

A ROAD MAP FOR KILLER APPLICATIONS IN RESOURCE DESCRIPTION FRAMEWORK (RDF) AND TOPIC MAPS

Fakhre Alam¹, Sami Ur Rahman², Shah Khusro³, Shaukat Ali⁴
^{1,2}Department of Computer Science and IT, University of Malakand

Dir (Lower), Pakistan

^{3,4}Department of Computer Science University of Peshawar, Peshawar, Pakistan

fakhrealam@uom.edu.pk, srahman@uom.edu.pk, khusro@upesh.edu.pk, shoonikhan@upesh.edu.pk

ABSTRACT- The size of current web is increasing day-by-day at exponential rate and has created difficulties for the users to access precise and specific information. Although Information on the current web is accessible through computers but only understandable to human beings. Semantic Web is a response to this problem the idea of which was coined by the original creator of the web, Tim-Berners-Lee. This future web aims to attach metadata to web resources in a format that makes web contents machine-processable. Resource Description Framework (RDF) and Topic Maps are the two prominent standards of Semantic Web developed for machine processing of web contents. These two standards can effectively create metadata relationship among web contents. Applications are necessary to embed semantic structure in the current web in a manner to implement the vision of Semantic Web into reality. Applications based on RDF and Topic Maps can store and organize knowledge in a better way and manage large repositories in an efficient manner. Moreover, applications which never existed before, and had extraordinary functions that superseded their competitors, are called killer applications. In this paper, we are aimed to present a comprehensive survey of the available applications, determine the similarities and differences among them. We also investigated the main reason due to which RDF and Topic Maps have not come to the main stream market yet. It is concluded that a Lack of killer application is the prominent factor effecting the wide spread use of RDF and Topic Maps.

Keywords: Current Web, Semantic Web, RDF, Topic Maps, Applications, Killer Application

1. INTRODUCTION

Information on the current web is only presented in a human readable form without any annotation for making the machine capable to deduce anything on its own [1]. Information is presented in different structured formats to the user and then he/she can try to retrieve and interpret specific information of his/her own interest. In this type of web, information is conveyed to the user without any semantic relation among them. Due to the rapid changes and unrelated and excessive amount of information, on the web today, humans become overwhelmed and retrieval of precise information are difficult and time consuming for them. Semantic Web is a response to this problem. This future web is the extension of the current web, where the relationship between information will be in implicit, meaningful and in machine understandable form and thus an environment will be created on the web where people and computers will work in cooperation [2]. The machine will not only display this information but also integrate it in more effective and efficient way. The machine will easily apply computation on this information and then such type of information will be reusable across multiple domains.

To implement the vision of Semantic Web and make it a useful medium for both humans and machines, the need of technologies and standards arises to effectively understand web contents. RDF and Topic Maps are the two prominent among them. Although RDF and Topic Maps were developed by different organizations but the goal was same i.e. make the Web useful for humans and understandable by machine by facilitating knowledge integration and sharing. RDF was developed by the W3C and the main purpose of this standard was to implement metadata relationship between web resources. RDF makes a way for different software applications to interchange the web resources which is more machine dependent so that the different software applications become interoperable and the resources on the Web process

automatically by machine [3]. Topic Maps can create a meta model from the existing knowledge on the web which could be used for wider applications e.g. to represent exchange and convey knowledge on the Semantic Web.

To translate the dream of Semantic Web into a reality, the semantics in the form of metadata should be fully embedded in two standards i.e. RDF and Topic Maps. To embed the semantic structure in the current web, there is a need of applications which integrate data and improve search mechanism to more specialized and intelligent level. Applications generally show the characteristics of RDF and Topic Maps tools. With the help of applications, distributed and heterogeneous information resources can be enabled for visual access. Applications based on RDF and Topic Maps can store and organize knowledge in a better way and manage large repositories in an efficient manner.

RDF and Topic Maps based applications were developed to achieve the above goals and provide users the facility to create and manage Semantic Web technologies in a simple and flexible way. RDF and Topic Maps applications can provide adaptive and customized views by analyzing the user current task/activity, and based on it, gives response to the users in a particular context. Specialized browsers based on these applications are used for visualization and navigation within specific domains, due to which the users can easily and quickly explore inside the domain and build up their own thinking of conceptual associations and problem solving paths. In short, due to these applications RDF and Topic Maps based information can be efficiently manipulated, structure of knowledge / resources could be maintained precisely and both knowledge and information layer can be easily searched, navigated and visualized.

Invention of application software from time to time in computer industry becomes a source of attraction for the customers. In these applications development, some of the

applications at a particular time become so popular that a large number of people purchase the systems on which these applications could work. Such type of applications which never existed before, and had extraordinary functions that superseded their competitors, are called killer applications [4]. For example, spread sheet package was the killer application in 1980's that was run on apple computer only at that time and became a source of attraction for the people who were involved in financial matters. In the World Wide Web jargons, the email was called the killer application in early 90's. In short, one can say that for any technology to be used everywhere in the global market and become a source of attraction for everyone, the development of killer application would be needed.

Lack of a killer application is a prominent factor effecting RDF and Topic Maps wide spread use. In spite of the availability of a number of applications and tools for RDF and Topic Maps, the development of a killer application is still missing. This research paper is aimed to provide a comprehensive overview and analysis of the available RDF and Topic Maps applications and their possible application areas, covering all of their possible aspects, and pros and cons. It also attempts to find out how RDF and Topic Maps can be used widely in main stream market with the presence of killer application. In this paper, a comprehensive literature study has been done and comparison of RDF and Topic Maps applications are drawn. Main contributions of the paper are:

- To provides a concise overview of the available applications for RDF and Topic Maps
- Explore the possible application areas of RDF and Topic Maps
- The work is almost unique in its integrity and opens new area of research.
- The classification and comparison of RDF and Topic Maps applications in such a manner have never done before in a single document. Therefore, it will provide a compact platform for the users and researchers to grab almost all of the relevant possible information about the topic in a single document.
- This research paper will catch and boost interest of the new researchers because the literature about the topic is organized and classify in an attractive manner.
- Information about the topic is currently available in various domains and with their success stories and common reasons of failure. Therefore, this paper will provide all the available information in a single document which grabs the interest of new researchers in this area.

2. EVALUATION FRAMEWORK AND METHODOLOGY

RDF and Topic Maps are trying to fulfill the vision of Semantic Web by enriching the dispersed resources in the Web with metadata to solve the problem of knowledge sharing and integration. Although RDF and Topic Maps were standardized by two independent organizations i.e. W3C and ISO respectively but the goals is unique, which is to represent the metadata relationship between web resources. In the Semantic Web paradigm applications integrate data, improve search mechanism and embed semantic structure in the current World Wide Web. It is due to these applications

that the current web is enhanced day by day with intelligent techniques. The characteristics of the tools belong to RDF and Topic Maps can be easily shown easily to the users with the help of these applications. Visual access of RDF and Topic data is possible due to the unique features of their applications. Knowledge storage and organization in large repositories can be done in an effective way due to the advanced features of RDF and Topic Maps applications. Practically, Applications and RDF/Topic Maps are two different things. An application generally show the features and characteristics of related to particular tool and technique whereas, a RDF/Topic Map represents a metal conceptual data model of information in a domain. But, to make a RDF/Topic Maps data more understandable and flexible to users, it needs to be represented in an application. In other words, application is like the interface between inside and outside world, while RDF and Topic Maps are the data model is the informational content behind words. A data model is an abstract model – it does not matter how one represent it as long as one stay true to its abstract properties. An application typically show the information provided by the associated data modeling technology. To win the race, both of the competitors RDF and Topic Maps supports a variety of applications varying in different aspects such as open source and commercial availability, availability of tools and APIs, different underlying development language and different market values. However, each individual application provides excellent overall results and has the potential to boost the associated technology in the race but eventually the Semantic Web technology. In this paper, to give insight knowledge and understanding of the onhand RDF and Topic Maps applications, they are evaluated against a set of criteria including availability as open source or commercial, development platforms, tools and APIs availability, market value and the most important the availability of killer application in the market. In order to compare the different applications, simple book ontology is developed and tested by different RDF and Topic Maps applications to derive conclusions for the criteria (shown in Table 1).

- Availability: RDF and Topic Maps applications are mostly available as open source due to which users can easily download and use them without any payment and other formalities. An application with open source availability is obviously a liked one but often result in low computational performance. Similarly, an open source applications can effected by external threats such as virus and worms much easily as compared to commercial one.
- Development Platform: The development platforms for these applications are Java, C and Ruby. However, most of them are developed in Java which is platform and independent and have much advanced features due to which programmer can take benefit from it.
- Tools/ APIs Support: For a applications to be accepted by users needs strong support from software tools and APIs paradigms. A tool or an API provides an environment for users to create, store, edit, maintain, and visualize a data model. From the analysis it is deduced that several types of tools and APIs such as protégé, Onotoa, Sesame, Bigdata, Ontopia, TM4J etc are available for each application. The

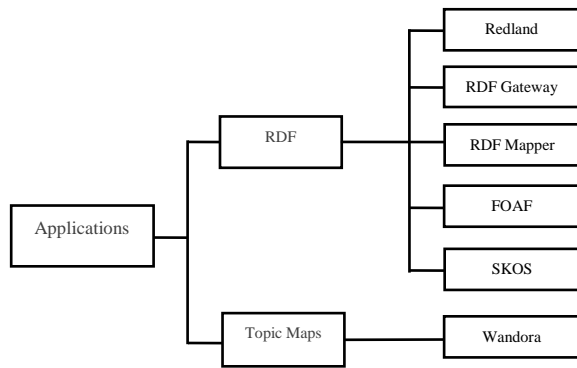


Figure 1. Categorization of RDF and Topic Maps Applications

more an application is supported by the tools and APIs, the higher will be its market value.

- **Killer Application:** A killer application determines the wide spread use and availability of any technology in the main stream market. There is no killer application available for RDF and Topic Maps yet. It is due to the absence of killer application that these two technologies have not adopted by the main stream market.

3. POTENTIAL APPLICATION AREAS OF RDF/ PERSONAL INFORMATION MANAGEMENT

In Personal Information Management (PIM) [5], digital resources on the Web are used, systematically organized, accessed to, and maintained with the help of specialized tools for the users to work better in a collaborative environment. Due to the use of these tools and techniques, a user spends less time while searching information and each time the precise information is available to the user at the right time. Although personalized information on the Web is available in huge amount but due to the lack of semantics, users face great problem when searching and organizing it. These resources can be produced and organized in a standardized form if used with Semantic Web technology such as RDF. The reason is that RDF establishes a semantic relationship between web resources and expresses web resources in a customized and flexible environment.

The major requirement for information to be personalized is to put it in one place, which was not possible in traditional web. In traditional web, information was located at different places i.e. in file, specific repositories, between web and email client and servers [6]. Therefore, to combine different types of information such as email, chat, news, and community blogs in a single page, different ontological tools based on RDF were developed and deployed. One of the features provided by the PIM to the users is to perform operation on information objects by just clicking on the link without any need to go into the detailed coding of these objects. Due to PIM, based on RDF technology, information is presented to the users according to the situation and user selection. To represent PIM resources in RDF, several types of ontologies are already available such as vCard, FOAF, MediaWiki, Calendar based on RDF, Iannella 2002, Studer 2001, Brickley 2001, Miller 2002, SWRC and Dublin core-1999.

4. RESOURCE DESCRIPTION FRAMEWORK (RDF) AND TOPIC MAPS APPLICATIONS

Several types of powerful applications are available in the market for RDF and Topic Maps authoring, accessing, viewing, visualizing, and merging as shown in Figure 1. These applications are further discussed in the sub-sections below.

4.1. Applications Based on Topic Maps

The complexity in Topic Maps technology is increasing day by day due to the additions of millions of topics with complex associations and wide occurrences. To properly run this technology, effectively and without any crash, improve its performance and to easily access the data, different software applications were developed. The purpose of Topic Maps based applications are to analyze performance and management, provide easy and flexible environment for the users to interact with Topic Maps, create sub applications, link and integrate different Topic Maps components, quicker and intelligent retrieval of information, browsing and visualization, and finding out errors.

Topic Maps based applications are used in a variety of ways, ranging from simple to complex type. A simple Topic Maps based application can provide facility for the user through its simple interface, to create and browse not only their own topics and associations but also the topics and associations created by other users [7]. On the other hand, several types of complex applications are also available which are used to manage collaborative system and discussion forums, contents management systems in digital libraries, e-learning, enterprise level information integration, knowledge management and web publishing. These applications can store and manipulate Topic Maps data in a persistent way using different types of methods and techniques.

Topic Maps applications also play a vital role in the management and maintenance of digital e-learning web based libraries [8]. These types of libraries are useful for the students when they want to learn in their own particular area based on context. Powerful and efficient applications based on Topic Maps are available which include searching tools for quick and easy access to learning resources and authoring tools for the instructor to manage and keep instructional materials. With the development of Topic Maps, several types of powerful applications for Topic Maps standard were also developed to author, visualize, edit, search, access and manage Topic Maps metadata.

4.1.1. Wandora

Wandora [9] is an application of Topic Maps which is freely available to the users and it works under the GNU GPL license. Wandora is written in Java and its architecture is flexible and pluggable to other software and APIs. This general purpose application is a complete model for browsing and visualization of both Topic Maps data and graph. Besides its built-in capability to visualize topics as tree map, it also provides a mechanism through which users can create their own visualization, distribute knowledge in multiple layers due to which users can only view information of their interest only and unrelated information will be hidden from them. Using Wandora, scattered and distributed knowledge in multiple and independent locations can be merged automatically, and locking mechanism of any type, for

instance, read/write can be applied to any part of the Topic Maps. Topic Maps data can be stored in both memory based and database storage format. Wandora can import and export Topic Maps data in several interchange formats such as XTM and LTM. Topic Maps can be extracted from more than 40 sources including, PDF Extractor, Flickr Extractors, Twitter Extractor, YouTube extractor and Simple Text Document Extractors.

4.2. Applications Based on RDF

Resources in RDF are related to each other through SPO (subject, predicate and object). The relationship in this form becomes very cumbersome due to the huge and increasing amount of resources on the current web. The main reason behind this complex and confusing situation is due to the additions of millions of subjects, objects and their relationship through predicates. Due to this reason it will not be easy for users to manage, retrieve and work with RDF data. Therefore, different software applications based on RDF were developed which help users to easily and efficiently work with RDF data.

RDF resources in the form of SPO can be efficiently read and written with the help of these web applications. RDF based applications provide flexible and domain specific architecture for an application developer to work with data in familiar formats, and retrieve and integrate the data in short time due to the working in domain of his own interest only. Although information are stored and manipulated by the RDF model but still there is an intense need of effective applications to work with RDF technology [10]. In other words, one can say that the application requirements and its implementation are two different things due to which the interaction with RDF system will not be so efficient. Since the internal work of any system depends greatly on its applications, because applications optimize the working of the system, this becomes necessary that we not only implement RDF data but also create a flexible application framework which may enhance and improve performance and interaction with the RDF system more efficiently.

Various applications for RDF are available, which provide semantically unified interfaces for the users. These applications range from simple searching to complex resource exploration of hypermedia documents and contents management systems of large repositories.

4.2.1. Redland

Redland [10] is an application framework developed in C programming language and is used for manipulation of RDF resources as a whole or in parts. In this application, several types of facilities are available for parsing, querying and storing RDF model. The APIs of this application framework are written in multiple languages such as C, Perl and Python due to which Redland is a good choice for the integration of data in a rapidly changeable environment. This open-source software uses multiple parsers and layers for different types of RDF interchange syntaxes e.g. RDF/XML and persistent storage of RDF data in memory.

Using Raptor RDF Syntax Library, Redland can read and write RDF in several serialization formats such as RDF/XML, N3 and Turtle [11]. Querying RDF resources can be done by this application with the help of Rasql RDF Query Library. The connectivity of Redland with other tools and

languages such as Perl, PHP, Python and Ruby is also very effective due to the availability of Redland Bindings Package.

4.2.2. RDF Gateway

RDF gateway [12] is a commercial application which contains several important features including full text search, inference engine, Query language similar to SQL, wide range of data types support, support for the integration of data that is remotely located, and availability of different types of interfaces. This tool provides an efficient support similar to ASP and JSP for web page template such as web services and storage and querying facility. RDF gateway is an extended application having several types of additional services and supporting tools for the effective management of RDF resources. The extendibility and additional support can be achieved by the RDF gateway using COM/COM+ objects and Gateway packages. Besides this, the important features of this application are to precisely access data from multiple RDF storage and its strong inferencing capability.

4.2.3. RDF Mapper

RDF Mapper [13] is an open source application and web mapping service developed in Ruby which supports several types of RDF vocabularies that contain geographic information. Using this application, users can retrieve resources in the form of maps from RDF files based on geographic locations. This application has full functionality of Ruby library which has high performance, support for SPARQL, XML and N-Triples. RDF Mapper is under developmental stage; therefore, its market value is minimal as compared to other applications.

4.2.4. Friend-of-a-Friend (FOAF)

FOAF [14] is another open-source software application based on RDF which describes the ontology of a person, his social and daily activities and his relations and links to other persons. FOAF is easy to use and there is no need / restriction for people to consult a centralized database. Anyone can use its services and can join group of people in a social network. For RDF and OWL resources, FOAF acts as a kind of descriptive vocabulary because while using it, relationships among people are defined and based on it profiles are created. These profiles are then used by the computer to locate appropriate people belonging to particular areas of interest. Although the FOAF implementation on the Web is limited but still there are several communities such as My Opera, Live Journal, FriendFeed¹, TypePad services and plug-in for Safari and Firefox browser.

FOAF has the capability to interrelate itself with RDF/XML and automatically discover its files with the help of web bots [12]. A unique feature of this application is that any type of technology that is suitable and workable with RDF/XML can also work with FOAF along with its own specialized technologies. Efforts are being made to extend this technology from personal connectivity to a large environment of corporate connectivity.

4.2.5. Simple Knowledge Organization System (SKOS)

SKOS application is another system based on RDF, developed for the publishing of different types of vocabularies and for the indexing of resources related to the

¹ <http://friendfeed.com/>

Table 1. Analysis and Comparison of RDF and Topic Maps Applications

RDF and Topic Maps	Technology	Application Name	Availability	Development Platform	Tools/APIs Availability	Market Value	Killer
	Topic Maps		Wandora	Open Source	Java	Yes	High
RDF		Redland	Open Source	C	Yes	High	Not Available
		RDF Gateway	Commercial	Java	Yes	----	
		RDF Mapper	Open Source	Ruby	Yes	Low	
		FOAF	Open Source	Java	Yes	Low	
		SKOS	Open Source	Java	Yes	High	

Semantic Web and information system [15]. RDF resources can be collected, associated, integrated and published on the Web with SKOS application. This open source application was developed by the SWAD-Europe project in 2003 and then standardized by W3C’s SWDWG² working group in 2004. The main feature of SKOS is its easy and cheap way to port existing system to the Semantic Web system. The architecture of SKOS is extendible and consists of concepts and their schemes, labels, semantic relationships and documentation.

4.3. Tabulated Representation and Analysis of RDF and Topic Maps Applications

Table 1 is the representation of RDF and Topic Maps applications based on the parameters discussed in sections 3.1 and 3.2. It is obvious from the Table that most of the applications are open source, have high market value, developed in Java and tools/APIs are available for each application.

5. KILLER APPLICATIONS IN RDF AND TOPIC MAPS

Topic Maps is struggling to enter into the main stream market with a killer application but still there is no killer application developed yet for this technology [16]. The main reasons due to which Topic Maps do not become the powerful technology for Knowledge Management in the world of science and business, mainly due to the absence of killer application for it. Some of the important reasons, due to which killer application was not developed yet for Topic Maps, are in the subsequent paragraph.

The lack of adaptation of this technology by the main stream market and gap between early adopters’ market sector and the early majority market sector. Poor definition and explanation of its primary values due to which there is no primary market for this technology. Lack of availability of applications for the collaborative development of Topic Maps. Poor visualization of complex and problem-oriented Topic Maps and no availability of Topic Maps engines and APIs in different languages. Although this technology has many good standardized graphical notations while modelling data, it fails to model knowledge in a standardized graphical notation. Absence of user cases, repository and information about successful and unsuccessful projects. Less number of published and model Topic Maps because most of them are just for testing purpose. There is no common agreement on the scope, usage and merging. Missing of Topic Maps

courses in universities curriculum and less number of application developers.

To bring Topic Maps into the main stream market, it needs to be made transparent to the beginner and expert users, and applicable to any specific domain of the users own choice. An application would be needed which should be powerful, smart to work according to the context, have clear and different types of visual effects such as tree and graph, flexible, cheap and can run easily in any type of environment. Application with the above mentioned characteristics would surely be called killer application for Topic Maps. To achieve this target a lot of work and success has already been done by the Topic Maps programmers and it is hoped that soon there will be a Topic Maps technology everywhere because of its killer application

As compared to Topic Maps, RDF has several powerful and flexible tools and applications and one can say that this technology is more dominant and common among the Semantic Web community. Although RDF has large number of tools and applications but still no such application fulfils the requirements of killer application to attract the web community because of its early stages [17]. The potential of Killer application development of RDF is easier as compared to Topic Maps because information in RDF can be integrated from various sources much easily and efficiently.

With the introduction of killer applications in RDF, the disintegrated and diverse users will unite into a common practicing platform and will interact with RDF in a natural language [17]. Knowledge will be used by the beginner without prior expertise and will be shared easily among communities and users will get the benefit of high quality service without any extra cost and burden. Personalization and ontology construction will become easier for common users due to killer application. Also due to intelligent techniques the old contents would be up to date and maintained according to the new needs. On the other hand, care should be taken while introducing killer application that the lives and privacy of the users should be safe and not be at any type of risk.

6. CONCLUSION

To enhance searching mechanism by embedding semantic structure in the current web, several types of applications have been developed for RDF and Topic Maps technologies. These applications can visually access heterogeneous and distributed information. Knowledge storage and organization can also be effective with the help of these applications. Beside this, several types of other facilities are also provided by these applications, such as analysis of user’s current tasks

² <http://www.w3.org/2006/07/swdwg-charter>

and activities, performance and management analysis, integration of various components of RDF and Topic Maps, error finding and recovery and the management of collaborative systems. In Personal Information Management (PIM) systems digital resources from diverse sources on the Web and desktop are organized in a systematic and evolutionary manner in order to make it scalable over lifetime. These tools have successfully utilized RDF and OWL technology, however, Topic Map technology has attracted very little attention of researchers in the field. Topic Maps being more close to the PIM world needs an equal opportunity. However, Lack of a killer application is a prominent factor effecting RDF and Topic Maps wide spread use. In spite of the availability of a number of applications and tools for RDF and Topic Maps, the development of a killer application is still missing. It is due to the lack of wide-spread adoption of this technology by the mainstream market, poor definition and exploration, failure to model knowledge in a standardized graphical notation, absence of use cases, repository and projects, no agreement on scope usage and merging, and less number of application developers due to non-availability of RDF and Topic Maps based courses in university curriculum.

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