An Ontology Based Approach for Exploring Knowledge in Networking Domain.

Zameer Gulzar[#1],
[#1]Department of Computer Applications,
B.S.Abdur Rahman University.
Tamil Nadu-Chennai, India.
zamir045@gmail.com,

Dr. A. Anny Leema[#2]
[#2]Department of Computer Applications,
B.S. Abdur Rahman University.
Tamil Nadu-Chennai, India.
annyleema@gmail.com

Abstract: **Ontologies were applied to impart knowledge in different fields and in this regard many Ontologies were built on domains like medicine Mathematics, physics etc. The Ontologies in the domain of computer Science & Engineering is very limited. The Ontologies related to a domain provide shared and common understanding and include mainly concepts in domain and relationship among the concepts. In this paper, we have proposed an Ontology-based approach for networking domain related courses on different perspectives like Security, Performance, and communication. The knowledge in the field of Networking is huge and dispersed which makes it difficult for humans to expertise it. The Ontologies were developed using Protégé tool in OWL format that can be easily integrated with any other Ontology in Computer science & Engineering. This networking Ontology can be employed in recommender systems to help users to recommend Courses related to networking domain. Identifying the learner's needs and area of interest and then suggesting the courses can make it possible to suggest an appropriate course to a learner. Finally, a framework, which will use this ontology as knowledge base has been proposed.**

Keywords— Ontology, Recommender system, Networking.

I. INTRODUCTION

A large amount of explicit knowledge is scattered around in various computer science domains and the possibility of accessing and reusing such knowledge is very limited. As a result of it, most of the Domain Knowledge is not sufficiently exploited by learners. Therefore, it's vital to make the best use of knowledge and information gathered from various domains and Ontology representation of such domain knowledge will fit best in such condition.

Ontology is an explicit formal description of a shared conceptualization in a domain of discourse also called as concepts. The Classes are the center attention of almost all Ontologies since Classes describe concepts in the domain and Ontologies along with a set of individual Classes constitutes a knowledge base. The Ontology has been regarded as an efficient method for knowledge modeling and its aim is developing knowledge representation of a Specific domain that can be shared and reused late **[1].** Classes being the main components of Ontologies represent a unique concept of a domain, Objects of those classes represents Some specific Items and values for each item feature belonging to that class, and the properties of objects present some binary relationships between two or more classes like "is-a" relationship shows that some class "X" is a subclass of class "Z" **[2]**

Ontologies can be represented as OWL, RDFS, SHOE, XOL DAML+ OIL, but W3C recommended the Web Ontology Language (OWL) definition on the web rather than other different formats mentioned above. The " is a " Relationship is a default relationship created in OWL between the classes which means SubclassOf tag in Web Ontology Language like "X" is a SubclassOf "Y". The key advantage of Ontology is that once developed it can be reused and integrated into other applications, allows to share more data, and provide semantic information **[3].** Ontologies are better than taxonomy as they can be used for inferring new relationships and are not limited to a single domain. They include concept definitions that are understandable by machines and allow the better analysis of information by the system. There are various Classification of Networking Sub-domains but there is no particular conformity on their proper nature and structure.

Therefore, the main objective of this paper is to use the concept of Ontology for defining a knowledge-based model in networking domain. This model can be used for future integration with other computer science domains, Ontologies and recommendation systems for providing knowledge regarding a particular domain and recommending Course related to Learners area of interest. Here we have developed the Ontology structure for networking domain which consists of Sub-Domains, areas, and more than 50 concepts and different relations which have been built according to the standards, which if integrated can alleviate the complexity for its users.

The Rest of the paper is structured as follows. Section 2 describes Ontology overview and the Methodology is discussed in section 3. In section 4 we describe the Network Ontology Development. Implementation phase is discussed in section 5. The conclusions and future research will be discussed in section 6. References of this paper are stated in last section

II. ONTOLOGY OVERVIEW

Initially, The Ontology was proposed for knowledge-based systems to model declarative knowledge by Artificial Intelligence Community and the semantic web development evolution encouraged ontology development because Ontologies represent shared understanding of the domain of interest which enables the system and people to collaborate in a better way. Domain Ontologies containing domain-related concepts and relationships in a structured and machine-interpretable format are used to annotate domain resources. Ontologies are typically Content theories because their main contribution is to identify particular classes of objects and the relationship that exist in some domain. They provide potential terms for describing our knowledge about the domain.

Ontology classification on the basis subject conceptualization and is distinguished as Application Ontologies, domain-task Ontologies, domain Ontologies, and task Ontologies. **Domain Ontologies** are reusable within a particular domain E.g. Sports, Medical, Tourism, History etc the key feature of these Ontologies are that they are independent of any Particular task or application and they provide a vocabulary for concepts and represent knowledge within a specific domain. .

Task Ontologies explain terminology relevant to a general task or activity E.g. Selling and Buying and are Independent of a domain. **Domain-Task** Ontologies are not reusable across domains and correspond to the vocabulary for a task within a specific domain. **Application Ontologies** describe vocabulary relevant to a particular application i.e. they are application-dependent and can expand their domain and task Ontologies, with much more relevancy to a specific application or problem [4]. In our study, we are employing Domain Ontology for Courses present in a particular domain.

There are four basic reasons to develop the Ontology according to Noy et al [5] 1) Making explicit domain assumptions 2) To analyze and Share domain knowledge among software agents or people. 3) Enabling reuse of domain knowledge. 4) To separate operational knowledge from the domain knowledge .Ontology represents knowledge of a particular domain as a graph model which can be used by machines and developers to share information related to the domain.

The chore of Building Ontologies is to put the concepts in some hierarchical manner along with the concept relations and their properties. The basic components of ontology given in figure 1 as per their contents are heavy weight and light weight Ontologies See [6]. The Most popular definition for Ontology was proposed by Gruber who defined Ontology as "An explicit Formal specifications of the concepts in the domain and relations among them" [7] which can be depicted as in Fig. 1-2. The Concepts represents the classes, various features, and attributes of the concepts are described by properties and the Instance represents the element of a particular class or concept. An Ontology together with a set of instances of classes constitutes a knowledge base.

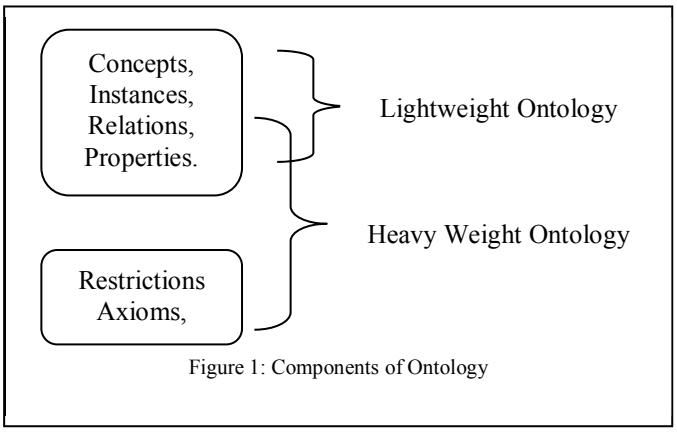

Figure 1: Components of Ontology

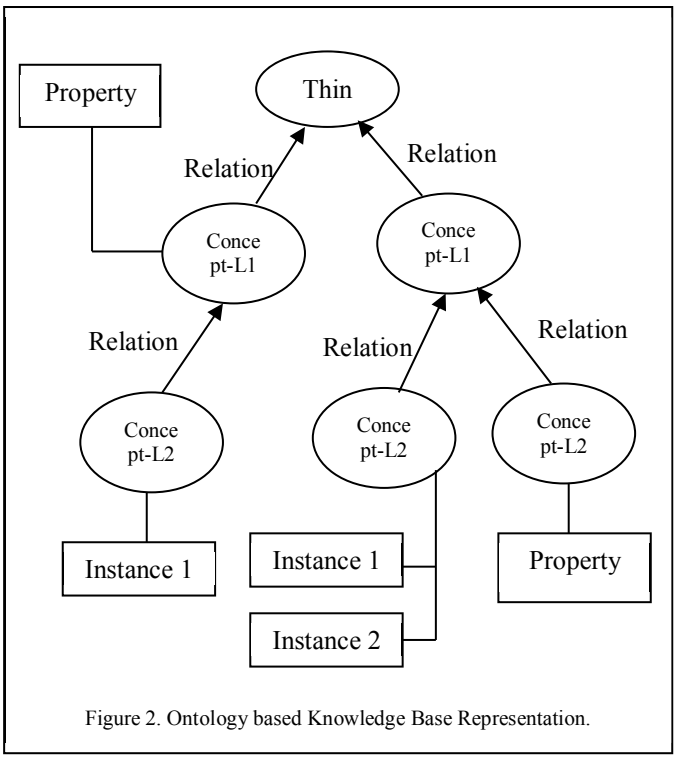

Figure 2. Ontology based Knowledge Base Representation.

III. METHODOLOGY

The aim of this study is to match semantically the course contents, objectives, and the learning outcomes of Networking Domain of educational institutions. To achieve this goal the steps to be taken are as Follows:

Step 1. Collect curriculum data related with the domain of IT, CS, CE, CA, from the educational institution. E.g. Here we have taken data from BSA University M.Tech Curriculum.

Step 2. Parse the data collected during step 1 and transfer it to a database.

Step 3. Collected course information and group courses into Domains and Programs.

Step 4. Analyse data to make explicit classes, relations and Properties.

Step 5. Develop the courses ontology using an ontology editor like Protégé.

Step 6. Implement an inferencing tool to make inferences over the ontology.

Step 7. Designing and developing the user interface.

The Seven Step Methodology in Table 1is used to Structure the Ontology development process proposed by [5]. We developed the Ontology for networking domain using Protégé Tool. In Fig 3. A screen shot shows that Ontology related to Courses in Network Security domain, programs and the courses related to those programs. In the popup box Learning outcomes, credits, Objectives, Department will be listed.

TABLE 1. Ontology Development Methodology.

Stages	Explanation	Relevant to "Computer Science Courses Ontology"
1. Determine scope	The domain, aim, purpose, audience, maintenance	Domain: curricula in CS, CE, IT, CA. Purpose: course prescription Audience: Research Scholars
2. Consider reuse	Search if ontology in the same domain is developed before.	Ontology of Similar Kind Not Found
3. Enumerate terms	Highlight important terms in the ontology	Title, Course code, content, learning Outcomes, purpose.
4. Define classes	Determining the hierarchy of the classes	1. Curriculum Program 2.Subject 3.Courses (Biometric Security, MANET)
5. Define properties	Describe attributes of instances of the class	Each course will have code, Department, content, Credits, Has Courses etc.
6. Define constraints	Constraints are placed on the type of data that are allowed	Title of a course is a String, Credits is numeric Each course has one code, have multiple Departments
7. Create Instances	Create instances of the classes	Eample: Digital Forensics

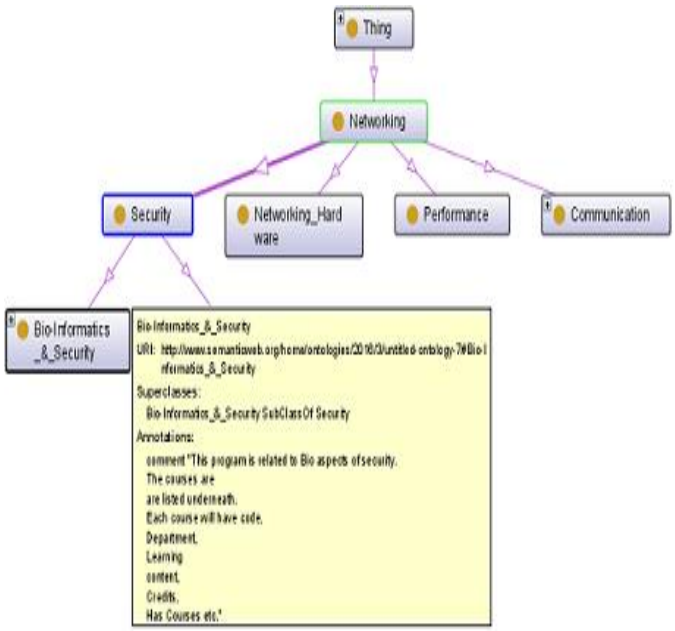

Figure 3. Protégé Snapshot of Course Ontology Graph

.IV. NETWORKING ONTOLOGY DEVELOPMENT

The development process for Ontology starts with identification of the basic and key concepts, their relation and the properties. Different Ontology related to sub-area of Networking was proposed earlier. Oltramari et-al, [8-9], Proposes situation awareness Ontology for Cyber security, since it is the combination of both Machine and human elements and it presents challenge in present situations awareness of users and analytics. Leo Obrsta [10] designed and developed cyber security domain ontology from an initial malware ontology. The main focus was on malware and some of the preliminary aspects, which includes Infrastructure, Actor, Victim and the capabilities. Hui Xu & Debao Xiao [11] Use Otology to configure IP based network than that of normal SNMP and for that purpose they have developed Ontology on Information Specification to manage Computer Network based on Formal Concept Analysis. Ling [12] developed an ontology related to educational domain on computer networks by exploring concepts, communication, applications, standards and network security aiming to be used in education as a teaching aid. Chung and Kim [9], classifies research applying ontology. Technology to education as 1) syllabus or curriculum ontology creation 2) ontology-based learning contents retrieval and 3) ontology-based learning object organization. The weakness of all these Ontologies is that Relationship between concepts has not been properly analyzed. They have Used default relation "is- a" Common for all concepts that makes it weak Ontology. The main drawback of all this existing system is that they have

TABL E 2. Triplet of a Domain

Class	Instances	Properties
Domain	Bio-Informatics & Security	Has-Programs
Programme	1. Biometric Security 2. Computer Forensics	Has-Course Needs Credits
Course	1. Image Processing 2. Stenography & Cryptanalysis. 3. Hacking Tech. & Digital Forensics 4. Fundamentals of Digital Forensics 5. Digital Forensics & Investigation. 6. Digital Cyber Crime.	Credits Department Synset Course Code

Focused on a specialized area of the networks targeted for a limited number of users mostly organizations. The concepts are not explored in terms of student related scenario rather organizational point of view is targeted which limits its reach to put light on whole networking domain and its use will restricted in educational organizations .The relation between the concepts is also not analyzed to its full potential, which results in an open world semantics.

In our defined Ontology we analyzed the different areas of Networking, and created different sub-domains, Programs and the courses. The Concepts best suited to those programs, were created, their Instances and some of the properties which are present in Table 2. One of the Network security related program is given in figure 4. First a suitable domain was suggested "Bio-Informatics & Security" and then the associated concepts in the form programs were framed "Bio-Metric Security", "Computer Forensics". The courses related to these two programs were analysed and linked accordingly based on the learning content in these course. The Interrelations, which are quite visible in the figure were also analysed and drawn carefully. The relations used were Part-of, Related-to, Sub-domain-of, subclass-of etc.

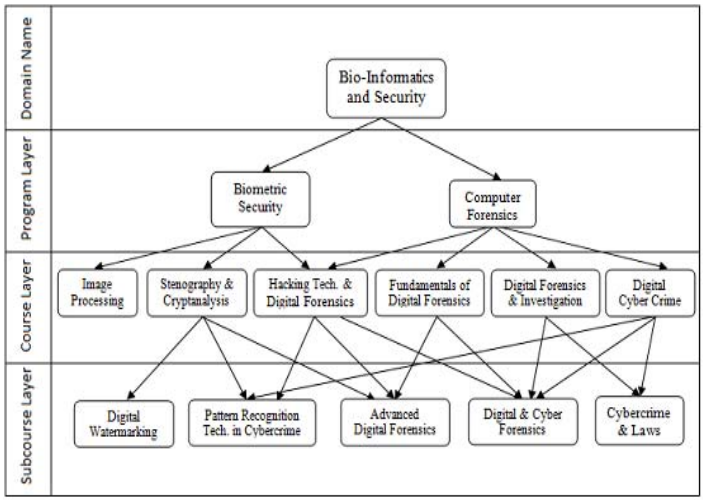

Figure 4. A Curriculum Program Ontology

We found key concepts in terms of domain, programs, course layer1 and Course layer2 in the domain of computer networks and try to analyse all the corresponding concepts to find a relation between two classes or concepts. Also we study the some of the properties of those concepts under one main concept like program. The proposed Ontology makes user to get more detailed knowledge about the domain and the concepts in it. A user can easily choose the courses related to his area of interest as our proposed Ontology will be later tested for recommendation system. The system will also help to achieve Personalization and tailor the learning and technical needs of learners such that it suits their area of

Interest, and helps them in improving their performance and also increase the quality of learning as well. This study allows students to understand the courses related to their field of study and what kind of curriculum program they are similar to. The system also can suggest adaptive learning based on the students' individual differences.

V. IMPLEMENTATION

There are many tools like SHOE, JENA, PROTEGE, KAON and OilEd which are used in Ontology Development. We Prefer Protégé user interface in the development of our Network related Ontology. Before categorization the Concepts in Networking a thorough was conducted and some sub-domains, programs, course layers were framed whose complex relation can be retrieved easily using the Ontology developed for this purpose. We have used Ontology as a tool in our study for abstracting the courses based on the content as the relevancy with the programs, learning Objectives of a course, their respective codes, credits and a tool for searching the learner's needs according to their area of interest or a program. The output is the program and the courses that will best suit learner and also enable the acquisition of the required compentencies. Figure 6 shows the different concepts explored with Networking Security in Protégé tool. 'Thing' is the default system class of the Protégé tool under which all other user defined classes can be created. Figure 5-7 shows the Visualization of classes and subclasses of the developed Ontology. OWLViz Tab Option is used to show the visualization of the class selected in the Class tab hierarchy and creates a default 'is-a' relationship between the concepts related by SubClassOf tag.

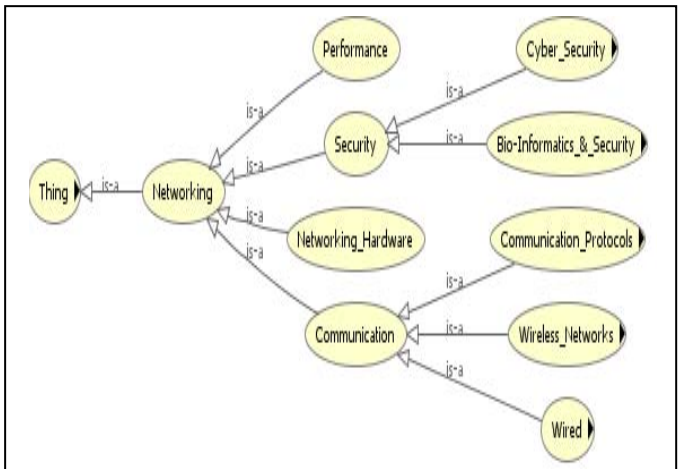

Figure 5 Assorted Model for Networking Domain

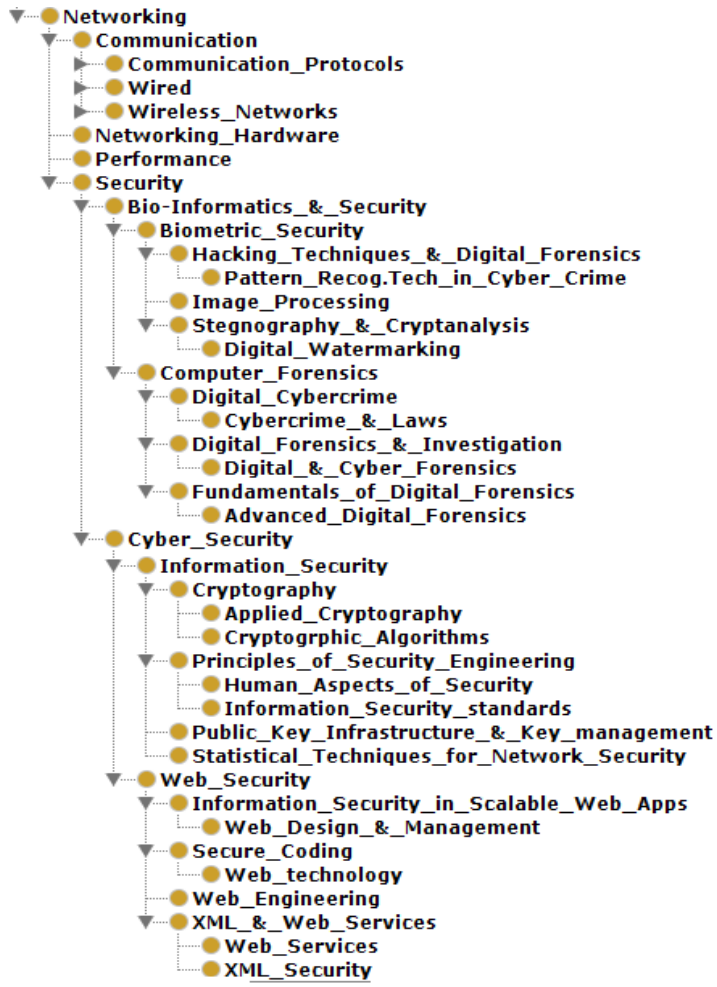

Figure 6. Protégé Snapshot of Networking Domain Ontology

VI. CONCLUSION

The Ontologies are being seen as a way-out to overcome the Semantic heterogeneity and to bring some common understanding. The development of Ontology in various domains has proved its efficiency in various ways. Although little effort has been made to develop Ontologies in domain of Information Systems as compared to other domains. The Ontology we have developed will serve as a domain Knowledge representation model for modern educational systems. This paper focus on the development Ontology for networking domain, which is more suitable and favorable to run recommendation systems and semantic applications as well. In future we are planned to add more domains from computer science and use this Ontology for our recommender system to provide personalization for research scholars in any Information system and also we will expand our system to other domains in our Institution including Mathematics, EEE, ECE, LS etc. as the Methodology given in this paper can be applied to any domain.

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Figure 7. Developed Network Ontology Using Protege