**RDF/OWL and SPARQL instead of NoSQL databases**

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1. **Introduction**

NoSQL database systems and especially MongoDB (MongoDB, 2014) have been gaining notoriety over the past several years. However, these systems are very similar to technology that has a very long history in the form of Entity-Attribute-Value (EAV) database systems (Stead, Hammond, & Straube, 1982) (McDonald, Blevins, Tierney, & Martin, 1988). EAV technology has evolved into the standards-based RDF/OWL and SPARQL technology of today. This paper will contrast building a web-based application using MongoDB and ReL[[1]](#footnote-1), and also show how to build a RESTful application using ReL. Both of these examples show that RDF/OWL and SPARQL are very well suited for these types of applications.

MongoDB and ReL will be contrasted using a very simple, flask-based (Flask, 2014), web-application for storing and retrieving “book” information. Figure 1 shows the main menu for this application.

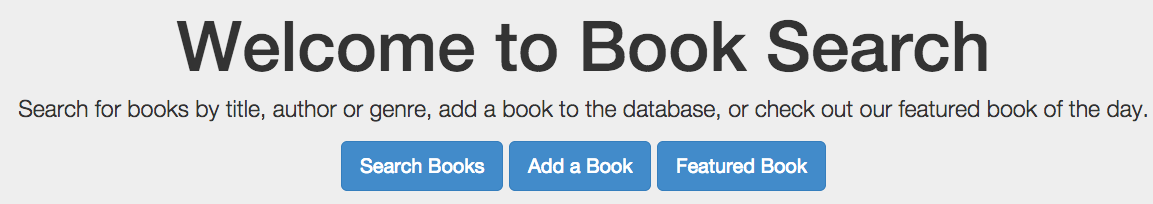


Figure 1

1. **Inserting data into the book application database.**

In this web application, the menu for adding a book is shown in Figure 2.

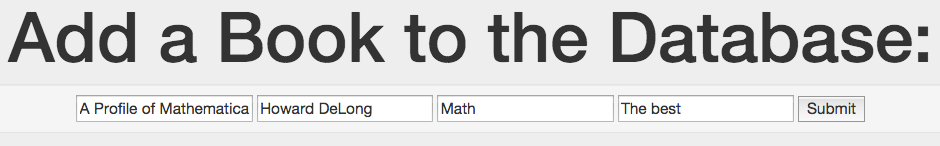


Figure 2

When the submit button is clicked, the following code is executed.

* 1. **For the MongoDB application,**

First a MongoDB connection is established -

from flask import Flask, render\_template, redirect, request

import pymongo

app = Flask(\_\_name\_\_, static\_url\_path = "")

connection\_string = "mongodb://127.0.0.1"

connection = pymongo.MongoClient(connection\_string)

database = connection.books

books = database.mybooks

Then the insert is done using the mongoDB insert API -

@app.route('/add/', methods=['GET', 'POST'])

def add():

if request.method == 'POST':

new\_data = {k : v for k, v in request.form.items()}

**books.insert(new\_data)**

return render\_template('add.html', alert =

"success")

else:

return render\_template('add.html', alert="")

* 1. **For the ReL application,**

First a connection to an Oracle RDF datastore is established -

from flask import Flask, render\_template, redirect, request

app = Flask(\_\_name\_\_, static\_url\_path = "")

conn = connectTo 'jdbc:oracle:thin:@host:1521:orcl' 'user'

'password' 'rdf\_mode' 'bookApp'

Then the insert is done using a standard SQL insert, however, no table named “books” has been created beforehand, so this is “scheme-less” just like MongoDB:

@app.route('/add/', methods=['GET', 'POST'])

def add():

if request.method == 'POST':

new\_data = {k : v for k, v in request.form.items()}

values = (str(new\_data['title']),

str(new\_data['author']), str(new\_data['genre']),

str(new\_data['description']))

**SQL on conn """insert into books(title, author,**

**genre, description) values"""values**

return render\_template('add.html', alert =

"success")

else:

return render\_template('add.html', alert="")

Behind the scenes, ReL converts the SQL insert into a series of several RDF/OWL insert statements as follows[[2]](#footnote-2) -

**BEGIN**

**commit ;**

**set transaction isolation level serializable ;**

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#89', 'owl#title', '"A Profile of Mathematical Logic"^^xsd:string'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#title', 'rdf:type', 'owl:DatatypeProperty'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#title', 'rdfs:domain', 'owl#books'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#title', 'rdf:range', 'rdfs:xsd:string'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#title', 'rdf:type', 'owl:FunctionalProperty'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#89', 'owl#author', '"Howard DeLong"^^xsd:string'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#author', 'rdf:type', 'owl:DatatypeProperty'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#author', 'rdfs:domain', 'owl#books'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#author', 'rdf:range', 'rdfs:xsd:string'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#author', 'rdf:type', 'owl:FunctionalProperty'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#89', 'owl#genre', '"Math"^^xsd:string'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#genre', 'rdf:type', 'owl:DatatypeProperty'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#genre', 'rdfs:domain', 'owl#books'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#genre', 'rdf:range', 'rdfs:xsd:string'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#genre', 'rdf:type', 'owl:FunctionalProperty'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#89', 'owl#description', '"The best"^^xsd:string'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#description', 'rdf:type', 'owl:DatatypeProperty'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#description', 'rdfs:domain', 'owl#books'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#description', 'rdf:range', 'rdfs:xsd:string'));

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#description', 'rdf:type', 'owl:FunctionalProperty'));

**END ;**

**/**

Notice that some of these insert statements are inserting appropriate OWL schema information into the RDF tuple-store, e.g., for the “title” attribute the following is inserted -

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#title', ***'rdf:type', 'owl:DatatypeProperty'***))

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#title', ***'rdfs:domain', 'owl#books'***))

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#title', ***'rdf:range', 'rdfs:xsd:string'***))

**INSERT** INTO BOOK\_DATA VALUES ( BOOK\_APP\_SQNC.nextval, SDO\_RDF\_TRIPLE\_S('FALL2014\_CS347\_PROF:<owl>', 'owl#title', ***'rdf:type', 'owl:FunctionalProperty'***))

This schema information is used when querying the book database.

1. **Searching the book application database.**

In this web application, the menu for searching for a book is shown in Figure 3.



Figure 3

When the submit button is clicked, the following code is executed,

* 1. **For the MongoDB application,**

The search is done using the mongoDB “find” API -

@app.route('/search/', methods=['GET', 'POST'])

def search():

if request.method == 'POST':

query = request.form['query']

return render\_template('search.html', posting=True,

query=query, title\_results = **books.find**({

'title':query}),author\_results = **books.find**({

'author':query}))

else:

return render\_template('search.html', posting =

False)

* 1. **For the ReL application,**

The ReL search is done using standard SQL select statements as follows (the SQL select statements return a python tuple of tuples) -

@app.route('/search/', methods=['GET', 'POST'])

def search():

#Return results for titles, authors and genres that match the search query

if request.method == 'POST':

query = request.form['query']

**titles = SQL on conn """select title, author from**

**books where title = '"""query"""'"""**

**authors = SQL on conn """select title, author from**

**books where author = '"""query"""'"""**

title\_dict = {}

num = 0

for j in titles :

title\_dict.update({'Key' + str(num) : {'title'

: j[0], 'author' : j[1]}})

num += 1

author\_dict = {}

num = 0

for j in authors :

author\_dict.update({'Key' + str(num) : {'title'

: j[0], 'author' : j[1]}})

num += 1

genre\_dict = {}

no\_results = title\_dict == 0 and author\_dict == 0

and genre\_dict == 0

return render\_template('search.html', posting=True,

query=query, no\_results=no\_results,

title\_results=title\_dict,

author\_results=author\_dict,

genre\_results=genre\_dict)

else:

return render\_template('search.html', posting =

False)

Behind the scenes, ReL converts the SQL select statements into SPARQL statements, as shown below -

SELECT v1 "title", v2 "author"

FROM TABLE(SEM\_MATCH('SELECT \* WHERE {

?s1 rdf:type :books .

OPTIONAL { ?s1 :title ?v1 }

OPTIONAL { ?s1 :author ?v2 }

?s1 :title ?f1 .

FILTER(?f1 = "Howard DeLong") }' ,

SEM\_MODELS('FALL2014\_CS347\_PROF'), null,

SEM\_ALIASES( SEM\_ALIAS('', 'http://www.example.org/people.owl#')), null) )

SELECT v1 "title", v2 "author"

FROM TABLE(SEM\_MATCH('SELECT \* WHERE {

?s1 rdf:type :books .

OPTIONAL { ?s1 :title ?v1 }

OPTIONAL { ?s1 :author ?v2 }

?s1 :author ?f1 .

FILTER(?f1 = "Howard DeLong") }' ,

SEM\_MODELS('FALL2014\_CS347\_PROF'), null,

SEM\_ALIASES( SEM\_ALIAS('', 'http://www.example.org/people.owl#')), null) )

1. **Transaction support in ReL.**

The SPARQL statements shown above can be included in a regular Oracle transaction (see the example below). The same is true for all other database operations in ReL. So, ReL can provide traditional transaction support (i.e., read committed and serializable) for all of its database operations. (Notice in Section 2 above, the inserts were wrapped in PL/SQL BEGIN and END statements, which makes the inserts ATOMIC.) One of the major criticisms of NoSQL database is that they don’t provide traditional transaction support. ReL does not suffer from this problem.

**commit ;**

**set transaction isolation level serializable ;**

SELECT v1 "title", v2 "author"

FROM TABLE(SEM\_MATCH('SELECT \* WHERE {

?s1 rdf:type :books .

OPTIONAL { ?s1 :title ?v1 }

OPTIONAL { ?s1 :author ?v2 }

?s1 :title ?f1 .

FILTER(?f1 = "Howard DeLong") }' ,

SEM\_MODELS('FALL2014\_CS347\_PROF'), null,

SEM\_ALIASES( SEM\_ALIAS('', 'http://www.example.org/people.owl#')), null) );

SELECT v1 "title", v2 "author"

FROM TABLE(SEM\_MATCH('SELECT \* WHERE {

?s1 rdf:type :books .

OPTIONAL { ?s1 :title ?v1 }

OPTIONAL { ?s1 :author ?v2 }

?s1 :author ?f1 .

FILTER(?f1 = "Howard DeLong") }' ,

SEM\_MODELS('FALL2014\_CS347\_PROF'), null,

SEM\_ALIASES( SEM\_ALIAS('', 'http://www.example.org/people.owl#')), null) );

1. **RESTful ReL**

ReL can also be run as a RESTful (Fielding, 2000) Server, which means ReL SQL calls (e.g., """select title, author from books where title = '"""query"""'""", which was discussed above) can be embedded in any environment that supports the CURL function. For instance, we use RESTful ReL in R to access data and convert it to R data frames for analysis. The same “data model to RDF/OWL and SPARQL” translations that were discussed above can be used with Restful ReL. Here’s how ReL can be invoked from R to query the standard Oracle emp table -

d = getURL( URLencode('host:5000/rest/native/?query = "**select \* from emp**"'), httpheader = c(DB='jdbc:oracle:thin:@host:1521:orcl', USER='user', PASS='password', MODE='rdf\_mode', MODEL='Fall2014' , returnFor = 'R'), verbose = TRUE)

The “returnFor = 'R'” httpheader parameter value above directs ReL to return data in the following format,

d

"list(c('COMM', 'HIREDATE', 'JOB', 'DEPTNO', 'SAL', 'ENAME', 'MGR', 'EMPNO'), list(c('NULL', 1400, 'NULL', 'NULL', 500, 'NULL', 300, 'NULL', 'NULL', 'NULL', 'NULL', 'NULL', 'NULL', 'NULL'),c('23-JAN-1982', '28-SEP-1981', '1-MAY-1981', '3-DEC-1981', '22-FEB-1981', '9-JUN-1981', '20-FEB-1981', '8-SEP-1981', '12-JAN-1983', '09-DEC-1982', '17-NOV-1981', '17-DEC-1980', '3-DEC-1981', '2-APR-1981'),c('CLERK', 'SALESMAN', 'MANAGER', 'ANALYST', 'SALESMAN', 'MANAGER', 'SALESMAN', 'SALESMAN', 'CLERK', 'ANALYST', 'PRESIDENT', 'CLERK', 'CLERK', 'MANAGER'),c(10, 30, 30, 20, 30, 10, 30, 30, 20, 20, 10, 20, 30, 20),c(1300, 1250, 2850, 3000, 1250, 2450, 1600, 1500, 1100, 3000, 5000, 800, 950, 2975),c('MILLER', 'MARTIN', 'BLAKE', 'FORD', 'WARD', 'CLARK', 'ALLEN', 'TURNER', 'ADAMS', 'SCOTT', 'KING', 'SMITH', 'JAMES', 'JONES'),c(7782, 7698, 7839, 7566, 7698, 7839, 7698, 7698, 7788, 7566, 'NULL', 7902, 7698, 7839),c(7934, 7654, 7698, 7902, 7521, 7782, 7499, 7844, 7876, 7788, 7839, 7369, 7900, 7566)))"

Then, the data can be converted to an R data frame using the following two commands,  
  
df <- data.frame(eval(parse(text=substring(d,1)))[2])  
  
colnames(df) <- unlist(eval(parse(text=substring(d,1)))[1])  
  
Finally, head(df) results in the following,

head(df)

COMM HIREDATE JOB DEPTNO SAL ENAME MGR EMPNO

1 NULL 23-JAN-1982 CLERK 10 1300 MILLER 7782 7934

2 1400 28-SEP-1981 SALESMAN 30 1250 MARTIN 7698 7654

3 NULL 1-MAY-1981 MANAGER 30 2850 BLAKE 7839 7698

4 NULL 3-DEC-1981 ANALYST 20 3000 FORD 7566 7902

5 500 22-FEB-1981 SALESMAN 30 1250 WARD 7698 7521

6 NULL 9-JUN-1981 MANAGER 10 2450 CLARK 7839 7782

1. **Summary**

In an InfoWorld article (Oliver, 2014), the author claims that “The time for NoSQL standards is now”. But, RDF/OWL and SPARQL are standards that exist now and this paper has demonstrated that they are perfectly well suited for building NoSQL type web applications and RESTful applications. What’s more, unlike most NoSQL systems, ReL supports all of the standard transaction processing capabilities of traditional relational database management systems. So, maybe “The time for NoSQL to use existing standards is now”.

The Oracle implementation of RDF/OWL and SPARQL (Oracle Graph, 2014) was used in this paper but any proper implementation of these standards could be used instead.

This paper did not discuss the “scale out rather than scale up” proposition of NoSQL databases, but that debate has a decades long history and needs no more discussion here. However, there is no reason that RDF/OWL and SPARQL could not be used just as effectively in a “scale out” system as opposed to Oracle’s “scale up” system.

# Bibliography

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1. ReL (Relation Language) is a python-based data management system that uses RDF/OWL and SPARQL as its tuple manager. ReL also allows data manipulation and retrieval using a mix and match of many different higher-level data models including the Relational Model, a Semantic Model based upon the work of Hammer and Mclead (Hammer & McLeod, 1981), and the OO python model. The ReL Relational Model (which is automatically translated to RDF/OWL and SPARQL) will be used in this paper. However, since ReL is a python-based system, it’s trivial to also support JSON by translating it into one of the other supported data models. This has been done in several ReL applications. [↑](#footnote-ref-1)
2. URI’s have been abbreviated to help with readability. [↑](#footnote-ref-2)