AN ONTOLOGY FOR EXPLORING KNOWLEDGE IN COMPUTER NETWORKS

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ABSTRACT
Ontology is applied to impart knowledge in various fields of Information Technology made it more intelligent in the past few decades. Many Ontologies was built on various domains like biology, medicine, physics, chemistry, and mathematics. The Ontology in computer science domain are limited and even the Ontology is not explored in detail. The knowledge in the field of computer networks is very large, which makes it more difficult for a human to expertise in. This paper proposes the Ontology in computer network domain on various perspectives like scope, scale, topology, communication media, OSI model, TCP/IP model, protocol, security, network operating system, network hardware and performance. The Ontology is developed in OWL format, which can be easily integrated with any other semantic based applications. The network Ontology can be employed in Semantic Web applications to help the users to search for concepts computer networks domain.

KEYWORDS
Computer Networks, Ontology, OWL, Semantic Web

1. INTRODUCTION
The Semantic Web is an extension of the current web in which information provides well-defined meaning that enables system and people for better understanding and can enable to work effectively [1]. The abundance knowledge available in web is made organized with the help of semantic web. Ontology is called as the core of Semantic Web since it is needed to develop semantic web applications.

Ontology is a, "formal and explicit specification of a shared conceptualization" [2]. These Ontologies can be represented as Web Ontology Language (OWL) [15], RDFS, DAML+OIL [24]. W3C [16] recommends OWL definition of Ontology on web than other available like OIL [14], SHOE [25] and XOL [26]. The main advantage of Ontology is once developed it can be integrated and reused in all the applications, it allows to share more data, uses simple tags to provide semantic information.

The development of Ontology in various domains has proved its efficiency in various ways. Though Ontology is the transformation of philosophy to Information Systems, little effort has been made to develop in domain of Information Systems compared to other growing research domains. The way computer communicates having evolved in the past few decades. This evolution leads to the introduction of new concepts and technologies being introduced frequently to improve the speed, efficiency, security and various aspects in domain of computer networks.
This introduction of large concepts makes it hard to expertise in its entire sub domain. We have
developed the Ontology for computer networks, which consists of 500+ concepts. These concepts
are built with W3C standard whereby integrating these Ontologies can alleviate the difficulty of
user. This paper is organized as follows: Section 2 describes the related work being carried out in
various domain Ontology. Section 3 explores the various concepts, relations and properties of
computer networks domain. Section 4 describes the implementation of Ontology and finally
Section 5 concludes the paper.

2. RELATED WORK

Many well published Ontology are publicly available like Gene Ontology (GO) [18] which
consists of gene and gene products of various species, Plant Ontology (PO) [19] which consists of
concepts about anatomy, morphology and stages of plants, Semantic Web for Earth and
Environmental Terminology (SWEET) [20] contains 6000 unique concepts and 200 distinct
Ontology in SWEET 2.2, Foundational Model of Anatomy Ontology (FMA) [21] contains
120000 terms with 75000 distinct concepts with 168 types of relationships.

Various domain Ontologies has been developed like Yip et al. [4] developed Ontology for
healthcare domain. Mei-Ying Jia et al. [5] developed Domain Ontology in Military Intelligence.
Song Jun-Feng et al. [6] worked for Network Centric Warfare on Construction and Integration of
Ontology for military domain, situation and military rule. Maojun Huang [7] developed
Geographic Ontology from the viewpoints of Philosophy Ontology, Information Ontology and
Fragiskos et al. [9] created Ontology for biosensor domain to support R&D in the science-based
sector.

Ontology developed to support reasoning for a model is more common in case of Computer
Network than those developed to provide domain knowledge. Hui Xu and Debao Xiao [10][11]
developed Information Specification Ontology to manage Computer Network based on Formal
Concept Analysis and configure IP based network based on Ontology than that of normal SNMP.
A.K.Y. Wong et al. [12] have developed Ontology to map the protocols of different networking
device providers. M.J. Taylor et al. [13] have developed knowledge for network support based on
case studies of organizational approach to troubleshoot network problems.

Ontology developed to provide domain knowledge in a broader domain like computer networks is
very limited. Ling et al. [3] developed an educational Ontology for computer networks, which
explores concepts, communication sub network, application sub network, standards and network
security with the main purpose to be used as a teaching aid. The major drawback of the existing
system is the relations between the concepts have not been analyzed properly. In general "is-a"
and "part-of" is used in common for all the relations, which makes the Ontology weak.

3. COMPUTER NETWORKS ONTOLOGY

3.1. Classification of Computer Networks

The domain of computer networks can be categorized based on scope, scale, topology,
communication media, OSI model, TCP/ IP model, protocol, security, network operating system,
network hardware and performance. The main concepts explored under scope are Intranet,
Extranet and Internet in terms of services provided and technology used. Scale is classified as
LAN, MAN and WAN and how it could be achieved. Topology is ranked out based on its types
and standards. Communication media are
analyzed based on its types of variant, the way it operates and standards. The main concepts make out of OSI and TCP/IP model are its layers and functionalities. Protocol is a vast area explored in terms of Ethernet standards and technologies, Internet Protocol (IP) versions, classes, support to upper layers. Security itself a vast sub domain which is categorized in terms of threats, attacks, encryption techniques, malicious software's and approaches to system security. The network operating system is classified based on its types of operating system used in router, types of server operating system and types of operating system used for peer-to-peer communication. Network hardware concepts are analyzed based on its types and functionalities. The factors to be considered to improve the performance of communication are explored under performance. Figure 1 shows the part of developed Ontology with the relation between them.

The relations are used to complete the meaning of the concepts. For example concepts 'IANA' and 'Internet Protocol' uses the relation 'allocate' which has knowledge 'IANA allocate Internet Protocol', concepts 'Transport Layer' and 'Datagram' uses relation 'transmits' which contains knowledge 'Transport Layer transmits Datagram'.

![Figure 1. Part of Developed Ontology](image-url)
2.2. Ontology Development

The Ontology development process is to first identify the key concepts and then the relation between the concepts and finally classify the concepts based on their properties. The main drawback of the existing system is the concepts not explored in detail, and the relation between the concepts is not analyzed, which provides open world semantics. In our Ontology we analyzed about 550-relationship instance with 33 types of relationship. Semantic annotations are available for most of the concepts, which make the user get to know more details about the concepts.

The key concepts or sub concepts are represented as Classes. We found key concepts in the domain of computer networks and analyzed all the equivalent concepts to find the relation between the concepts. We studied the properties of each concept to categorize all sub concepts under one main concept and we found the total number of concepts grouped under one main concept in Table 1. Table 2 and Table 3 are the sub concepts of Security and Protocol respectively.

Table 1. Explored Concepts in Computer Networks.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Concepts</th>
<th>No. of Sub Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scope</td>
<td>47</td>
</tr>
<tr>
<td>2</td>
<td>Scale</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Topology</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>Communication Media</td>
<td>94</td>
</tr>
<tr>
<td>5</td>
<td>OSI Model</td>
<td>37</td>
</tr>
<tr>
<td>6</td>
<td>TCP/IP Model</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>Protocol</td>
<td>121</td>
</tr>
<tr>
<td>8</td>
<td>Security</td>
<td>125</td>
</tr>
<tr>
<td>9</td>
<td>Network Operating System</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>Network Hardware</td>
<td>48</td>
</tr>
<tr>
<td>11</td>
<td>Performance</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 2. List of Concepts Related to Security.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Concepts</th>
<th>No. of Sub Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Goals</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Threads</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Attacks</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>Cryptography</td>
<td>23</td>
</tr>
<tr>
<td>5</td>
<td>Intrusion Detection System</td>
<td>18</td>
</tr>
<tr>
<td>6</td>
<td>Virtual Private Network</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>Firewall</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>Malicious Software</td>
<td>26</td>
</tr>
</tbody>
</table>
Table 3. Protocol Related Concepts.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Concepts</th>
<th>No. of Sub Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ethernet</td>
<td>19</td>
</tr>
<tr>
<td>2</td>
<td>Internet Protocol</td>
<td>68</td>
</tr>
<tr>
<td>3</td>
<td>SONET/ SDH</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>ATM</td>
<td>22</td>
</tr>
</tbody>
</table>

4. IMPLEMENTATION

There are many tools like Protégé [17], OilEd [22] and KAON [23], which are used to develop Ontology. We used Protégé user interface in developing the Ontology for Computer Networks. Through study about the concepts are made before categorizing it. There are some sub concepts, which are to be categorized under different main concepts whose complex relations can be easily retrieved through the developed Ontology.

The part of code of developed Ontology is given in Figure 2. This code is in XML format where "www.w3.org/2002/07/owl#" has the schema definition for Ontology development. The concepts 'Internet' and 'World Wide Web' are declared as classes in the Ontology, and the relation between them is 'uses' which is declared as object property. The actual knowledge stored in the code is 'Internet uses World Wide Web'.

```xml
<?xml version="1.0"?>
<Ontology xmlns="http://www.w3.org/2002/07/owl#"
  xml:base="http://www.semanticweb.org/ontologies/CN"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema#
  xmlns:owl="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:xml="http://www.w3.org/XML/1988/namespace"
  OntologyIRI="http://www.semanticweb.org/ontologies/CN">
  <Prefix name="owl" IRI="http://www.w3.org/2002/07/owl#"/>
  <Declaration>
    <Class IRI="#Internet"/>
  </Declaration>
  <Declaration>
    <Class IRI="#World_Wide/Web"/>
  </Declaration>
  <Declaration>
    <ObjectProperty IRI="#uses"/>
  </Declaration>
  <SubClassOf>
    <Class IRI="#World_Wide/Web"/>
    <ObjectSomeValuesFrom>
      <ObjectProperty IRI="#uses"/>
      <Class IRI="#Internet"/>
    </ObjectSomeValuesFrom>
  </SubClassOf>
</Ontology>
```

Figure 2. Screenshot of part of developed Ontology
Figure 3 shows the various concepts explored with Networking Hardware in Protégé tool. The 'Thing' is the system class of the Protégé tool under which the user defined classes are created.

Figure 4 shows the visualization of the developed Ontology. OWLViz plug-in has been used to show the visualization. It identifies the concepts from the classes in the OWL file and creates a default 'is a' relationship between those concepts which are related by the SubClassOf tag.
Figure 4. Visualization of Network Ontology
5. Conclusion

This paper reports the first stage of research which focuses on the development of Ontology for the domain of computer networks with 500+ concepts, 550 relationship instances with 33 types of relationships, which is considered as fuel to run the Semantic applications, so that the user can seek for domain knowledge. The domain of computer networks has evolved and is still growing, so the Ontology we have developed tends to dynamically grow with new invention and advancement in technology over time.

References