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Semantic Web and the Libraries: An Overview

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ABSTRACT

This paper discusses about the concept of semantic web, the technology, web content writing, and necessity for the development of web 3.0. The various components of semantic web technology such as HTTP, URI, RDF, XML, Ontology, W3C and other components specified as W3C standards are touched upon briefly. The benefits of implementing semantic web in the Library functions to provide effective information services and for optimum use of the Library collection are illustrated here.

Key words: Semantic web, Semantic Search engines, Web Ontology Language, web 3.0, Resource Descriptive Framework (RDF), world wild web consortia.

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1. INTRODUCTION

World Wide Web is the first source of information for everyone viz., students, research scholars, faculty, practitioners, Information Officers, etc. The Information Resources on the web are in the form of Uniform Resource Identifiers (URI) and the information in them is not machine-readable.

People search for the Information on a particular topic via a web portal by typing in the key words. The retrieved list display has few relevant ones. The search is done by using statistical methods such as most occurrences of words, co-occurrence of words, etc. The keyword search displays only the matching links. The keyword index is completely incapable of presenting relational information between concepts and.

The information professionals are advocating for more advanced technology search engines which have deductive reasoning like human beings. To achieve such a system the metadata and ontologies have to be developed and are embedded into the web pages.

2. LIMITATIONS OF HTML

The current web is a collection of static web documents mostly written in HTML, and are either generated dynamically from databases or by user interaction. Hypertext Markup Language (HTML) is a markup convention that is used for coding a body of text such as reports, brochures, data like calendars, address books, playlists, and spreadsheets which are presented using an application program, interspersed with multimedia objects such as images and interactive forms. These web pages can be viewed, searched and combined in different ways and are human readable only but not machine. Semantic HTML and Micro formats are the extensions of HTML where intension of the content is defined and machine-readable markup semantic objects are crated.

The machines cannot read, understand the WebPages like human beings, and perform the work without the human involvement. Thus need has arisen for the current web, which can enable the machines to find, combine and act upon the information by interpreting the data. If the information sources are semantically structured, this enables the machines to understand and respond to complex human requests based on their meaning. The Metadata tags provide a method by which computers can categorise the content on the web pages.

3. ORIGIN OF SEMANTIC WEB:

Many cognitive scientists have worked earlier on how to structure the knowledge semantically and enable the automated agents to access the web more intelligently and perform the work of the users on their behalf. Descriptive technologies such as XML, RDF, and OWL have been developed to address the limitations in using HTML. XML (Extensible Markup Language) provides a method for transmitting structured documents. It do not impose any semantic constraints or meaning on the data it carries. RDF (Resource Descriptive Framework) is a simple framework / data model to refer the content in the object. RDF is often represented in XML format. RSS is an RDF object.

The concept of Semantic Web was first coined by Tim Berners-Lee,[1] who had also developed Hyper Text Markup Language (HTML), Hyper Text Transfer Protocol (HTTP), Uniform Resource Identifiers (URI) and World Wide Web (WWW). He visualized Semantic Web as a platform where the intelligent software agents will analyze a particular given situation and present with the best possible alternatives to the users. Tim Berners-Lee has shown how the Semantic Web would work technically and explained about ontologies and as well as their importance in constructing the Semantic Web Companion Web site.[2] He told that Semantic Web will act as an integrator across different applications and content in publishing, blogging and other areas, information applications and systems.

4. WHAT IS THE SEMANTIC WEB?

The word ‘Semantics’ has been derived from Greek word ‘sēmantiká’ (neuter plural of sēmantikós) which means the study of meaning. The study focuses on the relation between signifiers, such as words, phrases, signs, and symbols, and what they stand for, their denotation. Linguistic semantics deals with the study of meaning that is used to understand human expression through language. Other forms of semantics include the semantics of programming languages, formal logics, and semiotics. The terms semantics, metadata and ontologies are used synonymously to refer to Semantic Web. [7]

The Semantic Web provides a common framework that allows data to be shared and reused across applications, enterprise, and community boundaries. It is a collaborative effort led by W3C [3] with participation from a large number of researchers and industrial partners. Its objective is to convert all the unstructured documents on the web into a web data. It is based on the Resource Description Framework (RDF). [47] "*a web of data that can be processed directly and indirectly by machines*." [7] W3C looks after the development of such Semantic Web standards[1]. In their Semantic Web Activity Page W3C states: "*the idea of having data on the Web defined and linked in such a way that it can be used by machines not just for display purposes, but for automation, integration and reuse of data across various applications.*" [3]

5. GOALS OF SEMANTIC WEB

The primary goal of the Semantic Web is to realize the full potential of the Web, making it cost-effective for people, effectively record the knowledge by giving maximum impetus on machine consumption by designing and adopting the technologies which support such machine facilitated global knowledge exchange. *"The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation."[2]*

6. SEMANTIC WEB SOLUTIONS

Resource Description Framework, Web Ontology Language and Extensible Markup Language (XML) will enable in providing machine-readable descriptions which append meaning to the content on the web documents. In Semantic Web the machines performs automated information gathering and analysis similar to that of human beings which results in retrieval of more relevant & meaningful results. Tim Berners-Lee has called this linked data network as the Giant Global Graph [1].

7. COMPONENTS

The term Semantic Web is used to refer to the technologies and standards used for structuring and linking of data by providing a proper description of concepts, terms, and their associations within a given knowledge domain. Such standards and technologies included under W3C [7] are:

a) Resource Description Framework (RDF)
b) RDF Schema (RDFS)
c) Simple Knowledge Organization System (SKOS)
d) SPARQL, which is a RDF query language
e) Notation3 (N3)
f) N-Triples, is a format for storing and transmitting data
g) Turtle (Terse RDF Triple Language)
h) Web Ontology Language (OWL)

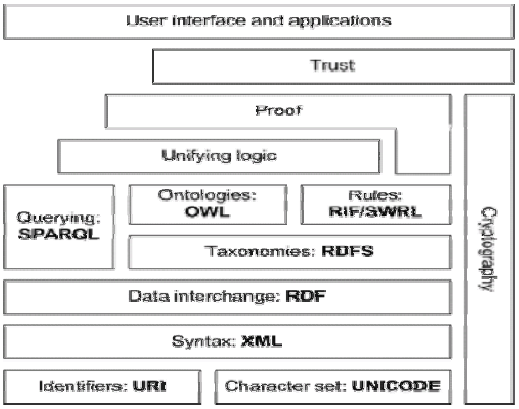

Figure 1. Semantic-web-stack.png The Semantic Web Technology foundational components

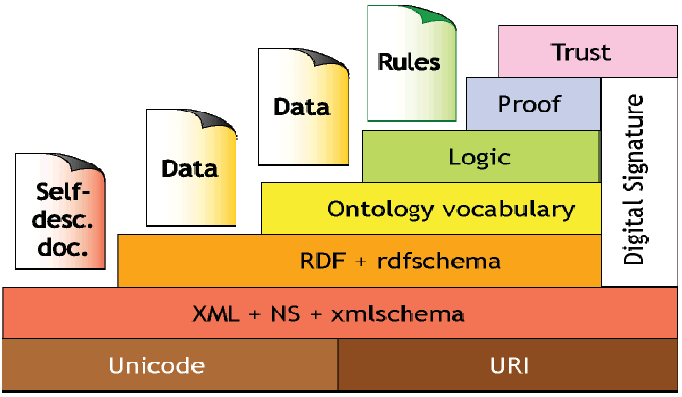

Figure 2. Semantic Web Tower (from Tim Berners-Lee)

8. SEMANTIC WEB STACK & SEMANTIC WEB TECHNOLOGIES

The challenges in the current web are in the areas of integration, standardization, development of tools, and adoption by users. The architecture and technologies of the Semantic Web are being illustrated in Semantic Web Stack. The following definitions are given by W3C consortium. [3]

8.1 HTTP

The Hypertext Transfer Protocol (HTTP) is an application protocol for distributed, collaborative, hypermedia information systems to exchange or transfer hypertext. W3C develops the standards for HTTP. [7]

8.2 HTML

HTML (Hypertext Markup Language) is the standard inextensible and rigid markup language derived from SGML (standard generalized markup language) for displaying web pages and other information in a web browser. HTML consists of *tags* enclosed in angle brackets. The images, objects, scripts,

etc., are embedded into a HTML Document for displaying via browsers. The standards for writing HTML are set by the W3C. [19]

8.3 EXTENSIBLE MARKUP LANGUAGE

XML is the extension of HTML, the popularly technology used to provide fundamental structure and syntax for the content in the web documents. XML allows for extensible data formats unlike HTML which is inextensible and rigid but does not provide semantic constraints. It has the capabilities of simplified data storage and sharing mechanisms. Own Vocabularies, Elements and Attributes can be defined by using the DTDs (Document Type Definition). XSLT (eXtensible Stylesheet Language Transformation) is a language could solve the problem of XML partially when data is shared between two applications or for interoperability. [28] The classical problem of retro-conversion from one MARC to other MARCs can be solved if the elements of source and target structures have one-one relation for sharing and transfer.

XML has following features:

- XML is a markup language much like HTML
- XML was designed to describe data
- XML tags are not predefined. One can define our own tags.
- XML can be used to create new languages

Eg. A resource "book" entitled "Prolegomena to Library Classification" authored by "S. R. Ranganathan", can be represented in an XML document as follows:

<book>
<title>'Prolegomena to Library Classification'</title>
<author>S. R. Ranganathan</author>
</book>

XML is most suitable to develop ontologies. The structure and syntax of description should be standardized using Resource Description Framework (RDF).

8.4 XML SCHEMA

It is a language to describe the content structure in terms of constraints in an XML document. The Document Type Definition (DTD) is a native schema language to the XML.

8.5 METADATA

Metadata is a general framework which provides machine understandable information.

8.6 LOGIC

It is the study of the principles of reasoning. Well understood formal semantics for expressing knowledge are provided by the Logic. The meaning of sentences is defined in most logics without operationalising the knowledge.

8.7 AGENTS

The software objects developed by using object-oriented programming and component-based software that work autonomously, proactively and intelligently are called agents.

8.8 URI (UNIFORM RESOURCE IDENTIFIER)

A uniform resource identifier (URI) is a unique name given to identify a resource over a network using specific protocols. URI provides a generic syntax and consists of a generic set of schemes such as URL, URN (Uniform Resource Name), URC (Uniform Resource Characteristic), etc for identification of document/resource. The generic syntax of a URI scheme is applicable for all its subsets. Semantic Web necessitates identifying a resource on the web available in different formats uniquely and globally.

8.9 RESOURCE DESCRIPTION FRAMEWORK (RDF)

RDF is a simple language used to create standard data models to refer resources, their relationships and data interchange on the web. RDF is a fundamental standard for the Semantic Web. RDF Schema is a vocabulary extending RDF used for describing properties and classes of RDF-based resources, with semantics for generalized-hierarchies of such properties and classes. [7]

An RDF-based model can be represented in a variety of syntaxes, e.g., RDF/XML, N3, Turtle, and RDFa. Each RDF statement is a collection of 'triples' viz., subject, predicate and object. The subject denotes the object the triple is describing, the predicate identifies the attribute of the subject within the statement and the object defines the value of the predicate. RDF uses 'triple' model which allows structured and semi-structured data to be mixed, exposed, and shared across different applications. This linking structure model allows to form a directed, labeled graph, where the edges/nodes are the named links between two resources. This *graph view* provides easy way to understand the technology of RDF.

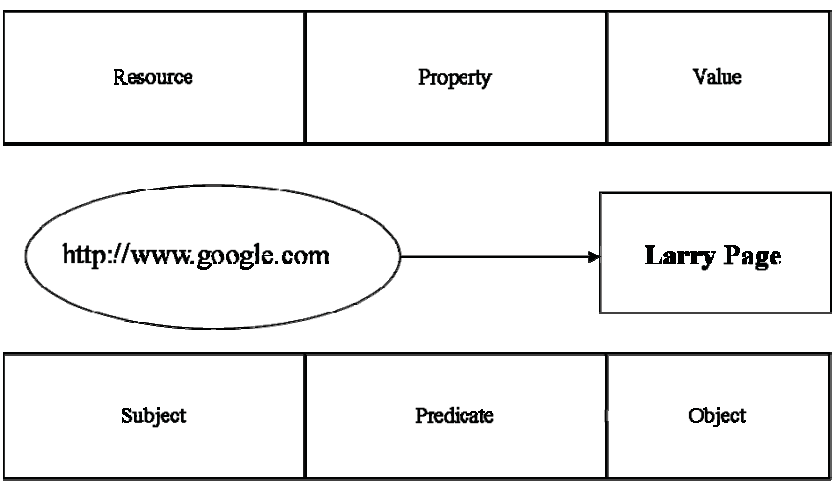

Figure 3. Simple Pictorial Data Representation in RDF (Source: BRAOU-MLISC Syllabus)

8.10 WEB ONTOLOGIES

The term ontology is taken from philosophy which means the study of the nature of existence (the literal translation of the Greek word Οντολογια). It is the branch of metaphysics which identifies and describes the things in the most general terms.

Ontology is the structural framework or pattern of knowledge representation in the form of objects / concepts within a specific domain, their definitions, properties and the associations with each other which models a domain. It is a prescribed, explicit, pattern of a shared conceptualisation, metadata schemas which provide the opportunity to share controlled authoritative vocabulary and taxonomy. These Ontologies help in defining machine understandable semantics which enable easy communication between the human and machine, and also support the exchange of semantics.

8.11 WEB ONTOLOGY LANGUAGE (OWL)

Web Ontology Language (WOL) is a language which allows us to describe the semantics of classes and properties, add more vocabulary in the domains of internet. Web ontologies provide richer integration and interoperability of data; the applications developed using WOL are intelligent, work at the level of human conceptual level, and searches across diverse communities and integrate the information. Eg. Project OntoWeb of University of Amsterdam

The formal ontologies are useful in structuring the content on the web to become comprehensive and machine transportable, a pre-requisite for Semantic Web.

8.12 TURTLE

It is a widely adopted W3C standard not fully standardized, if done then it will be an alternative to RDF/XML. It will eventually lead to greater Semantic Web adoption by the developers and users. [23]

8.13 SPARQL

It is a protocol and query language for semantic web data sources. SPARQL can be used to express queries across diverse data sources, whether the data is stored natively as RDF or viewed as RDF via middleware. SPARQL contains capabilities for querying required and optional graph patterns along with their conjunctions and disjunctions. SPARQL also supports extensible value testing and constraining queries by source RDF graph. The results of SPARQL queries can be results sets or RDF graphs. [21]

8.14 NOTATION N3

Notation 3 (also known as *N3*), an assertion and logic language, is a superset of RDF. N3 extends the RDF data model by adding formulae (literals which are graphs themselves), variables, logical implication, and functional predicates, as well as providing an textual syntax alternative to RDF/XML. [22]

8.15 N-TRIPLES

It is a line-based, plain text format for encoding an RDF graph. It was designed to be a fixed subset of N3 and hence N3 tools such as cwm, n-triples2kif, and Euler can be used to read and process it. cwm can output this format when invoked as "cwm -ntriples".

8.17 ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS

Semantic Web can be fully realized with the use of artificial intelligence. It is the study and design of intelligent agents which perceives its environment and takes actions that maximize its chances of success. John McCarthy, has coined this term in 1955, and defined it as "the science and engineering of making intelligent machines". [48]

An expert system is a computer system that has the ability to make decisions like a human expert. These are particularly designed and developed to solve complex problems by reasoning about knowledge, like human expert, and not by computer algorithms and procedures.

9. DEVELOPMENT OF A SEMANTIC LIBRARY

The Semantic Web comes in handy for the Librarians in providing effective library services. Using the experiences and knowledge of the Librarians the appropriate metadata can be embedded into the existing collections. As the Libraries are information gatekeepers they should bring information and people together. Semantic Web is a remarkable tool for Libraries where it protects proprietary information, and helps in sharing the wealth of knowledge.

The Semantic Web has emerged to address the shortcomings of HTML web pages by developing IT tools which are machine driven and required for integrated access across heterogeneous resources. The explicit meanings are given to the information which enables the machines to process without human intervention and put together it.

"*The Semantic Web is not a separate web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation*" [2]

The vision, goals, and mission of both the libraries and the Semantic web are similar. Both of these have been developed for accessing information available in abundance and discovering the knowledge through cooperation and collaboration for the advancement of society. The applicability of library functions for developing semantic library is discussed in the following sections.

9.1 LIBRARY PORTALS

The Library portals provide a gateway to information, services from multiple sources and access to the organization's resources. The use of Semantic Web technologies in developing Library portals facilitates users' search, access, and retrieval of learning resources. The portal should aim to provide access to a coalition of learning repositories with learning resources available in different formats. [46]

The implementation of Library portals with Semantic Web services will fulfill the vision of Libraries.

The large collections of learning resources are semantically annotated adopting various technologies that facilitate user's access to the content in one or more learning repositories.

Ontologies are used for annotating information to the web content and expressing its semantics in a machine-readable manner. The Ontology schema will be able to give more flexibility in providing semantic description to the content in learning object repositories and, at the same time, it facilitates automated functions and task delegation to intelligent agents.

The library portals search interface should have the capabilities for searching across the heterogeneous resources. The Semantic Library portal should have automated interaction with a search engine at the resource, combined with web ontologies, and the content is tagged with information. The adoption and implementation of technologies will enable ontology-facilitated sharing and reuse of learning resources. Such a portal will allow the library to provide best services.

9.2 SEMANTIC WEB SELECTION

Effective sharing and reuse of selected high quality data is necessary for providing best services. The linked data will help in select and sharing these complex metadata document resources. The approaches for selecting the documents are

a) Taking semantic similarity as metadata analysis to support the user comparison for resources
b) Development of huge amount of ontology driven metadata describing complex features as linked data

The Semantic web selection faces challenges in identifying resources which are distributed across a number of heterogeneous information stores. The non-authoritative, inconsistent metadata in these heterogeneous resources, metadata with different vocabularies having similarities in different fields of competency, semi-structured repositories are the major challenges in selection.

The distinct decentralized repositories provide more structured semantic metadata about the learning resources. The search for the resources in WWW or such repositories can be done using ontology driven which extends the combinations of the search terms which are similar semantically. The quality data which is of high quality can be obtained by identifying the resources using explicit metadata statements, compared with annotations of co-occurrences, then ranked and selected. The structure of ontology heavily relies on the measure of relatedness and match.

The Library catalogue contains structured content which can be made available to the Semantic Web applications. The Semantic Web focuses on the mechanisms of describing the resources and making them available to the user.

The collection development policies have to be reviewed and revised periodically as per the present requirements and demands. The collection developed should have the characteristics of semantic web. The web resources have to be identified, selected and information has to be semantically encoded with the defined type of format(s) that will be tagged. The people who are involved in the collection development and metadata creation should be guided in their selection and tagging of resources. A Semantic Web Selection Policy has to be drafted carefully. [40]

9.3 SEMANTIC WEB REPRESENTATION

There are variety of metadata schemes which guide in cataloguing of digital resources i.e., metadata creation. The description given to the resources should enable a user to identify and select appropriate resources with respect to content, format, etc. Resources have to be represented by simple description, following formal ontologies, which are machine support and have deductive reasoning, by following functional requirements for bibliographic records and cataloguing criteria. Rules for Description and Access (RDA) will be helpful in the development of semantic web catalog.

Coherent, accurate, consistent semantic representation is needed to ensure good quality semantics and for effective semantic web library operations. There should be a well defined semantic web representation policy for the library. The catalog should be rich with Ontologies, authority verification and MARC based scheme should be used for effective Semantic Catalogue.

RDF VOCABULARIES

All the collections / holdings in the library should be perfect description for their representation. The standards such as FOAF and SKOS are being used in recent times.

VoID (Vocabulary of Interlinked Datasets) is an RDF Schema vocabulary for expressing metadata about interlinked RDF datasets. It acts as interlink between the publishers and users of RDF data. Its applications range from data discovery to cataloging and archiving of datasets. VoID can be used to express general metadata based on Dublin Core, access metadata, structural metadata, and links between datasets.

9.4 SEMANTIC WEB REFERENCE SERVICE AND COMMUNITY OUTREACH ACTIVITIES

There are many types of reference services which include personal interaction, documentation services such as bibliographies, guides on collection resources and technology; user education and outreach activities include bibliographic instruction. These services are provided in conformation with the Library's collection development & access policies, and mission statement, for promotion of its facilities and optimum use of the collection. The semantic Web reference services should assist in search of knowledge and more sophisticated automatic processing. There should be Targeted searching for discovering knowledge.

The Semantic Web reference Service should always anticipate the information required and sought by the agents (both human & computer), provide them with accurate information regardless of the difficulty and complication in understanding the queries. The usage of latest technologies and media will enable the Semantic Web reference services reach the entire clientele by publicizing the information services. The information products created should promote the goals and reflect the needs and requirements of the Librarians, Library staff and users.

The challenges in designing of interface and architecture, new methods of marketing, evaluation and collaboration of digital reference services needs to be addressed. The IFLA guidelines, RUSA's Guideline for Information Services and other resources on digital reference can be useful in implementing Semantic Web Service plans in the library. [42]

9.5 SEMANTIC WEB RESOURCE USE

The circulation policy always promotes healthy use of the collection and protects the library holdings. The arrival of digital libraries have eliminated many challenges of the circulation section such as lending the limited collection, defining loan periods and renewal policies, issue of lost and damaged items, fragile &rare materials etc. There should be Semantic Web resource use policy in the library which promote resources use, and protect the integrity of resources. The policy should clearly mention the access procedures for agents; provide them with a unique identification number, and borrowing privileges of resources.

The information with regard to the availability of new resources both internally and externally shall be provided to the agents regularly. The Centralised information agents provide a cooperative approach to data sharing.

10. APPLICATIONS OF RDF AND DIGITAL LIBRARIES

Due to the information explosion digital libraries are facing challenges in managing, organizing and retrieving information from the digital resources. The digital libraries require active information access facilities and to acquire trusted and reliable information.

10.1 FRIEND OF A FRIEND (FOAF)

FOAF is an application of RDF, a machine readable ontology which describes people, the links between them and other people. It provides a rich vocabulary to describe personal information. Each person will be identified by a unique identifier (such as email, blog, URI, etc.) and this is used by computers to locate people or groups with similar interests and allows for social relationships within the network. This first social semantic web application was started by Libby Miller and Dan Brickley in 2000. [43] The FOAF is most useful in the digital libraries where merging of heterogeneous RDF data is done, and structured name authority files are created.

10.2 SIMPLE KNOWLEDGE ORGANISATION SYSTEM (SKOS)

SKOS is an application of RDF which provides a data model for Knowledge Organisation System (KOS) being developed by W3C. The SKOS specifications include tools such as information retrieval thesauri, taxonomies, classification schemes, subject heading lists, and other forms of authority list or knowledge structure. SKOS enables data to be linked or merged by semantic web applications with other controlled vocabularies or subject indexes where complex data integration is required. [26] It is used to improve the recall, retrieval precision and provides a number of searching methods for users.

SKOS is an application of RDF which provides a data model for Knowledge Organisation System (KOS) being developed by W3C, develops specifications and standards to support the use of knowledge organization systems (KOS) such as Information retrieval thesauri, classification schemes, subject heading systems and taxonomies within the RDF framework of the Semantic Web. Encoding information in RDF will enable it to be transmitted across multiple computer applications in an interoperable way.

10.3 DBPEDIA

DBPedia is a linked Data project created as part of the Wikipedia project by Tim Berners-Lee. Which is aimed at extracting the structured content from the information and that structured information is then made available on the WWW. The users can query the relationships and properties associated with the resources, links to related datasets available on Wikipedia. [44]

10.4 RESOURCE DESCRIPTION FRAMEWORK FOR ATTRIBUTES (RDFA)

W3C has introduced RDFa which provide a series of XHTML extensions used to annotate web pages with semantic data. [45] The detailed knowledge of RDF specifications such as FOAF, SKOS, and OWL is not necessary to learn to apply this.

11. CHALLENGES AND THREATS

The primary challenges of the Semantic Web are Privacy, Censorship, Double Entry/ Increased Workloads, Network-centric, and it's Cost in implementation. The other challenges for the Semantic Web include the vastness of the information on the web; overlapping and imprecise concepts which is leading to vagueness; logical contradictions leading to ambiguity, variation, and deception. Automated reasoning systems will have to deal with all of these issues in order to achieve the goals of the Semantic Web. The challenges to the "unifying logic" and "proof" layers of the Semantic Web will require extensions to the Web ontology language (OWL) and this is an area of active research.

The major possible threat is from the Vendors as they are incapable and reluctant to make necessary changes due to their failure in coordinating, apathy and indifference attitude towards the new technology. The other possible threats are particular to libraries concerned. The libraries have to identify the strategies to deal with the vendors and they need to begin adopting standards-based APIs, such as XML-based web service layers.

There was a hard criticism that developing of semantic web is time-consuming, as they have to create two formats for both human and machine. Microformats have solved this problem partially. DBPedia, Friend of a Friend (FOAF), Semantically Interlinked Online Communities (SIOC) and NextBio are few projects to be named that create Semantic Web solutions.

12. CONCLUSION

This article explored the possibilities of performing library functions and providing Library Services using Semantic Web Technologies. An inquiry into the system indicated that many of the Library functions and services can be applied to the Semantic Web. Each library function translates to a Semantic Web function. The functions have been redefined in the context of Semantic Web and are (1) Semantic Web Selection (2) Semantic Web representation (3) Semantic Web Reference and Community outreach activities and (4) Semantic Web resource use. A semantically intelligent

Integrated Library System will provide effective functioning in the provision of library services for making true impact on the society.

The various components of semantic web technology such as HTTP, URI, RDF, XML, Ontology, Vocabularies, W3C and other components specified as W3C standards have been discussed. The present article touched briefly on applications of Resource Description Framework, Development of Digital Libraries and Library Portals.

The librarians should acquire all the latest IT skills useful in developing and maintaining digital libraries, and develop communication skills in different languages and ontologies for better dissemination of information and provision of services and to reach the largest clientele. Even though the libraries have been adopting the latest IT technologies, they still have to embrace the Semantic Web. The Librarians who have skills, talent and knowledge are the advocates of Semantic Web and they can fulfill the vision and mission of the Semantic Web.

The primary challenges of the Semantic Web are Privacy, Censorship, Double Entry/ Increased Workloads, Network-centric, and it's Cost in implementation. The other challenges for the Semantic Web include the vastness of the information on the web; overlapping and imprecise concepts which is leading to vagueness; logical contradictions leading to ambiguity, variation, and deception. The research should be done to tackle these challenges and threats.

This article indicates that the library functions are applicable to the Semantic Web, and invite more research. In conclusion, continued efforts may bridge the Semantic Web/library gap and lead to new opportunities for both communities. The research is on and there are number of opportunities for Librarians in this area.

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