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The Quranic Nature Ontology: From Sparql Endpoint to Java Application and Reasoning

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Abstract— **In the holy Quran, verses about same or similar topics are scattered in different chapters. Moreover, it is hard for users to remember many keywords of a verse while they search for nature related concepts of Quran. In such a situation, semantic search can be very useful. This paper starts with a refined ontological model to facilitate the search of nature related concepts mentioned in Quran. It shows the implementation of a Fuseki server based sparql endpoint to enable the semantic search. We also integrate Jena Application Programming Interface (API) with the ontology and develop a Java application to access and query the ontology. We demonstrate that, it is possible to apply Web Ontology Language (OWL) reasoning on Quranic data and that application of the reasoning brings out new implicit facts. Finally, we compare the specific query answering capacity of our nature related ontological model of Quran to a general ontological model of Quran. Thus, we show that an ontology designed for nature related concepts of Quran can better answer nature related queries.**

Keywords — Quran Ontology, Semantic Quran, Quran Reasoning.

I. INTRODUCTION

The seemingly unstructured nature of Quranic data represents a challenging problem for ontology engineers, computational linguists, information retrieval experts and search engine designers. Even though the holy Quran was revealed in Arabic, English transliterations of Quranic concepts are often sought by thousands of web users all over the world. In our previous work [1], we highlighted the fact that, web users and readers of Quran search for nature related concepts mentioned in Quran. We also demonstrated an ontology for nature related concepts of the holy Quran. It was shown that, it is possible to capture knowledge about nature related concepts of Quran by forming triples from relevant Quranic verses. This triple based representation of Quranic data later facilitates retrieval of concepts/relations through use of sparql queries. It was also shown that verse-number and verse-text can be retrieved with sparql queries. In this work, the previous ontology is refined to accommodate more concepts and verses. The refinement results in a more detailed hierarchy of ontological concepts. A Fuseki server [2] based sparql endpoint is implemented to provide a sparql query interface to our ontology. We use Jena [3] which is a Java Application Programming Interface (API) to facilitate programmatic interaction with our OWL ontology and to develop a Java application.

We also demonstrate several types of OWL reasoning and compare the query answering capability of a generic Quranic ontology with our ontology. Rest of the paper is structured in the following manner: Section II discusses the previous works and Section III discusses the research problem. Section IV describes the methodological aspects. Section V presents the refined Quranic nature ontology and Section VI demonstrates the sparql endpoint. Section VII discusses about the Java application. Section VIII demonstrates OWL reasoning and Section IX shows the fact that an ontology focused on nature related concepts of Quran can better serve nature related queries compared to a generic ontology. Finally, conclusion and future plan are presented in Section X.

II. LITERATURE REVIEW

A few sparql endpoints are available for Quranic dataset. The work in [4] implemented a public sparql endpoint. It has more than 1000 triples at present. The triples can be shown on several forms including JSON and XML. The ontology covers many domains of holy Quran and is not specific to a particular area. Another sparql endpoint was created at Agile Knowledge and Semantic Web Research group [5]. However, the project is apparently inactive at present and we were unable to get any useful output using some generic sparql queries. It is desirable to have a system capable of reasoning on Quranic data. The work carried out by A. R. Yauri et al. [6] shows use of property restriction based reasoning to distinguish permitted food from prohibited food within the domain of Quran. The relative inefficiency of keyword based search and the effectiveness of WordNet model based semantic search is discussed in [7]. Quranic Arabic Corpus [8] still remains the strongest source of semantics based knowledge acquisition about topics of holy Quran. Based on [8] and some other earlier works, Ouda K. outlined the characteristics of an intelligent search system for holy Quran in his project [9]. His work implements an intelligent and semantically capable search and question answering system for the holy Quran. We tried a few queries on this system and the answers were quite satisfactory. Another framework [10] discusses semantics based search for Quran using XML formatted Quranic text. While use of Ontological reasoning is a standard technique in ontology, semantics and logic based search, [11] uses a statistical machine learning approach for semantic search on Quranic data.

Many Quranic verses were revealed in response to different situations. Therefore, context is significant in developing Quranic ontologies. This aspect is highlighted in [12]. While [13] discusses query expansion for Quranic search, a brief review of semantic search methods can be found on [14]. The work in [15] focusses on Cross Language Information Retrieval. There are a few Android apps which aim to incorporate semantic search for the holy Quran, however none focus on the nature domain and ontological aspects. Linguistic aspects of the holy Quran are closely related with semantics based information search on Quran and many works focused on this issue. However, we aim to discuss the linguistic aspects in our future work and focus on ontological and other semantics based approaches in this one.

III. RESEARCH PROBLEM

People often search for data on nature related topics of holy Quran. Quranic data is highly scattered. Information about a particular topic is scattered among different chapters. This makes the task of relevant information retrieval more difficult. While people may search for a range of different topics of Quran, we focus on effective retrieval of nature related topics of Quran. In our previous paper [1], we showed how nature related concepts and verses of Quran can be retrieved by having an ontological model of Quranic nature domain. This is part of the QREG project which is being conducted in our institution. The end goal of the project is to have a search engine which can answer Quranic nature related queries of users asked in natural language. It should be able to retrieve concepts and verses of interest. Moreover, it should be able to apply reasoning to retrieve implicit information. However, there are some steps before this goal can be achieved. Our previous work [1] demonstrated the first step by designing a Quranic nature ontology and showing how this can be used to retrieve concepts and verses of interest. In this work, we advance our previous work [1] and carry out some other intermediate steps towards the end goal. These intermediate steps are explained in the next section.

IV. Methodological Aspects

Based on the research problem presented in Section III, we specify some methodological aspects below:

- At first, we show the refined ontology and then demonstrate a sample sparql endpoint through which sparql queries related to nature can be issued. To the best of our knowledge, this is the only sparql endpoint so far which focuses on nature related topics mentioned in Quran. This is shown in Section VI.

- As mentioned in the previous section, we envision an application capable of retrieving nature related concepts and verses of holy Quran by using natural language queries of the user. However, as an intermediate step in this work, we show how a Java application can be used to retrieve the desired concepts by employing user specified concepts and relations. The Java application uses Jena API [3] to retrieve the concepts from the ontology. This is demonstrated in Section VII.

- It is also worth investigating whether OWL reasoning can be applied over Quranic nature related data to retrieve implicit concepts. In Section VIII, we show that indeed reasoning can retrieve useful implicit concepts. In the process we utilize OWLReasoner [16].

- Finally, in Section IX, we show how advanced sparql queries can be formulated using concepts and relations to retrieve additional concepts. It is notable that while similar or same Quranic concepts are scattered throughout the Quran, it is possible to retrieve and collect the same concepts from different places of Quran with these queries. Moreover, we justify that an ontology dedicated to Quranic nature is necessary because a generalized Quranic ontology fails to yield any useful information from nature related sparql queries.

V. The Quranic Nature Ontology

The prefix of our designed ontology is QNature. The ontology consists of nature related concepts of Quran. We have QuranNature class which is the root ontological class concerned with natural elements of Quran. It involves direct subclasses such as AstronomicalBodies, BiologicalBeing, WeatherPhenomena, etc. These second level classes again contain subclasses such as Planets, Rain, etc. Figure 1 shows a sample class hierarchy from the QNature ontology. While constructing the ontology, we tried to place the members in the specific class of the class hierarchy. For example, Figure 2 shows the subclasses of the class BiologicalBeing, as the name suggests, this class includes all biological beings mentioned in the holy Quran. A user may search for all mammals mentioned in the holy Quran, this sort of class hierarchy facilitates retrieval of such specific classes.

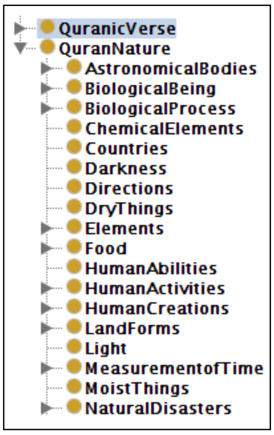

Fig.1. Part of QNature ontology

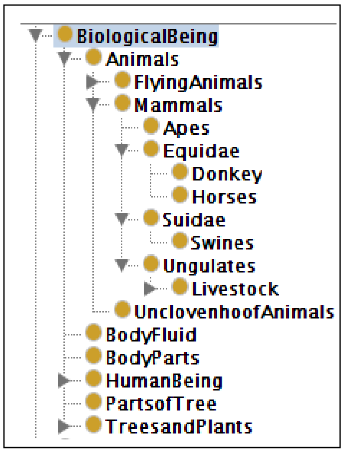

Fig.2. Subclasses of BiologicalBeing class

It is worth investigating the elements which should be included in the QuranNature class. We include historical figures such as Jesus, Moses, Mary, etc some of whom are also prophets. We argue that they are part of the human being and therefore they are part of the QNature ontology. In addition, some of them have relationships with each other, these relationships are also included in the QNature ontology. Another special part of the ontology is the Instance Allah. According to Islamic belief system, Allah is the creator. The holy Quran mentions many verses that talk about the relation between Allah and elements of nature including human being. These verses are of tremendous interest to investigators who are looking for the Quranic statements on creation of the universe, the natural elements and the human being. Therefore, the relations between elements of nature, human being and Allah are included in the ontology.

VI. THE SPARQL ENDPOINT

The next stage of our work focuses on making a prototype sparql endpoint to enable querying on QNature ontology. Fuseki [2] is a sparql server which can receive sparql queries in REST like fashion from client side. In the sparql server, TDB [17] is used as a data store which stores the triples of the QNature ontology. Figure 3 and Figure 4 show sample sparql queries on the sparql endpoint and the returned results from the QNature ontology.

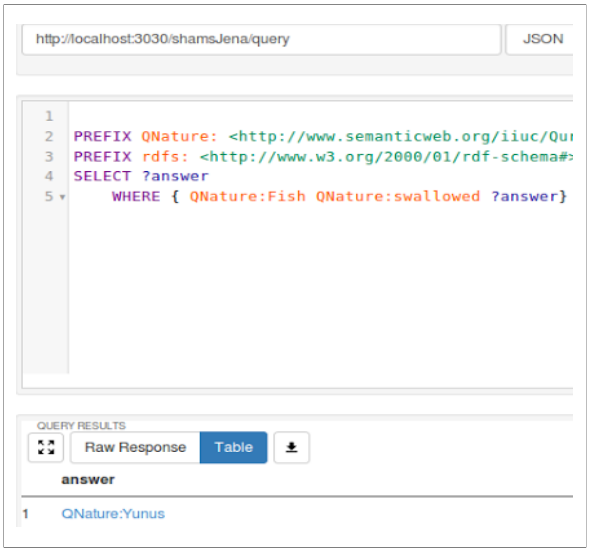

Fig.3. Sparql query-1 on Fuseki server

In Figure 3, Fish is a subclass of Animals class, it is mentioned in the holy Quran that a Fish swallowed Yunus. However, here it is assumed that the user who issued the query does not know the one who was swallowed by a Fish. The user rather remembers that Quran mentions swallowing of something by a Fish. Therefore, the unknown concept/instance is assigned the variable name "?answer". The sparql query successfully retrieves the value of "?answer" from the QNature ontology. The "?answer" "Yunus" is an instance of the class HumanBeing. In Figure 4, we show a different type of sparql query issued to the sparql endpoint. In this query, the concepts Allah and Sea are known to the user while the relation between these concepts are unknown which is assigned the "?answer" variable.

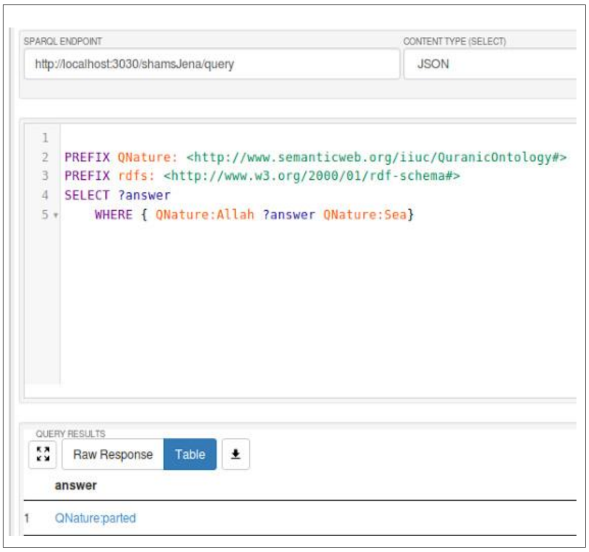

Fig.4. Sparql query-2 on Fuseki server

As expected, the sparql query retrieves the relation "parted" which was part of the QNature triple "Allah parted Sea".

VII. JAVA APPLICATION TO INTERACT WITH THE ONTOLOGY

Apache Jena provides a Java Application Programming Interface (API) [3] to access/update and to interact with RDF data. In other words, programmatic interaction from Java with an ontology can be done with integration of the Jena framework. The framework has classes and libraries to enable the programmatic interaction. The Jena framework also provides support for OWL reasoning which we demonstrate in a later section. We developed a Java application using the Jena API and the QNature ontology. The application is developed with an aim to provide general users access to the knowledge base represented by QNature ontology. This application has a Graphical User Interface (GUI) by which the user can perform a guided search of Quranic concepts/verses. Figure 5 shows the process through which a user's query from the Java application brings out the desired result. As depicted in the figure, the user selects the known concepts and relation and submits the query to retrieve the unknown concept/relation. In the Java class file, sparql queries are formed by using the concepts/relations selected by the user. Later these queries are issued to the QNature ontology through the Jena API and the results are retrieved. Finally, the results are formatted and shown to the user through the GUI. Figure 6 shows part of the Java application by which a user can search for all descendants of prophet Abraham. Figure 7 shows another part of the Java application by which unknown concepts can be retrieved.

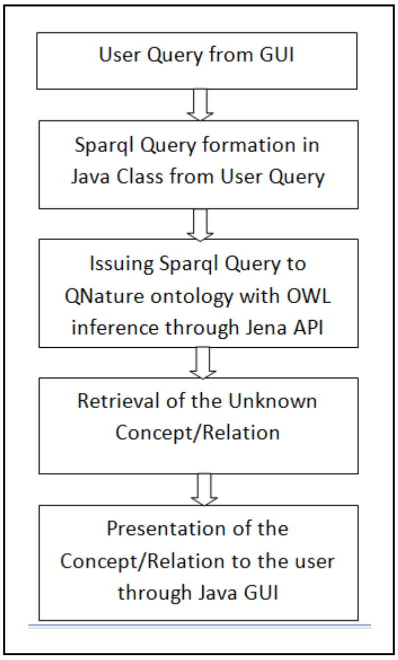

Fig.5. The working process of the Java application

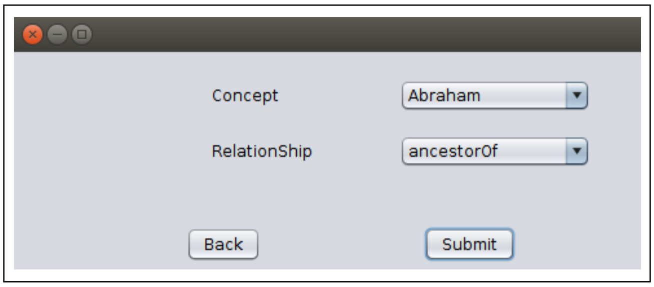

Fig.6. Search for descendants using Java application

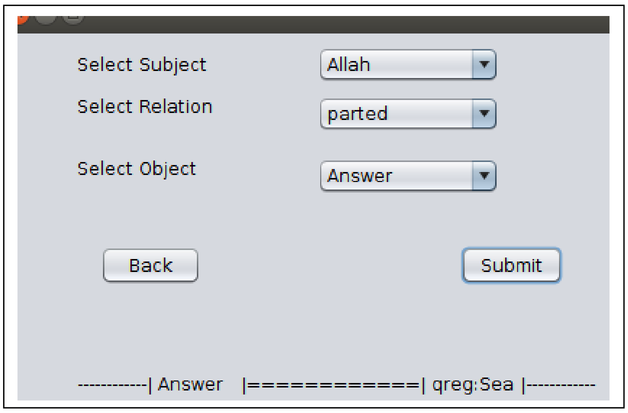

Fig.7. Concept retrieval through Java application

VIII. Reasoning Over The Ontology

Reasoning is a useful mechanism through which new facts can be discovered based on existing facts. OWL 2 supports different types of reasoning. While we have the QNature ontology with explicit facts mentioned in Quran, it is desirable to reason about those facts and bring out new facts. Indeed, reasoning can be applied to nature related data of the holy Quran and we show some examples of reasoning over Quranic data in this section. The first type of reasoning we show is the class hierarchy based reasoning. In the QNature ontology, we have explicitly mentioned direct subclasses. Use of the OWLReasoner derives all direct and indirect subclasses of a particular class. Figure 8 shows the result where all subclasses of animals mentioned in the holy Quran are retrieved. This query can be useful when a user wants to know all types animals mentioned in the holy Quran. Similarly, a user can retrieve all mammals mentioned in holy Quran with a similar query. Next, we show transitive property based reasoning. A good example of transitive property is an object property such as PartOf. For example, if France is PartOf Europe and Lyon is PartOf France then Lyon is also PartOf Europe. In the QNature ontology, ancestorOf is a transitive property. In this ontology for example, prophet Adam has an ancestorOf relation with prophet Noah, Noah has an ancestorOf relation with Abraham and so on. Explicitly, only direct ancestry is set in the QNature ontology. However, according to transitive property based reasoning, Adam is retrieved as the ancestorOf all the subsequent historical figures mentioned in the holy Quran in the chain of ancestors/descendants. Figure 9 shows this kind of reasoning.

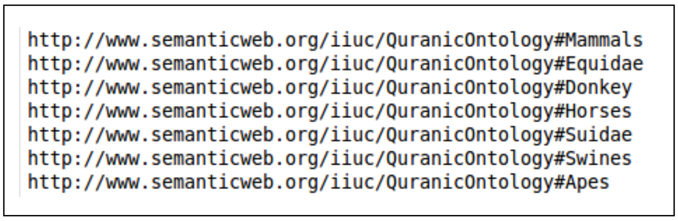

Fig.8. Reasoning based on class hierarchy

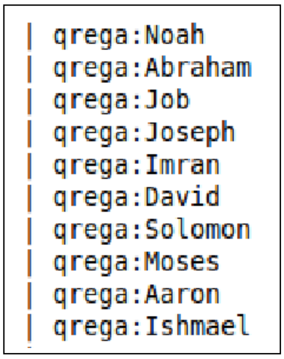

Fig.9. Transitive property based reasoning

Inverse property based reasoning can often be useful in semantic search of the holy Quran or other religious scriptures. ChildOf and ParentOf are inverse properties of each other. Once, this is specified in the ontology, one only has to explicitly state one relation in the ontology, the opposite relation and corresponding instance are inferred by the OWLReasoner. For example, the QNature ontology has the fact that Mary is ChildOf Imran, therefore the inverse property based reasoning derives Imran as the ParentOf Mary when a user searches for ParentOf Mary. This is shown in Figure 10.

```
---------------
| ans         |
===============
| qrega:Imran |
---------------
```

Fig.10. Inverse property based reasoning

Finally, we show the symmetric property based reasoning. The property brotherOf is a symmetric property because if a man A is brotherOf another man B, then B is also a brotherOf A. It is mentioned in Quran that Aaron is brotherOf Moses and this fact is included in the QNature ontology, as brotherOf is set as a symmetric property, it is inferred that Moses has brother Aaron. Figure 11 shows the answer of the query.

```
---------------
| ans         |
===============
| qrega:Aaron |
---------------
```

Fig.11. Symmetric property based reasoning

IX. Query Answering Over Quranic Nature: The Case for A Quranic Nature Ontology

In this section, we formulate a number of queries constructed from corresponding sample questions from users searching for nature related concepts of holy Quran. Table I shows the questions.

TABLE I. Questions Of Users Related to Nature Related Concepts of Quran

Sequence Number	Queries
1.	Find everything which Allah created.
2.	Find relation between Rain and Fruits.
3.	Find all instances which Allah favored or punished.
4.	Find all elements of nature which have relations with each other.
5.	Find all elements of nature which have relation with Allah.

The sparql queries designed to answer the questions in table I are given in table II with the same sequence number. We have explored different Quranic ontologies as mentioned in Section II. However, to the best of our knowledge, we have not found any ontology that exclusively focuses on Quranic Nature domain. We therefore tested the queries on quranontology.com [4] sparql endpoint and our sparql endpoint. We argue that these types of queries/questions are quite typical and are commonly asked by users searching for nature related concepts of holy Quran. We found that, even though some of the concepts are present in Quranic ontology of quranontology.com [4], relations between nature related concepts/individuals as well as relations between Allah and nature related concepts/individuals are not adequately specified in the ontology. Therefore the questions asked in table I could not be answered through corresponding sparql queries, even after customizing the queries according to the namespace and ontology presented in [4].

Even though it remains a work in progress, our argument is that nature domain of Quran needs an ontological model itself optimized for nature related queries. Figure 12 and Figure 13 show the result of the fourth query on the QNature ontology's sparql endpoint. Due to space constraints, one result is split in two figures, Figure 12 shows the subject of the fourth query, Figure 13 shows the predicate and object of fourth query.

TABLE II. SPARQL QUERIES TO ANSWER THE QUESTIONS OF TABLE-I AND THE RESULTS

No.	Sparql Query	Result on quranontology.com endpoint	Result on QNature ontology endpoint
1.	SELECT ?ans WHERE {QNature:Allah QNature:created ?ans}	None	Retrieved all instances from QNature ontology which were created by Allah
2.	SELECT ?ans WHERE{ QNature:Rain ?ans QNature:Fruits}	None	Retrieved relation between Rain and Fruits as mentioned in Quran.
3.	Select * WHERE{ {QNature:Allah QNature:punished ?a1.} UNION {QNature:Allah QNature: favoured ?a2.} }	None	Retrieved all instances which were favored or punished by Allah
4.	SELECT ?i ?p ?k WHERE{ ?i ?p ?k. ?s rdfs:subClassOf* qr:QuranNature. ?o rdfs:subClassOf* qr:QuranNature. ?i rdf:type ?s. ?k rdf:type ?o. }	None	Retrieved all instances which are part of QuranNature and which are related to each other.
5.	SELECT ?o ?p WHERE{qr:Allah ?p ?o. ?o rdfs:subClassOf* qr:QuranNature. ?i rdf:type ?o. }	None	Retrieved all instances which are subclass of QuranNature and which have relation with Allah. For example: Sea, Earth, etc.

Fig.12. Part of data (subject) retrieved by fourth query

Fig.13. Part of data (object and predicate) retrieved by fourth query

From the results presented in this section, it is evident that the presence of different and diverse elements of nature mentioned in Quran requires an ontological approach in order to be effectively analyzed and retrieved. Proper and well specified ontological modeling of nature domain of holy Quran can answer interesting semantic questions asked by users, while a generalized ontological model of Quran often fails in answering nature related questions of users.

X. CONCLUSION AND FUTURE WORK

In this work, we have presented a refined ontology for the Quranic nature domain which we call the QNature ontology. We have demonstrated a sparql endpoint for the ontology. We have integrated Jena API with the ontology and developed a Java application so that general users can access and query the QNature ontology. We have shown that it is possible to apply OWL reasoning on the QNature ontology. We have also shown that useful and new implicit facts can be obtained through application of transitive, inverse and symmetric property based OWL reasoning. Finally, we have demonstrated that, an ontology specifically designed for nature domain of holy Quran can better answer nature related sparql queries compared to a generalized Quranic ontology. We are working towards natural language question answering system for nature related data of holy Quran. In addition, connecting ontologically similar concepts and relations of the Quran, the Torah and the Bible through semantic technologies remains an interesting research direction.

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