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Toward An Agreement on Semantic Web Architecture

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***Abstract*—**There are many problems associated with the World Wide Web: getting lost in the hyperspace; the web content is still accessible only to humans and difficulties of web administration. The solution to these problems is the Semantic Web which is considered to be the extension for the current web presents information in both human readable and machine processable form. The aim of this study is to reach new generic foundation architecture for the Semantic Web because there is no clear architecture for it, there are four versions, but still up to now there is no agreement for one of these versions nor is there a clear picture for the relation between different layers and technologies inside this architecture. This can be done depending on the idea of previous versions as well as Gerber's evaluation method as a step toward an agreement for one Semantic Web architecture.

***Keywords*—**Semantic Web Architecture, XML, RDF and Ontology.

I. Introduction

SINCE the last decade, the World Wide Web (WWW) has been occupying our lives. It was originally created as a repository to store information. Hyper Text Markup Language (HTML) added new features to the web by linking different documents and facilitating the creation of web pages by means of better presentations. The improvement of technology helps in increasing the number and quality of images, movies and other media elements. This has helped the WWW to be used in many fields such as learning, commerce, government and health. According to this and the dramatically increasing number of internet users as in Table I [1], the number of web pages has been increased and the number of search engines has also multiplied.

TABLE I
THE WORLD INTERNET USAGE FROM DEC. 31, 2000 TO JUNE 30, 2008

World Regions	Internet Users Dec/31, 2000	Internet Usage, June 30, 2008	Usage Growth 2000-2008
Africa	4,514,400	51,065,630	1,031.2 %
Asia	114,304,000	578,538,257	406.1 %
Europe	105,096,093	384,633,765	266.0 %
Middle East	3,284,800	41,939,200	1,176.8 %
North America	108,096,800	248,241,969	129.6 %
America/Caribbean	18,068,919	139,009,209	669.3 %
Oceania / Australia	7,620,480	20,204,331	165.1 %
WORLD TOTAL	360,985,492	1,463,632,361	305.5 %

All these factors have caused many problems to the WWW such as web administration difficulties due to the huge number of web pages available on the web today. It also limits accessibility of the web content only to humans because it is written using the HTML and machines cannot participate in taking a decision. The Semantic Web is assumed to be the solution for all these problems. It is considered to be the extension for the current web which presents information in both human readable and machine processable form. Tim Berners-Lee, the creator of the Semantic Web idea defines the Semantic Web in 2001 as *" The Semantic Web will bring structure to the meaningful content of web pages, creating an environment where software agents roaming from page to page can readily carry out sophisticated tasks for users"* [2].Semantic Web is still the main topic of many researches. But there are problems facing the Semantic Web now, such as there is no clear architecture for it; there are four versions created by Tim Berners-Lee, but still up to now there is no agreement for one of these visions nor is there no clear picture for the relation between different layers inside this architecture and the associated technologies. This paper is organized as follows: Section I introduces the meaning of the Semantic Web, while Section II presents the related work. Section III introduces the meaning of layered architecture; in addition to the evaluation of the Semantic Web architecture according to Gerber's method. Section IV introduces a new architectural model for the Semantic Web. Finally Section V concludes the results in this paper and suggests future work.

II. Related Works

The Semantic Web was introduced by Tim Berners-Lee for the first time in one of his speeches in 1998 as an extension to the current web [3]. He described the different versions of the Semantic Web architecture in 2000 [4], 2003 [5], 2005[6], 2006 [7]. Fensel is one of the main contributors in the Semantic Web field discussed the Semantic Web and the languages associated with its architecture in 2000 [8], while in 2002, he describeed OIL and its relation to OWL and the future capabilities of OWL [9]. Fensel was not the only scientist who made great efforts in this area, but there are Ian Horrocks [10], Patel-Schneider [11] and Gerber [12] also participated in this domain. There is still a long way for the full vision for the Semantic Web and the full implementation of it [13] [14].

III. The Semantic Web Architecture

The Semantic Web architecture depends on the layered architecture [15]. The layered architecture consists of a number of layers organized hierarchically depend on each other and the most famous example for the layered architecture is ISO/OSI (International Standards Organization/Open Systems Interconnected) as in Fig. 1 [16].

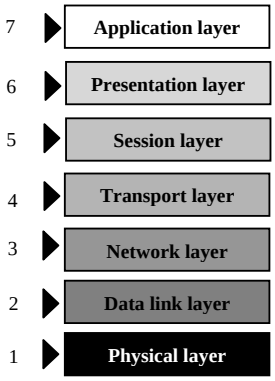

Fig. 1 The ISO/OSI Network Architecture

The Semantic Web architecture will be evaluated using Gerber evaluation method to diagnose the weakness of this architecture and explain the possible modification and adaptation can be done to the Semantic Web architecture. Different versions of the Semantic Web architecture are shown in Fig. 2, Fig. 3, Fig. 4 & Fig. 5.

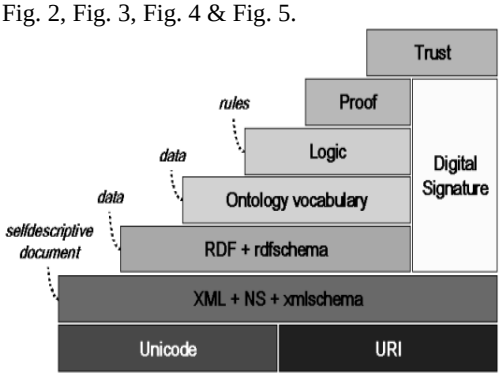

Fig. 2 Semantic Web Layered Architecture for V1 [4]

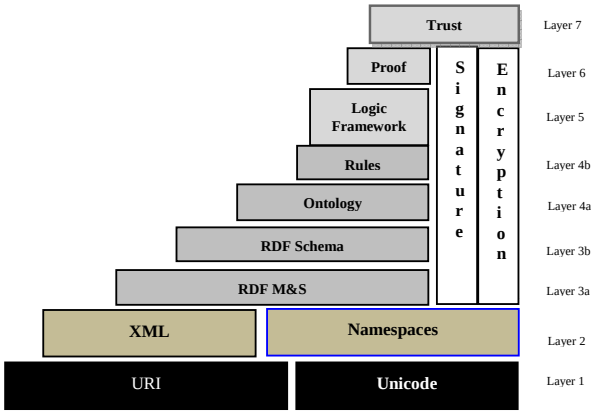

Fig. 3 Semantic Web Layered Architecture V2 [5]

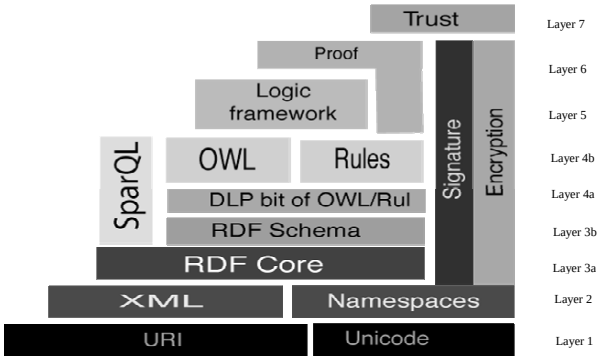

Fig. 4 Semantic Web Layered Architecture V3 [6]

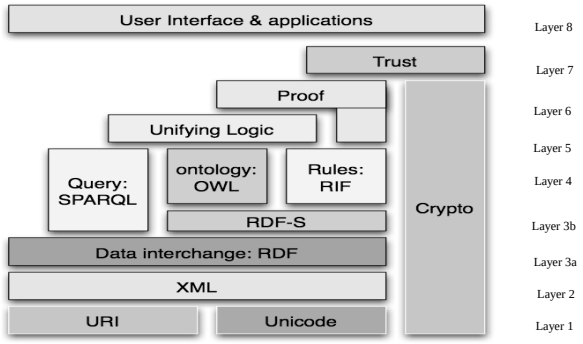

Fig. 5 Semantic Web Layered Architecture V4 [7]

Gerber evaluation criteria can be described as:

- *Clearly defined context:* the meaning of this criterion can be the answer of this question. What are the components used in this architecture and why they are collected together? [12]

- *Appropriate level of abstraction:* Abstraction means that the system can be viewed as one thing and this is an advantage, because this architecture does not bother the user with a lot of details [12].

- *Hiding of implementation details:* The good design is the design that hides the implementations details from the architectural model.

- *Clearly defined functional layers:* This criterion focuses on the function of each component.

- *Appropriate layering including well-defined interfaces and dependencies:* The meaning of this criterion can be the answer of this question: Are the layers clearly built on one another and are their relationships and dependencies clear? [17]

- *Modularity:* By modularity Gerber means that it is possible to change the implementation of a layer as long as interfaces and functionality remain the same [17].

TABLE II
THE EVALUATION FOR THE FOUR VERSIONS OF THE SEMANTIC WEB ARCHITECTURE

Criteria	Conformity
Clearly defined context	Conform
Appropriate Level of Abstraction	Does not Conform
Hiding of Implementation details	Does not Conform
Clearly defined functional layer	Partially
Appropriate Layering including well defined interfaces and dependencies	Partially
Modularity	We disagree with Gerber's definition of modularity. According to Berners-Lee definition of modularity [18] this architecture supports modularity.

From the evaluation done for the four versions of the Semantic Web architecture, it appears that this architecture needs a modification. But before making any new modification, we think that addition principles of the design in software engineering presented by the creator of the Semantic Web idea should be added to the evaluation criteria such as simplicity, tolerance, decentralization, in addition to modularity that be described clearly by Berners-Lee and is not obvious as a meaning in Gerber explanation. Berners-Lee defines modularity as; it is a good thing that this system can be broken into parts that can be grouped with relatively closely bound features. Because if we want to improve the system, this means that we will not destroy the whole system, but only one part or more can be changed [18]. When design a new architecture for the Semantic Web or modify one of the four versions, the main interest should be in layer functionality not languages and technologies because languages and technologies can be changed fast but the layer function is still the same.

IV. A NEW ARCHITECTURAL MODEL FOR THE SEMANTIC WEB

This architecture consists of eleven horizontal layers and one vertical layer. Layers are built one over another taking the same architectural view of OSI/ISO, which is not built as the triangular shape of the before four versions, because there is no description of the use of the triangular shape. The only reason for this shape can be predicted that upper layers can only use part, not all, of the lower layers. But this is not a strong reason for the usage of the triangular shape, the OSI /ISO shape, which has different layers of the same width and length, will be more general and suitable for the Semantic Web. Note that the technologies suggested to be used with different layers, are suggested according to the technologies available at the time of writing of this research. Fig. 6 shows the new architectural model for the Semantic Web which will be described here.

Layer 1: The Unique & Uniform Representation Mechanism

This layer is responsible for encoding of any character whatever this character was written by any language, and at the same time is responsible for uniquely identifying different resources. The technology suitable for the job of encoding is the Unicode and URI that will be suitable for representing and identifying uniquely different resources.

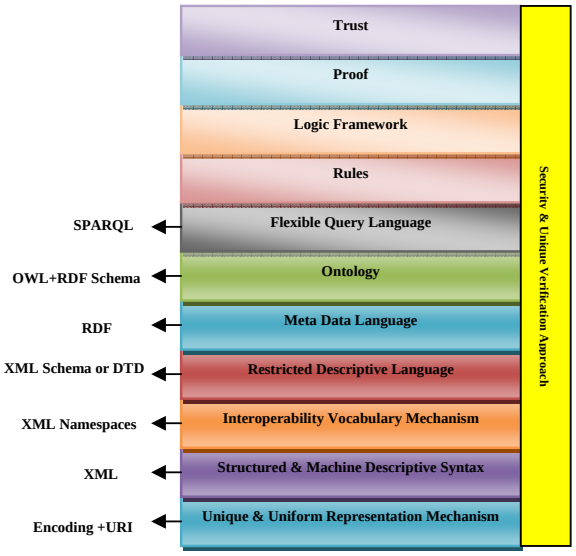

Fig. 6 The new Architectural Model for the Semantic Web

Layer 2: Structured & Machine Descriptive Syntax

This is a layer that has the capability of being used as a base syntax for other technologies developed for other upper layers of the Semantic Web architecture and should be processed by machines to help in the communication of machine together in addition to human. The suitable language to do this now is the XML.

Layer 3: The Interoperability Vocabularies Mechanism

This is the base that can support mixing of different elements from different vocabularies to do a specific function. So Namespaces can be used in this layer as a mechanism for identifying and distinguishing between different XML elements come from different vocabularies.

Layer 4: Restricted Descriptive Language

This is a language used to describe documents written in a Structured & Machine Descriptive Syntax language to be sure that the documents are written correctly according to recommendations. The technology used here can be XML Schema or DTD. The main importance of this layer appears when two applications at this level exchange information between each other, and it should be a way that assures that the received information is equal to the sent information.

Layer 5: Meta Data Language

This layer contains the language that provides meaning to the Semantic Web architecture by representing Meta data to be accessible and processable by machines. The technology available now that can be used here is RDF.

Layer 6: Ontology

Ontology can be described as a collection of terms used to describe a specific domain. It provides a mechanism for describing properties and the relation between properties and different resources. Ontology should have the ability to support inference. Some applications may need simple ontologies while others may need ontologies with great capability. So the ontologies that can be used here are one of two technologies, RDF Schema for describing properties and relations of simple ontologies, while OWL used for the more descriptive ontologies. Both ontologies can be used in one application. This depends on the needs and the aim of this ontology.

Layer 7: A Flexible Query Language

The Semantic Web is a collection of functional layers; these layers presented by different technologies need a query language able to retrieve decentralized information depending on a syntax that can be processed by machines. SPARQL could be the technology available to do this job now and recommended by the W3C.

Layer 8: Rules layer

This layer aims to support inference, in addition to allow query and filtering. Up to now there is no recommended language for the Rule layer but there is a language called RIF for rules which is still a working draft in the W3C.

Layer 9: Logic Framework

Logic Framework layer provides the answer for the question of why this piece of information is taken or appear to the user? There is no technology specification at present for this layer.

Layer 10: Proof

The Proof layer is assumed to answer agents about the question of why they should believe the results. At present, there is no technology recommended by W3C to this layer, but there is an attempt for developing a proof language by the knowledge systems laboratory at Stanford University. This language was called PML [19].

Layer 11: Trust

Trust in the Semantic Web area can be concluded as to be sure that the information provided is valid and there is a degree of confidence in the resource providing this information. At present, there is no recommended technology to be used in this layer.

Vertical Layer: Security & Unique Verification Approach

In our proposed architecture there is only one vertical layer aiming to provide security and uniquely identifies different resources. This can be done at present using two technologies tied together: they are Encryption and Decryption and Digital Signature. This layer is placed from layer 2 up to the top of the architecture. Both technologies are recommended by the W3C [20].

TABLE III
THE EVALUATION FOR THE NEW MODEL OF THE SEMANTIC WEB ARCHITECTURE

Criteria	Conformity
Clearly defined context	Conform: The architecture components are layers required for the implementation of the Semantic Web architecture.
Appropriate level of abstraction	Conform: The system can be viewed as one thing because it consists of functional layers and do not describe technologies inside the layers
Hiding of implementation details.	Conform: In this architecture each layer named by its functionality while technologies were not described inside the layers, but annotated for better understanding
Clearly defined functional layer	Conform: All layers defined by their functionality.
Appropriate layering including well defined interfaces and dependencies	Conform: Layers in the Semantic Web architecture built on one another according to their functionality. It is an open system.
Modularity	Conform
Simplicity	Conform: Compared with V2,V3 &V4 find that this architecture has fewer elements . and Berners-Lee defined simplicity as using of fewer basic elements to achieve the same power
Tolerance	Conform
Decentralization	Conform

V. CONCLUSION

Our study of the Semantic Web architecture highlighted some weaknesses of this architecture, modify, adapt and reach a new architecture that corrects these weaknesses that existed in the previous architecture. The main problem is compounded by the fact that there are technologies that do not ever exist and some others, though existent, have not become standard yet. Consequently, this study of Semantic Web needs more than one study, given its multifarious aspects and details with a view to attaining a general viable and operable framework for the Semantic Web.

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