MarkLogic Server

Semantics Developer’s Guide

MarkLogic 8
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# Semantics Developer’s Guide

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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, SPARQL Update, and JavaScript, XQuery, or REST.

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

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 across the Semantic Web.

SPARQL (SPARQL Protocol and RDF Query Language) is used to query data in RDF serialization. SPARQL Update is used to create, delete, and update (delete/insert) triple data and graphs.

You can derive additional semantic information from your data using inference. You can also 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.

Note: Semantics is a separately licensed product. To use SPARQL features, a license that includes the Semantics Option is required. Use of APIs leveraging Semantics without using SPARQL, such as the Optic API or SQL API, does not require a Semantics Option license.

For more information, see the following resources:

- [http://www.w3.org/standards/semanticweb](http://www.w3.org/standards/semanticweb)
- [http://www.w3.org/RDF](http://www.w3.org/RDF)
- [http://www.w3.org/TR/rdf-sparql-query](http://www.w3.org/TR/rdf-sparql-query)
- [http://www.w3.org/TR/sparql11-update](http://www.w3.org/TR/sparql11-update)

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
1.1 Terminology

Terms used in this guide:

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<td>RDF</td>
<td><strong>RDF (Resource Description Framework)</strong> is a data model used to represent facts as a triple made up of a subject, predicate, and an object. The framework is <strong>W3C</strong> specification with a defined vocabulary.</td>
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<tr>
<td>RDF Triple</td>
<td>An RDF statement containing atomic values representing a subject, predicate, object, and optionally a graph. Each triple represents a single fact.</td>
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<td>Subject</td>
<td>A representation of a resource such as a person or an entity. A node in an graph or triple.</td>
</tr>
<tr>
<td>Predicate</td>
<td>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 <em>arc</em> or <em>edge</em>.</td>
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<tr>
<td>Object</td>
<td>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 17.</td>
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<td>Graph</td>
<td>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 <strong>Named Graphs</strong>.</td>
</tr>
<tr>
<td>Quad</td>
<td>A representation of a subject, predicate, object, and an additional resource node for the context of the triple.</td>
</tr>
<tr>
<td>Vocabularies</td>
<td>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.</td>
</tr>
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<td>Triple Index</td>
<td>An index that indexes triples ingested into MarkLogic to facilitate the execution of SPARQL queries.</td>
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<td>RDF Triple Store</td>
<td>A storage tool for the persistent storage, indexing, and query access to RDF graphs.</td>
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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.

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<td>IRI</td>
<td>An IRI (Internationalized 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.</td>
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<tr>
<td>CURIE</td>
<td>Compact URI Expression.</td>
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<td>SPARQL</td>
<td>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.</td>
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<td>SPARQL Protocol</td>
<td>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).</td>
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<td>SPARQL Update</td>
<td>An update language for RDF graphs that uses a syntax derived from the SPARQL Query language.</td>
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<td>RDFa</td>
<td>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.</td>
</tr>
<tr>
<td>Blank node</td>
<td>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.</td>
</tr>
</tbody>
</table>
For more about Linked Open Data, see [http://linkeddata.org/](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:

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

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” can be derived.

This triple looks like this in XML:

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

In JSON this same triple would look like:

```
{
  "my" : "data",
  "triple" : {
    "subject": "http://xmlns.com/foaf/0.1/name/John Smith",
    "predicate": "http://example.org/livesIn",
    "object": { "value": "London", "datatype": "xs:string" }
  }
}
```

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 16.
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:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Predicate</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Smith</td>
<td>livesWith</td>
<td>Jane Smith</td>
</tr>
<tr>
<td>John Smith</td>
<td>livesIn</td>
<td>London</td>
</tr>
<tr>
<td>London</td>
<td>isIn</td>
<td>England</td>
</tr>
</tbody>
</table>

### 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. For example:

```html
<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/knowns> "Jane Smith".
```

For more examples of RDF formats, see “Example RDF Formats” on page 34.

The triples in this example are stored in MarkLogic as XML documents, 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/knows</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 a element node of sem:triple. You do not need the outer sem:triples element for unmanaged triples, but you do need the subject, predicate, and object elements within the sem:triple element.

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:triple>
        <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:triple>
    </sem:triples>
  </info>
</article>

The loaded triples are automatically indexed with a special-purpose triple index called a 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
{
  ?place <http://example.org/IsIn> "England".
}
```

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

```
xquery version "1.0-mlotec";
import module namespace sem = "http://marklogic.com/semantics" at "/MarkLogic/semantics.xqy";
sem:sparql("PREFIX kennedy:<http://example.org/kennedy>
SELECT *
WHERE
{
  FILTER (regex(?o, 'Joseph', 'i'))
}")
```

For more information about using SPARQL and sem:sparql to query triples, see “Semantic Queries” on page 70.

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-mlotec";
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
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
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/";

crts:search(collection()//sem:triple, cts:or-query(
 cts:triple-range-query(), sem:curie-expand("foaf:name"),
 "Lamar Alexander", ",="),
 ",="))
```

For more information about cts:triples and the cts:triple-range-query queries, see “Semantic Queries” on page 70.

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

For example:

```xquery
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";

define $xml := semi:sparql-results-xml($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 or JavaScript” on page 117.

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:
  
  &lt;http://xmlns.com/foaf/0.1/Person&gt;
  foaf:person

- Literals are strings with an optional language tag or a number. These 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. Blank nodes are 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 18.
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 can be 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](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 a 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 depends on the serialization 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 serialization 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:

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Prefix IRI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cc</td>
<td><a href="http://web.resource.org/cc#ns">http://web.resource.org/cc#ns</a></td>
<td>Creative Commons</td>
</tr>
<tr>
<td>dc</td>
<td><a href="http://purl.org/dc/elements/1.1/">http://purl.org/dc/elements/1.1/</a></td>
<td>Dublin Core vocabulary</td>
</tr>
<tr>
<td>dcterms</td>
<td><a href="http://purl.org/dc/terms">http://purl.org/dc/terms</a></td>
<td>Dublin Core terms</td>
</tr>
<tr>
<td>rdfs</td>
<td><a href="http://www.w3.org/2000/01/rdf-schema#">http://www.w3.org/2000/01/rdf-schema#</a></td>
<td>RDF schema</td>
</tr>
<tr>
<td>rdf</td>
<td><a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#">http://www.w3.org/1999/02/22-rdf-syntax-ns#</a></td>
<td>RDF vocabulary</td>
</tr>
<tr>
<td>owl</td>
<td><a href="http://www.w3.org/2002/07/owl#">http://www.w3.org/2002/07/owl#</a></td>
<td>Web Ontology Language</td>
</tr>
<tr>
<td>foaf</td>
<td><a href="http://xmlns.com/foaf/0.1/">http://xmlns.com/foaf/0.1/</a></td>
<td>FOAF (Friend of a Friend)</td>
</tr>
<tr>
<td>skos</td>
<td><a href="http://www.w3.org/2004/02/skos/core">http://www.w3.org/2004/02/skos/core</a></td>
<td>SKOS (Simple Knowledge Organization System)</td>
</tr>
<tr>
<td>vcard</td>
<td><a href="http://www.w3.org/2001/vcard-rdf/3.0">http://www.w3.org/2001/vcard-rdf/3.0</a></td>
<td>VCard vocabulary</td>
</tr>
<tr>
<td>void</td>
<td><a href="http://rdfs.org/ns/void">http://rdfs.org/ns/void</a></td>
<td>Vocabulary of Interlinked Datasets</td>
</tr>
<tr>
<td>xhtml</td>
<td><a href="http://www.w3.org/1999/xhtml">http://www.w3.org/1999/xhtml</a></td>
<td>XHTML namespace</td>
</tr>
<tr>
<td>xs</td>
<td><a href="http://www.w3.org/2001/XMLSchema#">http://www.w3.org/2001/XMLSchema#</a></td>
<td>XML Schema</td>
</tr>
<tr>
<td>fn</td>
<td><a href="http://www.w3.org/2005/xpath-functions">http://www.w3.org/2005/xpath-functions</a></td>
<td>XQuery function and operators</td>
</tr>
</tbody>
</table>
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 Getting Started with Semantics in MarkLogic

This chapter includes the following sections:

- Setting up MarkLogic Server
- Loading Triples
- Querying Triples

2.1 Setting up MarkLogic Server

When you install MarkLogic Server, a database, REST instance, and XDBC server (for loading content) are created automatically for you. The default Documents database is available on port 8000 as soon as you install MarkLogic Server, with a REST instance attached to it.

The examples in this guide use this pre-configured database, XDBC server, and REST API instance on port 8000. This section focuses on setting up MarkLogic Server to store triples. To do this, you will need to configure the database to store, search, and manage 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:

- Configuring the Database to Work with Triples
- Setting Up Additional Servers

2.1.1 Configuring the Database to Work with Triples

To use the default database for triples, you will need to enable the Triples index and the Collection Lexicon.

1. To configure the database for triples, navigate to the Admin Interface (localhost:8001). Click the Documents database, and then click the Configure tab.

2. Scroll down the Admin Configure page and set the triple index to true.

   ![Triple Index Configuration](image)

   The triple index shown in the Admin Interface is the semantics index.
3. Scroll down a bit further and set the collection lexicon to true.

![Collection Lexicon](image)

The Collection Lexicon index is required and used by the REST endpoint. You will only need the collection lexicon if you are querying a named graph.

4. Click OK when you are done.

This is all you need to do before loading triples into your default database.

### 2.1.2 Setting Up Additional Servers

In a production environment, 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](https://marklogic.com/developer-guide/administrator) in the *Administrator’s Guide*.

- REST instances: To create a different REST instance on another port, see [Administering REST Client API Instances](https://marklogic.com/developer-guide/rest) 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](https://marklogic.com/developer-guide/administrator) 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 serialization) for the examples. Or use a different subset of Persondata if you prefer.

1. Download the Persondata example dataset from DBPedia: [downloads.dbpedia.org/3.8/en/persondata_en.ttl.bz2](http://downloads.dbpedia.org/3.8/en/persondata_en.ttl.bz2). You will use this dataset for the steps in the rest of this chapter. The dataset is available at [http://wiki.dbpedia.org/Downloads](http://wiki.dbpedia.org/Downloads). To manually select it, scroll down on the page to find Persondata and select the “en” (English) and “ttl” (Turtle) version ([persondata_en.ttl.b2zip](http://downloads.dbpedia.org/3.8/en/persondata_en.ttl.bz2)).
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 serialized formats.

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 [Installation and Configuration](#) in the mlcp User 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-1.3-1\bin
   ```

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

   ```
   mlcp.bat import -host localhost -port 8000 -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 8000 -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.

   The triples will be imported and stored in the default Documents database.
4. The successful triples data import (Unix output) looks like this when it is complete:

```
14/09/15 14:35:38 INFO contentpump.ContentPump: Hadoop library version: 2.0.0-alpha
14/09/15 14:35:38 INFO contentpump.LocalJobRunner: Content type: XML
14/09/15 14:35:38 INFO input.FileInputFormat: Total input paths to process: 1
  file:///home/persondata_en.ttl : persondata_en.ttl
14/09/15 14:35:40 INFO contentpump.LocalJobRunner: completed 0%
14/09/15 14:40:27 INFO contentpump.LocalJobRunner: completed 100%
  ATTEMPTED_INPUT_RECORD_COUNT: 59595
14/09/15 14:40:28 INFO contentpump.LocalJobRunner: SKIPPED_INPUT_RECORD_COUNT: 0
14/09/15 14:40:28 INFO contentpump.LocalJobRunner: Total execution time: 289 sec
```

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:8000

   where hostname is the name of your MarkLogic Server host machine, and 8000 is the default port number for the REST instance that was created when you installed MarkLogic Server.
2. Append “/v1/graphs/things” to the end of the web address URL.

For example:

http://hostname:8000/v1/graphs/things

The first one thousand subjects are displayed:

```
<http://dbpedia.org/resource/%E2%80%9C%B3n_i_Casanovas>
<http://dbpedia.org/resource/%C3%80ngel_Rangel>
<http://dbpedia.org/resource/%C3%80strid_Berg%C3%A8s-Frisbey>
<http://dbpedia.org/resource/%C3%81bra%C3%A1m_Lederer>
<http://dbpedia.org/resource/%C3%BDr_Death%22_Steve_Williams>
<http://dbpedia.org/resource/%E2%80%9C%22_Teddy_Mann>
<http://dbpedia.org/resource/%E2%80%9C%22_Bennie_Nawahi>
<http://dbpedia.org/resource/%E2%80%9C%22_Baker>
<http://dbpedia.org/resource/%E2%80%9C%22_Sonny_Payne>
<http://dbpedia.org/resource/%E2%80%9C%22_Yankovic>
<http://dbpedia.org/resource/%E2%80%9C%22_Abdul-Bah%C3%A1>
<http://dbpedia.org/resource/%C3%88lex_Corretja>
<http://dbpedia.org/resource/%C3%88lex_Crivill%C3%A9s>
<http://dbpedia.org/resource/%C3%88lex_Pascual>
```
3. Click on a subject link to view the triples. Subject and object IRIs are presented as links.

8 triples

<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/firstName> "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 23.

#### 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 Documents database.
3. From the Query Type drop-down list, select SPARQLQuery.

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

   ```sparql
   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 Documents database.
2. From the Query Type drop-down list, select “XQuery”.
3. In the query window, enter this query:

```xquery
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.

```xquery
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 }
')
```
5. The results show people born in Brooklyn as IRIs, the same as in “Querying with Native SPARQL” on page 27.

For more information and examples of SPARQL queries, see “Semantic Queries” on page 70.
3.0 Loading Semantic 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

You can also use SPARQL Update to load triples. See “SPARQL Update” on page 155 for more information.

3.1 Loading Embedded RDF Triples

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 12 for details.

3.2 Loading Triples

There are a number of ways to load documents containing serialized triples in a supported RDF serialization into MarkLogic. “Supported RDF Triple Formats” on page 33 describes these RDF formats.

When you load one or more groups of triples, 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 graph and the directory as part of the import options. For more information, see “Loading Triples with mlcp” on page 38.

This section includes the following topics:

- Supported RDF Triple Formats
- Example RDF Formats
- Loading Triples with mlcp
- Loading Triples with XQuery
- Loading Triples Using the REST API

### 3.2.1 Supported RDF Triple Formats

MarkLogic Server supports loading these RDF data formats:

<table>
<thead>
<tr>
<th>Format</th>
<th>Description</th>
<th>File Type</th>
<th>MIME Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDF/XML</td>
<td>A syntax used to serialize an RDF graph as an XML document. For an example, see “RDF/XML” on page 34.</td>
<td>.rdf</td>
<td>application/rdf+xml</td>
</tr>
<tr>
<td>Turtle</td>
<td>Terse RDF Triple Language (Turtle) serialization 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 35.</td>
<td>.ttl</td>
<td>text/turtle</td>
</tr>
<tr>
<td>RDF/JSON</td>
<td>A syntax used to serialize RDF data as JSON objects. For an example, see “RDF/JSON” on page 35.</td>
<td>.json</td>
<td>application/rdf+json</td>
</tr>
<tr>
<td>N3</td>
<td>Notation3 (N3) serialization is a non-XML syntax used to serialize RDF data. For an example, see “N3” on page 36.</td>
<td>.n3</td>
<td>text/n3</td>
</tr>
<tr>
<td>N-Triples</td>
<td>A plain text serialization for RDF graphs. N-Triples is a subset of Turtle and Notation3 (N3). For an example, see “N-Triples” on page 36.</td>
<td>.nt</td>
<td>application/n-triples</td>
</tr>
<tr>
<td>N-Quads</td>
<td>A superset serialization that extends N-Triples with an optional context value. For an example, see “N-Quads” on page 37.</td>
<td>.nq</td>
<td>application/n-quads</td>
</tr>
</tbody>
</table>
3.2.2 Example RDF Formats

This section includes examples for the following RDF formats:

- 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”.

```xml
<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="http://www.w3.org/2001/XMLSchema#date">
            2013-05-14
        </d:shipped>
        <d:quantity rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">
            27
        </d:quantity>
        <d:invoiced rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">
            true
        </d:invoiced>
        <d:costPerItem rdf:datatype="http://www.w3.org/2001/XMLSchema#decimal">
            10.50
        </d:costPerItem>
    </rdf:Description>
</rdf:RDF>
```
3.2.2.2 Turtle
Terse RDF Triple Language (or Turtle) serialization 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:

```xml
<http://example.org/item/item22>
<http://example.org/details/shipped>
```

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.

```turtle
@prefix i: <http://example.org/item> .
@prefix dt: <http://example.org/details#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
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:

```json
{    "http://example.com/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 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:

```plaintext
@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 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://www.w3.org/2001/sw/RDFCore/ntriples/>
<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 serialization 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 “acquaintanceOf” to the vocabulary IRI.

```
<http://example.org/#Jane>
<http://example.org/#Joe>
<http://example.org/graphs/directory> .
```
3.2.2.7 TriG

TriG is a plain text serialization 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/trig and the content encoding is UTF-8.

This example contains a default graph and two named graphs.

```plaintext
@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 options for the import. 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 Loading Content 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. Be sure that you have the latest version of mlcp. For more information about installing and using mlcp and system requirements, see Installation and Configuration in the mlcp User 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. For these examples we will use the default database (Documents) and forest (Documents). To create your own database see Creating a New Database in the Administrator’s Guide.

3. Enable the triple index (and optionally enable the collection lexicon) on the Documents database configuration page of the Admin Interface, or using the Admin API. You will only need the collection lexicon if you are querying a named graph. See “Enabling the Triple Index” on page 58 for details. **Note:** The collection lexicon index is required for the Graph Store HTTP Protocol used by REST API instances and for use of the GRAPH “?g” construct in SPARQL queries. See “Configuring the Database to Work with Triples” on page 22 for information on the collection lexicon.

4. You can use mlcp with the default server on port 8000, which includes an XDBC server. To create your own XDBC server, see Creating a New XDBC Server in the Administrator’s Guide.

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

```bash
$ 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:

```bash
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 `mlcp.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. If you use your own database, be sure to add the `-database` parameter for your database. If no database parameter is specified, the content will be put into the default Documents database.

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. For triples, the `-input_file_type` should be RDF.

**Note:** The file extension of the file found in the `-input_file_path` is used by mlcp to identify the type of content being loaded. The type of RDF serialization is determined by the file extension (.rdf, .ttl, .nt, and so on).

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 Formats” on page 33.

**Note:** You must have sufficient MarkLogic privileges to import to the specified host. See Security Considerations in the mlcp User 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 41 for more details about these options. For example, you can load triples and quads by specifying RDF as the `-input_file_type` option:

```bash
$ mlcp.sh import -host localhost -port 8000 -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 8000.
On a Windows environment, the command would look like this:

```bash
> mlcp.bat import -host localhost -port 8000 ^
> -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

These options can be used with the `import` command to load triples or quads.

<table>
<thead>
<tr>
<th>Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-input_file_type string</code></td>
<td>Specifies the input file type. Default: document. For triples, use RDF.</td>
</tr>
<tr>
<td><code>-input_compressed boolean</code></td>
<td>When set to “true” this option enables decompression on import. Default: false</td>
</tr>
<tr>
<td><code>-fastload boolean</code></td>
<td>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 mlcp User Guide.</td>
</tr>
<tr>
<td><code>-output_directory</code></td>
<td>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 mlcp User Guide. Default: /triplestore</td>
</tr>
<tr>
<td><code>-output_graph</code></td>
<td>The graph value to assign to quads with no explicit graph specified in the data. Cannot be used with -output_override_graph.</td>
</tr>
<tr>
<td><code>-output_override_graph</code></td>
<td>The graph value to assign to every quad, whether a quad is specified in the data or not. Cannot be used with -output_graph.</td>
</tr>
</tbody>
</table>
MarkLogic Server

Loading Semantic Triples

<table>
<thead>
<tr>
<th>Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-output_collections</td>
<td>Creates a comma-separated list of collections. Default: <a href="http://marklogic.com/semantics#default-graph">http://marklogic.com/semantics#default-graph</a>. If -output_collections is used with -output_graph and -output_override_graph, the collections specified will be added to the documents loaded.</td>
</tr>
<tr>
<td>-database string</td>
<td>(optional) The name of the destination database. Default: The database associated with the destination App Server identified by -host and -port.</td>
</tr>
</tbody>
</table>

**Note:** When you load triples using mlcp, the -output_permissions option is ignored - triples (and, under the covers, triples documents) inherit the permissions of the graph that you're loading into.

If -output_collections and -output_override_graph are set at the same time, a graph document will be created for the graph specified by -output_override_graph, and triples documents will be loaded into collections specified by -output_collections and -output_override_graph.

If -output_collections and -output_graph are set at the same time, a graph document will be created for the graph specified by -output_graph (where there is no explicit graph specified in the data). Quads with no explicit graph specified in the data will be loaded into collections specified by -output_collections and the graph specified by -output_graph, while those quads that contain explicit graph data will be loaded into the collections specified by -output_collections and the graph(s) specified.

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 more information about import and output options for mlcp, see [Import Command Line Options](#) in the mlcp User Guide.

For example:

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

$ mlcp.sh import -host localhost -port 8000 -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.

**Note:** To create a new graph, you need to have the `sparql-update-user` role. For more information about roles, see Understanding Roles in the Understanding and Using Security Guide.

For example:

```bash
$ mlcpx.sh import -host localhost -port 8000 -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.

```xml
<http://dbpedia.org/resource/London_Heathrow_Airport> \
<http://xmlns.com/foaf/0.1/homepage> \
<http://www.heathrowairport.com/> \
```

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 8000 -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. 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/215710576eb4328.xml
/triplestore/25ec5ded9bfdb7c2.xml
```

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

```xml
<?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: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>
```

**Note:** You can leave out the `sem:triples` tag, but you cannot leave out the `sem:triple` tags.

### 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:

```xml
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
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
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 serialization, 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 of the triples, such as `turtle` for Turtle files or `rdfxml` for RDF files.

For example:

```xml
    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:

```xml
    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/81b14a8e51b07c11.xml | E sem:triple | (no properties) | http://marklogic.com/semantics#default-graph, mygraph |
| /triplestore/82c99c27f87c9.xml |

**Note:** To use `sem:rdf-load` you need the `xdmp:document-get` privilege.

### 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 serialization from the local filesystem:

```xml
    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 serialization 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 8.0-4 or later.

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

3. You can use the default database and forest (Documents) on port 8000 or create your own. To create a new database and forest, see Creating a New Database in the Administrator’s Guide.

4. Enable the triple index and the collection lexicon on the Documents database configuration page of the Admin Interface or with the Admin API. See “Enabling the Triple Index” on page 58.

   **Note:** The collection lexicon is required for the Graph Store HTTP Protocol of REST API instances.

5. You can use the default REST API instance associated with port 8000. If you want to create a new 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 HTTP Protocol as specified in the SPARQL 1.1 Graph Store HTTP Protocol:


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. The Graph Store HTTP Protocol is a mapping from RESTful HTTP requests to the corresponding SPARQL 1.1 Update operations. 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:


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

For example:

http://localhost:8000/v1/graphs?default

When a GET request is issued with no parameters, the list of graphs will be given in list format. See GET:/v1/graphs for more details.

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:

<table>
<thead>
<tr>
<th>Verb</th>
<th>Description</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET</td>
<td>Retrieves a named graph.</td>
<td>rest-reader</td>
</tr>
<tr>
<td>POST</td>
<td>Merges triples into a named graph or adds triples to an empty graph.</td>
<td>rest-writer</td>
</tr>
<tr>
<td>PUT</td>
<td>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.</td>
<td>rest-writer</td>
</tr>
<tr>
<td>DELETE</td>
<td>Removes triples in a named graph.</td>
<td>rest-writer</td>
</tr>
<tr>
<td>HEAD</td>
<td>Test for the existence of a graph. Retrieves a named graph, without the body.</td>
<td>rest-reader</td>
</tr>
</tbody>
</table>

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 Formats” on page 33.

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. Specify the graph in which to load the triples.
   a. To specify the default graph, set the `graph` parameter to the default graph.
   b. To specify a named graph, set the `graph` parameter to the named 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 Formats” on page 33.

4. Specify the user credentials.

The triples are 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 graph:

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

$ curl -s -X PUT --data-binary '@example.nt' \
   -H "Content-type: application/n-triples" \
   --digest --user "admin:password" \
   "http://localhost:8000/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:

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-s</td>
<td>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.</td>
</tr>
<tr>
<td>-X http_method</td>
<td>The type of HTTP request (PUT) that curl should send. Other supported requests are GET, POST and DELETE. See “Supported Verbs” on page 50.</td>
</tr>
<tr>
<td>--data-binary data</td>
<td>Data to include in the request body. Data may be placed directly on the command line as an argument to --data-binary, or read from a file by using @filename. If you are using Windows, a Windows version of curl that supports the &quot;@&quot; operator is required.</td>
</tr>
<tr>
<td>-H headers</td>
<td>The HTTP header to include in the request. The examples in this guide use Content-type.</td>
</tr>
<tr>
<td>--digest</td>
<td>The authentication method specified encrypts the user’s password.</td>
</tr>
<tr>
<td>--user user:password</td>
<td>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.</td>
</tr>
</tbody>
</table>

For more information about the REST API, see the Semantics documentation in the REST Client API. For more about REST and Semantics see “Using Semantics with the REST Client API” on page 175.

### 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.

These response errors may be returned:

- **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 serialization.
• 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 whatsoever 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:

- Understanding the Triple Index and How It’s Used
- Enabling the Triple Index
- Other Considerations

4.1 Understanding the Triple Index and How It’s Used

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 triple index stores each unique value only once, in the dictionary. The dictionary gives each value an ID, and the triple data then uses that ID to reference the value in the dictionary.

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 60.

### 4.1.1.1 Triple Cache and Triple Value Cache

The triple cache holds blocks of compressed triples from disk, which are flushed using a least recently used (LRU) algorithm. Blocks in the triple cache refer to values from a dictionary. The triple value cache holds uncompressed values from the triple index dictionary. The triple value cache is also a least recently used cache.

Triples in the triple index are filtered out depending on the query timestamp and timestamps of the document they came from. The triple cache holds information generated before the filtering happens, so deleting a triple has no effect on triple caches. However, after a merge, old stands may be deleted. When a stand is deleted, all its blocks are flushed from the triple caches.

Cache timeout controls how long MarkLogic Server will keep triple index blocks in the cache after the last time it was used (when it hasn’t been flushed to make room for another block). Increasing the cache timeout might be good for keeping the cache hot for queries that are run at infrequent periods. Other more frequent queries may push the information out of the cache before the infrequent query is re-run.

### 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 can be 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:

```xml
xquery version "1.0-ml";

ccts:search(doc(),
  ccts:near-query(
    ccts:triple-range-query(sem:iri("http://www.rdfabout.com/rdf/
      usgov/sec/id/cik0001075285")), (), ()),
    ccts:triple-range-query(sem:iri("http://www.rdfabout.com/rdf/
      usgov/sec/id/cik0001317036"), (), ()),
    ccts:triple-range-query(sem:iri("http://www.rdfabout.com/rdf/
      usgov/sec/id/cik0001317036"), ()), ()),
    ccts:triple-range-query(sem:iri("http://www.rdfabout.com/rdf/
      usgov/sec/id/cik0001317036"), (), ()),
  ),11), "unfiltered")
```

The `ccts: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 `ccts: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 58.

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.

<table>
<thead>
<tr>
<th>Index File</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TripleIndex</td>
<td>Block indexes for TripleData and TripleValueData</td>
</tr>
<tr>
<td>TripleValueIndex</td>
<td></td>
</tr>
<tr>
<td>TripleTypeData</td>
<td>Type information for the triple values</td>
</tr>
<tr>
<td>TripleTypeIndex</td>
<td></td>
</tr>
<tr>
<td>StringData</td>
<td>Also used by the string-based range indexes</td>
</tr>
<tr>
<td>StringIndex</td>
<td></td>
</tr>
<tr>
<td>AtomData</td>
<td></td>
</tr>
<tr>
<td>AtomIndex</td>
<td></td>
</tr>
<tr>
<td>TripleValueFreqs</td>
<td>Statistical information about the triples. The triple index keeps statistics on the triples for every value kept in the database.</td>
</tr>
<tr>
<td>TripleValueFreqsIndex</td>
<td></td>
</tr>
</tbody>
</table>

**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 Admin Interface (http://hostname:8001) database configuration page. The hostname is the MarkLogic Server host for which the triple index is to be enabled.

For more information about index settings, see Index Settings that Affect Documents of the Administrator’s Guide and “Configuring the Database to Work with Triples” 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 59 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 256MB:

```
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, 
    $Sample-Database, 256)
return admin:save-configuration($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. This partitioning enables parallelism and speeds up processing.

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:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>admin:group-set-triple-cache-size</td>
<td>Changes the triple cache size setting of the group with the specified ID to the specified value</td>
</tr>
<tr>
<td>admin:group-set-triple-cache-partitions</td>
<td>Changes the triple cache partitions setting of the group with the specified ID to the specified value</td>
</tr>
<tr>
<td>admin:group-set-triple-cache-timeout</td>
<td>Changes the number of seconds a triple block can be unused before being flushed from caches</td>
</tr>
<tr>
<td>admin:group-set-triple-value-cache-timeout</td>
<td>Changes the number of seconds a triple value block can be unused before being flushed from caches</td>
</tr>
<tr>
<td>admin:group-set-triple-value-cache-size</td>
<td>Changes the triple value cache size setting of the group with the specified ID to the specified value</td>
</tr>
</tbody>
</table>
### 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:

```text
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:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>admin:group-set-triple-value-cache-partitions</td>
<td>Changes the triple value cache partitions setting of the group with the specified ID to the specified value</td>
</tr>
</tbody>
</table>
• `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 Embedded Triples

Triples that are part of an XML or a JSON document, and have a element node of `sem:triple` are called embedded triples. These triples are referred to as unmanaged triples. Embedded triples must be in the MarkLogic XML or JSON format defined in the schema for `sem:triple` (semantics.xsd).

**Note:** Embedded triples cannot be modified with SPARQL Update. Use XQuery or JavaScript to modify embedded triples. See “Updating Triples” on page 237 for more details.

With embedded triples MarkLogic works like a triple store and a document store. You have the functionality of a triple store and a document store for your data.

This example inserts an embedded triple into an XML document (`xml.xml`):

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

xdmp:document-insert("xml.xml",
    <article>
        <info>
            <title>News for April 9, 2013</title>
            <sem:triples xmlns:sem="http://marklogic.com/semantics">
                <sem:triple>
                    <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:triple>
            </sem:triples>
        </info>
    </article>)
```

**Note:** You can leave out the `sem:triples` tag, but you cannot leave out the `sem:triple` tags.

An XML or JSON document can contain many kinds of information, along with the embedded triples.
This example shows a suspicious activity report document that contains both XML and triples:

```xml
<SAR>
  <title>Suspicious vehicle...Suspicious vehicle near airport</title>
  <date>2014-11-12Z</date>
  <type>observation/surveillance</type>
  <threat>
    <type>suspicious activity</type>
    <category>suspicious vehicle</category>
  </threat>
  <location>
    <lat>37.497075</lat>
    <long>-122.363319</long>
  </location>
  <description>A blue van with license plate ABC 123 was observed parked behind the airport sign...
    <sem:triple>
      <sem:subject>IRIID</sem:subject>
      <sem:predicate>isa</sem:predicate>
      <sem:object>license-plate</sem:object>
    </sem:triple>
    <sem:triple>
      <sem:subject>IRIID</sem:subject>
      <sem:predicate>value</sem:predicate>
      <sem:object>ABC 123</sem:object>
    </sem:triple>
  </description>
</SAR>
```

Embedded triples ingested into a MarkLogic database are indexed by the triple index and stored for access and query by SPARQL. Here is another representation of the same information:
You can also embed triples into JSON documents. Here is how you would insert a triple using JavaScript:

```javascript
declareUpdate();
var sem = require("/MarkLogic/semantics.xqy");
xdmp.documentInsert(
    "testDoc.json", {
        "my": "data", "triple": {
            "subject": "http://example.org/ns/dir/js/",
            "predicate": "http://xmlns.com/foaf/0.1/firstname/",
            "object": {
                "datatype": "http://www.w3.org/2001/XMLSchema#string",
                "value": "John"
            }
        }
    }
)

Here is the triple embedded in a JSON document:

```json
{
    "my": "data",
    "triple": {
        "subject": "http://example.org/ns/dir/js/",
        "predicate": "http://xmlns.com/foaf/0.1/firstname/",
        "object": {
            "datatype": "http://www.w3.org/2001/XMLSchema#string",
            "value": "John"
        }
    }
}
```

You can do the same document insert with XQuery:

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

xdmp:document-insert("myData.xml",
    <sem:triples xmlns:sem="http://marklogic.com/semantics">
        <sem:triple>
            <sem:subject>http://example.org/ns/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:triples>
)`
When triples are embedded in an XML or JSON document, they can include additional information about the triple and additional metadata about the triple (time/date information, bitemporal information, source of the triple). You can also add useful information about the triple to the XML or JSON file (like the provenance of the triple). When you update the triple, you update the document and the triple together.

5.1 Uses for Triples in XML Documents

With embedded triples you can do combination queries on both the document and the embedded triples. The triples stay “in context” with the other information in the document in which they are embedded and have the security and permissions associated with that document. These triples are updated with the document and deleted when the document is deleted.

5.1.1 Context from the Document

When you have triples embedded in a document, the document can provide context for the data described by the triples. The source of the triples and more information about when the document and triples were created can be included as part of the document.

```xml
<article>
    <info>AP Newswire - Nixon went to China</info>
    <triples-context>
        <confidence>80</confidence>
        <pub-date>2011-10-14</pub-date>
        <source>AP Newswire</source>
    </triples-context>
    <sem:triple xmlns:sem="http://marklogic.com/semantics">
        <sem:subject>http://example.org/news/Nixon</sem:subject>
        <sem:predicate>http://example.org/wentTo</sem:predicate>
        <sem:object>China</sem:object>
    </sem:triple>
</article>
```

You can annotate embedded triples to provide even more information, such as the level of confidence in the reliability of the information or the date of publication.

5.1.2 Combination Queries

A combination query operates on both the document and any embedded triples. Here is a complex query for the information in the AP newswire document:

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

sem:sparql('"
    SELECT ?country
    WHERE {
    }
)
The cts query in this example identifies a set of documents. Any triples in those documents are used to build a semantic store and the SPARQL query is then run against that store. This means that the query says, “Find countries in triples that are in documents identified by the cts query; which is any document that has a confidence >= 80 and a pub-date later than 1974, and has a source element with either “AP Newswire” or “BBC”.

5.1.3 Security

For embedded triples, the security permissions for the document also apply to the embedded triples. You will need to have the appropriate permissions to modify or add triples to the document. To find the current permissions for a document, use `xdmp:document-get-permissions`:

```xml
xquery version "1.0-ml";
xdmp:document-get-permissions("/example.json")
```

```xml
<sec:permission xmlns:sec="http://marklogic.com/xdmp/security">
  <sec:capability>read</sec:capability>
  <sec:role-id>111808369995942796002</sec:role-id>
</sec:permission>
<sec:permission xmlns:sec="http://marklogic.com/xdmp/security">
  <sec:capability>update</sec:capability>
  <sec:role-id>111808369995942796002</sec:role-id>
</sec:permission>
```

To set the permissions on a document, you can use `xdmp:document-set-permissions`:

```xml
xdmp:document-set-permissions(
  "/example.json",
  (xdmp:permission("sparql-update-user","update"),
   xdmpp:permission("sparql-update-user","read"))
)
```

5.2 Bitemporal Embedded Triples

You can use SPARQL to perform bitemporal search queries with embedded triples. In this example, the bitemporal query is wrapped inside the SPARQL query as a `cts:period-range-query`.

```sparql
let $q := 'SELECT ?derivation WHERE {
  <http://example.com/prov/trader/> <http://www.w3.org/ns/prov#wasDerivedFrom/> ?derivation
} ',
```

This bitemporal SPARQL query searches for events between 2014-04-01T16:10:00 and 2014-04-01T16:12:00. See Understanding Temporal Documents in the Temporal Developer’s Guide for more information about temporal documents.
6.0 Semantic Queries

This chapter discusses the principal techniques and tools used 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.

MarkLogic supports the syntax and capabilities in SPARQL 1.1. 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/

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” on page 27.

You can combine SPARQL with XQuery or JavaScript. For example, you can restrict a SPARQL query by passing in a cts:query (XQuery) or cts.query (JavaScript) and you can call built-in functions (including cts:contains or cts.contains for full-text search) as part of your SPARQL query. For more details, see “Using Built-in Functions in a SPARQL Query” on page 93.

You can use following methods to query triples:

- SPARQL mode in Query Console. For details, see “Querying Triples with SPARQL” on page 71
- XQuery using the semantics functions, and Search API, or a combination of XQuery and SPARQL. For details, see “Querying Triples with XQuery or JavaScript” on page 117.
- HTTP via a SPARQL endpoint. For details, see “Using Semantics with the REST Client API” on page 175.

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 or JavaScript
- Serialization
- Security
6.1 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
- Prefix Declaration
- Query Pattern
- Target RDF Graph
- Result Clauses
- Query Clauses
- Solution Modifiers
- Property Path Expressions
- SPARQL Aggregates
- SPARQL Resources


6.1.1 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.
6.1.2 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 Query.

   Query Console supports syntax highlighting for SPARQL keywords.

   **Note:** Select SPARQL Update when you are working with SPARQL Update. See “SPARQL Update” on page 155 for more information.

3. Construct your SPARQL query. See “Constructing a SPARQL Query” on page 76.

   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 for the target database, an XDMP-TRPLIDXNOTFOUND exception is thrown. See “Enabling the Triple Index” on page 58 for details.

6.1.3 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

6.1.3.1 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 serialization:

```
[
  {
    "person": "<http://dbpedia.org/resource/40_Illuminati>",
    "name": "Will 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)>",
    "name": "Abraham Klein"@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://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"^^xsd:date ;
<http://dbpedia.org/ontology/deathDate> "2001-08-25"^^xsd:date .

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

6.1.3.2 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 serialization:

```
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.
6.1.4 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 triple store. A SPARQL query typically contains the following (in order):

- **Prefix Declaration** - abbreviates prefix IRIs
- **Query Pattern** - specifies what to query in the RDF graph, compares and matches 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.

6.1.5 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 prefix for a commonly used vocabulary is also known as a CURIE (Compact URI Expression).
In this example, the prefix definitions are declared and the query pattern is written with abbreviated prefixes:

```sparql
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  dc:description "Physicist"@en ;
  rdf:type foaf:Person ;
}
```

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.

### 6.1.6 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 triple store
- 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 can be 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 triple store, 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 “db:Paris” - to find subjects who were born or died in Paris. The query consists of two parts; the `SELECT` clause specifies what is in the query results (subject and predicate) and the `WHERE` clause provides the basic graph pattern to match against the data graph:

```sparql
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 102 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 “db:Paris” is in the object position of the triple:

![Example IRIs](image)

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 72.

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 can be 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”:

```sparql
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 . }
```

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:

```sparql
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:

![Image of role or title returns](image)

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

### 6.1.7 Target RDF Graph

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

- 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 [http://my_collections](http://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 GRAPH Keyword” on page 84 describes the use of `GRAPH` in a query.
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](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, REST, or Javascript 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](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](http://example.org/bob/foaf.rdf) graph:

```xquery
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/> .
  ?person foaf:name ?name }
}
("default-graph-uri=http://example.org/bob/foaf.rdf")
```

The **FROM** in a SPARQL query functions the same as **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**

### 6.1.7.1 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:

```sparql
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” on page 117 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:

```sparql
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](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:

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

SELECT ?s ?p ?o
FROM <http://example.org/foaf/alice>
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.

### 6.1.7.2 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” on page 32.

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:

```sparql
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.

6.1.7.3 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.

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.

6.1.8 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
### 6.1.8.1 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:

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

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

**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, JSON, or passed to another function as a map. The results of a `SELECT` query may not always be triples.

### 6.1.8.2 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 in memory.

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

```sparql
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.
These triples are created for Albert Einstein from the existing triples in the dataset:

```rxml
@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Albert_Einstein>
<http://dbpedia.org/ontology/birthPlace>

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Albert_Einstein>
<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/German_Empire> .

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Albert_Einstein>
<http://dbpedia.org/ontology/deathPlace>

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Albert_Einstein>
<http://dbpedia.org/ontology/deathPlace>

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Albert_Einstein>
```

These triples are constructed in memory and not added to the database.

**Note:** The “@en” language tag means that this is an English word and will match differently than any other language tag.
6.1.8.3 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 W3C specification leaves the details implementation dependent. In MarkLogic, we return a Concise Bounded Description of the IRIs identified, which includes all triples which have the IRI as a subject, and for each of those triples that has a blank node as an object, all triples with those blank nodes as a subject.

For example, this query finds triples containing “Pascal Bedrossian”:

```
DESCRIBE <http://dbpedia.org/resource/Pascal_Bedrossian>
```

The triples found by the DESCRIBE query are returned in Turtle format. You can also select JSON or Text as the format.

```
@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Pascal_Bedrossian>
<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/France> .

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Pascal_Bedrossian>
<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Marseille> .

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Pascal_Bedrossian>
<http://xmlns.com/foaf/0.1/name> "Pascal Bedrossian"@en .

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Pascal_Bedrossian>
<http://xmlns.com/foaf/0.1/givenName> "Pascal"@en .

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Pascal_Bedrossian>
<http://xmlns.com/foaf/0.1/surname> "Bedrossian"@en .

@prefix xs: <http://www.w3.org/2001/XMLSchema#> .
<http://dbpedia.org/resource/Pascal_Bedrossian>
```
6.1.8.4 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.

```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).
}
=>
true
```

The response is true.

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

6.1.9 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**
- **Comparison Operators**
- **Negation in Filter Expressions**
- **BIND Keyword**
- **Values Sections**
6.1.9.1 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:email ?mb .}
```

Only triples that match *all* the triple patterns are returned. In the *persondata* dataset there may be people with no email address. In this case, the Query Console will silently leave these people out of the result set.

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 .
  OPTIONAL{?x foaf:email ?mb .}}
```

**Note:** Optional patterns may yield unbound variables. See “ORDER BY Keyword” on page 103 for more about unbound variables.

6.1.9.2 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 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 . }  
}
```
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.

### 6.1.9.3 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 (>) or 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:

<table>
<thead>
<tr>
<th>Operator</th>
<th>Type</th>
<th>Result Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td><code>xsd:boolean</code></td>
<td><code>xsd:boolean</code></td>
</tr>
<tr>
<td>+</td>
<td>numeric</td>
<td>numeric</td>
</tr>
<tr>
<td>-</td>
<td>numeric</td>
<td>numeric</td>
</tr>
<tr>
<td><code>BOUND()</code></td>
<td>variable</td>
<td><code>xsd:boolean</code></td>
</tr>
<tr>
<td><code>isURI()</code></td>
<td>RDF term</td>
<td><code>xsd:boolean</code></td>
</tr>
<tr>
<td><code>isBlank()</code></td>
<td>RDF term</td>
<td><code>xsd:boolean</code></td>
</tr>
<tr>
<td><code>isLITERAL</code></td>
<td>RDF term</td>
<td><code>xsd:boolean</code></td>
</tr>
<tr>
<td><code>STR()</code></td>
<td>literal/IRI</td>
<td>simple literal</td>
</tr>
<tr>
<td><code>LANG()</code></td>
<td>literal</td>
<td>simple literal</td>
</tr>
<tr>
<td><code>DATATYPE()</code></td>
<td>literal</td>
<td>IRI</td>
</tr>
</tbody>
</table>

**Note:** For a full list of operations, see *Operator Mapping* in the [SPARQL Query Language for RDF](https://www.w3.org/TR/rdf-sparql-query/).
This example is a query pattern that provides meaning to the variable \(?bd\) (a person’s birth date). The \texttt{FILTER} clause of the query pattern compares the variable value to the date January 1st, 1999 and returns people born after the given date:

```sparql
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 \texttt{a} is a shortcut for the common predicate \texttt{rdf:type}, giving the class of a resource. For example, the \texttt{WHERE} clause could be written as:

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

You can express a \texttt{FILTER} clause with a regular expression pattern by using the \texttt{regex} function. For example:

```sparql
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 \texttt{Lister} in any case. Regular expression matches are made case-insensitive with the \texttt{i} flag.

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

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

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Using Built-in Functions in a SPARQL Query

In addition to SPARQL functions, you can use XQuery or JavaScript built-in functions (for example, functions with the prefix fn, cts, math, 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 or “var <module> = require” in JavaScript. These 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 “Server-Side JavaScript APIs” (or “Server-Side XQuery APIs”). The built-ins listed are under “MarkLogic Built-In Functions” and “W3C-Standard Functions.” See “Using Semantic Functions to Query” on page 119 for more information.

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, cts, math, and xdmp (or any other prefix IRIs that do not end with a "/" or "#"), append a # to the prefix IRI and then the function localname, for example:

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 *
  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:

```sparql
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.

### 6.1.9.4 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:

```sparql
ASK {
  FILTER(2 IN (1, 2, 3))
}
=>
true

ASK {
  FILTER(2 NOT IN (1, 2, 3))
}
=>
false
```

### 6.1.10 Negation in Filter Expressions

Negation can be used with the `FILTER` expression to eliminate solutions from the query results. There are two types of negation - one type filters results depending on whether a graph pattern does or does not match in the context of the query solution being filtered, and the other type is based on removing solutions related to another pattern. MarkLogic supports SPARQL 1.1 Negation (using `EXISTS`, `NOT EXISTS`, and `MINUS`) for use with `FILTER`.

The examples for negation use this data:

```sparql
PREFIX : <http://example.org/>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

:alice rdf:type foaf:Person .
:alice foaf:name "Alice" .
:bob rdf:type foaf:Person .
```

This section contains these topics:
6.1.10.1 EXISTS

The filter expression `EXISTS` checks to see whether the query pattern can be found in the data. For example, the `EXISTS` filter in this example checks for the pattern `?person foaf:name ?name` in the data:

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

SELECT ?person
WHERE
{
  FILTER EXISTS { ?person foaf:name ?name }
}
=>
  person
    <http://example.org/alice>
```

The result of the query is Alice. The `EXISTS` filter does not generate any additional bindings.

6.1.10.2 NOT EXISTS

With the `NOT EXISTS` filter expression, the query tests whether a graph pattern does not match a dataset, given the values of variables in the group graph pattern in which the filter occurs. This query tests whether the `?person foaf:name ?name` does not occur in the data:

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

SELECT ?person
WHERE
{
  FILTER NOT EXISTS { ?person foaf:name ?name }
}
=>
  person
    <http://example.org/bob>
```
The graph pattern for <http://example.org/bob> does not have a predicate foaf:name for ?person, so the query returns Bob as the result for this query. The NOT EXISTS filter does not generate any additional bindings.

### 6.1.10.3 MINUS

The another type of SPARQL negation is MINUS, which evaluates both its arguments, then calculates solutions in the left-hand side that are not compatible with the solutions on the right-hand side of the pattern.

For this example we will add additional data:

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

:alice  foaf:givenName "Alice" ;
         foaf:familyName "Smith" .

:bob    foaf:givenName "Bob" ;
         foaf:familyName "Jones" .

:carol  foaf:givenName "Carol" ;
         foaf:familyName "Smith" .
```

This query looks for patterns in the data that do not match ?s foaf:givenName "Bob" and returns those results:

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

SELECT DISTINCT ?s
WHERE {
  MINUS {
    ?s foaf:givenName "Bob" .
  }
}

=>
  <http://example/carol>
  <http://example/alice>
```

The results are Carol and Alice.

The filters NOT EXISTS and MINUS represent two ways of approaching negation. The NOT EXISTS approach tests whether a pattern exists in the data, based on the bindings determined by the query pattern. The MINUS approach removes matches based on the evaluation of two patterns. In some cases, they can produce different results. The MINUS filter does not generate any additional bindings.
6.1.10.4 Differences Between NOT EXISTS and MINUS

The filter expressions NOT EXISTS and MINUS represent two ways of using negation. The NOT EXISTS filter tests whether a pattern exists in the data, given the bindings already determined by the query pattern. The MINUS filter removes matches from the result set based on the evaluation of two patterns in the query. In some cases, these two approaches can produce different answers.

Example: Sharing of variables
For instance, if we have this dataset:

```prefix @ <http://example.com/> .
a b c .```

And we use this query:

```sql
SELECT *
{
    ?s ?p ?o
    FILTER NOT EXISTS {?x ?y ?x}
}
=>
(This query has no results.)```

The result set will be empty because there are no matches for `{?x ?y ?x}` in the data and the NOT EXISTS filter eliminates any results.

When we use MINUS in the same query, there is no shared variable between the first part (?s ?p ?o) and the second part (?x ?y ?z), so no bindings are eliminated:

```sql
PREFIX : <http://example.com/>
SELECT *
{
    ?s ?p ?o
    FILTER MINUS {?x ?y ?x}
}
=>
s p o
<http://example.com/a> <http://example.com/b> <http://example.com/c>```

Example: Fixed pattern
Another case where the results will be different for NOT EXISTS and MINUS is where there is a concrete pattern (no variables) in the example query.

This query uses NOT EXISTS as the filter for negation:

```sql
PREFIX : <http://example.com/>
SELECT *
{
    ?s ?p ?o
```
FILTER NOT EXISTS { :a :b :c }

=>

(This query has no results.)

This query uses `MINUS` as the filter:

```sparql
PREFIX : <http://example.com/>
SELECT * {
  ?s ?p ?o
  MINUS { :a :b :c }
}
=>

s p o
<http://example.com/a> <http://example.com/b> <http://example.com/c>
```

Since there is no match of bindings, no solutions are eliminated, and the solution includes a, b, and c.

**Example: Inner FILTERs**

Differences in results will also occur because in a filter, variables from the group are in scope. In this example, the `FILTER` inside the `NOT EXISTS` has access to the value of `?n` for the solution being considered. For this example, we will use this dataset:

```sparql
PREFIX : <http://example.com/>
:a :q 1 .
:a :q 2 .
:b :p 3.0 .
:b :q 4.0 .
:b :q 5.0 .
```

When using `FILTER NOT EXISTS`, the test is on each possible solution to `?x :p ?n` in this query:

```sparql
PREFIX : <http://example.com/>
SELECT * WHERE {
  ?x :p ?n
  FILTER NOT EXISTS {
    ?x :q :m .
    FILTER (?n = ?m)
  }
}
=>

x n
<http://example.com/b> 3.0
With MINUS, the FILTER inside the pattern does not have a value for \(?n\) and it is always unbound.

```
PREFIX : <http://example.com/>
SELECT * WHERE {
  ?x ?p  ?n
  MINUS {
    ?x :q  ?m .
    FILTER (?n = ?m)
  }
}
```  

6.1.10.5 Combination Queries with Negation

A combination query operates on triples embedded in documents. The query searches both the document and any triples embedded in the document. You can add negation with the FILTER keyword to constrain the results of the query.

For example:

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

let $query := '  
  PREFIX foaf: <http://xmlns.com/foaf/0.1/>
  SELECT ?country
  WHERE {
    <http://example.org/news/Nixon> <http://example.org/wentTo>
    ?country
    FILTER NOT EXISTS {?country foaf:isIn ?location .
      ?location foaf:isIn "Europe"} . }
  '
let $store := sem:store((),cts:and-query( 
  cts:path-range-query( "/tripples-context/confidence", ">=", 80) ,
  cts:path-range-query( "/tripples-context/pub-date", ">",
  xs:date("1974-01-01")),
  cts:or-query( 
    cts:element-value-query( xs:QName("source"), "AP Newswire" ),
    cts:element-value-query( xs:QName("source"), "BBC" )
  )))

let $result := sem:sparql($query, (), (), $store)
return <result>{$result}</result>
```

**Note:** The `cts:path-range-query` requires the path index to be configured to work correctly. See [Understanding Range Indexes](#) in the Administrator’s Guide.
This is a modification of an earlier query that says “Find all of the documents containing triples that have information about countries that Nixon visited. From that group, return only those triples that have a confidence level of 80% or above and a publication data after January 1st, 1974. And only return triples with a source element of AP Newswire or BBC.” The \texttt{MINUS} filter removes any countries that are located in Europe from the results.

\textbf{Note:} SPARQL Update will not modify triples embedded in documents. SPARQL Update can be used to insert new triples into graphs as part of a combination query, or to modify managed triples. See “Embedded Triples” on page 64 for more about triples in documents.

\subsection{6.1.10.6 BIND Keyword}

The \texttt{BIND} keyword allows a value to be assigned to a variable from a basic graph pattern or property path expression. The use of \texttt{BIND} ends the preceding basic graph pattern. The variable introduced by the \texttt{BIND} clause must not have been used in the group graph pattern up to the point of use in \texttt{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 \texttt{CONSTRUCT} query. The syntax is \texttt{(expression AS ?var)}. For example:

\begin{verbatim}
PREFIX db: <http://dbpedia.org/resource/>
PREFIX onto: <http://dbpedia.org/ontology/>

SELECT ?person
WHERE { BIND (db:London AS ?location)
}
LIMIT 10
\end{verbatim}
6.1.10.7 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:

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

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

This query says “find subjects with foaf:name John or Jane” - supplying the values the ?n can have instead of searching for ?n in the dataset. This is the same as a query 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.

6.1.11 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
- Subqueries
- Projected Expressions

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

6.1.11.1 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.

### 6.1.11.2 The LIMIT Keyword

Use the `LIMIT` keyword to further restrict the results of a SPARQL query that are displayed. 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:

<table>
<thead>
<tr>
<th>x</th>
<th>fn</th>
<th>ln</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://dbpedia.org/resource/A_S_King">http://dbpedia.org/resource/A_S_King</a></td>
<td>&quot;A.S. King&quot;</td>
<td>&quot;King&quot;</td>
</tr>
<tr>
<td><a href="http://dbpedia.org/resource/A_H_Amaas">http://dbpedia.org/resource/A_H_Amaas</a></td>
<td>&quot;A.H. Amaas&quot;</td>
<td>&quot;Amaas&quot;</td>
</tr>
<tr>
<td><a href="http://dbpedia.org/resource/A_Lee_Martinez">http://dbpedia.org/resource/A_Lee_Martinez</a></td>
<td>&quot;A. Lee Martinez&quot;</td>
<td>&quot;Martinez&quot;</td>
</tr>
<tr>
<td><a href="http://dbpedia.org/resource/A_M_Barrage">http://dbpedia.org/resource/A_M_Barrage</a></td>
<td>&quot;A. M. Barrage&quot;</td>
<td>&quot;Barrage&quot;</td>
</tr>
<tr>
<td><a href="http://dbpedia.org/resource/A_Muthuraman">http://dbpedia.org/resource/A_Muthuraman</a></td>
<td>&quot;A. Muthuraman&quot;</td>
<td>&quot;Raman&quot;</td>
</tr>
<tr>
<td><a href="http://dbpedia.org/resource/Abdemi_Sanusi">http://dbpedia.org/resource/Abdemi_Sanusi</a></td>
<td>&quot;Abdemi Sanusi&quot;</td>
<td>&quot;Sanusi&quot;</td>
</tr>
<tr>
<td><a href="http://dbpedia.org/resource/Ada_Abrecht">http://dbpedia.org/resource/Ada_Abrecht</a></td>
<td>&quot;Ada Abrech&quot;</td>
<td>&quot;Abrecht&quot;</td>
</tr>
<tr>
<td><a href="http://dbpedia.org/resource/Adlie_Geras">http://dbpedia.org/resource/Adlie_Geras</a></td>
<td>&quot;Adlie Geras&quot;</td>
<td>&quot;Geras&quot;</td>
</tr>
<tr>
<td><a href="http://dbpedia.org/resource/Agnete_Frisk">http://dbpedia.org/resource/Agnete_Frisk</a></td>
<td>&quot;Agnete Frisk&quot;</td>
<td>&quot;Fris&quot;</td>
</tr>
<tr>
<td><a href="http://dbpedia.org/resource/Ahmad_Atbapour">http://dbpedia.org/resource/Ahmad_Atbapour</a></td>
<td>&quot;Ahmad Atbapour&quot;</td>
<td>&quot;Atbapour&quot;</td>
</tr>
</tbody>
</table>

6.1.11.3 ORDER BY Keyword

Use the ORDER BY clause to specify the values of one or more variable by which to sort the query results. SPARQL provides an ordering for 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" ;
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):
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
```

<table>
<thead>
<tr>
<th>x</th>
<th>fn</th>
<th>ln</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://dbpedia/resource/Ioan_de_Hamel">http://dbpedia/resource/Ioan_de_Hamel</a></td>
<td>&quot;Ioan de Hamel&quot;@en</td>
<td>&quot;de Hamel&quot;@en</td>
</tr>
<tr>
<td><a href="http://dbpedia/resource/Lala_al-Oukhaydib">http://dbpedia/resource/Lala_al-Oukhaydib</a></td>
<td>&quot;Lala al-Oukhaydib&quot;@en</td>
<td>&quot;al-Oukhaydib&quot;@en</td>
</tr>
<tr>
<td><a href="http://dbpedia/resource/Shahul_Zahir">http://dbpedia/resource/Shahul_Zahir</a></td>
<td>&quot;Shahul Zahir&quot;@en</td>
<td>&quot;Zahir&quot;@en</td>
</tr>
<tr>
<td><a href="http://dbpedia/resource/Ahmer_Zahir">http://dbpedia/resource/Ahmer_Zahir</a></td>
<td>&quot;Ahmer Zahir&quot;@en</td>
<td>&quot;Zahir&quot;@en</td>
</tr>
<tr>
<td><a href="http://dbpedia/resource/Helen_Zahir">http://dbpedia/resource/Helen_Zahir</a></td>
<td>&quot;Helen Zahir&quot;@en</td>
<td>&quot;Zahir&quot;@en</td>
</tr>
<tr>
<td><a href="http://dbpedia/resource/Rachel_Zadok">http://dbpedia/resource/Rachel_Zadok</a></td>
<td>&quot;Rachel Zadok&quot;@en</td>
<td>&quot;Zadok&quot;@en</td>
</tr>
<tr>
<td><a href="http://dbpedia/resource/Michele_Zachhem">http://dbpedia/resource/Michele_Zachhem</a></td>
<td>&quot;Michele Zachhem&quot;@en</td>
<td>&quot;Zachhem&quot;@en</td>
</tr>
<tr>
<td><a href="http://dbpedia/resource/Shan_Sa">http://dbpedia/resource/Shan_Sa</a></td>
<td>&quot;Shan Sa&quot;@en</td>
<td>&quot;Sa&quot;@en</td>
</tr>
<tr>
<td><a href="http://dbpedia/resource/Eve_Wyld">http://dbpedia/resource/Eve_Wyld</a></td>
<td>&quot;Eve Wyld&quot;@en</td>
<td>&quot;Wyld&quot;@en</td>
</tr>
<tr>
<td><a href="http://dbpedia/resource/Patricia_Wrede">http://dbpedia/resource/Patricia_Wrede</a></td>
<td>&quot;Patricia C. Wrede&quot;@en</td>
<td>&quot;Wrede&quot;@en</td>
</tr>
</tbody>
</table>

### 6.1.11.4 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 can be 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 twenty, 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 20
```

The results are returned, skipping the first eight matches.
Note: SPARQL uses a 1-based index, meaning the first item is 1 and not 0, so an offset of 8 will skip items one through eight.

6.1.11.5 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 who were born in London and then 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

{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
```

6.1.11.6 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 \texttt{AS} keyword. The syntax is \texttt{(expression AS ?var)}.

For example:

```sparql
PREFIX ex: <http://example.org/>

SELECT ?Item (?price * ?qty AS ?total_price)
WHERE {
  ?Item ex:quantity ?qty
}
```

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

6.1.12 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.

6.1.12.1 Enumerated Property Paths

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

<table>
<thead>
<tr>
<th>Property Path</th>
<th>Construct</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence</td>
<td>path1/path2</td>
<td>Forwards path from path1 to path2</td>
</tr>
<tr>
<td>Inverse</td>
<td>^path</td>
<td>Backwards path from object to subject</td>
</tr>
<tr>
<td>Alternative</td>
<td>path1</td>
<td>path2</td>
</tr>
<tr>
<td>Group</td>
<td>(path)</td>
<td>A group path path, brackets control precedence</td>
</tr>
</tbody>
</table>
The following examples illustrate property paths using this simple graph model:

![Graph model diagram]

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

```turtle
@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 ;
   a foaf:Person ;
   foaf:name "John" .
```

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 ?name
WHERE {?s foaf:name "Alice".
     ?s foaf:hasParent/foaf:name ?name .
}
=>
  s   name
  <http://marklogic.com/semantics/alice> "Jane"

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

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

SELECT ?s ?name
WHERE {?s foaf:name "John".
     ?s foaf:hasParent/foaf:hasParent/foaf:name ?name .
}
=>
  s   name
  <http://marklogic.com/semantics/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 {<http://marklogic.com/semantics/mary> ^foaf:hasChild ?s }
=>
  s
  <http://marklogic.com/semantics/Jane>

6.1.12.2 Unenumerated Property Paths

Unenumerated paths enable you to query triple paths and discover relationships, along with simple facts. This table describes the unenumerated path operators (+, *, or ?) that can be combined with predicates in a property path:

<table>
<thead>
<tr>
<th>Property Path</th>
<th>Construct</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>One or more</td>
<td>path+</td>
<td>A path that connects the subject and the object of the path by one or more matches of a path element.</td>
</tr>
</tbody>
</table>
Note: A path element may itself be composed of path constructs.

The inverse operator (^) can be used with the enumerated path operators. Precedence of these operators is left-to-right within groups.

For these next examples, we can use `sem:rdf-insert` to add these triples to express the concept of `foaf:knows`:

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

let $string := '
  @prefix foaf: <http://xmlns.com/foaf/0.1/> .
  @prefix p0: <http://marklogic.com/semantics/> .

  p0:alice foaf:knows p0:jane .
  p0:jane foaf:knows p0:mary,
      p0:alice .
  p0:mary foaf:knows p0:john,
      p0:jane .
  p0:john foaf:knows p0:mary .'
return sem:rdf-insert(sem:rdf-parse($string, "turtle"))
```
To find the names of all the people who are connected to Mary, use `foaf:knows` with the “+” path operator:

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

SELECT ?s ?name
WHERE {?s foaf:name "Mary" .
  ?s foaf:knows+/foaf:name ?name .}
```

```sparql
=>
   s name
   <http://marklogic.com/semantics/mary>  "Jane"
   <http://marklogic.com/semantics/mary>  "John"
   <http://marklogic.com/semantics/mary>  "Mary"
   <http://marklogic.com/semantics/mary>  "Alice"
```

This query will match all of the triples connected to Mary by `foaf:knows` where one or more paths exist. You can use `foaf:knows` with the “*” operator to find the names of anyone who is connected to Mary (including Mary) by zero or more paths.

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

SELECT ?s ?name
WHERE {?s foaf:name "Mary" .
  ?s foaf:knows*/foaf:name ?name .}
```

In this case the results will be same as in the previous example because the number of people connected to Mary by zero or more paths (the “*” path operator) is the same as the number connected by one or more paths.

Using the “?” operator finds the triples connected to Mary by one path element.

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

SELECT ?s ?name
WHERE {?s foaf:name "Mary" .
  ?s foaf:knows?/foaf:name ?name .}
```

```sparql
=>
   s name
   <http://marklogic.com/semantics/mary>  "Jane"
   <http://marklogic.com/semantics/mary>  "John"
   <http://marklogic.com/semantics/mary>  "Mary"
```

You can also use a property path sequence to discover connections between triples.
For example, this query will find triples connected to Mary by three path elements:

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?s ?name
WHERE {
  ?s foaf:name "Mary" .
}
```

- `<http://marklogic.com/semantics/mary>` "John"
- `<http://marklogic.com/semantics/mary>` "Jane"
- `<http://marklogic.com/semantics/mary>` "John"
- `<http://marklogic.com/semantics/mary>` "Jane"

The duplicate results are due to the different paths traversed by the query. You could add a `DISTINCT` keyword in the `SELECT` clause to return only one instance of each result and eliminate the duplicates.

You can combine SPARQL queries using property paths with a `cts:query` parameter to restrict results to only some documents (a combination query).

This combination query will find all the people connected to Alice, who have children:

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

SELECT ?s ?name
WHERE {
  ?s foaf:name "Mary" .
  ?s foaf:knows+/foaf:name ?name .
  FILTER cts:contains(?p, cts:word-query("http://xmlns.com/foaf/0.1/hasChild"))
}
=>
- `<http://marklogic.com/semantics/mary>` "Alice"
- `<http://marklogic.com/semantics/mary>` "Jane"
- `<http://marklogic.com/semantics/mary>` "John"
- `<http://marklogic.com/semantics/mary>` "Mary"
```

You could also use a `cts:query` parameter to restrict the query to a collection or directory.
6.1.12.3 Inference

You can use unenumerated paths to do simple inference using thesaural relationships. (A thesaural relationship is a simple ontology). For example, you can infer all the possible types of a resource, including supertypes of resources using this pattern:

```sql
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>

SELECT ?x ?type
{
  ?x rdf:type/rdfs:subClassOf* ?type
}
```

For example, this query will find the products that are subclasses of “shirt”:

```sql
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX ex: <http://example.com>

SELECT ?product
WHERE
{
}
```

For more about inference, see “Inference” on page 135.

6.1.13 SPARQL Aggregates

You can do simple analytic queries over triples using SPARQL aggregate functions. An aggregate function performs an operation over values or value co-occurrences in triples.

For example, you can use an aggregate function to compute the sum of values. This SPARQL query uses `SUM` to find the total sales:

```sql
PREFIX demov: <http://demo/verb/>
PREFIX vcard: <http://www.w3.org/2006/vcard/ns/>

SELECT (SUM (?sales) as ?sum_sales)
FROM <http://marklogic.com/semantics/COMPANIES100/>
WHERE {
  ?company a vcard:Organization .
  ?company demov:sales ?sales
}
```
These SPARQL aggregate functions are supported:

<table>
<thead>
<tr>
<th>Aggregate Function</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUNT</td>
<td>SELECT (COUNT (?company) as ?count_companies)</td>
</tr>
<tr>
<td></td>
<td>Count of &quot;companies&quot;</td>
</tr>
<tr>
<td>SUM</td>
<td>SELECT (SUM (?sales) as ?sum_sales)</td>
</tr>
<tr>
<td>MIN</td>
<td>SELECT (MIN (?sales) as ?min_sales)</td>
</tr>
<tr>
<td>MAX</td>
<td>SELECT ?country ( MAX (?sales) AS ?max_sales )</td>
</tr>
<tr>
<td>AVG</td>
<td>SELECT ?industry ( ROUND( AVG (?employees) ) AS ?avg_employees )</td>
</tr>
</tbody>
</table>

**Grouping Operations:**

All aggregate functions are supported with **GROUP BY**

- **GROUP BY**
  - GROUP BY ?industry
  - or
  - GROUP BY ?country ?industry

- **GROUP BY**
  - GROUP BY AVG

- **GROUP BY . HAVING**
  - GROUP BY ?industry
  - HAVING (?sum_sales > 3000000000 )

- **GROUP**
  - CONCAT<more_than_one_item>
    - SELECT ?region
      - ( GROUP_CONCAT( DISTINCT ?industry ; separator=" + " ) AS ?industries )

- **SAMPLE**
  - SELECT ?country
    - ( SAMPLE( ?industry ) AS ?sample_industry )
  - ( SUM (?sales) AS ?sum_sales )

**SAMPLE** is required for proper evaluation of unaggregated variables

Here is a SPARQL query using the aggregate function `COUNT` over a large number of triples:

```sparql
PREFIX demor: <http://demo/resource/>
PREFIX demov: <http://demo/verb/>
PREFIX vcard: <http://www.w3.org/2006/vcard/ns/>

# count the companies
# (more precisely, count things of type organization)

(SELECT ( COUNT (?company) AS ?count_companies )
FROM <http://marklogic.com/semantics/test/COMPANIES100/>
WHERE {
  ?company a vcard:Organization .
```

These SPARQL aggregate functions are supported:
Here is another example using \texttt{COUNT} and \texttt{ORDER BY DESC}:

$$\text{PREFIX demor: <http://demo/resource/>}
\text{PREFIX demov: <http://demo/verb/>}
\text{PREFIX vcard: <http://www.w3.org/2006/vcard/ns/>}

\text{SELECT DISTINCT } ?object \ (\text{COUNT}(?subject) \text{ AS } ?count)
\text{WHERE }
\{ ?subject <http://www.w3.org/1999/02/22-rdf-syntax-ns#type/> ?object \}
\text{ORDER BY DESC } (?count)
\text{LIMIT 10}

This query uses aggregates (\texttt{MAX}) to find the baseball player with the highest uniform number, and then get all the triples that pertain to him (or her). It uses an arbitrary triple (\texttt{bb:number}) that it knows every player in the dataset has, stores the subject in \texttt{?key}, then queries for all triples and filters out where the subject in the outer query matches the \texttt{?key} value:

$$\text{PREFIX bb: <http://marklogic.com/baseball/players/>}
\text{PREFIX bbr: <http://marklogic.com/baseball/rules/>}
\text{PREFIX xs: <http://www.w3.org/2001/XMLSchema#>}

\text{SELECT *}
\text{FROM <Athletics>}
\{ \text{SELECT}(\text{MAX}(?s1) \text{ as } ?key) \text{WHERE }
\{ ?s1 bb:number ?o1 . \}
\} \text{FILTER } (?s = ?key) \}
\text{ORDER BY ?p}

This complex nested query uses \texttt{COUNT AVG} to find the ten cheapest vendors for a specific product type, selected by the highest percentage of their product below the average cost, and then filters for vendors containing either “name1” or “name2”:

$$\text{PREFIX bsbm: <http://www4.wiwi.fu-berlin.de/bizer/bsbm/v01/vocabulary/>}
\text{PREFIX bsbm-inst: <http://www4.wiwi.fu-berlin.de/bizer/bsbm/v01/instances/>}
\text{PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>}
\text{PREFIX cts: <http://marklogic.com/cts#>}

\text{SELECT } ?vendor \ (\text{xsd:float}(?belowAvg)/?offerCount \text{ As} \ldots
?cheapExpensiveRatio)
{
    { SELECT ?vendor (count(?offer) As ?belowAvg)
        {
            { ?product a <http://www4.wiwiss.fu-berlin.de/bizer/bsbm/v01/instances/ProductType459> .
            }
            GROUP BB ?product
        }
        FILTER (xsd:float(xsd:string(?price)) < ?avgPrice)
    }
    GROUP BY ?vendor
}
{ SELECT ?vendor (count(?offer) As ?offerCount)
    {
        { ?product a <http://www4.wiwiss.fu-berlin.de/bizer/bsbm/v01/
            instances/ProductType459> .
        }
        GROUP BY ?vendor
    }
    FILTER cts:contains(?vendor, cts:or-query("name1", "name2")))
}
ORDER BY desc(xsd:float(?belowAvg)/?offerCount) ?vendor
LIMIT 10

6.1.14 Using the Results of sem:sparql

Here’s an example of using the results of sem:sparql in a query:

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

ccts:search(
    fn:doc(),
    cts:triple-range-query(
        (), "takenIn",
        (: Use sem:sparql to run a query, then use the ! operator to
        : convert the solution to a sequence of strings
        :)
```
6.1.15 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/](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](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/](http://www.w3.org/TR/rdf-sparql-XMLres/)
- SPARQL 1.1 Graph Store HTTP Protocol:

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

- [http://www.cambridgesemantics.com/semantic-university](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](http://www.w3.org/wiki/SparqlImplementations)
- SPARQL query results - JSON format: [http://www.w3.org/TR/2012/PR-sparql11-results-json-20121108/](http://www.w3.org/TR/2012/PR-sparql11-results-json-20121108/)
- SPARQL Frequently Asked Questions: [http://thefigtrees.net/lee/sw/sparql-faq](http://thefigtrees.net/lee/sw/sparql-faq)
6.2 Querying Triples with XQuery or JavaScript

This section contains examples of using XQuery or JavaScript with semantic data. When you use JavaScript or 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 Query
- Using Bindings for Variables
- Viewing Results as XML and RDF
- Working with CURIEs
- Using Semantics with cts Searches

6.2.1 Preparing to Run the Examples

These examples for querying triples with XQuery or Javascript 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 8.0-4 or later.
- MarkLogic Content Pump (mlcp). See Installation and Configuration in the mlcp User 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 the following 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

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2. Create a *govtrack* database and forest. For these examples you can use the application server on port 8000 with the GovTrack data. This default server can function as an XDBC server and REST instance as well.

To create your own XDBC server and REST instance see *Setting Up Additional Servers* in this guide and *Administering REST Client API Instances* in the in the *REST Application Developer’s Guide* for more information.

3. Enable the triples index and the collection lexicon for the *govtrack* database. See “Enabling the Triple Index” on page 58.

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 38. Your import command on Windows should look similar to the following:

```
mlcp.bat import -host localhost -port 8000 -username admin ^
  -password password -database govtrack ^
  -input_file_type rdf ^
  -input_file_path c:\space\GovTrack -input_compressed true^
  -input_compression_codec gzip ^
  -output_collections "info:govtrack/people,info:govtrack/bills"
```

Modify the *host*, *port*, *username*, *password*, and *-input_file_path* options to match your environment. In this example, long lines have been broken for readability and Windows continuation characters (“\^”) have been added.

**Note:** Be sure to add the *-database* parameter to the command. If you leave this parameter out, the data will go into the default Documents database.

The equivalent command for Unix is:

```
mlcp.sh import -host localhost -port 8000 -username admin \ 
  -password password -database govtrack -input_file_type RDF \ 
  -input_file_path /space/GovTrack -input_compressed true \ 
  -input_compression_codec gzip \ 
  -output_collections 'info:govtrack/people,info:govtrack/bills'
```

In this example, the long lines have been broken and the Unix continuation characters (“\”) have been added.

**Note:** It is important to specify the *-input_file_type* as RDF to invoke the correct parser.
6.2.2 Using Semantic Functions to Query

You can execute SPARQL SELECT, ASK, and CONSTRUCT queries with the sem:sparql and sem:sparql-values functions in XQuery, and the sem.sparql and sem.sparqlValues functions in Javascript. 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 117.

Note: Although some of the semantics functions are built-in, others are not, so we recommend that you import the Semantics API library into every XQuery module or JavaScript module that uses the Semantics API.

Using XQuery, the import statement is:

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

For Javascript, the import statement is:

```javascript
var sem = require("/MarkLogic/semantics.xqy");
```

6.2.2.1 sem:sparql

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

Using XQuery the query would look like:

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

SELECT ?predicate ?object
WHERE { bill:h963 ?predicate ?object }
')
```
Using Javascript, the query would be:

```javascript
var sem = require("/MarkLogic/semantics.xqy");

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

**Note:** In JavaScript, you cannot have a string literal span multiple lines. You must put them together with a "+" or "\".

The XQuery code returns an array as a sequence, whereas the JavaScript code returns a ValueIterator. See [ValueIterator](#) in the [JavaScript Reference Guide](#) for more information.

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

<table>
<thead>
<tr>
<th>predicate</th>
<th>object</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://www.rdfabout.com/wrd/schema/number">http://www.rdfabout.com/wrd/schema/number</a></td>
<td>c27eb564.14039b22ed1-3313</td>
</tr>
<tr>
<td><a href="http://www.w3.org/1999/02/22-rdf-syntax-ns#type">http://www.w3.org/1999/02/22-rdf-syntax-ns#type</a></td>
<td><a href="http://www.rdfabout.com/rdf/scHEMA/usbill/houseBill">http://www.rdfabout.com/rdf/scHEMA/usbill/houseBill</a></td>
</tr>
<tr>
<td><a href="http://purl.org/doctypes/created">http://purl.org/doctypes/created</a></td>
<td>&quot;2003-02-27&quot;</td>
</tr>
<tr>
<td><a href="http://www.rdfabout.com/wrd/schema/number/number">http://www.rdfabout.com/wrd/schema/number/number</a></td>
<td>&quot;963&quot;</td>
</tr>
<tr>
<td><a href="http://purl.org/doctypes/lastUpdated">http://purl.org/doctypes/lastUpdated</a></td>
<td>&quot;H. R. 103/963. To redesignate the facility of the United States Postal Service located at 2777 Logan &quot;Cesar E. Chavez Post Office&quot;.&quot;</td>
</tr>
<tr>
<td><a href="http://www.w3.org/2000/01/rdf-schema#sameAs">http://www.w3.org/2000/01/rdf-schema#sameAs</a></td>
<td>&quot;H. R. 983: To redesignate the facility of the United States Postal Service located at 2777 Logan Av. &quot;Cesar E. Chavez Post Office&quot;. (108th Congress)&quot;</td>
</tr>
<tr>
<td><a href="http://www.rdfabout.com/wrd/schema/number/type">http://www.rdfabout.com/wrd/schema/number/type</a></td>
<td>&quot;h&quot;</td>
</tr>
<tr>
<td><a href="http://www.rdfabout.com/wrd/schema/number/introduction">http://www.rdfabout.com/wrd/schema/number/introduction</a></td>
<td>&quot;introduced&quot;</td>
</tr>
<tr>
<td><a href="http://www.rdfabout.com/wrd/schema/number/introduced">http://www.rdfabout.com/wrd/schema/number/introduced</a></td>
<td>&quot;2003-02-27&quot;</td>
</tr>
</tbody>
</table>

For more information about constructing SPARQL queries, see “Constructing a SPARQL Query” on page 76.
You can also construct your SPARQL query as an input string in a FLWOR statement. In the following 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:

```xml
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
```

### 6.2.2.2 `sem:sparql-values`

Use the `sem:sparql-values` function to allow sequences of bindings to restrict what a SPARQL query returns. In this example, a sequence of values are bound to the subject IRIs that represent two members of congress.

```xml
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:

<table>
<thead>
<tr>
<th>s</th>
<th>p</th>
<th>o</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://www.rdfabout.com/rdf/usgov/congress/people/A000369">http://www.rdfabout.com/rdf/usgov/congress/people/A000369</a></td>
<td><a href="http://www.w3.org/2001/vcard-rdf/3.0#N">http://www.w3.org/2001/vcard-rdf/3.0#N</a></td>
<td>276e05f94 114008b2</td>
</tr>
<tr>
<td><a href="http://www.rdfabout.com/rdf/usgov/congress/people/A000369">http://www.rdfabout.com/rdf/usgov/congress/people/A000369</a></td>
<td><a href="http://www.rdfabout.com/rdf/schema/politics/hasRole">http://www.rdfabout.com/rdf/schema/politics/hasRole</a></td>
<td>705fa6e 1403c27</td>
</tr>
<tr>
<td><a href="http://www.rdfabout.com/rdf/usgov/congress/people/A000369">http://www.rdfabout.com/rdf/usgov/congress/people/A000369</a></td>
<td><a href="http://www.rdfabout.com/rdf/schema/politics/hasRole">http://www.rdfabout.com/rdf/schema/politics/hasRole</a></td>
<td>705fa6e 1403c27</td>
</tr>
<tr>
<td><a href="http://www.rdfabout.com/rdf/usgov/congress/people/A000369">http://www.rdfabout.com/rdf/usgov/congress/people/A000369</a></td>
<td><a href="http://www.xmms.com/leaf/0.1/name">http://www.xmms.com/leaf/0.1/name</a></td>
<td>&quot;Daniel Akaka&quot;</td>
</tr>
</tbody>
</table>

The `sem:sparql-values` function can be considered as equivalent to the SPARQL 1.1 facility of an outermost `VALUES` block. See “Values Sections” on page 101 for more information.

Everywhere you use a variable in a SPARQL values query, you can set the variable to a fixed value by passing in external bindings as arguments to `sem:sparql-values`. See “Using Bindings for Variables” on page 123.

### 6.2.2.3 `sem:store`

The `sem:store` function contains a set of criteria used to select the set of triples to be passed in to `sem:sparql`, `sem:sparql-values`, or `sem:sparql-update` and evaluated as part of the query. The triples included in `sem:store` come from the current database’s triple index, restricted by the options and the `cts:query` argument in `sem:store` (for instance “all triples in documents matching this query”). If multiple `sem:store` constructors are supplied, the triples from all the sources are merged and queried together.

If a `sem:store` constructor is not supplied as an option for `sem:sparql`, `sem:sparql-values`, or `sem:sparql-update`, then the default `sem:store` constructor for the query will be used (the default database’s triple index).
6.2.2.4 Querying Triples in Memory

You can use `sem:in-memory-store` to query triples in memory.

For example:

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

let $triples := sem:rdf-parse($string, ("turtle", "myGraph"))
let $query := '
PREFIX ad: <http://marklogic.com/addressbook/>
PREFIX d:  <http://marklogic.com/id/>
CONSTRUCT{ ?person ?p ?o .}
FROM <myOtherGraph>
WHERE
{
  ?person ad:firstName "Elvis" ;
  ad:lastName  "Presley" ;
  ?p ?o .
}
,'
for $result in sem:sparql($query, (), (), sem:in-memory-store($triples))
order by sem:triple-object($result)
return <result>{$result}</result>
```

This query constructs a graph of triples in memory named “myGraph” containing persons named Elvis with a last name of Presley. The source of these triples is “myOtherGraph” and the results are returned in order.

6.2.3 Using Bindings for Variables

Extensions to standard SPARQL enable you to use bindings for variables in the body of a query statement. Everywhere you use a variable in a SPARQL query, you can set the variable to a fixed value by passing in external bindings as arguments to `sem:sparql`.

Bindings for variables can also be used as values in `OFFSET` and `LIMIT` clauses (in the syntax where they previously were not allowed). This example query uses bindings for variables with both `LIMIT` and `OFFSET`.

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

let $query := '
PREFIX bb: <http://marklogic.com/baseball/players/>
```
SELECT ?firstname ?lastname ?team
FROM <SportsTeams>
{
  {
    ?s bb:team ?team .
    FILTER (?position = ?pos)
  }
}
ORDER BY ?lastname
LIMIT ?lmt
'
let $mymap := map:map()
let $put := map:put($mymap, "pos", "pitcher")
let $put := map:put($mymap, "lmt", "3")
let $triples := sem:sparql($query, $mymap)
let $triples-xml := sem:query-results-serialize($triples, "xml")
return <results>{$triples-xml}</results>

=>
<results>
<sparql xmlns="http://www.w3.org/2005/sparql-results/">
  <head>
    <variable name="firstname"></variable>
    <variable name="lastname"></variable>
    <variable name="team"></variable>
  </head>
  <results>
    <result>
      <binding name="firstname">
        <literal datatype="http://www.w3.org/2001/XMLSchema#string">
          Fernando
        </literal>
      </binding>
      <binding name="lastname">
        <literal datatype="http://www.w3.org/2001/XMLSchema#string">
          Abad
        </literal>
      </binding>
      <binding name="team">
        <literal datatype="http://www.w3.org/2001/XMLSchema#string">
          Athletics
        </literal>
      </binding>
    </result>
    <result>
      <binding name="firstname">
        <literal datatype="http://www.w3.org/2001/XMLSchema#string">
          Jesse
        </literal>
      </binding>
      <binding name="lastname">
        <literal datatype="http://www.w3.org/2001/XMLSchema#string">
          Chavez
        </literal>
      </binding>
    </result>
  </results>
</sparql>
<binding name="team">
  <literal datatype="http://www.w3.org/2001/XMLSchema#string">
    Athletics
  </literal>
</binding>
</result>

<result>
  <binding name="firstname">
    <literal datatype="http://www.w3.org/2001/XMLSchema#string">
      Ryan
    </literal>
  </binding>

  <binding name="lastname">
    <literal datatype="http://www.w3.org/2001/XMLSchema#string">
      Cook
    </literal>
  </binding>

  <binding name="team">
    <literal datatype="http://www.w3.org/2001/XMLSchema#string">
      Athletics
    </literal>
  </binding>
</result>

<results>
</sparql>

Bindings can be used with SPARQL (sem:sparql), SPARQL values (sem:sparql-values), and SPARQL Update (sem:sparql-update). See “Bindings for Variables” on page 171 for an example of bindings for variables used with SPARQL Update.

### 6.2.4 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
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:

```xml
<sparql xmlns="http://www.w3.org/2005/sparql-results#">
  <head>
    <variable name="bill"/>
    <variable name="person"/>
    <variable name="name"/>
  </head>
  <results>
  <result>
    <binding name="bill">
      <value>http://www.rdfabout.com/rdf/usgov/congress/108/bills/s1024</value>
    </binding>
  </result>
  <result>
    <binding name="person">
      <value>http://www.rdfabout.com/rdf/usgov/congress/people/C008888</value>
    </binding>
    <binding name="name">
      <literal datatype="http://www.w3.org/2001/XMLSchema#string">Michael Crapo</literal>
    </binding>
  </result>
  <result>
    <binding name="bill">
      <value>http://www.rdfabout.com/rdf/usgov/congress/108/bills/s1024</value>
    </binding>
    <binding name="person">
      <value>http://www.rdfabout.com/rdf/usgov/congress/people/C001041</value>
    </binding>
    <binding name="name">
      <literal datatype="http://www.w3.org/2001/XMLSchema#string">Hillary Clinton</literal>
    </binding>
  </result>
  </results>
</sparql>
```

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

For example:

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

For example:

```xml
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 serialization options available for the output:

<table>
<thead>
<tr>
<th>Serialization</th>
<th>Output As</th>
</tr>
</thead>
<tbody>
<tr>
<td>ntriple</td>
<td>xs:string</td>
</tr>
<tr>
<td>nquad</td>
<td>xs:string</td>
</tr>
<tr>
<td>turtle</td>
<td>xs:string</td>
</tr>
<tr>
<td>rdfxml</td>
<td>an element</td>
</tr>
<tr>
<td>rdfjson</td>
<td>a json:object</td>
</tr>
<tr>
<td>triplexml</td>
<td>a sequence of sem:triple elements</td>
</tr>
</tbody>
</table>

You can also select different ways to display results. See “Selecting Results Rendering” on page 75.

**6.2.5 Working with CURIEs**

A CURIE (Compact URI Expression) is a shortened version of a URI signifying a specific resource. With MarkLogic, lengthy 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:

```xml
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("rdfs", "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:

```xml
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 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`.

```xml
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)
```
In the following 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 $subject := sem:triple-subject($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:

```xml
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)
```

Instead, either of the following can be used:

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

Or alternatively expand the prefix to the full IRI:

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

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.
6.2.6 Using Semantics with cts Searches

This section discusses using cts searches to return RDF data from a MarkLogic triple store. It includes the following topics:

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

6.2.6.1 cts:triples

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

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

```xml
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 triples for that member of congress (Archibald Darragh):

```xml
@prefix xs: <http://www.w3.org/2001/XMLSchema> .
<http://www.rdfabout.com/rdf/usgov/congress/people/D000060> <http://www.w3.org/2001/vcard-rdf/3.0#N> _:bnoded8fa5e4a8e4e0d3d82 ;
    <http://www.rdfabout.com/rdf/schema/politicalhasRole> _:bnoded483c5e3c733a0bf , _:bnoded4a2c5c473290b7bf , _:bnoded69e6f612f0bd ;
    <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://www.rdfabout.com/rdf/schema/political/Politician> ,
    <http://xmlns.com/foaf/0.1/Person> ;
<http://www.w3.org/2001/vcard-rdf/3.0#BDAY> "1840-12-23"^^xs:string ;
<http://www.rdfabout.com/rdf/schema/usgov/name> "Archibald Darragh"^^xs:string ;
<http://xmlns.com/foaf/0.1/name> "Archibald Darragh"^^xs:string ;
<http://xmlns.com/foaf/0.1/gender> "male"^^xs:string .
```
6.2.6.2 cts:triple-range-query

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
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)
```

6.2.6.3 cts:search

The built-in cts 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
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
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(
```
You can construct sequences in SPARQL expressions and the SPARQL 1.1 IN and NOT IN operators to make effective use of built-in cts functions such as cts:and-query, which expect a sequence of cts:query values as the first argument.

You can also use cts:order constructors as an option to cts:search to to specify an ordering. This lets you order cts search results using a specified index for better, predictable performance. See Creating a cts:order Specification in the Query Performance and Tuning Guide.

### 6.2.6.4 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 91.

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:

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

SELECT DISTINCT *
WHERE
   FILTER cts:contains(?o, cts:word-query("Environment")) } )
=>
53
```

The following example is a simple cts query to verify if there is a bill number “hr543”.

```xml
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
```
6.3 Serialization

You can set the output serialization for results in a variety of ways. These options can be set at the query level as part of the JSON or XQuery function to override any default options, or you could set the method in an XQuery declaration, or the method can be configured in the app server. These output options affect how data returned from the App Server or sent over REST is serialized.

6.3.1 Setting the Output Method

You can set the output method for the results of your query in the following ways. Each method overrides the next method in the list:

- set an option to `xdmp:quote()`
- set `xdmp:set-response-output-method()`
- set the XSLT output method
- Use a static declaration in XQuery (or JavaScript)
- Configure the output in app server

In otherwords, any configuration you have set in the app server will be overwritten by a static declaration in XQuery or Javascript.

To set the output method in an XQuery declaration use:

```xml
declare option xdmp:output "method = sparql-results-json"
```

To set the output method as part of an XQuery function use:

```xml
set-response-output-method("sparql-results-json")
```

As part of a server-side JavaScript function use to set the output method:

```javascript
setResponseOutputMethod("sparql-results-json")
```

6.4 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.

<table>
<thead>
<tr>
<th>Task</th>
<th>Privilege</th>
</tr>
</thead>
</table>

For more information about MarkLogic security, see Document Permissions in the Understanding and Using Security Guide.
7.0 Inference

In the context of MarkLogic Semantics, and Semantic technology in general, the process of “inference” involves the automated discovery of new facts based on a combination of data and rules for understanding that data. Inference is the process of “inferring” or discovering new facts about your data based on a set of rules. Inference with semantic triples means that automatic procedures can generate new relationships (new facts) from existing triples.

An inference query is any SPARQL query that is affected by automatic inference, that is automatic processing by a computer program. The W3C specification describing inference, with links to related standards, can be found here: http://www.w3.org/standards/semanticweb/inference

New facts may be added to the database (forward-chaining inference), or they may be inferred at query time (backward chaining inference), depending on the implementation. MarkLogic supports backward-chaining inference.

This chapter includes the following sections:

- Automatic Inference
- Other Ways to Achieve Inference
- Using Inference with the REST API
- Summary of APIs Used for Inference

7.1 Automatic Inference

Automatic inference is done using rulesets and ontologies. As the name implies, automatic inference is performed automatically and can also be centrally managed. MarkLogic semantics uses backward-chaining inference, meaning that the inference is performed at query time. This is very flexible - it means you can specify which ruleset(s) and ontology (or ontologies) to use per-query, with defaults per-database.

This section includes these topics:

- Ontologies
- Rulesets
- Memory Available for Inference
7.1.1 Ontologies

An ontology is used to describe your data; it describes relationships in your data that can be used to infer new facts about your data. What data is related to what other data, and how is it related? In Semantics, an ontology is a set of triples that provides a semantic model of a portion of the world, a model that enables knowledge to be represented for a particular domain (relationships between people, types of publications, or a taxonomy of medications). This knowledge model is a collection of triples used to describe the relationships in your data. Different vocabularies can supply sets of terms to define concepts and relationships to represent facts.

An ontology describes what types of things exist in the domain (classes), the relationships between them (properties), and the logical ways that they can be used together. A vocabulary is composed of terms with clear definitions controlled by some internal or external authority. An ontology is a vocabulary expressed in a language like OWL (Web Ontology Language) or RDFS (Resource Description Framework Schema).

For example, the ontology triple ex:color owl:equivalentProperty ex:hue states that hue and color are equivalent properties.

This SPARQL Update example inserts that ontology triple into a graph.

```
PREFIX owl: <http://www.w3.org/2002/07/owl/>
PREFIX ex: <http://example.org/>

INSERT DATA
{
  GRAPH <http://marklogic.com/semantics/products/inf-1>
  {
    ex:color owl:equivalentProperty ex:hue .
  }
}
```

You may want to use an ontology you have created to model your business or your area of research, and use that along with one or more rulesets to discover additional information about your data.

There are a number of ways to choose an ontology used to do inference:

- Use **FROM** or **FROM NAMED/GRAPH** in the query to specify what data is being accessed. Ontologies are organized by collection/named graph.
- Use **default-graph=** and **named-graph=** options to **sem:sparql** or **sem:sparql-update**.
- Use a **cts:query** to include/exclude data to be queried. Ontologies can be organized by directory, or anything else that a cts:query can find.
- Add the ontology to an in-memory store, and query across both the database and the in-memory store. In this case, the ontology is not stored in the database, and can be manipulated and changed for each query.
• Add the ontology to a ruleset as axiomatic triples. Axiomatic triples are triples that the ruleset says are always true - indicated by having an empty WHERE clause in the rule. You can then choose to include the ontologies in certain ruleset files or not at query time.

Here is a JavaScript example of a SPARQL query where an ontology is added to an in-memory store:

```javascript
var sem = require("/MarkLogic/semantics.xqy");

var inmem = sem.inMemoryStore(sem.rdfParse('"
prefix ch: <http://marklogic.com/semantics/cheeses/>
prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
prefix owl: <http://www.w3.org/2002/07/owl#>
prefix dcterms: <http://purl.org/dc/terms/>

ch:FreshGoatsCheese owl:intersectionOf ( 
    ch:SoftFreshCheese
    [ owl:hasValue ch:goatsMilk ;
      owl:onProperty ch:milkSource ]
) .'"'),"turtle"));
var rules = sem.rulesetStore(""
["intersectionOf.rules","hasValue.rules"],
inmem,sem.store());

sem.sparql(""
prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
prefix dcterms: <http://purl.org/dc/terms/>
prefix f: <http://linkedrecipes.org/schema/>
prefix ch: <http://marklogic.com/semantics/cheeses/>

select ?title ?ingredient WHERE {
    ?recipe dcterms:title ?title ;
    f:ingredient [ 
        a ch:FreshGoatsCheese ;
        rdfs:label ?ingredient]
}"",[],[],rules)
```

The query searches for a recipe using fresh soft cheese made of goat’s milk and returns the title of the recipe. To get results back from this query, you would need to have a triplestore of recipes, along with some triples describing cheese made from goat’s milk.
7.1.2 Rulesets

A ruleset is a set of inference rules, rules that can be used to infer additional facts. Rulesets are used by the inference engine in MarkLogic to infer new triples at query time from existing triples. A ruleset may be built up by importing other rulesets.

When inference is done at query time using rulesets, it is referred to as “backward chaining” inference. The rules are applied at query time; each SPARQL query looks at the specified ruleset and creates new triples as a result. This type of inferencing is faster during ingestion and indexing, but potentially a bit slower at query time.

For example, if I know that John lives in London and London is in England, I (as a human) know that John lives in England. I inferred that fact. Similarly, if there are triples in the database that say that John lives in London and London is in England, and there are triples that express the meaning of “lives in” and “is in” as part of an ontology, MarkLogic can infer that John lives in England. When you query your data for all the people that live in England, John will be included in the results.

Here is a simple rule to express the concept of “lives in”:

```
# geographic rules for inference
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema/>
PREFIX ex: <http://example.com/>
PREFIX gn: <http://www.geonames.org/ontology/>

rule "livesIn" CONSTRUCT {
  ?person ex:livesIn ?place2
} {
  ?person ex:livesIn ?place1 .
  ?place1 gn:parentFeature ?place2
}
```

This rule states (reading from the bottom up): if place1 is in (has a parentFeature) place2, and a person lives in place1, then a person also lives in place2.

In general, inference is more expensive as you add more (and more complex) rules. MarkLogic allows you to apply just the rulesets you need for each query. For convenience, you can specify the default rulesets for a database, but you can also ignore those defaults for some queries. It is possible to override the default ruleset association to allow querying without using inferencing and/or querying with alternative rulesets.
### 7.1.2.1 Using Rulesets

Inference rules enable you to search over both asserted triples and inferred triples. The semantic inference engine uses rulesets to create new triples from existing triples at query time. You can associate one or more rulesets with a database, so that by default, queries made against that database will include the ruleset. You can also specify one or more rulesets for each query at query time.

A ruleset location is either a URI in the Schemas database for the database you are using, or a file name in <MarkLogic Install Directory>/Config, which contains standard, pre-defined rulesets such as rdfs, rdfs+ and OWL-Horst. The pre-defined rulesets can be specified as a simple name rather than a URI in a Schemas database (like /rules/livesIn.rules).

These standards-based rulesets (RDFS, RDFS-Plus, and OWL Horst) are included with MarkLogic. Each ruleset has two versions; the full ruleset (xxx-full.rules) and the optimized version (xxx.rules). The components of each of these rulesets are available separately so that you can do fine-grained inference for queries. You can create your own rulesets by importing some of those rulesets and/or writing your own rules.

To see these rulesets (in Linux), go to your MarkLogic install directory, then the Config directory under that (/<MarkLogic_install_dir>/Config/*.*.rules). There you will see a set of files with a .rules extension.

```
/opt/MarkLogic/Config/*.*.rules
```

Each of these .rules files is a ruleset. If you open one in a text editor you will see that the rulesets are componentized – that is, they are defined in small component rulesets, then built up into larger rulesets. Here is an example of the rule domain.rules:

```xml
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema/>

...  

rule "domain rdfs2" CONSTRUCT {  
  ?x a ?c  
}  
  
  ?p rdfs:domain ?c  
```

In this example, a means “type of” (rdf:type or rdfs:type). This rule states that if all the things in the second set of braces matches a triple (p has domain c - that is, for every triple that has the predicate p, the object must be in the domain c), then construct the triple in the first set of braces (if you see x p y, then x is a c).

By using a building block approach to creating and using rules, you can enable only the rules you really need, so that your query can be as efficient as possible.
**Note:** If you have a default ruleset associated with a database and you specify a ruleset as part of your query, both rulesets will be used. Rulesets are additive. Use the `no-default-ruleset` option to ignore the default ruleset.

This example uses the `rdfs.rules` ruleset from the `<MarkLogic-install-dir>/Config` location:

```xml
import module namespace sem = "http://marklogic.com/semantics"
at "'/MarkLogic/semantics.xqy";
let $sup :=

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>

INSERT DATA
{ <someMedicalCondition> rdf:type <osteoarthritis> .
<osteoarthritis> rdfs:subClassOf <bonedisease> . }
return sem:sparql-update($sup)
; (: transaction separator :) 

let $sq :=

'PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX d: <http://diagnoses#>
PREFIX foaf: <http://xmlns.com/foaf/0.1/>
SELECT ?diagnosis
WHERE { ?diagnosis rdf:type <bonedisease>. } ' 

let $rs := sem:ruleset-store("rdfs.rules", sem:store() )

(: rdfs:rules is a predefined rule set in <MarkLogic-install-dir>/Config :) 
return sem:sparql($sq, (), (), $rs)
(: the rules specify that query for <bonedisease> will return the subclass <osteoarthritis> :) 

You can manage rulesets using the REST Mangement API or XQuery Admin API. For details see the default-ruleset property in `<PUT:/manage/v2/databases/{id|name}/properties` and `admin:database-add-default-ruleset`.

### 7.1.2.2 Choosing Rulesets for Queries

You can choose which rulesets to use for your SPARQL query by using `sem:ruleset-store`. The `sem:ruleset-store` function returns a set of triples that result from the application of the ruleset to the triples defined by the `sem:store` function provided in `$store` (for example, “all of the triples that can be inferred from the rule”).

This statement specifies the `rdfs.rules` ruleset as part of `sem:ruleset-store`:

```xml
```
So this says, let the $rdf-store contain triples derived by inference using the rdfs.rules against the sem:store. If no value is provided for sem:store, the query uses the triples in the current database’s triple index. The built-in functions sem:store and sem:ruleset-store are used to define the triples over which to query and the rulesets (if any) to use with the query. The $store definition includes a ruleset, as well as other ways of restricting a query’s domain, such as a cts:query.

This example executes a SPARQL query against the data in $triples, using the inference rules rdfs:subClassOf and rdfs:subPropertyOf:

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

PREFIX skos: <http://www.w3.org/2004/02/skos/core#Concept/>

sem:sparql("select * { ?c a skos:Concept; rdfs:label ?l }",(),(),
sem:ruleset-store(("subClassOf.rules","subPropertyOf.rules"),
($triples)
)
```

### 7.1.2.3 Specifying a Default Ruleset for a Database

In addition to the Admin API with XQuery, you can also use the Admin UI to set the default ruleset to be used with a database for queries. To specify the ruleset or rulesets for a database, click the database name under Databases in left-hand navigation in the Admin UI. Click the database name to expand the list. Scroll to Default Rulesets.
Click Default Rulesets to see the rulesets currently associated with the Documents database.
To add your own ruleset, click Add to enter the name and location of the ruleset.

Your custom rulesets will be located in the Schemas database. The rulesets supplied by MarkLogic are located in the Config directory under your MarkLogic installation directory (`/<MarkLogic_install_dir>/Config/*.rules`).

Click more items to associate additional rulesets with this database.

**Note:** Security for rulesets is managed the same way that security is handled for MarkLogic schemas.

You can use Query Console to find out what default rulesets are currently associated with a database using the `admin:database-get-default-rulesets` function.
This example will return the name and location of the default rulesets for the Documents database:

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

let $config := admin:get-configuration()
let $dbid := admin:database-get-id($config, "Documents")
return admin:database-get-default-rulesets($config, $dbid)

=>
<default-ruleset xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xmlns="http://marklogic.com/xdmp/database">
   <location>/rules/livesin.rules</location>
</default-ruleset>
```

### 7.1.2.4 Overriding the Default Ruleset

You can turn off or ignore a ruleset set as the default on a database. In this example, a SPARQL query is executed against the database, ignoring the default rulesets and using the rdfs:subClassOf inference ruleset for the query:

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

PREFIX skos: <http://www.w3.org/2004/02/skos/core#Concept/>

sem:spaqrl("SELECT * {
    ?c a skos:Concept;
    rdfs:label ?l }",(),(),
   sem:ruleset-store("subClassOf.rules",sem:store("no-default-rulesets"))
 )
```

You can also turn off or ignore a ruleset as part of a query, through the Admin UI, or by using XQuery or JavaScript to specify the ruleset.
You can also change the default ruleset for a database in the Admin UI by “deleting” the default ruleset from that database. In the Admin UI, select the database name from the left-hand navigation panel, click the database name. Click Default Rulesets.

On the Database: Documents panel, select the default ruleset you want to remove, and click delete. Click OK when you are done. The ruleset is no longer the default ruleset for this database.

**Note:** This action does not delete the ruleset, only removes it as the default ruleset.

You can also use `admin:database-delete-default-ruleset` with XQuery to change a database’s default ruleset. This example removes `subClassOf.rules` as the default ruleset for the Documents database.

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

let $config := admin:get-configuration()
let $dbid := admin:database-get-id($config, "Documents")
let $rules := admin:database-ruleset("subClassOf.rules")
let $c := admin:database-delete-default-ruleset($config, $dbid, $rules)

return admin:save-configuration($c)```
7.1.2.5 Creating a Ruleset

One way to think of inference rules is as a way to construct some inferred triples, then search over the new data set (one that includes the database - the `sem:store` - plus the inferred triples). MarkLogic rulesets have the `.rules` extension and are located in the install directory:

```
/<MarkLogic_install_dir>/Config/*.rules
```

**Note:** When you create your own rulesets, you will store them in the Schemas database.

The syntax of an inference rule uses the grammar of a SPARQL `CONSTRUCT` with the `WHERE` clause restricted to a combination of only triple patterns, joins, and filters.

The ruleset must have a unique name. If the name is used more than once, the operation will return an error. The import statement in the prolog of the ruleset file includes all rules from the ruleset found at the location given.

This ruleset from the `/<MarkLogic Install>/Config` directory includes four rules named `rdfs8`, `rdfs9`, `rdfs10`, and `rdfs11`. The ruleset includes prefixes, and each rule has a rule name and a `CONSTRUCT` clause:

```sparql
PREFIX rdf:   <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs:  <http://www.w3.org/2000/01/rdf-schema#>

rule "rdfs8" CONSTRUCT {
    ?c rdfs:subClassOf rdfs:Resource
} {
    ?c a rdfs:Class
}

rule "rdfs9" CONSTRUCT {
    ?x a ?c2
} {
    ?x a ?c1 .
    ?c1 rdfs:subClassOf ?c2 .
    FILTER(?c1!=?c2)
}

rule "rdfs10" CONSTRUCT {
    ?c rdfs:subClassOf ?c
} {
    ?c a rdfs:Class
}

rule "rdfs11" CONSTRUCT {
    ?c1 rdfs:subClassOf ?c3
} {
    ?c1 rdfs:subClassOf ?c2 .
    ?c2 rdfs:subClassOf ?c3 .
}
Note that two of the rules also include a **FILTER** clause.

This ruleset from same directory imports smaller rulesets to make a ruleset approximating the full RDFS ruleset:

```xml
import "rdf.rules"
import "domain.rules"
import "range.rules"
import "subPropertyOf.rules"
import "subClassOf.rules"

PREFIX rdf:   <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs:  <http://www.w3.org/2000/01/rdf-schema#>

# Miscellaneous other axiomatic triples

rule "rdfs properties" CONSTRUCT {
    rdf:type rdfs:domain rdfs:Resource .
    rdf:type rdfs:range rdfs:Class .
}
```

If a ruleset at a given location is imported more than once, the effect of the import will be the same as if it had only been imported once. If a ruleset is imported more than once from different locations (for example from the `/<MarkLogic Install>/Config` directory and from the Schemas database directory), MarkLogic will assume they are different rulesets and raise an error if they contain duplicate rule names.

Here is a rule that you could create to infer geographic locations:

```xml
# geographic rules for inference
PREFIX rdf:   <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs:  <http://www.w3.org/2000/01/rdf-schema#>
PREFIX ex:    <http://example.com/>  
PREFIX gn:    <http://www.geonames.org/ontology/>  

rule "lives in" CONSTRUCT {
    ?person ex:livesIn ?place2
} {
    ?person ex:livesIn ?place1 .
    ?place1 gn:parentFeature ?place2
}
```
In Query Console, you can add the livesIn rule to the Schemas database using xdmp:document-insert. Make sure the Schemas database is selected as the Content Source before you run the code:

```xquery
xquery version "1.0-ml";

xdmp:document-insert(
'/rules/livesin.rules',
'text{

# geographic rules for inference
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema/>
PREFIX ex: <http://example.com/>
PREFIX gn: <http://www.geonames.org/ontology/>

rule "lives in" CONSTRUCT {
  ?person ex:livesIn ?place2
}
  ?person ex:livesIn ?place1 .
  ?place1 gn:parentFeature ?place2
}
')
```

The example stores the livesin.rule in the Schemas database, in the rules directory (/rules/livesin.rules).

You can include your ruleset as part of inference in the same way you can include the supplied rulesets. MarkLogic will check the location for rules in the Schemas database and then the location for the supplied rulesets.

### 7.1.3 Memory Available for Inference

The default, maximum, and minimum inference size values are all per-query, not per-system. The maximum inference size is the memory limit for inference. The `appserver-max-inference-size` function allows the administrator to set a memory limit for inference. You cannot exceed this amount.

The default inference size is the amount of memory available to use for inference. By default the amount of memory available for inference is 100mb (`size=100`). If you run out of memory and get an inference full error (`INFFULL`), you need to increase the default memory size using `appserver-set-default-inference-size` or by changing the default inference size on the HTTP Server Configuration page in the Admin UI.

You can also set the inference memory size in your query as part of `sem:ruleset-store`. This query sets the memory size for inference to 300mb (`size=300`):
Let $store := \text{sem:ruleset-store}((\text{"baseball.rules"}, \text{"rdfs-plus-full.rules"}), \text{\text{sem:store}}(), \text{\{"size=300"\}})$

If your query returns an INFFULL exception, you can change the size in ruleset-store.

### 7.2 Other Ways to Achieve Inference

Before going down the path of automatic inference, you should consider other ways to achieve inference, which may be more appropriate for your use case.

This section includes these topics:

- [Inference Using Paths](#)
- [Materialization](#)

#### 7.2.1 Inference Using Paths

In many cases, you can do inference by rewriting your query. For example, you can do some simple inference with using unenumerated property paths. Property paths (as explained in “Property Path Expressions” on page 106) enable a simple kind of inference.

You can find all the possible types of a resource, including supertypes of a resource, using RDFS and the “/” property path in a SPARQL query:

```sparql
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2001/01/rdf-schema#>
SELECT ?type
{<http://example/thing> rdf:type/rdfs:subClassOf* ?type}
```

The result will be all resources and their inferred types. The unenumerated property path expression with the asterisk (*) will look for a path that connects the subject and the object of the path by zero or more matches of a predicate (rdfs:subClassOf in the example).

For example, you could use this query to find the products that are subclasses of “shirt”:

```sparql
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX ex: <http://example.com>

SELECT ?product
WHERE
{ ?product rdf:type/rdfs:subClassOf* ex:Shirt ;
}
```
Or you could use a property path to find people who live in England:

```sparql
PREFIX gn: <http://www.geonames.org/ontology/>
PREFIX ex: <http://www.example.org>

SELECT ?p
{
  ?p ex:livesIn/gn:parentFeature "England"
}
```

For more about property paths and how to use them with semantics, see “Property Path Expressions” on page 106.

### 7.2.2 Materialization

A possible alternative to automatic inference is materialization, or forward-chaining inference, where you perform inference on your data as a whole, not as part of a query; and then store those inferred triples to be queried later. Materialization will work best for triple data that is fairly static, performing inference with rules and ontologies that do not change often.

To materialize these triples, construct SPARQL queries for the rules that you want to use for inference and run them on your data.

This process of materialization may be time consuming and will require a significant amount of memory for storage. You will need to write code or scripts to handle transactions and security, and to handle changes in data and ontologies.

**Note:** These tasks are all handled for you if you choose automatic inference.

Materialization can be very useful if you need very fast queries and you are prepared to do the pre-processing work up front and use the extra disk space for the inferred triples. You may want to use this type of inference in situations where the data, rulesets, and ontologies do not change very much.

### 7.3 Using Inference with the REST API

When you execute a SPARQL query or update using the REST Client API methods

- POST:/v1/graphs/sparql
- GET:/v1/graphs/sparql

you can specify rulesets through request parameters `default-rulesets` and `rulesets`. If you omit both of these parameters, the default rulesets for the database are applied.

After you set `rdfs.rules` and `equivalentProperties.rules` as the default rulesets for the database, you can perform this SPARQL query using REST from the Query Console:

```
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
  at "/MarkLogic/semantics.xqy";
let $uri := "http://localhost:8000/v1/graphs/sparql"
```
return
let $sparql :='PREFIX rdf:    <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs:   <http://www.w3.org/2000/01/rdf-schema#>
PREFIX prod:   <http://example.com/products/>
PREFIX ex:     <http://example.com/>

SELECT ?product
FROM <http://marklogic.com/semantics/products/inf-1>
WHERE
{ ?product rdf:type ex:Shirt ; ex:color "blue" }

let $response :=
xmp:http-post($uri,
<options xmlns="xdmp:http">
  <authentication method="digest">
    <username>admin</username>
    <password>admin</password>
  </authentication>
  <headers>
    <content-type>application/sparql-query</content-type>
    <accept>application/sparql-results+xml</accept>
  </headers>
</options>
text {$sparql})
return

=>

product
<http://example.com/products/1001>
<http://example.com/products/1002>
<http://example.com/products/1003>

Using the REST endpoint and curl (with the same default rulesets for the database), the same
query would look like this:

curl --anyauth --user Admin:janem-3 -i -X POST
-H "Content-type:application/x-www-form-urlencoded"
-H "Accept:application/sparql-results+xml"
SELECT ?product FROM <http://marklogic.com/semantics/products/inf-1>
WHERE {?product rdf:type ex:Shirt ; ex:color "blue"}'
http://localhost:8000/v1/graphs/sparql
See “Using Semantics with the REST Client API” on page 175 and *Querying Triples* in the *REST Application Developer’s Guide* for more information.

### 7.4 Summary of APIs Used for Inference

MarkLogic has a number of APIs that can be used for semantic inference. Semantic APIs are available for use as part of the actual inference query (specifying which triples to query and which rules to apply). Database APIs can be used to choose rulesets to be used for inference by a particular database. Management APIs can control the memory used by inference by either an appserver or a taskserver.

- **Semantic APIs**
- **Database Ruleset APIs**
- **Management APIs**

#### 7.4.1 Semantic APIs

MarkLogic Semantic APIs can be used for managing triples for inference and for specifying rulesets to be used with individual queries (or by default with databases). Stores are used to identify the subset of triples to be evaluated by the query.

<table>
<thead>
<tr>
<th>Semantic API</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>sem:store</strong></td>
<td>The query argument of <code>sem:sparql</code> accepts <code>sem:store</code> to indicate the source of the triples to be evaluated as part of the query. If multiple <code>sem:store</code> constructors are supplied, the triples from all the sources are merged and queried together. The <code>sem:store</code> can contain one or more options along with a <code>cts:query</code> to restrict the scope of the triples to be evaluated as part of the <code>sem:sparql</code> query. The <code>sem:store</code> parameter can also be used with <code>sem:sparql-update</code> and <code>sem:sparql-values</code>.</td>
</tr>
<tr>
<td><strong>sem:in-memory-store</strong></td>
<td>Returns a <code>sem:store</code> that represents the set of triples from the <code>sem:triple</code> values passed in as an argument. The default rulesets configured on the current database have no effect on a <code>sem:store</code> created with <code>sem:in-memory-store</code>.</td>
</tr>
<tr>
<td><strong>sem:ruleset-store</strong></td>
<td>Returns a new <code>sem:store</code> that represents the the set of triples derived by applying the ruleset to the triples in <code>sem:store</code> in addition to the original triples.</td>
</tr>
</tbody>
</table>

**Note:** The `sem:in-memory-store` function should be used with `sem:sparql` in preference to the deprecated `sem:sparql-triples` function (available in MarkLogic 7). The `cts:query` argument to `sem:sparql` has also been deprecated.
If you call `sem:sparql-update` with a store that is based on in-memory triples (that is, a store that was created by `sem:in-memory-store`) you will get an error because you cannot update triples that are in memory and not on disk. Similarly, if you pass in multiple stores to `sem:sparql-update` and any of them is based on in-memory triples you will get an error.

### 7.4.2 Database Ruleset APIs

These Database Ruleset APIs are used to manage the rulesets associated with databases.

<table>
<thead>
<tr>
<th>Ruleset API</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>admin:database-ruleset</td>
<td>The ruleset element to be used for inference on a database. One or more rulesets can be used for inference. By default, no ruleset is configured.</td>
</tr>
<tr>
<td>admin:database-get-default-rulesets</td>
<td>Returns the default ruleset(s) for a database.</td>
</tr>
<tr>
<td>admin:database-add-default-ruleset</td>
<td>Adds a ruleset to be used for inference on a database. One or more rulesets can be used for inference. By default, no ruleset is configured.</td>
</tr>
<tr>
<td>admin:database-delete-default-ruleset</td>
<td>Deletes the default ruleset used by a database for inference.</td>
</tr>
</tbody>
</table>

### 7.4.3 Management APIs

These Management APIs are used to manage memory sizing (default, minimum, and maximum) allotted for inference.

<table>
<thead>
<tr>
<th>Management API (admin:)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>admin:appserver-set-default-inference-size</td>
<td>Specifies the default value for any request’s inference size on this application server.</td>
</tr>
<tr>
<td>admin:appserver-get-default-inference-size</td>
<td>Returns the default amount of memory (in megabytes) that can be used by <code>sem:store</code> for inference by an application server.</td>
</tr>
<tr>
<td>admin:taskserver-set-default-inference-size</td>
<td>Specifies the default value for any request’s inference size on this task server.</td>
</tr>
<tr>
<td>admin:taskserver-get-default-inference-size</td>
<td>Returns the default amount of memory (in megabytes) that can be used by <code>sem:store</code> for inference by a task server.</td>
</tr>
<tr>
<td>Management API (admin:)</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>admin:appserver-set-max-inference-size</td>
<td>Specifies the upper bound for any request’s inference size. The inference size is the maximum amount of memory in megabytes allowed for \texttt{sem:store} performing inference on this application server.</td>
</tr>
<tr>
<td>admin:appserver-get-max-inference-size</td>
<td>Returns the maximum amount of memory (in megabytes) that can be used by \texttt{sem:store} for inference by an application server.</td>
</tr>
<tr>
<td>admin:taskserver-set-max-inference-size</td>
<td>Specifies the upper bound for any request’s inference size. The inference size is the maximum amount of memory in megabytes allowed for \texttt{sem:store} performing inference on this task server.</td>
</tr>
<tr>
<td>admin:taskserver-get-max-inference-size</td>
<td>Returns the maximum amount of memory (in megabytes) that can be used by \texttt{sem:store} for inference by a task server.</td>
</tr>
</tbody>
</table>
8.0 SPARQL Update

The SPARQL1.1 Update language is used to delete, insert, and update (delete/insert) triples and graphs. An update is actually an INSERT/DELETE operation in the database.

SPARQL Update is a part of the SPARQL 1.1 suite of specifications at http://www.w3.org/TR/2013/REC-sparql11-update-20130321. It is a separate language from the SPARQL Query. SPARQL Update enables you to manipulate triples or sets of triples, while the SPARQL query language enables you to search and query your triple data.

You can manage security level using SPARQL Update. All SPARQL queries over managed triples are governed by the graph permissions. Triple documents will inherit those permissions at ingest.

Only triples managed by MarkLogic - triples whose document root is sem:triples - are affected by SPARQL Update. Managed triples are triples that have been loaded into the database using:

- mlcp with -input_file_type RDF
- sem:rdf-load
- sem:rdf-insert
- sem:sparql-update

Embedded triples are part of an XML or JSON document. If you want to create, delete, or update embedded triples, use the appropriate document update functions. See “Embedded Triples” on page 64 for more information about triples embedded in documents. Unmanaged triples can also be modified and updated with document management functions. See “Inserting, Deleting, and Modifying Triples with XQuery and Server-Side JavaScript” on page 237 for details.

This section includes the following parts:

- Using SPARQL Update
- Graph Operations with SPARQL Update
- Graph-Level Security
- Data Operations with SPARQL Update
- Bindings for Variables
- Using SPARQL Update with Query Console
- Using SPARQL Update with XQuery or Server-Side JavaScript
- Using SPARQL Update with REST
8.1 Using SPARQL Update

You can use SPARQL Update to insert and delete managed triples in a Graph Store. There are two kinds of SPARQL Update operations: graph data operations and graph management operations.

There are several ways to use SPARQL Update:

- From Query Console - Select SPARQL Update as the Query Type from the drop-down list. See “Using SPARQL Update with Query Console” on page 172.
- Using XQuery or JavaScript - Call SPARQL Update from XQuery (sem:sparql-update) or JavaScript (sem.sparqlUpdate). See “Using SPARQL Update with XQuery or Server-Side JavaScript” on page 173.
- Through the REST API (GET:/v1/graphs/sparql or POST:/v1/graphs/sparql). See “Using SPARQL Update with REST” on page 174.

SPARQL Update is used with managed triples. To modify “embedded” or unmanaged triples, use the appropriate document update functions with XQuery or JavaScript. See “Inserting, Deleting, and Modifying Triples with XQuery and Server-Side JavaScript” on page 237.

A new role has been added for SPARQL Update - sparql-update-user. Users must have sparql-update-user capabilities to INSERT, DELETE, or DELETE/INSERT triples into graphs. See Role-Based Security Model in the Understanding and Using Security Guide for details.
8.2 Graph Operations with SPARQL Update

You can manipulate RDF graphs using SPARQL Update. Graph management operations include CREATE, DROP, COPY, MOVE, and ADD.

The SPARQL Update spec includes these commands and options for working with RDF graphs:

<table>
<thead>
<tr>
<th>Command</th>
<th>Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREATE</td>
<td>SILENT, GRAPH IRIref</td>
<td>Creates a new graph. Use GRAPH to name the graph. SILENT creates the graph silently. This means if the graph already exists, do not return an error.</td>
</tr>
<tr>
<td>DROP</td>
<td>SILENT, GRAPH IRIref, DEFAULT, NAMED, ALL</td>
<td>Drops a graph and its contents. Use GRAPH to name a graph to remove, DEFAULT to remove the default graph.</td>
</tr>
<tr>
<td>COPY</td>
<td>SILENT, GRAPH, IRIref_from, DEFAULT, TO, IRIref_to</td>
<td>Copies the source graph into the destination graph. Any content in the destination graph will be overwritten (deleted).</td>
</tr>
<tr>
<td>MOVE</td>
<td>SILENT, GRAPH, IRIref_from, DEFAULT, TO, IRIref_to</td>
<td>Moves the contents of the source graph into the destination graph, and removes that content from the source graph. Any content in the destination graph will be overwritten (deleted).</td>
</tr>
<tr>
<td>ADD</td>
<td>SILENT, GRAPH, IRIref_from, DEFAULT, TO, IRIref_to</td>
<td>Add the contents of the source graph to the destination graph. The ADD operation keeps the content of both the source graph and destination graph intact.</td>
</tr>
</tbody>
</table>

Multiple statements separated by semicolons (;) in one SPARQL Update operation, run in the same transaction, and can be included in the same request. It is important to note that each statement can see the result of the previous statements.
For example, in this query, the COPY operation can see the graph <TEST> created in the first statement:

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

INSERT DATA
{
};
COPY <TEST> TO <BOOKS1>
```

**Note:** SPARQL Update operations return the empty sequence.

### 8.2.1 CREATE

This operation creates a graph. If the graph already exists, an error will be returned unless the SILENT option is used. The contents of already existing graphs remain unchanged. If you do not have permission to create the graph, an error is returned (unless the SILENT option is used).

The syntax for a CREATE operation is:

```
CREATE ( SILENT )? GRAPH IRIref
```

If the SILENT option is used, the operation will not return an error. The GRAPH IRIref option specifies the IRI for the new graph.

For example:

```
CREATE GRAPH <http://marklogic.com/semantics/tutorial/update> ;
```

If the specified destination graph does not exist, the graph will be created. The CREATE operation will create a graph with the permissions specified through sem:sparql-update, or with the user’s default permission if no permissions are specified.

### 8.2.2 DROP

The DROP operation removes the specified graph or graphs from the Graph Store. The syntax for a DROP operation is:

```
DROP ( SILENT )? GRAPH IRIref | DEFAULT | NAMED | ALL )
```

The GRAPH keyword is used to remove a graph specified by IRIref. The DEFAULT keyword option is used to remove the default graph from the Graph Store. The NAMED keyword is used to remove all named graphs from the Graph Store. All graphs are removed from the Graph Store with the ALL keyword; this is the same as resetting the Graph store.
For example:

```
DROP SILENT GRAPH <http://marklogic.com/semantics/tutorial/intro> ;
```

After successful completion of this operation, the specified graphs are no longer available for further graph update operations. This operation returns an error if the specified named graph does not exist. If SILENT is present, the result of the operation will always be success.

**Note:** If the default graph of the Graph Store is dropped, MarkLogic creates a new, empty default graph with the user’s default permissions.

### 8.2.3 COPY

The **COPY** operation is used for inserting all of the triples from a source graph into a destination graph. Triples from the source graph are not affected, but triples in the destination graph, if any exist, are removed before the new triples are inserted.

The syntax for a **COPY** operation is:

```
COPY ( SILENT )? ( ( GRAPH )? IRIref_from | DEFAULT) TO ( ( GRAPH )?
  IRIref_to | DEFAULT )
```

The **COPY** operation copies permissions from a source graph to the destination graph. Since source graph has the permission info, $perm parameter in sem:sparql-update does not apply in a **COPY** operation.

For example:

```
COPY <http://marklogic.com/semantics/tutorial/intro> TO
  <http://marklogic.com/semantics/tutorial/start> ;
```

If the destination graph does not exist, it will be created. The operation returns an error if the source graph does not exist. If the SILENT option is used, the result of the operation will always be success.

The **COPY** operation is similar to dropping a graph and then inserting a new graph:

```
DROP SILENT (GRAPH IRIref_to | DEFAULT); INSERT { ( GRAPH IRIref_to )?
  { ?s ?p ?o } } WHERE { ( GRAPH IRIref_from )? { ?s ?p ?o } }
```

If **COPY** is used to copy a graph onto itself, no operation is performed and the data is left as it was.

If you want the update to fail when the destination graph does not already exist, the existing-graph option in sem:sparql-update needs to be specified. If you copy into a new graph, that new graph takes the permissions of the graph that you copied from. If you copy into an existing graph, the permissions of that graph do not change.
8.2.4 MOVE

The MOVE operation is used for moving all triples from a source graph into a destination graph. The syntax for a MOVE operation is:

MOVE (SILENT)? ( ( GRAPH )? IRIref_from | DEFAULT) TO ( ( GRAPH )? IRIref_to | DEFAULT)

The source graph is removed after insertion. Triples in the destination graph, if any exist, are removed before destination triples are inserted.

For example:

MOVE <http://marklogic.com/semantics/tutorial/queries> TO <http://marklogic.com/semantics/tutorialSearches> ;

The graph <http://marklogic.com/semantics/queries> is removed after its triples have been inserted into <http://marklogic.com/semantics/searches>. Any triples in the graph <http://marklogic.com/semantics/searches> are deleted before the other triples are inserted.

Note: If MOVE is used to move a graph onto itself, no operation will be performed and the data will be left as it was.

If the destination graph does not exist, it will be created. The MOVE operation returns an error if the source graph does not exist. If the SILENT option is used, the result of the operation will always be success.

The MOVE operation is similar to:

DROP SILENT (GRAPH IRIref_to | DEFAULT); INSERT { (GRAPH IRIref_to )? { ?s ?p ?o } } WHERE { (GRAPH IRIref_from )? { ?s ?p ?o } };
DROP (GRAPH IRIref_from | DEFAULT)

The MOVE operation moves permissions from source graph to destination graph. Since source graph has the permission info, the $perm parameter in sem:sparql-update does not apply to the operation.

If you want the update to fail when the destination graph does not already exist, the existing-graph option in sem:sparql-update needs to be specified. If you copy into a new graph, that new graph takes the permissions of the graph that you copied from. If you copy into an existing graph, the permissions of that graph do not change.
8.2.5 ADD

The ADD operation is used for inserting all triples from a source graph into a destination graph. The triples from the source graph are not affected, and existing triples from the destination graph, if any exist, are kept intact.

The syntax for an ADD operation is:

\[
\text{ADD} \ ( \text{SILENT})? \ ( \ ( \text{GRAPH} )? \ \text{IRIref\_from} \ | \ \text{DEFAULT}) \ \text{TO} \ ( \ ( \text{GRAPH} )? \ \text{IRIref\_to} \ | \ \text{DEFAULT})
\]

For example:

\[
\text{ADD} \ <\text{http://marklogic.com/semantics/tutorial/queries}> \ \text{TO} \ <\text{http://marklogic.com/semantics/searches}> \ ;
\]

If ADD is used to add a graph onto itself, no operation will be performed and the data will be left as it was. If the destination graph does not exist, it will be created. The ADD operation returns an error if the source graph does not exist. If the SILENT option is used, the result of the operation will always be success.

If you are adding triples into a new graph, you can set the permissions of the new graph through \text{sem:sparql-update}. If no permissions are specified, your default graph permissions will be applied to the graph.

The ADD operation is equivalent to:

\[
\text{INSERT} \ { \ ( \ \text{GRAPH} \ \text{IRIref\_to})? \ { \ ?s \ ?p \ ?o } } \ \text{WHERE} \\
{ \ ( \ \text{GRAPH} \ \text{IRIref\_from})? \ { \ ?s \ ?p \ ?o } } 
\]

If you want the update to fail when the destination graph does not already exist, the existing-graph option in \text{sem:sparql-update} needs to be specified. If you copy into a new graph, that new graph takes the permissions of the graph that you copied from. If you copy into an existing graph, the permissions of that graph do not change.
8.3 Graph-Level Security

You can manage security at the graph level using SPARQL Update. Graph-level security means that only users with a role corresponding to the permissions set on a graph can view a graph, change graph content, or create a new graph. As a user, you can only see the triples and graphs for which you have read permissions (via a role). See Role-Based Security Model in the Understanding and Using Security Guide.

By default, graphs are created with the default permissions of the user creating the graph. If graph permissions are specified by passing in permissions as an argument to the sem:sparql-update call, graph operations and graph management operations that result in the creation of a new graph will use the specified permissions. This is true whether the graph is created explicitly using CREATE GRAPH, or implicitly by inserting or copying triples (INSERT or a graph operation to copy, move, or add) into a graph that does not already exist.

If you pass in permissions with sem:sparql-update on an operation that inserts triples into an existing graph, the permissions you passed in are ignored. If you're copying a graph from one graph to another, the permissions are ignored in favor of “transferring” the data and the permissions from one graph to another.

Note: Graph-level security is enforced for all semantic operations using SPARQL or SPARQL Update, via XQuery or JavaScript, and includes semantic REST functions.

Your default user permissions are set by the MarkLogic administrator. These are the same default permissions for document creation that are discussed in Default Permissions in the Understanding and Using Security Guide.

To see what permissions are currently on a graph, use sem:graph-get-permissions:

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

sem:graph-get-permissions(
    sem:iri("MyGraph"))
=>
<sec:permission xmlns:sec="http://marklogic.com/xdmp/security">
    <sec:capability>read</sec:capability>
    <sec:role-id>5995163769635647336</sec:role-id>
</sec:permission>

<sec:permission xmlns:sec="http://marklogic.com/xdmp/security">
    <sec:capability>update</sec:capability>
    <sec:role-id>5995163769635647336</sec:role-id>
</sec:permission>
```
This returns the two capabilities set on in this graph: read and update. If you have the role with the ID 5995163769635647336, you will be able to read information in this graph, you will be able to see the graph and the triples in the graph. If you have the role with the ID 5995163769635647336, you will be able to update the graph. You must have read capability for the graph to use sem:graph-get-permissions.

**Note:** In a new database, the graph document for the default graph does not exist yet. Once you insert triples into this database, the default graph is created.

To set permissions on a graph, use `sem:graph-set-permissions`:

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

declare namespace sec = "http://marklogic.com/xdmp/security";

sem:graph-set-permissions(sem:iri("MyGraph"),
  (xdmp:permission("sparql-update-role", "update")))
```

This will set the permissions on the graph and the triples in the graph. If the specified IRI does not exist, the graph will be created. You must have update permissions for the graph to set the permissions.

To add permissions to a graph, use `sem:graph-add-permissions`:

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

declare namespace sec = "http://marklogic.com/xdmp/security";

sem:graph-add-permissions(sem:iri("MyGraph"),
  (xdmp:permission("sparql-read-role", "read"),))
```

This will add read permissions for the `sparql-read-role` to the graph and to the triples in the graph. If the graph named by the IRI does not exist, the graph will be automatically created. You must have update permissions for the graph to add permissions to an existing graph.

**Note:** A graph that is created by a non-admin user (that is, by any user who does not have the admin role) must have at least one update permission for the graph, otherwise the creation of the graph will return an XDMP-MUSTHAVEUPDATE exception.
To remove permissions, use `sem:graph-remove-permissions`:

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

declare namespace sec = "http://marklogic.com/xdmp/security";

sem:graph-remove-permissions(sem:iri("MyGraph"),
  (xdmp:permission("sparql-read-role", "read"),))
```

This removes the read permission on “MyGraph” for `sparql-read-role`. You must have update permissions for the graph to remove permissions. If the graph does not exist, this will result in an error.

### 8.4 Data Operations with SPARQL Update

These data operations are part of SPARQL Update: `INSERT DATA`, `DELETE DATA`, `DELETE/INSERT`, `LOAD`, and `CLEAR`. Data operations involve triple data contained in graphs.

SPARQL Update includes these commands and options for working with data in RDF graphs:

<table>
<thead>
<tr>
<th>Command</th>
<th>Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INSERT DATA</strong></td>
<td>QuadData, WITH, GRAPH</td>
<td>Inserts triples into a graph. If no graph is specified, the default graph will be used.</td>
</tr>
<tr>
<td><strong>DELETE DATA</strong></td>
<td>QuadData</td>
<td>Deletes triples from a graph, as specified by QuadData. If no graph is specified, deletes from all in-scope graphs.</td>
</tr>
<tr>
<td><strong>DELETE..INSERT WHERE</strong></td>
<td>WITH, IRIref, USING, NAMED, WHERE, DELETE, INSERT</td>
<td>Remove or add triples from/to the Graph Store based on bindings for a query pattern specified in a <code>WHERE</code> clause.</td>
</tr>
<tr>
<td><strong>DELETE WHERE</strong></td>
<td>WITH, IRIref, USING, NAMED, WHERE, DELETE, INSERT</td>
<td>Remove triples from the Graph Store based on bindings for a query pattern specified in a <code>WHERE</code> clause. <code>DELETE WHERE</code> is <code>DELETE..INSERT WHERE</code> with a missing <code>INSERT</code> (which is optional).</td>
</tr>
</tbody>
</table>
Multiple statements separated by semicolons (;) in one SPARQL Update operation, run in the same transaction, and can be included in the same request. It is important to note that each statement can see the result of the previous statements.

**Note:** SPARQL Update operations return the empty sequence.

Other ways to load triples into MarkLogic: mlcp, `sem:rdf-load`, or the HTTP REST endpoints. See “Loading Triples with mlcp” on page 38, “sem:rdf-load” on page 47, “Addressing the Graph Store” on page 49, and “Loading Semantic Triples” on page 32. For bulk loading, mlcp is the preferred method.

### 8.4.1 INSERT DATA

INSERT DATA adds triples specified in the request into a graph. The syntax for **INSERT DATA** is:

```
INSERT DATA QuadData
(GRAPH VarOrIri) ? {TriplesTemplates}
```

The `QuadData` parameter is made up of sets of triple patterns (`TriplesTemplates`), which can optionally be wrapped in a `GRAPH` block.

**Note:** All of the managed triples from a triples document will go into the default graph unless you specify the destination graph when inserting them using SPARQL Update.

If you are inserting triples into a new graph, you should create the graph with the permissions you want, specified through `sem:sparql-update`. If you do not specify permissions on the graph, the graph will be created with your default permissions. To manage the permissions of the graph, use `sem:graph-add-permissions`. See “Graph-Level Security” on page 162 for more about permissions and security.
For example, this update uses sem:graph-add-permissions to add update permissions to the sparql-update-role to update for "My Graph", and inserts three triples into that graph:

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

sem:graph-add-permissions(sem:iri("MyGraph"),
xdmp:permission("sparql-update-role", "update")),
sem:sparql-update(''

PREFIX exp: <http://example.org/marklogic/people>
PREFIX pre: <http://example.org/marklogic/predicate>

INSERT DATA {
  GRAPH <MyGraph>{
    exp:John_Smith pre:livesIn "London" .
    exp:Jane_Smith pre:livesIn "London" .
    exp:Jack_Smith pre:livesIn "Glasgow" .
  }
}
''
)
```

If no graph is described in QuadData, the default graph is assumed (http://marklogic.com/semantics#default-graph). If data is inserted into a graph that does not exist in the Graph Store, a new graph is created for the data with the user’s permissions.

This example uses INSERT DATA to insert a triple into a default graph and then insert three triples into a graph named “BOOKS”.

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

sem:sparql-update(''

PREFIX dc: <http://marklogic.com/dc/elements/1.1/>
INSERT DATA

}
''
);
```
This example will delete any book titled “A new book” in the graph “BOOKS” and insert the title “Inside MarkLogic Server” in its place:

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

WITH <BOOKS>
DELETE {?b dc:title "A new book"}
INSERT {?b dc:title "Inside MarkLogic Server" }
WHERE {
}');
```

The WITH keyword means to use this graph (<BOOKS>) in every clause.

### 8.4.2 DELETE DATA

The DELETE DATA operation removes some triples specified in the request, if the respective graphs in the Graph Store contain them. The syntax for DELETE DATA is:

```xquery
DELETE DATA QuadData
```

The QuadData parameter specifies the triples to be removed. If no graph is described in QuadData, then the default graph is assumed.

Any MarkLogic-managed triple that matches subject, predicate, and object on any of the triples specified in QuadData will be deleted. If a graph is specified in QuadData, the scope of deletion is limited to the triples in that graph; otherwise, the scope of deletion is limited to the triples in default graph.

This example deletes triples that match “true” and “Retail/Wholesale” from the <http://marklogic.com/semantics/COMPANIES100A/> graph.

```xquery
PREFIX demov: <http:demo/verb#>
PREFIX demor: <http:demo/resource#>

DELETE DATA
{
  GRAPH <http://marklogic.com/semantics/COMPANIES100A/> 
  {
    demor:COMPANY100 demor:listed "true" .
    demor:COMPANY100 demov:industry "Retail/Wholesale" .
  }
}
```
An error will be thrown if a `DELETE DATA` operation includes variables or blank nodes. The deletion of non-existing triples has no effect. Any triples specified in `QuadData` that do not exist in the Graph Store are ignored.

### 8.4.3 DELETE..INSERT WHERE

The `DELETE..INSERT WHERE` operation is used to remove and/or add triples from/to the Graph Store based on bindings for a query pattern specified in a `WHERE` clause. You can use `DELETE..INSERT WHERE` to specify a pattern to match against and then delete and/or insert triples.

See [http://www.w3.org/TR/sparql11-update/#updateLanguage](http://www.w3.org/TR/sparql11-update/#updateLanguage) for details.

To delete triples according to a specific pattern, use the `DELETE..INSERT WHERE` construct without the optional `INSERT` clause. If you do not specify a graph, you will insert into or delete triples from the default graph ([http://marklogic.com/semantics#default-graph](http://marklogic.com/semantics#default-graph)), also called the unnamed graph. The syntax for `DELETE..INSERT WHERE` is:

```sql
( WITH IRIref )?
( ( DeleteClause InsertClause? ) | InsertClause )
( USING ( NAMED )? IRIref )* 
WHERE GroupGraphPattern
DeleteClause ::= DELETE  QuadPattern
InsertClause ::= INSERT  QuadPattern
```

This operation identifies data using the `WHERE` clause, which is used to determine matching sequences of bindings for a set of variables. The bindings for each solution are then substituted into the `DELETE` template to remove triples, and then in the `INSERT` template to create new triples.

If an operation tries to insert into a graph that does not exist, that graph will be created. `DELETE` and `INSERT` run in the same transaction, and obey MarkLogic security rules.

In this example each triple containing “Healthcare/Life Sciences” will be deleted and two triples and two triples will be inserted, one for “Healthcare” and a second one for “Life Sciences”.

```sql
PREFIX demov: <http:demo/verb#>

WITH <http://marklogic.com/semantics/COMPANIES100A/> 
DELETE 
{   ?company demov:industry "Healthcare/Life Sciences" .
}
INSERT 
   ?company demov:industry "Life Sciences" .
}
WHERE {
    ?company demov:industry "Healthcare/Life Sciences" .
}
```

Note that the `DELETE` and `INSERT` are independent of each other.
8.4.4 DELETE WHERE

The `DELETE WHERE` operation is used to remove triples from the Graph Store based on bindings for a query pattern specified in a `WHERE` clause. `DELETE WHERE` is `DELETE..INSERT WHERE` with a missing `INSERT`, which is optional. You can use `DELETE WHERE` to specify a pattern to match against and then delete the matching triples.

To delete triples according to a specific pattern, use the `DELETE WHERE` construct without the optional `INSERT` clause. If you do not specify a graph, you will delete triples from the default graph (`http://marklogic.com/semantics#default-graph`), also called the unnamed graph.

The syntax for `DELETE WHERE` is:

```
( WITH IRIref )?
  ( ( DeleteClause InsertClause? ) | InsertClause )
  ( USING ( NAMED )? IRIref )* 
WHERE GroupGraphPattern
DeleteClause ::= DELETE  QuadPattern
InsertClause ::= INSERT  QuadPattern
```

This example of `DELETE WHERE` deletes the sales data for any companies with less than 100 employees from the graph `<http://marklogic.com/semantics/COMPANIES100A/>`:

```sparql
PREFIX demov: <http:demo/verb#>
PREFIX vcard: <http:www.w3c.org/2006/vcard/ns#>

WITH <http://marklogic.com/semantics/COMPANIES100A/>
DELETE
{
}
WHERE {
  ?company a vcard:Organization .
} 
FILTER ( ?employees < 100 )
```

8.4.5 INSERT WHERE

The `INSERT WHERE` operation is used to add triples to the Graph Store based on bindings for a query pattern specified in a `WHERE` clause. `INSERT WHERE` is `DELETE..INSERT WHERE` with a missing `DELETE`, which is optional. You can use `INSERT WHERE` to specify a pattern to match against and then insert triples based on that match.

To insert triples according to a specific pattern, use the `INSERT WHERE` construct without the optional `DELETE` clause. If you do not specify a graph, you will insert triples into the default graph (`http://marklogic.com/semantics#default-graph`), also called the unnamed graph.
The syntax for **INSERT WHERE** is:

```
( WITH IRIref )?
  ( ( DeleteClause InsertClause? ) | InsertClause )
  ( USING ( NAMED )? IRIref )*  
WHERE GroupGraphPattern
DeleteClause ::= DELETE QuadPattern
InsertClause ::= INSERT QuadPattern
```

This example of **INSERT WHERE** finds each company in New York, USA and adds `State="NY"` and `deliveryRegion="East Coast"`.

```
PREFIX demov: <http:demo/verb#>
PREFIX vcard: <http:www.w3c.org/2006/vcard/ns#>

WITH <http://marklogic.com/semantics/sb/COMPANIES100A/>
INSERT
{
  ?company demov:State "NY" .
  ?company demov:deliveryRegion "East Coast"
}
WHERE {
  ?company a vcard:Organization .
  ?company vcard:hasAddress [
    vcard:region "New York" ;
    vcard:country-name "USA"
  ]
}
```

### 8.4.6 CLEAR

The **CLEAR** operation removes all of the triples in the specified graph(s). The syntax for **CLEAR** is:

```
CLEAR (SILENT)? (GRAPH IRIref | DEFAULT | NAMED | ALL )
```

The **GRAPH IRIref** option is used to remove all triples from the graph specified by **GRAPH IRIref**. The **DEFAULT** option is used to remove all the triples from the default graph of the Graph Store. The **NAMED** option is used to remove all of the triples in all of the named graphs of the Graph Store, and the **ALL** option is used to remove all triples from all graphs of the Graph Store.

For example:

```
CLEAR GRAPH <http://marklogic.com/semantics/COMPANIES100A/> ;
```

This operation removes all of the triples from the graph. The graph and its metadata (such as permissions) will be kept after the graph is cleared. The **CLEAR** will fail if the specified graph does not exist. If the **SILENT** option is used, the operation will not return an error.
8.5 Bindings for Variables

Binding variables can be used as values in INSERT DATA, and DELETE DATA, and are passed in as arguments to sem:sparql-update.

To create bindings for variables to be used with SPARQL Update, you create an XQuery or JavaScript function to map the bindings and then pass in the bindings as part of a call to sem:sparql-update.

In this example we create a function, assign the variables, build a set of bindings, and then use the bindings to insert repetitive data into the triple store using INSERT DATA:

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

declare function local:add-player-triples($id as xs:integer,
  $lastname as xs:string,
  $firstname as xs:string,
  $position as xs:string,
  $team as xs:string,
  $number as xs:integer
)
{
  let $query := 'PREFIX bb: <http://marklogic.com/baseball/players/>
PREFIX xs: <http://www.w3.org/2001/XMLSchema#>

INSERT DATA
{
  GRAPH <PlayerGraph>
  {
    ?playertoken bb:playerid ?id .
    ?playertoken bb:number ?number .
    ?playertoken bb:team ?team .
  }
}

, 

  let $playertoken := fn:concat("bb:", $id)
  let $player-map := map:entry("id", $id)
  let $put := map:put($player-map, "playertoken", $playertoken)
  let $put := map:put($player-map, "lastname", $lastname)
  let $put := map:put($player-map, "firstname", $firstname)
  let $put := map:put($player-map, "position", $position)
  let $put := map:put($player-map, "number", $number)
  let $put := map:put($player-map, "team", $team)

  return sem:sparql-update($update, $player-map)
```
The order of the variables does not matter because of the mapping.

This same pattern can be used with LIMIT and OFFSET clauses. Bindings for variables can be used with SPARQL Update (sem:sparql-update), SPARQL (sem:sparql), and SPARQL values (sem:sparql-values). See “Using Bindings for Variables” on page 123 for an example using bindings for variables with SPARQL using LIMIT and OFFSET clauses.

### 8.6 Using SPARQL Update with Query Console

You can use SPARQL Update with Query Console. It is listed as a Query type in the Query Console drop-down menu.

Query Console highlights SPARQL Update keywords as you create your query. You can run your SPARQL Update queries in the Query Console the same way you run SPARQL Queries.
8.7 Using SPARQL Update with XQuery or Server-Side JavaScript

You can execute SPARQL Updates with `sem:sparql-update` in XQuery and `sem.sparqlUpdate` in Javascript. For details about the function signatures and descriptions, see the Semantics documentation under XQuery Library Modules in the MarkLogic XQuery and XSLT Function Reference and Querying Semantic Triples With SPARQL in the Node.js Application Developer's Guide.

**Note:** Although some of the semantics functions are built-in, others are not, so we recommend that you import the Semantics API library into every XQuery module or JavaScript module that uses the Semantics API.

Using XQuery, the import statement is:

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

For Javascript, the import statement is:

```
var sem = require("/MarkLogic/semantics.xqy");
```

Here is a complex query using SPARQL Update with XQuery. The query selects a random player from the Athletics baseball team, formerly with the Twins, and deletes that player the Athletics:

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

let $query := ';
  PREFIX bb: <http://marklogic.com/baseball/players#>
  PREFIX bbr: <http://marklogic.com/baseball/rules#>
  PREFIX xs: <http://www.w3.org/2001/XMLSchema#>

  WITH <Athletics>
  DELETE
  {
  }
  INSERT
  {
  }
  WHERE
  {
    {
      SELECT (max(?s1) as ?key) (count(?s1) as ?inner_numbers)
        WHERE
        {
          ?s1 bb:number ?o1 .
        }
      
      DELETE
      {
        ?s1 .
      }
    }
    
    INSERT
    {
      ?s1 .
    }
  }
```
8.8 Using SPARQL Update with REST

SPARQL Update can be used with REST in client applications to manage graphs and triple data via the SPARQL endpoint. See “SPARQL Update with the REST Client API” on page 199 for information about using SPARQL Update with REST.

For more information about using SPARQL with Node.js client applications, see Working With Semantic Data in the Node.js Application Developer’s Guide. For semantic client applications using Java, you can find the Java Client API on GitHub at http://github.com/marklogic/java-client-api or get it from the central Maven repository.
9.0 Using Semantics with the REST Client API

This section describes how to use MarkLogic Semantics with the REST Client API to view, query, and modify triples and graphs using REST (Representational State Transfer) over HTTP. The REST Client API enables a client application to perform SPARQL queries and updates. A MarkLogic SPARQL endpoint (/v1/graphs/sparql) is available to use with SPARQL query and SPARQL Update to access triples in MarkLogic. The /v1/graphs/sparql service is a compliant SPARQL endpoint, as defined by the SPARQL 1.1 Protocol: http://www.w3.org/TR/2013/REC-sparql11-protocol-20130321/#terminology. If your client requires configuration of a SPARQL Update or Query endpoint, use this service.

A SPARQL endpoint is a web service that implements the SPARQL protocol and can respond to SPARQL queries. RDF data published to the web using a SPARQL endpoint can be queried to answer a specific question, instead of downloading all of the data. If you have an application that does standard queries and updates over a SPARQL endpoint, you can point the application to this endpoint.

The SPARQL endpoint URL is addressed as:

http://host:port/v1/graphs/sparql

The graph endpoint is used for CRUD procedures on graphs; creating, reading, updating, and deleting graphs. The URL is addressed as:

http://host:port/v1/graphs

The things endpoint is used for viewing content in the database. The URL is addressed as:

http://host:port/v1/graphs/things

The following table shows the supported operations available for Semantics (viewing, querying, inserting, or deleting content):

<table>
<thead>
<tr>
<th>Operation</th>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>/v1/graphs/sparql</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retrieve</td>
<td>GET</td>
<td>Perform a SPARQL query on the database.</td>
</tr>
<tr>
<td>Create/Retrieve</td>
<td>POST</td>
<td>Perform a SPARQL query or SPARQL Update on one or more graphs. (These two operations are mutually exclusive.)</td>
</tr>
<tr>
<td>/v1/graphs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Supported Operations for the REST Client API

<table>
<thead>
<tr>
<th>Operation</th>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieve</td>
<td>GET</td>
<td>Retrieve the contents or permissions metadata of a graph, or a list of available graph URIs.</td>
</tr>
<tr>
<td>Merge</td>
<td>POST</td>
<td>Merge N-quads into the triple store, merge other types of triples, or new permissions into a named graph or the default graph.</td>
</tr>
<tr>
<td>Create/Replace</td>
<td>PUT</td>
<td>Create or replace quads in the triple store; or create or replace other kinds of triples in a named graph or the default graph; or replace the permissions on a named graph or the default graph.</td>
</tr>
<tr>
<td>Return</td>
<td>HEAD</td>
<td>Returns the same headers as an equivalent GET on the <code>/graphs</code> service.</td>
</tr>
<tr>
<td>Delete</td>
<td>DELETE</td>
<td>Remove triples in a named graph or the default graph, or remove all graphs from the triple store.</td>
</tr>
<tr>
<td><code>/v1/graphs/things</code> Retrieve</td>
<td>GET</td>
<td>Retrieve a list of all graph nodes in the database, or a specified set of nodes.</td>
</tr>
</tbody>
</table>

For more information about usage and parameters for a service, see the [REST Client APIs for Semantics](#).

This chapter includes the following sections:

- Assumptions
- Specifying Parameters
- Supported Operations for the REST Client API
- Serialization
- Simple Examples Using `curl` and REST
- Response Output Formats
- SPARQL Query with the REST Client API
To use the SPARQL endpoint or graphs endpoints with SPARQL query, you must have the rest-reader privilege, along with any security requirements for your environment. To use SPARQL Update with the SPARQL endpoint or graphs endpoints, you must have the rest-writer privilege. See Controlling Access to Documents Created with the REST API in the REST Application Developer’s Guide for more information about permissions.

9.1 Assumptions

To follow along with the examples later 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 117. 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.
- You have 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.

9.2 Specifying Parameters

A variety of parameters can be used with REST services. The complete list can be found in the REST Client APIs, for instance POST:/v1/graphs/sparql. This section describes a selection of those parameters that can be used with SPARQL query and/or SPARQL Update.

For the parameters, “*” and “?” both imply that a parameter is optional. “*?” means that you can use a parameter 0 or more times and “??” means that you can use a parameter 0 or 1 times.

9.2.1 SPARQL Query Parameters

Some of the parameters supported for SPARQL query on the SPARQL endpoint, using POST:/v1/graphs/sparql or GET:/v1/graphs/sparql, include:

- query - SPARQL query to execute
- default-graph-uri* - The URI of the graph or graphs to use as the default graphs in the query operation. This is addressed as http://host:port/v1/graphs/sparql?default-graph-uri=<default-graph-uri>
• named-graph-uri* - The URI of the graph or graphs to include in the query operation. This is addressed as http://host:port/v1/graphs/sparql?named-graph-uri=<named-graph-uri>*

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.

• database? - The database on which to perform the query.
• base? - The initial base IRI for the query.
• bind:{name}* - A binding name and value. This format assumes that the type of the bind variable is an IRI.
• bind:{name}:{type}* - A binding name, type, and value. This parameter accepts an XSD type, for example “string”, “date” or “unsignedLong”.
• bind:{name}@{lang}* - A binding name, language tag, and value. Use this pattern to bind to language-tagged strings.
• txid? - The transaction identifier of the multi-statement transaction in which to service this request. Use the /transactions service to create and manage multi-statement transactions.
• start? - The index of the first result to return. Results are numbered beginning with 1. The default is 1.
• pageLength? - The maximum number of results to return in this request.

These optional search query parameters can be used to constrain which documents will be searched with the SPARQL query:

• q? - A string query.
• structuredQuery? - A structured search query string, a serialized representation of a search:query element.
• options? - The name of query options.

If you do not 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 (this is not the “default” graph that contains the unnamed triples). You can also query http://marklogic.com/semantics#default-graph, where unnamed triples 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 is used to specify one or more default graphs to query as part of the operation, and the named-graph-uri can specify one or more additional graphs to use in the operation. 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 the REST Client API, the format will be http://host:port/v1/graphs/sparql?named-graph-uri=<named-graph-uri> for each graph named in the query.

For example, this is a simple REST request to send the SPARQL query in the bills.sparql file and return the results as JSON:

```
curl --anyauth --user admin:admin -i -X POST \
--data-binary @./bills.sparql \ 
-H "Content-type: application/sparql-query" \ 
-H "Accept: application/sparql-results+json" \ 
http://localhost:8000/v1/graphs/sparql
```

*=>
HTTP/1.1 200 OK
Content-type: application/sparql-results+json; charset=UTF-8
Server: MarkLogic
Content-Length: 1268
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"}},
...
]}
```
Note: In the command line example above, long lines have been broken into multiple lines using the Unix line continuation character '\\' and extra line breaks have been added for readability. Extra line breaks for readability have been added in the results.

9.2.2 SPARQL Update Parameters

In addition to the query parameters, these parameters can be used with SPARQL Update on the POST:/v1/graphs/sparql endpoint:

- **update** - The URL-encoded SPARQL Update operation. Only use this parameter when you put the request parameters in the request body and use application/x-www-form-urlencoded as the request content type.
- **using-graph-uri** - The URI of the graph or graphs to address as part of a SPARQL Update operation. This is addressed as http://host:port/v1/graphs/sparql?using-graph-uri=<using-graph-uri>
- **using-named-graph-uri** - The URI of a named graph or graphs to address as part of a SPARQL update operation. This is addressed as http://host:port/v1/graphs/sparql?using-named-graph-uri=<using-named-graph-uri>
- **perm:{role}** - Assign permissions to the inserted graph(s), and the permission has a role and a capability. When you insert a new graph, you can set its permissions to allow a certain capability for a certain role. Valid values for the permissions: read, update, execute. These permissions only apply to newly created graphs. See “Managing Graph Permissions” on page 206 for more about permissions.
- **txid** - The transaction identifier of the multi-statement transaction in which to service this request. Use the /transactions service to create and manage multi-statement transactions.
- **database** - The database on which to perform the query.
- **base** - The initial base IRI for the query.
- **bind:{name}** - A binding name and value. This format assumes that the type of the bind variable is an IRI.
- **bind:{name}:{type}** - A binding name, type, and value. This parameter accepts an XSD type, for example “string”, “date” or “unsignedLong”.
- **bind:{name}:@{lang}** - A binding name, language tag, and value. Use this pattern to bind to language-tagged strings.

See “Target RDF Graph” on page 80 for more information about graphs. See Querying Triples in the REST Application Developer’s Guide for more information about using the REST Client API with RDF triples.
9.3  Supported Operations for the REST Client API

For the /v1/graphs/sparql endpoint, these operations are supported:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
<th>Method</th>
<th>Privilege</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieve</td>
<td>Evaluates a SPARQL query to retrieve a named graph.</td>
<td>GET</td>
<td>rest-reader</td>
</tr>
<tr>
<td>Create/Retrieve</td>
<td>Evaluates a SPARQL query as a parameter or URL-encoded as part of the POST body. Using SPARQL Update, POST merges triples into a named graph when used as parameter, or as a URL-encoded SPARQL Update in the POST body. SPARQL query and SPARQL Update operations are mutually exclusive.</td>
<td>POST</td>
<td>rest-writer (SPARQL query), rest-writer (SPARQL Update)</td>
</tr>
</tbody>
</table>

**Note:** For SPARQL Update, only POST:/v1/graphs/sparql is supported.

There is also a /v1/graphs endpoint and a /v1/graphs/things endpoint to access and view RDF data. For the /v1/graphs endpoint, these verbs are supported:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
<th>Method</th>
<th>Privilege</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieve</td>
<td>Retrieve a graph or a list of available graph URIs.</td>
<td>GET</td>
<td>rest-reader</td>
</tr>
<tr>
<td>Merge</td>
<td>Without parameters, merges quads into the triple store. With graph or default, merges triples into a named graph or the default graph.</td>
<td>POST</td>
<td>rest-writer</td>
</tr>
<tr>
<td>Create/Replace</td>
<td>Without parameters, creates or replaces quads. With default or graph, creates or replaces triples in a named graph or the default graph. Using PUT with an empty graph, will delete the graph.</td>
<td>PUT</td>
<td>rest-writer</td>
</tr>
<tr>
<td>Delete</td>
<td>Without parameters, removes all graphs from the triple store. With graph or default, removes triples in a named graph or the default graph.</td>
<td>DELETE</td>
<td>rest-writer</td>
</tr>
<tr>
<td>Return</td>
<td>Returns the same headers as an equivalent GET on the /graphs service.</td>
<td>HEAD</td>
<td>rest-reader</td>
</tr>
</tbody>
</table>
And for the `/v1/graphs/things` endpoint, the verb `GET` is supported for REST requests:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
<th>Method</th>
<th>Privilege</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrieve</td>
<td>Retrieves a list of all graph nodes in the database, or a specified set of nodes.</td>
<td>GET</td>
<td>rest-reader</td>
</tr>
</tbody>
</table>

### 9.4 Serialization

Serialization of RDF data occurs whenever it is loaded, queried, or updated. The data can be serialized in a variety of ways. The supported serializations are shown in the table shown in “Supported RDF Triple Formats” on page 33.

Several types of optimized serialization are available for SPARQL results (solutions - sets of bindings) and RDF (triples) over REST. Using these serializations in your interactions will make them faster. These serializations specify a MIME type for the input and output format. Formats are specified as part of the accept headers of the REST request.

We recommend using one of the following choices for optimized serialization of SPARQL results when using the `/v1/graphs/sparql` endpoint:

<table>
<thead>
<tr>
<th>Format</th>
<th>SPARQL Query Type <code>/v1/graphs/sparql</code></th>
<th>MIME Type/Accept Header</th>
</tr>
</thead>
<tbody>
<tr>
<td>json</td>
<td>SELECT or ASK</td>
<td>application/sparql-results+json</td>
</tr>
<tr>
<td>csv</td>
<td>SELECT or ASK</td>
<td>application/sparql-results+csv</td>
</tr>
<tr>
<td>n-triples</td>
<td>CONSTRUCT or DESCRIBE</td>
<td>application/n-triples</td>
</tr>
</tbody>
</table>

For `CONSTRUCT` or `DESCRIBE` all of the supported triples formats are supported. See the table in “Supported RDF Triple Formats” on page 33.

**Note:** N-Quads and TriG formats are quad formats, not triple formats, and REST does not serialize quads.

For optimized RDF results (triple or quads), choose one of these serialization options when using the `/v1/graphs` endpoint:

<table>
<thead>
<tr>
<th>Format</th>
<th>RDF Query Type <code>/v1/graphs</code></th>
<th>MIME Type/Accept Header</th>
</tr>
</thead>
<tbody>
<tr>
<td>n-triples</td>
<td>CONSTRUCT or DESCRIBE</td>
<td>application/n-triples</td>
</tr>
</tbody>
</table>
This information is shown in a different way in “SPARQL Query Types and Output Formats” on page 186. For more about serialization, see Setting Output Options for an HTTP Server in the Administrator’s Guide.

### 9.4.1 Unsupported Serialization

A GET or POST request for a response in an unsupported serialization 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>
```

For more about the REST Client API error handling, see Error Reporting in the REST Application Developer’s Guide.

### 9.5 Simple Examples Using curl and REST

These two examples use curl with cygwin (Linux) and Windows to do Semantic queries over REST. This SPARQL query is encoded and used in the examples:

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

For readability, the character (“\”) is used in the cygwin (Linux) example to indicate a line break. The actual request should be entered on one continuous line. The query looks like this:

```
curl --anyauth --user user:password
  "http://localhost:8000/v1/graphs/sparql" \
  -H "Content-type:application/x-www-form-urlencoded" \
  -H "Accept:application/sparql-results+xml" \
  -X POST --data-binary 'query=SELECT+*+WHERE+{+%3fs+%3fp+%3fo+}'
  =>
  <sparql xmlns="http://www.w3.org/2005/sparql-results#">
      <head>
```
<variable name="s"/>
<variable name="p"/>
<variable name="o"/>
</head>
<results>
<result>
   <binding name="s"><uri>http://example/book1/</uri></binding>
   <binding name="p"><uri>http://purl.org/dc/elements/1.1/title</uri></binding>
   <binding name="o"><literal>A new book</literal></binding>
</result>
<result>
   <binding name="s">
      <uri>http://example/book1/</uri>
   </binding>
   <binding name="p">
      <uri>http://purl.org/dc/elements/1.1/title</uri>
   </binding>
   <binding name="o">
      <literal>Inside MarkLogic Server</literal>
   </binding>
</result>
<result>
   <binding name="s">
      <uri>http://www.w3.org/2000/01/rdf-schema#subClassOf</uri>
   </binding>
   <binding name="p">
      <uri>http://www.w3.org/2000/01/rdf-schema#domain</uri>
   </binding>
   <binding name="o">
      <uri>http://www.w3.org/2000/01/rdf-schema#Class</uri>
   </binding>
</result>
<result>
   <binding name="s">
      <uri>http://www.w3.org/2000/01/rdf-schema#subClassOf</uri>
   </binding>
   <binding name="p">
      <uri>http://www.w3.org/2000/01/rdf-schema#range</uri>
   </binding>
   <binding name="o">
      <uri>http://www.w3.org/2000/01/rdf-schema#Class</uri>
   </binding>
</result>
</results></sparql>

Note: The results have been formatted for clarity.
In the Windows example, the character ("\n") is used to indicate a line break for readability. The actual request should be entered on one continuous line. The Windows query looks like this:

```
curl --anyauth --user user:password
"http://localhost:8000/v1/graphs/sparql" ^
-H "Content-type:application/x-www-form-urlencoded" ^
-H "Accept:application/sparql-results+xml" ^
-X POST --data-binary 'query=SELECT+*+WHERE+{+%3fs+%3fp+%3fo+}'
=>
<sparql xmlns="http://www.w3.org/2005/sparql-results#">
<head>
  <variable name="s"/>
  <variable name="p"/>
  <variable name="o"/>
</head>
<results>
  <result>
    <binding name="s">
      <uri>http://example.org/marklogic/people/Jack_Smith</uri>
    </binding>
    <binding name="p">
      <uri>http://example.org/marklogic/predicate/livesIn</uri>
    </binding>
    <binding name="o">Glasgow</binding>
  </result>
  <result>
    <binding name="s">
      <uri>http://example.org/marklogic/people/Jane_Smith</uri>
    </binding>
    <binding name="p">
      <uri>http://example.org/marklogic/predicate/livesIn</uri>
    </binding>
    <binding name="o">London</binding>
  </result>
  <result>
    <binding name="s">
      <uri>http://example.org/marklogic/people/John_Smith</uri>
    </binding>
    <binding name="p">
      <uri>http://example.org/marklogic/predicate/livesIn</uri>
    </binding>
    <binding name="o">London</binding>
  </result>
</results></sparql>
```

**Note:** The results have been formatted for clarity.
9.6 Response Output Formats

This section describes the header types and response output formats available when using SPARQL endpoints with the REST Client API. Examples of results in different formats are included. These topics are covered:

- SPARQL Query Types and Output Formats
- Example: Returning Results as XML
- Example: Returning Results as JSON
- Example: Returning Results as HTML
- Example: Returning Results as CSV
- Example: Returning Results as CSV
- Example: Returning a Boolean as XML or JSON

9.6.1 SPARQL Query Types and Output Formats

When you query the SPARQL endpoint with REST Client APIs (GET:/v1/graphs/sparql or POST:/v1/graphs/sparql), you can specify the result output format. The response type format depends on the type of query and the MIME type in the HTTP Accept header.

A SPARQL SELECT query can return results as XML, JSON, HTML or CSV, while a SPARQL CONSTRUCT query can return the results as triples in N-Triples or N-Quads format, or XML or JSON triples in any of the supported triples formats. A SPARQL DESCRIBE query returns triples in XML, N-Triples, or N-Quads format describing the triples found by the query. Using SPARQL ASK query will return a boolean (true or false) in either XML or JSON. See “Types of SPARQL Queries” on page 71 for more about query types.
This table describes the MIME types and Accept Header/Output formats (MIME type) for different types of SPARQL queries.

<table>
<thead>
<tr>
<th>Query Type</th>
<th>Format</th>
<th>Accept Header MIME Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>SELECT</code> or <code>ASK</code></td>
<td><code>xml</code></td>
<td><code>application/sparql-results+xml</code></td>
</tr>
<tr>
<td>Returns SPARQL results - solutions</td>
<td></td>
<td>See “Example: Returning Results as XML” on page 188 and “Example: Returning a Boolean as XML or JSON” on page 193.</td>
</tr>
<tr>
<td></td>
<td><code>json</code></td>
<td><code>application/sparql-results+json</code></td>
</tr>
<tr>
<td></td>
<td><code>html</code></td>
<td><code>text/html</code></td>
</tr>
<tr>
<td></td>
<td><code>csv</code></td>
<td><code>text/csv</code></td>
</tr>
</tbody>
</table>

**Note:** Select queries return a boolean (true or false).

<table>
<thead>
<tr>
<th>Query Type</th>
<th>Format</th>
<th>Accept Header MIME Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>CONSTRUCT</code> or <code>DESCRIBE</code></td>
<td><code>n-triples</code></td>
<td><code>application/n-triples</code></td>
</tr>
<tr>
<td>Returns RDF triples</td>
<td></td>
<td>For faster serialization - see “Example: Returning Results as N-triples” on page 192.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Note:</strong> If you want triples returned as JSON, the proper MIME type is <code>application/rdf+json</code>.</td>
</tr>
<tr>
<td></td>
<td><code>other</code></td>
<td><code>CONSTRUCT</code> or <code>DESCRIBE</code> queries return RDF triples in any of the available formats. See “Supported RDF Triple Formats” on page 33</td>
</tr>
</tbody>
</table>

**Note:** You can request any of the triple MIME types (`application/rdf+xml`, `text/turtle`, and so on), but you should use `application/n-triples` for best performance. See “Serialization” on page 182 for details.
The following examples use this SPARQL SELECT query to find US Congress bills that were sponsored by Robert Andrews (“A000210”):

```sparql
#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
```

The SPARQL query is saved as `bills.sparql`. The query limits responses to 5 results. Using curl and the REST Client API you can query the SPARQL endpoint and get the results back in a variety of formats.

**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.

### 9.6.2 Example: Returning Results as XML

The SPARQL SELECT query in the `bills.sparql` file returns the response in XML format in this example.

```bash
curl --anyauth --user admin:password -i -X POST "http://localhost:8050/v1/graphs/sparql"
-H "Content-type: application/sparql-query"
-H "Accept: application/sparql-results+xml"
--data-binary @./bills.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">
  </binding>
  <binding name="title">
  </binding>
</result>

<result>
  <binding name="bill">
    <uri>http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1314/</uri>
  </binding>
  <binding name="title">
  </binding>
</result>

...<result>
</results>
</sparql>

Note: In the example above, long lines have been broken into multiple lines using the Unix line continuation character "\" and extra line breaks have been added for readability. Extra line breaks for readability have also been added in the results.

9.6.3 Example: Returning Results as JSON
The SPARQL SELECT query in the bills.sparql file 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


9.6.4 Example: Returning Results as HTML
The same SPARQL SELECT query in the bills.sparql file 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" \ 
```

=>

HTTP/1.1 200 OK
Content-type: text/html; charset=UTF-8
Server: MarkLogic
Content-Length: 1448
Connection: Keep-Alive

Note: In the command line example above, long lines have been broken into multiple lines using the Unix line continuation character '\' and extra line breaks have been added for readability. Extra line breaks for readability have also been added in the results.
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>H.R. 108/1171: Iris Scan Security Act of 2003</td>
</tr>
<tr>
<td>H.R. 108/1314: Screening Mammography Act of 2003</td>
</tr>
<tr>
<td>H.R. 108/1384: To amend the Railroad Retirement Act of 1974 to eliminate a limitation on benefits.</td>
</tr>
</table></body>

Note: In the example above, long lines have been broken into multiple lines using the Unix line continuation character '" and extra line breaks have been added for readability. Extra line breaks for readability have also been added in the results.

### 9.6.5 Example: Returning Results as CSV

Here is the same SPARQL SELECT query (`bills.sparql`) with the results returned in CSV format:

```
bill,title

```
http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1314,H.R.  
108/1314: Screening Mammography Act of 2003

http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1384,H.R.  
108/1384: To amend the Railroad Retirement Act of 1974 to eliminate a limitation on benefits.

http://www.rdfabout.com/rdf/usgov/congress/108/bills/h1418,H.R.  
108/1418: Veterans' Housing Equity Act

108/1419: Seniors' Family Business Enhancement Act

Note: In the example above, long lines have been broken into multiple lines using the Unix line continuation character "\" and extra line breaks have been added for readability. Extra line breaks for readability have also been added in the results.

9.6.6 Example: Returning Results as N-triples
For this example, we will use a DESCRIBE query that was introduced and used earlier:

    DESCRIBE <http://dbpedia.org/resource/Pascal_Bedrossian>

The following command uses this query to match triples that describe Pascal and return the results as N-Triples. Long lines in the command below have been broken with the Unix line continuation character "\". The query is URL encoded and passed as the value of the “query” request parameter.

    curl -X GET --digest --user "admin:password"  
    -H "Accept: application/n-triples"  
    -H "Content-type: application/x-www-form-urlencoded"  
    =>  
    <http://dbpedia.org/resource/Pascal_Bedrossian>  
    <http://dbpedia.org/ontology/birthPlace>  
    <http://dbpedia.org/resource/France> .  
    <http://dbpedia.org/resource/Pascal_Bedrossian>  
    <http://dbpedia.org/ontology/birthPlace>  
    <http://dbpedia.org/resource/Marseille> .  
    <http://dbpedia.org/resource/Pascal_Bedrossian>  
    <http://www.w3.org/1999/02/22-rdf-syntax-ns#type>  
    <http://xmlns.com/foaf/0.1/Person> .  
    <http://dbpedia.org/resource/Pascal_Bedrossian>  
    <http://xmlns.com/foaf/0.1/surname> "Bedrossian"@en .  
    <http://dbpedia.org/resource/Pascal_Bedrossian>  
    <http://xmlns.com/foaf/0.1/givenName> "Pascal"@en .
9.6.7 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 Kennedy was born after Eunice Kennedy.

Here are the contents of the `ask-sparql.sparql` file used in the following query:

```sparql
#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).
}
```

**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.

This request, containing 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 request (containing the SPARQL \texttt{ASK} query) where the boolean result is returned as JSON:

```bash
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}
```

9.7 SPARQL Query with the REST Client API

SPARQL queries (\texttt{SELECT}, \texttt{DESCRIBE}, \texttt{CONSTRUCT}, and \texttt{ASK}) can be used with either \texttt{POST} or \texttt{GET} and the REST Client API. For more about query types and output, see the table in “SPARQL Query Types and Output Formats” on page 186.

This section includes the following:

- SPARQL Queries in a POST Request
- SPARQL Queries in a GET Request

9.7.1 SPARQL Queries in a POST Request

This section describes how SPARQL query can be used to manage graphs and triple data through \texttt{/v1/graphs/sparql} endpoint.

\texttt{http://hostname:port/v1/graphs/sparql}

where the \textit{hostname} and \textit{port} are the host and port on which you are running MarkLogic.

You can specify your input SPARQL query to \texttt{POST:/v1/graphs/sparql} in the following ways:

- Include a SPARQL query as a file in the \texttt{POST} body
- Include the SPARQL query as URL-encoded data
This is a simple SPARQL DESCRIBE query used to find out about US Congress bill 44. The query is saved as a file, named bill44.sparql.

```
#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" . }
```

**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.

The endpoint requires a SPARQL query to be either a parameter or in the 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/rdf+xml" \ 
http://localhost:8000/v1/graphs/sparql
```

The request body MIME type is specified as `application/sparql-query` and the requested response MIME type (the `Accept:`) is specified as `application/rdf+xml`. The output is returned as triples in XML format. See “Response Output Formats” on page 186 for more details.

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/" 
    /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/" 
    /ShortTitle" />
</rdf:RDF>
```
Another way to use the `POST` request is to specify the URL-encoded query as the value of the "query" parameter and use `application/x-www-form-urlencoded` as the request body MIME type, 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 "Accept:application/sparql-results+xml" --data-binary \
"query=PREFIX%20rdf%3A%20%3Chttp%3A%2F%2Fwww.w3.org%2F1999%2F02%2F22-rdf-syntax-ns\%23%3E%20PREFIX%20bill%3A%20%3CHttp%3A%2F%2Fwww.rdfabout.com%2Fschema%2Fusbill\%2Fs\%2F2Fpeople%3A%20%3Chttp%3A%2F%2Fwww.rdfabout.com%2Fcongress%2Fpeople\%3E%0ASELECT%20%3Fx%20WHERE%20%7B%0A%20%3Fx%20rdf%3Atype%20bill%3AHouseBill%20%3B%20bill%3Acosponsor%20people%3A000358.%20%7D%0A" \
-H "Content-type:application/x-www-form-urlencoded" \
http://localhost:8000/v1/graphs/sparql
=>
```
<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>
```
Note: For readability, the long command line is broken into multiple lines using the Unix line continuation character `\`. Extra line breaks have been inserted for readability of the URL-encoded query.

9.7.2 SPARQL Queries in a GET Request

For GET request, the SPARQL query in the query request parameter must be URL-encoded. Here is the SPARQL DESCRIBE query, searching for a US Congress bill (44), before it is encoded:

```
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" .
}
```

In this example curl sends an HTTP GET request to execute the SPARQL DESCRIBE query:

```
curl -X GET --digest --user "user:password" \
  -H "accept: application/sparql-results+xml" \
  "http://localhost:8000/v1/graphs/sparql?query=PREFIX%20rdf%3A%20%3C\http%3A%2F%2Fwww.w3.org%2F1999%2F02%2F22-rdf-syntax-ns%23%20%3E%20%0A\PREFIX%20bill%3A%20%3Chttp%2F%2Fwww.rdfabout.com%2Frdf%2Fschema%2Fusbill%2F%3E%20DESCRIBE%20%3Fx%20WHERE%20%7B%20%3Fx%20rdf%3Atype%20bill%3AHouseBill%20%3B%20%20bill%3Anumber%20%2244%22%20.%207D"
```
Your results should be similar to these triples:

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>

<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/108/bills/h44>
<http://www.rdfabout.com/rdf/schema/usbill/cosponsor>

<http://www.rdfabout.com/rdf/usgov/congress/108/bills/h44>
<http://www.rdfabout.com/rdf/schema/usbill/cosponsor>

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.

9.8 SPARQL Update with the REST Client API

This section describes how SPARQL Update can be used to manage graphs and triple data through /v1/graphs/sparql endpoint.

http://hostname:port/v1/graphs/sparql

where the hostname and port are the host and port on which you are running MarkLogic.

You can specify your SPARQL Update (which is a DELETE/INSERT) to POST:/v1/graphs/sparql in the following ways:

- Include a SPARQL Update as a file in the POST body in the form of:

  http://host:port/v1/graphs/sparql
  content-type:application/sparql-update

  See “SPARQL Update in a POST Request” on page 200.
• Include the SPARQL Update as URL-encoded data in the form of:

```
http://host:port/v1/graphs/sparql
content-type:application/x-www-form-urlencoded
```

See “SPARQL Update via POST with URL-encoded Parameters” on page 202.

The examples in this section use POST request, with no URL encoding, and with content-type:application/sparql-update.

You can specify the RDF dataset against which to execute the update using the using-graph-uri and using-named-graph-uri request parameters, or within the update. If the dataset is specified in both the request parameters and the update, the dataset defined by the request parameters is used. If neither is specified, all graphs (the UNION of all graphs) are included in the operation.

**Note:** Including the using-graph-uri or using-named-graph-uri parameters, with a SPARQL 1.1 Update request that contains an operation that uses the USING, USING NAMED, or WITH clause, will cause an error.

See “Specifying Parameters” on page 177 for details on specifying parameters for use with the REST Client API. See “Supported Operations for the REST Client API” on page 181 and the list of verbs supported by the Graph store endpoint for SPARQL Update for more about POST. See POST:/v1/graphs/sparql for more about the SPARQL endpoint.

This section includes the following:

- SPARQL Update in a POST Request
- SPARQL Update via POST with URL-encoded Parameters

### 9.8.1 SPARQL Update in a POST Request

You can send requests using the POST method by including SPARQL Update in the request body. Set the Content-type HTTP header to application/sparql-update.

Here is the SPARQL Update before it is added to the request body:

```
PREFIX dc: <http://purl.org/dc/elements/1.1/>
WITH <BOOKS>
DELETE {?b dc:title "A new book"}
INSERT {?b dc:title "Inside MarkLogic Server" }
WHERE {?b dc:title "A new book".}
```

In the graph named <BOOKS>, SPARQL Update matches a triple with dc:title in the predicate position and A new book in the object position and deletes it. Then a new triple is inserted (?b dc:title "MarkLogic Server").
In this example, the SPARQL Update is sent in the request body using `application/sparql-update` and the `-d` option for the query:

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

curl --anyauth --user admin:admin -i -X POST \
-H "Content-type:application/sparql-update" \
-H "Accept:application/sparql-results+xml" \
-d 'PREFIX dc: <http://purl.org/dc/elements/1.1/> \\
WITH <BOOKS>
DELETE {?b dc:title "A new book"} \\
INSERT {?b dc:title "Inside MarkLogic Server" } \\
WHERE {?b dc:title "A new book"}.' \
http://localhost:8000/v1/graphs/sparql

Note: For clarity, long command lines are broken into multiple lines using the line continuation characters “\”. Remove the line continuation characters when you use the `curl` command. (For Windows the line continuation character would be “^”.)

Alternatively, you can use `curl` to execute a SPARQL Update from a file as part of a `POST` request. The SPARQL Update is saved in a file named `booktitle.sparql`. Here are the file contents:

```sparql
PREFIX dc: <http://purl.org/dc/elements/1.1/>
INSERT DATA
{
  dc:creator "author name" .
}
```

The `POST` request with the SPARQL Update in a file would look like this:

```bash

curl --anyauth --user admin:admin -i -X POST \n--data-binary @./booktitle.sparql \n-H "Content-type:application/sparql-update" \n-H "Accept:application/sparql-results+xml" \nhttp://localhost:8000/v1/graphs/sparql

Notice that the request uses the `--data-binary` option instead of `-d` to call the file containing the SPARQL Update. You can include `using-graph-uri`, `using-named-graph-uri` and `role-capability` as HTTP request parameters. The `perm` parameter is expected in this syntax, with role and capability.

```bash
perm:admin=update&perm:admin=execute
```

See “Default Permissions and Required Privileges” on page 206 for more about permissions.
9.8.2 SPARQL Update via POST with URL-encoded Parameters

You can also send update protocol requests via the HTTP POST method by URL-encoding the parameters. When you do this, URL percent-encode all parameters and include them as parameters within the request body via the application/x-www-form-urlencoded media type. The content type header of the HTTP request is set to application/x-www-form-urlencoded.

This next example uses SPARQL Update and POST with url-encoded parameters, to insert data (along with a set of permissions) into graph C1.

```bash
curl --anyauth --user admin:admin -i -X POST \
--data-urlencode update='PREFIX dc: <http://purl.org/dc/elements/1.1/> 
\nINSERT DATA 
{<http://example/book1> dc:title "book title" ; \n dc:creator "author name" .}; 
\n-H "Content-type:application/x-www-form-urlencoded" \
-H "Accept:application/sparql-results+xml" \
'http://localhost:8000/v1/graphs/sparql?using-named-graph-uri=C1 \
&perm:admin=update&perm:admin+execute'
```

If you supply the using-graph-uri or using-named-graph-uri parameters when using this protocol to convey a SPARQL 1.1 Update request that uses the USING NAMED, or WITH clause, the operation will result in an error.

This curl example uses POST with URL-encoding for the SPARQL Update and permissions:

```bash
curl --anyauth --user admin:admin -i -X POST \
-H "Content-type:application/x-www-form-urlencoded" \
-H "Accept:application/sparql-results+xml" \
--data-urlencode update='PREFIX dc: <http://purl.org/dc/elements/1.1/> 
\nINSERT DATA{ GRAPH <C1> {http://example/book1/> dc:title "C book"} }' \
--data-urlencode perm:rest-writer=read \
--data-urlencode perm:rest-writer=update \
http://localhost:8321/v1/graphs/sparql
```

If a new RDF graph is created, the server responds with a 201 Created message. The response to an update request indicates success or failure of the request via HTTP response status code (200 or 400). If the request body is empty, the server responds with 204 No Content.

9.9 Listing Graph Names with the REST Client API

You can list the graphs in your database with the REST Client API using the things endpoint.

```
http://hostname:port/v1/things
```

where the hostname and port are the host and port on which you are running MarkLogic.

For example when this endpoint is called with no parameters, a list of graphs in the database is returned:
The request might return graphs like these:

- graphs/MyDemoGraph
- http://marklogic.com/semantics#default-graph
- http://marklogic.com/semantics#graphs

### 9.10 Exploring Triples with the REST Client API

The following endpoint provides RESTful access to knowledge (things) referred to in the database. This endpoint retrieves a list of all subject nodes 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
```

You can also specify a set of subject nodes to be returned. 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, a list of nodes as IRIs, in a Web browser:

---

**Subjects**

<http://dbpedia.org/resource/Abraham_Lincoln>

<http://dbpedia.org/resource/Alain_Connes>

<http://dbpedia.org/resource/Allan_Dwan>

<http://dbpedia.org/resource/Aristotle>

- _bnode1375398754161/-2217616413582301424/-7059da6e-1403e27791b:-103f
- _bnode1375398754161/-2217616413582301424/-7059da6e-1403e27791b:-108f
- _bnode1375398754161/-2217616413582301424/-7059da6e-1403e27791b:-10c2
- _bnode1375398754161/-2217616413582301424/-7059da6e-1403e27791b:-1202
- _bnode1375398754161/-2217616413582301424/-7059da6e-1403e27791b:-13de

**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 clicking on the links and drilling down the nodes. Clicking on an IRI may return one or more related triples:

5 triples

`:bnodes137398751461/2217616413582301424/7059da6e1403c27791b-1145
<http://pervasive.semanticweb.org/ont/2004/06/time/to>
<7059da6e1403c27791b-6a9a>
`:bnodes137398754161/2217616413582301424/7059da6e1403c27791b-1145
<http://pervasive.semanticweb.org/ont/2004/06/time/from>
<7059da6e1403c27791b-6a9a>
`:bnodes137398754161/2217616413582301424/7059da6e1403c27791b-1145
<http://www.w3.org/1999/02/22-rdf-syntax-nat#type>
<http://www.rdfabout.com/rdf/schema/politico/Term>
`:bnodes137398754161/2217616413582301424/7059da6e1403c27791b-1145
<http://www.rdfabout.com/rdf/schema/politico/forOffice>
<http://www.rdfabout.com/rdf/usgov/congress/house/33/in>
`:bnodes137398754161/2217616413582301424/7059da6e1403c27791b-1145
<http://www.rdfabout.com/rdf/schema/politico/party="Democrat".>

You can use an optional \texttt{iri} parameter to specify particular IRIs about which to return information, in Turtle triple serialization.

For example, you could paste this request into your browser:


The nodes selected by the IRI \texttt{http://dbpedia.org/resources/Abraham_Lincoln} are returned in Turtle serialization:

6 triples

<http://dbpedia.org/resource/Abraham_Lincoln> <http://dbpedia.org/ontology/birthDate> "1809-02-12"^^\texttt{xsd:date}.
<http://dbpedia.org/resource/Abraham_Lincoln> <http://dbpedia.org/ontology/deathDate> "1865-04-15"^^\texttt{xsd:date} .}
If you are using curl or an equivalent command-line tool for issuing HTTP requests, you can specify the following MIME types in the request Accept header:

- When no parameters are specified, use text/html in the request Accept header.
- When you use the iri parameter one of the MIME types listed in “SPARQL Query Types and Output Formats” on page 186 should be used. See “Supported RDF Triple Formats” on page 33 for additional information about RDF triple formats.

In this example, the GET request returns the nodes selected by the given iri parameter in Turtle triple serialization:

```
curl --anyauth --user admin:password -i -X GET \
-H "Accept: text/turtle" \
```

=>

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/Aristotle>
<http://dbpedia.org/ontology/birthPlace>
<http://dbpedia.org/resource/Stagira_(ancient_city)> .
<http://dbpedia.org/resource/Aristotle> <http://xmlns.com/foaf/0.1/name>
"Aristotle" .
<http://dbpedia.org/resource/Aristotle> <http://xmlns.com/foaf/0.1/name>
"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 serialization will yield “406 Not Acceptable”.
9.11 Managing Graph Permissions

This section covers the REST Client API support for setting, modifying, and retrieving graph permissions. If you are not already familiar with the MarkLogic security model, you should review the *Understanding and Using Security Guide*.

The following topics are covered:

- Default Permissions and Required Privileges
- Setting Permissions as Part of Another Operation
- Setting Permissions Standalone
- Retrieving Graph Permissions

9.11.1 Default Permissions and Required Privileges

All graphs created and managed using the REST Client API grant “read” capability to the *rest-reader* role and “update” capability to the *rest-writer* role. These default permissions are always assigned to a graph, even if you do not explicitly specify them.

For example, if you create a new graph using `PUT /v1/graphs` and do not specify any permissions, the graph will have permissions similar to the following:

<table>
<thead>
<tr>
<th>XML</th>
<th>JSON</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;metadata xmlns=&quot;http://marklogic.com/rest-api&quot;&gt;</code></td>
<td>`{&quot;permissions&quot;: [</td>
</tr>
<tr>
<td><code>  &lt;permissions&gt;</code></td>
<td><code>  {&quot;role-name&quot;:&quot;rest-writer&quot;,</code></td>
</tr>
<tr>
<td><code>    &lt;permission&gt;</code></td>
<td><code>    &quot;capabilities&quot;: [&quot;update&quot;]</code></td>
</tr>
<tr>
<td><code>      &lt;role-name&gt;rest-writer&lt;/role-name&gt;</code></td>
<td><code>    },</code></td>
</tr>
<tr>
<td><code>      &lt;capability&gt;update&lt;/capability&gt;</code></td>
<td><code>    {&quot;role-name&quot;:&quot;rest-reader&quot;,</code></td>
</tr>
<tr>
<td><code>    &lt;/permission&gt;</code></td>
<td><code>    &quot;capabilities&quot;: [&quot;read&quot;]</code></td>
</tr>
<tr>
<td><code>  &lt;/permissions&gt;</code></td>
<td><code>  }</code></td>
</tr>
<tr>
<td><code>&lt;/metadata&gt;</code></td>
<td><code>]}</code></td>
</tr>
</tbody>
</table>

If you explicitly specify other permissions when creating the graph, the above default permissions are still set, as well as the permissions you specify.

You can use custom roles to limit access to selected users on a graph by graph basis. Your custom roles must include equivalent *rest-reader* and *rest-writer* privileges. Otherwise, users with these roles cannot use the REST Client API to manage or query semantic data.

For details, see [Security Requirements](#) in the *REST Application Developer’s Guide*. 
9.11.2 Setting Permissions as Part of Another Operation

Use the `perm` request parameter to set, overwrite, or add permissions as part of another graph operation. To manage permissions when not modifying graph content, use the `category` parameter instead. For details, see “Setting Permissions Standalone” on page 208.

The `perm` parameter has the following form:

```
perm:role=capability
```

Where `role` is the name of a role defined in MarkLogic and `capability` is one of “read”, “insert”, “update”, or “execute”.

You can specify the `perm` parameter multiple times to grant multiple capabilities to the same role or set permissions for multiple roles. For example, the following set of parameters grants the “readers” role the “read” capability and the “writers” role the “update” capability:

```
perm:readers=read&perm:writers=update
```

**Note:** Setting or changing the permissions on a graph does not effect the permissions on documents that contain embedded triples in that graph.

You can use the `perm` parameter with the following operations:

<table>
<thead>
<tr>
<th>Operation</th>
<th>REST Client API Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set or overwrite permissions on a named graph or the default graph while creating or overwriting the graph contents.</td>
<td>PUT /v1/graphs?graph=uri&amp;perm:role=capability&lt;br&gt;PUT /v1/graphs?default&amp;perm:role=capability&lt;br&gt;Request body contains new graph contents (triples).</td>
</tr>
<tr>
<td>During a SPARQL Update operation, set permissions on all graphs created as part of the update.</td>
<td>POST /v1/graphs/sparql?perm:role=capability&lt;br&gt;Request body contains SPARQL Update.</td>
</tr>
<tr>
<td>Add permissions to a named graph while adding content to the graph.</td>
<td>POST /v1/graphs?graph=uri&amp;perm:role=capability&lt;br&gt;POST /v1/graphs/default&amp;perm:role=capability&lt;br&gt;Request body contains graph updates (triples)</td>
</tr>
</tbody>
</table>

The following restrictions apply:

- When you use the `perm` parameter with `/v1/graphs`, you must also include either the `graph` or the `default` request parameter.
- You cannot use the `perm` parameter in conjunction with `category=permissions` or `category=metadata`.


• When you use the `perm` parameter to specify permissions as part of a SPARQL Update operation, the permissions only affect graphs created as part of the update. The permissions on pre-existing graphs remain unchanged.

### 9.11.3 Setting Permissions Standalone

Set the `category` request parameter to `permissions` to manage permissions without affecting the contents of a graph. For example, a request of the following form that includes permissions metadata in the request body sets the permissions on the default graph, but does not change the graph contents.

```
PUT /v1/graphs?default&category=permissions
```

To set or add permissions along with your graph content, use the `perm` request parameter. For details, see “Setting Permissions as Part of Another Operation” on page 207.

You can set the `category` parameter to either `permissions` or `metadata`. They are equivalent in the context of graph management.

The request body must contain permissions metadata. In XML, the metadata can be rooted at either a `metadata` element or the `permissions` element. Also, in XML, the metadata must be in the namespace `http://marklogic.com/rest-api`.

For example, all of the following are acceptable:

<table>
<thead>
<tr>
<th>XML</th>
<th>JSON</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;metadata xmlns=&quot;http://marklogic.com/rest-api&quot;&gt;</code></td>
<td>`{&quot;permissions&quot;:{</td>
</tr>
<tr>
<td><code>&lt;permissions&gt;</code></td>
<td>`{&quot;role-name&quot;:&quot;roleA&quot;,</td>
</tr>
<tr>
<td><code>&lt;permission&gt;</code></td>
<td>&quot;capabilities&quot;:{</td>
</tr>
<tr>
<td><code>&lt;role-name&gt;roleA&lt;/role-name&gt;</code></td>
<td>&quot;read&quot;, &quot;update&quot;</td>
</tr>
<tr>
<td><code>&lt;capability&gt;read&lt;/capability&gt;</code></td>
<td>}},</td>
</tr>
<tr>
<td><code>&lt;capability&gt;update&lt;/capability&gt;</code></td>
<td>`{&quot;role-name&quot;:&quot;roleB&quot;,</td>
</tr>
<tr>
<td><code>&lt;/permission&gt;</code></td>
<td>&quot;capabilities&quot;:{</td>
</tr>
<tr>
<td><code>&lt;permission&gt;</code></td>
<td>&quot;read&quot;]</td>
</tr>
<tr>
<td><code>&lt;role-name&gt;roleB&lt;/role-name&gt;</code></td>
<td>}</td>
</tr>
<tr>
<td><code>&lt;capability&gt;read&lt;/capability&gt;</code></td>
<td>}</td>
</tr>
<tr>
<td><code>&lt;/permissions&gt;</code></td>
<td><code>}</code></td>
</tr>
<tr>
<td><code>&lt;/metadata&gt;</code></td>
<td><code>}</code></td>
</tr>
</tbody>
</table>
Note: Setting or changing the permissions on a graph does not effect the permissions on documents that contain embedded triples in that graph.

You can use the category=permissions pattern to manage graph permissions with the following methods. In all cases, the graph contents are unaffected.

<table>
<thead>
<tr>
<th>Operation</th>
<th>REST Client API Pattern</th>
</tr>
</thead>
</table>
| Set or overwrite permissions on a named graph or the default graph. | PUT /v1/graphs?graph=uri&category=permissions  
PUT /v1/graphs?default&category=permissions  
Request body contains permissions metadata. You can also use category=metadata. |
| Add permissions to a named graph or the default graph. | POST /v1/graphs?graph=uri&category=permissions  
POST /v1/graphs?default&category=permissions  
Request body contains permissions metadata. You can also use category=metadata. |
| Reset the permissions to default permissions on a named graph or the default graph. | DELETE /v1/graphs?graph=uri&category=permissions  
DELETE /v1/graphs?default&category=permissions |

The following restrictions apply:

- When you use category=permissions or category=metadata with /v1/graphs, you must also include either the graph or the default request parameter.
- You cannot use category=permissions or category=metadata in conjunction with the perm parameter.
9.11.4 Retrieving Graph Permissions

To retrieve permissions metadata about a named graph, make a GET request of the following form:

GET /v1/graphs?graph=graphURI&category=permissions

To retrieve permissions metadata about the default graph, make a GET request of the following form:

GET /v1/graphs?default&category=permissions

You can request metadata in either XML or JSON. The default format is XML.

For example, the following command retrieves permissions for the graph with URI /my/graph, as XML. In this case, the graph includes both the default rest-writer and read-reader permissions and permissions for a custom role named “GroupA”.

```
curl --anyauth --user user:password -X GET -i \
-H "Accept: application/xml" \ 
'http://localhost:8000/v1/graphs?graph=/my/graph&category=permissions'
```

HTTP/1.1 200 OK
Content-Type: application/xml; charset=utf-8
Server: MarkLogic
Content-Length: 868
Connection: Keep-Alive
Keep-Alive: timeout=5

```xml
<rapi:metadata uri="/my/graph" ... 
  xmlns:rapi="http://marklogic.com/rest-api" ...>
  <rapi:permissions>
    <rapi:permission>
      <rapi:role-name>rest-writer</rapi:role-name>
      <rapi:capability>update</rapi:capability>
    </rapi:permission>
    <rapi:permission>
      <rapi:role-name>rest-reader</rapi:role-name>
      <rapi:capability>read</rapi:capability>
    </rapi:permission>
    <rapi:permission>
      <rapi:role-name>GroupA</rapi:role-name>
      <rapi:capability>read</rapi:capability>
      <rapi:capability>update</rapi:capability>
    </rapi:permission>
  </rapi:permissions>
</rapi:metadata>
```
The following data is the equivalent permissions metadata, expressed as JSON:

```json
{"permissions": [  {"role-name":"rest-writer","capabilities": ["update"]},  {"role-name":"rest-reader","capabilities": ["read"]},  {"role-name":"GroupA","capabilities": ["read","update"]}]
}
```
10.0 XQuery and JavaScript Semantics APIs

This chapter describes the XQuery and JavaScript Semantics APIs, which include an XQuery library module, built-in semantics functions, and support for SPARQL, SPARQL Update, and RDF. The Semantics API is designed for large-scale, production triple stores and applications. The complete list of semantic functions can be found at http://docs.marklogic.com/sem/semantics.

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 Semantics features; XQuery API, REST API, Node.js Client API, and Java Client API, using a variety of query styles, as described in the Loading Semantic Triples, Semantic Queries and Inserting, Deleting, and Modifying Triples with XQuery and Server-Side JavaScript chapters of this guide.

This chapter includes the following sections:

- XQuery Library Module for Semantics
- Generating Triples
- Extracting Triples from Content
- Parsing Triples
- Exploring Data

**Note:** Semantics is a separately licensed product: you need a valid semantics license key to use semantics.

10.1 XQuery Library Module for Semantics

Some of the Semantics XQuery functions are built-in functions that do not require an import statement, while others are implemented in an XQuery library module that does require an import statement. To simplify things, MarkLogic recommends that you import the Semantics API library into every XQuery module or JavaScript module that uses the Semantics API.

10.1.1 Importing the Semantics Library Module with XQuery

You can use the Semantics API library module with XQuery by importing the module into your XQuery with the following prolog statement:

```xquery
import module namespace sem = "http://marklogic.com/semantics"
    at "/MarkLogic/semantics.xqy";
```
The prefix for all semantic functions in XQuery is `http://marklogic.com/semantics`. The Semantics API uses the prefixes `sem:` or `rdf:`, which are 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*.

### 10.1.2 Importing the Semantics Library Module with JavaScript

For JavaScript you can use the Semantics API library module by importing the module into your JavaScript with this statement:

```javascript
var sem = require("/marklogic/semantics.xqy");
```

The prefix for all semantic XQuery functions in JavaScript is `/marklogic.com/semantics.xqy`. With JavaScript, 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 JavaScript Library Modules in the *JavaScript Reference Guide* and the *MarkLogic XQuery and XSLT Function Reference*.

### 10.2 Generating Triples

The XQuery `sem:rdf-builder` function is a powerful tool for dynamically generating triples in the Semantics API. (For JavaScript, the function is `sem.rdfBuilder`.)

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:

```xml
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/669570065232466909>
  <http://xmlns.com/foaf/0.1/knows> _:bnode4892021155019117627 ;
```
In the example, there are three triples generated in Turtle serialization 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 127.
- The blank nodes produced in the third triple match the identity of those defined in the first and second.

10.3 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.
### Table: City Index

<table>
<thead>
<tr>
<th>Ranking</th>
<th>City</th>
<th>Inflation</th>
<th>Ranking</th>
<th>City</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>London (United Kingdom)</td>
<td>270</td>
<td>71</td>
<td>Minneapolis (United States)</td>
<td>134</td>
</tr>
<tr>
<td>2</td>
<td>Stockholm (Sweden)</td>
<td>266</td>
<td>72</td>
<td>Turin (Italy)</td>
<td>134</td>
</tr>
<tr>
<td>3</td>
<td>Zurich (Switzerland)</td>
<td>251</td>
<td>73</td>
<td>Shanghai (China)</td>
<td>133</td>
</tr>
<tr>
<td>4</td>
<td>Geneva (Switzerland)</td>
<td>247</td>
<td>74</td>
<td>Ljubljana (Slovenia)</td>
<td>132</td>
</tr>
<tr>
<td>5</td>
<td>New York City (United States)</td>
<td>225</td>
<td>75</td>
<td>Orlando (United States)</td>
<td>129</td>
</tr>
<tr>
<td>6</td>
<td>Singapore (Singapore)</td>
<td>219</td>
<td>76</td>
<td>Saint Petersburg (Russia)</td>
<td>125</td>
</tr>
<tr>
<td>7</td>
<td>San Francisco (United States)</td>
<td>209</td>
<td>77</td>
<td>Austin (United States)</td>
<td>125</td>
</tr>
<tr>
<td>8</td>
<td>Paris (France)</td>
<td>208</td>
<td>78</td>
<td>Phoenix (United States)</td>
<td>123</td>
</tr>
<tr>
<td>9</td>
<td>Sydney (Australia)</td>
<td>205</td>
<td>79</td>
<td>Almaty (Kazakhstan)</td>
<td>121</td>
</tr>
<tr>
<td>10</td>
<td>Brisbane (Australia)</td>
<td>203</td>
<td>80</td>
<td>Salt Lake City (United States)</td>
<td>120</td>
</tr>
<tr>
<td>11</td>
<td>Copenhagen (Denmark)</td>
<td>202</td>
<td>81</td>
<td>Beijing (China)</td>
<td>120</td>
</tr>
<tr>
<td>12</td>
<td>Oslo (Norway)</td>
<td>201</td>
<td>82</td>
<td>Lisbon (Portugal)</td>
<td>120</td>
</tr>
<tr>
<td>13</td>
<td>Tokyo (Japan)</td>
<td>200</td>
<td>83</td>
<td>Santiago (Chile)</td>
<td>120</td>
</tr>
<tr>
<td>14</td>
<td>Hong Kong (Hong Kong)</td>
<td>200</td>
<td>84</td>
<td>Montevideo (Uruguay)</td>
<td>119</td>
</tr>
<tr>
<td>15</td>
<td>Perth (Australia)</td>
<td>198</td>
<td>85</td>
<td>Belo Horizonte (Brazil)</td>
<td>116</td>
</tr>
<tr>
<td>16</td>
<td>Melbourne (Australia)</td>
<td>190</td>
<td>86</td>
<td>Brasilia (Brazil)</td>
<td>116</td>
</tr>
<tr>
<td>17</td>
<td>Amsterdam (Netherlands)</td>
<td>189</td>
<td>87</td>
<td>Valencia (Spain)</td>
<td>116</td>
</tr>
<tr>
<td>18</td>
<td>Wellington (New Zealand)</td>
<td>186</td>
<td>88</td>
<td>Kansas City (United States)</td>
<td>116</td>
</tr>
<tr>
<td>19</td>
<td>Washington D C. (United States)</td>
<td>185</td>
<td>89</td>
<td>Raleigh, North Carolina (United States)</td>
<td>115</td>
</tr>
<tr>
<td>20</td>
<td>Helsinki (Finland)</td>
<td>182</td>
<td>90</td>
<td>Istanbul (Turkey)</td>
<td>114</td>
</tr>
<tr>
<td>21</td>
<td>Dublin (Ireland)</td>
<td>182</td>
<td>91</td>
<td>Bangkok (Thailand)</td>
<td>114</td>
</tr>
<tr>
<td>22</td>
<td>Boston (United States)</td>
<td>174</td>
<td>92</td>
<td>Bogotá (Colombia)</td>
<td>111</td>
</tr>
<tr>
<td>23</td>
<td>Frankfurt am Main (Germany)</td>
<td>172</td>
<td>93</td>
<td>Zagreb (Croatia)</td>
<td>109</td>
</tr>
<tr>
<td>24</td>
<td>Toronto (Canada)</td>
<td>170</td>
<td>94</td>
<td>Oporto (Portugal)</td>
<td>108</td>
</tr>
<tr>
<td>25</td>
<td>Munich (Germany)</td>
<td>168</td>
<td>95</td>
<td>Taipei (Taiwan)</td>
<td>108</td>
</tr>
<tr>
<td>26</td>
<td>Manchester (United Kingdom)</td>
<td>166</td>
<td>96</td>
<td>Amman (Jordan)</td>
<td>107</td>
</tr>
<tr>
<td>27</td>
<td>Vancouver (Canada)</td>
<td>165</td>
<td>97</td>
<td>Curitiba (Brazil)</td>
<td>107</td>
</tr>
<tr>
<td>28</td>
<td>Tel Aviv (Israel)</td>
<td>165</td>
<td>98</td>
<td>Porto Alegre (Brazil)</td>
<td>107</td>
</tr>
<tr>
<td>29</td>
<td>Malmo (Sweden)</td>
<td>165</td>
<td>99</td>
<td>Kuala Lumpur (Malaysia)</td>
<td>105</td>
</tr>
<tr>
<td>30</td>
<td>Caléarv (Canada)</td>
<td>164</td>
<td>100</td>
<td>Johannesburg (South Africa)</td>
<td>103</td>
</tr>
</tbody>
</table>

**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:

```html
<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</th>
      <th class="inflation-explanation"></th>
    </tr>
  </thead>
  <tbody>
    <tr>
      <td class="ranking">1</td>
      <td class="city-name"></td>
      <td class="inflation"></td>
    </tr>
  </tbody>
</table>
```
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
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']
```

```xml
<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">
      <a href="http://www.example.org/IncreasedCoL/new-york">
         New York City (United States)</a></td>
   <td class="inflation">225</td>
</tr>
```
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:

10.4 Parsing Triples
This example extends the previous example and inserts parsed triples into the database by using
the sem:rdf-insert function:

```xquery
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>))
```

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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:

```
/triplestore/2ca88f284b7dd96d.xml
/triplestore/7c19fe172da48828.xml
/triplestore/6a45de9c436d854f.xml
/triplestore/47f9e478bda7921d.xml
/triplestore/6e674215fbeb6b99.xml
/triplestore/a039ff4f4117ff53.xml
/triplestore/5a261fb1e13f247a.xml
/triplestore/d57ed5a09ff8b1d3.xml
/triplestore/2c21d435cba81f5f.xml
```

**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 “Understanding the Triple Index and How It’s Used” on page 54.

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.
10.5 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`

10.5.1 `sem:triple Functions`
This table describes the `sem:triple` functions used to define or search for triple data:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>sem:triple</code></td>
<td>Creates a triple object that represents an RDF triple containing atomic values representing the subject, predicate, object, and optionally a graph identifier (graph IRI)</td>
</tr>
<tr>
<td><code>sem:triple-subject</code></td>
<td>Returns the subject from a <code>sem:triple</code> value</td>
</tr>
<tr>
<td><code>sem:triple-predicate</code></td>
<td>Returns the predicate from a <code>sem:triple</code> value</td>
</tr>
<tr>
<td><code>sem:triple-object</code></td>
<td>Returns the object from a <code>sem:triple</code> value</td>
</tr>
<tr>
<td><code>sem:triple-graph</code></td>
<td>Returns the graph identifier (graph IRI) from a <code>sem:triple</code> value</td>
</tr>
</tbody>
</table>

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:

```xml
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 .
```
10.5.2 **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. (In JavaScript, you would use the `sem.transitiveClosure` function.) 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/](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:

```xml
<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/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/>.
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 strictly transitive, it is a sub-property of skos:broaderTransitive, which is a transitive.

**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
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”:

```xquery
<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 .
...
```
11.0 Client-Side APIs for Semantics

MarkLogic Semantics can be accessed through client-side APIs that provide support for management of triples and graphs, SPARQL and SPARQL Update, and access to the search features of MarkLogic server. The Java Client and Node.js Client source are available on GitHub. Also on GitHub are MarkLogic Sesame and MarkLogic Jena.

The chapter includes the following sections:

- Java Client API
- MarkLogic Sesame API
- MarkLogic Jena API
- Node.js Client API

11.1 Java Client API

The Java Client API enables you to use Java to manage graphs and triples, and to access SPARQL query and SPARQL Update functionality in MarkLogic (Java Client API 3.0.4 or later).

The Java Client API supports a variety of formats for RDF. For example, you can write a graph with data in Turtle syntax, read it back as N-Triples syntax, and query it using JacksonHandle and SPARQL.

The Java Client API is available on GitHub at http://github.com/marklogic/java-client-api or from the central Maven repository. Use the following Java Client API interfaces in the com.marklogic.client.semantics package for Semantic operations:

- GraphManager
- SPARQLQueryManager
- SPARQLQueryDefinitions
- GraphPermissions
- SPARQLBindings
- RDFTypes
- RDFMimeTypes
- SPARQLRuleset

The following topics cover the Java Client API semantic features in more detail:

- Core Java Client API Concepts
- Graph Management
- SPARQL Query
11.1.1 Core Java Client API Concepts

This section provides a very brief introduction to Java Client API concepts that will help you understand the Semantics examples that use this API. For details, see the Java Application Developer’s Guide.

All interactions with MarkLogic Server through the Java Client API require a DatabaseClient object. A DatabaseClient object encapsulates connection details to MarkLogic Server. Use DatabaseClientFactory.newClient to create a DatabaseClient object. For details, see Creating, Working With, And Releasing a Database Client in the Java Application Developer’s Guide.

For example, the following code creates a DatabaseClient and then uses it to create a GraphManager object. The example DatabaseClient represents connection details to a MarkLogic installation on localhost, listening on port 8000, acting on the database named “myDatabase”. The client uses the user “myuser” and digest authentication.

```java
import com.marklogic.client.DatabaseClientFactory;
...
DatabaseClient client = DatabaseClientFactory.newClient(
    "localhost", 8000, "myDatabase", "myuser", "mypassword",
    Authentication.DIGEST);
GraphManager gmgr = client.newGraphManager();
```

The Java Client API commonly uses Handle objects to reference data exchanged between your application and MarkLogic Server. For example, you can read triples from a file using a FileHandle or create a StringHandle that references a serialized triple in memory. For details, see Handles in the Java Application Developer’s Guide.

The following example demonstrates reading triples in Turtle format from a file into a FileHandle. The resulting handle can be used as input to operations such as GraphManager.write.

```java
import com.marklogic.client.io.FileHandle;
...
FileHandle fileHandle = 
    new FileHandle(new File("example.ttl"))
    .withMimetype(RDFMimeTypes.TURTLE);
```
11.1.2 Graph Management

Use the GraphManager interface to perform graph management operations such as creating, reading, updating, and deleting graphs. The following table summarizes key GraphManager methods. For more details, see the Java Client API Documentation.

<table>
<thead>
<tr>
<th>GraphManager Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>read</td>
<td>Retrieve triples from a specific graph.</td>
</tr>
<tr>
<td>readAs</td>
<td></td>
</tr>
<tr>
<td>write</td>
<td>Create or overwrite a graph. If the graph already exists, the effect is the same as removing the graph and then recreating it from the input data.</td>
</tr>
<tr>
<td>writeAs</td>
<td></td>
</tr>
<tr>
<td>replaceGraphs</td>
<td>Remove triples from all graphs, and then insert the quads in the input data set. Unmanaged triples are not affected. The effect is the same as first calling GraphManager.deleteGraphs, and then inserting the quads.</td>
</tr>
<tr>
<td>replaceGraphsAs</td>
<td></td>
</tr>
<tr>
<td>merge</td>
<td>Add triples to a named graph or the default graph. If the graph does not exist, it is created.</td>
</tr>
<tr>
<td>mergeAs</td>
<td></td>
</tr>
<tr>
<td>mergeGraphs</td>
<td>Add quads to the graphs specified in the input quad data. Any graphs that do not already exist are created.</td>
</tr>
<tr>
<td>mergeGraphsAs</td>
<td></td>
</tr>
<tr>
<td>delete</td>
<td>Delete a specific graph.</td>
</tr>
<tr>
<td>deleteGraphs</td>
<td>Delete all graphs. Unmanaged triples are not affected.</td>
</tr>
</tbody>
</table>

To reference the default graph in methods that accept a graph URI as input, use GraphManager.DEFAULT_GRAPH.

As you saw in the earlier example, use DatabaseClient.newGraphManager to create a GraphManager object. The following code creates a DatabaseClient and then uses it to create a GraphManager:

```java
DatabaseClient client = DatabaseClientFactory.newClient(...);
GraphManager gmgr = client.newGraphManager();
```

To create (or replace) a graph, use GraphManager.write. The following example reads triples in Turtle format from a file into a FileHandle and then writes the triples to a named graph with the URI “myExample/graphURI”:

```java
FileHandle fileHandle =
    new FileHandle(new File("example.ttl"))
    .withMimetype(RDFMimeTypes.TURTLE);
gmgr.write("myExample/graphURI", fileHandle);
```

Note that if you use GraphManager.write to load quads, any graph URI in a quad is ignored in favor of the graph URI parameter passed into write.
To merge triples into an existing graph, use `GraphManager.merge`. The following example adds a single triple in Turtle format to the default graph. The triple is passed via a `StringHandle`, using `StringHandle.withMimetype` to indicate the triple format to the operation.

```java
StringHandle stringHandle = new StringHandle()
    .with("<http://example.org/subject2> " +
        "<http://example.org/predicate2> " +
        "<http://example.org/object2> .")
    .withMimetype(RDFMimeTypes.TURTLE);

gmgr.merge("myExample/graphUri", stringHandle);
```

You can also set a default MIME type on the `GraphManager` object rather than on each Handle. For details, see `GraphManager.setMimetype` in the *Java Client API Documentation*.

To read the contents of a graph, use `GraphManager.read`. Specify the output triple format by calling `setMimetype` on the output Handle or by setting a default MIME type on your `GraphManager` object. The following example retrieves the contents of the default graph, as triples in Turtle format. The results are available as strings, through a `StringHandle`.

```java
StringHandle triples = gmgr.read(
    GraphManager.DEFAULT_GRAPH,
    new StringHandle().withMimetype(RDFMimeTypes.TURTLE);
    //...work with the triples as one big string
```

To remove a graph, use `GraphManager.delete`. To remove all graphs, use `GraphManager.deleteGraphs`. The following example removes the graph with URI “myExample/graphUri”:

```java

gmrg.delete("myExample/graphUri");
```

You can also use the `GraphManager` interface to manage graph permissions, either by passing permissions into individual graph operations (write, merge, and so on) and or by calling explicit permission management methods such as `GraphManager.writePermissions`. Use `GraphManager.permission` to create the set of permissions to be applied to a graph.

For example, the following code replaces any permissions on the graph “myExample/graphUri” with a new set of permissions:

```java
import com.marklogic.client.semantics.Capability;
...
gmgr.writePermissions(  "http://myExample/graphUri",
    gmgr.permission("role1", Capability.READ)  
    .permission("role2", Capability.READ, Capability.UPDATE));
```
The following example adds similar permissions as part of graph merge.

```java
gmgr.merge(
    "myExample/graphUri", someTriplesHandle,
    gmgr.permission("role1", Capability.READ)
    .permission("role2", Capability.READ, Capability.UPDATE));
```

### 11.1.3 SPARQL Query

Use the `SPARQLQueryManager` interface to query RDF datasets using `SELECT`, `CONSTRUCT`, `DESCRIBE`, and `ASK` queries. The `SPARQLQueryManager` interface supports both update and read queries. The `SPARQLQueryDefinition` interface encapsulates the format of a query and bindings. Use `SPARQLBindings` interface to bind variables used in a SPARQL query.

Evaluating a SPARQL read or update query consists of the following basic steps:

1. **Create a query manager using** `DatabaseClient.newSPARQLQueryManager`. For example:

   ```java
   DatabaseClient client = ...;
   SPARQLQueryManager sqmgr = client.newSPARQLManager();
   ```

2. **Create a query using** `SPARQLQueryManager.newSPARQLQueryDefinition` and configure the query as needed. For example:

   ```java
   SPARQLQueryDefinition query = sqmgr.newSPARQLQueryDefinition(
       "SELECT * WHERE { ?s ?p ?o } LIMIT 10")
       .withBinding("o", "http://example.org/object1");
   ```

3. **Evaluate the query and receive results by calling one of the execute* methods of SPARQLQueryManager.** For example:

   ```java
   JacksonHandle results = new JacksonHandle();
   results.setMimetype(SPARQLMimeTypes.SPARQL_JSON));
   results = sqmgr.executeSelect(query, results);
   ```

The `SPARQLQueryManager` interface includes the following methods for evaluating the supported SPARQL query types:

- `executeSelect`
- `executeAsk`
- `executeConstruct`
- `executeDescribe`
- `executeUpdate`
The following example puts it all together to evaluate a `SELECT` query. The query includes a binding for the variable “o”. The query results are returned as JSON.

```java
import com.marklogic.client.semantics.SPARQLQueryManager;
import com.marklogic.client.semantics.SPARQLQueryDefinition;
import com.marklogic.client.io.JacksonHandle;

// create a query manager
SPARQLQueryManager sparqlMgr = databaseClient.newSPARQLQueryManager();

// create a SPARQL query
String sparql = "SELECT * WHERE { ?s ?p ?o } LIMIT 10";
SPARQLQueryDefinition query = sparqlMgr.newQueryDefinition(sparql)
    .withBinding("o", "http://example.org/object1");

// evaluate the query
JacksonHandle handle = new JacksonHandle();
handle.setMimetype(SPARQLMimeTypes.SPARQL_JSON);
JacksonHandle results = sparqlMgr.executeSelect(query, handle);

// work with the results
JsonNode tuples = results.get().path("results").path("bindings");
for ( JsonNode row : tuples ) {
    String s = row.path("s").path("value").asText();
    String p = row.path("p").path("value").asText();
    ...
}
```

You can configure many aspects of a SPARQL query, including defining variable bindings, setting the default or named graphs to which to apply the query, and setting an optimization level. For details, see `SPARQLQueryDefinition` in the `Java Client API Documentation`.

You can define variable bindings one at a time using the fluent `SPARQLQueryDefinition.withBinding` definition, or build up a set of bindings using `SPARQLBindings` and then attach them to the query using `SPARQLQueryDefinition.setBindings`.

For example:

```java
// incrementally attach bindings to a query
SPARQLQueryDefinition query = ...;
query.withBinding("o", "http://example.org/object1")
    .withBinding(...);

// build up a set of bindings and attach them to a query
SPARQLBindings bindings = new SPARQLBindings();
bindings.bind("o", "http://example.org/object1");
bindings.bind(...);
query.setBindings(bindings);
```

See `SPARQLBindings` for more examples using bindings.
When you evaluate a SPARQL SELECT query, by default, all results are returned. You can limit the number of results returned in a “page” using `SPARQLQueryManager.setPageLength` or a SPARQL LIMIT clause. You can retrieve successive pages of results by repeatedly calling `executeSelect` with a different page start position. For example:

```java
// Change the max page length
sqmgr.setPageLength(NRESULTS);

// Fetch at most the first N results
long start = 1;
JacksonHandle results = sparqlMgr.executeSelect(query, handle, start);

// Fetch the next N results
start += N;
JacksonHandle results = sparqlMgr.executeSelect(query, handle, start);
```

The Java Client API includes the `SPARQLRuleset` class with a set of built-in rulesets and a factory method to enable you to use custom rulesets. To associate a ruleset with a query, use `SPARQLQueryDefinition.withRuleset` or `SPARQLQueryDefinition.setRulesets`.

Default inferencing can be turned on or off using the `SPARQLQueryDefinition.withIncludeDefaultRulesets(Boolean)` method. By default it is on. Maintaining rulesets is a Management API function. See “Using Rulesets” on page 139.

For a complete list of the MarkLogic Java Client Semantic methods, see `GraphManager` and `SPARQLQueryManager` in the Java Client API Documentation.

### 11.2 MarkLogic Sesame API

Sesame is a Java API for processing and handling RDF data, including creating, parsing, storing, inferencing, and querying over this data. Java developers who are familiar with the Sesame API can now use that same API to access RDF data in MarkLogic. The MarkLogic Sesame API is a full-featured, easy-to-use interface, that provides simple access to MarkLogic Semantics functionality. The MarkLogic Sesame API includes the `MarkLogicRepository` interface, part of the persistence layer.

By including the MarkLogic Sesame API, you can leverage MarkLogic as a Triple Store using standard Sesame for SPARQL query and SPARQL Update. The MarkLogic Sesame API extends the standard Sesame API so that you can also do combination queries, variable bindings, and transactions. The `MarkLogicRepository` class provides support for both transactions and variable bindings.
The following example uses the MarkLogic Sesame API to perform a SPARQL query and a SPARQL Update against Semantic data stored in a MarkLogic database. The example first instantiates a `MarkLogicRepository` and defines a default ruleset and default permissions. Notice that the SPARQL query is constrained by an additional query that limits results to the results of the combined query:

```java
package com.marklogic.semantics.sesame.examples;

import com.marklogic.client.DatabaseClient;
import com.marklogic.client.DatabaseClientFactory;
import com.marklogic.client.io.Format;
import com.marklogic.client.io.StringHandle;
import com.marklogic.client.query.QueryManager;
import com.marklogic.client.query.RawCombinedQueryDefinition;
import com.marklogic.client.query.StringQueryDefinition;
import com.marklogic.client.semantics.Capability;
import com.marklogic.client.semantics.GraphManager;
import com.marklogic.client.semantics.SPARQLRuleset;
import com.marklogic.semantics.sesame.MarkLogicRepository;
import com.marklogic.semantics.sesame.MarkLogicRepositoryConnection;
import com.marklogic.semantics.sesame.query.MarkLogicTupleQuery;
import com.marklogic.semantics.sesame.query.MarkLogicUpdateQuery;
import org.openrdf.model.Resource;
import org.openrdf.model.URI;
import org.openrdf.model.ValueFactory;
import org.openrdf.model.vocabulary.FOAF;
import org.openrdf.model.vocabulary.RDF;
import org.openrdf.model.vocabulary.RDFS;
import org.openrdf.model.vocabulary.XMLSchema;
import org.openrdf.query.
import org.openrdf.repository.RepositoryException;
import org.openrdf.rio.RDFParseException;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import java.io.IOException;

public class Example2_Advanced {

    protected static Logger logger = LoggerFactory.getLogger(Example2_Advanced.class);

    public static void main(String... args) throws RepositoryException, IOException, RDFParseException,
            MalformedQueryException, QueryEvaluationException {

        // instantiate MarkLogicRepository with Java api
        // client DatabaseClient
        DatabaseClient adminClient =
                DatabaseClientFactory.newClient("localhost", 8200,
                        "admin","admin", DatabaseClientFactory.Authentication.DIGEST);
        GraphManager gmgr = adminClient.newGraphManager();
        QueryManager qmgr = adminClient.newQueryManager();
```
// create repo and init
MarkLogicRepository repo = new MarkLogicRepository(adminClient);
repo.initialize();

// get repository connection
MarkLogicRepositoryConnection conn = repo.getConnection();

// set default rulesets
conn.setDefaultsRulesets(SPARQLRule.ALL_VALUES_FROM);

// set default perms
conn.setDefaultGraphPerms(
    gmgr.permission("admin", Capability.READ),
    .permission("admin", Capability.EXECUTE));

// set a default Constraining Query
StringQueryDefinition stringDef =
    qmgr.newStringDefinition().withCriteria("First");
conn.setDefaultsConstrainingQueryDefinition(stringDef);

// return number of triples contained in repository
logger.info("1. number of triples: {}", conn.size());

// add a few constructed triples
Resource context1 = conn.getValueFactory()
    .createURI("http://marklogic.com/examples/context1");
Resource context2 = conn.getValueFactory()
    .createURI("http://marklogic.com/examples/context2");
ValueFactory f = conn.getValueFactory();
String namespace = "http://example.org/";
URI john = f.createURI(namespace, "john");

//use transactions to add triple statements
conn.begin();
conn.add(john, RDF.TYPE, FOAF.PERSON, context1);
conn.add(john, RDFS.LABEL,
    f.createLiteral("John", XMLSchema.STRING), context2);
conn.commit();
logger.info("2. number of triples: {}", conn.size());

// perform SPARQL query
String queryString = "select * { ?s ?p ?o }";
MarkLogicTupleQuery tupleQuery =
    conn.prepareTupleQuery(QueryLanguage.SPARQL, queryString);

// enable rulesets set on MarkLogic database
tupleQuery.setIncludeInferred(true);

// set base uri for resolving relative uris
tupleQuery.setBaseURI("http://www.example.org/base/");

// set rulesets for infererencing
tupleQuery.setRulesets(SPARQLRuleset.ALL_VALUES_FROM, SPARQLRuleset.HAS_VALUE);

// set a combined query
String combinedQuery = "{"search": {"qtext": "*"}}";
RawCombinedQueryDefinition rawCombined = qmgr.newRawCombinedQueryDefinition(
    new StringHandle()
    .with(combinedQuery)
    .withFormat(Format.JSON));
tupleQuery.setConstrainingQueryDefinition(rawCombined);

// evaluate query with pagination
TupleQueryResult results = tupleQuery.evaluate(1, 10);

// iterate through query results
while(results.hasNext()){
    BindingSet bindings = results.next();
    logger.info("subject: ", bindings.getValue("s"));
    logger.info("predicate: ", bindings.getValue("p"));
    logger.info("object: ", bindings.getValue("o"));
}
logger.info("3. number of triples: ", conn.size());

// update query
String updatequery = "INSERT DATA { " + "GRAPH <http://marklogic.com/test/context10> { " + "<http://marklogic.com/test/subject> <pp1> <oo1> } }";
MarkLogicUpdateQuery updateQuery = conn.prepareUpdate(QueryLanguage.SPARQL, updatequery, "http://marklogic.com/test/baseuri");

// set perms to be applied to data
updateQuery.setGraphPerms(
    gmgr.permission("admin", Capability.READ)
    .permission("admin", Capability.EXECUTE));

try {
    updateQuery.execute();
} catch (UpdateExecutionException e) {
    e.printStackTrace();
}
logger.info("4. number of triples: ", conn.size());

// clear all triples
conn.clear();
logger.info("5. number of triples: ", conn.size());

// close connection and shutdown repository
conn.close();
repo.shutDown();
The MarkLogic Sesame API is available on GitHub at http://github.com/marklogic/marklogic-sesame, along with javadocs and examples.

The key interfaces of MarkLogic Sesame API are listed below:

- MarkLogicRepository
- MarkLogicRepositoryConnection
- MarkLogicQuery
  - MarkLogicTupleQuery
  - MarkLogicGraphQuery
  - MarkLogicBooleanQuery
  - MarkLogicUpdateQuery

### 11.3 MarkLogic Jena API

Jena is a Java API for processing and handling RDF data, including creating, parsing, storing, inferencing, and querying over this data. Java developers who are familiar with the Jena API can now use that same API to access RDF data in MarkLogic. The MarkLogic Jena API is a full-featured, easy-to-use interface, that provides simple access to MarkLogic Semantics functionality.

By including the MarkLogic Jena API, you can leverage MarkLogic as a Triple Store using standard Jena for SPARQL query and SPARQL Update. The MarkLogic Jena API extends Jena so that you can also do combination queries, variable bindings, and transactions. The MarkLogicDataSet class provides support for both transactions and variable bindings.

Here is an example showing how to run queries using MarkLogic Jena:

```java
package com.marklogic.jena.examples;

import org.apache.jena.riot.RDFDataMgr;
import org.apache.jena.riot.RDFFormat;
import com.hp.hpl.jena.graph.NodeFactory;
import com.hp.hpl.jena.query.QueryExecutionFactory;
import com.hp.hpl.jena.query.QuerySolution;
import com.hp.hpl.jena.query.ResultSet;
import com.hp.hpl.jena.update.UpdateExecutionFactory;
import com.hp.hpl.jena.update.UpdateFactory;
import com.hp.hpl.jena.update.UpdateProcessor;
import com.hp.hpl.jena.update.UpdateRequest;
import com.marklogic.semantics.jena.MarkLogicDatasetGraph;

/**
* How to run queries. */

```java
public class SPARQLUpdateExample {

private MarkLogicDatasetGraph dsg;

public SPARQLUpdateExample() {
    dsg = ExampleUtils.loadPropsAndInit();
}

private void run() {
    dsg.clear();

    String insertData = "PREFIX foaf: <http://xmlns.com/foaf/0.1/> 
    + "PREFIX : <http://example.org/> " 
    +"INSERT DATA {GRAPH :g1 { 
    + " :charles a foaf:Person ; 
    + " foaf:name \"Charles\" ; 
    + " foaf:knows :jim ." 
    + " :jim a foaf:Person ; 
    + " foaf:name \"Jim\" ; 
    + " foaf:knows :charles ." 
    + " } }"; 

    System.out.println("Running SPARQL update");

    UpdateRequest update = UpdateFactory.create(insertData);
    UpdateProcessor processor = UpdateExecutionFactory.create(update, dsg);
    processor.execute();

    System.out.println("Examine the data as JSON-LD");
    RDFDataMgr.write(System.out, 
    dsg.getGraph(NodeFactory.createURI("http://example.org/g1")), 
    RDFFormat.JSONLD_PRETTY); 

    System.out.println("Remove it.");

    update = UpdateFactory.create("PREFIX : <http://example.org/> DROP GRAPH :g1");
    processor = UpdateExecutionFactory.create(update, dsg);
    processor.execute();
    dsg.close();
}

public static void main(String... args) {
    SPARQLUpdateExample example = new SPARQLUpdateExample();
    example.run();
}
}
```
The MarkLogic Jena source is available on GitHub at http://github.com/marklogic/marklogic-jena, along with javadocs and examples.

The key interfaces of the MarkLogic Jena API are listed below:

- MarkLogicDatasetGraph
- MarkLogicDatasetGraphFactory
- MarkLogicQuery
- MarkLogicQueryEngine

11.4 Node.js Client API

The Node.js Client API can be used for CRUD operations on graphs; creating, reading, updating, and deleting triples and graphs. The DatabaseClient.graphs.write function can be used to create a graph containing triples, the DatabaseClient.graphs.read function reads from a graph. The DatabaseClient.graphs.remove function removes a graph. To query semantic data, use the DatabaseClient.graphs.sparql function.

See Working With Semantic Data in the Node.js Application Developer’s Guide for more details. The Node.js Client source can be found on GitHub at http://github.com/marklogic/node-client-api. For additional operations, see the Node.js Client API Reference.

Note: These operations only work with managed triples contained in a graph. Embedded triples cannot be manipulated using the Node.js Client API.
12.0 Inserting, Deleting, and Modifying Triples with XQuery and Server-Side JavaScript

Triples can be modified with XQuery or Server-side JavaScript, using MarkLogic `xdmp` built-ins. Triples managed by MarkLogic - those triples having a document root of `sem:triples` - can be modified using SPARQL Update. See “Using SPARQL Update” on page 156 for more information about modifying managed triples.

“Unmanaged” triples, those triples embedded in another document with an element node of `sem:triple`, can only be modified using XQuery or Server-Side JavaScript and `xdmp` built-ins. To perform updates on triples in your datastore (for either managed or unmanaged triples), you will insert a new triple and delete the existing one. You are not updating the existing triple, the update operation is actually an INSERT/DELETE procedure.

This chapter includes the following sections:

- Updating Triples
- Deleting Triples

12.1 Updating Triples

You can use XQuery or Server-Side JavaScript functions to update existing triples in a database, by using INSERT/DELETE to replace nodes. For a managed triple, the `sem:database-nodes` (`sem.databaseNode` in Server-Side JavaScript) and the `xdmp:node-replace` (`xdmp.nodeReplace` in Server-Side JavaScript) 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”:

```xml
<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 next 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);

Only the triple bound to the variable $builder in the example matches the expression and is updated (replaced).

In Server-Side JavaScript, the example would look very similar.

declareUpdate();
var sem = require("/MarkLogic/semantics.xqy");
var builder = sem.rdfBuilder();
var triple = xdmp.apply(builder, "dbpedia:André-Marie_Ampère",
  "a","foaf:Person");
var node = sem.databaseNodes(triple);

var replace = new NodeBuilder();
replace.startElement("sem:triple","http://marklogic.com/semantics/");
replace.addElement("sem:subject","http://dbpedia.org/resource/André-
  Marie_Ampère/","http://marklogic.com/semantics");
replace.addNode(node.getElementsByTagNameNS("http://marklogic.com/
  semantics","predicate")[0]);
replace.addNode(node.getElementsByTagNameNS("http://marklogic.com/
  semantics","object")[0]);
replace.endElement();
for (var node of nodes) {
  xdmp.nodeReplace(node, replace);
}

When you have multiple triples to update, you can use XQuery or Server-Side JavaScript (or if they are managed triples, SPARQL Update), 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 replaces each occurrence:

```xquery
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:

```xquery
ccts: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.

### 12.2 Deleting Triples

This section discusses methods for deleting RDF data in MarkLogic and includes the following topics:

- Deleting Triples with XQuery or Server-Side JavaScript
- Deleting Triples with REST API

#### 12.2.1 Deleting Triples with XQuery or Server-Side JavaScript

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`
12.2.1.1 sem:graph-delete

Note: This function only works for managed triples.

You can use the sem:graph-delete function to delete all managed triple documents in a named graph. You specify the graph IRI as the parameter.

For example:

```xquery
xquery version "1.0-ml";
import module namespace sem = "http://marklogic.com/semantics"
    at "'/MarkLogic/semantics.xqy";
sem:graph-delete(sem:iri("mynamedgraph"))
```

In Server-Side JavaScript the command would be:

```javascript
var sem = require("/marklogic/semantics.xqy");
sem.graphDelete(sem.iri("mynamedgraph"))
```

The following example deletes all managed triples in the default graph. If no other named graphs exist, this may remove all triples from the database:

```xquery
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:triple. 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.
12.2.1.2 xdmp:node-delete

To delete a set of triples from the database, use the sem:database-nodes function with xdmp:node-delete. This function will work with managed or unmanaged triples.

For example:

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

let $triples :=
for $triple in $triples
return (sem:database-nodes($triple) ! xdmp:node-delete(.))
```

**Note:** This query will not delete empty sem:triple document elements if all the triples are deleted from a single document.

In Server-Side JavaScript, the example would look like this:

```
var sem = require("/MarkLogic/semantics.xqy");

let $triples :=
cts.triples(sem.iri("http://www.rdfabout.com/rdf/usgov/congress/people/D000596"),())
for $triple in $triples
return (sem.databaseNodes($triple) ! xdmp.nodeDelete(.))
```

12.2.1.3 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, and works with both managed and unmanaged triples. 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.
In Server-Side JavaScript, the example would look like this:

```javascript
var sem = require("/MarkLogic/semantics.xqy");
xdmp.documentDelete("example.xml")
```

### 12.2.2 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:

```bash
#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`.

```bash
#Windows users, see Modifying the Example Commands for Windows
$ curl --anyauth --user user:password -X DELETE  
```

As with the `sem:graph-delete` function, the DELETE request removes triples from graphs where `sem:triples` is the root element of the containing document (managed triples). XML documents that contain embedded 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:

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

$ curl --digest --user admin:password -s -X PUT
   -H "Content-type:text/turtle" --data-binary '@./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.
13.0 Technical Support

MarkLogic provides technical support according to the terms detailed in your Software License Agreement or End User License Agreement.

We invite you to visit our support website at http://help.marklogic.com to access information on known and fixed issues, knowledge base articles, and more. For licensed customers with an active maintenance contract, see the Support Handbook for instructions on registering support contacts and on working with the MarkLogic Technical Support team.

Complete product documentation, the latest product release downloads, and other useful information is available for all developers at http://developer.marklogic.com. For general questions, join the general discussion mailing list, open to all MarkLogic developers.
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