Knowledge Based System using Ontology for Accessing Sentiments of Indian Railways Tweets

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Abstract*: *The interactions in social networks like Twitter are reflecting sentiments of people at large. Especially opinion mining has wherewithal to provide social feedback that complements traditional feedback for making strategic decisions. The sentiments data is basically stored in the Relational Data Base. But the demerits of this data base is that it comes back with an answer at most once and it is very difficult to address complex queries over the data, lagging inherent properties such as transitivity or symmetry. It also has closed world assumption i.e., what is not known to be true in the data base is by default considered as false because knowledge represented in the data base is assumed to be complete. To overcome all these demerits, we have developed knowledge-based system using ontology, for accessing sentiments of Indian Railways tweets. Indian Railways (IR) is very huge organization which consistently strives to improve its services from time to time. In our prior work, a framework was proposed and implemented using sentiment analysis for Indian railways tweets. The results were grouped into clusters based on five attributes pertaining to IR such as Cleanliness, Staff Behaviour, Punctuality, Security and Timeliness. These clusters are being updated from time to time to reflect up to date social feedback. However, the problem with the existing system is that, its accessibility and ease of use to stakeholders is not easy. So, we proposed a knowledge based system which will represent clusters for a universal and interoperable data representation that is from database to RDF schema to ontology and apply inference rules and query using SPARQL. This system is accessible to humans and also programs in heterogeneous Machine-to-Machine (M2M) environments. We proposed a methodology to achieve this and the knowledge is made available for further processing and stakeholders can access. The proposed system is evaluated with a prototype application and found to be useful and flexible.

Keywords: Indian Railways, Knowledge Based System, Sentiment Analysis, Ontology, RDF.

I. INTRODUCTION

As of now, most of the organizations gain access to their data by constructing a Relational Database (RDB). The World Wide Web (WWW) provides users of the applications to obtain data and manipulate it strictly based on the interfaces and privileges given. The data has gone to deep web and that cannot be accessed from outside the application given by the organization.

It is so good as far as the organization operates in an isolated way. However, in the contemporary world, businesses cannot run in isolation and they need to have collaboration with a chain or organizations. For instance, Supply Chain Management (SCM) is a group of organizations that need to have cooperative effort to achieve business objectives. The world is fast moving to such scenarios where data exchange is essential to have natural and automated approach to the dynamics of the real world. The problem with traditional data models is to have limited accessibility and it is not easy to share data to other organizations. To say it differently, deep web is not accessible and thus sharing and exchanging information purposefully is not possible. This is against the concept of interoperable and machine readable sharing of business intelligence (BI) across a chain of businesses.

To overcome the problem aforementioned, many solutions came into existence as found in the literature. In [3] ontology is exploited to have a system of sharing knowledge. Ontology based opinion mining is another important contribution in [4] and [5] for different domains like healthcare. Knowledge based approach is studied in [13] for public health index. Public disease monitoring [14] is another solution that tried to use knowledge based system. Formal ontology is used in [23] to build interactive and intuitive interface for knowledge sharing. Resource Description Framework (RDF), Ontology Web Language (OWL) and SPARQL protocol and RDF query language (SPARQL) are incorporated in knowledge based system [20]. From the literature it is understood that there needs to be comprehensive framework without which the transformation from RDB to truly semantic data model. Our contributions in this paper are as follows:

1. Proposed a framework for transformation between RDB data model to RDF and enable interactive and machine readable interface for making queries.
2. An algorithm named RDB to RDF Mapping (RRM) is proposed and implemented to have multiple procedures for transformation. It has provision for mapping database in relational model to RDF schema besides mapping column, constraints and relationships to corresponding objects in RDF schema.
3. We built a prototype application and evaluated it with the proposed system. It could provide interface to achieve transformation of data from other model for enabling user interaction. It also helps in machine readability besides realizing knowledge based system which serves in knowledge sharing and exchange of the same.

The remainder of the paper is structured as follows. Section 2 reviewed literature on the prior works of knowledge based systems. Section 3 defines the problem and presents a framework as solution to the problem of interoperable knowledge sharing and exchange to gain access to deep web knowledge. Section 4 presents implementation details and results. Section 5 concludes the paper and provides directions for future work.

II. RELATED WORK

Knowledge based systems play pivotal role in the contemporary era. The technological advances help in realizing such systems. There has been significant effort towards it. Due to proliferation of various Internet applications as virtual platforms, knowledge is made available for enterprises over such media. For instance, opinions of people can be used to build a knowledge based system. Gupta and Shalini [1] explored improvisation of experience in terms of gaining access to knowledge by defining a polarity dictionary for sentiment analysis. They quantified sentiments for analysis. However, they have not exploited semantic web components. Knowledge can be represented in the form of ontology. Ontology based techniques are proposed by Kontopoulos *et al*. [2] for sentiment analysis. By defining domain ontology, they could load and represent knowledge for enabling interface to M2M applications. However, a fully ontology-based solution is not realized in their work. Borth *et al*. [3] exploited ontology further to have large scale ontology with visualization of sentiments and emotions. They used more than 1200 concepts and a classifier known as SentiBank. Each concept is associated with Adjective Noun Pair (ANP) for stronger visualization of knowledge leading to multi-modal visualization.

Ontology can be used in building knowledge based system in any domain. With respect to customer reviews, Sam and Chatwin [4] and Efstratios Kontopoulos et al. [6] proposed a knowledge model for ontology based opinion mining. Named-Entity Recognizers (NERs) became important for effective retrieval of knowledge. Polpinij and Ghose [9] on the other hand used lexical variable ontology for knowledge representation of consumer reviews. Yasavur *et al*. [5] proposed one such system based on ontology for healthcare domain. With NER, the system can automatically tag important words in sentences. However, dynamic distance thresholds for the system are not yet studied. Thakor and Sasi [7] proposed a novel framework named Ontology-based Sentiment Analysis Process for Social Media (OSAPS). It incorporates negative sentiments. Ontology based knowledge retrieval system is proved to be effective with ontology representation. The rationale behind this is that it is interoperable and machine readable.

Polarity refers to the associated sentiments that can be quantified. Zhou and Chaovalit [8] proposed a method known as Ontology-supported polarity mining (OSPM). This system enables effective retrieval and mining of polarities based on the concepts built using ontology. However, they were yet to explore multiple-property assignments with different level of membership. In the wake of unprecedented growth of micro-blogging services, ontology based opinion mining became essential. In this context, Cotfas *et al*. [10] proposed semantic social media analysis framework known as TweetOntoSense which is used to represent knowledge using ontology in terms of sadness, anger, surprise, affection and happiness. There is notion of business ontology as well. Smeureanu *et al*. [11] proposed ontology named as business ontology to represent company's Corporate Social Responsibility (CSR). However, the system was not yet supporting automated access to knowledge.

Human emotions are also reflected in the form of opinions. In other words, opinions reflect human emotions also. Ptaszynski *et al*. [12] proposed a methodology to build ontology based solution to analyze human emotions. However, they are yet to explore formal objects of emotions for standardization. Thus it is understood that ontology based solutions make the systems to gain access to knowledge with interoperability. It is also reflected in the review made by Patel and Media [13]. Knowledge based approach is essential for different real world applications. Healthcare is one such domain where it is essential. For instance, knowledge based system might provide public health index and details across regions of the country. Ji, Chun and Geller [14] proposed such system for public disease monitoring. This kind of system is made accessible across the platform as it is made interoperable. The proposed intelligence model is known as Epidemic Sentiment Monitoring System (ESMOS). It is meant for automatically measuring disease concerns and also measure of concern (MOC). This will help in understanding disease outbreak and help officers to make strategic decisions. Apart from knowledge based systems, it is also possible to have ensemble approaches for sentiment analysis. Ensemble is nothing but union of multiple classifiers in order to have highly accurate analysis. Ankita and Saleena [15] proposed an ensemble classification system which can complement well to knowledge based systems that make use of ontology for machine readability. They opined that study of neutral tweets also provides some kind of intelligence. However, it was not yet explored by them. Such knowledge based system can be realized with ontology platforms. Arp *et al*. [23] explored and presented the way of building formal ontology which can help researchers to build knowledge based systems with M2M communication provision. Smith [16], [17] provided the next version of basic formal ontology to enhance user experience. It is understood from the review of literature that knowledge based systems can be built using ontology. However, the reverse is also possible. The fact is that ontology can be built from knowledge based systems. Kharbat *et al*. [18] have demonstrated the same. They opined that the business intelligence gained from data mining algorithms can be represented in the form of ontology. Thus they called it so.

There are some contributions where ontology based systems are built for rail domain. The system built in [19] provides access to ontology based knowledge related to railways. When data is stored in databases, generally they go inside a deep web. However, with knowledge based systems it is possible to query such data as well. Mei *et al*. [20] explored usage of RDF and OWL ontologies to realize such phenomenon. They studied ontology query answering on databases with SPARQL. This is somewhat closer to the work of this paper. Like SPARQL, there are query languages that can work on ontology. Zhang and Miller [21] explored different languages that support queries on SWRL, OWL, RDFS and RDF. Out of these RDF is studied in this paper along with SPARQL for realizing knowledge based systems. Ortiz [22] also investigated the process of making queries on ontology based knowledge representations. The existing knowledge based systems found in the literature are useful in making interoperable queries and machine readable knowledge representations. However, there is need for having a complete system that converts and builds knowledge based systems from legacy systems or new systems to support machine readability and interoperable querying.

III. PROPOSED METHODOLOGY

This section presents the proposed methodology for construction of knowledge based system for accessing sentiments of Indian Railways Tweets which can provide access to business intelligence in an interoperable and cognitive means with programmable interface.

3.1 Problem Definition

Traditional applications that have web based interface store data in the form of relational databases. Such databases may be in the server machine of the organization or outsourced to public cloud. Whatever be the case, the database is behind deep web. It is not accessible to other applications. There is merit in this when the information needs to be kept confidential and in deep web. However, in the era of information and distributed computing, organizations cannot afford to be alone and have isolated systems. Real time business interactions like B2B, B2C and C2C can be reflected with automated systems. Therefore, in such scenarios, providing data in relational database hides it in deep web and sharing in M2M environment is not possible. This is the problem to be addressed. The motivation behind this is that when there is data to be shared across organizations in an interoperable and machine readable fashion, of course, as per possible business contracts between organizations, constructing semantic database with RDF schema can help to achieve the intended purpose. The following sub sections provide the solution proposed in this paper.

3.2 Different Database Models

Data available in relational models and non-relational models (other than semantic data model) needs to be transformed into semantic data model for building a knowledge based system. Out of database models like Network Data Base Management System (NDBMS), Hierarchical Data Base Management System (HDBMS) and Relational Data Base Management System (RDBMS), the widely used model is RDBMS. We considered the transformation or mapping between relational data model to semantic model. Relational model has associated data, metadata, views, triggers and other objects stored in the form of relations. It needs efficient mapping algorithms to have transformation of knowledge between the models. The implementation of mapping involves various techniques or standards pertaining to semantic web. They are known as RDF, web ontology languages like OWL and RDF-compatible query languages like SPARQL. It also needs semantic rule languages. Managed knowledge environment can be realized with the semantic architecture of RDF. There are many considerations while proposing transformation algorithms. They include primary key, foreign key, different database constraints at field level and table level like CHECK, NOT NULL and UNIQUE to mention few, relationships among tables like one-to-one, one-to-many and many-to-many. It is also important to have domain data knowledge in order to represent knowledge in RDF schema correctly.

3.3 The Framework

The proposed framework is for knowledge based system by transforming relational data model to semantic data model automatically. In other words, it is responsible to convert business intelligence into a knowledge based, accessible or programmable system that can be directly queried or queries through a program in an interoperable way. This is quite interesting and useful phenomenon which is taken care of by the framework as shown in Figure 1. Input dataset is given to the framework. It is nothing but the BI of Indian Railways that reflects social feedback on different operational trains across the country. The BI generated through sentiment analysis is in the form of 5 clusters. Each cluster provides BI pertaining to an important attribute associated with given train. The five attributes thus associated with each train are punctuality, staff behaviour, security, cleanliness and food quality. These five clusters are there, for instance, in a legacy system where data is stored in a relational model. When data is in relational model, there is limitation to its accessibility. The rationale behind this is that the data goes behind deep web. Therefore, transforming it to a semantic data model and making it accessible through interface that is interoperable and machine readable is supported by the framework.

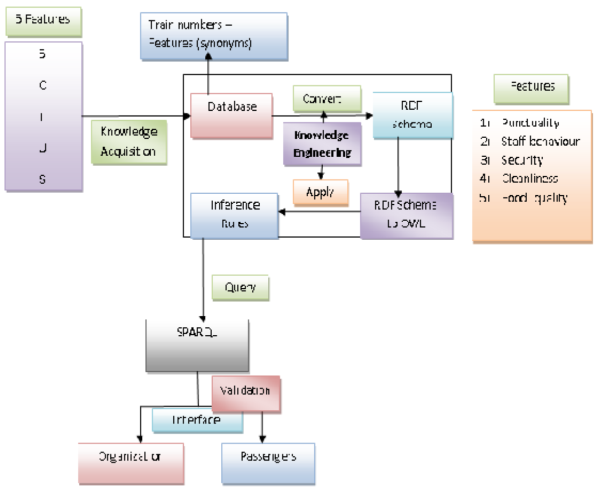

Figure 1: Framework for knowledge based system

The conventional database is converted into an RDF schema to facilitate access to deep web. It is the Resource Description Framework (RDF) which resurfaces deep web with semantic interpretation and further processing of the BI. When BI is behind the deep web, it has limitations in accessibility. When the same is in the form of RDF, it has become interoperable with machine queries and human queries. Thus the proposed framework narrows down the gap between the traditional deep web and the surface web. Resource Description Framework Schema (RDFS) is a standard framework to store data. It forms semantic web and Web Ontology Language (OWL) for interpretation of data. RDF schema has both literals and semantic meanings of the same. Thus it provides rich interoperable interface to a knowledge domain in fully automated and interactive fashion. The concept of ontology has made this possible as ontology is the knowledge representation which is made up of concepts and relationships among them.

RDF schema was introduced in order to handle situations where web data needs to be processed and exchanged by applications instead of just showing data to users. This ability of exchanging data between applications makes RDF very useful in the contemporary era. Semantic data models like RDF and frameworks based can help organizations of specific domain to organize domain BI or knowledge and share it to throughput the enterprise. Such models ensure that "semantic" means of accessing knowledge leads to fully automated systems in distributed environments. Many expert systems are constructed from knowledge extracted in whole or in part from databases. With the increased amount of knowledge stored in databases, the acquisition of such knowledge becomes more difficult. Knowledge engineers are human professionals who are able to communicate with experts and consolidate knowledge from various sources to build a valid knowledge base. They can use computers and special methods to overcome difficulties in knowledge engineering. Validation is a critical process in the whole knowledge-based system life cycle. A knowledge base incorporated into such systems has to be verified or (more generally) validated. There have been many approaches to develop specialized procedures and techniques, aimed at assuring the highest level of knowledge equality.

3.4 Input Dataset

The input dataset is in the form of clusters. It is stored in relational database. The dataset contains any kind of relational data. However, we have considered the data of Indian Railways. It is in the form of sentiment value associated with different train numbers. For each train five attributes have been observed which are considered as sentiments. Positive sentiment is represented by the value 1, negative sentiment by -1 and neutral is by 0. The attributes used are punctuality, food quality, cleanliness, security and staff behaviour. These attributes are used to obtain synonyms using lexical dictionary like WordNet. Therefore, every attribute has n-number of synonyms. All of them can be used while transforming and while making SPARQL queries. Thus more flexible knowledge based data retrieval system will be in place. Table 1 shows the input data given to the knowledge based transformation framework.

Train number	*Punctuality*	*Food quality*	*cleanliness*	*security*	*Staff Behaviour*
06060	1	1	-1	0	1
04403	-1	0	1	-1	0
13407	0	-1	1	1	0
05036	1	1	0	1	1
12486	0	-1	1	1	1
06056	-1	0	-1	1	1
11487	1	1	1	-1	0
07092	-1	0	1	1	-1
06042	0	-1	0	1	1
04912	1	1	-1	0	-1

Table 1: An excerpt from dataset containing sentiment details for Indian Railways

Each train has associated sentiments obtained from sentiment analysis as part of our prior work [24]. The train 06060 has positive sentiments related to three attributes such as punctuality, food quality and staff behaviour. It has neutral sentiment with respect to security. In case of cleanliness, it has negative sentiment. In the same fashion different trains do have the social feedback resulted from the sentiment analysis. When this data is given to the proposed framework, it automatically stores in relational database. Up to this extent it is required for applications that are specific to accessing relational databases using SQL queries. It is important to convert from relational schema to RDF schema. In other words, it is the conversion from relational data model to semantic data model.

3.5 Mapping Relational Data Model to RDF Data Model

Mapping from relational data model to semantic data model (RDF in this case) is done with three layers associated with the relational model use case. The first layer is known as relational database area of knowledge. The second layer is domain data knowledge and the third layer is known as application specific knowledge.

3.5.1 Database Mapping Procedure

In case of database having multiple tables, the database mapping procedure is an iterative and incremental approach. It uses all tables denoted as ***T*** and all attributes of each table denoted as **A** in an associated schema denoted as ***S***. The tables in relational model need to have corresponding classes in semantic data model. Therefore, a table ***t*** is mapped to class ***c***. The columns in table are mapped to properties of corresponding class. The column data types are mapped to responding data types of properties. The primary key, foreign key and other constraints associated with a relational table are mapped to corresponding keys in semantic data model RDF. Then different relationships are mapped to equivalent items in RDF. It considers different aspects like disjointness, transitive chain of relation and the degree of relationship.

3.5.2 RDB to RDF Mapping (RRM) Algorithm

This algorithm plays crucial role in transforming traditional deep web models into modern semantic web models. Stated differently, it helps to convert traditional knowledge store (RDBMS) into RDF schema that is machine readable and interoperable besides making web applications to represent and exchange knowhow. It takes all relational tables as input and performs various procedures (complexities such as constraints, relationships and so on) to have a compatible RDF schema and data is mapped from relational model to knowledge based model with underlying mechanisms of the algorithm.

```
Algorithm: RDB to RDF Mapping (RRM)
Inputs: All relational tables T

Mapping Database
Procedure MapDatabase(S)
Begin
MapTables(S)
MapColumns(S)
MapConstraints(S)
MapRelationships(S)
End
Mapping Tables
Procedure MapTables(S)
Begin
For each table t in T
  Create Class Ci in RDF repository Ci_RDF
<owl:Classrdf:ID="Ci"/>
End For
End
Mapping Columns
Procedure MapColumns(S)
Begin
  For each table t in T
    For each column c in C
      Use class c of t
     Set c as property of last
getType(t)
<owl:DatatypePropertyrdf:ID="hasAj">
<rdfs:domainrdf:resource="#Ci" />
<rdfs:rangerdf:resource="&xsd:type_equivalent" />
</owl:DatatypeProperty>
     End For
  End For
End
Mapping Constraints
Procedure MapConstraints(S)
Input: Schema S
Output: RDFS including OWL cardinalities
Begin
For each table t in T
  For each column c in C
    get resultant Class Table Ci of Ti
     If c in pk(Ti) Then
<rdfs:subClassOf>
<owl:Restriction>
<owl:maxCardinality
rdf:datatype="&xsd:nonNegativeInteger">1
</owl:maxCardinality>
</owl:Restriction>
</rdfs:subClassOf>
     Else If c in fk(Ti) Then
       If c in pk(Ti) Then
<rdfs:subClassOfrdf:resource="#C" />
       End If
<owl: ObjectPropertyrdf:ID="hasA">
<rdfs:domainrdf:resource="#C" />
<rdfs:rangerdf:resource="#C'" />
</owl: ObjectProperty>
     Else If unq(c) Then
<owl:InverseFunctionalPropertyrdf:resource="# hasAj" />
     Else If nn(c) and !pk(c) Then
<owl:Restriction>
<owl:minCardinality
rdf:datatype="&xsd:nonNegativeInteger">1
</owl:minCardinality>
</owl:Restriction>
      Else If ck(c) Then
<rdfs:subClassOf>
<owl:Restriction>
<owl:onPropertyrdf:resource="#hasAj" />
<owl:hasValuerdf:datatype="&xsd;string" > v(Aj)
</owl:hasValue>
</owl:Restriction>
</rdfs:subClassOf>
      End If
    End For
End For
End
Procedure MapRelationship(S)
Input: S
Output: Class C and Property P
Begin
For each Tablet in S
  For each column c in t
```

Algorithm 1: RDB to RDF Mapping (RRM)

As shown in Algorithm 1, the mapping of different database objects is carried out. They include the whole database, tables, columns, constraints and relationships. This algorithm is implemented to have knowledge based system that can be used to have interoperable and machine readable queries.

IV. IMPLEMENTATION AND RESULTS

The implementation of the algorithm is based on the BI available for Indian Railways that is in the form of social feedback obtained through sentiment analysis. The application has provision to execute mapping procedures to build a knowledge based system. The algorithm described in the previous section is implemented to achieve this. Before showing the application, the rules pertaining to the proposed empirical study are as follows:

IF (Train No. "is" 06060) and (Food Quality "is" 1) and (Punctuality "is" 1)
   THEN (Sentiment "is" Positive)
IF (Train No. "is" 04403) and (Food Quality "is" 0) and (Punctuality "is" 0)
   THEN (Sentiment "is" Neutral)
IF (Train No. "is" 13407) and (Food Quality "is" 0) and (Punctuality "is" 0)
   THEN (Sentiment "is" Neutral)
IF (Train No. "is" 05036) and (Food Quality "is" 1) and (Punctuality "is" 1)
   THEN (Sentiment "is" Positive)
IF (Train No. "is" 12486) and (Food Quality "is" 1) and (Punctuality "is"0)
   THEN (Sentiment "is" Positive)
IF (Train No. "is" 06056) and (Food Quality "is" 0) and (Punctuality "is"-1)
   THEN (Sentiment "is" Positive)
IF (Train No. "is" 11487) and (Food Quality "is" 1) and (Punctuality "is"1)
   THEN (Sentiment "is" Positive)
IF (Train No. "is" 07092) and (Food Quality "is" -1) and (Punctuality "is"0)
   THEN (Sentiment "is" Negative)
IF (Train No. "is" 06042) and (Food Quality "is" -1) and (Punctuality "is"0)
   THEN (Sentiment "is" Negative)
IF (Train No. "is" 04912) and (Food Quality "is" 1) and (Punctuality "is"1)
   THEN (Sentiment "is" Positive)

As shown above, the rules contain the essence of sentiment analysis that is based on each train. The attributes considered are used in the formation of rules.

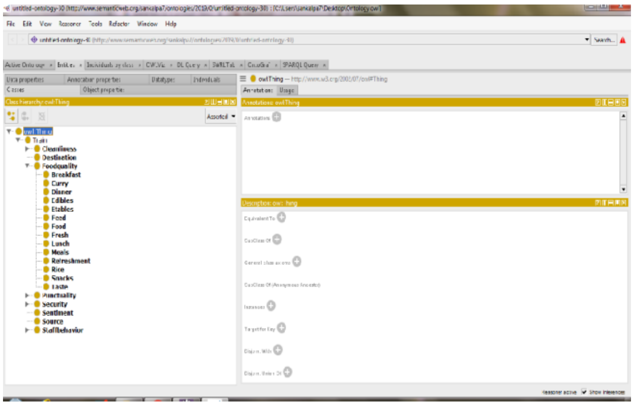

Figure 2: Shows class names

As shown in Figure 2, class hierarchy of OWL is built. It is compatible with the Indian Railways case study for building knowledge based system. Each class may have sub classes in the semantic domain. The classes reflect all the attributes associated with each train for querying BI.

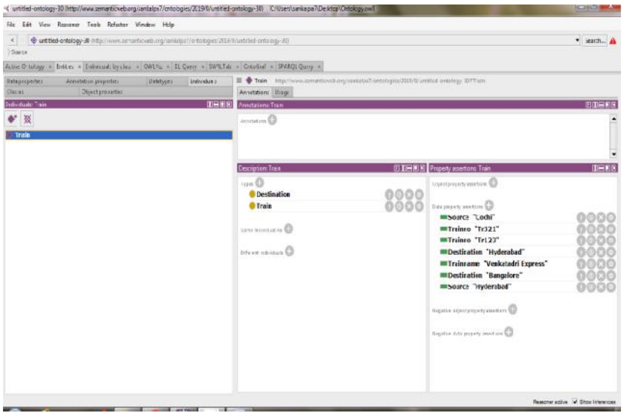

Figure 3: Shows train selected

As presented in Figure 3, the Train is the chosen item under the individuals. Its description and property assertions are made available.

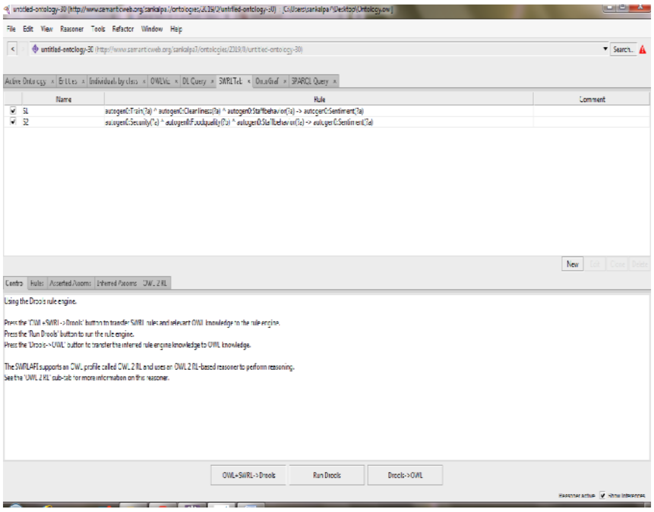

Figure 4: Inference Rules

As presented in Figure 4, Inference rules are made in order to obtain required information based on knowledge based Intelligence. When such queries are made from different applications, the proposed implementation could realize the expected knowledge based system that shares to BI to different applications or individuals or query based interface. Sample of two rules are executed and checked with Reasoner.

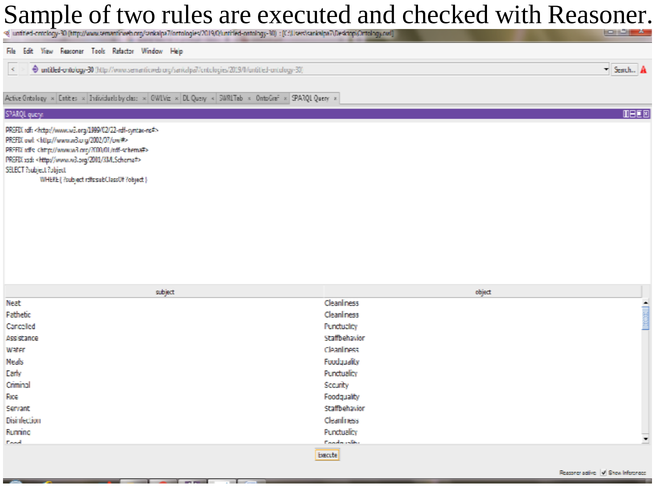

Figure 5: Sample SPARQL query made

As presented in Figure 5, sample SPARQL query is made on the knowledge based system built by transforming RDB schema into OWL. SPARQL is an RDF query language which has its syntax and semantics. In other words, it is semantic query language for knowledge databases. Retrieving and manipulating data present in the form of RDF is made using SPARQL.

V. CONCLUSION AND FUTURE WORK

Knowledge based intelligence system is made by implementing RDF schema to OWL having machine readable and interoperable access to a knowledge base. The problem of deep web access in the contemporary era where knowledge needs to be represented and shared in a quite natural and intuitive way among organizations and individuals is investigated. A framework is proposed to have a systematic approach to convert traditional RDB model to semantic data model. The rationale behind this is that Web Ontology Language (OWL) and RDF schema provide machine readable knowledge base that not only represents knowledge in the form of concepts but also provide means of data exchange across web applications. Such data can be accessed with either direct SPARQL query or query made through a program in M2M environment. An algorithm is proposed which has multiple procedures to map different objects of relational database to the equivalent objects in RDF schema. The empirical study revealed that the proposed framework is useful for transforming RDB behind deep web into readily accessible semantic data model which is proved to be ideal for modern business use cases. The proposed framework needs to be standardized with different database dialects (RDB) available in the real world so as to make it robust and work for all databases. This is one direction for future work. Another direction is to work on simplifying query interface to end users by building query browser to facilitate interactive means of accessing knowledge to make well informed decisions.

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