Modeling RDF data for MetOcean Information Systems

Kamaluddeen Usman Danyaro
Department of Computer & Information Sciences, Universiti Teknologi PETRONAS, Tronoh Perak, Malaysia
Email: kudanyaro@dandali.com

Jafreezal Jaafar and M. S. Liew
Department of Civil Engineering, Universiti Teknologi PETRONAS, Tronoh Perak, Malaysia
Email: {jafreez, shahir_liew}@petronas.com.my

Abstract—**This paper suggests an RDF Model for effective handling of distributed data relating to the Semantic Web. Resource Description Framework (RDF) is a data model that integrates aptly structured data. The World Wide Web is facing great challenges in data retrieval as a result of increase and requests of knowledge from different sources. This brings the issue of information overload. In minimizing this challenge, we present a knowledge model for structuring data which is the initial step of creating Semantic Web. Where we elucidate the model using Meteorological and Oceanographic (MetOcean) datasets and provide the basic concepts of RDF Serialization retrospectively. We present the results using the SPARQL query method. Thus, the finding implies that the model is good for querying as well as data representation of distributed data.**

Keywords-Resource Description Framework (RDF); RDFModel; Semantic Web; MetOcean

I. INTRODUCTION

Since from the inception of Resource Description Framework (RDF) in 1990s, various processes have been followed as a way to produce the ideal model or structure for language specification. In 2004, there were extended RDF specifications for representing semantic data that have been Standardized by World Wide Web Consortium (W3C). RDF is the most essential source of Semantic Web that works with various things on the networks. It manages and handles the distributed data that gives techniques for data representation [1]. The representation of data from unstructured information into organized information are called modeling [1]. Nevertheless, RDF is a language for specifying languages. It is among the three modeling languages (RDF, RDFs and Web Ontology Language) of Semantic Web. These languages stipulate the expressivity and structure within the Web knowledge. Semantic Web is about information systems integration in meaningful way. Therefore, it really depends on information sharing between community as well as the systems.

An RDF application follows the typical sources of data. This can be done by integrating the data with relational database management system and later incorporate it with the Web through Uniform Resource Identifiers (URIs). URI offers a good level of data presentation and enabling shared data from different sources; global references. The infrastructure is laid over the distributed networks through Uniform Resource Locator (URL). Then become interoperable by exchanging and handling the eXtensive Markup Language (XML) data [2] [3]. XML has been the mediator between human and computers (on the Web) with the help of standard syntax that produce documents. Although, XML and database supply the consistency of every Web that initiate all sorts of data models [1]. However, XML as being a data model alone cannot handle large amount of data and system interoperability. It is because that XML provides syntax not semantics for data representation over the web. Nevertheless, many Web database systems are not on linked data model structure. For instance, the database of Meteorological and Oceanographic (MetOcean) information system is built on XML and XML metadata only [4].

MetOcean is a meteorological and oceanographic industry that handles large amounts of data and metadata. A lot of companies and research industries depend on its data that has been built on XML schema. However, these tights on the capabilities of describing data or metadata in meaningful way and later on brings the issue of information overload. Information overload is the process of getting information that might not be sufficiently organized as a result of rapid advancement of information and communication technology [5] [6] [7].

The aim of this paper is to define and describe the distributed data of MetOcean in a meaningful way. In this regard, we design a network graph, perhaps a triplestore that stores graphs of MetOcean's semantic repository.

The structure of this paper has the following outline. Section 2 provides the RDF and its basic concepts. Section 3 discusses the need for RDF model in meteorological and oceanographic information systems. Section 4 provides the related works. In section 5 we present the proposed RDF data model consisting of the structure of MetOcean's triplestore, RDF representation and graphical data representation. Section 6 contains conclusions and the way forward for the study.

II. RDF AND THE INFORMATION EXCHANGE

In this part, we provide and elucidate the basic concepts of the RDF data model as well as the RDF serialization. These concepts consist of publishing RDF data and representing it in text format so that it could be understood easily. RDF syntax modeling is the fundamental root of structuring data in a Semantic Web environment.

The RDF graphs enable individuals to share data with other people via the W3C standardization. The expression or specification of these data by means of triples using a language statement can be referred as resource description framework or RDF [8] [9]. RDF reduces ambiguities by conceptualizing the complete resources of anything. This can be done through URI. URI is the superset of Uniform Resource Locator (URL) that describes how digital information retrieves data over RDF resources [9]. As we described in [10], an RDF triple consists of subject, predicate and object (*s*, *p*, *o*), see Figure 1.

Subject ↑	Predicate ↑	Object ↑
UTP	partOf	PETRONAS
Total	isLocatedIn	"North Bali"
MetOcean	owned	SEAFINE
SEAFINE	hasCompany	Shell
Kinabalu	hasFrequency	"20 minutes"

Figure 1. Triple relationship

A. N-Triples

N-triples is a simple format for exchanging data in RDF serialization. Its serialization format allows the machine to be mapped and process data in a more precise recorded manner [11]. Therefore, N-triple is a more machine-readable format than the other serializations. It is also a full line-based URIs. See the examples of URIs below:

```
<http://www.metocean.com/seafine/participant#
  http://www.metocean.com/seafine/participant#participant1
  http://www.metocean.com/seafine/participant#participant
```

Each URI in N-Triples must be in a single line that starts with "<" and end with ">". N-Triples can also be represented in a basic RDF/XML format.

B. Turtle

Turtle or Terse RDF Triple Language is serialization format that can be applied to express data in an RDF data model. It is compatible with N-Triples and N3 [12].

The turtle starts with local qnames that leads the expression of triples by setting subject, predicate, and object in order, as in the following:

```
spd : Participant1  rdf : type  spd : Participant  .
```

Representing the Turtle in triple format ends with a period (.). Similarly, when representing many triples a semicolon (;) is used at the end of the line which signifies the presence of another triple. See the Turtle representation of participant triples as appeared in table 1.

```
spd : Participant1   rdf : type  spd : Participant ;
      spd : Participant_ID "1"  ;
      spd : Participant_Location "M1 Field West"  ;
      spd : Participant_Company "Shell"  ;
      spd : Participant_Sampling_period"1993-1994"  .

spd : Participant2   rdf : type   spd : Participant ;
      spd : Participant_ID "2"  ;
      spd : Participant_Location "Satun Platform"  ;
      spd : Participant_Company "Chevron"  ;
      spd : Participant_ Sampling_period  "1998"  .

 spd : Participant3   rdf: type  spd : Participant ;
      spd : Participant_ID "3"  ;
      spd : Participant_Location "Kinabalu"  ;
      spd : Participant_Company "Shell"  ;
      spd : Participant_Sampling_period"1992-1994"  .

spd : Participant4   rdf : type  spd : Participant ;
      spd : Participant_ID "4"  ;
      spd : Participant_Location "Jerneh"  ;
      spd : Participant_Company "Exxon-Mobil"  ;
      spd : Participant_Sampling_period"1995-1996"  .

spd : Participant5   rdf : type  spd : Participant ;
      spd : Participant_ID "5"  ;
      spd : Participant_Location "Kikeh Field"  ;
      spd : Participant_Company "Murphy"  ;
      spd : Participant_Sampling_period"2003-2005"  .

      -     -    -
```

C. RDF/XML

RDF/XML is considered the most common serialization formats [13]. In other words, it is a method of the XML serialization of RDF. Web interfaces present information to the user in HTML or/and XML documents. Where the data depend on the URL processes. In semantic Web, the qualified URI processes are based on RDF/XML which contains qnames declaratives. See the examples of the qname declarative; *rdf* and *spd* below.

```
<rdf : RDF
  xmlns : spd ="http://www.metocean.com/seafine/participant#"
   xmlns : spd =http://www.w3.org/1999/02/22-rdf-syntax-ns#>
     <spd : Particpant
       rdf : about =
       http://www.metocean.com/seafine/participant#Participant1>
          <spd : ID>1</spd : ID>
          <spd : Company>Shell</spd : Company>
          <spd : Location>M1 Field West</spd : Location>
          <spd : SamplingPeriod>1993-1994</spd : SamplingPeriod>
     </spd : Particpant>
     <spd : Particpant
       rdf : about =
```

```
        http://www.metocean.com/seafine/participant#Participant2>
            <spd : Location>Satun Platform</spd : Location>
            <spd : SamplingPeriod>1998</spd : SamplingPeriod>
            <spd : ID>2</spd : ID>
            <spd : Company>Chevron</spd : Company>
      </spd : Particpant>
      <spd : Particpant
        rdf : about =
        http://www.metocean.com/seafine/participant#Participant3>
            <spd : Location>Kinabalu</spd : Location>
            <spd : ID>3</spd : ID>
            <spd : Company>Shell</spd : Company>
            <spd : SamplingPeriod>1992-1994</spd : SamplingPeriod>
      </spd : Particpant>
  <rdf : RDF>
        -     -    -
```

D. N3

N3 or Notation 3 is made for easy expression of triples between the backward and forward links [14]. In other words, N3 is the text-encoded and abstract compact RDF syntax that allows the extension of the query expressiveness [1], [15], [16], [17]. Nevertheless, it helps in shorting the URI. For instance, a URI for *kinabalu*; <metocean.com/seafine/participant/kinabalu> can be reduced to *metocean:kinabalu*. This provides entity identification as well as prefix declaration which usually occurs at the beginning of documents.

E. Blank Node

In a situation where the URIs' resources could be referenced or identified, the blank (anonymous) nodes would be used to address the subjects and objects using URIs [9]. RDF provides the connection of nodes without any URI which is then called bnode or blank nodes. This usually occurs when modeling many-valued relationships [9].

III. The Need for RDF Model in MetOcean IS

There were many researches on various models regarding sea or particularly South East Asia Fine Grid Hindcast (SEAFINE). These researches ([8], [18], [19], [20]) targeted prediction, simulation, and hindcast analysis. Obviously, the primary target is to retrieve data in an accurate and easier manner. However, these models have not yet been implemented the RDF or linked data accessibility. Consequently, this paper is based upon an RDF development for Semantic Web. The SEAFINE includes the MetOcean's participants namely: BP, ChevronTexaco, ConocoPhillips, Murphy Oil, Statoil, Total, BP and Sarawak Shell Berhad [18], [21], [22] , [23].

Oceanweather Inc. and Joint Industry Project (JIP) created SEAMOS (South East Asia Meteorological and Oceanographic Hindcast Study) hindcast in 1992 with intention to investigate the storm influences basically in southern South China Sea [21], [18]. The specific objectives for SEAFINE is to provide: a fine grid wind and wave hindcast that constitutes 50-year continuous data, large grid resolution for waves and wind fields, and 20-50 years fine resolutions for current hindcast [22].

Notwithstanding, the fundamental reason why SEAMOS has been produced is because of the need of higher spatial resolution models by SEAFINE which itself is a hindcast model. As laid out in [21], the resolution is located within the areas like Gulf of Thailand, Java Sea and Makassar Strait. Moreover, in SEAFINE alone, the MetOcean data comprises: (i) wind and wave data series with grid of 6km x 6km, a period of 50 years data (1956-2007) and (ii) ocean current series with grid of 12km x 12km, period of 20 years data (1981-2007) [21].

Thus, hindcasting or hindcast models are viewed as common tools for data specification and testing in the meteorological and oceanographic environment numerically. Users are able to retrieve the data in a single query if only they depend on such tools. This is because the current MetOcean system models are not interoperable. Thus, the RDF is considered as the heart of Semantic Web data application which will provide data integration and solve the problem of interoperablity.

IV. Related Work

Allemang and Hendler [1] used Turtle as their RDF serialization for better compactness of the model. They display the model from N-Triple and the qnames. Also, N-Triples are employed to express different data models of RDF [13], where it can be applied for testing and debugging the dataset applications.

For the blank nodes, the documents require RDF serialization [24]. When querying the data relationship, Oren et al. [25] have evaluated ActiveRDF that manipulates data using bnode in both quantitative and qualitative sense. Therefore, bnodes are helping nodes that explicitly used in RDF which requires no URI. They cannot be addressed or referenced globally with respect to URI [1] [9].

RDF Serialization is a foundation for RDF data model interpretation. Zander and Schandl [26] serialized RDF data on mobile device in which the files for the devices have been utilized for RDF standardization formats. However, [26] also found the delay in processing RDF graphs as a result of loaded working memory (RAM) before querying the SPARQL Protocol and RDF Query Language (SPARQL). While Yoo [27], proposes three methods using the SPARQL query for querying the knowledge base of Semantic Web. He provides the inference engine that interprets the meaning of information on RDF knowledge base. He found that the machine could be assessed by individual user requirement using reasonable query method. The finding was in hybrid query processing of hotel search. Unlike Rodriguez [16], that used serialization language to translate the Ripple query. In serializing RDF graphs, the run-time along with the number of triples stored have proven to be linear with regards to his framework [26].

An entity relational model was developed for the better expressiveness of what has been called semi-structured data models which include RDF and microformats [15]. Therefore, the query expressiveness of RDF databases has sufficient power in answering the complex graph-shaped queries where mostly are designed to provide flexibility to users [15], [28] [29]. This implies the unique of Delbru et al. [15] finding that the system provides efficient index maintenance and faster query processing.

Thus, almost all the above authors find that their system sufficient for query or indexing large amount of data, which is also among the target of this paper. Furthermore, due to the expressive nature of Turtle, we follow [1] and (Becket and Berners-Lee [12]) in order to have the strong binding between the global and local (URIs and qnames) for our RDF development.

V. METOCEAN RDF DATA MODEL

In this section, we show the RDF model can be developed through designing triplestore. We design a query for subject, predicate and object. These triples represent the index relating to their permutations within the program.

Therefore, we maintained the standard querying representation pattern (s, p, o). For instance; the interpretation of the triple in Figure 2 means that the subject *Kinabalu* is related to the object *20 minutes* (of sampling frequency) by the predicate *hasFrequency*. In other words, the predicate *hasFrequency* is connecting the *Kinabalu* with *20 minutes* value.

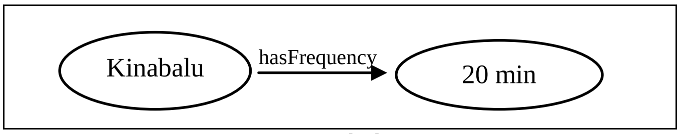

Figure 2. A triple description

A. MetOcean TripleStore Structure

The Semantic Web itself cannot provide ideal representation devoid of the utilization of any data structure of the system. The Semantic representation enables metadata applications to connect with RDF and XML for better operation. Specifically, the connection of the MetOcean Information Systems (IS) in the non-RDF MetOcean database of Figure 3 is the bedrock of the architectural model. It comprises the data and metadata which have been preserved in MetOcean IS. The MetOcean XML is the XML that would be serialized in the triplestore. This allows the heterogeneity of the data sources. The RDF semantic application is placed in order to bridge the gap between the semantic application and the raw data. Nonetheless, these three components have direct connectivity with the triplestore which causes the repository to keep MetOcean's knowledge. Most of the research industries and various oil and gas sectors would depend on this knowledge base. At this juncture, the data representation could only be through RDF. However, the SPARQL client is the endpoint that the user will retrieve the query through. See Figure 6.

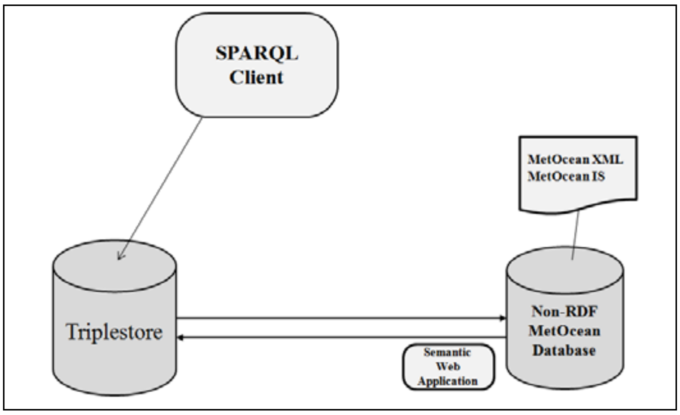

Figure 3. The structure of MetOean triplestore

B. RDF Representation

In this work, we consider the data available by SEAFINE participants. We refer the reader to Table I of [10] that shows the basic metadata and locations for current measurements. First off, we converted the datasets into tabular format for simplification. Then we produced the sample data as triples. It describes the observational dataset that includes: location, company, water depth, sampling frequency, sampling duration and sampling period.

To represent the data in RDF while the column and row as the information and single entity respectively. If a row has distinct entity then it most have single URI [1]. In Semantic Web, we only need a global unique identifier in order to have the single URI for each identifier in the database.

Now, let *spd* be the namespace, then we concatenate the name of the table (Participant) with a unique key that expresses the identifier. Impliedly, *spd:participant1*, *spd:participant2*, *spd:participant3*, and so on correspond to the location, company, sampling frequency, sampling duration, water depth and sampling period properties in RDF representation.

To have the global unique identifiers for these properties, we merged the column name and table name. Then the property become: *spd:participant_ID*, *spd:participant_Location*, *spd:participant_Company*, etc.

Therefore, each cell in the table has one triple which expresses the table information, see Table I.

Table I
Participant's Triple Representation

SUBJECT	PREDICATE	OBJECT
spd:Participant1	spd:Participant_ID	1
spd:Participant1	spd:Participant_Location	M1 Field West
spd:Participant1	spd:Participant_Company	Shell
spd:Participant1	spd:Participant_Sampling_Frequency	20 minutes
spd:Participant1	spd:Participant_Sampling_Duration	16 months
spd:Participant1	spd:Participant_Water_Depth	139m
spd:Participant1	spd:Participant_Sampling_Period	1993-1994
spd:Participant2	spd:Participant_ID	2
spd:Participant2	spd:Participant_Location	Satun Platform
spd:Participant2	spd:Participant_Company	Chevron
spd:Participant2	spd:Participant_Sampling_Frequency	20 minutes

spd:Participant2	spd:Participant_Sampling_Duration	12 months
spd:Participant2	spd:Participant_Water_Depth	71m
spd:Participant2	spd:Participant_Sampling_Period	1998
spd:Participant3	spd:Participant_ID	3
spd:Participant3	spd:Participant_Location	Kinabalu
spd:Participant3	spd:Participant_Company	Shell
spd:Participant3	spd:Participant_Sampling_Frequency	20 minutes
spd:Participant3	spd:Participant_Sampling_Duration	25 months
spd:Participant3	spd:Participant_Water_Depth	61m
spd:Participant3	spd:Participant_Sampling_Period	1992-1994
-	-	-

We have 119 triples that consist of subjects, predicates and objects. The subjects and predicates are in RDF formats while objects are literal formats which include integers and strings. Clearly, each row in Table I corresponds to a participant. If we add one triple per row, we could represent it in RDF. This also describes the type of individual in a row. Hence, we finally produced the result in graphs.

As described in section I, MetOcean has a huge amount of data. Therefore, it needs a lot of RDF networks, see Figure 5. Nevertheless, the model provides the linking statement graphically; the portion of participant1 in Figure 4 depicts the SEAFINE participant1 statement. We also derive the directed graphs from the statements. Apparently, this would be the required data model that can handle huge amount of data and metadata.

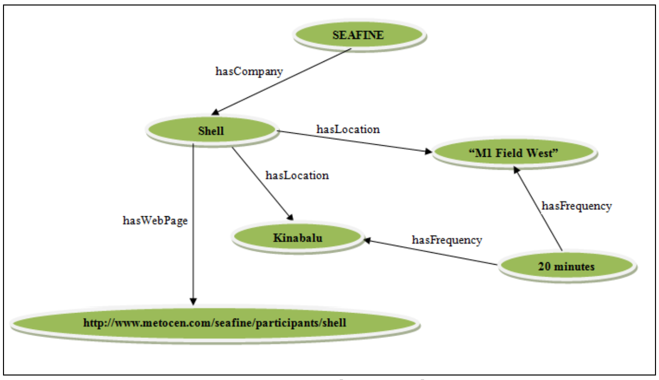

Figure 4. Linking graph

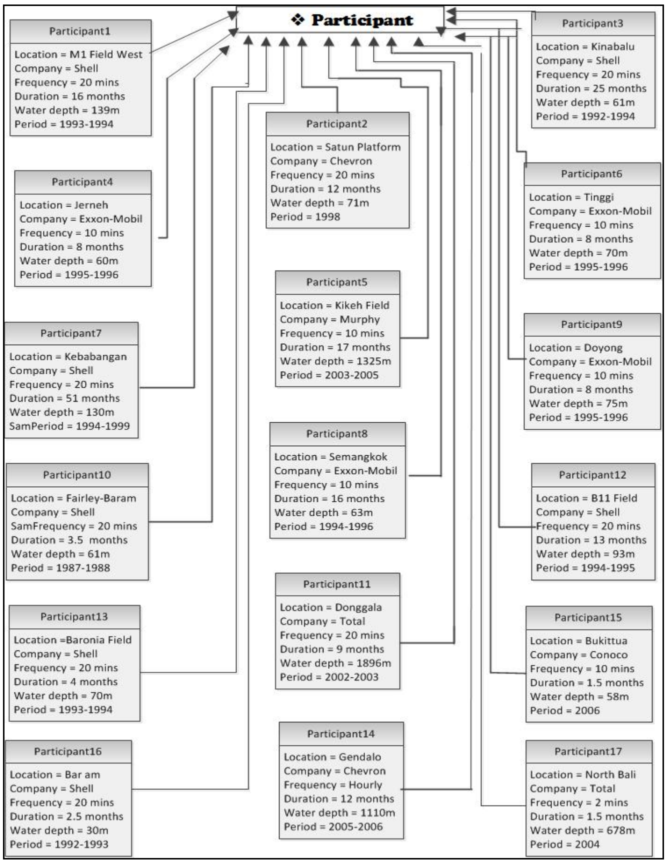

Figure 5. The graph

The model is visually represented and simplified. In this sense, the triplestore is established and the data can be queried using SPARQL, See Figure 6 for a simple query of participant1.

C. MetOcean and the Distributed Data

We focus on making the data globally distributed on the Web. Therefore, exchanging the data between the distributed users are relevant to meteorological and oceanographic environment which can be achieved depending on the developmental knowledge base.

We set the namespace URI for MetOcean IS knowledge and we develop the model knowledge using the class description. The knowledge description of instance identifies the classes with URIrefs. See the domain definition below:

```
<rdf:RDF xmlns="http://www.metocean.com/participants.owl#"
   xml:base="http://www.metocean.com/participants.owl"
   xmlns:participants2="&participants;20"
   xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
   xmlns:owl="http://www.w3.org/2002/07/owl#"
   xmlns:xsd=http://www.w3.org/2001/XMLSchema#

xmlns:participant="&participants;www.metocean.com/seafine/participant/"
   xmlns:rdf=http://www.w3.org/1999/02/22-rdf-syntax-ns#
   xmlns:participants="http://www.metocean.com/participants.owl#">
          - - -
    <owl:DatatypeProperty rdf:about="&participants;hasLocation">
      <rdf:type rdf:resource="&owl;FunctionalProperty"/>
      <rdfs:domain rdf:resource="&participants;Shell"/>
      <rdfs:range rdf:resource="&xsd;string"/>
    </owl:DatatypeProperty>
          - - -
</rdf:RDF>
```

To query the data of the distributed knowledge in the database, we run the data into the program and produces the result as shown in Figure 6. This is the simple SPARQL query result. The classes that have been created using the program became the triplestore. We consider the class with three indexes. Therefore, this indexing pattern is amenable for larger database or even more sophisticated queries.

Conclusion

One of the main fundamental roots of building Semantic Web is RDF database. Through this work, we found that the RDF model is sufficient for building the triplestore in the meteorological and oceanographic sector. The data are set in a manner to which each triple could be queried using SPARQL. Moreover, the result suggests that it can be employed to query a lot of graphs.

In the future, we intend to develop more sophisticated queries as a way for developing Semantic Web in the meteorological and oceanographic environment. Also, we will then infer the system using Typ-2 fuzzy logic systems for rule-based inference reasoning with RDF as well as Web Ontology Language (OWL).

```
>>> ================================ RESTART ================================
>>>
[('Kinabalu', 'hasFrequency', '20 minutes'), ('shell', 'hasWebPage', 'www.metocean.com/seafine/part
icipants/shell'), ('shell', 'hasLocation', 'Kinabalu'), ('shell', 'hasLocation', 'M1 Field West'),
('M1_Field_West', 'hasFrequency', '20 minutes')]
[('shell', 'hasWebPage', 'www.metocean.com/seafine/participants/shell'), ('shell', 'hasLocation', '
Kinabalu'), ('shell', 'hasLocation', 'M1 Field West')]
[('shell', 'hasLocation', 'Kinabalu'), ('shell', 'hasLocation', 'M1 Field West')]
[]
[('shell', 'hasWebPage', 'www.metocean.com/seafine/participants/shell')]
[('shell', 'hasLocation', 'M1 Field West')]
[]
[]
[('shell', 'hasLocation', 'Kinabalu')]
[('Kinabalu', 'hasFrequency', '20 minutes')]
>>>
>>> |
```

Figure 6. The query

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Kamaluddeen Usman Danyaro is currently a PhD student and graduate assistant at the department of computer and information sciences, Universiti Teknologi PETRONAS, Malaysia. He obtained his MSc. in Business IT from Northumbria University, UK. His research focuses on the development of Semantic Web in Meteorological and Oceanographic sector, as well as computational methods using Type-2 Fuzzy Logic in Semantic Web development.

Jafreezal Jaafar is the Head of Computer and Information Sciences Department, Universiti Teknologi PETRONAS (UTP), Malaysia. He obtains B.Sc in Computer Scienc from Universiti Teknologi Malaysia in 1998, MAppSc. (IT) from RMIT University (Australia) in 2002 and PhD in AI from University of Edinburgh (Scotland, UK) in 2009. Previously he has worked as a System Engineer for several years. He has been Assessor for Malaysia Qualification Agencies (MQA) for Computer Science since 2009. At the University level, he is among the Senate members, panel for curriculum Review, Internal Quality Auditor and QAT team for ISO implementation. His main research interest is Agent Systems and Soft Computing. He also had secured research grants and actively produced numerous journals, conferences and workshop papers.

M. S. Liew is the Head of the offshore Engineering Center and Civil Engineering Department at the Universiti Teknologi PETRONAS. He obtained his PhD from Texas Tech University, USA. He is currently researching on MetOcean conditions on Malaysian water and is actively engaged in the transformation of oil and gas sector for the local companies.