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Semantic Web and Ontology: Effective Approaches to Build Intelligent Web

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ABSTRACT: Semantic Web enhances the current Web to the next generation in which machines are enhanced to understand the meaning of data rather than reading the data, overcoming the current issues of Web. Semantic Web Mining integrates Semantic Web and Data Mining which are the two looming areas of research. Semantic Web uses Ontology as its key feature to define the semantics of entities. Ontology derives the relationship of entities based on its behavior and provides a common vocabulary to provide a shared conceptualization of domain with formal and explicit specification. This paper presents the architecture and key layers of Semantic Web, Structure and Operations of Ontology and the working of RDF, Ontology and Semantic Web Rule Language with a practical Scenario.

KEYWORDS: Semantic Web; Resource Description Framework; Web Ontology Language; Ontology Operations; Semantic Web Rule Language

I. INTRODUCTION

Semantic Web promotes Web to function in a way that represents information more meaningfully for humans and computers as well. It is an extension of Web through standards by the World Wide Web Consortium (W3C). "The Semantic Web is termed as the Web of Data that provides a common framework allowing data to be shared and reused across application, enterprise and community boundaries". The importance of semantic web rose to overcome the weakness of the current web. "It enables the description of contents and services in a machine-readable form, and enables annotating, discovering, publishing, advertising and composing services to be automated and transforms from machine-readable form to machine-understandable form"[3].Ontology acts as an important role in Semantic Web. Ontology describes information by its nature of being or existence of entities. It creates a shared understanding of common domains and works in resolving the problem of interoperability between systems, products across different organizations. To provide a better way of interoperability, many solutions, tools and applications of Semantic Web technologies have recently made available and its Intelligence is used in the fields of Education, Health Science, E-Commerce, Artificial Intelligence etc…This paper describes the major terminologies of semantic web and ontology in detail.

II. RELATED WORK

R.Rubini and Dr.R.Manicka Chezian [1] provided an analysis on Search engine architecture, tools and different techniques for generation and optimization of Search engines. T. Berners-Lee et al. [2] discussed about the potential of the Semantic Web and its future, believing Semantic Web can assist the evolution of human knowledge as a whole in future. Mohammad Mustafa Taye [3] presented many relevant terms of Semantic Web and Ontology in order to provide a basic understanding of the theory and applications describing the Ontology structure and interoperability functions. Nupur Choudhury [4] provided an overview from the evolution of the Web from Web 1.0, Web 2.0, Web 3.0 and Web 4.0 and their characteristics were also described concluding that the Web is moving towards an intelligent path. R.Akil Sindhu and Dr.R.Manicka Chezian [5] made a comparative study on the positive movement of Web from Web 0.0 to Web 5.0. Aurona Gerber et al. [6] analysed the different versions of the semantic web architecture and the unique features of each layer. K.Vanitha et al. [7] discussed in detail about Semantic Web, Web Ontology and its development process. Ian Horrocks [8] presented the advantages of Semantic Web over the present approach with

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numerous examples illustrating syntactically with OWL and RDF syntaxes and described the features of the Web Ontology Languages.

III. THE GROWTH OF WEB

WEB 1.0: Tim Berners-Lee considers the Web1.0 as "read-only" Web. Web 1.0 was referred as the first generation of World Wide Web. Web 1.0 was basically defined as Web containing static pages and used for content delivery purpose only. It allowed us only to search for information and read it. The user interaction and content contribution was very limited.

WEB 2.0: Web 2.0 is the Second Generation Web. Web 2.0 is called as People-centric web and participative web [4][5]. Web 2.0 facilities reading and writing on the web which makes the web transaction bi-directional. It encourages Participation, Collaboration and Information Sharing. Web 3.0 is designed to be an Intelligent Web that is focussed to overcome the current drawbacks.

WEB 3.0: Web 3.0 is the Third Generation Web. Web 3.0 can be also stated as "executable Web". Web 3.0 is to define structure data and link them in order to make more effective discovery, automation, integration, and reuse across various applications [4][5]. Web 3.0 is a semantic web which refers to the future web. In Web 3.0, computers can interpret information similar to humans and intelligently produce and distribute useful content customizing to the needs of users. "The Semantic Web provides a common framework permitting data to be shared and reused across different applications and enterprises. Table.1 presents the comparison of Web1.0, Web 2.0 and future Web, Web 3.0.

Table.1 Comparison of Web 1.0, Web 2.0 and Web 3.0

WEB 1.0	WEB 2.0	WEB 3.0
Web 1.0, the Web of Documents was developed during 1996 to 2004.	Web 2.0, the Web of People, was developed during 2000 to 2010.	Web 3.0, the Web of Data, was developed during 2010 to 2020.
Web 1.0, the "read only Web" is built with HTML, HTTP and URI.	Web 2.0, the "read-write Web" is built with XML, XHTML, VBScript, ASP, JSP, PHP, CGI, PERL, Flash etc…	Web 3.0 the "read-write-execute Web" is built with RDF/RDFS/OWL/SWRL.
It focuses on Companies and Owning Content.	It focuses on Communities and Sharing Content.	It focuses on Individuals and Consolidating Content.
It includes Web Forms, Netscape, basic HTML editors, Search engines etc...	It includes Blogs and Web Applications like Facebook, YouTube, Del-icio-us, MySpace, Flickr, Freesound etc...	It includes Smart Applications such as Twine, Freebase, DBpedia, Tripit etc...

IV. THE NEW SEMANTIC WEB FRAMEWORK

The Semantic Web [3] is distributed and heterogeneous. It has brought the evolution of the Web to a higher level. Tim Berners-Lee, who invented the World Wide Web, has worked on the Semantic Web stating "Semantic Web is not a separate Web but an extension of the current one, where the information is given in a well-defined meaning, enhancing to create collaborative environment for computers and people to work in cooperation."[2].Hence, Semantic Web aims to make information available on the Web understandable by humans and computers focusing to enhance its usability as a medium of collaboration and to ensure its contents can be understood by machines. Web Services use HTTP to display the content of a page whereas Semantic Web focuses to generate machine readability by semantically representing the data or information in resources.

A. URI: The Uniform Resource Locator is the subset of URI which is the Uniform Resource Identifier. A URI typically describes the mechanism to access the resource by assigning unique names to the resources.

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B. Unicode: Unicode provides a unique number for every character using 16 bits per character to represent 65,536 (2^16) unique characters. It is the standard computer character representation.

C. Extensible Markup Language: Extensible Markup Language (XML) defines a set of rules for encoding documents in a format which is both human-readable and machine-readable. It is defined by the W3C's XML 1.0 Specification. It is used for interchanging data over the Internet. It provides flexible text format and used in numerous Software development activities.

D. The Resource Description Framework (RDF): Resource Description Framework is a simple modelling language providing a standard model for data interchange on the Web. RDF generates the linking structure of the Web to use URIs to name the relationship between things as well as the two ends of the link which is usually referred to as a "triple". It uses URI to identify the Web resources and forms a graph model describing the relation between the resources. Resource Description Framework Schema has been added additionally with RDF as a layer in the later versions [6]. Fig.1 presents the key layers of Semantic Web Architecture and its growth from Version 1 to Version 4 along with its layers [6].

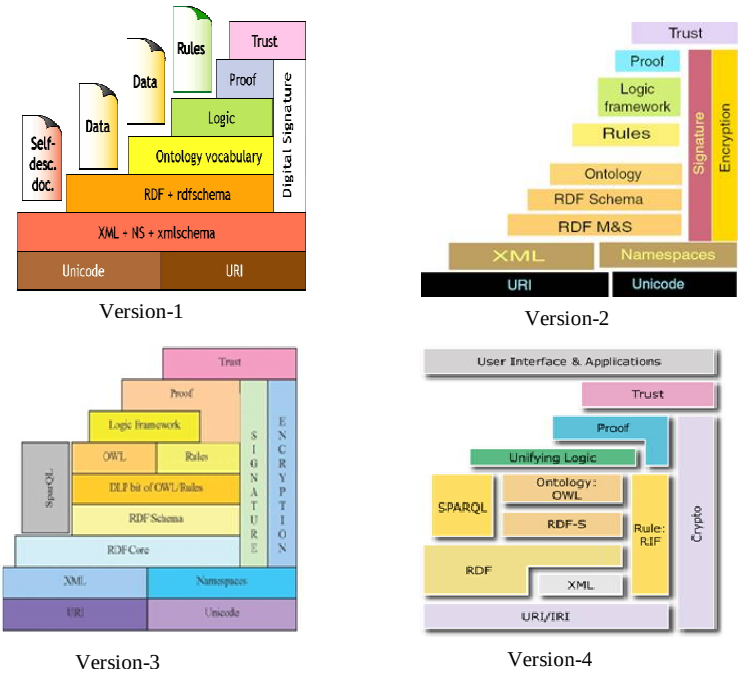

Fig.1 Version change in the Semantic Web Architecture

E. Ontology Vocabulary: Ontology is a language which provides a common vocabulary and grammar for published data, providing a semantic description of the data. Ontology can be defined as a collection of terms used to describe a specific domain with the ability of inference. In general it is called as a specification of a conceptualization". Ontology focuses domain knowledge and creates semantics explicitly in a generic way. It enables interoperation between Web applications from different areas or from different views on one area.

F. Rules: Rules Interchange Framework (RIF) is added in the third version of Semantic architecture's layer. RIF is made as a draft specification for a rule language under RDF schema and ontology as its base. Semantic Web Rule Language (SWRL) is initiated by W3C as a Rule language is required above Ontology.

G. SPARQL: Simple Protocol and RDF Query Language is a query language similar to SQL used for querying RDF data.

H. Logic: The building of the system is done based on the logic provided by the structure of Ontology.

I. Proof: The redundancy of concept translation and consistency problem is checked. This layer deals with the Proof validation.

J. Trust: Trust concerns the trustworthiness of the information on the Web to confirm the assurance of its quality.

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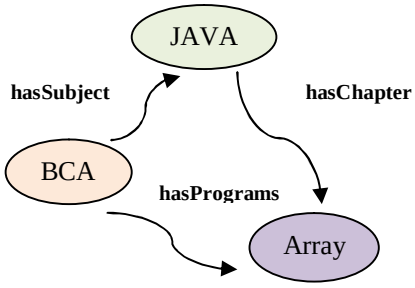
(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2016

K. Security Layers: The Digital Signatures, Encryption and Crypto appearing in different versions of semantic architecture serves the security purposes for the Semantic Web.

V. RESOURCE DESCRIPTION FRAMEWORK

The Resource Description Framework (RDF) is a metadata data model belonging to family of World Wide Web Consortium (W3C) specifications [1]. It is used as a general method for conceptual description or modelling of information that is applied in web resources, using a variety of syntax notations and data serialization formats. It is also used in knowledge management applications. The RDF data model's approach is in the form of Subject-Predicate-Object expressions. These expressions are triples including Subject-Predicate-Object representing the relationships between two resources, the first being a Subject and the other one being object and the relation is considered as Predicate. Fig 2 is an example of RDF triple expression, where the relationship representing the Subject, Predicate and Object is illustrated with an example and it is triplet form is presented as a table.



Subject	Predicate	Object
BCA	hasSubject	JAVA
JAVA	hasChapter	Arrays
BCA	hasPrograms	Arrays

Fig.2 Example RDF Triples

RDF is an abstract model with several serialization formats (i.e., file formats), hence the way in which triple is encoded varies from format to format. RDF Vocabulary Description Language (RDF Schema) extends RDF to include the basic features required to define Ontologies. This is achieved by giving additional meaning to more "special" resources, including rdfs: Class, rdfs: subClassOf, rdfs: subPropertyOf, rdfs: domain and rdfs: range the rdfs: Class resource is the class of all RDF classes [8]. A collection of RDF statements are a labelled, directed multi-graph, describing the relation between the resources. Fig.3 provides the sample RDF representation of the entities: Programming Books, Books and its ISBN Number.

This example states "All Programming Books are Books"

```
<rdfs:Class rdf:about="ProgrammingBooks">
  <rdfs:subClassOf rdf:resource="#Books"/>
</rdfs:Class>
```

This example states "ISBN Number applies to Books only and its value is always a Literal"

```
<rdf:Property rdf:ID="ISBNNumber">
  <rdfs:domain rdf:resource="#Books"/>
  <rdfs:range rdf:resource="&rdf;Literal"/>
</rdf:Property>
```

Fig.3 Representation of RDF Framework

VI. THE WEB ONTOLOGY LANGUAGE

Ontology is the study of existence, inference and nature of an entity, analysing its structure and behaviour of existence. The key factor of Semantic Web is the Ontology which comprises of four main components namely Concepts, Instances, Relations, and Axioms. The relation among rdfs: Class, rdfs: subClassOf, rdfs: subPropertyOf, rdfs: domain and rdfs: range can be represented using Ontologies. Fig.4 presents Ontology representation for relating

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Vol. 4, Issue 3, March 2016

the entities such as: Books and its features such as ISBN Number and version, Programming Books, which is the subclass of Books and its chapter for the course BCA. It illustrates the relationship of every entity in terms of class, subclass, properties and subproperties.

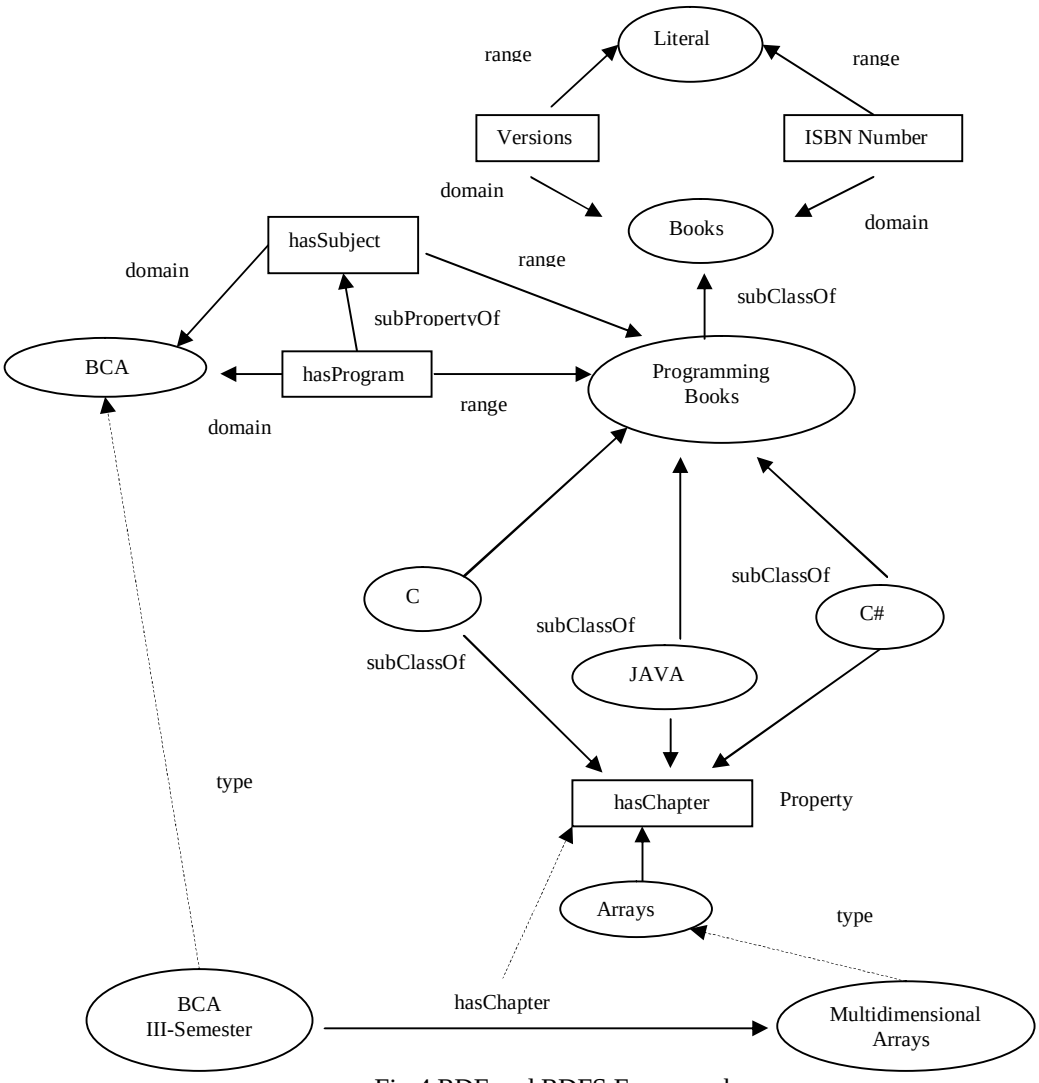

Fig.4 RDF and RDFS Framework

A. Structure of Ontology: In general, the structure of ontology [3] is described as

"5-tuple O: = (C, HC, R, HR, I)"

- Where, "C" denotes a set of "Concepts" or "Classes" representing the group of similar objects. Concept is the super class or "parent class".
- "R" denotes a set of "relations" that relate every concepts.
- "HC" denotes a "hierarchy of concept" in the form of a relation (correspondingly relating to "rdfs: subClassOf"). HC (subset) (C × C), where HC (C1, C2) denotes that C1 is a sub concept of C2.
- "HR" denotes a relation hierarchy in the form of a relation HR (subset) R×R, where HR (R1, R2) denotes that R1 is a sub relation of R2 ("rdfs: subPropertyOf")
- "I" is the "instantiation" of the concepts in a particular domain ("rdf: type").

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- Axiom is used to provide constraint restriction on the values of classes or instances. Axioms are used to verify the consistency of the Ontology. Ontologies share the common taxonomy for building several Knowledge bases, The light weight Ontologies includes concepts, concept taxonomies, relationships between concepts,

and properties that describe concepts, while heavyweight Ontologies add axioms and constraints to lightweight ones[3]. Fig.5 provides a sample OWL representation of the rdf and rdfs framework for the entities illustrated in Fig.4.

The Class JAVA can be defined as:

```
<owl:Class rdf:ID="JAVA">
  <rdfs:subClassOf rdf:resource="#ProgrammingBooks"/>
</owl:Class>
```

The Class Arrays can be defined with its property as:

```
<owl:Class rdf:ID="Arrays">
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:Property rdf:resource="#hasChapter"/>
      <owl:allValuesFrom rdf:resource="#JAVA"/>
    </owl:Restriction>
  </rdfs:subClassOf>
</owl:Class>
```

The rdf property can be represented in owl as object property and data type property, the object property representation can be defined as:

```
<owl:ObjectProperty rdf:ID="hasProgram">
  <rdfs:domain rdf:resource="#BCA"/>
  <rdfs:range rdf:resource="ProgrammingBooks"/>
  <rdfs:subPropertyOf rdf:resource="#hasSubject"/>
</owl:ObjectProperty>
```

Fig.5.Owl Representation of RDF and RDFS schema based on RDF's XML.

B. Ontology Operations: The Ontology Interoperability serves several operations listed in Table.2.Ontology integrates heterogeneous application systems effectively. There are various tools available to build Ontology. They are Protégé 3.4, IsaViz, Apollo, and SWOOP.

ONTOLOGY OPERATIONS	DESCRIPTIONS
Ontology Transformation	The ontology semantics and representation of the existing one can be transformed to develop a new ontology based on the new requirements.
Ontology Integration	A consistent Ontology is developed by merging more than one existing ontologies of different domain.
Ontology Mapping	The entities of different ontologies are connected to one another to define its semantic relationship. The ontologies are matched based on its similarities.
Ontology Merging	A consistent Ontology is developed by merging more than one existing ontologies of similar domain.
Ontology alignment	The differently structured ontology is aligned together based on its similar meaning and behaviour.
Ontology Refinement	Mapping of ontology to another, where if X and Y are two ontologies then every concept/class of ontology X has equivalent in ontology Y. The refinement of such ontologies in both the direction is called Ontology Unification.
Ontology Inheritance	Ontology inheritance occurs If ontology Y inherits the concepts, relations and axioms of ontology X.

Table.2.Ontology Interoperability Services

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(An ISO 3297: 2007 Certified Organization)

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C. SWRL: A Semantic Web Rule Language Combining OWL and RuleML

Ontology uses strict rules to represent rules and relationships between resources. The Semantic Web Rule Language (SWRL) is suitable for the Semantic Web that is used to express rules and logic. It Combines the Web Ontology Language and Rule Markup Language. The simple Rule is the form of an implication between an antecedent (body) and consequent (head). The Rule must satisfy the condition, "Whenever the conditions specified in the antecedent hold, then the conditions specified in the consequent must also hold"

The Ontology root element of the OWL XML presentation Syntax is extended to include "imp" (implication rule) and "var" (variable declaration) axioms as found under the rule base root of RuleML. The integration of OWL and RDF has the advantage of making OWL Ontologies directly accessible to Web based applications [8]. This new approach of Web Ontology Language analyses the relationship of every entity in a detailed way based on Ontology Vocabulary which builds a hierarchical structure of relations enabling efficient representation of data. Fig.6 illustrates the human readable syntax of the SWRL rule for the triples BCA, JAVA and Arrays, where the rule is illustrated with the combination of hasSubject and hasChapter properties which together implies the hasPrograms property and the XML Concrete Syntax of the triples, which is a combination of the OWL Web Ontology Language XML Presentation Syntax with the RuleML XML syntax.

The rule asserting the composition of BCA (course) and JAVA (Programming Book) properties that implies the Arrays (Chapter) can be written as:

"hasSubject(?BCA,?JAVA) ∧ hasChapter(?JAVA,?Arrays) ⇒ hasPrograms(?BCA,?Arrays)"

In an abstract syntax, the rule would be written like:

"Implies (Antecedent (hasSubject (I-variable (BCA) I-variable (JAVA))
hasChapter (I-variable (JAVA) I-variable(Arrays)))
Consequent (hasPrograms (I-variable (BCA) I-variable (Arrays))))"

The XML Concrete Syntax of the triples would be written like:

```
<ruleml:imp>
<ruleml:_rlab ruleml:href="#example1"/>
<ruleml:_body>
<swrlx:individualPropertyAtom swrlx:property="hasSubject">
<ruleml:var>BCA</ruleml:var>
<ruleml:var>JAVA</ruleml:var>
</swrlx:individualPropertyAtom>
<swrlx:individualPropertyAtom swrlx:property="hasChapter">
<ruleml:var>JAVA</ruleml:var>
<ruleml:var>Arrays</ruleml:var>
</swrlx:individualPropertyAtom>
</ruleml:_body>
<ruleml:_head>
<swrlx: individualPropertyAtom swrlx: property="hasPrograms">
<ruleml:var> BCA </ruleml: var>
<ruleml:var>Arrays</ruleml: var>
</swrlx:individualPropertyAtom>
</ruleml: _head>
</ruleml: imp>
```

Fig.6 Sample SWRL and XML Concrete Syntax

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(An ISO 3297: 2007 Certified Organization)

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VII. CONCLUSION

This paper focuses on the Semantic Web framework and its major terminologies along with the nature of Web Ontology Language and Semantic Web Rule Language with examples. There are many Open Source Tools available to build Ontology, which is the backbone of the Semantic Web. As Semantic Web extends the current Web from machine-readable to machine-understandable form, it has brought the evaluation of Web to a higher level, overcoming the current issues such as information overload and organization in Web. The positive impact of Semantic Web can bring more advancement in various domains. So, in future, major fields such as e-learning, e-government, e-library, e-commerce etc... can achieve greater utilization with the extension of the current Web to the Semantic Web.

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BIOGRAPHY

R.Akil Sindhu received her M.Sc., in Software Engineering from MCET, Pollachi under Anna University, Chennai in 2012. She worked as a Software Engineer from 2013 to 2015 in HCL Technologies Ltd, Chennai. Currently she is a Research Scholar in Department of Computer Science, NGM College, Pollachi under Bharathiar University, Coimbatore. She has presented her Research Papers in National and International Conferences. Her Areas of interest includes Data Mining, Semantic Web Mining, Ontology Engineering and Big Data Analytics.

Dr. R. Manicka Chezian received his M.Sc., in Applied Science from PSG College of Technology, Coimbatore, India in 1987. He completed his M.S. degree in Software Systems from Birla Institute of Technology and Science, Pilani, Rajasthan, India and Ph.D degree in Computer Science from School of Computer Science and Engineering, Bharathiar University, Coimbatore, India. He served as a Faculty of Maths and Computer Applications at P.S.G College of Technology, Coimbatore from 1987 to 1989. Presently, he has been working as an Associate Professor of Computer Science in NGM College (Autonomous), Pollachi, India since 1989. He has published more than hundred papers in various International Journals and Conferences. He is a recipient of many awards such as Desha Mithra Award, Best paper Award, Best Research Supervisor Award, Life Time Achievement Award in Computer Science Field, and Best Computer Science Faculty of 2015. He is a member of various professional bodies like Computer Society of India and Indian Science Congress Association. His research focuses on Network Databases, Data Mining, Data Compression, Mobile Computing and Real Time Systems, Network Security, Bio-Informatics and Distributed Computing.