:

- RDF/XML
- Turtle
- RDF/JSON
- N3
- N-Triples
- N-Quads
- TriG

3.2.2.1 RDF/XML

RDF/XML is the original standard for writing unique RDF syntax as XML. It is used to serialize an RDF graph as an XML document.

This example defines three prefixes, “rdf”, “xsd”, and “d”.

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:d="http://example.org/data#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#">
  <rdf:Description rdf:about="http://example.org/data#item22">
    <d:shipped rdf:datatype="xsd:date">2013-05-14</d:shipped>
    <d:quantity rdf:datatype="xsd:integer">27</d:quantity>
    <d:invoiced rdf:datatype="xsd:boolean">true</d:invoiced>
    <d:costPerItem rdf:datatype="xsd:decimal">10.50</d:costPerItem>
  </rdf:Description>
</rdf:RDF>
```

3.2.2.2 Turtle

Terse RDF Triple Language (or Turtle) format expresses data in the RDF data model using a syntax similar to SPARQL. Turtle syntax expresses triples in the RDF data model in groups of three IRIs.

For example:

```
<http://example.org/item/item22>
<http://example.org/details/shipped>
<http://purl.org/dc/elements/1.1/date> "2013-05-14".
```

This triple states that item 22 was shipped on May 14th, 2013.

Turtle syntax provides a way to abbreviate information for multiple statements using `@prefix` to factor out the common portions of IRIs. This makes it quicker to write RDF Turtle statements. The syntax resembles RDF/XML, however unlike RDF/XML, it does not rely on XML. Turtle syntax is also valid Notation3 (N3) since Turtle is a subset of N3.

> **Note:** Turtle can only serialize valid RDF graphs.

In this example, four triples describe a transaction. The “shipped” object is assigned a “date” datatype, making it a typed literal enclosed in quotes. There are three untyped literals for the “quantity”, “invoiced”, and “costPerItem” objects.

```
@prefix i: <http://example.org/item#> .
@prefix dt: <http://example.org/details#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#>
  i:item22 dt:shipped "2013-05-14"^^xsd:date .
  i:item22 dt:quantity 100 .
  i:item22 dt:invoiced true .
  i:item22 dt:costPerItem 10.50 .
```

3.2.2.3 RDF/JSON

RDF/JSON is a textual syntax for RDF that allows an RDF graph to be written in a form compatible with JavaScript Object Notation (JSON).

For example:

```
{ "http://example.com/ns/directory#m":
  { "http://example.com/ns/person#firstName":
    [ { "value": "Michelle",
        "type": "literal",
        "datatype": "http://www.w3.org/2001/XMLSchema#string" }
    ]
  }
}
```

3.2.2.4 N3

Notation3 (N3) is a non-XML syntax to used to serialize RDF graphs in a more compact and readable form than XML RDF notation. N3 includes support for RDF-based rules.

When you have several statements about the same subject in N3, you can use a semicolon (;) to introduce another property of the same subject. You can also use a comma to introduce another object with the same predicate and subject.

For example:

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix dc: <http://purl.org/dc/elements/1.1/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix foafcorp: <http://xmlns.com/foaf/corp#> .
@prefix vcard: <http://www.w3.org/2001/vcard-rdf/3.0#> .
@prefix sec: <http://www.rdfabout.com/rdf/schema/ussec/> .
@prefix id: <http://www.rdfabout.com/rdf/usgov/sec/id/> .

id:cik0001265081 sec:hasRelation [
  dc:date "2008-06-05";
  sec:corporation id:cik0001000045;
  rdf:type sec:OfficerRelation;
  sec:officerTitle "Senior Vice President, CFO"] .

id:cik0001000180 sec:cik "0001000180";
  foaf:name "SANDISK CORP";
  sec:tradingSymbol "SNDK";
  rdf:type foafcorp:Company.

id:cik0001009165 sec:cik "0001009165";
  rdf:type foaf:Person;
  foaf:name "HARARI ELIYAHOU ET AL";
  vcard:ADR [ vcard:Street "601 MCCARTHY BLVD.; ";
  vcard:Locality "MILPITAS, CA"; vcard:Pcode "95035" ] .
```

3.2.2.5 N-Triples

N-Triples is a plain text serialization format for RDF graphs. It is a subset of Turtle, designed to be simpler to use than Turtle or N3. Each line in N-Triples syntax encodes one RDF triple statement and consists of the following:

- Subject (an IRI or a blank node identifier), followed by one or more characters of whitespace
- Predicate (an IRI), followed by one or more characters of whitespace
- Object (an IRI, blank node identifier, or literal) followed by a period (.) and a new line.

Typed literals may include language tags to indicate the language. In this N-Triples example, `@en-US` indicates that title of the resource is in US English.

```
<http://www.w3.org/2001/sw/RDFCore/ntriples/>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://xmlns.com/foaf/0.1/Document> .

<http://www.w3.org/2001/sw/RDFCore/ntriples/>
<http://purl.org/dc/terms/title> "Example Doc"@en-US .

<http://www.w3.org/2001/sw/RDFCore/ntriples/>
<http://xmlns.com/foaf/0.1/maker> _:jane .

<http://www.w3.org/2001/sw/RDFCore/ntriples/>
<http://xmlns.com/foaf/0.1/maker> _:joe .

  _:jane <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
  <http://xmlns.com/foaf/0.1/Person> .

  _:jane <http://xmlns.com/foaf/0.1/name> "Jane Doe".

  _:joe <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
  <http://xmlns.com/foaf/0.1/Person> .

  _:joe <http://xmlns.com/foaf/0.1/name> "Joe Bloggs".
```

Note: Each line breaks after the end period. For clarity, additional line breaks have been added.

3.2.2.6 N-Quads

N-Quads is a line-based, plain text format for encoding an RDF dataset. N-Quads syntax is a superset of N-Triples, extending N-Triples with an optional context value. The simplest statement is a sequence of terms (subject, predicate, object) forming an RDF triple, and an optional IRI labeling the graph in a dataset to which the triple belongs. All of these are separated by a whitespace and terminated by a period (.) at the end of each statement.

This example uses the relationship vocabulary. The class or property in the vocabulary has a IRI constructed by appending a term name “acquantanceOf” to the vocabulary IRI.

```
<http://example.org/#Jane>
<http://http://purl.org/vocab.org/relationship/acquantanceOf>
<http://example.org/#Joe>
<http://example.org/graphs/directory> .
```

3.2.2.7 TriG

TriG is a plain text format for serializing RDF graphs. TriG is similar to Turtle, but is extended with curly braces ({) and (}) to group triples into multiple graphs and precede named graphs with their names. An optional equals operator (=) can be used to assign graph names and an optional end period (.) is included for Notation3 compatibility.

Characteristics of TriG serialization include:

- Graph names must be unique within a TriG document, with one unnamed graph per TriG document.
- TriG content is stored in files with an '.trig' suffix. The mime type of TriG is application/x-trig and the content encoding is UTF-8.

This example contains a default graph and two named graphs.

```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix dc: <http://purl.org/dc/elements/1.1/> .
@prefix foaf: <http://xmlns.com/foaf/0.1/> .

# default graph is http://marklogic.com/semantics#default-graph
    {
    <http://example.org/joe> dc:publisher "Joe" .
    <http://example.org/jane> dc:publisher "Jane" .
    }
# first named graph
    <http://example.org/joe>
    {
      _:a foaf:name "Joe" .
      _:a foaf:mbox <mailto:joe@jbloggs.example.org> .
    }
# second named graph
  <http://example.org/jane>
    {
      _:a foaf:name "Jane" .
      _:a foaf:mbox <mailto:jane@jdoe.example.org> .
    }
```

3.2.3 Loading triples with mlcp

MarkLogic Content Pump (mlcp) is a command line tool for importing into, exporting from, and copying content to MarkLogic from a local file system or Hadoop distributed file system (HDFS).

Using mlcp, you can bulk load billions of triples and quads into a MarkLogic database and specify the import options. For example, you can specify the directory into which the triples or quads are loaded. It is the recommended tool for bulk loading triples. For more detailed information about mlcp, see Using MarkLogic Content Pump in the *Loading Content Into MarkLogic Server Guide*.

This section discusses loading triples into MarkLogic Server with mlcp and includes the following topics:

- Preparation
- Import Command Syntax
- Loading Triples and Quads
- Specifying Collections and a Directory

3.2.3.1 Preparation

Use these procedures to load content with mlcp:

1. Download and extract the mlcp binary files from developer.marklogic.com. For more information about installing and using mlcp and system requirements, see Downloading and Installing mlcp in the *Loading Content Into MarkLogic Server Guide*.

   Note: Although the extracted mlcp binary files do not need to be on the same MarkLogic host machine, you must have access and permissions for the host machine into which you are loading the triples.

2. Create a database and forest. For more information, see Creating a New Database in the *Administrator's Guide*.

3. Enable the triple index (and *optionally* enable the collection lexicon) on the database configuration pages of the Admin Interface or Application Services, or with the Admin API. See "Enabling the Triple Index" on page 57 for details.

   Note: The collection lexicon index is required for the graph store protocol used by REST API instances and for use of the GRAPH "?g" construct in SPARQL queries.

4. To use mlcp, first associate or create an XDBC server for your database. For more information, see Creating a New XDBC Server in the *Administrator's Guide*.

5. (Optional) Put the mlcp bin directory in your path. For example:

   ```
   $ export PATH=${PATH}:/space/marklogic/directory-name/bin
   ```

   where *directory-name* is derived from the version of mlcp that you downloaded.

6. Use a command-line interpreter or interface to enter the import command as a single-line command.

3.2.3.2 Import Command Syntax

The mlcp import command syntax required for loading triples and quads into MarkLogic is:

```
mlcp_command import -host hostname -port port number \
-username username -password password \
-input_file_path filepath -input_file_type filetype
```

Note: Long command lines in this section are broken into multiple lines using the line continuation characters "\" or "^". Remove the line continuation characters when you use the import command.

The *mlcp_command* you use depends on your environment. Use the mlcp shell script `mclp.sh` for Unix systems and the batch script `mlcp.bat` for Windows systems. The `-host` and `-port` values specify the MarkLogic host machine into which you are loading the triples. Your user credentials, `-username` and `-password` are followed by the path to the content , the `-input_file_path` value.

The `-input_file_path` may point to a directory, file, or compressed file in `.zip` or `.gzip` format. The `-input_file_type` is the type of content to be loaded. The file extension of the file found in the `-input_file_path` is used by mlcp to identify the type of content being loaded. A document with a file extension of `.nq` or `.trig` is identified as quad data, all other file extensions are identified as triple data. For more information about file extensions, see "Supported RDF Triple Serializations" on page 34.

Note: You must have sufficient MarkLogic privileges to import to the specified host. See Security Considerations in the *Loading Content Into MarkLogic Server Guide*.

3.2.3.3 Loading Triples and Quads

In addition to the required import options, you can specify several input and output options. See "Import Options" on page 42 for more details about these options. For example, you can load triples and quads by specifying RDF as the `-input_file_type` option:

```
$ mlcp.sh import -host localhost -port 8006 -username user \
-password passwd -input_file_path /space/tripledata/example.nt \
-mode local -input_file_type RDF
```

This example uses the shell script to load triples from a single N-Triples file `example.nt`, from a local file system directory `/space/tripledata` into a MarkLogic host on port `8006`.

On a Windows environment, the command would look like this:

```
> mlcp.bat import -host localhost -port 8006 ^
-username admin -password passwd ^
-input_file_path c:\space\tripledata\example.nt -mode local ^
-input_file_type RDF
```

Note: For clarity, these long command lines are broken into multiple lines using the line continuation characters "\" or "^". Remove the line continuation characters when you use the import command.

When you specify RDF as `-input_file_type` the mlcp RDFReader parses the triples and generates XML documents with `sem:triple` as the root element of the document.

3.2.3.4 Import Options

Use these options with the `import` command to load triples or quads.

Options	Description
`-input_file_type` *string*	Specifies the input file type. Default: document.
`-input_compressed` *boolean*	When set to "true" this option enables decompression on import. Default: false
`-fastload` *boolean*	When set to "true" this option forces optimal performance with a direct forest update. This may result in duplicate document IRIs. See Time vs. Correctness: Understanding -fastload Tradeoffs in the *Loading Content Into MarkLogic Server Guide.*
`-output_directory`	Specifies the destination database directory in which to create the loaded documents. Using this option enables `-fastload` by default, which can cause duplicate IRIs to be created. See Time vs. Correctness: Understanding -fastload Tradeoffs in the *Loading Content into MarkLogic Server Guide.* Default: `/triplestore`
`-output_collections`	Creates a comma-separated list of collections. Default: `http://marklogic.com/semantics#default-graph`

For more information about import options, see Import Options in the *Loading Content into MarkLogic Server Guide.*

You can split large triples documents into smaller documents to parallelize loading with mlcp and load all the files in a directory that you specify with `-input_file_path`.

For example:

```
# Windows users, see Modifying the Example Commands for Windows

$ mlcp.sh import -host localhost -port 8006 -username user \
-password passwd -input_file_path /space/tripledata \
-mode local -input_file_type RDF
```

3.2.3.5 Specifying Collections and a Directory

To load triples into a named graph, specify a collection by using the `-output_collections` option.

For example:

```
# Windows users, see Modifying the Example Commands for Windows

$ mlcp.sh import -host localhost -port 8006 -username user \
-password passwd -input_file_path /space/tripledata \
-mode local -input_file_type RDF \
-output_collections /my/collection
```

This command puts all the triples in the `tripledata` directory into a named graph and overwrites the graph IRI to `/my/collection`.

> **Note:** Use `-output_collections` and not `-filename_as_collection` to overwrite the default graph IRI.

For triples data, the documents go in the default collection (`http://marklogic.com/semantics#default-graph`) if you do not specify any collections.

For quad data, if you do not specify any collections, the triples are parsed, serialized, and stored in documents with the fourth part of the quad as the collection.

For example with this quad, the fourth part is an IRI that identifies the homepage of the subject.

```
<http://dbpedia.org/resource/London_Heathrow_Airport>
<http://xmlns.com/foaf/0.1/homepage>
<http://www.heathrowairport.com/>
<http://en.wikipedia.org/wiki/London_Heathrow_Airport?oldid=495283228#
absolute-line=26> .
```

When the quad is loaded into the database, the collection is generated as a named graph, `http://en.wikipedia.org/wiki/London_Heathrow_Airport?oldid=495283228#absolute-line=26`.

> **Note:** If the `-output_collections` import option specifies a named graph, the fourth element of the quad is ignored and the named graph is used.

If you are using a variety of loading methods, consider putting all of the triples documents in a common directory. Since the `sem:rdf-insert` and `sem:rdf-load` functions put triples documents in the `/triplestore` directory, use `-output_uri_prefix /triplestore` to put mlcp-generated triples documents there as well.

For example:

```
$ mlcp.sh import -host localhost -port 8006 -username user \
-password passwd -input_file_path /space/tripledata/example.zip \
-mode local -input_file_type RDF \
```

```
-input_compressed true
-output_collections /my/collection \
-output_uri_prefix '/triplestore'
```

When you load triples or quads into a specified named graph from a compressed `.zip` or `.gzip` file, mlcp extracts and serializes the content based on the serialization format. For example, a compressed file containing Turtle documents (`.ttl`) will be identified and parsed as triples.

When the content is loaded into MarkLogic with mlcp, the triples are parsed as they are ingested as XML documents with a unique IRI. These unique IRIs are random numbers expressed in hexadecimal. This example shows triples loaded with mlcp from the `persondata.ttl` file, with the `-output_uri_prefix` specified as `/triplestore`:

```
/triplestore/d2a0b25bda81bb58-0-10024.xml
/triplestore/d2a0b25bda81bb58-0-12280.xml
/triplestore/d2a0b25bda81bb58-0-13724.xml
/triplestore/d2a0b25bda81bb58-0-14456.xml
```

Carefully consider the method you choose for loading triples. The algorithm for generating the document IRIs with mlcp differs from other loading methods such as loading from a system file directory with `sem:rdf-load`.

For example, loading the same `persondata.ttl` file with `sem:rdf-load` results in IRIs that appear to have no relation to each other:

```
/triplestore/11b53cf4db02080a.xml
/triplestore/19b3a986fcd71a5c.xml
/triplestore/215710576ebe4328.xml
/triplestore/25ec5ded9bfdb7c2.xml
```

When you load triples with `sem:rdf-load`, the triples are bound to the `http://marklogic.com/semantics` namespace (or prefix) in the resulting documents.

For example:

```
<?xml version="1.0" encoding="UTF-8"?>
<sem:triples xmlns:sem="http://marklogic.com/semantics">
  <sem:triple>
    <sem:subject>http://dbpedia.org/resource/Wayne_Stenehjem
    </sem:subject>
    <sem:predicate>http://purl.org/dc/elements/1.1/description
    </sem:predicate>
    <sem:object datatype="http://www.w3.org/2001/XMLSchema#string"
    xml:lang="en">American politician
    </sem:object>
  </sem:triple>
  <sem:triple>
    <sem:subject>http://dbpedia.org/resource/Wayne_Stenehjem
    </sem:subject>
    <sem:predicate>http://dbpedia.org/ontology/birthDate
    </sem:predicate>
    <sem:object datatype="http://www.w3.org/2001/XMLSchema#date">
    1953-02-05
    </sem:object>
  </sem:triple>
</sem:triples>
```

3.2.4 Loading Triples with XQuery

Triples are typically created outside MarkLogic Server and loaded via Query Console by using the following `sem:` functions:

- sem:rdf-insert
- sem:rdf-load
- sem:rdf-get

The `sem:rdf-insert` and `sem:rdf-load` functions are update functions. The `sem:rdf-get` function is a return function that loads triples in memory. These functions are included in the XQuery Semantics API that is implemented as an XQuery library module.

To use `sem:` functions in XQuery, import the module with the following XQuery prolog statement in Query Console:

```
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";
```

For more details about semantic functions in XQuery, see the Semantics (`sem:`) documentation in the *MarkLogic XQuery and XSLT Function Reference*.

3.2.4.1 sem:rdf-insert

The `sem:rdf-insert` function inserts triples into the database as triples documents. The triple is created in-memory by using the `sem:triple` and `sem:iri` constructors. The IRIs of the inserted documents are returned on execution.

For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
at "/MarkLogic/semantics.xqy";

  sem:rdf-insert(
    sem:triple(
      sem:iri("http://example.org/people#m"),
      sem:iri("http://example.com/person#firstName"),
      "Michael"))

=>
(: Returns the document IRI :)
/triplestore/70eb0b7139816fe3.xml
```

By default, `sem:rdf-insert` puts the documents into the directory `/triplestore/` and assigns the default graph. You can specify a named graph as a collection in the fourth parameter.

For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

  sem:rdf-insert(sem:triple(
        sem:iri("http://example.com/ns/directory#jp"),
        sem:iri("http://example.com/ns/person#firstName"),
        "John-Paul"), (), (),  "mygraph")
```

When you run this example, the document is inserted into both the default graph and mygraph.



Note: If you insert quads or triples in TriG format, the graph name comes from the value in the “fourth position” in the quads/trig file.

3.2.4.2 sem:rdf-load

The `sem:rdf-load` function loads and parses triples from files in a specified location into the database and returns the IRIs of the triples documents. You can specify the serialization format of the triples, such as `turtle` for Turtle files or `rdfxml` for RDF files.

For example:

```
sem:rdf-load('C:\rdfdata\example.rdf', "rdfxml")

=>
/triplestore/fbd28af1471b39e9.xml
```

As with `sem:rdf-insert`, this function also puts the triples documents into the default graph and `/triplestore/` directory unless a directory or named graph is specified in the options. This example specifies `mynewgraph` as a named graph in the parameters:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

   sem:rdf-load("C:\turtledata\example.ttl", "turtle", (), (),
        "mynewgraph")
```

The document is inserted:

/triplestore/91b14a8e61b07c11.xml	E sem:triples	(no properties)	http://marklogic.com/semantics#default-graph, mygraph
/triplestore/9f2cfe9ecf2f87c9.xml	E sem:triples	(no properties)	http://marklogic.com/semantics#default-graph, mynewgraph

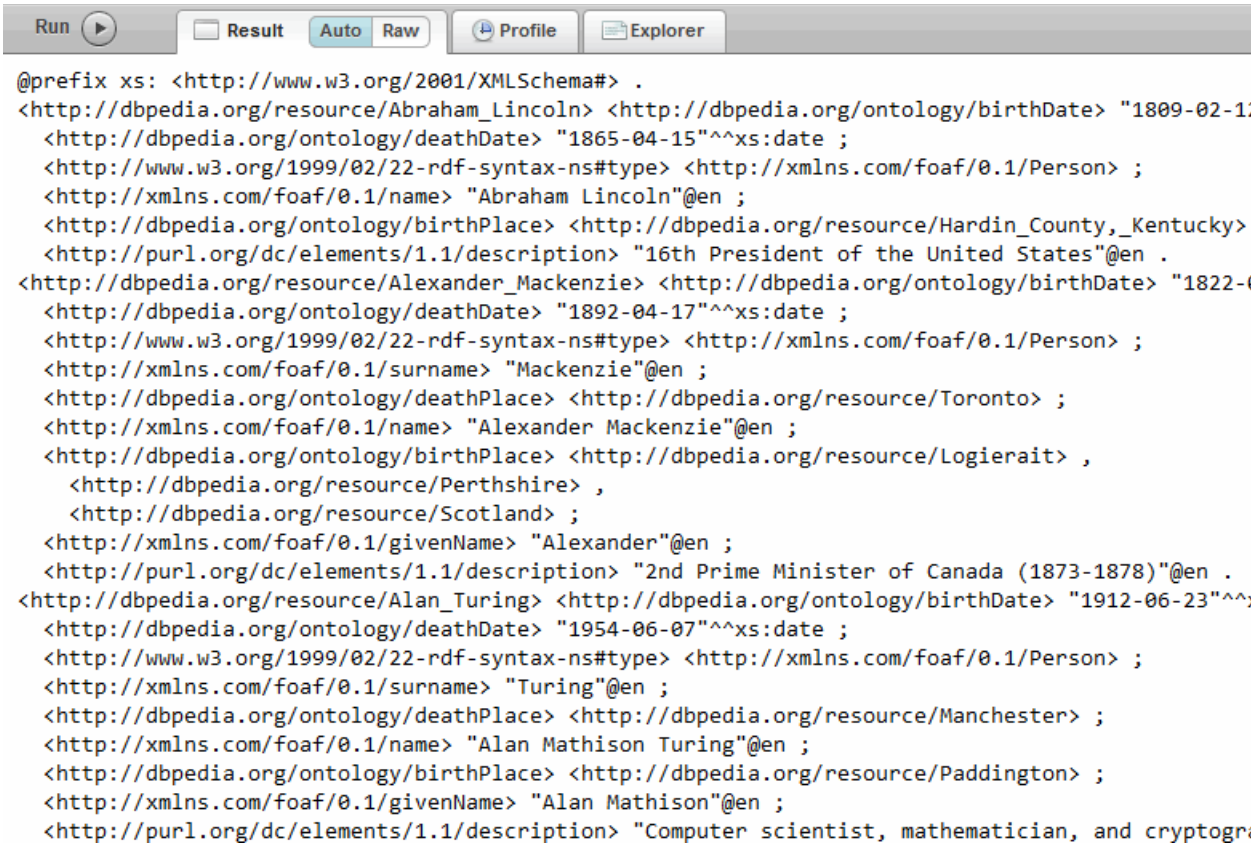
3.2.4.3 sem:rdf-get

The `sem:ref-get` function returns triples in triples files from a specified location. The following example retrieves triples serialized in Turtle format from the local filesystem:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

sem:rdf-get('C:\turtledata\people.ttl', "turtle")
```

The triples are returned as triples in Turtle format with one triple per line. Each triple ends with a period.



This Query Console display format allows for easy copying from the Result pane.

3.2.5 Loading Triples Using the REST API

A REST endpoint is an XQuery module on MarkLogic Server that routes and responds to an HTTP request. An HTTP client invokes endpoints to create, read, update, or delete content in MarkLogic. This section discusses using the REST API to load triples with a REST endpoint. It covers the following topics:

- Preparation
- Addressing the Graph Store
- Specifying Parameters
- Supported Verbs
- Supported Media Formats
- Loading Triples
- Response Errors

3.2.5.1 Preparation

If you are unfamiliar with the REST API and endpoints, see Introduction to the MarkLogic REST API in the *REST Application Developer's Guide*.

Use the following procedures to make requests with REST endpoints:

1. Install MarkLogic Server, version 7.0-1 or later.

2. Install curl or an equivalent command line tool for issuing HTTP requests.

3. Create a database and forest. See Creating a New Database in the *Administrator's Guide*.

4. Enable the triple index and the collection lexicon on the database configuration pages of the Admin Interface or Application Services, or with the Admin API. See "Enabling the Triple Index" on page 57.

   Note: The Collection lexicon is required for the graph store protocol of REST API instances.

5. Create a REST API Instance. See Creating an Instance in the *REST Application Developer's Guide*.

3.2.5.2 Addressing the Graph Store

The graph endpoint is an implementation of the W3C Graph Store protocol as specified in the SPARQL 1.1 Graph Store HTTP Protocol:

http://www.w3.org/TR/2012/CR-sparql11-http-rdf-update-20121108/

The base URL for the graph store is:

```
http://hostname:port/version/graphs
```

where *hostname* is the MarkLogic Server host machine and *port* is the port on which the REST API instance is running, and *version* is the version number of the API.

See Summary of the /graphs Service in the *REST Application Developer's Guide*.

3.2.5.3 Specifying Parameters

The graph endpoint accepts an optional parameter for a particular named graph. For example:

```
http://localhost:8009/v1/graphs?graph=http://named-graph
```

If omitted, the default graph must be specified as a default parameter with no value. For example:

```
http://localhost:8009/v1/graphs?default
```

When a GET request is issued with no parameters, the list of graphs will be given in list format.

3.2.5.4 Supported Verbs

A REST client uses HTTP verbs such as `GET` and `PUT` to interact with MarkLogic Server. This table lists the supported verbs and the role required to use each:

Verb	Description	Role
`GET`	Retrieves a named graph.	rest-reader
`POST`	Merges triples into a named graph or adds triples to an empty graph.	rest-writer
`PUT`	Replaces triples in a named graph or adds triples to an empty graph. Functionally equivalent to DELETE followed by POST. For an example, see "Loading Triples" on page 51.	rest-writer
`DELETE`	Removes triples in a named graph.	rest-writer
`HEAD`	Test for the existence of a graph. Retrieves a named graph, without the body.	rest-reader

The role you use to make a MarkLogic REST API request must have appropriate privileges for the content accessed by the HTTP call; for example, permission to read or update documents in the target database. For more information about REST API roles and privileges, see Security Requirements in the *REST Application Developer's Guide*.

Note: This endpoint will only update documents with the element `sem:triple` as the root.

3.2.5.5 Supported Media Formats

For a list of supported media formats for the `Content-type` HTTP header, see "Supported RDF Triple Serializations" on page 34.

3.2.5.6 Loading Triples

To insert triples, make a `PUT` or `POST` request to a URL of the form:

```
http://host:port/v1/graphs?graph=graphname
```

When constructing the request:

1. Set the `graph` parameter to a named graph or the default graph.
2. Place the content in the request body.
3. Specify the MIME type of the content in the `Content-type` HTTP header. See "Supported RDF Triple Serializations" on page 34.
4. Specify the user credentials.

The triples are parsed and loaded into the default directory, `/triplestore`.

This is an example of a `curl` command for a Unix or Cygwin command line interpreter. The command sends a `PUT` HTTP request to insert the contents of the file `example.nt` into the database as XML documents in the default collection:

```
# Windows users, see Modifying the Example Commands for Windows

$ curl -s -X PUT -d'@example.nt' \
    -H "Content-type: application/n-triples" \
    --digest --user "admin:password" \
    "http://localhost:8033/v1/graphs?default"
```

Note: When you load triples with the REST endpoint using `PUT` or `POST`, you must specify the default graph or a named graph.

These `curl` command options are used in the example above:

Option	Description
`-s`	Specifies silent mode, so that the `curl` output does not include the HTTP response headers in the output. The alternative is `-i` to include the response headers.
`-X` *`http_method`*	The type of HTTP request (`PUT`) that `curl` should send. Other supported requests are `GET`, `POST` and `DELETE`. See “Supported Verbs” on page 50.
`-d` *`data`*	Data to include in the request body. Data may be placed directly on the command line as an argument to `-d`, or read from a file by using `@`*`filename`*. If you are using Windows, a Windows version of `curl` that supports the "`@`" operator is required.
`-H` *`headers`*	The HTTP header to include in the request. The examples in this guide use `Content-type`.
`--digest`	The authentication method specified encrypts the user’s password.
`--user` *`user:password`*	Username and password used to authenticate the request. Use a MarkLogic Server user that has sufficient privileges to carry out the requested operation. For details, see Security Requirements in the *REST Application Developer’s Guide*.

For more information about the REST API, see the Semantics documentation in the *REST Client API*.

3.2.5.7 Response Errors

This section covers the error reporting conventions followed by the MarkLogic REST API. If a request to a MarkLogic REST API Instance fails, an error response code is returned and additional information is detailed in the response body.

Possible response errors include:

- `400 Bad Request` returns for `PUT` or `POST` requests that have no parameters at all.
- `400 Bad Request` returns for `PUT` or `POST` requests for payloads that fails to parse.
- `404 Not Found` returns for `GET` requests to a graph that does not exist (the IRI is not present in the collection lexicon).
- `406 Not Acceptable` returns for `GET` requests for triples in an unsupported format.
- `415 Unsupported Media Type` returns for `POST` or `PUT` request in an unsupported format.

Note: The `repair` parameter for `POST` and `PUT` requests can be set to `true` or `false`. By default this is `false`. If set to `true`, a payload that does not properly parse will still insert any triples that do parse. If set to `false`, any payload errors at all will result in a `400 Bad Request` response.

4.0 Triple Index Overview

This chapter provides an overview of the triple index in MarkLogic Server and includes the following sections:

- Triple Index: Understanding and Using
- Enabling the Triple Index
- Other Considerations

4.1 Triple Index: Understanding and Using

The triple index is used to index schema-valid `sem:triple` elements found anywhere in a document. The indexing of triples is performed when documents containing triples are ingested into MarkLogic or during a database reindex.

The validity of `sem:triple` elements is determined by checking elements and attributes in the documents against the `sem:triple` schema (`/MarkLogic/Config/semantics.xsd`). If the `sem:triple` element is valid, an entry is created in the triple index, otherwise the element is skipped.

Unlike range indexes, triple indexes do not have to fit in memory, so there is little up-front memory allocation.

This section covers the following topics:

- Triple Data and Value Caches
- Triple Values and Type Information
- Triple Positions
- Index Files
- Permutations

4.1.1 Triple Data and Value Caches

Internally, MarkLogic stores triples in two ways: *triple values* and *triple data*. The *triple values* are the individual values from every triple, including all typed literal, IRIs, and blank nodes. The *triple data* holds the triples in different permutations, along with a document ID and position information. The triple data refer to the triple values by ID, making for very efficient lookup. Triple data is stored compressed on disk, and triple values are stored in a separate compressed value store. Both the triple index and the value store are stored in compressed four-kilobyte (4k) blocks.

When triple data is needed (for example during a lookup), the relevant block is cached in either the triple cache or the triple value cache. Unlike other MarkLogic caches, the triple cache and triple value cache shrinks and grows, only taking up memory when it needs to add to the caches.

Note: You can configure the size of the triple cache and the triple value cache for the host of your triple store, as described in "Sizing Caches" on page 59.

4.1.2 Triple Values and Type Information

Values are stored in a separate value store on disk in "value equality" sorted order, so that in a given stand, the value ID order is equivalent to value equality order.

Strings in the values are stored in the range index string storage. Anything that is not relevant to value equality is removed from the stored values, for example timezone and derived type information.

Since type information is stored separately, triples are returned directly from the triple index. This information is also used for RDF-specific "sameTerm" comparison required by SPARQL simple entailment.

4.1.3 Triple Positions

The triple positions index is used to accurately resolve queries that use `cts:triple-range-query` and the `item-frequency` option of `cts:triples`. The triple positions index is also used to accurately resolve searches that use the `cts:near-query` and `cts:element-query` constructors. The triple positions index stores locations within a fragment of the relative positions of triples within that fragment (typically, a fragment is a document). Enabling the triple positions index makes index sizes larger and will make document loads a little slower, but increases the accuracy of queries that need those positions.

For example:

```
xquery version "1.0-ml";

cts:search(doc(),
  cts:near-query((
  cts:triple-range-query(sem:iri("http://www.rdfabout.com/rdf/
    usgov/sec/id/cik0001075285"), (), ()),

  cts:triple-range-query(sem:iri("http://www.rdfabout.com/rdf/
  usgov/sec/id/cik0001317036"), (), ())
  ),11), "unfiltered")
```

The `cts:near-query` returns a sequence of queries to match, where the matches occur within the specified distance from each other. The distance specified is in the number of words between any two matching queries.

The unfiltered search selects fragments from the indexes that are candidates to satisfy the specified `cts:query` and returns the document.

4.1.4 Index Files

To efficiently make use of memory, the index files for triple and value stores are directly mapped into memory. The type store is entirely mapped into memory.

Both the triple and value stores have index files consisting of 64-byte segments. The first segment in each is a header containing checksums, version number, and counts (of triples or values). This is followed by:

- Triples index - After the header segment, the triples index contains an index of the first two values and permutation of the first triple in each block, arranged into 64-byte segments. This is used to find the blocks needed to answer a given lookup based on values from the triple. Currently triples are not accessed by ordinal, so an ordinal index is not required.
- Values Index - After the header segment, the values index contains an index of the first value in each block, arranged into 64-byte segments. The values index is used to find the blocks needed to answer a given lookup based on value. This is followed by an index of the starting ordinal for each block, which is used to find the block needed to answer a given lookup based on a value ID.

  Note: The triple index stores positions if the `triple positions` is enabled. See “Enabling the Triple Index” on page 57.

The type store has an index file that stores the offset into the type data file for each stored type. This is also mapped into memory.

This table describes the memory-mapped index files that store information used by the triple indexes and values stores.

Index File	Description
`TripleIndex` `TripleValueIndex`	Block indexes for TripleData and TripleValueData
`TripleTypeData` `TripleTypeIndex`	Type information for the triple values

`StringData`
`StringIndex`
`AtomData`
`AtomIndex`
	Also used by the string-based range indexes

`TripleValueFreqs` `TripleValueFreqsIndex`	Statistical information about the triples. The triple index keeps statistics on the triples for every value kept in the database.

4.1.5 Permutations

The permutation enumeration details the role each value plays in the original triple. Three permutations are stored in order to provide access to different sort orders, and to be able to efficiently look up different parts of the triple. The permutations are acronyms made up from the initials of the three RDF elements (subject, predicate, and object), for example:{ `SOP, PSO, OPS` }.

Use the `cts:triples` function to specify one of these sort orders in the options:

- `order-pso` - Returns results ordered by predicate, then subject, then object
- `order-sop` - Returns results ordered by subject, then object, then predicate
- `order-ops` - Returns results ordered by object, then predicate, then subject

4.2 Enabling the Triple Index

By default, the triple index is not enabled when you create a database. This section discusses enabling the triple index, related indexes, and configuration settings. It includes the following topics:

- Using the Database Configuration Pages
- Using the Admin API

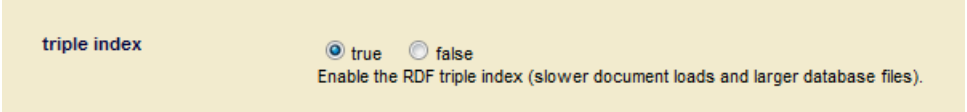
4.2.1 Using the Database Configuration Pages

The triple index can be enabled on the following database configuration pages (*hostname* is the MarkLogic Server host for which the triple index is to be enabled):

- In the Admin Interface, `http://hostname:8001`. For more information about index settings, see Index Settings that Affect Documents of the *Administrator's Guide*.
- In Application Services, `http://hostname:8000/appservices`. Use Application Services to enable or disable the triple index, which is labeled `Semantics`. See "Configuring a Database" on page 22.

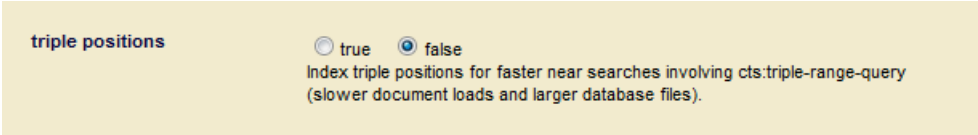
Use the following procedures to configure the triple index and related settings. To enable the triple positions index, the in-memory triple index size, and collection lexicon, use the Admin Interface (`http://hostname:8001`) or the Admin API. See "Using the Admin API" on page 58 for details.

In the Admin Interface, scroll down to the triple index setting and set it to true.



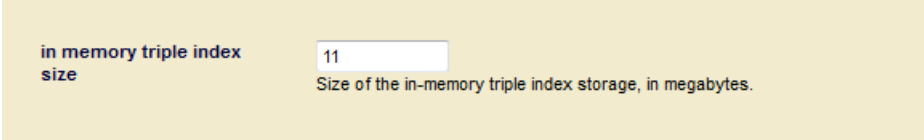
When you enable the triples index for the first time, or if you are reindexing your database after enabling the triple index, only documents containing valid `sem:triple` elements are indexed.

You can enable the triple positions index for faster near searches using `cts:triple-range-query`.



It is not necessary to enable the triple position index for querying with native SPARQL.

You can set the size of cache and buffer memory to be allocated for managing triple index data for an in-memory stand.



Note: When you change any index settings for a database, the new settings will take effect based on whether reindexing is enabled (`reindexer enable` set to `true`).

4.2.2 Using the Admin API

Use these Admin API functions to enable the triple index, triple index positions, and configure the in-memory triple index size for your database:

```
admin:database-set-triple-index
admin:database-set-triple-positions
admin:database-set-in-memory-triple-index-size
```

This example sets the triple index of “Sample-Database” to `true` using the Admin API:

```
xquery version "1.0-ml";
import module namespace admin = "http://marklogic.com/xdmp/admin"
  at "/MarkLogic/admin.xqy";

(: Get the configuration :)
let $config := admin:get-configuration()

(: Obtain the database ID of 'Sample-Database' :)
let $Sample-Database := admin:database-get-id(
  $config, "Sample-Database")
let $c := admin:database-set-triple-index($config, $Sample-Database,
fn:true())
return admin:save-configuration($c)
```

This example uses the Admin API to set the triple positions of the database to `true`:

```
xquery version "1.0-ml";
import module namespace admin = "http://marklogic.com/xdmp/admin"
  at "/MarkLogic/admin.xqy";

let $config := admin:get-configuration()
let $Sample-Database := admin:database-get-id(
  $config, "Sample-Database")
let $c := admin:database-set-triple-positions($config,
  Sample-Database, fn:true())
return admin:save-configuration($c)
```

This example sets the in-memory triple index size of the database to `true`:

```
xquery version "1.0-ml";
import module namespace admin = "http://marklogic.com/xdmp/admin"
  at "/MarkLogic/admin.xqy";

let $config := admin:get-configuration()
let $Sample-Database := admin:database-get-id(
  $config, "Sample-Database")
let $c := admin:database-set-in-memory-triple-index-size($config,
  $Sample-Database, fn:true())
return admin:save-configuration($c)
```

Note: For details about the function signatures and descriptions, see the `admin:database` functions (database) in the *XQuery and XSLT Reference Guide*.

4.3 Other Considerations

This section includes the following topics:

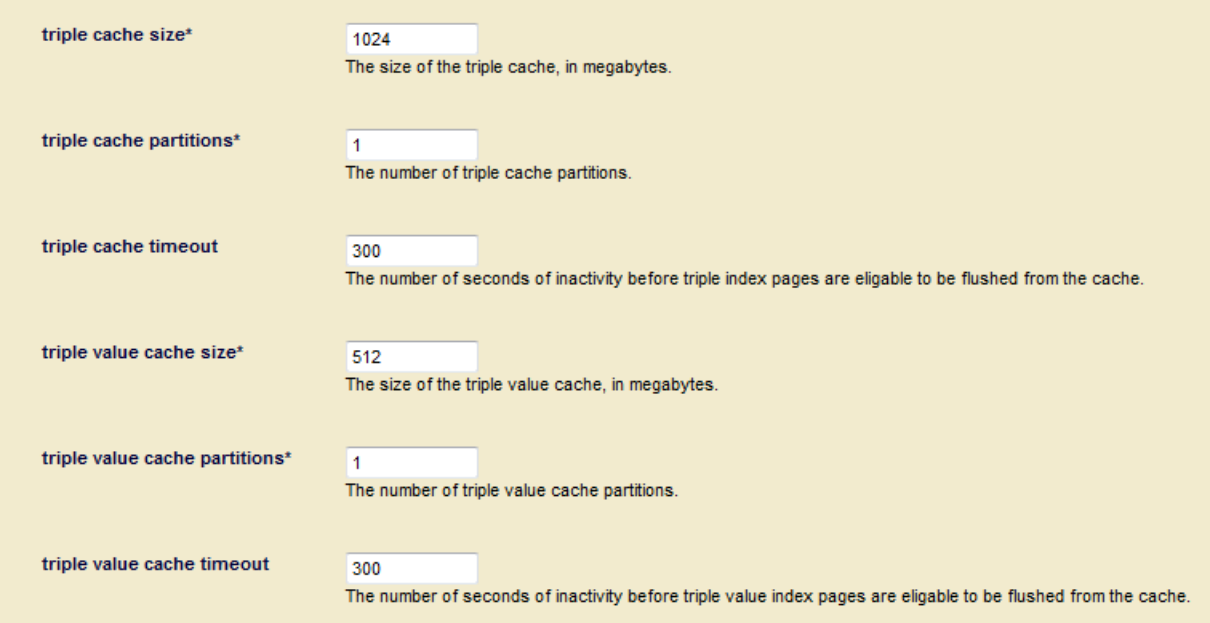
- Sizing Caches
- Unused Values and Types
- Scaling and Monitoring

4.3.1 Sizing Caches

The triple cache and the triple value cache are d-node caches, which are partitioned for lock contention.

The maximum sizes of the caches and number of partitions are configurable. To change the triple or triple value cache sizes for the host, you can use the Groups configuration page in the Admin Interface or use the Admin API.

In the Admin Interface (`http://hostname:8001`) on the Groups configuration page, specify values for caches sizes, partitions, and timeouts:



This table describes the Admin API functions for group cache configurations:

Function	Description
`admin:group-set-triple-cache-size`	Changes the triple cache size setting of the group with the specified ID to the specified value
`admin:group-set-triple-cache-partitions`	Changes the triple cache partitions setting of the group with the specified ID to the specified value
`admin:group-set-triple-cache-timeout`	Changes the number of seconds a triple block is unused before being flushed from caches
`admin:group-set-triple-value-cache-timeout`	Changes the number of seconds a triple value block is unused before being flushed from caches
`admin:group-set-triple-value-cache-size`	Changes the triple value cache size setting of the group with the specified ID to the specified value

Function	Description
`admin:group-set-triple-value-cache-partitions`	Changes the triple value cache partitions setting of the group with the specified ID to the specified value

4.3.2 Unused Values and Types

During a merge, triple values and types may become unused by the triple index. To merge the triple index in a single streaming pass, type and value stores are merged before the triples. Unused values and types are identified during the merge of the triples. During the next merge, the unused types and values identified are be removed, releasing the space they previously used.

> **Note:** For best compaction, two merges are needed. This is not an issue in normal operations because MarkLogic Server is designed to periodically merge.

Since the type store is ordered by frequency, it is merged entirely in memory. The value and triple stores are merged in a streaming fashion, from and to disk directly.

For more information about merging, see Understanding and Controlling Database Merges in the *Administrator's Guide*.

4.3.3 Scaling and Monitoring

Since SPARQL execution does not fetch fragments, there is the potential to scale back on expanded and compressed tree caches on triple-only deployments. You can configure tree caches from the Group configuration page in the Admin Interface, or by using these functions:

```
admin:group-set-expanded-tree-cache-size
admin:group-set-compressed-tree-cache-size
```

You can monitor the status of the database and forest from the database Status page in the Admin Interface:

```
http://hostname:8001/
```

You can also use the MarkLogic monitoring tools, Monitoring Dashboard and Monitoring History:

```
http://hostname:8002/dashboard
http://hostname:8002/history
```

For more information, see Using the MarkLogic Server Monitoring Dashboard in the *Monitoring MarkLogic Guide*.

You can also use these functions for query metrics and to monitor the status of forests and caches:

- `xdmp:query-meters` - Cache hits or misses for a query
- `xdmp:forest-status` - Cache hits or misses, hit rate, and miss rate for each stand
- `xdmp:cache-status` - Percentage busy, used, and free by cache partition

5.0 Semantic Queries

This chapter discusses the principal techniques and tools for performing semantic queries on RDF triples. Just as with loading and deleting triples, you can select your preferred method for querying RDF triples in MarkLogic. You can query triples in several ways, though the main focus in this chapter is using SPARQL to query triples.

SPARQL is a query language specification for querying over RDF triples. The SPARQL language is a formal W3C recommendation from the RDF Data Access Working Group. It is described in the SPARQL Query Language for RDF recommendation:

http://www.w3.org/TR/rdf-sparql-query/

MarkLogic supports all of the capabilities in SPARQL 1.0 and most of the capabilities in SPARQL 1.1. For more information, see "SPARQL 1.0 vs. SPARQL 1.1 Features" on page 89. SPARQL queries are executed natively in MarkLogic to query either in-memory triples or triples stored in a database. When querying triples stored in a database, SPARQL queries execute entirely against the triple index. For examples of running SPARQL queries, see "Querying Triples with SPARQL" on page 64.

You can combine SPARQL and XQuery. For example, you can restrict a SPARQL query by passing in a `cts:query`, and you can call XQuery built-in functions (including `cts:contains` for full-text search) as part of your SPARQL query. For more details, see "Using XQuery Built-in Functions in a SPARQL Query" on page 84.

You can use these methods to query triples:

- SPARQL mode in Query Console. For details, see "Querying Triples with SPARQL" on page 64
- XQuery using the semantics functions, and Search API, or a combination of XQuery and SPARQL. For details, see "Querying Triples with XQuery" on page 95.
- HTTP via a SPARQL endpoint. For details, see "Querying Triples with REST API" on page 109.

Note: SPARQL keywords are shown in uppercase in this chapter, however SPARQL keywords are not case sensitive.

This chapter includes the following sections:

- Querying Triples with SPARQL
- Querying Triples with XQuery
- Querying Triples with REST API
- Security

5.1 Querying Triples with SPARQL

This section is a high-level overview of the SPARQL query capabilities in MarkLogic and includes the following topics:

- Types of SPARQL Queries
- Executing a SPARQL Query in Query Console
- Specifying Query Result Options
- Selecting Results Rendering
- Constructing a SPARQL Query
- SPARQL 1.0 vs. SPARQL 1.1 Features
- SPARQL Resources

Note: The examples in this section use the `persondata-en.ttl` dataset from http://wiki.dbpedia.org/Downloads38/. See “Downloading the Dataset” on page 26.

5.1.1 Types of SPARQL Queries

You can query an RDF dataset using any of these SPARQL query forms:

- SELECT Queries - A SPARQL `SELECT` query returns a *solution*, which is a set of bindings of variables and values.
- CONSTRUCT Queries - A SPARQL `CONSTRUCT` query returns *triples* as a sequence of `sem:triple` values in an RDF graph. These triples are constructed by substituting variables in a set of triple templates to create new triples from existing triples.
- DESCRIBE Queries - A SPARQL `DESCRIBE` query returns a *sequence* of `sem:triple` values as an RDF graph that describes the resources found.
- ASK Queries - A SPARQL `ASK` query returns a *boolean* (`true` or `false`) indicating whether a query pattern matches the dataset.

5.1.2 Executing a SPARQL Query in Query Console

To execute a SPARQL query:

1. In a Web browser, navigate to Query Console:

   ```
   http://hostname:8000/qconsole
   ```

   where *hostname* is the name of your MarkLogic Server host.

2. From the Query Type drop-down list, select SPARQL.

Note: Query Console supports syntax highlighting for SPARQL keywords.

3. Construct your SPARQL query. See “Executing a SPARQL Query in Query Console” on page 64.

   You can add comments prefaced with the hash symbol (#).

4. From the Content Source drop-down list, select the target database.

5. In the control bar below the query window, click Run.

   Note: If the triple index is not enabled, an XDMP-TRPLIDXNOTFOUND exception is thrown. See “Enabling the Triple Index” on page 57.

5.1.3 Specifying Query Result Options

In Query Console, SPARQL results are returned as a sequence of `json:object` values in the case of a `SELECT` query, a sequence of `sem:triple` values in the case of a `CONSTRUCT` or `DESCRIBE` query, or a single `xs:boolean` value in the case of an `ASK` query. The results for each will look different in Query Console.

This section discusses the following topics:

- Auto vs. Raw Format
- Selecting Results Rendering

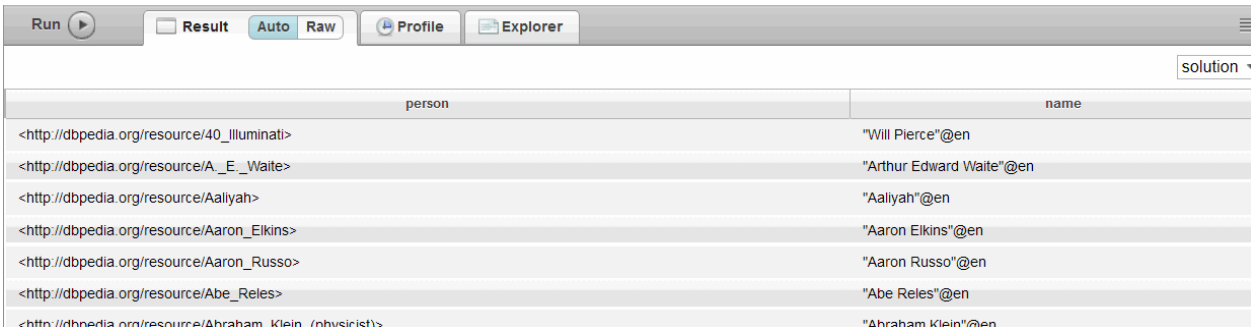
5.1.3.1 Auto vs. Raw Format

The results of a SPARQL query displays triples or `SELECT` solutions. Solution objects show a mapping from variable names to typed values. Each heterogeneous item in the result sequence will have specific rendering, which is by default shown in Auto format.

For example, this `SELECT` query returns a solution:

```
PREFIX db: <http://dbpedia.org/resource/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX onto: <http://dbpedia.org/ontology/>

SELECT ?person ?name
WHERE { ?person onto:birthPlace db:Brooklyn;
foaf:name ?name .}
```



To change the display format to Raw, click Raw on the Result tab. In Raw format, the results for the same query are displayed in RDF/JSON format:

```
[{"person":"<http://dbpedia.org/resource/40_Illuminati>","name":"\"Wil
l Pierce\"@en"},
{"person":"<http://dbpedia.org/resource/A._E._Waite>","name":"\"Arthur
Edward
Waite\"@en"},{"person":"<http://dbpedia.org/resource/Aaliyah>","name":
"\"Aaliyah\"@en"},
{"person":"<http://dbpedia.org/resource/Aaron_Elkins>","name":"\"Aaron
Elkins\"@en"},
{"person":"<http://dbpedia.org/resource/Aaron_Russo>","name":"\"Aaron
Russo\"@en"},
{"person":"<http://dbpedia.org/resource/Abe_Reles>","name":"\"Abe
Reles\"@en"},
{"person":"<http://dbpedia.org/resource/Abraham_Klein_(physicist)>","n
ame":"\"Abraham Klein\"@en"},
{"person":"<http://dbpedia.org/resource/Abraham_S._Fischler>","name":"
\"Abraham S. Fischler\"@en"},
{"person":"<http://dbpedia.org/resource/Abraham_S._Luchins>","name":"\
"Abraham S. Luchins\"@en"},
{"person":"<http://dbpedia.org/resource/Abram_Cohen>","name":"\"Abram
Cohen\"@en"}]
```

If you run a similar `DESCRIBE` query, the output is returned in Query Console in triples format:

```
PREFIX db: <http://dbpedia.org/resource/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX onto: <http://dbpedia.org/ontology/>

DESCRIBE ?person ?name
WHERE { ?person onto:birthPlace db:Brooklyn;
foaf:name ?name .}

=>

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/40_Illuminati>
<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Brooklyn> ,
<http://dbpedia.org/resource/New_York> ;
```

```
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://xmlns.com/foaf/0.1/Person> ;
<http://xmlns.com/foaf/0.1/surname> "Pierce"@en ;
<http://purl.org/dc/elements/1.1/description> "Rapper"@en ;
<http://xmlns.com/foaf/0.1/givenName> "Will"@en ;
<http://xmlns.com/foaf/0.1/name> "Will Pierce"@en .
<http://dbpedia.org/resource/A._E._Waite>
<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Brooklyn> ;
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://xmlns.com/foaf/0.1/Person> ;
<http://xmlns.com/foaf/0.1/givenName> "Arthur Edward"@en ;
<http://xmlns.com/foaf/0.1/name> "Arthur Edward Waite"@en ;
<http://purl.org/dc/elements/1.1/description> "English writer"@en ;
<http://xmlns.com/foaf/0.1/surname> "Waite"@en .
<http://dbpedia.org/resource/Aaliyah>
<http://dbpedia.org/ontology/deathPlace>
<http://dbpedia.org/resource/Abaco_Islands> ,
<http://dbpedia.org/resource/Marsh_Harbour> ,
<http://dbpedia.org/resource/The_Bahamas> ;
<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Brooklyn> ,
<http://dbpedia.org/resource/New_York_City> ;
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://xmlns.com/foaf/0.1/Person> ;
<http://xmlns.com/foaf/0.1/name> "Aaliyah"@en ;
<http://purl.org/dc/elements/1.1/description> "Singer, dancer,
actress, model"@en ;
<http://dbpedia.org/ontology/birthDate> "1979-01-16"^^xs:date ;
<http://dbpedia.org/ontology/deathDate> "2001-08-25"^^xs:date .
. . .
```

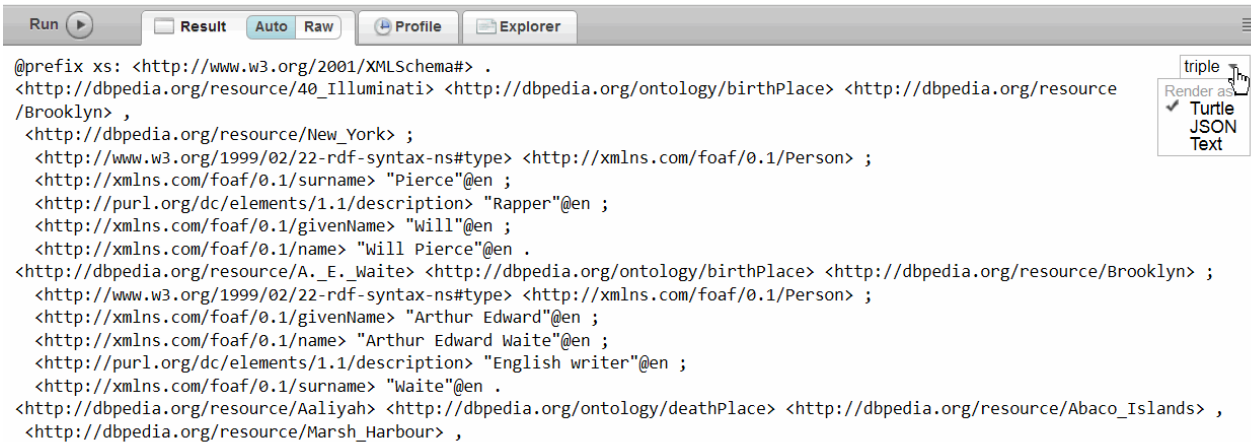
Note: When you run a query that returns triples as a subgraph, the default output format is Turtle.

5.1.4 Selecting Results Rendering

Use the Render as: drop-down list options to choose the display for query results. For example, this `DESCRIBE` query returns triples in Turtle format:

```
PREFIX db: <http://dbpedia.org/resource/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX onto: <http://dbpedia.org/ontology/>

DESCRIBE ?person ?name
WHERE { ?person onto:birthPlace db:Brooklyn;
foaf:name ?name .}
```



Or you can select JSON or text as the format for the results.

> **Note:** For a `DESCRIBE` query, the rendering options are Turtle, JSON, or Text. Rendering options may be different for queries that use `cts:search`, a combination of SPARQL and `cts:` queries, or use query results that are serialized by a serialization function.

5.1.5 Constructing a SPARQL Query

You can construct a SPARQL query to ask specific questions about triples or to create new triples from triples in your triplestore. A SPARQL query typically contains the following (in order):

- Prefix Declaration - abbreviates prefix IRIs
- Query Pattern - specifies what to query in the RDF graph, by comparing and matching query patterns
- Target RDF Graph - identifies the dataset to query
- Result Clauses - specifies the information to return from the graph
- Query Clauses - extends or restricts the scope of your query

- Solution Modifiers - specifies the order in which to return the results and the number of results

The query pattern and a result clause are the minimum required components for a query. The prefix declaration, target RDF graph, query clauses, and solution modifiers are optional components that structure and define your query.

The following example is a simple SPARQL `SELECT` query that contains a query pattern to find people whose birthplace is Paris:

```
SELECT ?s
WHERE {?s <http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Paris>
}
```

The following sections discuss the components of the SPARQL query in more detail, and how to compose simple and complex queries.

5.1.6 Prefix Declaration

IRIs can be long and unwieldy, and the same IRI may be used many times in a query. To make queries concise, SPARQL allows the definition of prefixes and base IRIs. Defining prefixes saves time, makes the query more readable, and can reduce errors. The prefixes for commonly used vocabularies are also known as CURIEs (Compact URIs).

In this example, the prefix definitions are declared and the query pattern is written with abbreviated prefixes:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX db: <http://dbpedia.org/resource/>
PREFIX onto: <http://dbpedia.org/ontology/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

SELECT *
WHERE{
?s  rdf:type foaf:Person ;
dc:description "Physicist"@en ;
onto:birthPlace db:England .
}
```

The query results returns the people described as “Physicist” who were born in England. The “@en” language tag means that you are searching for the English word “Physicist”. The query will match only triples with “Physicist” and an English language tag.

5.1.7 Query Pattern

At the heart of a SPARQL query is a set of triple patterns called a graph pattern. Triple patterns are like RDF triples except the subject, predicate, and object nodes may be a variable.

A graph pattern matches a subgraph of the RDF data when RDF terms from that subgraph may be substituted for the variables, and the result is an RDF graph equivalent to the subgraph.

The graph pattern is one or more triple patterns contained within curly braces ({ }). The following types of graph patterns for the query pattern are discussed in this chapter:

- Basic graph pattern - a set of triple patterns must match against triples in the triplestore
- Group graph pattern - a set of graph patterns must all match using the same variable substitution
- Optional graph pattern - additional patterns may extend the solution
- Union graph pattern - where two or more possible patterns are tried
- Graph graph pattern - where patterns are matched against named graphs

SPARQL variables are denoted with a question mark (`?`) or a dollar symbol (`$`). The variables are positioned to match any subject, predicate, or object node, and match any value in that position. Thus, the variable may be bound to an IRI or a literal (string, boolean, date, and so on). Each time a triple pattern matches a triple in the triplestore, it produces a binding for each variable.

This example shows a basic graph pattern with variables to match the subject (`?s`) and predicate (`?p`) of triples where the object is “Paris”. The query consists of two parts; the `SELECT` clause specifies what is in the query results and the `WHERE` clause provides the basic graph pattern to match against the data graph:

```
PREFIX db: <http://dbpedia.org/resource/>
PREFIX onto: <http://dbpedia.org/ontology/>

SELECT ?s ?p
WHERE {?s ?p db:Paris }
```

This query will return every person in your dataset who was born or died in Paris. You may want to limit the number of results by adding “`LIMIT 10`” to the end of the query. See “The LIMIT Keyword” on page 86 for details.

> **Note:** A variable may only be bound once. The `?s` and `?p` in the `SELECT` clause are the same variables as in the `WHERE` clause.

The results of the query, include the subject and predicate IRIs (for birthPlace and deathPlace) where “Paris” is in the object position:

<http://dbpedia.org/resource/Étienne-Denis_Pasquier>	<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Étienne-Louis_Malus>	<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/A._Kingsley_Macomber>	<http://dbpedia.org/ontology/deathPlace>
<http://dbpedia.org/resource/Abdul_Rasul_(Iraqi_scientist)>	<http://dbpedia.org/ontology/deathPlace>
<http://dbpedia.org/resource/Abdülmecid_II>	<http://dbpedia.org/ontology/deathPlace>
<http://dbpedia.org/resource/Abel_Decaux>	<http://dbpedia.org/ontology/deathPlace>

A SPARQL SELECT query returns a *solution*, which is a set of bindings of variables and values. By default, the results of SELECT queries are returned in *Auto* format, a formatted view made for easy viewing. You can change the output display. For details, see “Specifying Query Result Options” on page 65.

The previous example is a single triple pattern match (the basic graph pattern). You can query with SPARQL using multiple triple pattern matching. SPARQL uses a syntax similar to Turtle for expressing query patterns, where each triple pattern ends with a period.

Similar to an AND clause in SQL queries, every triple in the query pattern must be matched exactly. For example, consider place names in our dataset that are found in different countries such as Paris, Texas or Paris, France. The following example returns the IRIs for all resources born in Paris, France that are described as “Footballers”:

```
PREFIX db: <http://dbpedia.org/resource/>
PREFIX onto: <http://dbpedia.org/ontology/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>

SELECT ?s
WHERE {?s onto:birthPlace db:Paris .
       ?s onto:birthPlace db:France .
       ?s dc:description "Footballer"@en .
}
```

s	p
<http://dbpedia.org/resource/Abdoulaye_Baldé_(footballer)>	<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Abdoulaye_Keita_(footballer_born_1990)>	<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Abdoulaye_Méïté>	<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Aboubacar_Sankhare>	<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Aboubacar_Tandia>	<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Ahmed_Soukouna>	<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Alain_de_Martigny>	<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Albert_Jourda>	<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Alexandre_Raineau>	<http://dbpedia.org/ontology/birthPlace>

An alternative way to write the query pattern above is to use a semicolon (`;`) in the `WHERE` clause to separate triple patterns that share the same subject.

For example:

```
PREFIX db: <http://dbpedia.org/resource/>
PREFIX onto: <http://dbpedia.org/ontology/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>

SELECT ?s
WHERE {?s onto:birthPlace db:Paris ;
          onto:birthPlace db:France ;
          dc:description "Footballer"@en .
}
```

The SPARQL specification allows you to use a blank node as subject and object of a triple pattern in a query.

For example:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>

SELECT  ?desc
WHERE { _:p rdf:type foaf:Person ;
            dc:description ?desc .
      }
```

The query returns the role or title for resources as defined in the triples in the dataset:

desc
"Ukrainian musician"
"Competitive eater"
"American guitarist"
"American martial artist"
"Boxer"
"American guitarist"

Note: If there are blank nodes in the queried graph, blank node identifiers may be returned in the results.

5.1.8 Target RDF Graph

A SPARQL query is executed against an RDF dataset that contains graphs. These graphs are:

- A single default graph - a set of triples with no name attached to them
- One or more named graphs - where inside a `GRAPH` clause, each named graph is a pair, made up of a name and a set of triples

For example, this query will be executed on the graph named `my_collections`:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dc:   <http://purl.org/dc/elements/1.1/>

SELECT ?name ?mbox ?date
FROM <http://my_collections>
WHERE { ?g dc:publisher ?name ;
       dc:date ?date .
      GRAPH ?g { ?person foaf:name ?name ;
      foaf:mbox ?mbox }
      }
```

The `FROM` and `FROM NAMED` keywords are used to specify an RDF dataset in a SPARQL query, as described in the W3C SPARQL Query Language for RDF:

http://www.w3.org/TR/rdf-sparql-query/#specifyingDataset

In the absence of `FROM` or `FROM NAMED` keywords, a SPARQL query executes against all graphs that exist in the database. In otherwords, if you don't specify a graph name with a query, the `UNION` of all graphs will be queried.

Using XQuery or REST you can also specify one or more graphs to be queried by using:

- a `default-graph-uri*` - Selects the graph name(s) to query, usually a subset of the available graphs.
- a `named-graph-uri* -` Used with `FROM NAMED` and `GRAPH` to specify the IRI(s) to be substituted for a name within particular kinds of queries. You can have one or more `named-graph-uri` parameters specified as part of a query.

If you specify `default-graph-uri`, one or more graph names that you specify will be queried. The "`*`" indicates that one or more `default-graph-uri` or `named-graph-uri` parameters can be specified.

> **Note:** This `default-graph-uri` is not the "default" graph that contains unnamed triples - `http://marklogic.com/semantics#default-graph`.

In this example a SPARQL query is wrapped in XQuery, to search the data set in the `http://example.org/bob/foaf.rdf` graph:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
    at "/MarkLogic/semantics.xqy";

sem:sparql('
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?g ?name
WHERE {graph ?g { ?alum foaf:schoolHomepage <http://www.ucsb.edu/> .
    ?alum foaf:knows ?person .
    ?person foaf:name ?name }
      }
      '
      ()
      ("default-graph-uri=http://example.org/bob/foaf.rdf")
```

The `FROM` in a SPARQL query functions the same as the `default-graph-uri`, and the `FROM NAMED` functions the same as `named-graph-uri`. These two clauses function in the same way as part of the SPARQL query, except that one is written into queries (wrapped in the query), while the other is specified outside of the query.

This section discusses the following topics:

- The FROM Keyword
- The FROM NAMED Keywords
- The GRAPH Keyword

5.1.8.1 The FROM Keyword

The `FROM` clause in a SPARQL query tells SPARQL where to get data to query, which graph to query. To use `FROM` as part of a query, there has to be a graph with the name in the `FROM` clause. Graph names in MarkLogic are implemented as collections, which you can view using Explore in the Query Console.

This SPARQL query uses the `FROM` keyword to search data in the `info:govtrack/people` graph:

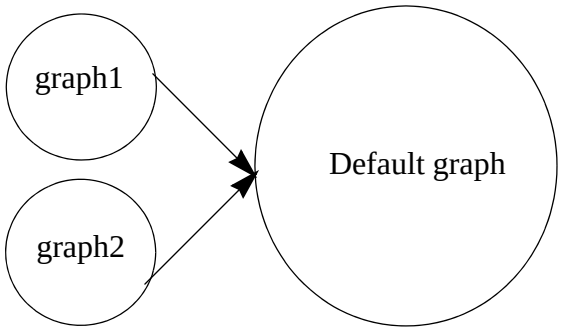
```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT  ?name
FROM    <http://marklogic.com/semantics#info:govtrack/people>
WHERE   { ?x foaf:name ?name }
LIMIT 10
```

See Preparing to Run the Examples for information about the GovTrack dataset.

The default graph is the result of an RDF merge of the graphs (a union of graphs) referred to in one or more FROM clauses. Each FROM clause contains an IRI that indicates a graph to be used to form the default graph.

For example, graph1 and graph2 are merged to form the default graph:

```
FROM graph1
FROM graph2
```



Note: When we talk about the default graph in this sense, it is not the same as the default collections, `http://marklogic.com/semantics#default-graph`.

This example shows a SPARQL SELECT query that returns all triples where "Alice" is in the object position. The RDF dataset contains a single default graph and no named graphs:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?s ?p ?o
FROM <http://example.org/foaf/aliceFoaf>
WHERE {?s foaf:name "Alice";
?p ?o .}
```

Note: The FROM keyword must be placed before the WHERE clause. Placing the FROM keyword after the WHERE clause causes a syntax error.

5.1.8.2 The FROM NAMED Keywords

A query can supply IRIs for the named graphs in the dataset using the FROM NAMED clause. Each IRI is used to provide one named graph in the dataset. Having multiple FROM NAMED clauses causes multiple graphs to be added to the dataset. With FROM NAMED, every graph name you use in the query will be matched only to the graph provided in the clause.

You can set the `named-graph` at load time using mlcp with the collection parameter `-output_collections http://www.example.org/my_graph`. See "Specifying Collections and a Directory" on page 43. You can also set the `named-graph` using the REST client with `PUT:/v1/graphs`.

Note: A named graph is typically created when you load RDF data. See "Loading Triples from Triples Files" on page 33.

In a query, FROM NAMED is used to identify a named graph that is queried from the WHERE clause by using the GRAPH keyword.

For example:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>

SELECT ?who ?g ?mbox
FROM <http://example.org/foaf/aliceFoaf>
FROM NAMED <http://example.org/alice>
FROM NAMED <http://example.org/bob>
WHERE
{
   ?g dc:publisher ?who .
   GRAPH ?g { ?x foaf:mbox ?mbox }
}
```

In the example, the FROM and FROM NAMED keywords are used together. The FROM NAMED is used to scope the graphs that are considered during query evaluation, and the GRAPH construct specifies one of the named graphs.

Note: When FROM or FROM NAMED keywords are used, the graphs you can use in a GRAPH clause potentially become restricted.

5.1.8.3 The GRAPH Keyword

The GRAPH keyword instructs the query engine to evaluate part of the query against the named graphs in the dataset. A variable used in the GRAPH clause may also be used in another GRAPH clause or in a graph pattern matched against the default graph in the dataset.

For example:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dc:   <http://purl.org/dc/elements/1.1/>

SELECT ?name ?mbox ?date
WHERE { ?g dc:publisher ?name ;
      dc:date ?date .
     GRAPH ?g { ?person foaf:name ?name ;
     foaf:mbox ?mbox }
     }
```

Note: You must enable the collection lexicon when you use a `GRAPH` construct in a SPARQL query. You can enable the collection lexicon from the database configuration pages or the Admin Interface. See "Configuring a Database" on page 22.

Triples inside of a `GRAPH` clause with an explicit IRI, such as `GRAPH <...uri...> { ...graph pattern... }`, are matched against the dataset using the IRI specified in the graph clause.

5.1.9 Result Clauses

Querying the dataset with different types of SPARQL queries returns different types of results. These SPARQL query forms return the following result clauses:

- SELECT Queries - returns a sequence of variable bindings
- CONSTRUCT Queries - returns an RDF graph constructed by substituting variables in a set of triple templates
- DESCRIBE Queries - returns an RDF graph that describes the resources found
- ASK Queries - returns a boolean indicating whether a query pattern matches

5.1.9.1 SELECT Queries

The SPARQL `SELECT` keyword indicates that you are requesting data from a dataset. This SPARQL query is the most widely used of the query forms. SPARQL `SELECT` queries return a sequence of bindings as a solution, that satisfies the query. Selected variables are separated by white spaces, not commas.

You can use the asterisk wildcard symbol (`*`) with SPARQL `SELECT` as shorthand for selecting all the variables identified in the query pattern.

For example:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT *
WHERE{ ?s foaf:givenName ?fn .
       ?s foaf:surname ?ln .
     }
```

Note: In single triple patterns, a period at the end is optional. In a query pattern with multiple triple patterns, the period at the end of final triple is also optional.

In the example, the `SELECT` query returns sequence of bindings that includes the IRI for the subject variable (`?s`), along with the first name (`?fn`) and last name (`?ln`) of resources in the dataset.

SPARQL SELECT query results are serialized as XML, or JSON, or passed to another function as a map. The results of a SELECT query may not always be triples.

5.1.9.2 CONSTRUCT Queries

You can create new triples from existing triples by using SPARQL CONSTRUCT queries. When you execute a CONSTRUCT query, the results are returned in a sequence of sem:triple values as triples.

This example creates triples for Albert Einstein from the existing triples in the database:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
CONSTRUCT
{?person ?p ?o .}
WHERE {?person foaf:givenName "Albert"@en ;
       foaf:surname "Einstein"@en;
       ?p ?o .}
```

The CONSTRUCT queries return an RDF graph created from variables in the query pattern.

s	p	o
<http://dbpedia.org/resource/Albert_Einstein>	<http://dbpedia.org/ontology/birthPlace>	<http://dbpedia.org/resource/Baden-Württem
<http://dbpedia.org/resource/Albert_Einstein>	<http://dbpedia.org/ontology/birthPlace>	<http://dbpedia.org/resource/German_Empire
<http://dbpedia.org/resource/Albert_Einstein>	<http://dbpedia.org/ontology/deathPlace>	<http://dbpedia.org/resource/Princeton,_New
<http://dbpedia.org/resource/Albert_Einstein>	<http://dbpedia.org/ontology/birthPlace>	<http://dbpedia.org/resource/Ulm>
<http://dbpedia.org/resource/Albert_Einstein>	<http://dbpedia.org/ontology/deathPlace>	<http://dbpedia.org/resource/United_States>
<http://dbpedia.org/resource/Albert_Einstein>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://xmlns.com/foaf/0.1/Person>
<http://dbpedia.org/resource/Albert_Einstein>	<http://xmlns.com/foaf/0.1/givenName>	"Albert"
<http://dbpedia.org/resource/Albert_Einstein>	<http://xmlns.com/foaf/0.1/name>	"Albert Einstein"

5.1.9.3 DESCRIBE Queries

SPARQL DESCRIBE queries return a sequence of sem:triple values. The DESCRIBE query result returns RDF graphs that describe one or more of the given resources. The results are nondeterministic. That is, the query processor determines the actual structure of the returned RDF subgraph.

This query finds a list of people described as “Conservationists”:

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>

DESCRIBE ?person
WHERE {?person dc:description "Conservationist"@en .}
```

Note: The “@en” language tag means that this is an English word and will match differently than any other language tag.

The subgraphs that describe the IRIs returned from the query pattern look like:

s	p	o
<http://dbpedia.org/resource/Allen_Bathurst,_9th_Earl_Bathurst>	<http://dbpedia.org/ontology/birthPlace>	<http://dbpedia.org/resource/(
<http://dbpedia.org/resource/Allen_Bathurst,_9th_Earl_Bathurst>	<http://dbpedia.org/ontology/birthPlace>	<http://dbpedia.org/resource/E
<http://dbpedia.org/resource/Allen_Bathurst,_9th_Earl_Bathurst>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://xmlns.com/foaf/0.1/Per
<http://dbpedia.org/resource/Allen_Bathurst,_9th_Earl_Bathurst>	<http://xmlns.com/foaf/0.1/givenName>	"Allen"
<http://dbpedia.org/resource/Allen_Bathurst,_9th_Earl_Bathurst>	<http://xmlns.com/foaf/0.1/name>	"Allen Bathhurst"
<http://dbpedia.org/resource/Allen_Bathurst,_9th_Earl_Bathurst>	<http://xmlns.com/foaf/0.1/surname>	"Bathhurst"
<http://dbpedia.org/resource/Allen_Bathurst,_9th_Earl_Bathurst>	<http://purl.org/dc/elements/1.1/description>	"Conservationist"
<http://dbpedia.org/resource/Allen_Bathurst,_9th_Earl_Bathurst>	<http://dbpedia.org/ontology/birthDate>	"1961-03-11"^^xs:date
<http://dbpedia.org/resource/Charles_Alexander_Sheldon>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://xmlns.com/foaf/0.1/Per
<http://dbpedia.org/resource/Charles_Alexander_Sheldon>	<http://xmlns.com/foaf/0.1/givenName>	"Charles Alexander"
<http://dbpedia.org/resource/Charles_Alexander_Sheldon>	<http://xmlns.com/foaf/0.1/name>	"Charles Alexander Sheldon"
<http://dbpedia.org/resource/Charles_Alexander_Sheldon>	<http://purl.org/dc/elements/1.1/description>	"Conservationist"
<http://dbpedia.org/resource/Charles_Alexander_Sheldon>	<http://xmlns.com/foaf/0.1/surname>	"Sheldon"
<http://dbpedia.org/resource/Charles_Alexander_Sheldon>	<http://dbpedia.org/ontology/birthDate>	"1867-10-17"^^xs:date
<http://dbpedia.org/resource/Charles_Alexander_Sheldon>	<http://dbpedia.org/ontology/deathDate>	"1928-09-21"^^xs:date

5.1.9.4 ASK Queries

SPARQL `ASK` queries return a single `xs:boolean` value. The `ASK` clause returns `true` if the query pattern has any matches in the dataset and `false` if there is no pattern match.

For example, in the `persondata` dataset are the following facts about two members of the Kennedy family: Carolyn Bessette-Kennedy and Eunice Kennedy-Shriver:

- Eunice Kennedy-Shriver, the founder of the Special Olympics precursor and a sister of John F. Kennedy was born on 1921-07-10.
- Carolyn Bessette-Kennedy, a publicist, and wife of JFK Junior, was born on 1966-01-07.

This query asks if Carolyn was born after Eunice.

```
PREFIX db: <http://dbpedia.org/resource/>
PREFIX onto: <http://dbpedia.org/ontology/>

ASK
{
   db:Carolyn_Bessette-Kennedy onto:birthDate ?by .
   db:Eunice_Kennedy_Shriver onto:birthDate ?bd .
   FILTER (?by>?bd).
}

=>
true
```

The response is `true`.

Note: `ASK` queries check to see if there is at least one result.

5.1.10 Query Clauses

Add the following query clauses to extend or reduce the number of potential results that are returned:

- The OPTIONAL Keyword
- The UNION Keyword
- The FILTER Keyword

5.1.10.1 The OPTIONAL Keyword

The `OPTIONAL` keyword is used to return additional results if there is a match in an optional graph pattern. For example, this query pattern returns triples in the database consisting of the first name (`?fn`), last name (`?ln`) and mail address (`?mb`):

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?fn ?ln
WHERE{?x foaf:givenName ?fn .
      ?x foaf:surname ?ln .
      ?x foaf:email ?mb .
}
```

Only triples that match *all* the triple patterns are returned. In the `persondata` dataset there may be no triples with an email address. In this case, the Query Console will return "`your query returned an empty sequence`" in response to your query. People without an email address will not appear in the results.

You can use the optional graph pattern (also known as a *left join*) to return matching values of any variables in common, if they exist. Since the `OPTIONAL` keyword is also a graph pattern, it has its own set of curly braces (inside the curly braces of the `WHERE` clause).

This example extends the previous example to return one or more email addresses, and just the first name and last name if there is no email address:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?fn ?ln
WHERE {?x foaf:givenName ?fn .
       ?x foaf:surname ?ln .
OPTIONAL{?x foaf:email ?mb .}
}
```

Note: Optional patterns may yield unbound variables.

5.1.10.2 The UNION Keyword

Use the UNION keyword to match multiple patterns from multiple different sets of data, and then combine them in the query result. The UNION keyword is placed inside the curly braces of the WHERE clause.

The syntax is:

```
{ triple pattern } UNION { triple pattern }
```

The UNION pattern combines graph patterns; each alternative possibility can contain more than one triple pattern (*logical disjunction*). This example finds people who are described as “Authors” or “Novelists” and their date of birth:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX onto: <http://dbpedia.org/ontology/>

SELECT  ?person ?desc ?date
WHERE { ?person rdf:type foaf:Person .
      ?person dc:description ?desc .
      ?person onto:birthDate ?date .

      { ?person dc:description "Novelist"@en . }
UNION
      { ?person  dc:description "Author"@en . }
      }
```

You can also group triple patterns into multiple graph patterns using a group graph pattern structure.

For example:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>

SELECT ?person ?desc
WHERE {{?person rdf:type foaf:Person }
       {?person dc:description ?desc }

      {{?person dc:description "Author"@en }
```

```
 UNION
      { ?person  dc:description "Novelist"@en . } } }
```

Note that each set of braces contains a triple. This is semantically equivalent to this next query and would yield the same results:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>

SELECT ?person
WHERE {?person rdf:type foaf:Person ;
               dc:description ?desc .

   {?person dc:description "Author"@en }

UNION
   {?person  dc:description "Novelist"@en . }
      }
```

Note: You can use multiple UNION patterns in a SPARQL query. The results from the OPTIONAL and UNION queries differ in that the UNION query allows a subgraph of another solution, while an OPTIONAL query explicitly does not.

5.1.10.3 The FILTER Keyword

There are multiple methods for limiting the results of a SPARQL query. You can use the FILTER, DISTINCT, or the LIMIT keywords to restrict the number of matching results that are returned.

You can use one or more SPARQL FILTER keywords to specify the variables by which to constrain results. The FILTER constraint is placed inside the curly braces of the WHERE clause and can contain symbols for logical, mathematical, or comparison operators such as greater than (>), less than(<), equal to (=), and so on. The FILTER constraints use boolean conditions to return matching query results. There are also a number of built-in SPARQL tests you can use such as isURI, isBlank, and so on.

This table lists some of the SPARQL unary operators in FILTER constraints:

Operator	Type	Result Type
!	xsd:boolean	xsd:boolean
+	numeric	numeric
-	numeric	numeric
BOUND()	variable	xsd:boolean

Operator	Type	Result Type
`isURI()`	RDF term	`xsd:boolean`
`isBLANK()`	RDF term	`xsd:boolean`
`isLITERAL`	RDF term	`xsd:boolean`
`STR()`	literal/URI	simple literal
`LANG()`	literal	simple literal
`DATATYPE()`	literal	URI

Note: For a full list of operations, see *Operator Mapping* in the SPARQL Query Language for RDF.

This example is a query pattern that provides meaning to the variable `?bd` (a person's birth date). The `FILTER` clause of the query pattern compares the variable value to the date January 1st, 1999 and returns people born after the given date:

```
PREFIX onto: <http://dbpedia.org/ontology/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

SELECT ?s
WHERE {?s rdf:type foaf:Person .
       ?s onto:birthDate ?bd .
FILTER (?bd > "1999-01-01"^^xsd:date)
}
```

The SPARQL keyword `a` is a shortcut for the common predicate `rdf:type`, giving the class of a resource. For example, the `WHERE` clause the previous example could be written as:

```
WHERE {?s a foaf:Person .
       ?s onto:birthDate ?bd .
```

You can express a `FILTER` clause with a regular expression pattern by using the `regex` function. For example:

```
SELECT ?s ?p ?o
WHERE {?s ?p ?o
FILTER (regex (?o, "Lister", "i"))
}
```

The SPARQL query returns all matching results where the text in the object position contains the string `Lister` in any case. Regular expression matches are made case-insensitive with the `i` flag.

Note: This type of `FILTER` query is the equivalent of the `fn:match` XQuery function. Regular expressions are not optimized in SPARQL. Use `cts:contains` for optimized full text searching.

The regular expression language is defined in *XQuery 1.0 and XPath 2.0 Functions and Operators*, section 7.6.1 Regular Expression Syntax.

Using XQuery Built-in Functions in a SPARQL Query

In addition to SPARQL functions, you can use built-in XQuery functions (for example, functions with the prefix `fn`, `cts`, or `xdmp`) in a SPARQL query where you can use a function, which includes `FILTER`, `BIND`, and the expressions in a `SELECT` statement.

A built-in function is one that can be called without using "import module" in XQuery. These XQuery functions are called extension functions when used in a SPARQL query. You can find a list of built-in functions at http://docs.marklogic.com by selecting "XQuery/XSLT APIs" and then looking for "XQuery/XSLT Functions By Category" on the left side of the page. The built-ins listed are under "MarkLogic Built-In Functions" and "W3C-Standard Functions."

Extension functions in SPARQL are identified by IRIs in the form of `http://www.w3.org/2005/xpath-functions#`*`name`* where *`name`* is the local name of the function and the string before the # is the prefix IRI of the function, for example `http://www.w3.org/2005/xpath-functions#starts-with`. For the prefix IRIs commonly associated with `fn`, `xdmp`, and `cts` (or any other prefix IRIs that don't end with a "`/`" or "`#`"), append a `#` to the prefix IRI and then the function localname, for example: `http://marklogic.com/cts#contains`.

You can access built-in functions like `cts` using `PREFIX` in the SPARQL query. In this example, `cts:contains` is added as using `PREFIX` and then included as part of the `FILTER` query:

```
PREFIX cts: <http://marklogic.com/cts#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX dc: <http://purl.org/dc/elements/1.1/>

SELECT *
WHERE{ ?s ?p ?o .
   FILTER cts:contains(?o, cts:or-query(("Monarch", "Sovereign")))
   FILTER(?p IN (dc:description, rdfs:type))
}
```

This is full-text search for the words "Monarch" or "Sovereign" where the predicate is either a description or a type. In the second `FILTER` clause, the use of `IN` specifies the predicates to filter on. The results include people that have a title of "Monarch" (of a kingdom, state or sovereignty) and things that have a description of "Monarch" such as the Monarch butterfly or Monarch Islands.

In this example the XPath function `starts-with` is used in a SPARQL query to return the roles or titles of people whose description begins with "Chief". The function is imported by including the IRI as part of the `FILTER` query:

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>

SELECT ?desc
WHERE {?s dc:description ?desc
FILTER (<http://www.w3.org/2005/xpath-functions#starts-with>( ?desc,
"Chief" ) )}
```

Note: You can use the `FILTER` keyword with the `OPTIONAL` and `UNION` keywords.

5.1.11 Solution Modifiers

A solution modifier modifies the result set for `SELECT` queries. This section discusses how you can modify what your query returns using the following solution modifiers:

- The DISTINCT Keyword
- The LIMIT Keyword
- ORDER BY Keyword
- The OFFSET Keyword

Note: With the exception of `DISTINCT`, modifiers appear after the `WHERE` clause.

5.1.11.1 The DISTINCT Keyword

Use the `DISTINCT` keyword to remove duplicate results from a results set.

For example:

```
SELECT DISTINCT ?p
WHERE {?s ?p ?o}
```

The query returns all of the predicates - just once - for all the triples in the `persondata` dataset.

p
<http://dbpedia.org/ontology/birthDate>
<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/ontology/deathDate>
<http://dbpedia.org/ontology/deathPlace>
<http://purl.org/dc/elements/1.1/description>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://xmlns.com/foaf/0.1/givenName>
<http://xmlns.com/foaf/0.1/name>
<http://xmlns.com/foaf/0.1/surname>

5.1.11.2 The LIMIT Keyword

You can use the `LIMIT` keyword to further restrict the displayed results of a SPARQL query. For example, in the DBPedia dataset, there could be thousands of authors that match this query:

```
PREFIX dc:<http://purl.org/dc/elements/1.1/>
PREFIX foaf:<http://xmlns.com/foaf/0.1/>

SELECT ?x ?fn ?ln
WHERE{?x dc:description "Author"@en ;
      foaf:name ?fn ;
      foaf:surname ?ln.}
```

To specify the number matching results to display, add the `LIMIT` keyword after the curly braces of the `WHERE` clause with an integer (not a variable).

For example:

```
PREFIX dc:<http://purl.org/dc/elements/1.1/>
PREFIX foaf:<http://xmlns.com/foaf/0.1/>

SELECT ?x ?fn ?ln
WHERE{?x dc:description "Author"@en ;
      foaf:name ?fn ;
      foaf:surname ?ln.}
LIMIT 10
```

The results of the query are limited to the first ten matches.

x	fn	
<http://dbpedia.org/resource/A.S._King>	"A.S. King"@en	"King"@en
<http://dbpedia.org/resource/A._H._Almaas>	"A.H. Almaas"@en	"Almaas"@en
<http://dbpedia.org/resource/A._Lee_Martinez>	"A. Lee Martinez"@en	"Martinez"@en
<http://dbpedia.org/resource/A._M._Burrage>	"A. M. Burrage"@en	"Burrage"@en
<http://dbpedia.org/resource/A._Muthukrishnan>	"A. Muthukrishnan"@en	"Muthukrishnan"@
<http://dbpedia.org/resource/Abidemi_Sanusi>	"Abidemi Sanusi"@en	"Sanusi"@en
<http://dbpedia.org/resource/Ada_Albrecht>	"Ada Albrecht"@en	"Albrecht"@en
<http://dbpedia.org/resource/Adèle_Geras>	"Adele Geras"@en	"Geras"@en
<http://dbpedia.org/resource/Agnete_Friis>	"Agnete Friis"@en	"Friis"@en
<http://dbpedia.org/resource/Ahmad_Akbarpour>	"Ahmad Akbarpour"@en	"Akbarpour"@en

5.1.11.3 ORDER BY Keyword

Use the `ORDER BY` clause to specify the values of one or more variable by which to sort the query results. You can also order unbound variables, blank nodes, IRIs, or RDF literals as described in the SPARQL 1.1 Query Language recommendation:

http://www.w3.org/TR/sparql11-query/#modOrderBy

The default ordering is ascending order.

For example:

```
PREFIX dc:<http://purl.org/dc/elements/1.1/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?x ?fn ?ln
WHERE{?x dc:description "Author"@en ;
      foaf:name ?fn ;
      foaf:surname ?ln.}
ORDER BY ?ln ?fn
LIMIT 10
```

The results are ordered by the author's last name (`?ln`) and then by the author's first name (`?fn`):

x	fn	ln
<http://dbpedia.org/resource/Patience_Abbe>	"Patience Abbe"@en	"Abbe"@en
<http://dbpedia.org/resource/Lynn_Abbey>	"Lynn Abbey"@en	"Abbey"@en
<http://dbpedia.org/resource/George_Abbot_(author)>	"George Abbot"@en	"Abbot"@en
<http://dbpedia.org/resource/Eleanor_Hallowell_Abbott>	"Eleanor Hallowell Abbott"@en	"Abbott"@en
<http://dbpedia.org/resource/Hailey_Abbott>	"Hailey Abbott"@en	"Abbott"@en
<http://dbpedia.org/resource/Walid_Abdallah>	"Walid Abdallah"@en	"Abdallah"@en
<http://dbpedia.org/resource/Robert_Abernathy>	"Robert Abernathy"@en	"Abernathy"@en
<http://dbpedia.org/resource/Susan_Abulhawa>	"Susan Abulhawa"@en	"Abulhawa"@en
<http://dbpedia.org/resource/Rodolfo_Acevedo>	"Rodolfo Acevedo"@en	"Acevedo"@en
<http://dbpedia.org/resource/John_M._Ackerman>	"John M. Ackerman"@en	"Ackerman"@en

To change the order of results to descending order, use the `DESC` keyword and place the variable for the values to be returned in brackets.

For example:

```
PREFIX dc:<http://purl.org/dc/elements/1.1/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?x ?fn ?ln
WHERE{?x dc:description "Author"@en ;
      foaf:name ?fn ;
      foaf:surname ?ln .}
ORDER BY DESC (?ln)
LIMIT 10
```

x	fn	ln
<http://dbpedia.org/resource/Joan_de_Hamel>	"Joan de Hamel"@en	"de Hamel"@en
<http://dbpedia.org/resource/Laila_al-Ouhaydib>	"Laila al-Ouhaydib"@en	"al-Ouhaydib"@en
<http://dbpedia.org/resource/Shahidul_Zahir>	"Shahidul Zahir"@en	"Zahir"@en
<http://dbpedia.org/resource/Anwer_Zahidi>	"Anwer Zahidi"@en	"Zahidi"@en
<http://dbpedia.org/resource/Helen_Zahavi>	"Helen Zahavi"@en	"Zahavi"@en
<http://dbpedia.org/resource/Rachel_Zadok>	"Rachel Zadok"@en	"Zadok"@en
<http://dbpedia.org/resource/Michele_Zackheim>	"Michele Zackheim"@en	"Zackheim"@en
<http://dbpedia.org/resource/Shan_Sa>	"Ni Yan"@en	"Yan"@en
<http://dbpedia.org/resource/Evie_Wyld>	"Evie Wyld"@en	"Wyld"@en
<http://dbpedia.org/resource/Patricia_Wrede>	"Patricia C. Wrede"@en	"Wrede"@en

5.1.11.4 The OFFSET Keyword

The `OFFSET` modifier is used for pagination, to skip a given number of matching query results before returning the remaining results. This keyword is used with the `LIMIT` and `ORDER BY` keywords to retrieve different slices of data from a dataset. For example, you can create pages of results from different offsets.

This example queries for Authors in ascending order and limits the results to the first ten, starting the list at position eight.

```
PREFIX dc:<http://purl.org/dc/elements/1.1/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?x ?fn ?ln
WHERE{?x dc:description "Author"@en .
      foaf:name ?fn ;
      foaf:surname ?ln.}
ORDER BY ?x
OFFSET 8
LIMIT 10
```

The results are returned, skipping the first eight matches.

x	fn	ln
<http://dbpedia.org/resource/Agnete_Friis>	"Agnete Friis"@en	"Friis"@en
<http://dbpedia.org/resource/Ahmad_Akbarpour>	"Ahmad Akbarpour"@en	"Akbarpour"@en
<http://dbpedia.org/resource/Ajip_Rosidi>	"Ajip Rosidi"@en	"Rosidi"@en
<http://dbpedia.org/resource/Alauddin_Masood>	"Alauddin Masood"@en	"Masood"@en
<http://dbpedia.org/resource/Alberto_Fortis>	"Abbe Alberto Fortis"@en	"Fortis"@en
<http://dbpedia.org/resource/Alexandra_Hawkins>	"Alexandra Hawkins"@en	"Hawkins"@en
<http://dbpedia.org/resource/Alexandre_Beljame>	"Alexandre Beljame"@en	"Beljame"@en
<http://dbpedia.org/resource/Alexis_Jenni>	"Alexis Jenni"@en	"Jenni"@en
<http://dbpedia.org/resource/Alexis_Lecaye>	"Alexis Lecaye"@en	"Lecaye"@en
<http://dbpedia.org/resource/Alfred_Leland_Crabb>	"Alfred Leland Crabb"@en	"Crabb"@en

5.1.12 SPARQL 1.0 vs. SPARQL 1.1 Features

These SPARQL 1.1 features are supported by MarkLogic:

- Subqueries
- Property Path Expressions
- Projected Expressions
- The BIND Keyword
- Values Sections
- Comparison Operators
- Graph Store Protocol

5.1.12.1 Subqueries

You can combine the results of several queries by using subqueries. You can nest one or more queries inside another query. Each subquery is enclosed in separate pairs of curly braces. Typically, subqueries are used with solution modifiers.

This example queries for Politicians that were born in London and limits the results to the first ten:

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>
PREFIX db: <http://dbpedia.org/resource/>
PREFIX onto: <http://dbpedia.org/ontology/>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT  ?name ?location ?date
WHERE
   {?person dc:description "Politician"@en .

    {SELECT ?location
     WHERE {?person onto:birthPlace db:London .
            ?person onto:birthPlace ?location .}
    }
    {SELECT ?date
```

```
      WHERE {?person onto:birthDate ?date .}
     }
     {SELECT ?name
      WHERE {?person foaf:name ?name}
     }
    }
LIMIT 10
```

5.1.12.2 Property Path Expressions

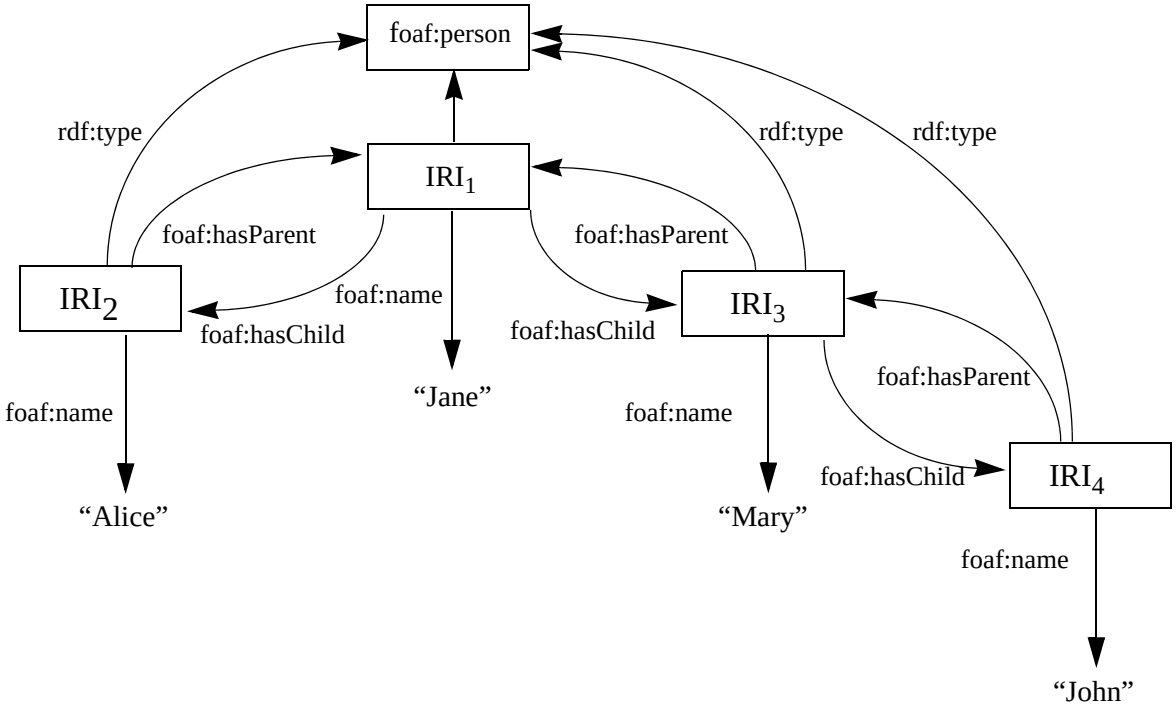
Property paths enable you to traverse an RDF graph. You can follow possible routes through a graph between two graph nodes. You can use property paths to answer questions like “show me all of the people who are connected to John, and all the people who know people who know John.” You can use property paths to query paths of any length in a dataset graph by using an XPath-like syntax. A property path query retrieves pairs of connecting nodes where the paths that link those nodes match the given property path. This makes it easier to follow and use relationships expressed as triples.

Query evaluation determines all matches of a path expression and binds subject or object as appropriate. Only one match per route through the graph is recorded - there are no duplicates for any given path expression.

The following table describes the supported path operators (|, ^, and /) that can be combined with predicates in a property path:

Property Path	Construct	Description
Sequence	`path1/path2`	Forwards path from path1 to path2
Inverse	`^path`	Backwards path from object to subject
Alternative	`path1|path2`	Either path1 or path2
Group	`(path)`	A group path `path`, brackets control precedence

The following examples illustrate property paths using this simple graph model.



Here is that same graph model expressed as triples in Turtle format:

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns> .
@prefix p0: <http://marklogic.com/semantics/> .

p0:alice foaf:hasParent p0:jane ;
a foaf:Person ;
foaf:name "Alice" .

p0:jane foaf:hasChild p0:alice ,
p0:mary ;
a foaf:Person ;
foaf:name "Jane" .

p0:mary foaf:hasParent p0:jane ;
a foaf:Person ;
foaf:hasChild p0:john ;
foaf:name "Mary" .

p0:john foaf:hasParent p0:mary ;
foaf:name "John" ;
<\u003chttp://www.w3.org/1999/02/22-rdf-syntax-ns#type/>
foaf:Person .
```

This example query uses paths (the / operator) to find the name of Alice's parent:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?s
WHERE {?s foaf:name "Alice".
?s foaf:hasParent/foaf:name ?name .
}

=>

  s       name
"Alice" "Jane"
```

This query finds the names of people two links away from John (grandparent) :

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?s
WHERE {?s foaf:name "John".
?s foaf:hasParent/foaf:hasParent/foaf:name ?name .
}

=>

  s     name
"John" "Jane"
```

This query reverses the property path direction (swaps the roles of subject and object using the ^ operator) to find the name of Mary's mother:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

SELECT ?s
WHERE { "Mary" ^foaf:hasChild ?x }

=>

  s
"Jane"
```

5.1.12.3 Projected Expressions

You can use projected expressions within SPARQL SELECT queries to project arbitrary SPARQL expressions, rather than only bound variables. This allows the creation of new values in a query.

This type of query uses values derived from a variable, constant IRIs, constant literal, function calls, or other expressions in the SELECT list for columns in a query result set.

> **Note:** Functions could include both SPARQL built-in functions and extension functions supported by an implementation.

Projected expressions must be in parentheses and must be given an alias using the AS keyword. The syntax is (expression AS ?var).

For example:

```
PREFIX ex: <http://example.org/>
SELECT ?Item (?price * ?qty AS ?total_price)
WHERE {?Item ex:price ?price}
```

The query returns values for ?total_price that do not occur in the graphs contained in the RDF dataset.

5.1.12.4 The BIND Keyword

The BIND keyword allows a value to be assigned to a variable from a basic graph pattern or property path expression. The use of BIND ends the preceding basic graph pattern. The variable introduced by the BIND clause must not have been used in the group graph pattern up to the point of use in BIND. When you assign a computed value to a variable in the middle of a pattern, the computed value can then be used in other patterns, such as a CONSTRUCT query. The syntax is (expression AS ?var).

For example:

```
BIND (2014 - ?birthYear AS ?age) .
```

5.1.12.5 Values Sections

You can use SPARQL VALUES sections to provide inline data as an unordered solution sequence that is joined with the results of the query evaluation. The VALUES section allows multiple variables to be specified in the data block.

For example:

```
SELECT *
WHERE { ?a :hasName ?n .
VALUES ?n { "John" "Jane" }}
```

This is the same as using the longer form where the parameter lists are contained in parentheses:

```
VALUES (?z) { ("John") ("Jane") }
```

Note: A VALUES block of data can appear in a query pattern or at the end of a SELECT query or subquery.

5.1.12.6 Comparison Operators

The `IN` and `NOT IN` comparison operators are used with the `FILTER` clause to return a boolean `true` if a matching term is in the set of expressions, or `false`, if not.

For example:

```
ASK {
FILTER(2 IN (1, 2, 3))
}

=>
true

ASK {
FILTER(2 NOT IN (1, 2, 3))
}

=>
false
```

5.1.12.7 Graph Store Protocol

The Graph Store HTTP Protocol is a mapping from RESTful HTTP requests to the corresponding SPARQL 1.1 Update operations. See “Loading Triples Using the REST API” on page 49.

5.1.13 SPARQL Resources

The SPARQL recommendation is closely related to these specifications:

- The SPARQL Protocol for RDF [SPROT] specification defines the remote protocol for issuing SPARQL queries and receiving the results.
  http://www.w3.org/TR/rdf-sparql-protocol/
- MarkLogic supports simple entailment, as described in the W3C recommendation:
  http://www.w3.org/TR/rdf-mt/#entail
- The SPARQL Query Results XML Format specification defines an XML document format for representing the results of SPARQL `SELECT` and `ASK` queries.
  http://www.w3.org/TR/rdf-sparql-XMLres/
- SPARQL 1.1 Graph Store HTTP Protocol:
  http://www.w3.org/TR/2012/CR-sparql11-http-rdf-update-20121108/

There are a variety of tutorials available for learning more about the SPARQL query language. For example:

- http://www.cambridgesemantics.com/semantic-university

Recommended reading:

- *Learning SPARQL* by Bob DuCharme (Publisher: O'Reilly)
- *Semantic Web for the Working Ontologist* by Dean Allemang and Jim Hendler (Publisher: Morgan Kaufmann)

Additional useful resources include:

- SPARQL Implementations: http://www.w3.org/wiki/SparqlImplementations
- SPARQL Working Group: http://www.w3.org/2009/sparql/wiki/Main_Page
- SPARQL query results - JSON format: http://www.w3.org/TR/2012/PR-sparql11-results-json-20121108/
- SPARQL Frequently Asked Questions: http://thefigtrees.net/lee/sw/sparql-faq

5.2 Querying Triples with XQuery

This section contains examples of using XQuery with semantic data. When you use XQuery to query triples in MarkLogic, you can use the Semantics API library, built-in functions, the Search API built-in functions, or a combination of these.

This section includes the following topics:

- Preparing to Run the Examples
- Using Semantic Functions to Search
- Viewing Results as XML and RDF
- Querying with the Search API

5.2.1 Preparing to Run the Examples

These examples for querying triples with XQuery assume that you have the GovTrack dataset. If you prefer to use your own dataset or cannot access http://www.govtrack.us/data/rdf/, you can skip this section.

`GovTrack.us` data is free, publicly available legislative information about bills in the US Congress, representatives, and voting records. The information originates from a variety of official government Web sites. `Govtrack.us` applies the principles of open data to legislative transparency.

Before installing the GovTrack dataset, you should have the following:

- MarkLogic Server 7.0-1 or later.
- MarkLogic Content Pump (mlcp). See Downloading and Installing mlcp in the *Loading Content Into MarkLogic Server Guide.*
- The GovTrack dataset and access to http://www.govtrack.us/data/rdf/.

Follow this procedure to download the GovTrack dataset and load it into MarkLogic Server.

1. Download these files into a directory on your local file system:

   - http://www.govtrack.us/data/rdf/bills.108.cosponsors.rdf.gz
   - http://www.govtrack.us/data/rdf/bills.108.rdf.gz
   - http://www.govtrack.us/data/rdf/people.rdf.gz
   - http://www.govtrack.us/data/rdf/people.roles.rdf.gz

2. Create a `govtrack` database, forest, and an XDBC application server on port 8082 for the GovTrack data. Use an alternate port number if port 8082 is in use.

3. Enable the triples index and the collection lexicon for the `govtrack` database. See "Enabling the Triple Index" on page 57.

4. Import the data into your `govtrack` database with mlcp, specifying the collections of `info:govtrack/people` and `info:govtrack/bills`. See "Loading triples with mlcp" on page 39. Your import command on Windows should look similar to the following:

   ```
   mlcp.bat import -host localhost -port 8082 -username admin ^
     -password password –input_file_type rdf ^
     -input_file_path c:\space\GovTrack ^
     -input_compressed true ^
     -input_compression_codec gzip ^
     -output_collections
   "http://marklogic.com/semantics#info:govtrack/people,http://marklogic.
   com/semantics#info:govtrack/bills"
   ```

   Modify the `host`, `port`, `username`, `password`, and `-input_file_path` options to match your environment.

   The equivalent command for Unix is:

   ```
   mlcp.sh import -host localhost -port 8082 -username admin \
   -password password -input_file_type RDF \
   -input_file_path /space/GovTrack \
   -input_compressed true \
   -input_compression_codec gzip \
   -output_collections
   'http://marklogic.com/semantics#info:govtrack/people,http://marklogic.
   com/semantics#info:govtrack/bills'
   ```

   Note: It is important to specify the `-input_file_type` as RDF to invoke the correct parser.

5.2.2 Using Semantic Functions to Search

You can execute SPARQL `SELECT`, `ASK`, and `CONSTRUCT` queries with the `sem:sparql`, `sem:sparql-triples` and `sem:sparql-values` functions. For details about the function signatures and descriptions, see the Semantics documentation under XQuery Library Modules in the *MarkLogic XQuery and XSLT Function Reference*.

The following examples execute SPARQL queries against the triples index of the `govtrack` database. See “Preparing to Run the Examples” on page 95.

> **Note:** Although some of the semantics functions are built-in, others are not, so it is recommended that you import the Semantics API library into every XQuery module that uses the Semantics API.

The import statment for semantic functions looks like this:

```
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";
```

5.2.2.1 sem:sparql

You can use the `sem:sparql` function to query RDF data in the database the same way you would using the SPARQL language. To use the `sem:sparql` function, you pass the SPARQL query to the function as a string.

For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

sem:sparql('
PREFIX bill: <http://www.rdfabout.com/rdf/usgov/congress/108/bills/>
SELECT ?predicate ?object
WHERE { bill:h963 ?predicate ?object }
')
```

The example queries the RDF dataset for all triples where the subject is bill number “h963”. For more information about constructing SPARQL queries, see “Executing a SPARQL Query in Query Console” on page 64.

The result of the example query for all triples where the subject is bill number “h963” would look like this:

predicate	object
<http://www.rdfabout.com/rdf/schema/usbill/hasTitle>	<-276ac564:14008b22ed1:-3313>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://www.rdfabout.com/rdf/schema/usbill/HouseBill>
<http://www.rdfabout.com/rdf/schema/usbill/inCommittee>	<http://www.rdfabout.com/rdf/usgov/congress/committees/HouseGovernmentReform>
<http://www.rdfabout.com/rdf/schema/usbill/cosponsor>	<http://www.rdfabout.com/rdf/usgov/congress/people/D000598>
<http://www.rdfabout.com/rdf/schema/usbill/sponsor>	<http://www.rdfabout.com/rdf/usgov/congress/people/F000116>
<http://www.rdfabout.com/rdf/schema/usbill/congress>	"108"
<http://purl.org/dc/terms/created>	"2003-02-27"
<http://www.rdfabout.com/rdf/schema/usbill/number>	"963"
<http://purl.org/dc/elements/1.1/title>	"H.R. 108/963: To redesignate the facility of the United States Postal Service located at 2777 Loga \"Cesar E. Chavez Post Office\"."
<http://purl.org/ontology/bibo/shortTitle>	"H.R. 963: To redesignate the facility of the United States Postal Service located at 2777 Logan A \"Cesar E. Chavez Post Office\"."
<http://www.rdfabout.com/rdf/schema/usbill/title>	"H.R. 963: To redesignate the facility of the United States Postal Service located at 2777 Logan A \"Cesar E. Chavez Post Office\"."
<http://www.w3.org/2000/01/rdf-schema#label>	"H.R. 963: To redesignate the facility of the United States Postal Service located at 2777 Logan A \"Cesar E. Chavez Post Office\". (108th Congress)"
<http://www.rdfabout.com/rdf/schema/usbill/type>	"h"
<http://www.rdfabout.com/rdf/schema/usbill/status>	"introduced"
<http://www.rdfabout.com/rdf/schema/usbill/introduced>	"2003-02-27"^^xs:date

You can also construct your SPARQL query as an input string in a FLWOR statement (an XQuery programming expression - For, Let, Where, Order by, and Return). In the example, the `let` statement contains the SPARQL query.

This is a SPARQL `ASK` query, to find out if there are any male politicians that are members of the Latter Day Saints:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $sparql := '
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX politico: <http://www.rdfabout.com/rdf/schema/politico/>
PREFIX govtrack: <http://www.rdfabout.com/rdf/schema/usgovt/>
PREFIX vcard: <http://www.w3.org/2001/vcard-rdf/3.0#>

ASK  { ?x rdf:type  politico:Politician ;
       foaf:religion "Latter Day Saints" ; foaf:gender "male". }
'
return sem:sparql($sparql)

=>
true
```

5.2.2.2 sem:sparql-triples

You can execute a SPARQL queries against in-memory triple data with the `sem:sparql-triples` function. In the following example, the in-memory triple data is about several members of the Kennedy family. First, the data parsed as Turtle by using the `sem:rdf-parse` function and then bound to the variable `?p`. The `return` statement contains the SPARQL `SELECT` query to find people that knew Jacqueline Kennedy Onassis.

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $string := "
<http://dbpedia.org/resource/Jacqueline_Kennedy_Onassis>
<http://xmlns.com/foaf/0.1/knows>
<http://dbpedia.org/resource/Eunice_Kennedy_Shriver> .

<http://dbpedia.org/resource/John_F._Kennedy,_Jr.>
<http://xmlns.com/foaf/0.1/knows>
<http://dbpedia.org/resource/Jacqueline_Kennedy_Onassis> .

<http://dbpedia.org/resource/Rosemary_Kennedy>
<http://xmlns.com/foaf/0.1/knows>
<http://dbpedia.org/resource/Jacqueline_Kennedy_Onassis> .

<http://dbpedia.org/resource/Joseph_Patrick_Kennedy_Sr.>
<http://xmlns.com/foaf/0.1/knows>
<http://dbpedia.org/resource/Rosemary_Kennedy> .
"
let $triples := sem:rdf-parse($string, "turtle")

return sem:sparql-triples('
   PREFIX foaf: <http://xmlns.com/foaf/0.1/>
   SELECT ?p
   WHERE { ?p foaf:knows
   <http://dbpedia.org/resource/Jacqueline_Kennedy_Onassis> .}
', $triples)
```

The results return matches for the query pattern:

p
<http://dbpedia.org/resource/John_F._Kennedy,_Jr.>
<http://dbpedia.org/resource/Rosemary_Kennedy>

5.2.2.3 sem:sparql-values

Use the `sem:sparql-values` function to allow sequences of bindings to restrict what a SPARQL query returns. The `sem:sparql-values` function are considered as equivalent to the SPARQL 1.1 facility of an outermost `VALUES` block. See “Values Sections” on page 93. In this example, a sequence of values are bound to the subject IRIs that represent two members of congress.

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $bindings := ( map:entry("s",
sem:iri("http://www.rdfabout.com/rdf/usgov/congress/people/A000069")),
map:entry("s",
sem:iri("http://www.rdfabout.com/rdf/usgov/congress/people/G000359"))
)
return
sem:sparql-values("select * { ?s ?p ?o }",$bindings)
```

The results are returned as sequences of values for the two members of congress:

s	p	o
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://www.w3.org/2001/vcard-rdf/3.0#N>	<-276ac564:14008b22ed1:-7fff>
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://www.rdfabout.com/rdf/schema/politico/hasRole>	<-7059da6e:1403c27791b:-7fe1>
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://www.rdfabout.com/rdf/schema/politico/hasRole>	<-7059da6e:1403c27791b:-7ffc>
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://www.rdfabout.com/rdf/schema/politico/hasRole>	<-7059da6e:1403c27791b:-7fff>
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://xmlns.com/foaf/0.1/img>	<http://www.govtrack.us/data/photos/300001.jpeg>
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://www.rdfabout.com/rdf/schema/politico/Politicia
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://xmlns.com/foaf/0.1/Person>
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://www.w3.org/2001/vcard-rdf/3.0#BDAY>	"1924-09-11"
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://www.rdfabout.com/rdf/schema/usgovt/congressBioGuideID>	"A000069"
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://xmlns.com/foaf/0.1/religion>	"Congregationalist"
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://www.rdfabout.com/rdf/schema/usgovt/name>	"Daniel Akaka"
<http://www.rdfabout.com/rdf/usgov/congress/people/A000069>	<http://xmlns.com/foaf/0.1/name>	"Daniel Akaka"

5.2.3 Viewing Results as XML and RDF

You can use `sem:query-results-serialize` and `sem:rdf-serialize` functions to view results in XML, JSON, or RDF serialization.

In this example, the `sem:sparql` query finds the cosponsors of bill number “1024” and passes the value sequence into `sem:query-results-serialize` to return the results as variable bindings in default XML format:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

sem:query-results-serialize(sem:sparql('
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
```

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX bill: <http://www.rdfabout.com/rdf/schema/usbill/>

SELECT ?bill ?person ?name
WHERE {?bill rdf:type bill:SenateBill ;
             bill:congress "108" ;
             bill:number "1024" ;
             bill:cosponsor ?person .
       ?person foaf:name ?name .}
'))
```

The results are returned in W3C SPARQL Query Results format:



To view the same results in JSON format, add the format option after the query.

For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

sem:query-results-serialize(sem:sparql('
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
PREFIX bill: <http://www.rdfabout.com/rdf/schema/usbill/>

SELECT ?bill ?person ?name
WHERE {?bill rdf:type bill:SenateBill ;
             bill:congress "108" ;
             bill:number "1024" ;
             bill:cosponsor ?person .
      ?person foaf:name ?name .}
'), "json")
```

When you use the `sem:rdf-serialize` function, you pass the triple to return as a string, or optionally you can specify a parsing format option.

For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

sem:rdf-serialize(
   sem:triple(
      sem:iri(
   "http://www.rdfabout.com/rdf/usgov/congress/people/D000060"),
      sem:iri("http://www.rdfabout.com/rdf/schema/usgovt/name"),
           "Archibald Darragh"), "rdfxml")
```

This table describes the format options:

Format	Output As
ntriple	`xs:string`
nquad	`xs:string`
turtle	`xs:string`
rdfxml	an element
rdfjson	a `json:object`
triplexml	a sequence of `sem:triple` elements

You can also select different ways to display results. See “Selecting Results Rendering” on page 68.

5.2.4 Working with CURIEs

A CURIE (Compact URI Expression) is a shortened version of a URI signifying a specific resource. With MarkLogic, lengthy URIs or IRIs can be shortened using a mechanism similar to that built into the SPARQL language. As a convenience, the definitions of several common prefixes are built in, as shown in the examples in this section.

CURIEs are composed of two components, a prefix and a reference. The prefix is separated from the reference by a colon (:), for example, `dc:description` is a prefix for Dublin Core and the reference - `http://purl.org/dc/elements/1.1/` - is the description.

These are the most common prefixes and their mapping:

```
map:entry("atom", "http://www.w3.org/2005/Atom/"),
map:entry("cc", "http://creativecommons.org/ns#"),
map:entry("dc", "http://purl.org/dc/elements/1.1/"),
map:entry("dcterms", "http://purl.org/dc/terms/"),
map:entry("doap", "http://usefulinc.com/ns/doap#"),
map:entry("foaf", "http://xmlns.com/foaf/0.1/"),
map:entry("media", "http://search.yahoo.com/searchmonkey/media/"),
map:entry("og", "http://ogp.me/ns#"),
map:entry("owl", "http://www.w3.org/2002/07/owl#"),
map:entry("prov", "http://www.w3.org/ns/prov#"),
map:entry("rdf", "http://www.w3.org/1999/02/22-rdf-syntax-ns#"),
map:entry("rdfs", "http://www.w3.org/2000/01/rdf-schema#"),
map:entry("result-set",
"http://www.w3.org/2001/sw/DataAccess/tests/result-set#"),
map:entry("rss", "http://purl.org/rss/1.0/"),
map:entry("skos", "http://www.w3.org/2004/02/skos/core#"),
map:entry("vcard", "http://www.w3.org/2006/vcard/ns#"),
map:entry("void", "http://rdfs.org/ns/void#"),
map:entry("xhtml", "http://www.w3.org/1999/xhtml#"),
map:entry("xs","http://www.w3.org/2001/XMLSchema#")
```

You can use the `sem:curie-expand` and `sem:curie-shorten` functions to work with CURIEs in MarkLogic. When you use `sem:curie-expand`, you eliminate the need to declare common prefixes.

For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

sem:curie-expand("foaf:name")
```

```
=>
<http://xmlns.com/foaf/0.1/name>
```

In this next example, the `cts:triple-range-query` finds a person named “Lamar Alexander”. Note that the results are returned from a `cts:search` to find the `sem:triple` elements where the `foaf:name` equals “Lamar Alexander”. The predicate CURIE is displayed as the fully expanded IRI for `foaf:name`.

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $query := cts:triple-range-query((),
sem:curie-expand("foaf:name"), "Lamar Alexander", "sameTerm")

return cts:search(fn:collection()//sem:triple, $query)

=>
<sem:triples xmlns="http://marklogic.com/semantics">
   <sem:subject>
      http://www.rdfabout.com/rdf/usgov/congress/people/A000360
   </sem:subject>
   <sem:predicate>
      http://xmlns.com/foaf/0.1/name
   </sem:predicate>
   <sem:object datatype="http://www.w3.org/2001/XMLSchema#string">
      Lamar Alexander
   </sem:object>
</sem:triples>
```

In this example, the query includes a series of `cts:triples` function calls and `sem:curie-expand` to find the name of the congressperson who was born on November 20, 1917. The person’s name is returned as an RDF literal string from the object position (`sem:triple-object`) of the returned triple statement:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $person-triples := cts:triples((), sem:curie-expand("vcard3:BDAY",
map:entry("vcard3", "http://www.w3.org/2001/vcard-rdf/3.0#")),
"1917-11-20")
let $subject := sem:triple-subject($person-triples)
let $name-triples := cts:triples($subject,
sem:curie-expand("foaf:name"), ())
let $name := sem:triple-object($name-triples)
return ($name)

=>

Robert Byrd
```

Use the `sem:curie-shorten` to compact an IRI to a CURIE. Evaluating the function involves replacing the CURIE with a concatenation of the value represented by the prefix and the part after the colon (the reference).

For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

sem:curie-shorten(sem:iri("http://www.w3.org/1999/02/
    22-rdf-syntax-ns#resource"))

=>
rdf:resource
```

Note: Although CURIEs map to IRIs, they should not be used as values for attributes or other content that are specified to contain only IRIs.

For example, the following query will return an empty sequence since the `cts:triple-range-query` expects an IRI (`sem:iri`) in that position not a `sem:curie-shorten`, which is a string.

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $query := cts:triple-range-query((),
   sem:curie-shorten(sem:iri("http://xmlns.com/foaf/0.1/name/")),
   "Lamar Alexander", "sameTerm")

return cts:search(fn:collection()//sem:triple, $query)

=>

your query returned an empty sequence
```

Instead, use either of the following:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $query := cts:triple-range-query((),
   sem:curie-expand("foaf:name"), "Lamar Alexander", "sameTerm")
return cts:search(fn:collection()//sem:triple, $query)
```

Or expand the prefix to the full IRI:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $query := cts:triple-range-query((),
   sem:iri("http://xmlns.com/foaf/0.1/name"), "Lamar Alexander",
   "sameTerm")
return cts:search(fn:collection()//sem:triple, $query)
```

Note: The `sameTerm` function that is defined in SPARQL, performs the value equality operation. It differs from the equality operator (`=`) in the way that types are handled. In MarkLogic, types and timezones are the only things that make `sameTerm` different from `=`. For example, `sameTerm(A,B)` implies A=B. In SPARQL terms, using `sameTerm` semantics to match graphs to the graph patterns in a SPARQL query is called *simple entailment*. For more information, see "Triple Values and Type Information" on page 55.

5.2.5 Querying with the Search API

This section discusses using the Search API to return RDF data from a MarkLogic triplestore. It includes the following topics:

- cts:triples
- cts:triple-range-query
- cts:search
- cts:contains

5.2.5.1 cts:triples

The `cts:triples` function retrieves the parameter values from the triple index. Triples are returned in any of the sort orders present in the triple index.

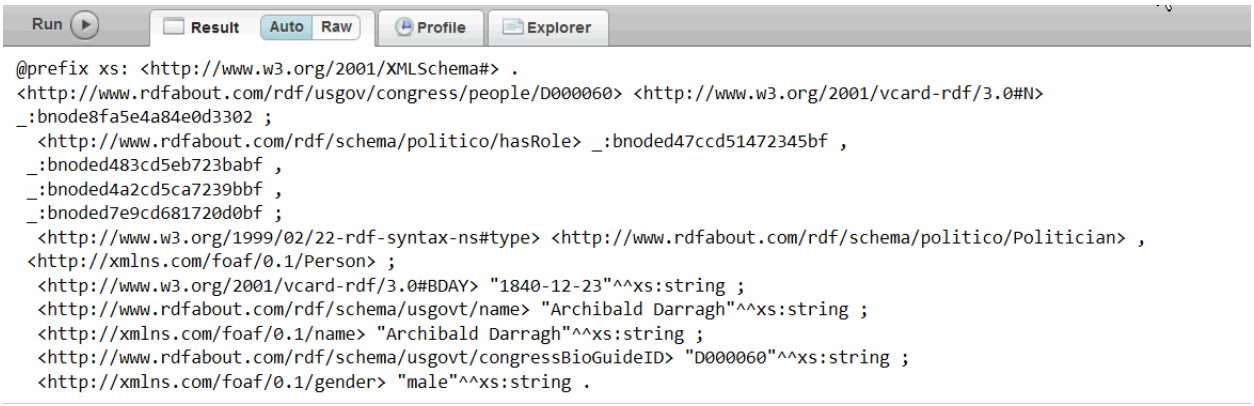
In the following example, the subject IRI for a member of congress is passed as the first parameter for the subject IRI:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $r := cts:triples
(sem:iri("http://www.rdfabout.com/rdf/usgov/congress/people/D000060"),
()())

return ($r)
```

The matching results return the triples for that member of congress (Archibald Darragh):



5.2.5.2 cts:triple-range-query

Search access to the triple index is provided through the `cts:triple-range-query` function. The first parameter in this example is an empty sequence for the subject. The predicate and object parameters are provided, along with the `sameTerm` operator to find someone named “Lamar Alexander”:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $query := cts:triple-range-query((),
sem:iri("http://xmlns.com/foaf/0.1/name"), "Lamar Alexander",
"sameTerm")

return cts:search(fn:collection()//sem:triple, $query)
```

5.2.5.3 cts:search

The built-in search functions are XQuery functions used to perform text searches. In this example, the `cts:search` queries against the `info:govtrack/bills` collection of XML docs to determine how many bills have the word “Guam” in the document (the `cts:word-query` of the specified string).

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $search := cts:search(//sem:triple,
cts:and-query((cts:collection-query("info:govtrack/bills"),
cts:word-query("Guam"))))[1]

return cts:remainder($search)
```

```
=>
16
```

You can use a combination of `cts:query` and comparison operators. The `cts:triple-range-query` function in this example is used within a `cts:search` to find the `sem:triple` elements, where the `foaf:name` equals “Lamar Alexander” or where Alexander’s subject IRI contains a `foaf:img` property conveying an image IRI.

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

declare namespace dc = "http://purl.org/dc/elements/1.1/";

cts:search(collection()//sem:triple, cts:or-query((
  cts:triple-range-query((), sem:curie-expand("foaf:name"),
"Lamar Alexander", "sameTerm"),
  cts:triple-range-query(
sem:iri("http://www.rdfabout.com/rdf/usgov/congress/people/A000360"),
sem:curie-expand("foaf:img"), (), "="))))
```

You can construct sequences in SPARQL expressions and the SPARQL 1.1 `IN` and `NOT IN` operators to make effective use of built-in functions such as `cts:and-query`, which expect a sequence of `cts:query` values as the first argument.

5.2.5.4 cts:contains

You can use the `cts:contains` function in SPARQL expressions, which occur in `FILTER` and `BIND` clauses. For an example, see “The FILTER Keyword” on page 82.

Since `cts:contains` allows any value as the first argument, you can pass a variable that is bound by a triple pattern in the query as the first argument. The triple pattern uses the full-text index to reduce the results it returns during the lookup in the triple index. For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

fn:count(sem:sparql('
PREFIX cts: <http://marklogic.com/cts#>

SELECT DISTINCT *
WHERE
{ ?s ?p ?o .
     filter cts:contains(?o, cts:word-query("Environment"))  }
'))

=>
53
```

The following example is a simple query to verify if there is a bill number “hr543”.

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

cts:contains(collection("info:govtrack/bills")//sem:subject,
cts:word-query('hr543'))

=>
true
```

5.3 Querying Triples with REST API

This section describes how to query triple data using the SPARQL endpoint, which is an implementation of the W3C SPARQL Protocol. This endpoint URL is addressed as:

```
http://host:port/v1/graphs/sparql?
```

In this section, the following topics are discussed:

- Assumptions
- Specifying Parameters
- Executing a SPARQL Query in POST Requests
- SPARQL DESCRIBE Query in GET Requests
- Supported Verbs
- Response Output Formats
- Exploring Triples with REST API

Note: You must have read permission for the rest-reader role to use the SPARQL endpoint, along with any security requirements for your environment. See Controlling Access to Documents Created with the REST API in the *REST Application Developer’s Guide* for more information.

5.3.1 Assumptions

To follow along with the examples in this section the following assumptions are made:

- You have access to the GovTrack dataset. For details, see “Preparing to Run the Examples” on page 95. If you do not have access to the GovTrack data or prefer to use your own data, you can modify queries to fit your data.
- `curl` or an equivalent command-line tool for issuing HTTP requests is installed.

Note: Though the examples rely on `curl`, you can use any tool capable of sending HTTP requests. If you are not familiar with `curl` or do not have `curl` on your system, see the Introduction to the curl Tool in the *REST Application Developer's Guide*.

5.3.2 Specifying Parameters

The following parameters are supported with the SPARQL endpoint using `POST:/v1/graphs/sparql` or `GET:/v1/graphs/sparql`:

- a query - SPARQL query to execute
- (optional) a default-graph-uri - addressed as `http://host:port/v1/graphs/sparql?default-graph-uri=<default-graph-uri*>`
- (optional) a named-graph-uri - addressed as `http://host:port/v1/graphs/sparql?named-graph-uri=<named-graph-uri*>`

  where *`default-graph-uri*`* selects the graph name(s) to query. The "`*`" indicates that one or more `default-graph-uri` or `named-graph-uri` parameters can be specified. The *`named-graph-uri`* parameter is used with `FROM NAMED` and `GRAPH` in queries to specify the IRI(s) to be substituted for a name within particular kinds of queries. You can have one or more *`named-graph-uri`* specified as part of a query.

If you don't specify a graph name with a query, the `UNION` of all graphs will be queried. If you specify `default-graph-uri`, one or more graph names that you specify will be queried (but this is *not* the "default" graph that contains the unnamed triples). You can also query `http://marklogic.com/semantics#default-graph`, where unnamed graphs are stored.

Any valid IRI can be used for these graph names (for example, `/my_graph` or `http://www.example.com/rdf-graph-store`). The `default-graph-uri` can be used to specify the dataset outside of the query itself. If no dataset is defined, the dataset will include all triples (the `UNION` of all graphs).

If you specify a dataset in both the request parameters and the query, the dataset defined with `named-graph-uri` or `default-graph-uri` takes precedence. When you specify more than one `default-graph-uri` or `named-graph-uri` in a query via REST, the format will be `http://host:port/v1/graphs/sparql?named-graph-uri=<named-graph-uri*>` for each graph named in the query.

This REST request has two named graph IRIs specified:

```
curl --anyauth --user admin:password
"http://host:port/v1/graphs/sparql?named-graph-uri=http://marklogic.co
m/info:govtrack/bills&named-graph-uri=http://marklogic.com/info:govtra
ck/people" -H "Content-type:application/x-www-form-urlencoded"
-H "Accept:application/sparql-results+xml"
-X POST -d 'query=PREFIX%20rdf%3A%20%3Chttp%3A%2F%2F
www.w3.org%2F1999%2F02%2F22-rdf-syntax-ns%23%3E%20%0A
PREFIX%20bill%3A%20%3Chttp%3A%2F%2Fwww.rdfabout.com%2Frdf%2F
```

```
schema%2Fusbill%2F%3E%0APREFIX%20people%3A%20%3Chttp%3A%2F%2F
www.rdfabout.com%2Frdf%2Fusgov%2Fcongress%2Fpeople%2F%3E%0A
SELECT%20%3Fx%20
WHERE%20%7B%20%3Fx%20rdf%3Atype%20bill%3AHouseBill%20%3B%20bill%3A
cosponsor%20%20people%3AA000358.%20%7D%0A'
```

The query passed by REST will search against the two named graphs, `http://marklogic.com/info:govtrack/bills` and `http://marklogic.com/info:govtrack/people`. See "Target RDF Graph" on page 73 for more information.

5.3.3 Executing a SPARQL Query in POST Requests

These two methods can be used for `POST` requests to query triples with REST API:

- Include a SPARQL query as a file in the `POST` body.
- Include the SPARQL query as URL-encoded data.

The following is a simple SPARQL `DESCRIBE` query to find out about US Congress bill 44. The query is saved as a file, named `bill44.sparql`.

Here is the file:

```
#file name bill44.sparql
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX bill: <http://www.rdfabout.com/rdf/schema/usbill/>
DESCRIBE ?x WHERE { ?x rdf:type bill:HouseBill ;
                       bill:number "44" . }
```

The SPARQL endpoint requires a SPARQL query as either a parameter or `POST` body. In the following example, the `bill44.sparql` file with the `DESCRIBE` query is passed to the body of the `POST` request:

```
# Windows users, see Modifying the Example Commands for Windows
curl --anyauth --user admin:password \
  -i -X POST --data-binary @./bill44.sparql \
  -H "Content-type: application/sparql-query" \
  -H "Accept: application/sparql-results+xml" \
  http://localhost:8050/v1/graphs/sparql
```

Note: For readability, long command lines are broken into multiple lines using the Unix line continuation character '\' and extra lines breaks have been added for readability. Remove these continuation characters and line breaks when you copy and paste commands.

The query returns the following triples describing bill 44:

```
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
 <OfficialTitle rdf:ID="bnodebnode309771418819f878"
    xmlns="http://www.rdfabout.com/rdf/schema/usbill/">
```

```
 <rdf:typerdf:resource="http://www.rdfabout.com/rdf/schema/usbill
   /OfficialTitle"/>
 <rdf:value rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
   To amend the Internal Revenue Code of 1986 to provide reduced
   capital gain rates for qualified economic stimulus gain and to
   index the basis of assets of individuals for purposes of
   determining gains and losses.</rdf:value></OfficialTitle>
<ShortTitle rdf:ID="bnodebnode30b47143b819db78"
  xmlns="http://www.rdfabout.com/rdf/schema/usbill/">
 <rdf:type rdf:resource="http://www.rdfabout.com/rdf/schema/usbill
  /ShortTitle"/>
 <rdf:value rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
  Investment Tax Incentive Act of 2003</rdf:value></ShortTitle>
<ShortTitle rdf:ID="bnodebnodee1860b72fb58b315"
  xmlns="http://www.rdfabout.com/rdf/schema/usbill/">
 <rdf:type rdf:resource="http://www.rdfabout.com/rdf/schema/usbill
  /ShortTitle"/>
 <rdf:value rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
  Investment Tax Incentive Act of 2003</rdf:value></ShortTitle>
<HouseBill rdf:about="http://www.rdfabout.com/rdf/usgov/congress/108
  /bills/h44" xmlns="http://www.rdfabout.com/rdf/schema/usbill/">
<inCommittee rdf:resource="http://www.rdfabout.com/rdf/usgov
  /congress/committees/HouseWaysandMeans"/>
<cosponsor
rdf:resource="http://www.rdfabout.com/rdf/usgov/congress/people/A00035
8"/>
 <cosponsor
rdf:resource="http://www.rdfabout.com/rdf/usgov/congress/people/B00020
8"/>
 <cosponsor
rdf:resource="http://www.rdfabout.com/rdf/usgov/congress/people/B00057
5"/>
 <cosponsor
.....
```

The `Content-type:` for the query is specified as `application/sparql-query` and the content response type (the `Accept:`) specifies the output as `application/rdf+xml`. The output is returned as triples in XML format. See “Response Output Formats” on page 115 for more details.

> **Note:** If you use `curl` to make a `PUT` or `POST` request and read in the request body from a file, use `--data-binary` rather than `-d` to specify the input file. When you use `--data-binary`, `curl` inserts the data from the file into the request body as-is. When you use `-d`, `curl` strips newlines from the input, which can make your triple data or SPARQL syntactically invalid.

Another way to use the `POST` request is to include the URL-encoded query in the form-encoded method, as described in the Semantics documentation of the *REST Client API*.

The following SPARQL SELECT query finds the House of Congress bills that were cosponsored by the person with a Congress BioGuideID of “A000358”:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX bill: <http://www.rdfabout.com/rdf/schema/usbill/>
PREFIX people: <http://www.rdfabout.com/rdf/usgov/congress/people/>
SELECT ?x
WHERE{ ?x rdf:type bill:HouseBill ;
    bill:cosponsor people:A000358 . }
```

In this example, the SELECT query is URL-encoded and then sent as form-encoded data:

```
curl -X POST --anyauth --user admin:password -H \
-H "Accept:application/sparql-results+xml" -d \
"query=PREFIX%20rdf%3A%20%3Chttp%3A%2F%2Fwww.w3.org%2F1999%2F02%2F22-r
df-syntax-ns%23%3E%20%0APREFIX%20bill%3A%20%3Chttp%3A%2F%2Fwww.rdfabou
t.com%2Frdf%2Fschema%2Fusbill%2F%3E%0APREFIX%20people%3A%20%3Chttp%3A%
2F%2Fwww.rdfabout.com%2Frdf%2Fusgov%2Fcongress%2Fpeople%2F%3E%0ASELECT
%20%3Fx%20WHERE%20%7B%20%3Fx%20rdf%3Atype%20bill%3AHouseBill%20%3B%20b
ill%3Acosponsor%20%20people%3AA000358.%20%7D%0A" -H
"Content-type:application/x-www-form-urlencoded"

=>

<sparql xmlns="http://www.w3.org/2005/sparql-results#">
   <head><variable name="x"/></head>
  <results>
    <result><binding name="x">
     <uri>http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1036
     </uri></binding></result>
    <result><binding name="x">
     <uri>http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1057
     </uri></binding></result>
    <result><binding name="x">
     <uri>http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1078
     </uri></binding></result>
    <result><binding name="x">
     <uri>http://www.rdfabout.com/rdf/usgov/congress/108/bills/h110
     </uri></binding></result>
    <result><binding name="x">
     <uri>http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1117
     </uri></binding></result>
    <result><binding name="x">
     <uri>http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1153
     </uri></binding></result>
.......
    <result><binding name="x">
     <uri>http://www.rdfabout.com/rdf/usgov/congress/108/bills/h975
     </uri></binding></result>
  </results>
</sparql>
```

Note: For aesthetic reasons, the long command line is broken into multiple lines using the Unix line continuation character '\'. Extra line breaks have ben inserted for readability of the URL-encoded query. To execute this example, remove the line continuation characters and remove the extra line breaks.

5.3.4 SPARQL DESCRIBE Query in GET Requests

The SPARQL query in the query request parameter must be URL-encoded. In this example, `curl` sends an HTTP `GET` request to execute a SPARQL `DESCRIBE` query for a US Congress bill (44):

```
curl -X GET --digest --user "admin:password" \
   -H "accept: application/sparql-results+xml" \
   "http://localhost:8050/v1/graphs/sparql?query=PREFIX%20rdf%3A%20%3C
   http%3A%2F%2Fwww.w3.org%2F1999%2F02%2F22-rdf-syntax-ns%23%3E%20%0A
   PREFIX%20bill%3A%20%3Chttp%3A%2F%2Fwww.rdfabout.com%2Frdf%2Fschema
   %2Fusbill%2F%3E%0ADESCRIBE%20%3Fx%20WHERE%20%7B%20%3Fx%20rdf%3Atype
   %20bill%3AHouseBill%20%3B%20%20bill%3Anumber%20%2244%22%20.%20%7D"
```

Your results should resemble these triples:

```
<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>
<http://purl.org/dc/elements/1.1/title> "H.R. 108/44: Investment Tax
Incentive Act of 2003" .

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>
<http://purl.org/dc/terms/created> "2003-01-07" .

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>
<http://purl.org/ontology/bibo/shortTitle> "H.R. 44: Investment Tax
Incentive Act of 2003" .

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>
<http://www.rdfabout.com/rdf/schema/usbill/congress> "108" .

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>
<http://www.rdfabout.com/rdf/schema/usbill/cosponsor>
<http://www.rdfabout.com/rdf/usgov/congress/people/A000358> .

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>
<http://www.rdfabout.com/rdf/schema/usbill/cosponsor>
<http://www.rdfabout.com/rdf/usgov/congress/people/B000208> .

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>
<http://www.rdfabout.com/rdf/schema/usbill/cosponsor>
<http://www.rdfabout.com/rdf/usgov/congress/people/B000575> .
```

The triples describe information about bill 44 in the U.S. Congress; it’s title, when it was created, who cosponsored the bill, and so on.

5.3.5 Supported Verbs

These verbs are supported for requests to the SPARQL endpoint:

Verb	Description	Role
`GET`	Perform a query based on URL-encoded SPARQL. Retrieves a named graph.	rest-reader
`POST`	Perform a query based on a SPARQL query as a parameter or a SPARQL query URL-encoded as part of the `POST` body.	rest-reader
`PUT`	Create or replace triples in a named graph or the default graph. Using PUT with an empty graph will delete the graph.	rest-writer
`DELETE`	Remove triples in a named graph or the default graph.	rest-writer
`HEAD`	Retrieve the named graph with no content	rest-reader

5.3.6 Response Output Formats

When you query the SPARQL endpoint with REST APIs (`GET:/v1/graphs/sparql` or `POST:/v1/graphs/sparql`), the result output format can vary. The response type format depends on the type of query and the parameters used for the Accept Header Type in the REST request. The Accept Header Type sets the expected MIME type for the response output. This table describes the Accept Header Types and the Response Output formats for different SPARQL queries.

Query Type	Response Headers	Response Output
`SELECT`	`application/sparql-results+xml`	Returns the results as XML, as defined in W3C specification. See “Example: Returning Results as XML” on page 117.
`SELECT`	`application/sparql-results+json`	Returns the results as JSON, as defined in W3C specification. See “Example: Returning Results as JSON” on page 118.

Query Type	Response Headers	Response Output
SELECT	text/html	Returns the results as HTML. See "Example: Returning Results as HTML" on page 119.
CONSTRUCT	application/sparql-results+xml or application/sparql-results+json	Returns the results in XML or JSON, as triples in any of the supported formats. See "Supported RDF Triple Serializations" on page 34.
DESCRIBE	application/rdf+xml	Returns the results in XML as triples. See "SPARQL DESCRIBE Query in GET Requests" on page 114.
ASK	application/sparql-results+xml or application/sparql-results+json	Returns a boolen (true or false) as JSON or XML. See "Example: Returning a Boolean as XML or JSON" on page 120.

A SPARQL SELECT query can return results as XML, JSON, or HTML, while a SPARQL CONSTRUCT query returns the results as triples in any of the supported triples formats. A SPARQL DESCRIBE query returns triples in XML format describing the triples found by the query. Using SPARQL ASK query will return a boolean (true or false).

The following examples use this SPARQL SELECT query to find US Congress bills that were sponsored by Robert Andrews ("A000210"). The query is saved as bills.sparql with the results limited to five bills.

Here is the file:

```
#filename bills.sparql
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX bill: <http://www.rdfabout.com/rdf/schema/usbill/>
PREFIX people: <http://www.rdfabout.com/rdf/usgov/congress/people/>
PREFIX dc: <http://purl.org/dc/elements/1.1/>

SELECT  ?bill ?title
WHERE { ?bill rdf:type bill:HouseBill ;
           dc:title ?title ;
           bill:sponsor people:A000210 .
    }
    LIMIT 5
```

5.3.6.1 Example: Returning Results as XML

The SPARQL SELECT query returns the response in XML format in this example:

```
curl --anyauth --user admin:password -i -X POST \
--data-binary @./bills.sparql \
-H "Content-type: application/sparql-query" \
-H "Accept: application/sparql-results+xml" \
http://localhost:8050/v1/graphs/sparql

=>

HTTP/1.1 200 OK
Content-type: application/sparql-results+xml
Server: MarkLogic
Content-Length: 1528
Connection: Keep-Alive
Keep-Alive: timeout=5

<sparql xmlns="http://www.w3.org/2005/sparql-results#">
 <head><variable name="bill"/>
       <variable name="title"/>
 </head>
 <results>
   <result>
     <binding name="bill">
      <uri>http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1171
      /uri>
     </binding><binding name="title">
       <literal datatype="http://www.w3.org/2001/XMLSchema#string">
       H.R. 108/1171: Iris Scan Security Act of 2003
       </literal>
     </binding>
   </result>
   <result>
     <bindingname="bill">
      <uri>http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1314
      </uri></binding><binding name="title">
      <literal datatype="http://www.w3.org/2001/XMLSchema#string">
      H.R. 108/1314: Screening Mammography Act of 2003</literal>
     </binding>
   </result>
   <result>
     <binding name="bill"><uri>http://www.rdfabout.com/rdf/usgov
     /congress/108/bills/h1384</uri>
     </binding>
...
   </result>
 </results>
</sparql>
```

5.3.6.2 Example: Returning Results as JSON

The SPARQL `SELECT` query returns the response in JSON format in this example:

```
curl --anyauth --user admin:password -i -X POST \
--data-binary @./bills.sparql \
-H "Content-type: application/sparql-query" \
-H "Accept: application/sparql-results+json" \
http://localhost:8050/v1/graphs/sparql

=>

HTTP/1.1 200 OK
Content-type: application/sparql-results+json
Server: MarkLogic
Content-Length: 1354
Connection: Keep-Alive
Keep-Alive: timeout=5

{"head":{"vars":["bill","title"]},
"results":{"bindings":[
   {"bill":{"type":"uri",
   "value":"http:\/\/www.rdfabout.com\/rdf\/usgov\/congress\/108\/
            bills\/h1171"},
   "title":{"type":"literal", "value":"H.R. 108\/1171: Iris Scan
            Security Act of 2003",
   "datatype":"http:\/\/www.w3.org\/2001\/XMLSchema#string"}},
   {"bill":{"type":"uri",
   "value":"http:\/\/www.rdfabout.com\/rdf\/usgov\/congress\/108\/
            bills\/h1314"},
   "title":{"type":"literal", "value":"H.R. 108\/1314: Screening
            Mammography Act of 2003",
   "datatype":"http:\/\/www.w3.org\/2001\/XMLSchema#string"}},
   {"bill":{"type":"uri",
   "value":"http:\/\/www.rdfabout.com\/rdf\/usgov\/congress\/108\/
            bills\/h1384"},
   "title":{"type":"literal", "value":"H.R. 108\/1384: To amend the
            Railroad Retirement Act of 1974 to eliminate a limitation
            on benefits.",
   "datatype":"http:\/\/www.w3.org\/2001\/XMLSchema#string"}},
   {"bill":{"type":"uri",
   "value":"http:\/\/www.rdfabout.com\/rdf\/usgov\/congress\/108\/
            bills\/h1418"},
   "title":{"type":"literal", "value":"H.R. 108\/1418: Veterans'
            Housing Equity Act",
   "datatype":"http:\/\/www.w3.org\/2001\/XMLSchema#string"}},
...
}]}}
```

5.3.6.3 Example: Returning Results as HTML

The same SPARQL SELECT query returns the response in HTML format in this example:

```
curl --anyauth --user admin:password -i \
-X POST --data-binary @./bills.sparql \
-H "Content-type: application/sparql-query" \
-H "Accept: text/html" http://localhost:8050/v1/graphs/sparql

=>

HTTP/1.1 200 OK
Content-type: text/html; charset=UTF-8
Server: MarkLogic
Content-Length: 1448
Connection: Keep-Alive
Keep-Alive: timeout=5

<html xmlns="http://www.w3.org/1999/xhtml">
  <head>
    <title>SPARQL results</title>
  </head>
  <body><table border="1"><tr>
    <th>bill</th>
    <th>title</th>
        </tr><tr>
          <td><ahref="/v1/graphs/things?iri=http%3a//www.rdfabout.com/
          rdf/usgov/congress/108/bills/h1171">http://www.rdfabout.com/
          rdf/usgov/congress/108/bills/h1171</a>
          </td>
          <td>H.R. 108/1171: Iris Scan Security Act of 2003</td>
        </tr><tr>
          <td><ahref="/v1/graphs/things?iri=http%3a//www.rdfabout.com/
          rdf/usgov/congress/108/bills/h1314">http://www.rdfabout.com/
          rdf/usgov/congress/108/bills/h1314</a>
          </td>
          <td>H.R. 108/1314: Screening Mammography Act of 2003</td>
        </tr><tr>
          <td><ahref="/v1/graphs/things?iri=http%3a//www.rdfabout.com/
          rdf/usgov/congress/108/bills/h1384">http://www.rdfabout.com/
          rdf/usgov/congress/108/bills/h1384</a>
          </td>
          <td>H.R. 108/1384: To amend the Railroad Retirement Act of
          1974 to eliminate a limitation on benefits.
          </td>
        </tr>
...
</table>
  </body>
</html>
```

5.3.6.4 Example: Returning a Boolean as XML or JSON

In this example, a SPARQL ASK query (from an earlier example) is used to determine whether Carolyn was born after Eunice.

Here is the file:

```
#file: ask-sparql.sparql
PREFIX db: <http://dbpedia.org/resource/>
PREFIX onto: <http://dbpedia.org/ontology/>
ASK
{
    db:Carolyn_Bessette-Kennedy onto:birthDate ?by .
    db:Eunice_Kennedy_Shriver onto:birthDate ?bd .
    FILTER (?by>?bd).
}
```

The SPARQL ASK query returns the boolean result as XML:

```
curl --anyauth --user user:password -i -X POST \
--data-binary @./ask-sparql.sparql \
-H "Content-type: application/sparql-query" \
-H "Accept: application/sparql-results+xml" \
http://localhost:8050/v1/graphs/sparql

=>

HTTP/1.1 200 OK
Content-type: application/sparql-results+xml
Server: MarkLogic
Content-Length: 89
Connection: Keep-Alive
Keep-Alive: timeout=5<sparql

<xmlns="http://www.w3.org/2005/sparql-results#">
<boolean>true</boolean>
</sparql>
```

Here is the same SPARQL ASK query with the boolean result returned as JSON:

```
curl --anyauth --user user:password -i -X POST \
--data-binary @./ask-sparql.sparql \
-H "Content-type: application/sparql-query" \
-H "Accept: application/sparql-results+json" \
http://localhost:8050/v1/graphs/sparql

=>

HTTP/1.1 200 OK
Content-type: application/sparql-results+json
Server: MarkLogic
Content-Length: 17
Connection: Keep-Alive
Keep-Alive: timeout=5

{"boolean":true}
```

5.3.6.5 Unsupported Serialization

A GET request for a response in an unsupported format yields a “406 Not Acceptable” error. If the SPARQL payload fails to parse, the response yields a “400 Bad Request” error.

For example:

```
<rapi:error xmlns:rapi="http://marklogic.com/rest-api">
  <rapi:status-code>400</rapi:status-code>
  <rapi:status>Bad Request</rapi:status>
  <rapi:message-code>RESTAPI-INVALIDCONTENT</rapi:message-code>
  <rapi:message>RESTAPI-INVALIDCONTENT: (err:FOER0000) Invalid
content:
  Unexpected Payload: c:\space\example.ttl</rapi:message>
</rapi:error>
```

5.3.7 Exploring Triples with REST API

The following endpoint provides RESTful access to knowledge (things) referred to in the database:

```
http://hostname:port/v1/graphs/things?
```

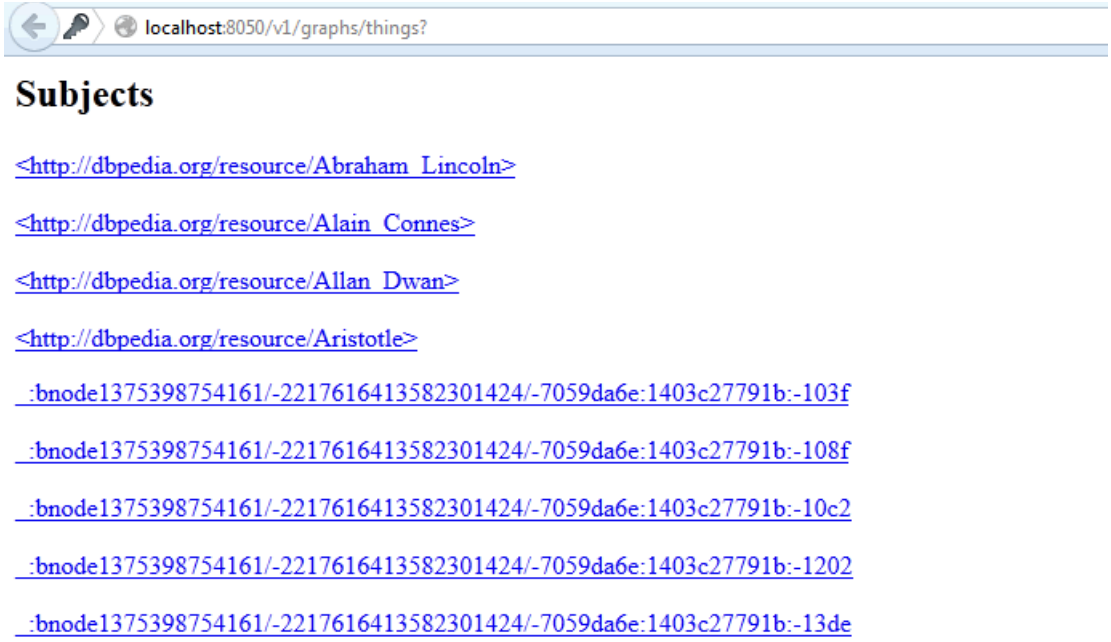
where the *hostname* and *port* are the host and port on which you are running MarkLogic.

For example:

```
http://localhost:8050/v1/graphs/things?
```

When this endpoint is called with no parameters, a list of subject nodes in the database is returned for all triples in the database.

This example shows the response in a Web browser:



Note: This endpoint has a hard-coded limit of 10,000 items to display, and does not support pagination.

You can traverse and navigate the triples in the database by drilling down the nodes.

For example, clicking on an IRI may return one or more related triples:

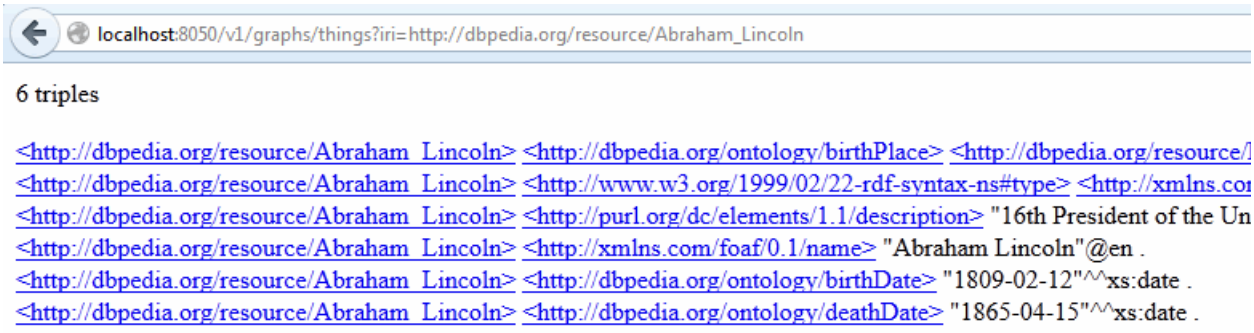


You can use an optional `iri` parameter to specify particular IRIs about which to return information, in Turtle triple format.

For example:

```
http://localhost:8050/v1/graphs/things?iri=http://dbpedia.org/resource
/Abraham_Lincoln
```

The nodes selected by the IRI `http://dbpedia.org/resources/Abraham_Lincoln` are returned in Turtle format:



If you are using `curl` or an equivalent command-line tool for issuing HTTP requests, you can add the following `accept` in the request header:

- text/html when no parameters are specified.
- MIME types when the `iri` parameter is used. See “Supported RDF Triple Serializations” on page 34.

Note: For this endpoint, `GET` is the only supported verb, which requires that you have the rest-reader privilege in order to return the requested information.

In this example, the `GET` request returns the nodes selected by the given `iri` parameter in Turtle triple format:

```
curl --anyauth --user admin:password -i -X GET \
-H "Accept: text/turtle" \
http://localhost:8051/v1/graphs/things?iri=http://dbpedia.org/ \
resource/Aristotle

=>

HTTP/1.1 200 OK
Content-type: text/turtle; charset=UTF-8
Server: MarkLogic
Content-Length: 628
Connection: Keep-Alive
Keep-Alive: timeout=5
```

```
@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Aristotle>
<http://dbpedia.org/ontology/deathPlace>
 <http://dbpedia.org/resource/Chalcis> .
<http://dbpedia.org/resource/Aristotle>
<http://dbpedia.org/ontology/birthPlace>
 <http://dbpedia.org/resource/Stagira_(ancient_city)> .
<http://dbpedia.org/resource/Aristotle>
<http://www.w3.org/1999/02/22-rdf-syntax
-ns#type> <http://xmlns.com/foaf/0.1/Person> .
<http://dbpedia.org/resource/Aristotle>
<http://xmlns.com/foaf/0.1/name>
"Aristotle" .
<http://dbpedia.org/resource/Aristotle>
<http://purl.org/dc/elements/1.1/description>
"Greek philosopher" .
```

Note: If a given IRI does not exist, the response is “404 Not Found”. A `GET` request for a response in an unsupported format will yield “406 Not Acceptable”.

5.4 Security

The triple index, `cts:triples`, and `sem:sparql` queries will only return triples from documents which the database user has permission to read.

Named graphs inherit the write protection settings available to collections.

Task	Privilege
Executing `sem:sparql`	http://marklogic.com/xdmp/privileges/sem-sparql

For more information about MarkLogic security, see Document Permissions in the *Understanding and Using Security Guide*.

6.0 XQuery Semantics API

This chapter describes the XQuery Semantics API, which includes an XQuery library module, built-in semantics functions, and support for SPARQL and RDF. The Semantics API is designed for large-scale, production triplestores and applications. The complete list of semantic functions can be found at docs.marklogic.com.

This chapter includes examples of using the Semantics API, which is an API designed to create, query, update, and delete triples and graphs in MarkLogic.

Additionally, the following APIs support the MarkLogic semantic features; XQuery API, REST API, and Java API, using a variety of query styles, as described in the Loading Triples, Semantic Queries and Updating and Deleting Triples chapters of this guide.

This chapter includes the following sections:

- XQuery Library Module
- Generating Triples
- Extracting Triples from Content
- Parsing Triples
- Exploring Data

6.1 XQuery Library Module

Some of the semantics XQuery functions are built-in functions that do not require an import statement, while others are implemented in a library module that does require an import statement. To simplify things, MarkLogic recommends that you import the Semantics API library into every XQuery module that uses the Semantics API.

You can use the Semantics API library module by importing the module into your XQuery module with the following prolog statement:

```
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";
```

The prefix for all semantic XQuery functions is `http://marklogic.com/semantics`. The Semantics API uses the prefix `sem:`, which is defined in the server. For details about the function signatures and descriptions, see the Semantics documentation under XQuery Library Modules in the *XQuery and XSLT Reference Guide* and the *MarkLogic XQuery and XSLT Function Reference*.

Note: Semantics is a separately licensed product: you need a valid semantics license key to use semantics.

6.2 Generating Triples

The `sem:rdf-builder` function is a powerful tool for dynamically generating triples in the Semantics API.

The function builds triples from the CURIE and blank node syntaxes. Blank nodes specified with a leading underscore (_) are assigned blank node identifiers, and maintain state across multiple invocations; for example, "`_:person1`" refers to the same node as a later invocation that also mentions "`_:person1`". For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

 let $builder := sem:rdf-builder((), sem:iri("my-named-graph"))
 let $t1 := $builder("_:person1", "a", "foaf:Person")
 let $t2 := $builder("_:person2", "a", "foaf:Person")
 let $t3 := $builder("_:person1", "foaf:knows", "_:person2")
 return ($t1,$t2,$t3)

=>

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .

<http://marklogic.com/semantics/blank/4892021155019117627>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://xmlns.com/foaf/0.1/Person> .

<http://marklogic.com/semantics/blank/6695700652332466909>
        <http://xmlns.com/foaf/0.1/knows>
        _:bnode4892021155019117627 ;
        <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
        <http://xmlns.com/foaf/0.1/Person> .
```

In the example, there are three triples generated in Turtle format using `sem:rdf-builder`. The triples represent the following facts; that person1 and person2 are people, and that their relationship is that person1 knows person2.

Note the following:

- The first parameter accepts an optional set of prefix mappings, which in this example is an empty argument. Since “empty” means default, the `$common-prefixes` are used for the first argument. The second argument is a named graph for the `sem:rdf-builder` output.
- In the predicate position, the special value of `"a"` is expanded to the full IRI for `rdf:type`.
- Human-readable CURIEs for common prefixes are used, such as `foaf:knows` instead of long IRIs. See “Working with CURIEs” on page 103.
- The blank nodes produced in the third triple match the identity of those defined in the first and second.

6.3 Extracting Triples from Content

With the `sem:rdf-builder` function you can easily extract triples from existing content or the results of a SPARQL query and quickly construct RDF graphs for querying or inserting into your database.

Assume that you have a web page that lists cities and countries that are sorted and ranked by the cost of living (COL), which is based on a Consumer Priced Index (CPI) and CPI-based inflation rate. The inflation rate is defined as the annual percent change in consumer prices compared with the previous year's consumer prices. Using a reference point of Monterrey, Mexico with an assigned a value of 100, the `Inflation` value of every other city in the database is calculated by comparing their COL to that of Monterrey. For example, an `Inflation` value of 150, means that the COL is 50% more expensive than living in Monterrey.

Ranking	City	Inflation *	Ranking	City	Inflation *
1	London (United Kingdom)	270	71	Minneapolis (United States)	134
2	Stockholm (Sweden)	266	72	Turin (Italy)	134
3	Zurich (Switzerland)	251	73	Shanghai (China)	133
4	Geneva (Switzerland)	247	74	Ljubljana (Slovenia)	132
5	New York City (United States)	225	75	Orlando (United States)	129
6	Singapore (Singapore)	219	76	Saint Petersburg (Russia)	125
7	San Francisco (United States)	209	77	Austin (United States)	125
8	Paris (France)	208	78	Phoenix (United States)	123
9	Sydney (Australia)	205	79	Almaty (Kazakhstan)	121
10	Brisbane (Australia)	203	80	Salt Lake City (United States)	120
11	Copenhagen (Denmark)	202	81	Beijing (China)	120
12	Oslo (Norway)	201	82	Lisbon (Portugal)	120
13	Tokyo (Japan)	200	83	Santiago (Chile)	120
14	Hong Kong (Hong Kong)	200	84	Montevideo (Uruguay)	119
15	Perth (Australia)	198	85	Belo Horizonte (Brazil)	116
16	Melbourne (Australia)	190	86	Brasília (Brazil)	116
17	Amsterdam (Netherlands)	189	87	Valencia (Spain)	116
18	Wellington (New Zealand)	186	88	Kansas City (United States)	116
19	Washington D.C. (United States)	185	89	Raleigh, North Carolina (United States)	115
20	Helsinki (Finland)	182	90	Istanbul (Turkey)	114
21	Dublin (Ireland)	182	91	Bangkok (Thailand)	114
22	Boston (United States)	174	92	Bogotá (Colombia)	111
23	Frankfurt am Main (Germany)	172	93	Zagreb (Croatia)	109
24	Toronto (Canada)	170	94	Oporto (Portugal)	108
25	Munich (Germany)	168	95	Taipei (Taiwan)	108
26	Manchester (United Kingdom)	166	96	Amman (Jordan)	107
27	Vancouver (Canada)	165	97	Curitiba (Brazil)	107
28	Tel Aviv (Israel)	165	98	Porto Alegre (Brazil)	107
29	Malmo (Sweden)	165	99	Kuala Lumpur (Malaysia)	105
30	Calgary (Canada)	164	100	Johannesburg (South Africa)	103

Note: These values are fictional and are not based on any official sources.

The underlying HTML code for the COL table may resemble the following:

```
<table class="city-index"
style="max-width:58%;float:left;margin-right:2em;">
    <thead>
        <tr>
            <th>Ranking</th>
            <th class="city-name">City</th>
            <th class="inflation">Inflation
            <a href="#inflation-explanation">*</a></th>
        </tr>
    </thead>

           <tbody><tr>
              <td class="ranking">1</td>
              <td class="city-name">
              <a href="http://www.example.org/IncreasedCoL/london">
              London (United Kingdom)</a></td>
              <td class="inflation">270</td>
             </tr>

             <tr>
              <td class="ranking">2</td>
              <td class="city-name">
              <a href="http://www.example.org/IncreasedCoL/stockholm">
              Stockholm (Sweden)</a></td>
              <td class="inflation">266</td>
             </tr>

             <tr>
              <td class="ranking">3</td>
              <td class="city-name">
              <a href="http://www.example.org/IncreasedCoL/zurich">
              Zurich (Switzerland)</a></td>
              <td class="inflation">251</td>
             </tr>

             <tr>
              <td class="ranking">4</td>
              <td class="city-name">
              <a href="http://www.example.org/IncreasedCoL/geneva">
              Geneva (Switzerland)</a></td>
              <td class="inflation">247</td>
             </tr>

             <tr>
              <td class="ranking">5</td>
              <td class="city-name">
              <ahref="http://www.example.org/IncreasedCoL/new-york">
              New York City (United States)</a></td>
              <td class="inflation">225</td>
             </tr>
```

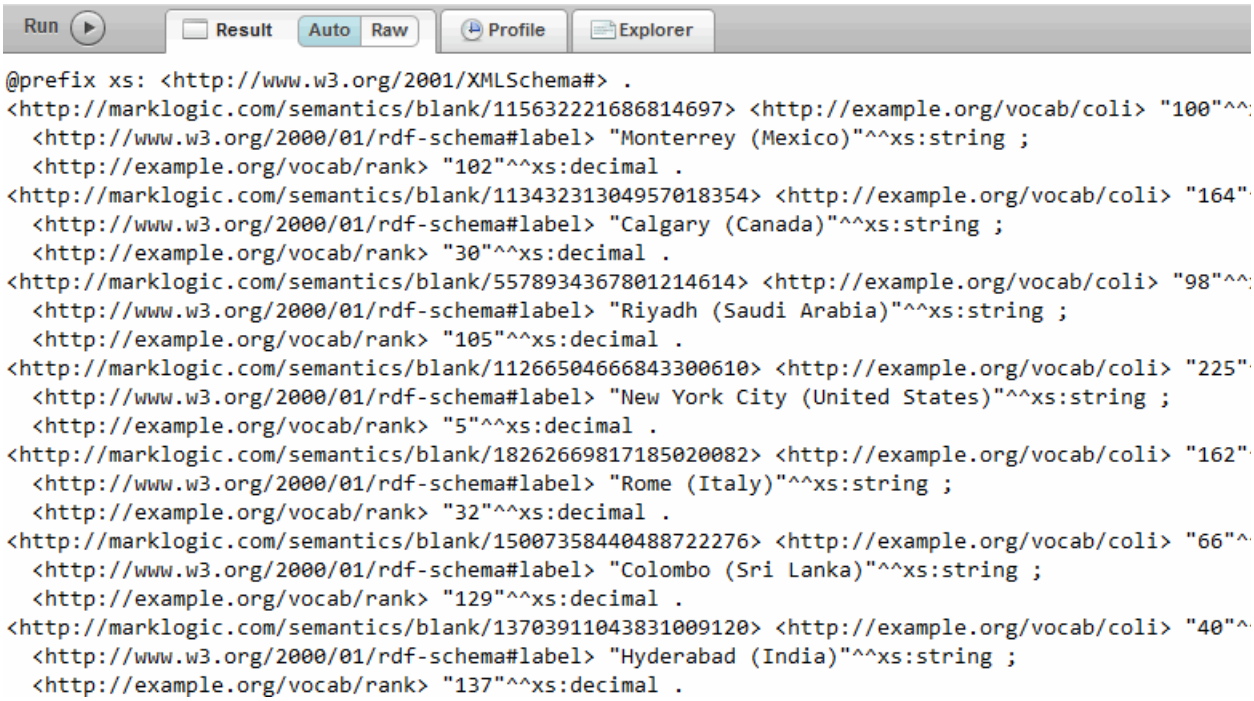
This example uses the `sem:rdf-builder` function to extract triples from the HTML content. The function takes advantage of the fact that the HTML code is already well-formed and has a useful classification node (`@class`):

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";
declare namespace html="http://www.w3.org/1999/xhtml";

let $doc := xdmp:tidy(xdmp:document-get("C:\Temp\CoLIndex.html",
      <options xmlns="xdmp:document-get">
        <repair>none</repair>
        <format>text</format>
      </options>))[2]

let $rows := ($doc//html:tr)[html:td/@class eq 'ranking']
let $builder := sem:rdf-builder
                (sem:prefixes("my: http://example.org/vocab/"))
for $row in $rows
let $bnode-name := "_:" || $row/html:td[@class eq 'ranking']
return (
        $builder($bnode-name, "my:rank", xs:decimal(
                $row/html:td[@class eq 'ranking'] )),
        $builder($bnode-name, "rdfs:label", xs:string(
                $row/html:td[@class eq 'city-name'] )),
        $builder($bnode-name, "my:coli", xs:decimal(
                $row/html:td[@class eq 'inflation'] ))
        )
```

The results are returned as in-memory triples:



6.4 Parsing Triples

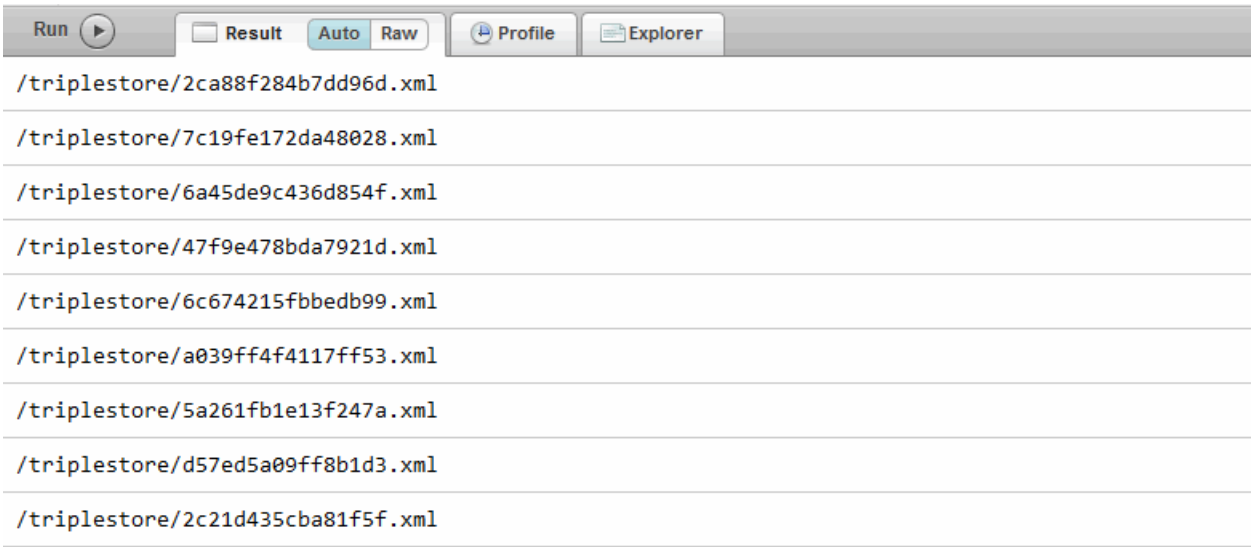
This example extends the previous example and inserts parsed triples into the database by using the `sem:rdf-insert` function:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";
declare namespace html="http://www.w3.org/1999/xhtml";

let $doc := xdmp:tidy(xdmp:document-get("C:\Temp\CoLIndex.html",
      <options xmlns="xdmp:document-get">
        <repair>none</repair>
        <format>text</format>
      </options>))[2]

let $rows := ($doc//html:tr)[html:td/@class eq 'ranking']
let $builder := sem:rdf-builder(
                  sem:prefixes("my: http://example.org/vocab/"))
for $row in $rows
let $bnode-name := "_:" || $row/html:td[@class eq 'ranking']
let $triples := $row
return (sem:rdf-insert((
      $builder($bnode-name, "my:rank", xs:decimal
            ( $row/html:td[@class eq 'ranking'] )),
      $builder($bnode-name, "rdfs:label", xs:string
            ( $row/html:td[@class eq 'city-name'] )),
      $builder($bnode-name, "my:coli", xs:decimal
            ( $row/html:td[@class eq 'inflation'] )))
))
```

The document IRIs are returned as strings:

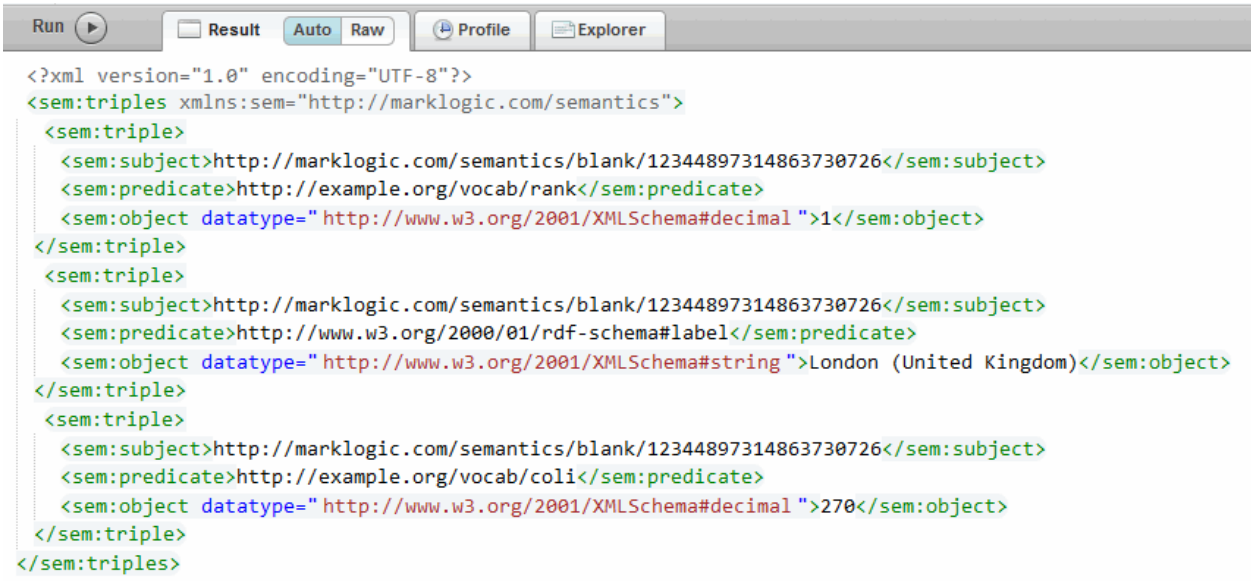


Note: For more information about inserting and parsing triples with XQuery, see "Loading Triples with XQuery" on page 45.

The parser ensures well-formed markup as the triples are inserted as schema-valid triples and indexed with the Triples index, provided it is enabled. See “Enabling the Triple Index” on page 57.

Use `fn:doc` to view the contents of the documents and verify the triples.

```
fn:doc("/triplestore/2ca88f284b7dd96d.xml")
```



One document is created for each blank node identifier (`$bnode-name`).

> **Note:** During the generation process `$builder` maintains state eliminating the need to keep track of every blank node label and ensuring that they map to the same `sem:blank` value.

The Semantics API includes a repair option for the N-Quad and Turtle parsers. During a normal operation, the RDF parsers perform these tasks:

- Turtle parsing uses the base IRI to resolve relative IRIs. If the result is relative, an error is raised.
- N-Quad parsing does not resolve using the base IRI. If a IRI in the document is relative, an error is raised.

During a repair operation the RDF parsers perform this task:

- Turtle parsing uses the base IRI to resolve relative IRIs. No error is raised for resultant relative IRIs.
- N-Quad parsing also uses the base IRI to resolve relative IRIs. No error is raised for resultant relative IRIs.

6.5 Exploring Data

The Semantics API provides a number of functions to access RDF data in a database. This section focuses on the following topics:

- sem:triple Functions
- sem:transitive-closure

6.5.1 sem:triple Functions

This table describes the `sem:triple` functions used to define or search for triple data:

Function	Description
`sem:triple`	Creates a triple object that represents an RDF triple containing atomic values representing the subject, predicate, object, and optionally a graph identifier (graph IRI)
`sem:triple-subject`	Returns the subject from a `sem:triple` value
`sem:triple-predicate`	Returns the predicate from a `sem:triple` value
`sem:triple-object`	Returns the object from a `sem:triple` value
`sem:triple-graph`	Returns the graph identifier (graph IRI) from a `sem:triple` value

In this example, the `sem:triple` function is used to create a triple that includes a CURIE for the predicate and an `rdf:langString` value as the object, with English (`en`) as the given language tag:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";
declare namespace html="http://www.w3.org/1999/xhtml";

sem:triple(sem:iri("http://id.loc.gov/authorities/subjects/sh85040989"
),
sem:curie-expand("skos:prefLabel"), rdf:langString("Education", "en"))

=>
@prefix xs: <http://www.w3.org/2001/XMLSchema#> .

<http://id.loc.gov/authorities/subjects/sh85040989>
<http://www.w3.org/2004/02/skos/core#prefLabel>
"Education"@en .
```

6.5.2 sem:transitive-closure

Use the `sem:transitive-closure` function to traverse RDF graphs in order to answer reachability questions and discover more information about your RDF data. For example, you can find out which nodes are reachable from a given node.

You can use a vocabulary such the Simple Knowledge Organization System (SKOS) with the `sem:transitive-closure` function. SKOS is "a common data model for knowledge organization systems such as thesauri, classification schemes, subject heading systems and taxonomies" as described by the W3C SKOS Simple Knowledge Organization System Reference:

http://www.w3.org/TR/skos-reference/

Assume that you have a file composed of triples for subject headings that relate to US Congress bills and that the triples are marked up with the SKOS vocabulary. The triples may look similar to this extract:

```
<http://id.loc.gov/authorities/subjects/sh85002310>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://www.w3.org/2004/02/skos/core#Concept> .

<http://id.loc.gov/authorities/subjects/sh85002310>
<http://www.w3.org/2004/02/skos/core#prefLabel>
"Agricultural education"@en .

<http://id.loc.gov/authorities/subjects/sh85002310>
<http://www.w3.org/2008/05/skos-xl#altLabel>
_:bnode7authoritiessubjectssh85002310 .

_:bnode7authoritiessubjectssh85002310
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://www.w3.org/2008/05/skos-xl#Label> .

_:bnode7authoritiessubjectssh85002310
<http://www.w3.org/2008/05/skos-xl#literalForm>
"Education, Agricultural"@en .

<http://id.loc.gov/authorities/subjects/sh85002310>
<http://www.w3.org/2004/02/skos/core#broader>
<http://id.loc.gov/authorities/subjects/sh85133121> .

<http://id.loc.gov/authorities/subjects/sh85002310>
<http://www.w3.org/2004/02/skos/core#narrower>
<http://id.loc.gov/authorities/subjects/sh85118332> .

<http://id.loc.gov/authorities/subjects/sh85133121>
<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>
<http://www.w3.org/2004/02/skos/core#Concept> .

<http://id.loc.gov/authorities/subjects/sh85133121>
<http://www.w3.org/2004/02/skos/core#prefLabel>
"Technical education"@en .
```

In this dataset, “Technical education” is a broader subject heading for “Agricultural education” as defined by the `skos:broader` predicate:

```
<http://id.loc.gov/authorities/subjects/sh85002310>
<http://www.w3.org/2004/02/skos/core#broader>
<http://id.loc.gov/authorities/subjects/sh85133121> .
```

Note: Although `skos:broader` is not stictly transitive, it is a sub-property of `skos:broaderTransitive`, which is a transitive.

```
<sem:triple>
  <sem:subject>http://id.loc.gov/authorities/subjects/sh85002310</sem:subject>
  <sem:predicate>http://www.w3.org/1999/02/22-rdf-syntax-ns#type</sem:predicate>
  <sem:object>http://www.w3.org/2004/02/skos/core#Concept</sem:object>
</sem:triple>
<sem:triple>
  <sem:subject>http://id.loc.gov/authorities/subjects/sh85002310</sem:subject>
  <sem:predicate>http://www.w3.org/2004/02/skos/core#prefLabel</sem:predicate>
  <sem:object xml:lang="en">Agricultural education</sem:object>
</sem:triple>
<sem:triple>
  <sem:subject>http://id.loc.gov/authorities/subjects/sh85002310</sem:subject>
  <sem:predicate>http://www.w3.org/2008/05/skos-xl#altLabel</sem:predicate>
  <sem:object>http://marklogic.com/semantics/blank/17142585114552908287</sem:object>
</sem:triple>
<sem:triple>
  <sem:subject>http://marklogic.com/semantics/blank/17142585114552908287</sem:subject>
  <sem:predicate>http://www.w3.org/1999/02/22-rdf-syntax-ns#type</sem:predicate>
  <sem:object>http://www.w3.org/2008/05/skos-xl#Label</sem:object>
</sem:triple>
<sem:triple>
  <sem:subject>http://marklogic.com/semantics/blank/17142585114552908287</sem:subject>
  <sem:predicate>http://www.w3.org/2008/05/skos-xl#literalForm</sem:predicate>
  <sem:object xml:lang="en">Education, Agricultural</sem:object>
</sem:triple>
<sem:triple>
  <sem:subject>http://id.loc.gov/authorities/subjects/sh85002310</sem:subject>
  <sem:predicate>http://www.w3.org/2004/02/skos/core#broader</sem:predicate>
  <sem:object>http://id.loc.gov/authorities/subjects/sh85133121</sem:object>
</sem:triple>
```

Note: If you load triples into MarkLogic with blank node identifiers, the original `_:bnode` identifiers are replaced with MarkLogic blank node identifiers. For example, `_:bnode7authoritiessubjectssh85002310` in the original dataset becomes `<http://marklogic.com/semantics/blank/17142585114552908287>` on ingestion. This identity is maintained for all triples that are related to the original blank node.

This example uses `cts:triples` to find the subject IRI for a triple where the predicate is a CURIE for `skos:prefLabel` and the object is `Agricultural education`. The subject IRI found in the `cts:triples` query is subsequently used with `skos:broader` to determine broader subject terms to a depth of `3`:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $triple-subject := sem:triple-subject(cts:triples((),
sem:curie-expand("skos:prefLabel"),
rdf:langString("Agricultural education", "en")))
return
sem:transitive-closure($triple-subject,
sem:curie-expand("skos:broader"), 3)

=>
<http://id.loc.gov/authorities/subjects/sh85133121>
<http://id.loc.gov/authorities/subjects/sh85002310>
<http://id.loc.gov/authorities/subjects/sh85026423>
<http://id.loc.gov/authorities/subjects/sh85040989>
```

Notice that in addition to the expected IRIs, for the following subjects:

- `<http://id.loc.gov/authorities/subjects/sh85002310>`
- `<http://id.loc.gov/authorities/subjects/sh85133121>`

IRIs were returned also in the results for the following subjects:

- `<http://id.loc.gov/authorities/subjects/sh85040989>`
- `<http://id.loc.gov/authorities/subjects/sh85026423>`

When we take a closer look at the dataset, the IRIs for “Education” and “Civilization” are also returned, since they are broader subjects still to “Agricultural education” and “Technical Education”:

```
<http://id.loc.gov/authorities/subjects/sh85040989>
<http://www.w3.org/2004/02/skos/core#prefLabel>
"Education"@en .
<http://id.loc.gov/authorities/subjects/sh85040989>
<http://www.w3.org/2004/02/skos/core#broader>
<http://id.loc.gov/authorities/subjects/sh85026423> .
...
<http://id.loc.gov/authorities/subjects/sh85026423>
<http://www.w3.org/2004/02/skos/core#prefLabel>
"Civilization"@en .
...
```

7.0 Updating and Deleting Triples

Triples can be modified with XQuery using MarkLogic `xdmp` build-in functions. To perform "updates" on triples in your datastore, you actually insert a new triple and delete the existing one. You are not updating the existing triples because the update operation is actually an insert/delete.

This chapter includes the following sections:

- Updating Triples
- Deleting Triples

7.1 Updating Triples

You can use XQuery functions to update existing triples in a database by doing an insert/delete (update) to replace nodes.

In this example, the `sem:database-nodes` and the `xdmp:node-replace` functions are used to correct inaccurate data. Let's assume that the data contains a subject node with the resource "André-Marie Ampère" entered as "Andr%C3%A9-Marie_Amp%C3%A8re":

```
<sem:triples xmlns:sem="http://marklogic.com/semantics">
 <sem:subject>http://dbpedia.org/resource/Andr%C3%A9-Marie_Amp%C3%A8re
 </sem:subject>
 <sem:predicate>http://www.w3.org/1999/02/22-rdf-syntax-ns#type
 </sem:predicate>
 <sem:object>http://xmlns.com/foaf/0.1/Person
 </sem:object>
</sem:triples>
```

In this code example, the `sem:rdf-builder` function constructs a triple and passes this to the `sem:database-nodes` function. A new `$replace` triple is created and passed to the `xdmp:node-replace` function.

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/Marklogic/semantics.xqy";

let $builder := sem:rdf-builder(sem:prefixes("dbpedia:
http://dbpedia.org/resource/"))

let $triple := $builder("dbpedia:Andr%C3%A9-Marie_Amp%C3%A8re", "a",
"foaf:Person")

let $node := sem:database-nodes($triple)

let $replace :=
<sem:triple>
<sem:subject>http://dbpedia.org/resource/André-Marie_Ampère
</sem:subject>
{$node[1]/sem:predicate, $node[1]/sem:object}
```

```
</sem:triple>

return $node ! xdmp:node-replace(., $replace);
```

In the example, only the triple bound to the variable `$builder` matches the expression and is updated (replaced).

When you have multiple triples to update, you can use a SPARQL query or XQuery to find matching triples, and then iterate over the nodes to replace them.

In this example, a `cts:triples` call finds all triples with "Andr%C3%A9-Marie_Amp%C3%A8re" in the subject position and updates (replaces) each occurrence:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/Marklogic/semantics.xqy";

let $triples :=
cts:triples(sem:iri("http://dbpedia.org/resource/Andr%C3%A9-Marie_Amp%
C3%A8re"
),()())
for  $triple in  $triples
let $node := sem:database-nodes($triple)
let $replace :=
    <sem:triple>
       <sem:subject>http://dbpedia.org/resource/André-Marie_Ampère
</sem:subject>
       {$node/sem:predicate, $node/sem:object}
    </sem:triple>
return $node ! xdmp:node-replace(., $replace)
```

An empty sequence is returned for both of the examples because the replacements have been made. Use a simple `cts:triples` call to verify that the updates have been made:

```
cts:triples(sem:iri("http://dbpedia.org/resource/
André-Marie_Ampère"),
         ()())
```

Note: Using the `xdmp:node-replace` function results in creating a new fragment and deleting the old fragment. When the system performs a merge, the deleted fragments are removed permanently. The system performs automatic merges, unless this feature has been disabled by an administrator.

7.2 Deleting Triples

This section discusses the principle methods for deleting RDF data in MarkLogic and includes the following topics:

- Deleting Triples with XQuery
- Deleting Triples with REST API

7.2.1 Deleting Triples with XQuery

There are several functions you can use to delete triples from a database. This section discusses the following functions:

- sem:graph-delete
- xdmp:node-delete
- xdmp:document-delete

7.2.1.1 sem:graph-delete

You can use the `sem:graph-delete` function to delete all triples documents in a named graph, that is, triples with a *document root* of `sem:triples`. This function will not work on triples embedded in documents, triples with a *node element* of `sem:triples`.

You specify the graph IRI as the parameter. For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

sem:graph-delete(sem:iri("mynamedgraph"))
```

The following example deletes all triples in the default graph. If no other named graphs exist, this may remove all triples from the database:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

sem:graph-delete(sem:iri("http://marklogic.com/semantics#default-graph
"))
```

Note: The `sem:graph-delete` function will only delete triples inserted by the Graph Store API, which have a document root element of `sem:triples`. A consequence of this is that if you delete a particular named graph, it will not affect documents with embedded triples (with a `sem:triples` element node), so the graph might still exist.

7.2.1.2 xdmp:node-delete

To delete a set of triples from the database, use the `sem:database-nodes` function with `xdmp:node-delete`.

For example:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";

let $triples :=
cts:triples(sem:iri("http://www.rdfabout.com/rdf/usgov/congress/people
/D000596"),()())

for $triple in $triples
return (sem:database-nodes($triple) ! xdmp:node-delete(.))
```

Note: This query will not delete empty `sem:triples` document elements if all the triples are deleted from a single document.

7.2.1.3 xdmp:document-delete

You can remove documents containing triples from the database with the `xdmp:document-delete` function. This function deletes a document and all of its properties. Specify the IRI of the document to be deleted as the parameter.

For example:

```
xquery version "1.0-ml";

xdmp:document-delete("example.xml")
```

Note: The `xdmp:document-delete` function deletes the documents and properties. This document also deletes all the triples embedded in that document. To delete all documents in a directory, use the `xdmp:directory-delete` function.

7.2.2 Deleting Triples with REST API

You can use the REST API to delete triples in the default graph or a named graph by sending a `DELETE` request to the `DELETE:/v1/graphs` service. To delete triples from a named graph, use `curl` to send the DELETE request in the following form:

```
http://<host:port>/<version>/graphs?graph=graph-iri
```

where *`graph-iri`* is the IRI of your named graph.

The IRI for the named graph in the request is `http://<host:port>/<version>/graphs?default`. For example, this `DELETE` request removes all triples from the default graph at port 8321:

```
#Windows users, see Modifying the Example Commands for Windows

$ curl --anyauth --user user:password -X DELETE \
http://localhost:8321/v1/graphs?default
```

Note: Caution should be used when specifying the graph, since there is no confirmation check before deleting the dataset.

This `curl` command will delete the triples in the graph named `mygraph`:

```
#Windows users, see Modifying the Example Commands for Windows

$curl --anyauth --user user:password -X DELETE
http://localhost:8321/v1/graphs?graph=http://marklogic.com/semantics#m
ygraph/
```

As with the `sem:graph-delete` function, the `DELETE` request removes triples from graphs where `sem:triples` is the document root of the containing document. XML documents that contain embedded triples (with an element node of `sem:triples`) are unaffected. Graphs may still exist after the `DELETE` operation if the graph contained both types of documents.

When you send a `PUT` request, triples are replaced in a named graph or added to an empty graph if the graph did not exist. This is the equivalent of a `DELETE` followed by `POST`.

For example:

```
# Windows users, see Modifying the Example Commands for Windows

$ curl --digest --user "admin:password" -s -X PUT
-H "Content-type:text/turtle" -d'@./example.ttl'
    "http://localhost:8033/v1/graphs?graph=mynamed-graph"
```

To perform the equivalent of a `DELETE` operation using the REST API, use `curl` to send a `PUT` request with an empty graph.

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