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أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

طريقة معتمدة على الانطولوجيا لنمذجة الروابط بين الأبحاث العلمية

An Ontology−Based Approach to Model the Interconnections between Research Artifacts

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Faculty of Information Technology

Information Technology Master Program

An Ontology-Based Approach to Model the Interconnections between Research Artifacts

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الجامعة الإسلامية – غزة
The Islamic University - Gaza

نتيجة الحكم على أطروحة ماجستير

بناءً على موافقة شئون البحث العلمي والدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث/ **تامر عدلي إبراهيم خريس** لنيل درجة الماجستير في كلية *تكنولوجيا المعلومات*/ قسم تكنولوجيا المعلومات وموضوعها:

طريقة معتمدة على الانطولوجيا لنمذجة الروابط بين الأبحاث العلمية

An Ontology-Based Approach to Model the Interconnections Between Research Artifacts

وبعد المناقشـة التي تمت اليـوم الأحـد 02 جمـادى الآخـر 1436 هـ، الموافـق 2015/03/22م السـاعة الواحدة ظهراً، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

د. إيـاد محمـد الأغـا	مشرفاً ورئيساً
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د. ناجي شكري الظاظا	مناقشاً خارجيًا

وبعد المداولـة أوصت اللجنـة بمـنح الباحـث درجـة الماجسـتير في كليـة *تكنولوجيـا المعلومـات*/ قسـم **تكنولوجيا المعلومات.**

واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

والله ولي التوفيق ،،،

مساعد نائب الرئيس للبحث العلمي و للدراسات العليا

أ.د. فؤاد علي العاجز

DEDICATION

TO MY DAD, MOM

BROTHER AND SISTERS,,,

MY FRIENDS AND LOVER,,,

FOR ALL THE LOVE AND SUPPORT,,,

ACKNOWLEDGMENTS

It has been a long and interesting journey getting to this point and I could not have done it without the guidance and support from many people.

First of all, I would like to express my deep gratitude and admiration to my supervisor, Dr. Iyad Al-Agha, for directing this research effort to completion. I could not have done it without your guidance, your insights, your friendship, encouragement, enthusiasm, generous counsel and for convincing me that I could do this. It has been a very rewarding and insightful experience to work with you in completing this project.

Finally, special thanks go out to my family for their patience and for all their love and support. I would also like to express my appreciation and thanks to all my friends who knowingly or unknowingly have assisted and encouraged me throughout my hard work.

<div align="right">

Tamer Khrais

Feb, 2015

</div>

ملخص العربية

إن التقدم التكنولوجي في أساليب البحث العلمي من قصاصة، فمقالة، فمدونة، فكتاب، وانتهاءً بالمؤتمرات العلمية المحكمة، جعل الكثير من الباحثين الجدد في المجالات الحديثة في متاهة كبيرة، فالمكتبات الرقمية على شبكة الإنترنت التي توفر أرشفة لهذه الأبحاث العلمية لا تقدم الدعم للباحث في تحديد كيف؟ ولماذا استدل، أو استعين، أو استخدمت هذه المراجع؟ داخل الورقة البحثية. مما يأرق الباحث للوصول للمعلومة بأقصر الطرق وأقلها جهدًا وزمنًا. لذلك أصبحت الحاجة ملحة للباحثين في المقدرة على الحصول آلية لربط الأفكار العلمية وتوثيقها بتصنيفات مجدية، تساعده على فهم دور كل بحث علمي مستخدم في الورقة العلمية.

ومن هنا أتت رسالتي هذه لتناقش أهمية الاتصال والتواصل في البحث العلمي، والتي ستوفر للباحثين في مجال معين لكي يكونوا قادرين على تحديد المساهمات البحثية من الباحثين السابقين بطريقة سلسة ومرنة، وكيفية وصولهم لما قد توصلوا إليه، لزيادة الانتاجية العلمية بتوفير الوقت والجهد وسرعة اكتشاف مجال البحث بالاعتماد على الانطولوجيا المستخدمة والحصول على نتائج أكثر دقة مما تفتح أفاقًا جديدة لهم، والذي يعتبر الهدف الرئيسي لهذه الرسالة. وتقديم الإضافة التي يسعى إليها الباحثين بواسطة: 1) تصنيف الأوراق البحثية بناء على درجة المطابقة فيما بينها واستدعاء العلاقات بين الأعمال المستقلة بالاعتماد على باستخدام النمذجة الدلالية (الانطولوجيا). 2) ربط الباحثين الذين لديهم نفس الاهتمامات أو المتعلقة بها أو التكميلية لما سبق نشره. 3) تحديد الجهود البحثية الناجحة التي تبنى على بعضها البعض على شكل متسلسلة يستطيع الباحث تتبعها في المجال الذي ينوي أن يخوض به أو يساهم به.

كما تمهد الطريق للدراسات المستقبلية في دعم الأبحاث المشتركة بين الباحثين من شتى البلدان وتبادل الأفكار عن طريق مطابقة وربط الباحثون الذين يشتركون في نفس الاهتمام أو ذات الصلة، الأمر الذي يستطيع أن يوسع مجتمع البحث العلمي.

Abstract

A huge amount of research artifacts (e.g. papers, journals) is published on the web, and there is an emerging need to link these artifacts in a suitable way. While this scholarly record represents a great source of knowledge, new researchers are struggling to explore these artifacts, find out the relations between them and determine how they build on each other. Without doing so, new researchers will not be able to identify research contributions. Existing digital libraries that archive research papers may provide access to references or related papers without identifying how and why these references are cited and used.

While few existing works have addressed the issue of modeling research arguments (e.g. how researchers interlinked existing research efforts), few research efforts have discussed how the semantic modeling can be employed in practice to enhance the research process in practice. The approach of this study builds using an Ontology model that is main target to offer a practical evidence of the potential of modeling research arguments for researchers. Example of the solutions we aim to support by utilizing the model of research argument include: 1) classify research papers based on the degree of matching in-between them. 2) Match researchers with similar/related/complementary interests according to the research arguments they give. 3) Identify the successive research efforts that build on each other and lean to a particular research contribution.

The approach of this study offers several benefits for researchers: First, it will enable researchers to quickly explore the research domain and recall the relationships between independent works rapidly. Second, it support collaborative research and brainstorming by matching and linking researchers who share the same or related interests, a thing that can be powerful to the research community.

Keywords: Ontology, Research Papers, OWL, Semantic Web.

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LIST OF ABBREVIATIONS

ACM	Association for Computing Machinery
API	Application Program Interface
DTD	Document Type Definition
GUI	Graphical User Interface
HeTMe	Hit Me (name of the project)
IEEE	Institute of Electrical and Electronics Engineers
JSP	Java Server Pages
MYSQL	My Structural Query Language
OWL	Web Ontology Language
RDF	Resource Description Framework
RDFS	Resource Description Framework Schema
SDK	Software Development Kit
SPARQL	SPARQL Protocol and RDF Query Language
XML	eXtensible Markup Language
URI	Uniform Resource Identifiers
URL	Uniform Resource Locater

LIST OF APPENDICES

Appendix A: Artifact Ontology

Appendix B: Sample of Core Code

Chapter 1.

INTRODUCTION

The Semantic Web definition [1] is an interdisciplinary research field which aims at augmenting the existing World Wide Web (WWW) with machine-readable and understandable metadata such that information on the Web becomes available for processing in intelligent systems. In particular, it shall establish solutions for seamless information creation, retrieval, reuse, and integration on the Web. The key underlying technology is the use of so-called ontology languages for representing metadata information. There exist several such languages endorsed by the WWW Consortium [2]. They support formal semantics which enables automated reasoning using deductive logical methods. Semantic Web is recently seeing a lot of adoption by the industry, and this also includes adoption for purposes other than for information on the WWW. One of the driving recent developments is the publishing of significant amounts of data in ontology language formats on the WWW —this information is referred to as Linked Data. Despite its success, many core issues still require further in-depth, and partially foundational, research, such as the systematic use of deep semantics on the Web by means of automated reasoning techniques.

The web, much like our global environment, is in a state of flux. Meanwhile the growth of the scholarly record is impressive, the extent of its use is even more staggering. By the scholarly record means the research artifacts (e.g. articles, journals, conference proceedings, etc.) published by scholars and researchers from all over the globe. While this scholarly record represents a great source of knowledge, new researchers are struggling to explore these artifacts, find out the relations between them and determine how they build on each other [3], [4], [5], [6]. Without doing so, new researchers are not be able to identify research contributions.

Another important term that needs to be definable during this study is the newest researcher, sometimes called novice researcher, is the person who had knowledge and

expertise at the research field but is newest to the domain field of searching and need to be up-to-date without wasting a lot of time on researching.

Recently, a huge scale of information is published on the web, and there is an emerging need to connect this information in a suitable way. Existing digital libraries that archive research papers may provide access to references or related papers without identifying how and why these references are cited and used [7]. What the approach looks for a solution that can identify the semantic associations between each research paper and the references it uses in order to determine how different efforts are related from the research perspective. If the scholarly artifacts are associated with semantic markup that identifies how research efforts complement, oppose, extend or build up on each other, researchers are able to quickly grasp existing research and determine gaps without making extensive effort.

In order to clarify the motivation for this study, imagine the scenario of a researcher who is trying to explore a particular research topic. He refers to many research papers to study the state of the art and explore related efforts from existing literature. While reading, the researcher needs to determine how the various research works relate to each other, for example, some research efforts may build upon or extend existing ones, while other efforts may present alternative or contradictory views. It is essential for any researcher to perceive the relationships that exist between the various research artifacts in order to identify the research problem and formulate the research questions. However, this process needs an extensive effort to be done as the researcher needs not only to read the majority of research papers in the research area, but also to recall and analyze the different relationships between all these artifacts.

In this work, the researcher intend to use semantic publishing to add more intelligence to research libraries and, hence, help researchers perceive the associations between research artifacts in depth and with minimal effort. Semantic publishing is the enhancement of scholarly publications by the use of modern web standards to improve interactivity, openness and usability, including the use of ontologies to encode rich semantics in the form of machine-readable RDF (Resource Description Framework) metadata.

The study gives an ontology-based approach to annotate the references given in any research artifact and model the research argument. The research argument is the map of relations which the researcher builds between research artifacts from the literature. Research arguments are likely to be different from a researcher to another because people process information in different ways. The annotation of research artifacts is done using an ontology that the researcher build to classify the relationships that exist between these research artifacts and its references. Consequently, software agents present infer new facts, obtain a better understanding about the researcher's point of view and track the source of the concept in any domain.

This approach offers several benefits for researchers: First, it enables researchers to quickly explore the research domain and recall the relationships between independent works rapidly. Second, by annotating and linking research artifacts, The approach provide a potential result to match and link researchers who share the same interests, a thing that can be powerful to the research community.

1.1 PROBLEM STATEMENT

Yet, developing tools for assessing scholarly communication artifacts and researchers on the basis of scholarly usage is considered as a tremendous challenge. New researchers in any domain spend a considerable time to gather these opinions and their reasoning for it.

While few existing works have addressed the issue of modeling research arguments, as discussed in the related work section, few research discussed how the semantic modeling can be employed in practice to enhance the research process in practice. The study approach builds on previous research and aims to offer a practical evidence of the potential of modeling research interconnections for researchers.

This study seeks to find suitable interconnections between research artifacts to serve novice researchers to get deeply through any new research field by given intelligence results that reduce time for mining and getting a magnificient accaracy. This is done by diviging the problem statement into three parts as shown in Figure 1-1, towards getting to the HeTMe System:

- Developing tools for assessing scholarly communication artifacts and researchers is a tremendous challenge.
- New researchers in any domain waste a lot of time to gather these opinions and their reasoning for it.
- Little research discussed how the semantic modeling can be employed in practice to enhance the research process in practice.
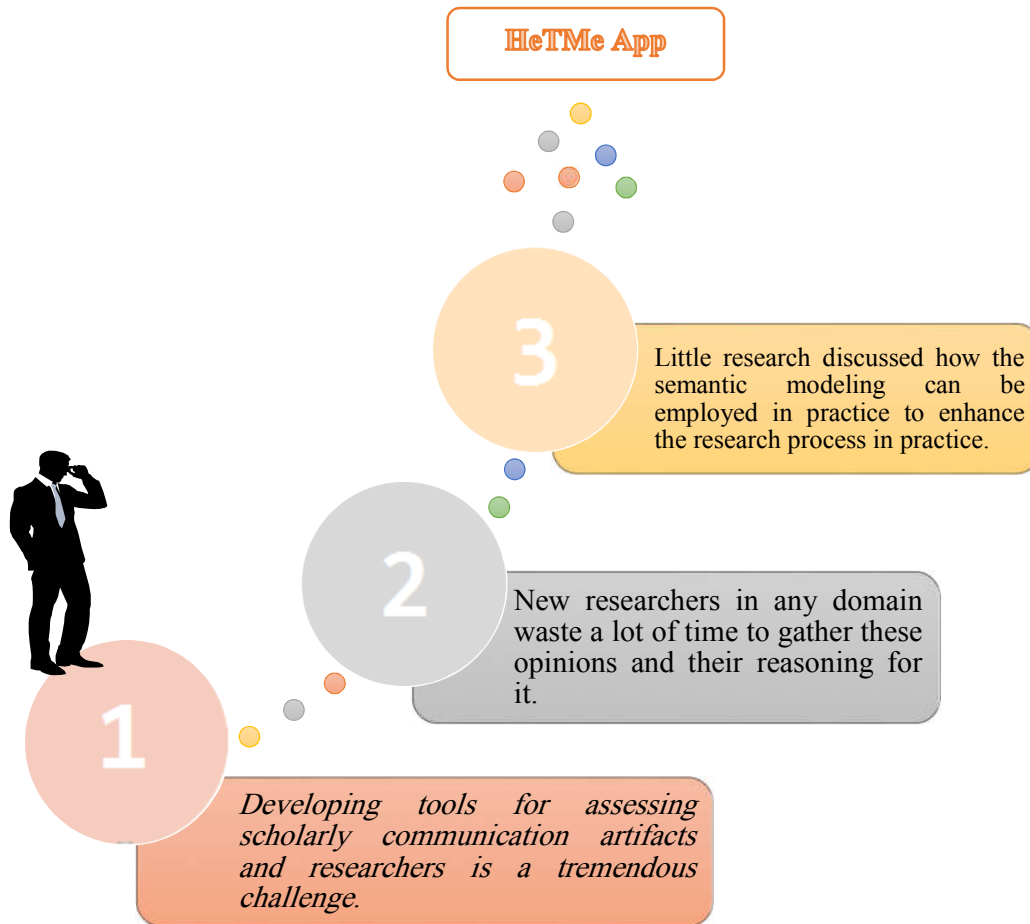
Figure 1-1 Problem Statement

1.2   RESEARCH QUESTION

How to facilitate the interconnection between research artifacts using ontology to discriminate the importance of each reference for novice researcher?

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1.3 OBJECTIVES

1.3.1 MAIN OBJECTIVE

The main objective of the research is building an ontology based system that can model the interconnections between research artifacts, based on the perspective of the researcher, by using semantic annotation. Subsequently, solutions are proposed to process the newly-attached annotation to offer intelligent results for new researchers. Anticipation the above results produce potential to facilitate the overall research process by offering the appropriate guidance for new researchers instead of wasting a lot of time.

1.3.2 SPECIFIC OBJECTIVES

The specific objectives of this research are:

- ☒ Identify the various relations that can exist between research artifacts and that can precisely model the conceptual thinking of the researcher.
- ☒ Anticipate the actual references that the researchers depend on in writing the artifact.
- ☒ Classify the research artifact to be identifying the matching, complementarity or disagreement.
- ☒ Examples of intelligent results include:
  - Classify papers based on the degree of matching in-between them.
  - Match researchers with similar/related/complementary interests according the research arguments they give.
  - Identify the successive research efforts that build on each other and lean to a particular research contribution.
- ☒ The thesis approach also opens the door for further extensions that the study approach aims to explore in the future work. These extensions include but are not limited to:
  - Possibility for citation-analysis systems to verify the provenance and trust of citation data, both in the short and long term.

- Integrate the proposed semantic annotation with professional research indexing libraries such as DBLP, LinkedIn, GoogleScholar to offer more intelligent searching and indexing services.

1.4 SIGNIFICANCE OF THE RESEARCH

The study approach is to model research arguments and relationships between research artifacts to present several benefits for research community such as:

1. Enabling more effective dissemination, debate, and analysis of ideas.
2. Improving collaboration and increasing the quantity of ideas by connecting researchers who have the similar/related/opposing or complementary interests.
3. Saving a considerable time and efforts by enabling new researcher to explore the research scope and literature in detail rapidly and effectively.
4. Offering a practical evidence of the potential of semantic web technologies to enhance the research process.

1.5 SCOPE AND LIMITATIONS

1. The process of annotating research artifacts is out of the scope of this work. While the study focus on how the annotation utilize and process in an intelligent manner, the annotation process was not be considered: this means that the study was not implement a dedicated tool for researcher to annotate research papers. Instead of that the approach used existing annotation tools to accomplish this process.
2. Prototype solutions was designed. This means that the study examined the proposed solutions using a limited number of research artifacts.
3. Finally, the study approach judging provided by asking two expert researchers to assess the usefulness and feasibility of the proposed solutions then comparing the given model with other models. Although it will more efficient to judge the approach using a long-term study and a large number of researchers, that wasn't adopted due to the limited time and resources and considered to be future work.

1.6 THESIS STRUCTURE

This thesis is organized as follows. Chapter two discuss the history of the web and the benefits of using semantic web technologies with the benefit of using ontology to

conduct the inferential results based upon the linkage between resources. Literature review of related works of existing meta-analyses of research artifact presented in chapter three. Design and methodology of the model followed by implementation of the model with a suitable example and the limitations of the study presented on chapter four and five respectively. Finally, discussion the implementation and presenting the thesis results and future work in chapter six.

Chapter 2.
STATE OF ART AND RELATED WORKS

2.1 ERA OF THE WEB

The revolution of Web development functionalities and technologies has empowered nearly all aspects of daily life, and changed the way people and organizations communicate and interact. The main essential factor of the revolution of the web is to transmit the web from web of things to web of thoughts [8], as shown in Figure 2-1 below, two essential factors that affected the development year by year: First, the huge amount of data that is found on the internet and entered day by day that's represented by Semantics of Social Connections. Second, achieving the search process to enhance the productivity and throughput of the given result which is represented by Semantics of information Connection.
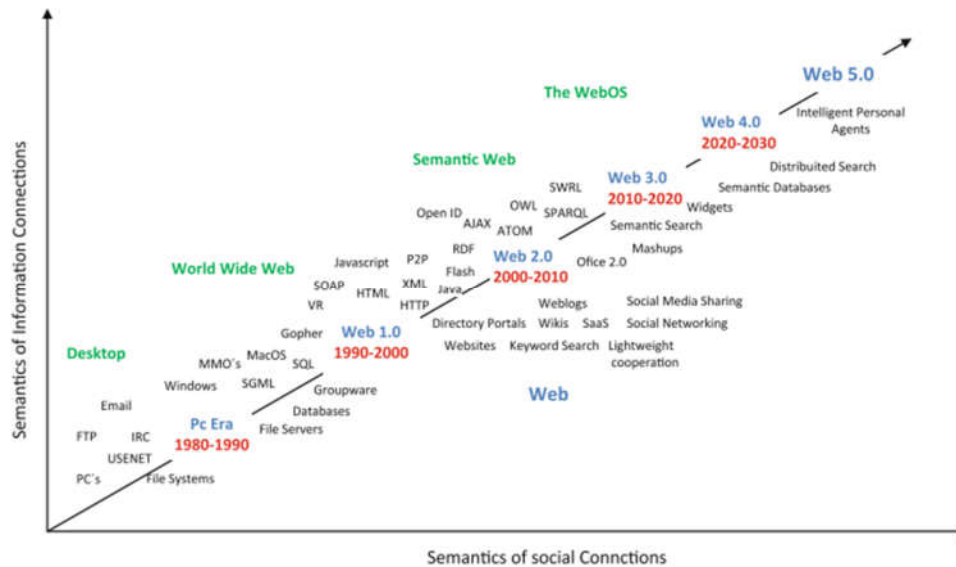
Figure 2-1 Evolution of WWW [1]

Despite the two produced criteria but making business is the essential factor that let companies to transform on each period of evolution of the WWW [9]. Therefore, the WEB technology had been updated to handle this issue and solve the lack of support. Here is a brief description about each version of the web technologies:

- **PC Era**

In the past, which was in 1980-1990, before the establishment of the World Wide Web WWW terminology. There was not any spreading of the internet through the world just in military systems with sharing FTP files.

- **Web1.0 (Keyword Search Approach)**

In this era, the average internet user's role was limited only to reading the information presented to him so expert's call it Read-Only era. As there was no communication or information of the consumer to producer. All static websites which mushroomed during the Dot-com bubble is an example of Web1.0. Wikipedia is an example of web 1.0 (as in Figure 2-2) because the site allows the user to only view pages or search information at best, but the user interaction is minimum and the site is basically static.
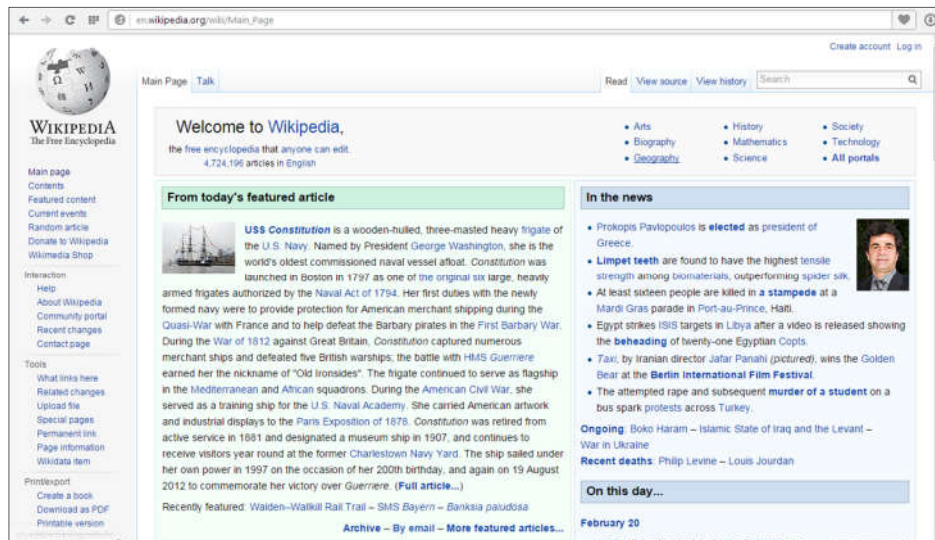
Figure 2-2 Web 1.0 Example

- **Web2.0 the Social Web (Tagging and Natural Language Approach)**

The advent of the Web 2.0 phenomenon, marked the beginning of a Read-Write-Publish era, which was differently from the previous era as its fill the lack of active interaction of common user with the web.

As user could easily do more than read information. Now even a non-technical user can actively interact & contribute to the web using different blog platforms. Web 2.0 facilitate information sharing, interoperability, user-centered design and collaboration in the WWW by any user. Examples of Web 2.0 are Web communities Web services, Web applications, social network services, video hosting services, wikis, blogs, mashups and folksonomies, among others [10].

Therefore, publishing your content is only a few clicks away! Few remarkable developments of Web 2.0 are Twitter, YouTube, eZine Articles, Flickr and Facebook. Facebook (as in Figure 2-3) is a social networking site and it is a prominent example of web 2.0. This site allows user to make friends, write them messages, chat with them, hang out with them, upload and share photos etc. of the available activities.
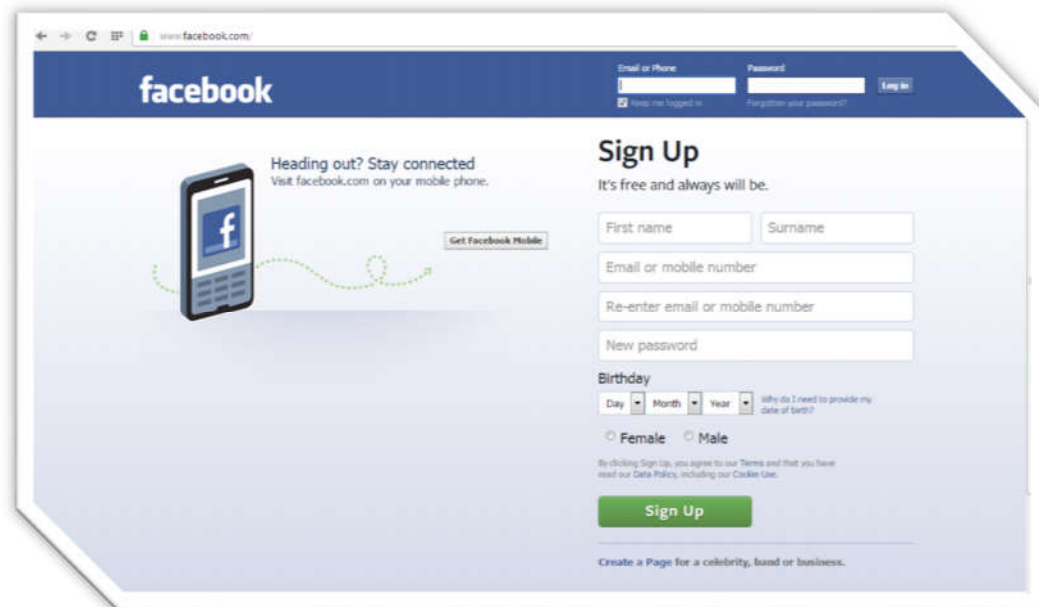
Figure 2-3 Web 2.0 Example

- **Web3.0 (Semantic Search Approach)**

As previously mentioned business are the fuel for evolution so even Web 2.0 was magnificent producible technology but it is way behind when it comes to intelligence. Though Web (as in Figure 2-4) is yet to see something which can be termed as fairly intelligent as we need to enrich the web and merge the efforts to achieve this goal has already began. For example Pictures & Photos are now treated as similar in meaning by using Metadata.
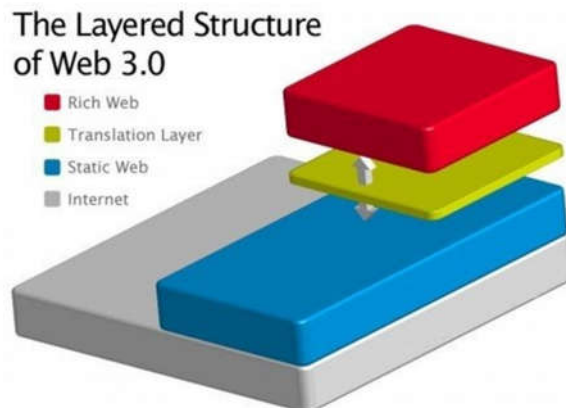
Figure 2-4 The Layered Structure of WEB 3.0

The web is indeed getting intelligent. When you search Google query with An Apple Mobile, Searching will not lead you to Apple website. Why? Cause, first by synonym identification Google will understand that you searching for Apple fruit. Then by context i.e. by the keyword Mobile it will deduce that the user wants information on mobile not fruit. Try out yourself to check how this newly added artificial intelligence works in Google. Also, there are many websites built on Web 3.0 which personalizes your search.

- **Web 4.0 & Web 5.0 (The Intelligent Web)**

It will not stop on this point and will come soon in 2020-2030 to handle the reasoning search approach with an intelligent manner. Therefore, the focus will be more and more to gather new intelligent outputs.

2.1.1 COMPARISONS OF WEB VERSIONS

Understanding the difference between Web 1.0 and Web 2.0 is relatively straight-forward. For now here is a comparison between the three versions of the web as seen in **Error! Reference source not found.** [9]**Error! Reference source not found.**.

Table 2-1 Comparison of Web 1.0, Web 2.0 and Web 3.0

	Web 1.0	**Web 2.0**	**Web 3.0**
Meaning is	Dictated	Socially constructed	Socially constructed & contextually reviewed
Technology is	Confiscated at the classroom door (digital refugees)	Cautiously adopted (digital immigrants)	Everywhere (digital universe)
Teaching	Teacher to student	Teacher to student or student to student	Teacher to student or student to student or student to teacher
Teachers are	Licensed professionals	Licensed professionals	Everybody, Everywhere
Schools located	In a building	In a building or online	Everywhere
Parent view school as	Daycare	Daycare	A place for them to learn , too
Hardware & software in schools	Are purchased at great cost and ignored	Are open source and available at lower cost	Are available at lower cost and are used purposively
Industry views graduates as	Assembly line workers	As ill-prepared Assembly line workers in knowledge economy	Ac co-workers or entrepreneur
Where does the content come from?	An organization displays information for viewers to read	Users upload their own content to pre-existing webpages and interact with one another	Organization pre-existing data to include metadata
How to find information?	Directors	Google keyword search	Databases with metadata
Ex. website of a water conversation club	List of facts about water conversation	Users upload pictures from their own projects, comment on others	Users are able to search projects by year, type, etc

2.2 SEMANTIC WEB

2.2.1 SEMANTIC WEB DEFINATION

Before proceeding it is probably worth pointing out that the use of the term semantics by programming language theorists has been much closer to the tradition of the logicians and the philosophers and less confused than in computational linguistics.

Figure 2-5 W3C SW logo

Semantic Web often means different things to different groups of individuals. Nevertheless, the term "Semantic Web" (Figure 2-5 shows the Semantic Web logo) was originally coined by World Wide Web Consortium (W3C) director Sir Tim Berners-Lee and formally introduced to the world by the May 2001 Scientific American article "The Semantic Web" [1]: "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". It represents a new vision about how the Web should be constructed so that its information can be processed automatically by machines on a large scale [10].

Semantics is related to syntax. In most languages syntax is how you say something, while semantics is the meaning behind what you have said. When substituting one part of the sentence with another word or symbol, the syntax of the sentence changes, while the semantics may remain the same (as shown in Figure 2-6).
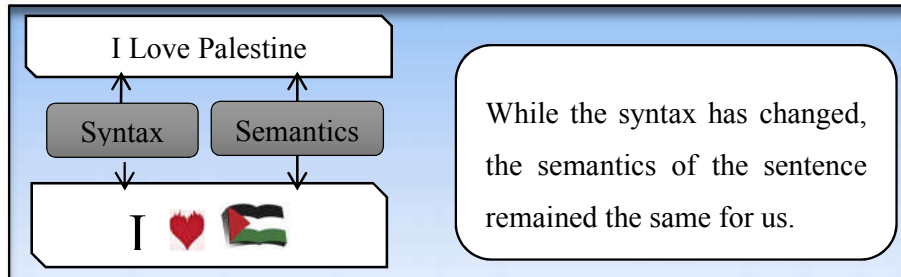
Figure 2-6 What's SEMATICS?

2.2.2 THE SEMANTIC WEB PYRIMAID OF LANGUAGES

Most apps use only a subset of the stack by making a mix of linked data uses a small selection of technologies. The Semantic Web Stack (as shown in Figure 2-6) is an illustration of the hierarchy of languages, where each layer exploits and uses capabilities of the layers below. It shows how technologies that are standardized for Semantic Web are organized to make the Semantic Web possible. It also shows how Semantic Web is an extension (not replacement) of classical hypertext web [11].
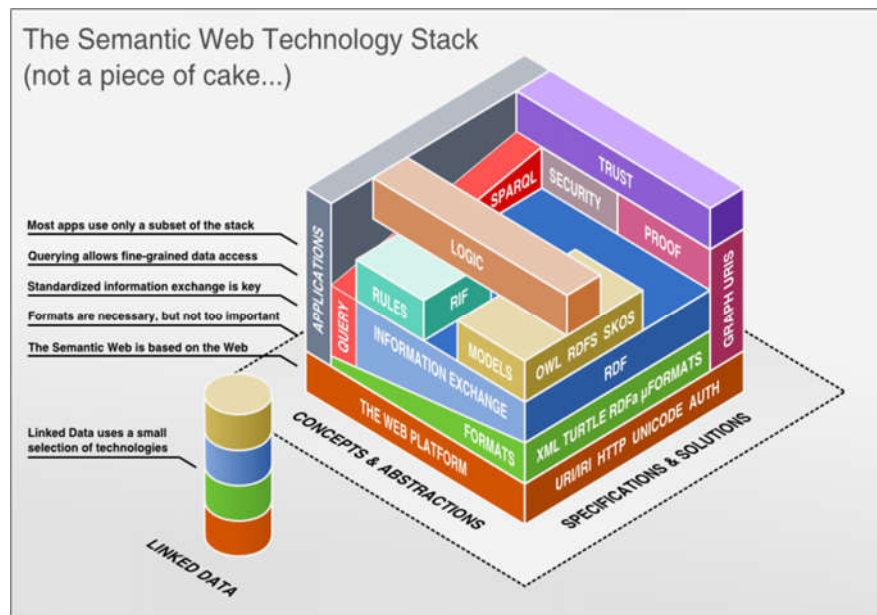
Figure 2-7 The Semantic Web Technology Stack[2]

The Semantic Web movement is comparable to the `knowledge is power' craze that started over 20 years ago. Apart from the existence of links which establish connections between documents, the main valuable, indeed indispensable, kind of tools are search engines. Keyword-based search engines, such as AltaVista, Yahoo and Google, are the main tool for using today's Web. It is clear that the Web would not have been the huge success it was, were it not for search engines.

The Semantic Web is growing up rapidly. Over the last few years technologies and standards to build up the architecture of this next generation of the Web have matured and are being deployed on large scale in many live Web sites. The underlying technology stack of the Semantic Web consists of several standards endorsed by the World Wide Web consortium (W3C) that provide the formal underpinnings of a machine-readable "Web of Data".

Although the standards that make up the Semantic Web architecture have all been established by the W3C, they do not always integrate smoothly, indeed these standards had yet to prove useful in the wild to be applied on real Web data [11]:

- **A Uniform Exchange Syntax - the eXtensible Markup Language (XML):** XML is one of the most widely-used formats for sharing structured information today: between programs, between people, between computers and people, both locally and across networks. It is designed for mark-up in documents of arbitrary structure, as opposed to HTML, which was designed for hypertext documents with fixed structures. A well-formed XML document creates a balanced tree of nested sets of open and close tags, each of which can include several attribute-value pairs [12].
- **A Uniform Data Exchange Format - the Resource Description Framework (RDF):** The jump from XML, which is a mere syntax format, to RDF, which is more declarative in nature, is not trivial, but needs to be addressed by appropriate transformation languages for exchanging information between RDF-based and XML-based applications [13]. However, RDF is equally well suited to representing data. The basic building block in RDF is designed to provide a basic object–attribute–value data model for meta-data triple, commonly written as

A(O,V) as shown in Figure 2-8. That is, an object O has an attribute A with value V:
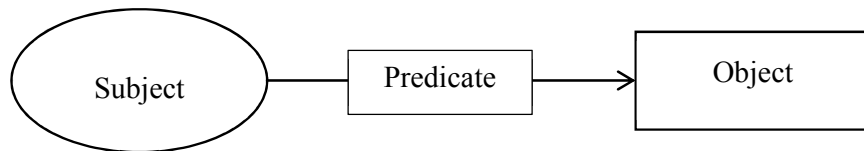
Figure 2-8 The RDF data model

Figure 2-9, for example, expresses the following three relationships in A(O,V) format, followed by Figure 2-10 which show RDF as its XML serialization syntax:

hasName('http://www.w3.org/employee/id1321', 'Jim Lerners')

authorOf('http://www.w3.org/employee/id1321', 'http://www.books.org/ISBN0062515861')

hasPrice('http://www.books.org/ISBN0062515861', "$62").

Figure 2-9 Example relationships in A(O,V)

<rdf:Description rdf:about="http://www.w3.org/employee/id1321">

</rdf:Description>

Figure 2-10 Example RDF's XML serialization

Finally, as shown in Figure 2-11, it is possible to indicate that a given object is of a certain type, such as stating that 'ISBN0012515866' is of the rdf:type book, by creating a type arc referring to the book definition in RDFS (Resource Description Framework Schema):

<rdf:Description rdf:about="http://www.books.org/ISBN0062515861">

  <rdf:type rdf:resource= "http://description.org/schema/book">

</rdf:Description>

Figure 2-11 Example Book definition in RDFS

- **Ontologies - RDF Schema and the Web Ontology Language (OWL):** The clean conceptual model of Description Logics underlying the OWL semantics is not necessarily applicable directly to all RDF data, particularly to messy, potentially inconsistent data as found on the Web [14].

  - RDF Schema – a lightweight ontology language that allows to describe essentially simple class hierarchies, as well as the domains and ranges of properties.

RDF Schema takes a step further into richer representation formalism and introduces basic ontological modeling primitives into the web. With RDFS, we can talk about classes, subclasses, sub properties, domain and range restrictions of properties. This type system uses some predefined terms, such as Class, subPropertyOf, and subClassOf. RDFS expressions are also valid RDF expressions (just as XML Schema expressions are valid XML). RDF objects as in Figure 2-12 can be defined as instances of one or more classes using the type property. The subClassOf property allows the developer to specify the hierarchical organization of such classes:

```
<rdfs:Class rdf:about="Book"/>
  <rdfs:Class rdf:about="HardCover">
        <rdfs:subClassOf rdf:resource="#Book"/>
  </rdfs:Class>

<Hardcover rdf:resource="http://www.books.org/ISBN0062515861"/>
```

Figure 2-12 Example of subClassOf

Properties can be defined with their domain and range, and they can be organized in a property hierarchy using subPropertyOf as shown below in Figure 2-13:

```
<rdfs:Property rdf:about="hasPrice">

  <rdfs:domain rdf:resource="#Book"/>

</rdfs:Property>
```

Figure 2-13 Example of subPropertyOf

- The Web Ontology language (OWL) which was first published in 2004 and recently has been extended with additional useful features in the OWL2 standard.

OWL allow to formally describe the relations between the terms used in an RDF graph [16]. Formal descriptions of these properties and classes can be understood as logical theories, also called ontologies, which allow to infer new connections in an RDF graph, or link otherwise unconnected RDF graphs. Standard languages to describe ontologies on the Web are:

OWL offers richer means than RDF Schema to define formal relations between classes and properties, such as intersection and union of classes, value restrictions or cardinality restrictions [7]. OWL2 offers even more features such as, for instance, the ability to define keys, property chains, or meta-modeling (i.e., speaking about classes as instances) [14].

RDF provides a simple data typing like model to represent Web content, closely related to the relational database model [17]. The objects and their relationships are assumed to exist within some domain of interest. Ontologies can include glossaries, taxonomies and thesauri and complex typing of concepts and relationships, but normally have greater expressivity and stricter rules than these tools. A formal ontology is a controlled vocabulary expressed in an ontology representation language. Ontologies resemble faceted taxonomies but use richer semantic relationships among terms and attributes, as well as strict rules about how to specify terms and relationships. The vocabulary is used to make queries and assertions. The oft-quoted definition of ontology is "the specification of a conceptualization of a knowledge domain" [19].

OWL is part of the growing stack of W3C recommendations related to the Semantic Web. The OWL standard consists of three languages, OWL provides three increasingly expressive sublanguages designed for use by specific communities of implementers and users in ascending expressivity: OWL Lite, OWL DL (Description Logics) and OWL Full. OWL Lite and OWL DL are based on a logic framework called description logic. OWL Lite is the least expressive of the three, but this is compensated by the existence of efficient

reasoning services for it. OWL DL provides more constructors than OWL Lite and extends the use of some of the constructors in OWL Lite. It is closer to standard description logic. OWL DL has been carefully designed to keep reasoning decidable, although there are still no known algorithms that can reason over all of OWL DL. OWL Full is the most expressive and most compatible with RDF semantics, but inference in OWL Full is un-decidable. It is unlikely that any reasoning software will be able to support complete reasoning for every feature of OWL Full [23].

In the Semantic Web architecture, ontology gives a shared and precise definition to RDF annotations. Several ontology languages have been developed to define the annotations in semantic markup. The earliest languages were OIL [20] and DAML [21], followed by DAML+OIL [22] and most recently, OWL (Web Ontology Language) [2]. OWL has been developed by the W3C Web Ontology Working Group and is a W3C Recommendation. OWL builds on the RDF schema and now also uses XML as syntax.

- **Rules: the Rule interchange format (RIF):** There are several theoretical and practical concerns in combining ontologies and rules, such as decidability issues or how to merge classical open world reasoning with non-monotonic closed world inference. The current RIF's specification leaves many of these questions open, subject to ongoing research [11].

- **Query and Transformation Languages: XQuery, SPARQL (SPARQL Protocol and RDF Query Language):** SQL is a standard structure query language for relational databases. On the other hand SPARQL is standard query language for RDF. Query answering over ontologies and rules and subtopics such as the semantics of SPARQL queries over RDF Schema and OWL ontologies, or querying over combinations of ontologies with RIF rule sets are still neglected by the current standards. A SPARQL query consists of a set of triples where the subject, predicate and/or object can consist of variables. It's main purpose to match RDF triples to find suitable solutions to the given variables [15].

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2.2.3 LEVERAGING OF SEMANTIC WEB

Semantic Web technologies can improve reusability and interoperability of each model. This is due to the fact that the increased level of reusability and interoperability of instruction and adaptation models is efficient if all other models are based on semantic technology. Meanwhile, not only does it improve knowledge sharing with other adaptive systems, but this approach also improves sharing knowledge among all models inside others.

The potential automation of the contribution relevance calculation of scholarly artifacts and scholarly professionals has attracted the interest of several parties within the scholarly environment, and even outside of it [24]. For example, one can find within articles of the Spanish law related to the scholarly personnel certification the requirement that the papers appearing in the curricula of candidates should appear in the Subject Category Listing of the Journal Citation Reports of the Science Citation Index. This example shows the growing relevance of these systems today.

2.3 CONCLUSION

The main essential factor of the revolution of the web is to transmit the web from web of things to web of thoughts. Web 1.0 is "read-only" meaning that companies would post information, and a user would read that information. In contrast, Web 2.0 is the "read-write web" meaning that if I read an article, I can comment about it or share it with others. Meanwhile, Web 3.0 does is re-organize existing web content in such a way where it can be more easily categorized and accessed.

The Semantic Web is a vision for the future of the Web, in which information is given explicit meaning, making it easier for machines to automatically process and integrate information available on the Web by mixing a group of methods and technologies.

Chapter 3.
LITERATURE REVIEW

Semantic Web are integrated to assist scholars during their research activities, in particular, by providing scholars with more knowledge about the individual artifacts in their research community and how they are related. Moreover, it enhances traditional scholarly activity to provide an environment in which scholars methodically and systematically explore their research field and make pertinent questions about it.

A scholar (researcher, scientist, or academic) is defined as an individual involved in advanced learning within a well-defined specialty area who desires in-depth information to support their research and enable the contribution of further ideas, thoughts, theories, and observations.

This chapter introduces the predominant activities of traditional scholars to explore and understand their research habits. This leads to a discussion on new electronic services that are emerging to support e-Scholars (electronic scholars) on the Web, in compare with our work.

3.1 THE TRADIONAL SCHOLAR

At the heart of scholarly activity is the consumption and production of knowledge within a scholar's esoteric field. Scholars consume work published by others to appreciate new ideas and become knowledgeable in their particular field of study. They then publish their own theories, experiments, observations, solutions, predictions, and refutations in journals and conferences. Following publication, debate ensues where peers refute, support, or modify the ideas by publishing further papers.

As Bishop [25] notes, "one begins by identifying and reading a source document and ends with the production of a document representing one's own work." It could be argued that the first publication appeared in around 2400 BC on a Sumerian clay tablet [26]. However, the first serious advance in publishing came in 1452, when Johannes Gutenberg, a goldsmith and businessman from the mining town of Mainz in southern

Germany, invented the printing press and enabled large-scale printing. His most significant work was the printing of a run of 300 two-volume bibles in 1456. However, the printing press was an aggregation of earlier technological advances, primarily the movable type and the proliferation of paper (as opposed to animal skin).

The printing press had an immeasurable effect on research as scholars could accurately publish their work in large quantity [27]. Before mass publication, a scholar's library consisted of a few hand-written manuscripts; with the advent of the printing press it was suddenly possible to obtain much larger amounts of knowledge and thereby improve the quality and quantity of research as communication between scholars improved. However, printing was expensive and therefore control of scholarly publishing moved to printers and publishers, a situation still evident today [28].

Furthermore, the printing press enabled the publication of non-verbal objects (e.g. diagrams, maps, images) [29]. A detailed account of the progress in the publication process is available in Eisenstein's book [30]. Although Eisenstein convincingly argues for the importance of technology (most notably the printing press) in promoting the scientific revolution, other historians disagree and point to the rise of universities and the changing, non-religious, attitude on books [31] and the transformation of beliefs in cosmology, astronomy, and physics [32].

The importance of publishing papers cannot be understated as they enable scholars to present their thoughts and claims to a large community of fellow researchers. Papers are mobile and permanent meaning they are consumed by scholars for many

These relationships between scholarly objects (or artifacts) weave an intricate network of associations and are used by researchers to obtain a complete understanding of the material, issues, and events in their field. Literature contains many of these associations (e.g. structural, semantic, rhetorical, logic) as implicit or explicit references that researchers recognize and use. For example, researchers are identified through author lists and references, pro jects are described in the paper's content, research teams and organizations are mentioned in the affiliation section, and conference or journal information is outlined in the copyright declaration.

3.2   THE CITATION

Citations are the most salient link between scholarly literatures and are a prominent factor in providing the facility for scholarly debate. They have been "the way researchers have been interconnecting their writings all along" [33]. "Documents are not independent. Like biological organisms, every document is always related to some other" [34]. Indeed, the research impact of a scientific community is often assessed by the number of citations it attracts [35].

Traversing citations is the primary method used by scholars to locate further literature. They enable scholars to uncover related ideas and produce a comprehensive literature survey. Citation indexes catalogue citations that a publication makes and link papers with cited works. Initially these indexes were used for locating literature and for providing a unique navigation experience. For example, the index enables a prospective search of the literature, in contrast to the conventional retrospective search, meaning scholars can establish how a paper has influenced a community and what subsequent papers and ideas it has contributed to.

One of the most common indexes in the field of science is the Science Citation Index (SCI) [36] which contains references from 3,500 journals. An example entry from the SCI. The table connects a paper published during a particular year with papers it has cited. It is organized alphabetically by the cited author, with a list of those papers that have cited it in references underneath. The SCI is frequently used by libraries to improve access to scientific information. Indeed, the National Research Library Alliance (NRLA) in America is using the SCI to create an advanced digital library for the Naval Research Laboratory (NRL) covering maritime research [37]. However, a limitation of citation indexes is that any references to journals outside the index are excluded from its coverage.

However, the citation is not a hugely reliable indicator; as with hypertext linking, a citation bears no indication on the quality of the linked material. For example, politics play a substantial role in what papers are cited and how (e.g. colleagues will often cite each other's works while adversaries will not). In fact, a flawed work is often highly cited as peers refute the work: Is this a seminal paper?

Citation linking is also very field dependent. For example, within the biochemistry discipline the average number of citations made by a paper lies at 30, while in mathematics this is usually less than 10 [38]. Also, isolated or specialized fields are likely to receive less citation attention than more general fields.

The citation link is fundamental to the academic world; however, it should be treated with the utmost caution and not used as the sole mechanism for understanding and traversing scholarly material.

3.3 PUBLICATION ON THE WEB

The most common facilities for digital access to scholarly literature have been digital libraries, electronic journals, and e-prints. Digital libraries and e-journals are more advanced in their support for scholarly activities than e-prints, and usually offer more than just a document download facility.

3.3.1 E-print ARCHIVES

E-prints Archives are highly automated and efficient repositories providing access to free scholarly papers. Although e-prints are less common and provide fewer services than digital libraries and e-journals, they contain papers that have usually been self-archived by authors or institutes with the purpose of making them easily available to the research community, and thereby removing the financial barrier evident in most e-journals and digital libraries. The Open Archives Initiative (OAI) [39] is developing and promoting such low barrier entry interoperability standards aimed at facilitating the dissemination of scholarly data between archives. OAI enables publishers to expose their scholarly material using the Open Archives Metadata Harvesting Protocol, which is based on XML and HTTP.

3.3.2 ELECTRONIC JOURNALS

Work exploring how journals could be presented and accessed in electronic form started as early as 1977, when Senders researched the possibilities of implementing an electronic journal [40]. Early projects such as BLEND (Birmingham Loughborough Electronic Network Development) [41] also explored the feasibility of digital journal

publication. However, the main transition from paper based journals to commercial electronic journals (e-journals) started in the early

E-journals are becoming more advanced with many offering features other than publication. Discourse features are appearing that enable scholars to initiate newsgroup style debates about issues in literature [42]. Moreover, several e-journals augment papers with links to discussions, other articles, notification and alerting services, and also to auxiliary information such as dictionary definitions (e.g. Elsevier, IOPP).

3.3.3 DIGITAL LIBRARIES

Digital libraries are like their traditional counterparts except they store, access, and disseminate digital documents. They contain literature from journals, conferences, magazines, and books. The software systems used to run digital libraries are more complex and diverse than e-journal or e-print software, and "can be among the most complex and advanced forms of information systems as they often involve collaboration support, digital document preservation, distributed database management, hypertext, information filtering, information retrieval, instructional modules, intellectual property rights, multimedia information, question answering and reference services, resource discovery and selective dissemination of information." [43]. Clearly, digital library construction is an expensive and resource-intensive task [44].

Although digital libraries are used to publish academic papers, their applications are extremely diverse. The Perseus Project (named after a Greek hero who explored the limits of the world) is a popular digital library, which contains resources for the study of the ancient world and beyond. As with the Post Modern Culture e-journal, the library has a familiar feel with tables of content and information retrieval (e.g. a search engine) being the dominant methods for locating literature.

Both textual and visual resources are available, coupled to search facilities and secondary resources (encyclopedias, dictionaries, grammar guides). Although many of the texts are heavily linked, this is mainly to help translate texts (e.g. the Greek phrase 'luchnou' is linked to the translation 'a portable light, a lamp').

A study conducted by Theng [45] concluded that digital libraries, including prominent ones such as the ACM (Association for Computing Machinery) Digital Library, caused users to become disorientated, with the main difficulties cited as the inability to:

(i)   Easily return to previously visited information and

(ii)   Retrieve information that users believed existed. This experience is a similar predicament to the 'lost in hypertext' syndrome that afflicts many hypertext systems.

3.3.4   e-SCHOLARS vs SEMANTIC WEB

Improving support for scholarly research on the Web has been the focus of several disciplines, such as library studies, hypertext, and knowledge management. This section presents significant research in this area. Which we will discuss some of the related previous work in the field and compare it with our work study as follow.

A considerable amount of research has explored the use of ontologies and Semantic Web technologies for modeling the scholarly domain, Ding et al [46], [47] develop a tool called Swoogle which is a crawler-based indexing and retrieval system for the Semantic Web. It extracts metadata for each discovered document, and computes relations between documents. That could be a good choice for us to connect and suggest connectors of idea between researchers and try to get the accurate result that we need to achieve. *While Swoogle aimed to utilize the metadata attached to existing web pages, our work is more specific by addressing research needs. It focuses on identifying, attaching and utilizing metadata particularly for the domain of research publications. Subsequently, it proposes solutions to utilize this metadata for recommendation of better results.*

OntoSeek [48] is a system designed for content based information retrieval from online yellow pages and product catalogs. OntoSeek combines an ontology-driven content-matching mechanism with a moderately expressive representation formalism. Meanwhile, ScholOnto [49] uses ontologies to model relationships among research documents and enriched the citation relationship with an ontology called "Claim". In "Claim", a document can have many relationships with other documents in the literature,

e.g., a document can be an example of another document, can be inconsistent with another document, can extend the content of another document, etc.

JeromeDL [50] used a collection of ontologies to model different aspects of bibliographic information. In JeromeDL, not only general ontologies, like Dublin Core and FOAF were used, but also event-based ontologies were included with relationships such as "isReviewed", "hasSubmissionStatus", "isUploadedBy", etc. JeromeDL used an interactive interface for publishers and creators to annotate pieces of data with the provided ontologies during the upload process.

Greenstone 3 [51] proposed how ontologies can be fully integrated into digital libraries. Greenstone used the FRBR [4] framework to model data. FRBR uses four entities: works, expressions, manifestations and items. With the four core entities and other attributes for expressing the identities of entities, FRBR is able to model data types, relationships among them, and data sources from different repositories. FRBR was first used for data ingestion, where the data were annotated with the FRBR vocabulary and indexed in the system. Greenstone 3 supports typed search using FRBR resulting in more accurate results than when FRBR was not used.

The Fedora [52] data model is used in the National Science Digital Library. Fedora is also a graph-based data model for exposing a repository as a network of objects. It is also flexible in that it allows overlaying statements from multiple ontologies. Another common feature of Fedora and ORE is that both enable fine-grained digital objects accessible through an architecture of remixed data sources and transformations. However, ORE is better than Fedora in two aspects: (i) ORE takes a resource-centric view that defines clear logical boundaries between resources and enhances the interoperability of information, and, (ii) ORE provides a standard for identifying web services and agents through resource maps with which information can be easily collected across different repositories without losing their provenance. ORE grants the power to users to easily choose their preferred repositories and services.

Rodriguez et al [53] project's main goal is providing novel mechanisms for assessing the impact of scholarly communication items, and hence of scholars, with metrics derived from use data. They define a semantic model for the scholarly

communication process, which is used within an associated large-scale semantic store containing bibliographic, citation, and use data. *However, this project aims to enhance the communication and assessment of scholars and researchers. In contrast, our project aims to model the research claims and arguments by identifying the relationships between the research artifacts.*

Similar to our approach, several approaches have tried to model research arguments and interconnections between research efforts. Tous et al in [24] focuses on modeling the dynamic aspects of the creation–editing–publishing workflow. Uren et al [3] proposed a network model for summarizing research debates over a whole literature as well as for individual documents. This can be done asynchronously by groups of distributed users who build their models on a central server, thus supporting debate at a distance. Furthermore, the models are machine interpretable, allowing us to develop novel user services such as analyzing the lineage of ideas.

One of the inspirations for our thesis is the ClaiMaker system [4] which aims to build a Semantic Web representation of the claims in research papers using ontology of relations. *Similar to these efforts, our work uses ontology of relations to model the different relationship between research artifacts and, hence, model the research argument. However, our work extends these efforts in the following:*

While all the above approaches share the same goal, which is modeling research arguments, we extend this idea by modeling the relationships between *researchers and scholars*. By analyzing research arguments and interconnections between research papers, we can infer which researchers share the same interest, have opposite or complementary views. We can also identify the chain of research efforts that successively build on each other and lead to a particular research contribution. While the previous solutions focused on the ontology construction and semantic annotation, we think that they did not show how the modeling of research arguments and reasoning can be useful in practice. There is a need to show how this approach can be integrated into recommendation services and web agents in practice to offer intelligent results to the research community.

3.4 CONCLUSION

This chapter explore the development of traditional scholars to understand their research habits. That leads to new electronic services that are emerging to support e-Scholars on the Web. Therefore, as previous solutions such as ClaiMaker, Fedora, … etc, focused on the ontology construction and semantic annotation, there was a need to show how this approach can be integrated into recommendation services and web agents in practice to offer intelligent results to the research community. Modeling research arguments is the relationships between researchers and scholars. By analyzing research arguments and interconnections between research papers to infer new intelligent rules that will guide the novice researchers to trace the path that reduce time and enhance the quality of the output.

Chapter 4.

DESIGN AND METHODOLOGY

Digital libraries search engines still suffer from the disability of identify accurate context for submitted queries which leads to retrieve non relative results to users. Therefore the proposed approach that we introduce through the thesis is to prepare a system that can achieve the following features that provide a lot of significant valuable knowledge that design the road for any new researcher in any new domain enquired by him.

We will describe the stages in details of the approach model provided, to examine the HeTMe system. As follows.

4.1 RESEARCH METHODOLOGY

Our research goes through the following stages as shown in Figure 4-1:

1. Ontology Construction and Engineering: the core of our approach is the construction of the ontology which defines the classes, properties and constraints that used to model the research domain and the disparate relationships that exist between research artifacts. The study approach used the recent advances in ontology languages (e.g. OWL 2) to build our ontology.

2. Web-based agent: on top of our proposed ontology, the system HeTMe build a web-based interface that used the appropriate inference engine and ontology processor to present the intelligent results about the relationships between research topics and artifacts. Please refer to the objectives sections for information about the intelligent results the approach aims to support.

3. The system evaluated by having two experts to judge the functionality of the system using a qualitative approach (e.g. interviews, observations). The reason of using short time study instead of longitudinal is while longitudinal involves repeated observations of the same variables over long periods of time which require enormous amounts of time and are often quite expensive. The evaluation

criteria in our research was on short-time studies involve data collected at a defined time. Meanwhile, another problem is that participants sometimes drop out of the study, shrinking the sample size and decreasing the amount of data collected [54], [55].
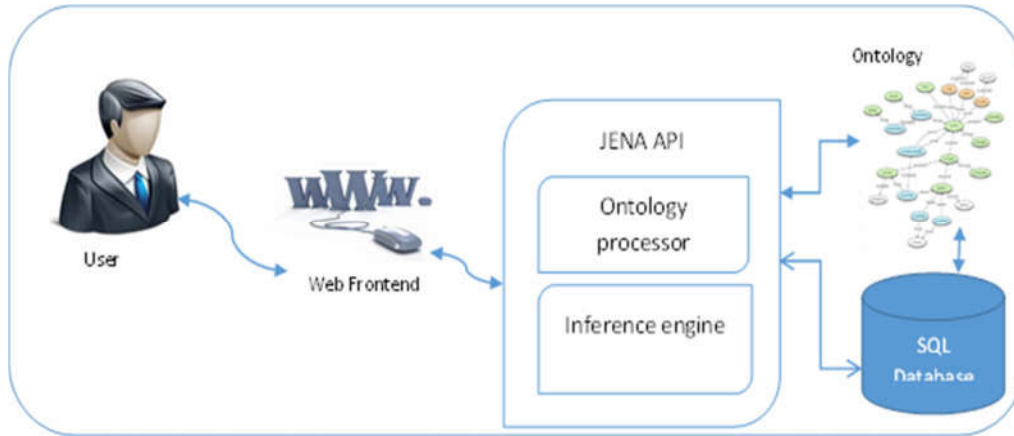
Figure 4-1 Architecture of the system

4.2 REUSED ONTOLOGY

The great about Sematinc Web that we can reuse availiable defined ontology which been created previously by others. Figure 4-2 displays how to retirve information from real world data using the Ontolgy to get triples depend on the Query constraints and store it on the Triple Store [7].

On the other hand, **Error! Reference source not found.** display a huge semantic ontology that is been developed until 2014 Profile which are connect by using the princible of semantic web. Some of them are more famous than other e.g. GeoName, DBpedia, DublicCore and FOAF. The diagram is classified on the following taxonomies: Publications, Life Sciences, Cross-Domain, Social Networking, Geographic, Government, Media, User-Generated Content and Linguistics. From this point we will not build the whole ontology of the researcher person from scratch. Instead, we will reuse an existing ontology which can help us to merge the useful benefits of it. Moreover, it will also let the door open for farther interconnection of the researchers with other researchers friends.

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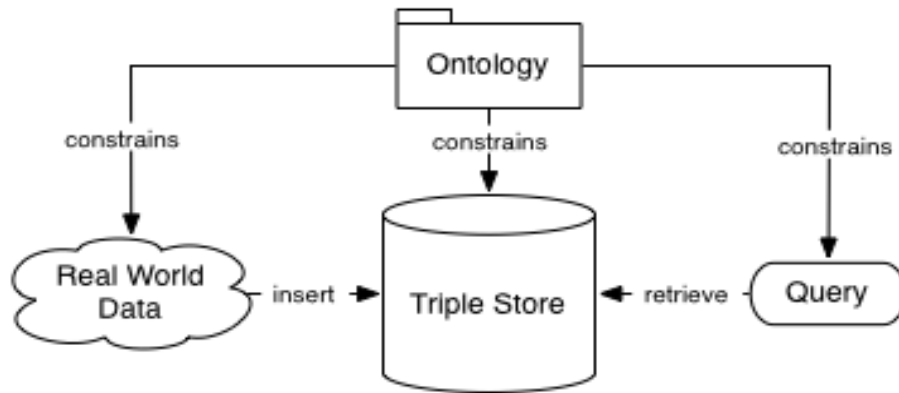
Figure 4-2 Construction Ontology

The FOAF (Friend of a Friend) [20] vocabulary has become one of the most used semantic web ontologies and can be found in millions of RDF documents on the web. FOAF is used to describe basic attributes of people and relationships among them. FOAF has been evolving gradually since its creation in mid-2000.

There is now a stable core of classes and properties that will not be changed, beyond modest adjustments to their documentation to track implementation feedback and emerging best practices.

For this stage we will just use the vocabulary that describe the Person in general like: foaf:givenName, foaf:lastName, foaf:topic_interest, foaf:mbox ... etc [53]. and in future work we can use foaf:knows to interconnet researchers to build trust between researchers on rely on the mutual friends of each other.


```
:Foaf:name rdf:datatype="http://www.w3.org/2001/XMLSchema#string">
        Tamer Khrais</foaf:name>
<Foaf:mbox rdf:resource="mailto:t_hyouth@hotmail.com"/>
<Foaf:homepage rdf:resource="http://www.tamer.com"/>
<Foaf:knows rdf:resource="http://wiki.ontoworld.org/index.php/IyadAlagha"/>
<rdf:type rdf:resource="http://xmlns.com/foaf/0.1/Person"/>
```

Figure 4-3 Sample of FOAF Ontology
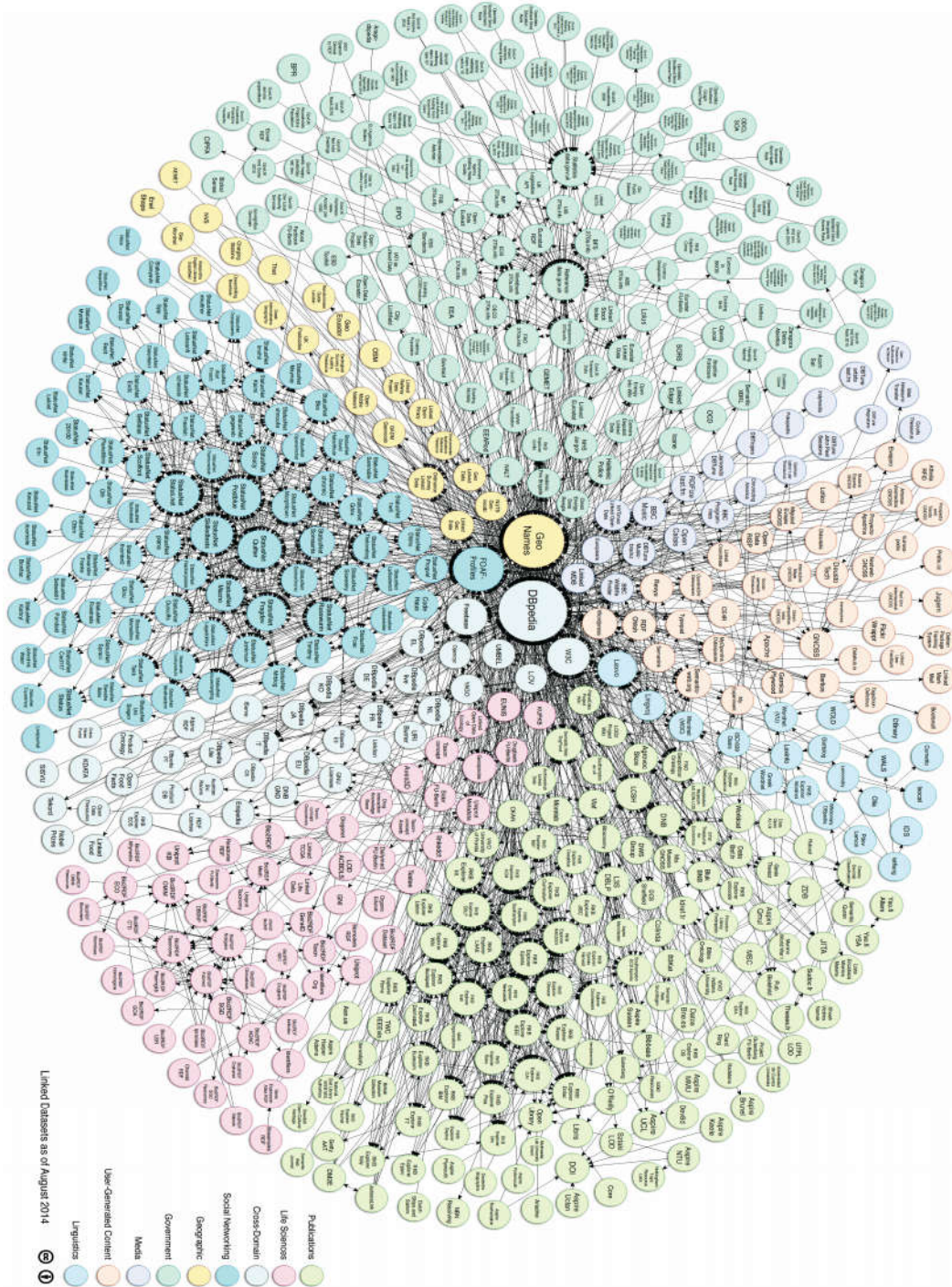
Figure 4-4 Linked Datasets[3]

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[3] Linking Open Data cloud diagram 2014, by Max Schmachtenberg, Christian Bizer, Anja Jentzsch and Richard Cyganiak. http://lod-cloud.net/

4.3 ONTOLOGY CONSTRUCTION AND ENGINEERING

Ontology Construction is the core of our approach by constructed the ontology which defines the classes, properties and constraints that will use to model the research domain and the disparate relationships that exist between research artifacts by using OWL 2 to build our ontology.

We start to build our own ontology in this situation to be a new beginning for the system which we develop with the reuse of some ontologies as mentioned before in the parts which doesn't contain the core of our work.

```
1  <?xml version="1.0"?>
3  <!DOCTYPE Ontology [
4      <!ENTITY xsd "http://www.w3.org/2001/XMLSchema#" >

        . . .
8  ]>
10 <Ontology xmlns="http://www.w3.org/2002/07/owl#"
11     xml:base="http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology"

        . . .
21     <Prefix name="xsd" IRI="http://www.w3.org/2001/XMLSchema#"/>
22     <Prefix name="rdfs" IRI="http://www.w3.org/2000/01/rdf-schema#"/>

24     <Declaration><Class IRI="#Artifact"/></Declaration>
25     <Declaration><Class IRI="#Author"/></Declaration>

        . . .
30     <Declaration><Class IRI="#Sponosor"/></Declaration>
31     <Declaration><ObjectProperty IRI="#OppositeWith"/></Declaration>
32     <Declaration><ObjectProperty IRI="#analogousTo"/></Declaration>
33     <Declaration><ObjectProperty IRI="#betterCompThan"/></Declaration>

        . . .
91     <Declaration><ObjectProperty IRI="#refused"/></Declaration>
92     <Declaration><ObjectProperty IRI="#similarTo"/></Declaration>
93     <Declaration><ObjectProperty IRI="#solved"/></Declaration>
94     <Declaration><DataProperty IRI="#abstract"/></Declaration>
95     <Declaration><DataProperty IRI="#address"/></Declaration>

        . . .
109    <Declaration><DataProperty IRI="#sponosorFees"/></Declaration>
110    <Declaration><DataProperty IRI="#sponosorYear"/></Declaration>
111    <Declaration><DataProperty IRI="#webSite"/></Declaration>
112    <Declaration><NamedIndividual IRI="#Analyzer"/></Declaration>
113    <Declaration><NamedIndividual IRI="#MainAuthor"/></Declaration>

        . . .
118    <Declaration><NamedIndividual IRI="#Tester"/></Declaration>
119    <Declaration><NamedIndividual IRI="#artifactInd1"/></Declaration>
120 </Ontology>
121 <!-- Generated by the OWL API (version 3.4.2) http://owlapi.sourceforge.net -->
```

Figure 4-5 Part of Artifact Ontology

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The reason of building a new one to handle the new features and options that is produced through our project which is not available on the existing ontologies that had been built before.

On Figure 4-5 a snapshot of the parts of the ontology artifact as the ontology is written on the same format of the XML language so line 1 is dedicated to verify the version that is written which is 1.0. After that at Lines 2-8 implies the DTD (Document Type Definition) which defines the document structure with a list of legal elements and attributes.
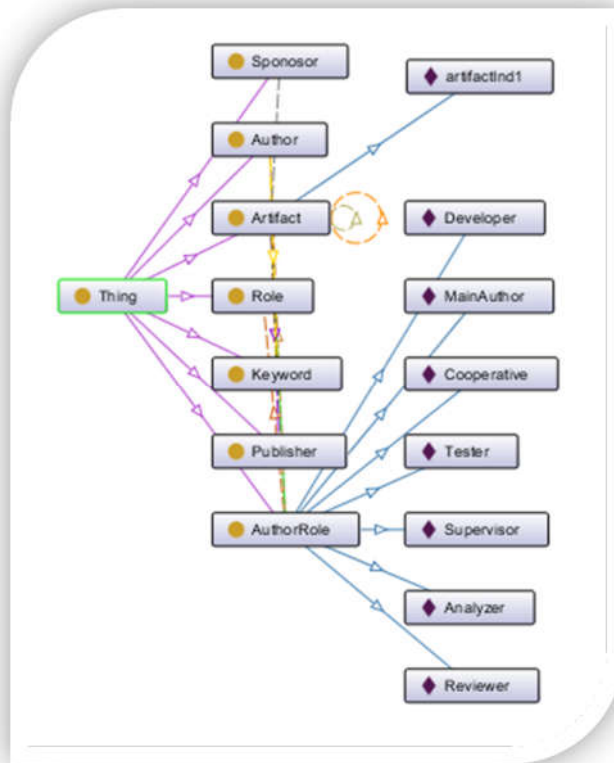
Figure 4-6 Basic Classes of Top Down Artifact Ontology

Through Lines 10-120 the ontology of the artifact ontology. In Lines 24-30 the classes' definitions that contains the following classes as shown in Figure 4-6, which we will describe in Table 4-1. Which contains the core class of the ontology and can be extended with any updates that can enrich the knowledge of the researcher and as they say: who own the knowledge is the owner of the power in the world.

Table 4-1 Artifact Ontology Class Description

Class	Description
Artifact	The main class on the ontology that contains the basic information about each artifact and contains the object properties (that we will describe in moments).
Author	Are the author that write the Artifact and usually it's allowed to have multiple values for each artifact.
AuthorRule	It define the rule of each Author participate in publishing the artifact e.g.: MainAuthor, Developer, Reviewer, Tester, Cooperator, Supervisor, Analyze … etc. The beneficial is for the new researcher or companies interested in the domain to connect the right needed person for other actions or new researches.
Sponsor	Defines the sponsor that concerns about the research which can help to call when they interested in the same domain with new ideas from the new researcher
Keyword	Is the usual part found in any artifact to classify the artifact to any taxonomies and interest for domain researcher
Publisher	The digital library that publish the artifact from a magazine, preceding. Workshops… etc. (ACM and IEEE are examples of famous digital library.

According to Figure 4-7 which display the object properties of the top level Artifact Ontology and how we classified the citation process according to one of the general form of classification to the specific citation type.
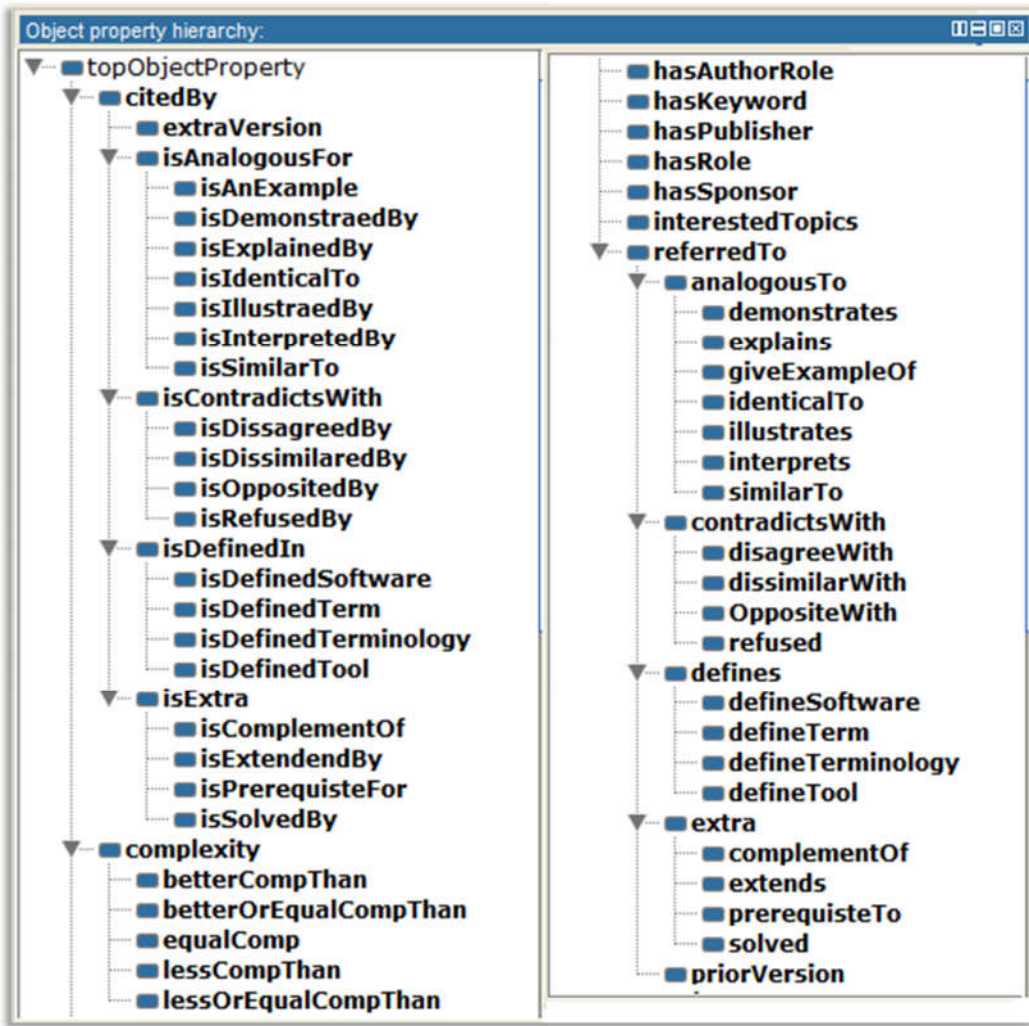
Figure 4-7 Object Properties of top-level Artifact Ontology

Lines 31-93 contains the definitions of the object properties for the HeTMe, system name, which is illustrated in **Error! Not a valid bookmark self-reference.** and describe every object property on details.

Table 4-2 Artifact Ontology Object Properties Description

Class	Description
citedBy	is the inverse object property for "referedTo" i.e. when we decide a triple it implies that we had the inverse on the other side.

Class	Description
Complexity	This is a new classification doesn't found in any paper before it's decide what's the complexity used in the paper comparing with other papers and it hadn't to be a reference to the paper.
hasAuthorRule	Join Author Class with AuthorRule Class.
hasKeyword	Join Artifact Class with Keyword Class.
hasPublisher	Join Artifact Class with Publisher Class.
hasSponsor	Join Artifact Class with Sponsor Class.
intresetedTopics	Join Author Class with Keyword Class.
referredTo	Every Artifact is referred by references that is could be classified under one of the following given taxonomies: • analogousTo: is the similar content of Artifacts to two different papers • contradictsWith: different opinion about an idea. • defines: have a definition of some expressions or terms. • extra: for papers doesn't classified in the previous and could one of the given as illustrated in the Figure 4-7. • priorVersion: this is used when the same Artifact has a various versions so it will not make confusion for researchers. So as it's apparently that it's join Artifact Class with another Artifact Class.

And last but not least the final part in the construction of the ontology is the data properties of the Artifact Ontology which can be found in Figure 4-8. Data properties are literal String at most properties and it is not affect the system with the specific objects that we are digging for so we will not describe each property as they are useless but in the same time it can't be discarded so it complete the whole idea for the researchers. This can be find in lines 94- 111.

Finally, at lines 112- 119 are the definitions of individual that classify the artifact author type from Main Author, Developer, Tester, or the supervisor of the research artifact.

For more details about the Artifact Ontology, you can refer to Appendix A: ARTIFACTS ONTOLOGY.

Figure 4-8 Dara Properties of top-level Artifact Ontology

4.4   SPARQL ENGINE

As we will see later in the case study scenarios that we aims to produce to have knowledge after applying intelligent and mining the given information on the Artifact Ontology with the stored information on the database.

So here come the need for using the SPARQL engine that will define the query which will execute on the SPARQL executer by regenerating the SPARQL query by applying the suitable expressions. As the system need to gain and derive an intelligent result by applying some matching algorithm which is based on following all paths, and detecting when a graph node (subject or object), has been already visited on the path [53]. Informally, this algorithm attempts to extend the multiset of results by one application

of path at each step, noting which nodes it has visited for this particular path. If a node has been visited for the path under consideration, it is not a candidate for another step.

Table 4-3 SPARQL ENGINE USED PROPERTIES

Syntax Form (path)	Algebra (path)
path*	ZeroOrMorePath(path)
path+	OneOrMorePath(path)
path?	ZeroOrOnePath(path)

Table 4-3 SPARQL ENGINE USED PROPERTIES shows some of the intelligent Algorithms we extremely need to apply which are ZeroOrMorePawth, OneOrMorePath and OneOrMorePath. Which the system can find the relational algebra definition of each in Figure 4-10, Figure 4-11 and Figure 4-12 respectively.

Figure 4-9 also contains a definition of an auxiliary function, ALP, used in the definitions of previous algorithms. The ZeroOrMorePath and OneOrMorePath forms return matches based on distinct nodes connected by the path.

The SPARQL engine could be categorized as the brain for the system as it be the responsible for all the actions that will be made by the HeTMe System.

Definition: Function ALP

```
Let eval(x:term, path) be the evaluation of 'path', starting at RDF
term x, and returning a multiset of RDF terms reached by repeated
matches of path.

ALP(x:term, path) =
    Let V = empty multiset
    ALP(x:term, path, V)
    return is V

# V is the set of nodes visited

ALP(x:term, path, V:set of RDF terms) =
    if ( x in V ) return
    add x to V
    X = eval(x,path)
    For n:term in X
        ALP(n, path, V)
        End
```

Figure 4-9 Definition: Function ALP

Definition: Evaluation of ZeroOrOnePath

```
eval(Path(X:term, ZeroOrOnePath(P), Y:var)) = { (Y, yn) | yn = X or
{(Y, yn)} in eval(Path(X,P,Y)) }
eval(Path(X:var, ZeroOrOnePath(P), Y:term)) = { (X, xn) | xn = Y or
{(X, xn)} in eval(Path(X,P,Y)) }
eval(Path(X:term, ZeroOrOnePath(P), Y:term)) =
    { {} } if X = Y or eval(Path(X,P,Y)) is not empty
    { } othewise
eval(Path(X:var, ZeroOrOnePath(P), Y:var)) =
    { (X, xn) (Y, yn) | either (yn in nodes(G) and xn = yn) or
{(X,xn), (Y,yn)} in eval(Path(X,P,Y)) }
```

Figure 4-10 Definition: Evaluation of ZeroOrOnePath

```
eval(Path(X:term, ZeroOrMorePath(path), vy:var)) =
    { { (vy, n) } | n in ALP(X, path) }

eval(Path(vx:var, ZeroOrMorePath(path), vy:var)) =
    { { (vx, t), (vy, n) } |  t in nodes(G), (vy, n) in
eval(Path(t, ZeroOrMorePath(path), vy)) }

eval(Path(vx:var, ZeroOrMorePath(path), y:term)) =
    eval(Path(y:term, ZeroOrMorePath(inv(path)), vx:var))

eval(Path(x:term, ZeroOrMorePath(path), y:term)) =
    { { } } if { (vy:var,y) } in eval(Path(x, ZeroOrMorePath(path)
vy)
    { } otherwise
```

Figure 4-11 Definition: Evaluation of ZeroOrMorePath

```
eval(Path(X, OneOrMorePath(path), Y))
# For OneOrMorePath, we take one step of the path then start
# recording nodes for results.

eval(Path(x:term, OneOrMorePath(path), vy:var)) =
    Let X = eval(x, path)
    Let V = the empty multiset
    For n in X
        ALP(n, path, V)
        End
    result is V

eval(Path(vx:var, OneOrMorePath(path), vy:var)) =
   { { (vx, t), (vy, n) } |  t in nodes(G), (vy, n) in eval(Path(t,
OneOrMorePath(path), vy)) }

eval(Path(vx:var, OneOrMorePath(path), y:term)) =
   eval(Path(y:term, OneOrMorePath(inv(path)), vx))

eval(Path(x:term, OneOrMorePath(path), y:term)) =
    { { } } if { (vy:var, y) } in eval(Path(x, OneOrMorePath(path),
vy))
    { } otherwise
```

Figure 4-12 Definition: Evaluation of OneOrMorePath

Here is an example of what the importance of each algorithm is and how it can help us to gain knowledge more and more without a lot of complication. So assume that a solution of research artifacts connected to each other as mentioned on Figure 4-13 Sample of interconnected Research Artifact.
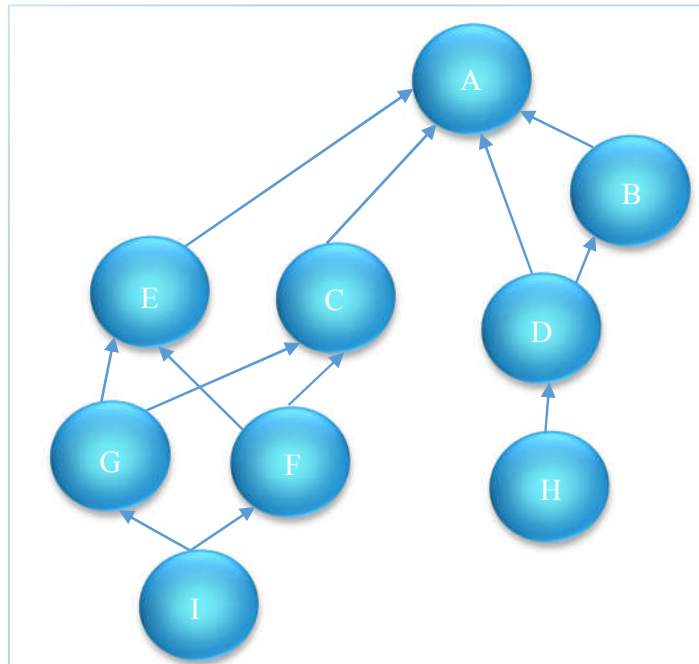
Figure 4-13 Sample of interconnected Research Artifact Ontology

The representation of the data as triple will be as follow on Figure 4-14:

```
@prefix dc: <http://purl.org/dc/elements/1.1/>.
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>.
@prefix :
<http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#">.
:resArtifactA dc:title "resArtifact A" .
:resArtifactB rdfs:label "resArtifact B" ;
      :referredTo :resArtifactA .
:resArtifactC :referredTo :resArtifactA .
:resArtifactD :referredTo :resArtifactA , :resArtifactB .
:resArtifactE :referredTo :resArtifactA .
:resArtifactF :referredTo :resArtifactC , :resArtifactE .
:resArtifactG :referredTo :resArtifactC , :resArtifactE .
:resArtifactH :referredTo :resArtifactD .
:resArtifactI :referredTo :resArtifactF , :resArtifactG .
```

Figure 4-14 Representation of example on triples

This data can also be displayed as Subject-Property-Object as displayed on Table 4-4.

Table 4-4 Representation of Data using S-P-O

Subject	Property	Object
:resArtifactA	dc:title	"resArtifact A"
:resArtifactB	rdfs:label	"resArtifact B"
:resArtifactB	referredTo	:resArtifactA
:resArtifactC	:referredTo	:resArtifactA
:resArtifactD	:referredTo	:resArtifactA
:resArtifactD	:referredTo	:resArtifactB
:resArtifactE	:referredTo	:resArtifactA
:resArtifactF	:referredTo	:resArtifactC
:resArtifactF	:referredTo	:resArtifactE
:resArtifactG	:referredTo	:resArtifactC
:resArtifactG	:referredTo	:resArtifactE
:resArtifactH	:referredTo	:resArtifactD
:resArtifactI	:referredTo	:resArtifactF
:resArtifactI	:referredTo	:resArtifactG

Now if a query is to find research artifacts that referred resArtifactA, and papers that refer papers that refer resArtifactA, and so on. This need to apply ZeroOrMorePath Algorithm by applying the following SPARQL formula (as shown in Figure 4-15):

```
SELECT ?S
WHERE {
 ?S :referredTo* /dc:title "resArtifact A" . }
ORDER BY ?S
```

Figure 4-15 SPARQL formula for ZeroOrMorePath Algorithm

And the result will be as shown on Figure 4-16 which includes resArtifactA even the specified research artifact doesn't referred to any research artifact, but the research artifact have title "resArtifactA".

S
:resArtifactA
:resArtifactB
:resArtifactC
:resArtifactD
:resArtifactE
:resArtifactF
:resArtifactG
:resArtifactH
:resArtifactI

Figure 4-16 Output of ZeroOrMorePath Algorithm

Meanwhile, if a query is to find research artifacts that referred research artifacts with title "resArtifactA". Here OneOrMorePath Algorithm need to be applied with the following SPARQL formula (as shown in Figure 4-17):

```
SELECT ?S
WHERE {
 ?S :referredTo+ /dc:title "resArtifact A" . }
ORDER BY ?S
```

Figure 4-17 SPARQL formula for OneOrMorePath Algorithm

And the result will be as shown on Figure 4-18 which does not include resArtifactA since we insist there's at least one ":referredTo" step in the path.

S
:resArtifactB
:resArtifactC
:resArtifactD
:resArtifactE
:resArtifactF
:resArtifactG
:resArtifactH
:resArtifactI

Figure 4-18 Output of OneOrMorePath Algorithm

Now if a query is to find research artifacts that referred research artifacts with title "resArtifactA" directly without any intermediate research artifact. Here ZeroOrOnePath Algorithm need to be applied to output the needed information with the following SPARQL formula (as shown in Figure 4-19):

```
SELECT ?S
WHERE {
 ?S :referredTo? /dc:title "resArtifact A" . }
ORDER BY ?S
```

Figure 4-19 SPARQL formula for OneOrMorePath Algorithm

The result will include research artifacts B, C, D and E. Which directly referred to research artifact A – plus A as the research artifact has the title "resArtifactA". And the result will be as shown on Figure 4-20.

S
:resArtifactA
:resArtifactB
:resArtifactC
:resArtifactD
:resArtifactE

Figure 4-20 Output of OneOrMorePath Algorithm

But if we want to output only the paper that refer to research artifact A without itself, then the SPARQL query will be as shown in Figure 4-21:

```
SELECT ?S
WHERE {
 ?S :referredTo/dc:title "resArtifact A" . }
ORDER BY ?S
```

Figure 4-21 SPARQL formula for OneOrMorePath Algorithm

The result will include research artifacts B, C, D and E. Which directly referred to research artifact A without A itself. The result as shown on Figure 4-22:

S
:resArtifactB
:resArtifactC
:resArtifactD
:resArtifactE

Figure 4-22 Output of OneOrMorePath Algorithm

Depend on the example that is described above each algorithm have its own purpose and need and therefore the result of each one gets a different output depend on what is the output that the researcher looking for.

4.5   WEB-BASED AGENT

So HeTMe web-based agent is the interface for all the thesis work that will be used by the user with an appropriate inference engine and ontology processor to present the intelligent results about the relationships between research topics and artifacts.

As illustrated in Figure 4-23 the architecture of the HeTMe Application as the user will log on to the web agent and searching for the needed Artifact that will be passed the query to the inference engine module that will manipulate the query by using the query processor then before prepare the SPARQL query the system will got through extension module if there is a need for stemming or annotation.

Semantic Annotation is the process of inserting metadata, which are concepts of an ontology (i.e. classes, instances, properties and relations), in order to assign semantics [55]. These tools are designed to enable users with limited knowledge of ontology languages to markup documents using ontology in a Semantic Web compliable fashion. With these tools, authoring linked data is mainly a matter of dragging in data and binding it together through ontology using a graphical interface. Manual annotation is difficult, slow, time-consuming, tedious and costly [55].

Lately, it will pass the query to the final stage i.e. the semantic module which will execute the result depend on the artifact ontology and the stored database to produce knowledge as a result by applying the previous approaches and produce the result depend on the algorithm that applied on search which was described previously on the last section.

Finally, the system will gather all possible answers and produce it to the user in a suitable GUI that is a can be extend to be visualized to be as a tree.
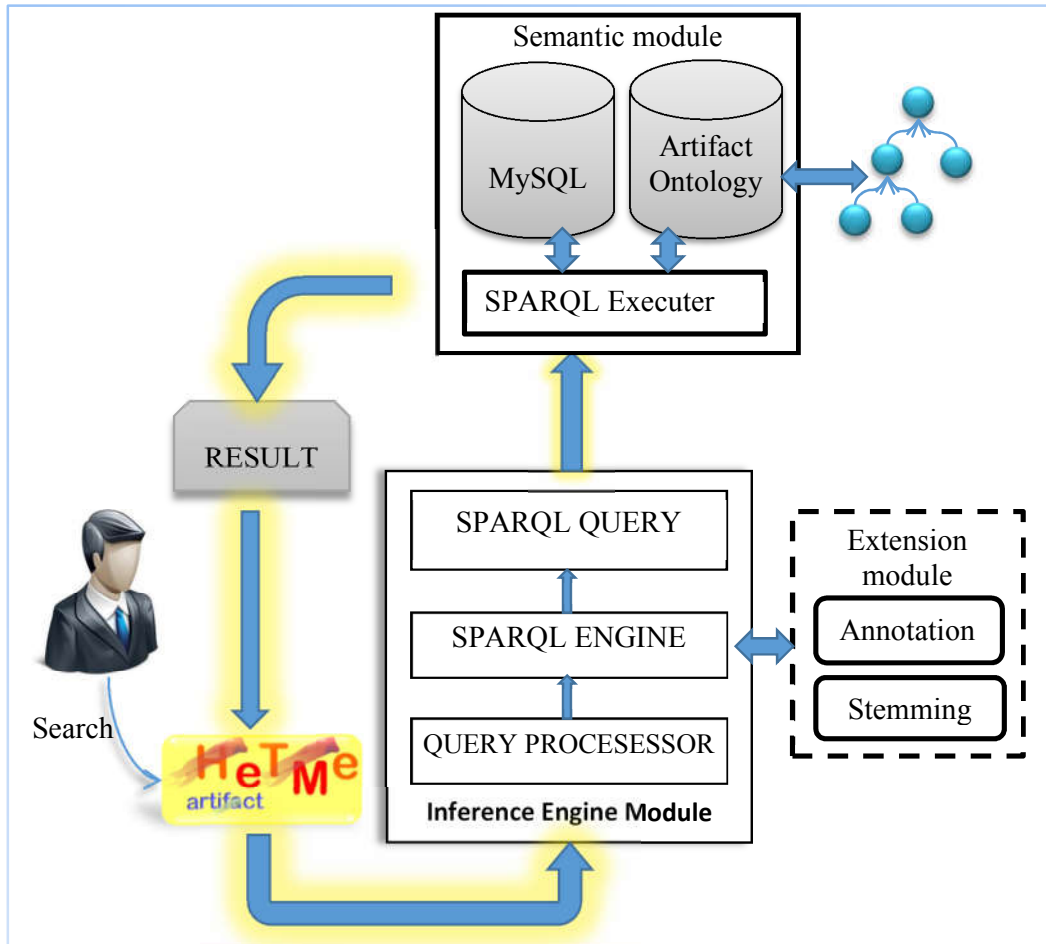
Figure 4-23 HeTMe Architecture

4.6 CASE STUDY

The following is a description about scenarios that what will be done in the HeTMe system so we will first begin with adding new artifact then we will continue with query an artifact search engine.

4.6.1 ADD ARTIFACT SCENARIO

As shown in Figure 4-24 Add Artifact Sequence , the sequence of steps carried out in the insertion flow proceeds as follows: The user, after registration to the system, Add a new Artifact. The HeTMe application check if the query is valid; the system information if the query is invalid and/or if there was error in sending request. If it is valid, the system fetches the query at the repository data and user history repository, and

check if data is existing; the system informs him if the data is existing and ask for if it is a new version or just discard it but if it is a new version, then the system retrieves the information to the inference engine to manipulate the changes then saves the inference result's to the repository and adds the result to the original data retrieved and responses to the user.
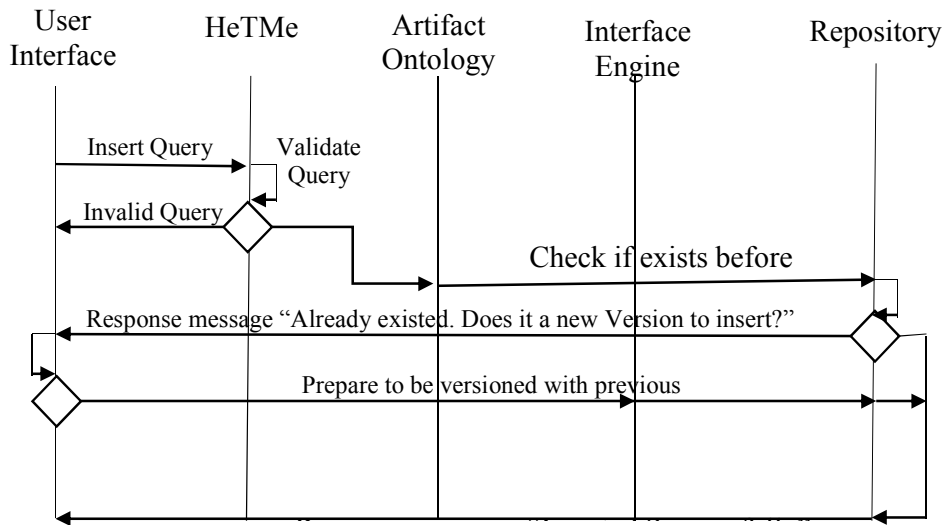
Figure 4-24 Add Artifact Sequence

4.6.2 SEARCHING ONTOLOGY

Comparing the sequence of insertion of an artifact doesn't different a lot with searching an ontology but it will give more effort to the inference to retrieve knowledge from the given information as illustrated in Figure 4-25.
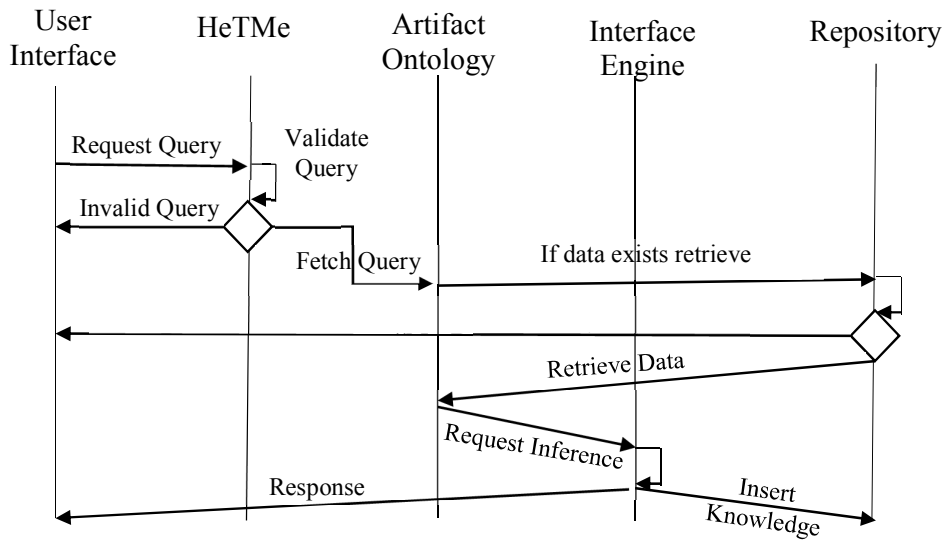
Figure 4-25 Search Artifact Sequence
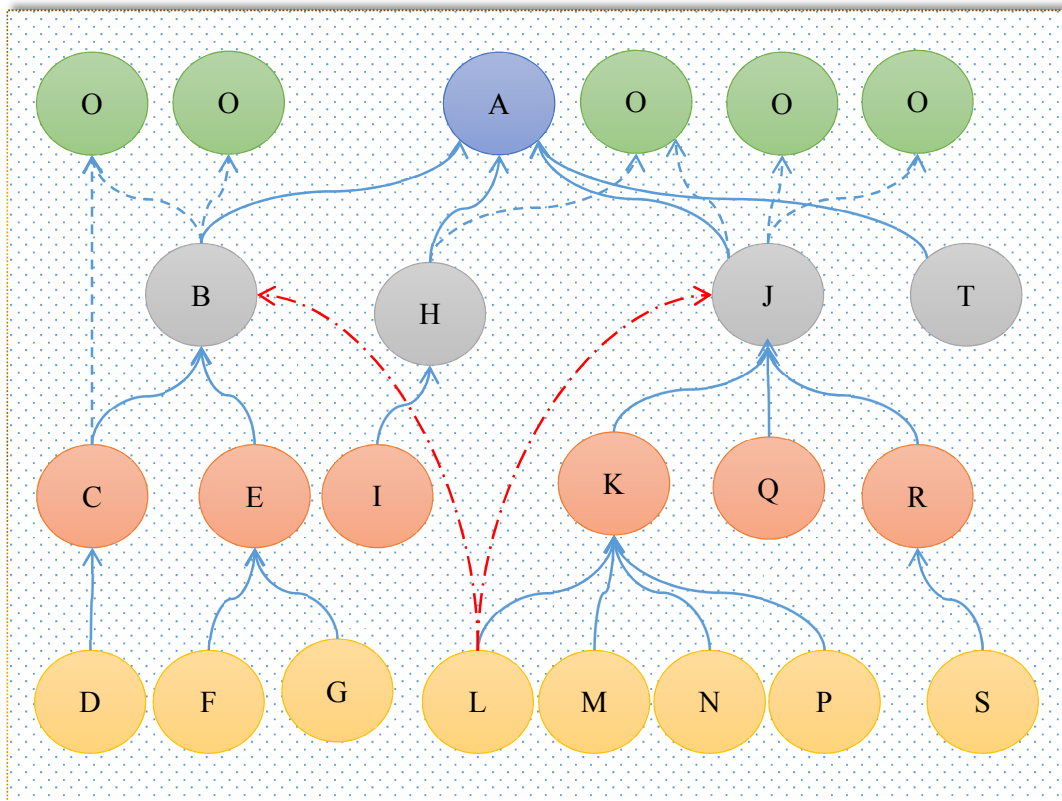
Figure 4-26 Sample Of Artifact Ontology

Suppose that we had a sample of the ontology as you can see above in Figure 4-26. Each node on the diagram represent an Artifact on the ontology and every edge represent the relationship between two Artifacts depending on the properties that we had describe previously in Figure 4-7 which are citedBy/isAnalogousFor/isContradictsWith/ referredTo etc. As you can see that every node has a letter and every edge has a number as a name for both to be able to distinguish between them in the following discussion:

- Node A is the root base reference for a lot of Paper like B, H, J and T. that could mean that this paper has a lot of magnificent information that built the road for all the researchers in that era.

- After years a lot of the Child paper of Node A have had new researchers that give a new ideas that based on and give new roads for them.

- Meanwhile, Node T couldn't be undertaken by any new researcher that means that even the paper is so weak that it had dead ends or the researcher didn't interest the content that proposed on it.

- Node H had only interested by a researcher and produce paper I. This means that Node H may had other future works that need to be reactivated to have a new tree on the road as a lot of the new researcher interest only the last 5-7 years.

- In addition, Suppose that Node F is similar to Node G in content which seems also that they got the same father Node E so they agree in the same content now if Node C is analogous or similar to Node E that implies that Node D is analogous to Node F and Node G but if Node C disagree with Node E that implies also that Node D is dissimilar with Node G and F. Therefore, If we suppose that we need to propose papers for a new researcher that read Node G we will affirmatively invite him to read Node F and Node as they are similar and will supposed to add Node C and Node D if they are similar with Node E or we will supposed to read only Node D and Node E when they disagree with Node E if he found that Node G is not what he believe in to give him the knowledge he digging for in a suitable manner and less time and effort.

- Moreover, If a researcher W like the content of Node D, a researcher X and researcher Y like the content of Node F and a researcher Z like the content of Node G then if researcher X try to find people interested in the same paper we will propose

researcher Y and then researcher Z if we explore the domain and will propose researcher W if he want the person who contradict with what he believe in Node F. This scenario will extremely connect people from the whole world without any friendship between them.

- Finally, the need for the intelligent SPARQL Engine to not enter the same Node again as you can see Node L is refereed by Node K, J and B which are in somehow the ancestor of each other that will make a duplication through the algorithm to be in the same path twice as mentioned before in discussion the SPARQL Engine.

4.7 EXTRA DECLARATION

Another explanation of the ontology construction could be described as on Figure 4-27. If we suppose that there were four research artifacts connected to each other to
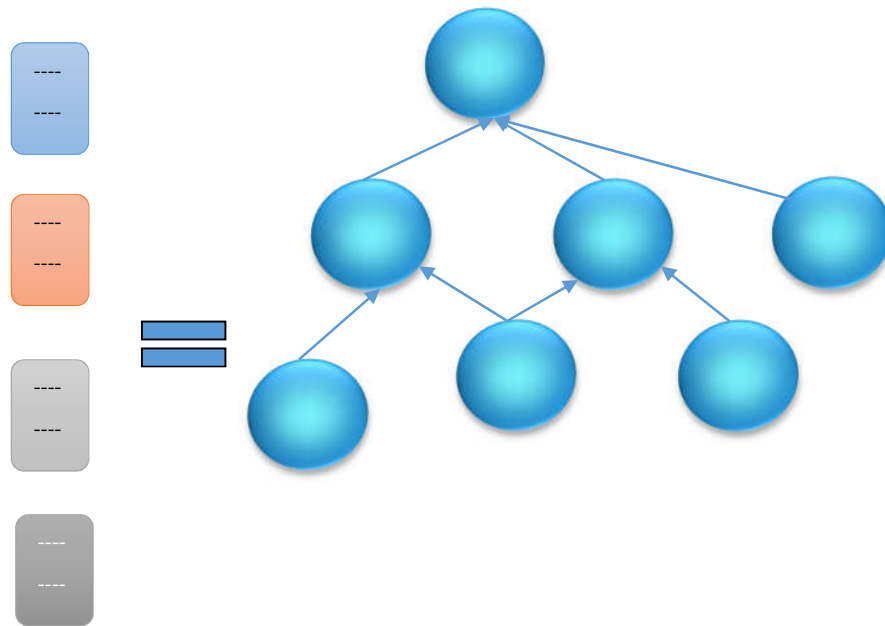
Figure 4-27 Artifact Ontology

produce the shown ontology. Then after review them the researcher found that there is a relation between research artifacts so as seen on Figure 4-28. So now based on the construction of the relation and interconnection between the researches artifacts. The new researcher now can be guided to what read first based on the references annotations. Moreover, the novice researcher can get new offers of the new artifacts versions that is published based on the tree of references that referred by new researchers who wrote new

papers on the field based on the derived references. According to what said, the system will recommend to read paper 1 and 2 as they are somehow related as the researchers connected on the root idea as shown. The paper 1 and 2 on the same way also could be related based on the original interconnection either agree/ disagree/ commentary/ related/ similar that will also be helpful to understand for novice researcher to read paper 2 if the researcher want to get obvious scene on the same opinion to get extra information.
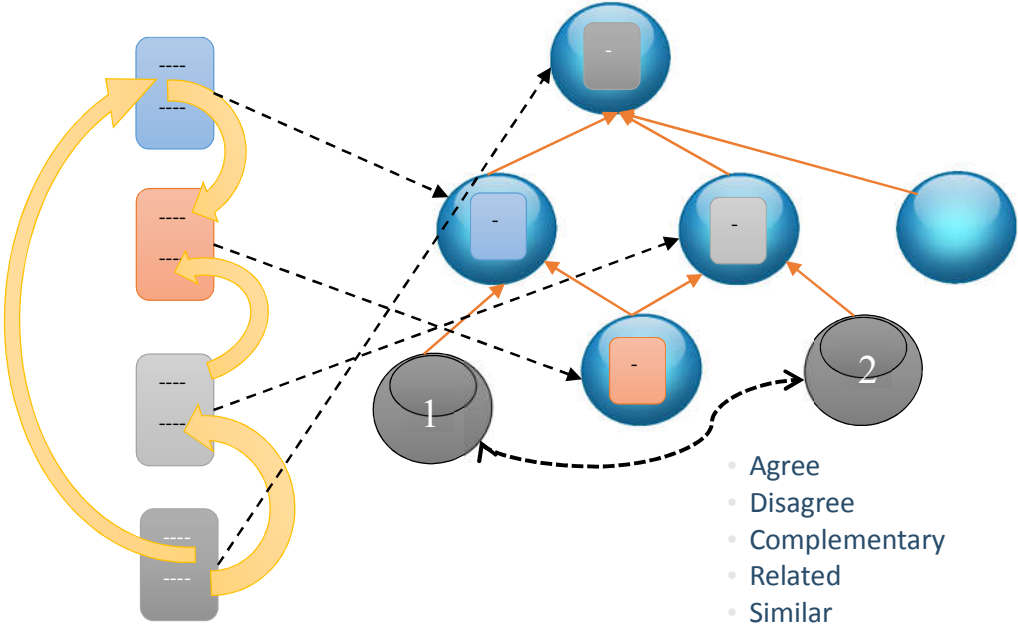
Figure 4-28 Artifact Annotation

Finally, if a novice researcher read paper 1 and another interested researcher read paper 2 and if as mentioned before that paper 1 and 2 are on the same agree of idea. Then it will be great offer to connect these two researchers. Therefore, the researcher can build their teams from the whole world without suffering to get people had the same interest as the system provide suggestion for them to connected which will expand the ideas moreover expected and can get rapidly publishing the research artifacts as the whole team considered get the same interest so no effort will be wasted.

4.8   CONCLUSION

Before explaining the experiment on the next chapter. This chapter provides the importance of the thesis by discussing the importance of ontology and how it is built on the system i.e. the classes, properties and constraints that defined to model the research domain and the disparate relationships that exist between research artifacts based on the SPARQL engine that produce intelligent results to be stored on the Triple store to be used on the future and to derived new results of the stored triples. The paths could be derived be applying one of the described algorithms i.e. ZeroOrMorePath, OneOrMorePath and ZeroOrOnePath. Furthermore, the benefits of reuse the research methodology to expand and get more amazing and gorgeous results by offering for novice researcher how to get suggestion for new research artifacts.

Chapter 5.
EXPERIMENT IMPLEMENTAION

The implementation of the project need a homogenous of Tools framework in addition to API to prepare the final output of the HeTMe Project. Therefore, in the beginning of this chapter classify each used framework and API that is used and then give an explanation about the HeTMe Application.

5.1 TOOLS FRAMEWORKS and API

Under the development of the thesis we will use the following frameworks in the execution of the program which are Protégé-4, Eclipse for editing and JENA API (Application Program Interface) for programming. Meanwhile, here is a brief description about each framework as follow:

5.1.1 Protégé

Various editors that is used to write libraries of human-selected ontologies. CLORE, DAML, Ontology Design Patterns portal, SchemaWeb and Protégé Ontology. Each editor have its own purpose and usage.

Protégé. Protégé [56] is a free, open source OWL ontology editor and a knowledge-based framework. Protégé is developed by University of Manchester. The main purpose of developing Protégé is for biomedical applications but lately it's had several domains on homogenous areas that had been successfully used for a while.

Protégé is used to load, manipulate and store ontologies on various format including, XML, XML Schema, RDF, RDFS, Relational Database and OWL (as shown in Figure 5-1). Which give it advance of used on comparing with other mentioned tools as Protégé had a flexible architecture makes it easy to configure and extend. Moreover, Protégé has an open-source Java API for the development of custom-tailored user interface components or arbitrary semantic Web services. For example, the OWL Plugin is an extension of Protégé with support for the Web Ontology Language (OWL). Virtually all of the functionality provided by the OWL API is utilized by Protégé-4.
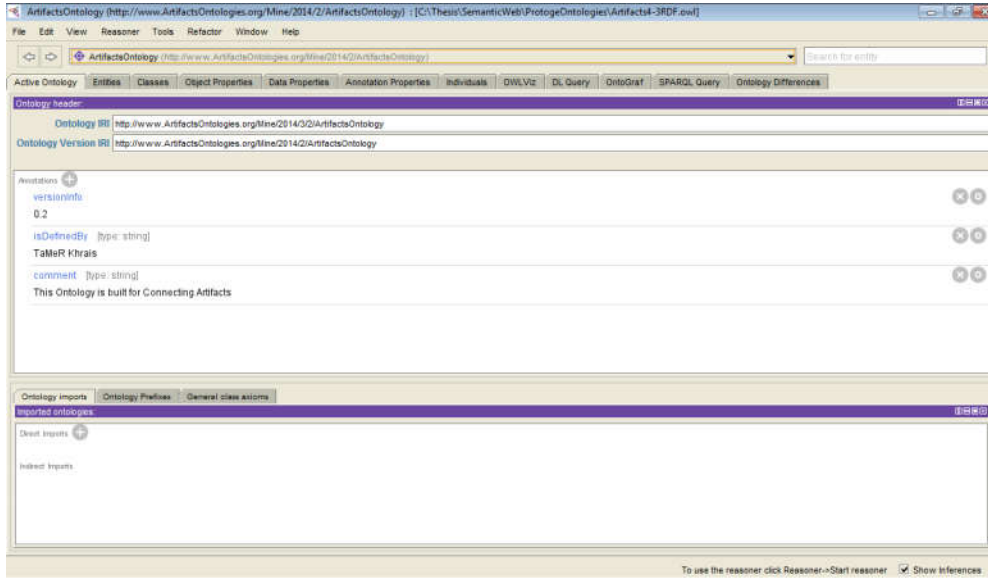
Figure 5-1 Protégé Software

Our decision to build our system on top of Protégé was driven by various factors. Since ontologies play such an important role in Semantic Web applications, it was straight-forward to take an existing ontology development environment as a starting point. Firstly, by basing the OWL Plugin on top of Protégé, we could also reuse Protégé's client-server-based multi-user mode that allows multiple people to edit the same ontology at the same time. Secondly, Protégé also provides a highly scalable database back-end, allowing users to create ontologies with hundreds of thousands of classes. Also, there is already a considerable library of plugins which can be either directly used for OWL or adapted to OWL with little effort. Furthermore, the fact that Protégé is open-source also encourages plugin development. Last but not least, Protégé is backed by a large community of active users and developers, and the feedback from this community proved to be invaluable for the development of the OWL Plugin.

5.1.2   Eclipse with Java SDK

Eclipse is an integrated development environment (IDE) as shown in Figure 5-2written mostly in Java, Eclipse can be used to develop applications. Eclipse may use to develop applications in other programming languages: Ada, ABAP, C, C++, COBOL, FORTRAN, Haskell, JavaScript, Lasso, Lua, Natural, Perl, PHP, Prolog, Python, R, Ruby, Scala, Clojure, Groovy, Scheme, Erlang and Web Services [57].

The Eclipse Software Development Kit (SDK), which includes the Java development tools, is meant for Java developers. Users can extend its abilities by installing plug-ins written for the Eclipse Platform, such as development toolkits for other programming languages, and can write and contribute their own plug-in modules.
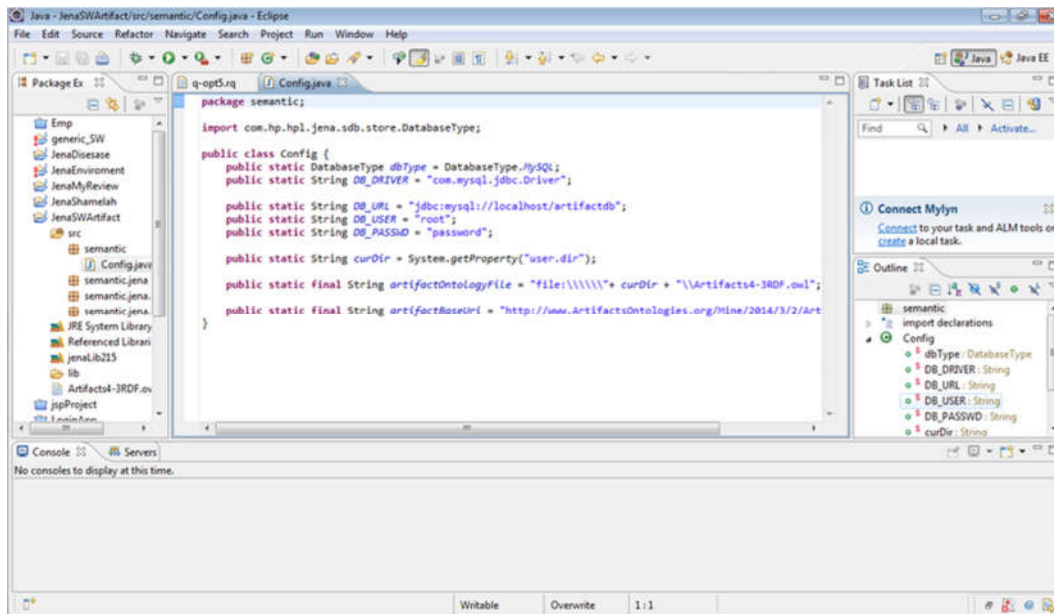
Figure 5-2 Eclipse Editor Snapshot

Jena is an open source Semantic Web framework for Java. It provides an API to extract data from and write to RDF graphs. The graphs are represented as an abstract "model". A model can be sourced with data from files, databases, URLs (Uniform Resource Locater) or a combination of these. A Model can also be queried through SPARQL and updated through SPARQL.

Jena [58] is a Java framework for building semantic Web applications. It provides a programmatic environment for RDF, RDFs and OWL, including a rule based inference engine. The Jena Framework includes a RDF API, reading and writing RDF in RDF/XM, an OWL API, in-memory and persistent storage and RDQL – a query language for RDF. Jena supports serialization of RDF graphs to: a relational database, RDF/XML, Turtle, Notation 3.
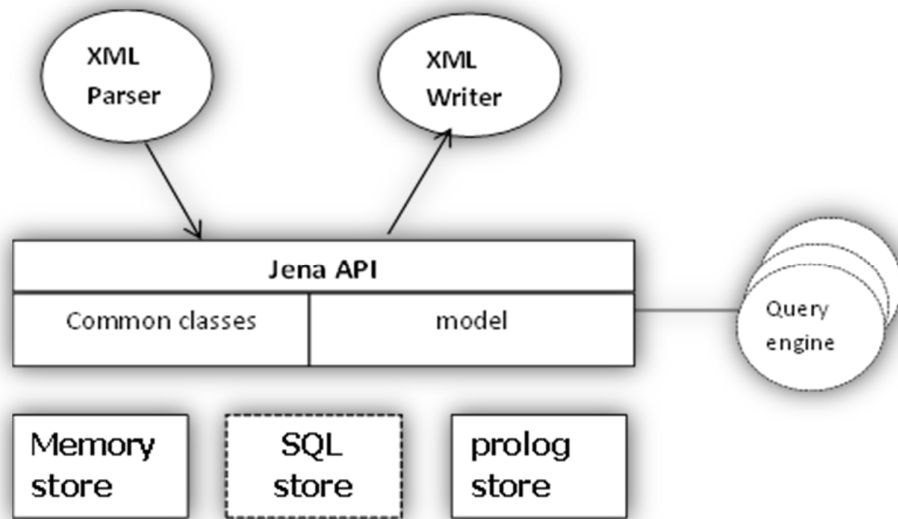
Figure 5-3 JENA API Architecture

As shown in Figure 5-3 JENA API Architecture which contains the JENA API that include the XML parser and XML writer which used to serialization, in addition to the Query Engine that is used by the reasoner to get intelligent results

5.1.3   MYSQL

MySQL officially the world's second most widely used relational database management system (RDBMS) and most widely used. It is named after co-founder Michael Widenius's daughter, My. The SQL acronym stands for Structured Query Language [59].

The MySQL development project has made its source code available under the terms of the GNU General Public License, MySQL is now owned by Oracle Corporation. MySQL is a popular choice of database for use in web applications, and is a central component of the widely used LAMP open source web application software stack. LAMP is an acronym for "Linux, Apache, MySQL, Perl/PHP/Python". Free-software-open source projects that require a full-featured database management system often use MySQL.

According to what said using MySQL as the relational database store was due to the tremendous spread of the tool amongst the world developer. Moreover, the working on storing the information doesn't need a complicated environment as the huge complexity is depend on the reasoner that is used to gain knowledge

5.1.4   JSP

JavaServer Pages (JSP) is a technology that helps software developers create dynamically generated web pages based on HTML, XML, or other document types. Released in 1999 by Sun Microsystemsm, JSP is similar to PHP, but it uses the Java programming language. JavaServer Pages (JSP) is a server-side programming technology that enables the creation of dynamic, platform-independent method for building Web-based applications as shown in Figure 5-4 The JSP Model 2 architecture. JSP have access to the entire family of Java APIs, including the JDBC API to access enterprise databases.

The using of the JSP is for implementing the whole engine for the user with a suitable and easy interface that keep it simple as possible to can be suitable for various users.
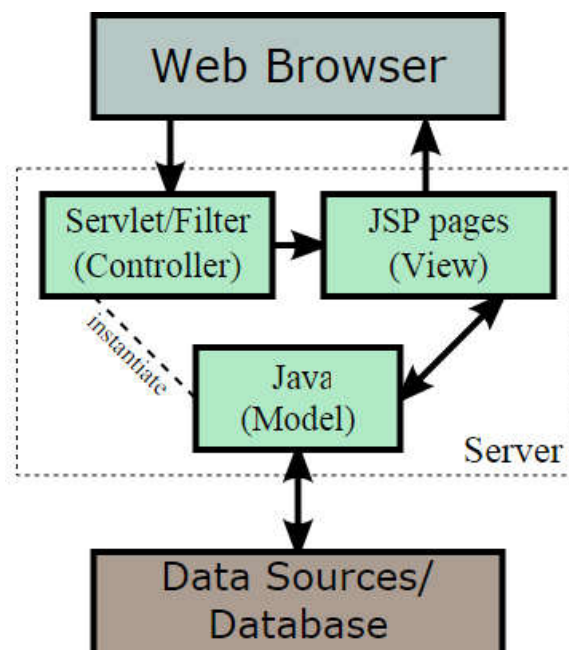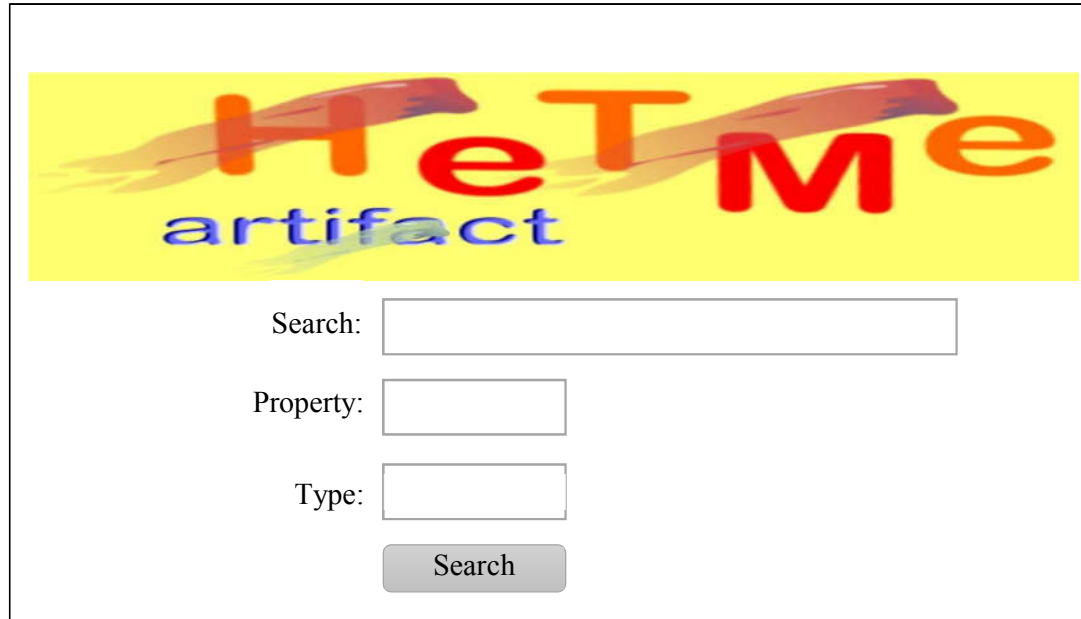
Figure 5-4 The JSP Model 2 architecture

5.2   IMPLEMENTATION OF HeTMe Application

Figure 5-5 HeTMe Website

You can insert the paper title in the search filed then select the property type that you need to classify then choose what to display under the type field if you interested in communicating with Persons had the same interest or what to read more if we want to increase the level of knowledge in the domain.

So HeTMe web application provides the following functionalities:

- Insertion/Manipulation/Deletion of research artifact.
- Searching the database store of the research artifact to gain intelligent interconnection between research artifacts.
- Provide suggestion of what can be a great beginning to continue reading on the new domain so the novice researcher can be applicable to understand the hot topics without wasting time of reading papers that outdated.
- The active domain is the Information Technology but it can be extended to contain multiple domains at the future.

5.3 CONCLUSION

The implementation of the experiment required a mix of multi frameworks and API to produce the final HeTMe application, by using Protégé (which used to write the needed ontology classes, class properties and data properties), Eclipse with Java SDK which are the environment that used to call the JENA API which is majority to work on ontologies, MYSQL which is the warehouse to store all the annotation that is produced by the SPARQL engine and store the local information that is connected with the research artifact and Last but not least the JSP that is the programing language that is used for coding HeTMe Application which in deed used as it support calling the java classes on the backend.

HeTMe Application is the provided solution that is provided by the thesis to produce intelligent results that is already derived when connecting artifacts with each other using the references of each research artifact. For each novice or inexpert user on the field HeTMe will decrease the time need to get a high quality of output results depend on the annotations that is facilitate the interconnections between research artifacts.

Chapter 6.

DISCUSSION, CONCLUSIONS AND FUTURE WORK

6.1 DISCUSSION

The researcher conducted an individual separated interview with two supervisors in the Information Technology field to evaluate the functionalities of the prototype of the website that the study deals with. After declaring the importance of the study and how it can be helpful to helps the novice researchers on any field of study by interfering the new knowledge that is mined by the SPARQL engine to have an interconnection between the researches through the references by the manual annotation to provide them with the system services and development. This system was appreciated by the supervisors and they recommended to go further deeply as it could facilitate the time of effort for researcher to get intelligent interference results that helped them to catch the main point of the example provided by the prototype in comparing with the same circumstances without using the HeTMe Application.

The proposed framework aims at bringing together linking data through the ontology to enrich the search engine with a suitable answers as mentioned before, so the following requirements and issues are taken into account when building the HeTMe application:

- Usability: This is made up of two aspects: i) following the Linked Data principles as it's been build using Semantic Web Ontology, especially the ability to be interlinked to RDF triples on the Web of Data; ii) ease of being fed with new information used by other ontologies.
- Extendibility: The mode in the form of a generic ontology, rather than a domain specific one, and easy to apply to different application areas.
- Expressiveness: The model describe complex chains of artifacts in an easy a hierarchy way.
- Simplicity: light-weight semantics of the proposed model minimize the impact of ontological reasoning on performance.

6.2 SYSTEM COMPARISON

The comparison is considered as the essential key to make progress in building better engines. Thus, It is also important to understand if a search engine is being used effectively in a specific application.

One of the primary distinctions made in the search engines is between effectiveness and efficiency. Effectiveness measures the ability of the search engine to find the right information, and efficiency measures how quickly this is done. Effectiveness and efficiency will be affected by many factors such as the interface used to display search results and techniques such as query suggestion and relevance feedback. It is important to mention that information retrieval research focuses on improving the effectiveness of search, and when a technique has been established as being potentially useful, the focus shifts to find efficient implementations . [59]

But as we are just building a prototype therefore we will evaluate the HeTMe application by comparing the features that's supported by the HeTMe with other previously system which had been developed, as mentioned in the literature review chapter, to conclude the differences between the system features in comparing with inmate systems. As you can see in Table 6-1 Comparison with the HeTMe .

Table 6-1 Comparison with the HeTMe

	ClaiMaker	ScholOnto	HeTMe App
Semantic Web	YES	YES	YES
Modeling research arguments	YES	YES	YES
Semantic Annotation	YES	YES	Manual
Integrated Plug-in	NO	NO	Partially
Chain of research efforts	NO	NO	YES
Intelligent Reasoners	NO	NO	YES
Suggesting Researcher Relationship	NO	NO	YES

While all the above table evaluate our system with two famous systems ClaiMaker and ScholOnto that share the same goal, which is modeling research arguments, but we extend this idea by modeling the relationships between researchers and scholars. By

analyzing research arguments and interconnections between research papers, we can infer which researchers share the same interest, have opposite or complementary views. We can also identify the chain of research efforts that successively build on each other and lead to a particular research contribution.

While the previous solutions focused on the ontology construction and semantic annotation, we think that they did not show how the modeling of research arguments and reasoning can be useful in practice. There is a need to show how this approach can be integrated into recommendation services and web agents in practice to offer intelligent results to the research community.

6.3 FUTURE WORK

The journey of the HeTMe application will not stop here, the approach open the door for future extensions work to the system that will concentrate mainly on enrich the researchers with every possible features they need to enhance the throughput of the system and solve all the limitations that we discuss previously. Therefore, the future work will be on the following points for further hobbies:

- The researcher intend to enrich the ontology with all valuable classes and properties that will raised up of using HeTMe system to enhance the recall of the system after using the system by expert's users.
- Implement a dedicated tool for researcher to annotate research papers so the system provide in with an intelligent manner to the system and classify the papers references
- Open the field for using other domains of research artifacts out the defined scope and can extend to define other languages.
- Integrate the proposed semantic annotation with professional research indexing libraries such as DBLP, LinkedIn, GoogleScholar to offer more intelligent searching and indexing services with our proposed approach.
- Finally, we can concentrate much more on the GUI of the system so we can repaint the output depend on the event trigger using tools such as infoViz or any suitable tool to facilitate the result for the researcher.

6.4 CONCLUSIONS

The thesis presents, through the HeTMe Application, an ontology based approach builds on gathering information of previous systems with extra properties defined by the system which offer several benefits for researcher's especially new novice researcher on the searched domain. So HeTMe enable researchers to quickly explore the research domain and recall the relationships between independent works rapidly. Finally, the system give a new opportunity to support collaborative research and brainstorming by matching and linking researchers who share the same or related interests, a thing that can be powerful to the research community.

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APPENDICES

6.5 Appendix A: ARTIFACTS ONTOLOGY

```xml
<?xml version="1.0"?>
<!DOCTYPE rdf:RDF [
    <!ENTITY owl "http://www.w3.org/2002/07/owl#" >
    <!ENTITY xsd "http://www.w3.org/2001/XMLSchema#" >
    <!ENTITY rdfs "http://www.w3.org/2000/01/rdf-schema#" >
    <!ENTITY rdf "http://www.w3.org/1999/02/22-rdf-syntax-ns#" >
    <!ENTITY ArtifactsOntology
"http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#" >
]>

<rdf:RDF xmlns="http://www.w3.org/2002/07/owl#"
    xml:base="http://www.w3.org/2002/07/owl"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"

xmlns:ArtifactsOntology="http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#"
    xmlns:owl="http://www.w3.org/2002/07/owl#"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
    <Ontology rdf:about="http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology">
        <rdfs:isDefinedBy rdf:datatype="&xsd;string">TaMeR Khrais</rdfs:isDefinedBy>
        <rdfs:comment
rdf:datatype="&xsd;string">This Ontology is built for Connecting Artifacts</rdfs:comment>
        <versionInfo>0.2</versionInfo>
        <versionIRI
rdf:resource="http://www.ArtifactsOntologies.org/Mine/2014/2/ArtifactsOntology"/>
    </Ontology>

    <!--
    ///////////////////////////////////////////////////
    //
    // Object Properties
    //
    ///////////////////////////////////////////////////
     -->

    <!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#OppositeWith -->

    <ObjectProperty rdf:about="&ArtifactsOntology;OppositeWith">
        <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;contradictsWith"/>
    </ObjectProperty>

    <!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#analogousTo -->

    <ObjectProperty rdf:about="&ArtifactsOntology;analogousTo">
        <rdf:type rdf:resource="&owl;SymmetricProperty"/>
        <rdf:type rdf:resource="&owl;TransitiveProperty"/>
        <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;referredTo"/>
    </ObjectProperty>
```

```
<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#betterCompThan -->

<ObjectProperty rdf:about="&ArtifactsOntology;betterCompThan">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;complexity"/>
    <inverseOf rdf:resource="&ArtifactsOntology;lessOrEqualCompThan"/>
</ObjectProperty>

<!--
http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#betterOrEqualCompThan --
>

<ObjectProperty rdf:about="&ArtifactsOntology;betterOrEqualCompThan">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;complexity"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#citedBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;citedBy">
    <rdfs:range rdf:resource="&ArtifactsOntology;Artifact"/>
    <rdfs:domain rdf:resource="&ArtifactsOntology;Artifact"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#complementOf -->

<ObjectProperty rdf:about="&ArtifactsOntology;complementOf">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;extra"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#complexity -->

<ObjectProperty rdf:about="&ArtifactsOntology;complexity">
    <rdfs:subPropertyOf rdf:resource="&owl;topObjectProperty"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#contradictsWith -->

<ObjectProperty rdf:about="&ArtifactsOntology;contradictsWith">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;referredTo"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#defineSoftware -->

<ObjectProperty rdf:about="&ArtifactsOntology;defineSoftware">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;defines"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#defineTerm -->
```

```xml
<ObjectProperty rdf:about="&ArtifactsOntology;defineTerm">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;defines"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#defineTerminology -
-->

<ObjectProperty rdf:about="&ArtifactsOntology;defineTerminology">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;defines"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#defineTool -->

<ObjectProperty rdf:about="&ArtifactsOntology;defineTool">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;defines"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#defines -->

<ObjectProperty rdf:about="&ArtifactsOntology;defines">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;referredTo"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#demonstrates -->

<ObjectProperty rdf:about="&ArtifactsOntology;demonstrates">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;analogousTo"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#disagreeWith -->

<ObjectProperty rdf:about="&ArtifactsOntology;disagreeWith">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;contradictsWith"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#dissimilarWith -->

<ObjectProperty rdf:about="&ArtifactsOntology;dissimilarWith">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;contradictsWith"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#equalComp -->

<ObjectProperty rdf:about="&ArtifactsOntology;equalComp">
    <rdf:type rdf:resource="&owl;SymmetricProperty"/>
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;complexity"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#explains -->
```

```xml
<ObjectProperty rdf:about="&ArtifactsOntology;explains">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;analogousTo"/>
</ObjectProperty>
```

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#extends -->

```xml
<ObjectProperty rdf:about="&ArtifactsOntology;extends">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;extra"/>
</ObjectProperty>
```

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#extra -->

```xml
<ObjectProperty rdf:about="&ArtifactsOntology;extra">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;referredTo"/>
</ObjectProperty>
```

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#extraVersion -->

```xml
<ObjectProperty rdf:about="&ArtifactsOntology;extraVersion">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;citedBy"/>
</ObjectProperty>
```

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#giveExampleOf -->

```xml
<ObjectProperty rdf:about="&ArtifactsOntology;giveExampleOf">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;analogousTo"/>
</ObjectProperty>
```

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasAuthor -->

```xml
<ObjectProperty rdf:about="&ArtifactsOntology;hasAuthor">
    <rdfs:range rdf:resource="&ArtifactsOntology;Author"/>
    <rdfs:domain rdf:resource="&ArtifactsOntology;AuthorRole"/>
</ObjectProperty>
```

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasAuthorRole -->

```xml
<ObjectProperty rdf:about="&ArtifactsOntology;hasAuthorRole">
    <rdfs:domain rdf:resource="&ArtifactsOntology;Artifact"/>
    <rdfs:range rdf:resource="&ArtifactsOntology;AuthorRole"/>
</ObjectProperty>
```

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasKeyword -->

```xml
<ObjectProperty rdf:about="&ArtifactsOntology;hasKeyword">
    <rdfs:domain rdf:resource="&ArtifactsOntology;Artifact"/>
    <rdfs:range rdf:resource="&ArtifactsOntology;Keyword"/>
</ObjectProperty>
```

```
<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasPublisher -->

<ObjectProperty rdf:about="&ArtifactsOntology;hasPublisher">
  <rdfs:domain rdf:resource="&ArtifactsOntology;Artifact"/>
  <rdfs:range rdf:resource="&ArtifactsOntology;Publisher"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasRole -->

<ObjectProperty rdf:about="&ArtifactsOntology;hasRole">
  <rdfs:domain rdf:resource="&ArtifactsOntology;AuthorRole"/>
  <rdfs:range rdf:resource="&ArtifactsOntology;Role"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasSponsor -->

<ObjectProperty rdf:about="&ArtifactsOntology;hasSponsor">
  <rdfs:domain rdf:resource="&ArtifactsOntology;Artifact"/>
  <rdfs:range rdf:resource="&ArtifactsOntology;Sponosor"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#identicalTo -->

<ObjectProperty rdf:about="&ArtifactsOntology;identicalTo">
  <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;analogousTo"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#illustrates -->

<ObjectProperty rdf:about="&ArtifactsOntology;illustrates">
  <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;analogousTo"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#interestedTopics -->

<ObjectProperty rdf:about="&ArtifactsOntology;interestedTopics">
  <rdfs:domain rdf:resource="&ArtifactsOntology;Author"/>
  <rdfs:range rdf:resource="&ArtifactsOntology;Keyword"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#interprets -->

<ObjectProperty rdf:about="&ArtifactsOntology;interprets">
  <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;analogousTo"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isAnExample -->
```

```xml
<ObjectProperty rdf:about="&ArtifactsOntology;isAnExample">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isAnalogousFor"/>
</ObjectProperty>



<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isAnalogousFor -->

<ObjectProperty rdf:about="&ArtifactsOntology;isAnalogousFor">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;citedBy"/>
</ObjectProperty>



<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isComplementOf -->

<ObjectProperty rdf:about="&ArtifactsOntology;isComplementOf">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isExtra"/>
</ObjectProperty>



<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isContradictsWith -->

<ObjectProperty rdf:about="&ArtifactsOntology;isContradictsWith">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;citedBy"/>
</ObjectProperty>



<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isDefinedIn -->

<ObjectProperty rdf:about="&ArtifactsOntology;isDefinedIn">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;citedBy"/>
</ObjectProperty>



<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isDefinedSoftware -->

<ObjectProperty rdf:about="&ArtifactsOntology;isDefinedSoftware">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isDefinedIn"/>
</ObjectProperty>



<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isDefinedTerm -->

<ObjectProperty rdf:about="&ArtifactsOntology;isDefinedTerm">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isDefinedIn"/>
</ObjectProperty>

<!--
http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isDefinedTerminology -->

<ObjectProperty rdf:about="&ArtifactsOntology;isDefinedTerminology">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isDefinedIn"/>
</ObjectProperty>
```

```
<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isDefinedTool -->

<ObjectProperty rdf:about="&ArtifactsOntology;isDefinedTool">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isDefinedIn"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isDemonstraedBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;isDemonstraedBy">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isAnalogousFor"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isDissagreedBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;isDissagreedBy">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isContradictsWith"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isDissimilaredBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;isDissimilaredBy">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isContradictsWith"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isExplainedBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;isExplainedBy">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isAnalogousFor"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isExtendendBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;isExtendendBy">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isExtra"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isExtra -->

<ObjectProperty rdf:about="&ArtifactsOntology;isExtra">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;citedBy"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isIdenticalTo -->

<ObjectProperty rdf:about="&ArtifactsOntology;isIdenticalTo">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isAnalogousFor"/>
</ObjectProperty>
```

```
<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isIllustraedBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;isIllustraedBy">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isAnalogousFor"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isInterpretedBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;isInterpretedBy">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isAnalogousFor"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isOppositedBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;isOppositedBy">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isContradictsWith"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isPrerequisteFor -->

<ObjectProperty rdf:about="&ArtifactsOntology;isPrerequisteFor">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isExtra"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isRefusedBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;isRefusedBy">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isContradictsWith"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isSimilarTo -->

<ObjectProperty rdf:about="&ArtifactsOntology;isSimilarTo">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isAnalogousFor"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isSolvedBy -->

<ObjectProperty rdf:about="&ArtifactsOntology;isSolvedBy">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;isExtra"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#lessCompThan -->

<ObjectProperty rdf:about="&ArtifactsOntology;lessCompThan">
    <inverseOf rdf:resource="&ArtifactsOntology;betterOrEqualCompThan"/>
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;complexity"/>
</ObjectProperty>
```

```
<!--
http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#lessOrEqualCompThan -->

<ObjectProperty rdf:about="&ArtifactsOntology;lessOrEqualCompThan">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;complexity"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#prerequisteTo -->

<ObjectProperty rdf:about="&ArtifactsOntology;prerequisteTo">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;extra"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#priorVersion -->

<ObjectProperty rdf:about="&ArtifactsOntology;priorVersion">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;referredTo"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#referredTo -->

<ObjectProperty rdf:about="&ArtifactsOntology;referredTo">
    <rdfs:range rdf:resource="&ArtifactsOntology;Artifact"/>
    <rdfs:domain rdf:resource="&ArtifactsOntology;Artifact"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#refused -->

<ObjectProperty rdf:about="&ArtifactsOntology;refused">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;contradictsWith"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#similarTo -->

<ObjectProperty rdf:about="&ArtifactsOntology;similarTo">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;analogousTo"/>
</ObjectProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#solved -->

<ObjectProperty rdf:about="&ArtifactsOntology;solved">
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;extra"/>
</ObjectProperty>
```

```xml
<!--
///////////////////////////////////////
//
// Data properties
//
///////////////////////////////////////
 -->

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#abstract -->

<DatatypeProperty rdf:about="&ArtifactsOntology;abstract">
    <rdfs:domain rdf:resource="&ArtifactsOntology;Artifact"/>
    <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#address -->

<DatatypeProperty rdf:about="&ArtifactsOntology;address">
    <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#details -->

<DatatypeProperty rdf:about="&ArtifactsOntology;details">
    <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#firstName -->

<DatatypeProperty rdf:about="&ArtifactsOntology;firstName">
    <rdfs:domain rdf:resource="&ArtifactsOntology;Author"/>
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;name"/>
    <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasAbstract -->

<DatatypeProperty rdf:about="&ArtifactsOntology;hasAbstract">
    <rdfs:domain rdf:resource="&ArtifactsOntology;Artifact"/>
    <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasEmail -->

<DatatypeProperty rdf:about="&ArtifactsOntology;hasEmail">
    <rdfs:domain rdf:resource="&ArtifactsOntology;Author"/>
    <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>
```

```xml
<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasPhone -->

<DatatypeProperty rdf:about="&ArtifactsOntology;hasPhone">
  <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasPhoto -->

<DatatypeProperty rdf:about="&ArtifactsOntology;hasPhoto">
  <rdfs:domain rdf:resource="&ArtifactsOntology;Author"/>
  <rdfs:range rdf:resource="&xsd;anyURI"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#hasTitle -->

<DatatypeProperty rdf:about="&ArtifactsOntology;hasTitle">
  <rdfs:domain rdf:resource="&ArtifactsOntology;Artifact"/>
  <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isDOB -->

<DatatypeProperty rdf:about="&ArtifactsOntology;isDOB">
  <rdfs:domain rdf:resource="&ArtifactsOntology;Author"/>
  <rdfs:range rdf:resource="&xsd;dateTime"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isDOD -->

<DatatypeProperty rdf:about="&ArtifactsOntology;isDOD">
  <rdfs:domain rdf:resource="&ArtifactsOntology;Author"/>
  <rdfs:range rdf:resource="&xsd;dateTime"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#isTitle -->

<DatatypeProperty rdf:about="&ArtifactsOntology;isTitle">
  <rdfs:domain rdf:resource="&ArtifactsOntology;Author"/>
  <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#lastName -->

<DatatypeProperty rdf:about="&ArtifactsOntology;lastName">
  <rdfs:domain rdf:resource="&ArtifactsOntology;Author"/>
  <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;name"/>
  <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>
```

```xml
<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#middleName -->

<DatatypeProperty rdf:about="&ArtifactsOntology;middleName">
    <rdfs:domain rdf:resource="&ArtifactsOntology;Author"/>
    <rdfs:subPropertyOf rdf:resource="&ArtifactsOntology;name"/>
    <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#name -->

<DatatypeProperty rdf:about="&ArtifactsOntology;name">
    <rdfs:range rdf:resource="&xsd;string"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#sponosorFees -->

<DatatypeProperty rdf:about="&ArtifactsOntology;sponosorFees">
    <rdfs:range rdf:resource="&xsd;double"/>
</DatatypeProperty>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#sponosorYear -->

<DatatypeProperty rdf:about="&ArtifactsOntology;sponosorYear"/>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#webSite -->

<DatatypeProperty rdf:about="&ArtifactsOntology;webSite">
    <rdfs:range rdf:resource="&xsd;anyURI"/>
</DatatypeProperty>


<!--
///////////////////////////////////////////////////////////////
//
// Classes
//
///////////////////////////////////////////////////////////////
 -->

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Artifact -->

<Class rdf:about="&ArtifactsOntology;Artifact"/>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Author -->

<Class rdf:about="&ArtifactsOntology;Author"/>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#AuthorRole -->
```

```
<Class rdf:about="&ArtifactsOntology;AuthorRole"/>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Keyword -->

<Class rdf:about="&ArtifactsOntology;Keyword"/>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Publisher -->

<Class rdf:about="&ArtifactsOntology;Publisher"/>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Role -->

<Class rdf:about="&ArtifactsOntology;Role"/>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Sponosor -->

<Class rdf:about="&ArtifactsOntology;Sponosor"/>


<!--
///////////////////////////////////////////////////////////
//
// Individuals
//
///////////////////////////////////////////////////////////
 -->

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Analyzer -->

<NamedIndividual rdf:about="&ArtifactsOntology;Analyzer">
    <rdf:type rdf:resource="&ArtifactsOntology;AuthorRole"/>
</NamedIndividual>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Cooperative -->

<NamedIndividual rdf:about="&ArtifactsOntology;Cooperative">
    <rdf:type rdf:resource="&ArtifactsOntology;AuthorRole"/>
</NamedIndividual>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Developer -->

<NamedIndividual rdf:about="&ArtifactsOntology;Developer">
    <rdf:type rdf:resource="&ArtifactsOntology;AuthorRole"/>
</NamedIndividual>

<!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#MainAuthor -->

<NamedIndividual rdf:about="&ArtifactsOntology;MainAuthor">
    <rdf:type rdf:resource="&ArtifactsOntology;AuthorRole"/>
```

```
    </NamedIndividual>

    <!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Reviewer -->

    <NamedIndividual rdf:about="&ArtifactsOntology;Reviewer">
        <rdf:type rdf:resource="&ArtifactsOntology;AuthorRole"/>
    </NamedIndividual>

    <!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Supervisor -->

    <NamedIndividual rdf:about="&ArtifactsOntology;Supervisor">
        <rdf:type rdf:resource="&ArtifactsOntology;AuthorRole"/>
    </NamedIndividual>

    <!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#Tester -->

    <NamedIndividual rdf:about="&ArtifactsOntology;Tester">
        <rdf:type rdf:resource="&ArtifactsOntology;AuthorRole"/>
    </NamedIndividual>

    <!-- http://www.ArtifactsOntologies.org/Mine/2014/3/2/ArtifactsOntology#artifactInd1 -->

    <NamedIndividual rdf:about="&ArtifactsOntology;artifactInd1">
        <rdf:type rdf:resource="&ArtifactsOntology;Artifact"/>
        <ArtifactsOntology:isTitle>ScholOnto: An Ontology-Based Digital Library Server for
Research Documents and Discourse</ArtifactsOntology:isTitle>
        <ArtifactsOntology:abstract>The internet is rapidly becoming the first place for researchers to
publish documents, but at present they receive little support in searching, tracking, analyzing or
debating concepts in a literature from scholarly perspectives. This paper describes the design
rationale and implementation of ScholOnto, an ontology-based digital library server to support
scholarly interpretation and discourse. It enables researchers to describe and debate via a semantic
network the contributions a document makes, and its relationship to the literature. The paper
discusses the computational services that an ontology-based server supports, alternative user
interfaces to support interaction with a large semantic network, usability issues associated with
knowledge formalization, new work practices that could emerge, and related
work.</ArtifactsOntology:abstract>
    </NamedIndividual>
</rdf:RDF>

<!-- Generated by the OWL API (version 3.4.2) http://owlapi.sourceforge.net -->
```

6.6   Appendix B: CODE OF APPLICATION

You can kindly found all the HeTMe System on the attachment CD.