A Survey on Distributed Information Systems using Semantic Web Techniques

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Abstract

Semantic web is the growing field whose integration with Distributed Information System helps it in gluing technology. The framework of Semantic web deals with the representation, logic, rules and trust. We in this work surveyed the representation aspect of Semantic web by exploring ontologies proposed in various domains in the last three years. We observed that the research trends in semantic web for distributed information system is going in two directions i) theoretical framework ii) development of ontologies across different domains. We limited our work towards the domain of distributed information systems. Several detailed ontologies have been identified that are developed for integration with distributed information system across different domains. We conclude that ontologies need extensive work in its foundation, while more domains should be further explored in the development of robust information system in distributed environment.

Index Terms: Semantic Web, Distributed Information Systems, Ontology, Semantic Web layered architecture.

I. Introduction

Distributed Information System is a multidisciplinary research area that brings information and system together from various sources. Researchers in [1] have identified several challenges including gathering of curated data from different systems and its analysis that is semantically consistent in distributed setting.

To overcome these challenges data analysts have begun using semantic web that provides schema and machine heterogeneity that are able to easily organize, understand and also take decisions on the basis of that data using the layers presented in figure 1.

Integration of semantics in distributed information systems helps in answering complex queries intelligently from glued sources to support users in decision-making, analysis and visualization. Example includes [2] in which ontology is used in e-Education that resolved the semantic gap by designing ontology in which user can get the desired results irrespective of semantics (for example teacher, faculty and instructor). Ontological representation of semantic data has been discussed in other domains as well for example: [3] developed Sharing Economy Description Language (SEDL) ontology in the domain of the Sharing Economy. In [4] the researchers proposed ontology-matching algorithm to perform ontology matching. Szilagyi et al in [5] performed research in the domain of Internet of Things (IOT) and presented the idea of "Semantic Web Stack for the Internet of Things (IOT). For the e-commerce domain, Maria et al. in [6] proposed a novel idea of gathering and collecting the data from the user's navigational behaviors and then applying the ontology-based approach on the collected data. In order to overcome the problem of analyzing large amounts of data that is in unstructured format, [1] designed an architecture, which uses ontology-based approach, which gathers the data of different sizes, structures and multiple formats from all over the web.

To integrate heterogeneous knowledge resources and to avoid unauthorized access or attacks in the information system, [7] presents a modeling approach which uses ontologies and Linked Data for this purpose. In order to automate the judicial domain [8] presented an ontology set built in OWL2 language, which helps in converting the judicial documents into some standard readable format.

This survey paper is presented in the following order. Section II reviews Semantic Web technologies; Section III contains the information about the research and survey. Framework for ontology management is presented in Section IV. Section V outlines some of the open research topics. Finally, Section VI concludes this study. The next subsections describe semantic layers briefly.

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II. SEMANTIC WEB TECHNOLOGIES

Tim Burner Lee in 2001 proposed the idea of the new world wide web with the name sematic web, also introduce a seven layered cake architecture known as semantic web cake, these layers are the major pillars of the semantic web. The next subsections describe these layers briefly.

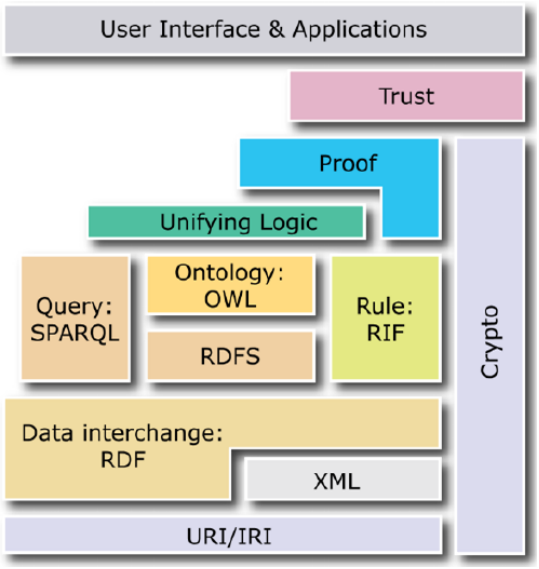

Figure. 1. – Tim Berners Lee's Semantic Web layer cake, adapted from [4].

A. Semantic Web Layers

URI/IRI is the (unique resource identifier/ Internationalized Resource Identifier) that is used to identify the resources on the web; the resources may be in the form of the document, images, files etc.

Unicode is the encoding system, which provides unique number to every character regardless of any operating system or programing language.

XML is the extensive markup language is the extension of HTML, which follow tree structure and uses self-descriptive tags to represent data and information.

RDF is the Resource Description Framework is one of the basic layers of the semantic web architecture; it is flexible and follows graph-based structure for representing resources or classes on the web. RDF statements are known as triples and are in the form of subject, predicate & object.

RDF Schema is a framework, which provides meanings to the basic vocabularies used in the RDF statements, like domain, range, class, subclass, instance etc.

OWL (Web Ontology Language) is used to define domain specific schemas and ontologies. OWL is a superset of RDF & RDFS. OWL has some extended vocabulary like classes & individuals, properties (like inverse, disjoint, cardinality etc) & data-types. The OWL language comes in three sublanguages called species: OWL Lite, OWL DL and OWL Full, which provides different levels of expressiveness.
SPARQL (Simple Protocol and RDF Query Language) is the standard query language for RDF graphs, and considered as the backbone of the semantic web based applications.
Rule Interchange Format (RIF) is the standard for sharing & exchanging rules in rule based systems on the semantic web, used for describing relations, which are not directly described.

Logic layer is responsible for the consistency and correctness of the data and to infer the results from the data, which are not visible for the common beings.

Proof layer uses the logic layer data to test and verify the results, also provides the facility of backtracking or the traceability of the results, which helps in increasing the acceptability of the data.

Trust layer is used to provide the information about the authenticity and the acceptability of the resources or data whether the data or resources are trustable or not.

User interface & Application is the final layer, which is visible to the user to use the semantic web-based applications. In this layer, we focused on ontology layer for representation.

B. Ontology & RDF Vocabularies

Ontology is one of the most important layers of the semantic web available on the sematic web cake layer architecture. Ontology can describe the overall architecture and system flow of the domain including the resources, relationships between the resources, classes, sub classes, instances the object and data properties etc. Ontological representation enables the computer to understand different words or vocabularies used in different places having same meaning like author, writer & creator. Similarly, in academic domain, teacher, faculty and instructor are same.

Ontology can also implement policies and restrictions on certain classes or subclasses, object or data properties. One of the advantages of the ontology is that in case of any change or expansion in the organization, the ontology can also be altered or updated in a seamless manner.

III. SURVEY ON INFORMATION SYSTEM

In this work we target only ontology layer of the semantic web. Our analysis on recent literatures shows that work has been done in two areas: (i) Framework of ontology development (ii) Ontology designing of new domains. The

next two subsections present the detail survey on these two areas.

A. Framework for Ontology Management

Apart from proposing ontologies, it has been observed that some authors work on the theoretical aspects of the information systems and proposed the framework for adaption of ontology and improvement of query results. The brief summary of such papers is mentioned below:

i. Ontology Application Management (OAM) framework

In [9] Buranarach et al. introduces a Semantic Web based application management framework which follows the rapid application development model. The framework is based on templates and does not need any programming language expertise to develop an application. The challenge is that the semantic web based applications which uses ontologies are not widely available in the market and those applications which are available are not designed for non-technology experts, researchers or domain experts. By keeping the challenge in mind the framework is specially designed for non-technology experts, researchers or domain experts, which enables the novice users to easily design the applications as per the requirement.

To access, manipulate and publish the RDF data from the database, the Ontology is the main source of the OAM application framework. For dealing with the heterogeneous data formats the OAM uses wrapper architecture and data mapping tool which acts as an interface between the OWL Ontology and the involved databases. The application framework doesn't engage and disturb the original data. It takes the copy of the original data in RDF format and then proceeds with the copied set of data. For customization purpose the graphical user interface is also provided by the framework, from where the user can select the application templates and also formulate the data. Some of the key technologies used are RDF, OWL, Protege, AllegroGraph, Jena framework, TopBraid Suite. Further work is going on towards visualization and support for Linked Data.

ii. Ontology Matching by using Query Expansion Algorithm

In [4] the researcher proposed an ontology matching algorithm, which uses Query String Expansion to perform ontology matching. A query expansion layer is used to expand the query string by finding the string which has exactly the same or nearly the same meaning or the set of words with the same meaning by using the WordNet lexical database. A WordNet is a dictionary which contains the sets of synonyms. To fetch the related Ontology from the ontology database and to check the similarity matching between the expanded query and the fetched ontology, they introduce a Semantic matching layer which is based on metadata information, Semantic similarity matching algorithm is used to calculate the similarity between query & ontologies. The algorithm is more efficient and also helps in reducing the matching time. Currently the system retrieves the result as a file rather than the data.

Query	Results	Similarity
transport of flower	transport.owl	52.14%
	flower.owl	51.58%
travel	-	0.0%
body and disease	disease.owl	42.28%
houseboat and people	people.owl	11.59

Fig.2 - shows the query and the resultant ontology file name, adapted from [4].

B. Development of Ontology

It is also observed that most of the authors have developed new ontologies or modify the existing ontologies of their related domains like for Internet of things, sharing economy, judiciary etc. The brief summary of such contributions are mentioned below:

i. Ontology for the Matchmaking of Peers

In [3] the researcher performed his research in the field of Sharing Economy and developed a Sharing Economy Description Language (SEDL) Ontology by using the techniques and technologies of the Semantic Web. The challenge aspect is the peer searching for a specific item and the related offers from the different websites which is currently a laborious process. Web Ontology Language (OWL) and the SKOS vocabulary are used to specify an appropriate category from DBpedia. The DBpedia is used in order to infer additional information about the resource, and then the information can be used in the matchmaking process. The matchmaking is between demand & supply. The user's request is considered as demand and expressed in OWL and the desired item is supplied on the basis of inference based on the ontology and rules.

ii. Ontology for the Internet of Things

The induction of semantics in the information system can enhance the consistency and standards in the system. In [5], each IOT device or resource is identified by its unique name, the link between the two different IOT devices, the behavior, and relationships. The interaction of the devices is presented

in a standardized and semantic way to enable ease of identification by the humans as well as machines for inferring decisions autonomously as shown in Figure 3.

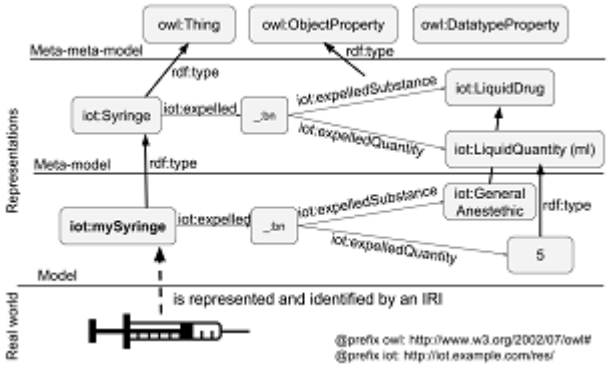

Fig.3 – shows the link, behaviour, relationships and interaction of devices in Semantic Web presented by [5]

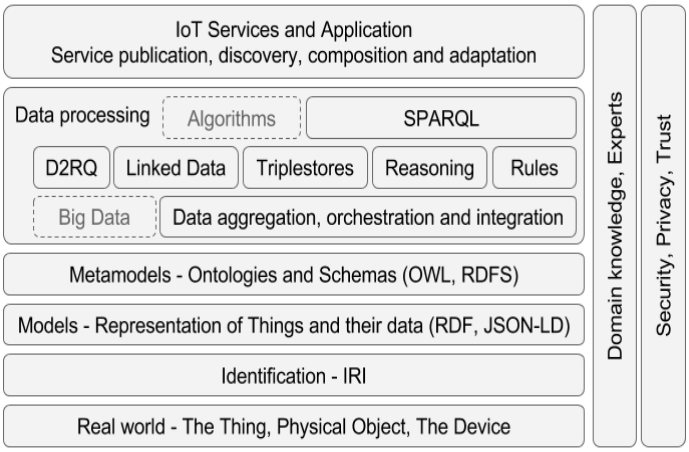

Fig.4 - Semantic Web Stack for IoT presented by Ioan et al. [5]

As per [5] with the passage of time the devices related to Internet of things are also increasing day by day and because of the increasing volume and the enormous variety of the devices, the available technologies are unable to handle them efficiently and effectively. To overcome this problem [5] introduces and suggested the use of Ontologies and Semantic web technologies in the field of Internet of things, which helps in the development of the better and smarter services and the applications related to the Internet of things. In Figure 4, it introduces a “Semantic Web Stack for the Internet of Things (IOT) and also discuss how the IOT systems can be easily developed with the improved performance by using Semantic Web Technologies”.

[5] further unveils about the three different integration levels of Semantic web technologies for the Internet of things system, which includes “modeling level” that contains the information about the Things, to collect and integrate the data from different sources the available ontologies and vocabularies are used for this purpose. The “data processing level” is used for the "reasoning and inference" purpose. The “description logics and OWL semantics” are used for this purpose. While the “IoT Services and Application” level is used to discover, compose and publish the Internet of things services.

The aim of the research is to focus on the different approaches used in the domain of the Internet of Things by using various Semantic Web Techniques, however the in-detailed analysis of the schemas and ontologies related to the IOT is not discussed. [5] adapted the ontology from Schema.org which does not provide specific IoT domain concepts. The semantic vocabularies called LOV (Linked Open Vocabularies) are managed through Open Knowledge Foundation.

Some of the key technologies used in a sematic web context are "JSON-LD" is used for the serialization of the RDF data, for the storage of the RDF triples the triplestores (e.g. "Fuseki", "StarDog") are used while the SPARQL is used for fetching the results from the RDF data.

iii. Ontology for ecommerce

The work in [6] presented a unique idea by utilizing the data of the User's traceable activities or the navigational trails. For this purpose, the data is collected from the reliable sources and the Ontology based approach is applied on that data.

The Challenge is that the current web analytics tools provides the limited services and analytics data while the provision of advanced features is not free of cost and available for commercial purpose only, also the analysis of these tools are not up to the mark.

The Ontology is used by [6] for the merger and portraying the user's trailing data, that was collecting from the different resources from the web, the collected data is then deposited into the RDF database, from where it can be easily utilized and queried using different tools and algorithms. For getting the advance features of the web analytics, this work will further be extended by integrated with the Linked Open Data, so that the system is linked with the connected data and the more powerful web analytics representation is available in the future.

The "RDF Repository" is used as a key technology, where the data from different resources are gathered and dumped into the "RDF repository", and then the "SPARQL" query language is used to retrieve the results from the repository.

iv. Ontology for tracing known security vulnerabilities

The work in [7] performed his research for the detection of Software security leakages by presenting a model-based approach using Semantic web technology. The aim is to develop some standard model by fetching the data from different types of repositories, which contains the information about the software, its lackness and the available loopholes in the software.

The challenge is that the developers are unaware or ignored the security laps or small mistakes while developing software's, which may lead to the security risk for the software so that the unauthorized access or attacks can be made in their software. The work utilized two different ontologies SECONT and MAVON[1]. As a first step the facts are extracted from Maven[2] & NVD[3] repositories. Maven open source JAVA based tool for build automation, develop for Apache webserver platform, contains dependencies information on other module or any external module or component, build order, directories & required plugins. While NVD is a National vulnerabilities database which maintain standardized information about reported software vulnerabilities. In second step the Maven facts are extracted in MAVON ontology and the NVD facts are extracted in SECONT ontology through JENA[4] framework and stored in triple store.

The OWL semantic relationships "owl:equivalentClass" and "owl:equivalentProperty" is used to find the equivalence relationship between classes and properties. In the last step the SPARQL is used to query and fetch the results from the knowledge base which identifies the impact of the loopholes available in the software within the entire project.

Some of the key technologies used are Jena for data extraction, OWL for finding semantic relationships and the SE-GPS [5] tool is used for visualization which is used to analyze and visualize the reported vulnerabilities.

[7] suggested that the extension in the SE-GPS tool is required so that the developer's input is also included in the system to improve the results, also the notifications from SE-GPS software are not automated which needs to be generated automatically.

[1] SECONT and MAVON are made publicly available at: https://github.com/segps/segps-ontologies.

[2] Maven http://www.sonatype.com/Books/Maven-The-Complete-Reference

[3] NVD https://nvd.nist.gov/vuln/search

[4] JENA https://jena.apache.org

[5] SE-GPS http://aseg.cs.concordia.ca/segps/

v. Ontology for Railway enquiry system

In [10] Narula et al. developed ontology of railway enquiry system by using the specification of "Web Ontology Language (OWL)" and "Semantic Web Rule Language (SWRL)", which is also used for inference. The challenge is that currently for railway enquiry systems the keyword extraction searching techniques are used by the search engines, due to which the produced results are not accurate, as per the user's requirement and are mostly useless for users. Ontology is proposed for railway enquiry system using Protégé[6]. However, it is not yet tested by integrating with search engines.

vi. Semantic web service for Raod Traffic information

Samper et al. in [11] performed research in the domain of traffic information system for travellers and introducing a multi agent platform by implementing hybrid matching algorithm, which provides ease to the travellers in finding the road traffic information in an automated way.

```
HYBRID_ALGORITHM (REQ,ADV)
{
Candidates = FilterByCategory (REQ,ADV)
ListCouples = Combiner (REQ,Candidates)
WeightedCandidatesOrdered = Null
forall Couples in ListCouples
{
Weight = MatchingWeight (Couples)
if Weight!=Null
(WeightedCandidatesOrdered =
Sort(Weight,WeightedCandidatesOrdered)
}
return WeightedCandidatesOrdered
}
```

Hybrid Matching Algorithm proposed by [11]

The challenge is that the Travellers are facing difficulty in finding the road traffic information. Two ontologies are developed including "Road Traffic Ontology" that contains the road information while for the categorization of the services, the "Road Traffic Services Categorization Ontology" is used. To check the efficiency of the system, it is compared with the Paolucci's algorithm[7]. The Paolucci's algorithm is designed for matching semantic web services and based on DAML-S

[6] Protégé https://protege.stanford.edu/

[7] Paolucci's algorithm https://link.springer.com/content/pdf/10.1007%2F3-540-48005-6_26.pdf

The hybrid matching algorithm returns the sequential list of the web services against the web services profile. Initially all the advertised services of the requested category are filtered by using Road Service Categorization Ontology. For the efficiency and time saving purpose the filter algorithm obtains a subset of OWL-S profile related to the user request, from this subset the combiner algorithm generates the different possible combination of the client request and the provider's advertisement in the form of multidimensional array. The similarity measure algorithm is applied on this data which analyzes the weight as per the order of the parameters. The sort algorithm sorts the matching services and the sort order is obtained by Sort Rule algorithm, which returns true if the web services Advertisement 1 is more feasible than the other Advertisements and thus considered as a best choice for user request and it is observed that hybrid matching algorithm produces more accurate results against the user's requirements. The algorithm is however not tested for different ontologies and Linked Data.

vii. Ontology for Supply Chain Management

Shukla et al. in [1] introduces Ontology based framework by using semantic web techniques which is used for storing, fetching and the presentation of the data. The aim of the designed architecture is to gather and collect the data from everywhere, whether the data belongs to any format or of any volume or velocity, from the archived or real time environment. The challenge is that because of the higher demands and requirements of the customers and modifications in the standards and governing policies for the energy efficiency, it is very difficult to analyze and conceptualize an efficient system for the supply chain management. The researchers in [1] designed an ontology that fetches the data from the supply chain domain. The concepts are taken from multiple resources in order to develop an efficient, smart and quality system which is also less expensive and provides some better services as per the customers' requirements. The designed ontology based system uses semantic web techniques, the user's data is linked with the various spreadsheets and data repositories available all around the world for the related domain, from where the data is extracted, integrated and presented to the user. They use Web Ontology Language (OWL) along with "Protégé version 4" which supports "OWL 2.0" as a key technology for designing the ontology, the "Anzo Enterprise" is also used to link and visualize the data, and the "WebProtégé" is used to make the Ontology publicly available.

viii. Ontology for Personalized feedback

The work in [12] focused his research in the domain of personalized feedback and develops a framework by using "Semantic Web technologies". The framework generates the user's feedback while attempting the online exams including quizzes or assessment tests. The system is feasible for the learning and education domain. The feedback is generated on the basis of the user's reply of the question and the difficulty level of the problem. Whenever the user attempts the question, the user feedback is examined in two ways, in first part the system will compare the feedback with user level and complexity level of the question and generates a positive or negative feedback while in the second part the system generates the references of the alter sources available against the tested topic and then the system will ask the next question with the user. The challenge is the need of intelligent personalized feedback framework based on "Semantic Web technologies" to evaluate the learner's progress & also helps tutor to adjust the course content as per the learner's feedback.

The philosophy behind the algorithm for personalized feedback is conceptualized on the basis of the multiple choice questions, which contains the options of right and wrong answers, out of which only one option is absolutely correct while the others are wrong. The architecture of the personalized feedback framework is based on web services, every web service performs different task and having strong interaction and interlinked with each other through an interface. The work suggested that the generation of open and closed questions must be linked with the positive or negative feedback of the user and the automation of feedback should be implemented in massive courses.

ix. Ontology for attack detection

An ontological model is presented in [13] which is not only used for the identification of the "HTTP protocol specification" attacks but it is also provides aid in finding the dangerous and harmful code from the request and response sections of the program which is threatening for the entire program. The challenge is that the Conventional detection techniques are unable to detect the ever growing variety of attacks on the web applications.

The proposed ontological model grabs the complete information about the crucial attacks, which includes the knowledge about the tools and techniques used by the intruder, the location from where the attack is launched, the destination where the attack is launched, the loopholes and lack ness of the program which causes this attack, the after effects of the attack on the entire program and how to deal with these types of attacks. By considering all the information regarding the attacks the proposed model is constructed by keeping in mind about the previous detailed history of the launched attack, which helps in the detection of the new attacks. The work uses Methontology ontology engineering framework[8] as a key technology for ontology development,

[8] Methontology ontology engineering framework

OntoClean methodology[9] is also used for correctness and the validation of the ontological model. OWL-DL is used for the designing of the ontological model.

x. Ontology for Academic Domain

To gain the maximum output in the education domain the semantics are also applied so that all the important keywords, relations depicts some meaningful information, it also helps in removing the ambiguity like the use of teacher, faculty and instructor keyword should be pointing towards the same meaning so that whenever the teacher, faculty or instructor keyword is available in the entire domain it will always considered as the same meaning.

In [2], researcher claims that OWL is less expressive with the least reasoning capabilities and has less smart and understandable formulations. He combines OWL based Ontology and Semantic Web Rule Language (SWRL) structure towards system integration for Academic Domain. Semantic Web Rule Language (SWRL) provides more robust and impressive reasoning as compare with the Web Ontology Language (OWL), by providing the luxury of creating their own rules to the developers.

The researcher uses Protégé 3.4.2 using OWL as a key technology, SWRL Editor is used for inferencing and SPARQL is used for querying the results.

xi. Ontology for Judicial Domain

In order to automate the judicial domain, the semantics are also applied in the field of legal knowledge representation [8]. For this all the judicial documents, legal cases, decisions and judges' remarks are studied from which the important phrases and keywords are extracted and semantics are applied with a particular focus on judicial interpretation, so that all the similar terms and phrases should depict meaningful & powerful representation of the legal documents and previous judgments. This lays the foundation of the fully automated judicial system. The work presented an ontology set built in OWL2 language, whose aim is to classify the metadata coming from judicial documents with a particular focus on judicial interpretation and aiding in conversion of the legal documents in some common machine acceptable format.

Multilayer paradigm is used; the legal resources are managed in separate levels which are linked together. The knowledge extracted from the legal documents is represented as a separate module in the ontology. It uses Akoma Ntoso standard[10] which is used to represent the judicial documents in xml format for modeling the main parts of the judgment, the core ontology is the extension of LKIF-Core[11] legal ontology, "Qualifying Legal Expression" design pattern is the backbone of the core ontology, while the domain ontology is based on the metadata extracted from the judicial documents.

The ontology set also support multi-language tool which is used to translate legal concepts across different languages, or for direct use abroad. The work uses Protégé 4.1.0 as key technology to model the ontology which supports the features of OWL2. The consistency of the Knowledge Base was checked with the Hermit 1.3.6 reasoner which extracts the data from the OWL ontology and also capable of predicting the outcome of the judgment.

xii. Ontology for eLearning environment

One of the important factors of the e-learning domain is to acquire the most appropriate information from the web about this domain. To achieve this task, the semantics are applied in the domain of e-learning also. The induction of semantics converts the information on the internet into more clear, expressive and interlinked format, which helps the novice users, visitors and scholars in finding their desired materials or course contents in an efficient and effective manner [14]. According to him the unifying academic study programs on the Web is required to fulfill the increasing demand & boom in the international student exchange programs. It presented an enterprise semantic framework based on the patterns of the users visiting behavior and the ontology related the particular domain, which not only helps in boosting and promoting the web mining outcomes but boost the communication and interaction ability of the e-learning system. The proposed framework utilizes the different semantic web and web mining techniques including Ontology and XML which assists in revealing the better and updated information and courses contents for the scholars, teachers and the related visitors and users.

The RDF data model triples cannot be directly used by the OOP languages, to overcome this issue, a framework is proposed that realize direct mapping between object-oriented classes and Semantic Web classes and embeds semantic descriptions in source code to convert objects to RDF data.

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.2653&rep=rep1&type=pdf

[9] OntoClean methodology http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.101.5706&rep=rep1&type=pdf

[10] Akoma Ntoso standards http://www.akomantoso.org/

[11] LKIF-Core11 legal ontology https://github.com/RinkeHoekstra/lkif-core

```
<?xml version="1.0"?> <rdf:RDF
xmlns:rdf=http://www.w3.org/1999/02/22-rdf-syntax-
ns#xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">
<rdfs:Class rdf:ID="Person">
<rdfs:comment>Person Class</rdfs:comment>
<rdfs:subClassOf
rdf:resource="http://www.w3.org/1999/02/22-rdf-syntaxns#
Resource"/> /rdfs:Class>
<rdfs:Class rdf:ID="Student"> <rdfs:comment>Student
Class</rdfs:comment> <rdfs:subClassOf
rdf:resource="#Person"/> </rdfs:Class>
<rdfs:Class rdf:ID="Teacher">
<rdfs:comment>Teacher Class</rdfs:comment>
<rdfs:subClassOf rdf:resource="#Person"/> </rdfs:Class>
<rdfs:Class rdf:ID="Course"> <rdfs:comment>Course
Class</rdfs:comment> <rdfs:subClassOf
rdf:resource="http://www.w3.org/1999/02/22-rdf-syntaxns#
Resource"/> </rdfs:Class>
<rdf:Property rdf:ID="teacher">
<rdfs:comment>Teacher of a
course</rdfs:comment></Teacher> </teacher>
<students><rdf:Seq><rdf:li>
<Student rdf:ID="er"> <name>Rajesh
Kumart</name> </Student> </rdf:li>
</rdf:Seq></students> </Course>
</rdf:RDF>
```

RDF Example used in [14]

[14] uses Protégé as a key technology to create Ontologies for faculty, students, and courses along with Java technology. Jena framework and Java programming language is used for implementation.

xiii. Semantic web for Library information system

[15] presented the analysis of the basic principles and models of the Semantic Web as well as the current usage of these principles in libraries and other cultural institutions. [15] also suggested Linked (Open) Data service improvements for the better visibility of library data.

IV. CONCLUSION

After going through the survey on the ontological representation of the information systems it has been observed that in the last 3 to 4 years the research work is conducted on the following domains including Sharing Economy, Internet of Things, Judiciary, e-learning, e-commerce, road traffic, academics etc.

It has been observed in this survey that the research related to the e-health domain is very limited and not available while searching different research journals, also new theoretical research, ideas and research applications in the field of e-health will bring great revolution in the field of health and education. It is also observed that the researchers are not shown much interest in the theoretical areas and aspects of the ontology as compare to the application areas of the ontology.

References

1. Perdikakis, A., et al. (2015). "Optimize Energy Efficiency in the Supply Chain of FMCGs with the Use of Semantic Web Technologies." Procedia Engineering 132(Supplement C): 1112-1119.

2. Swaminarayan, P. R. (2014). "Knowledge representation in Semantic Web and Development of Academic Ontology using Web Ontology Language& SWRL." International Journal of Emerging Trends & Technology in Computer Science 3 (1): 25-28.

3. Hoffen, M. v. (2017). The Sharing Economy Meets the Semantic Web: An Ontology for the Matchmaking of Peers. 11th International Conference on Semantic Computing, IEEE. San Diego, CA, USA 212-219.

4. Ancy Abraham, R. T. (2014). "Query Expansion Algorithm with Metadata Support for Ontology Matching." International Journal on Recent and Innovation Trends in Computing and Communication 2 (8): 2541-2544.

5. Ioan Szilagyi, P. W. (2016). Ontologies and Semantic Web for the Internet of Things - a survey. Industrial Electronics Society , IECON 2016 - 42nd Annual Conference of the IEEE. Florence, Italy: 6949-6954.

6. María del Mar RoldánGarcía, J.-N., José F.Aldana-Montes1 (2016). "An ontology-based data integration approach for web analytics in e-commerce." Expert Systems with Applications 63: 20-34.

7. Sultan S.Alqahtani, E. E. E., JuergenRilling (2016). "Tracing known security vulnerabilities in software repositories – A Semantic Web enabled modeling approach." Science of Computer Programming 121: 153-175.

8. Ceci, M. (2013). An OWL ontology framework for judicial knowledge. An OWL ontology framework for judicial knowledge, Conference on Legal Knowledge and Semantic Web framework, Bologna, Italy

9. Buranarach, M., et al. (2016). "OAM: An Ontology Application Management Framework for Simplifying Ontology-Based Semantic Web Application Development." International Journal of Software Engineering and Knowledge Engineering 26(01): 115-145.

10. Yadav, U., et al. (2016). "Development and Visualization of Domain Specific Ontology using Protege." Indian Journal of Science and Technology 9(16).

11. Samper Zapater, J. J., et al. (2015). "Semantic web service discovery system for road traffic information services." Expert Systems with Applications 42(8): 3833-3842.

12. Cheniti Belcadhi, L. (2016). "Personalized feedback for self-assessment in lifelong learning environments based on semantic web." Computers in Human Behavior 55(Part A): 562-570.

13. Razzaq, A., et al. (2014). "Ontology for attack detection: An intelligent approach to web application security." Computers & Security 45: 124-146.

14. Dubey, V. G. a. S. M. (2013). "Automatic collaboration and analysis of semantic web information for electronic learning environment " Computer Science and Engineering 54A 12745-12748.

15. Gardašević, S. (2013). "SEMANTIC WEB AND LINKED (OPEN) DATA POSSIBILITIES AND PROSPECTS FOR LIBRARIES " INFOtheca - Journal of Informatics & Librarianship 14 Issue 1(1): 26-36.