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Semantic Web and Grid Technology use in Collaborative Researches for Universities in Kenya

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Abstract: The study intended to explore the effects of semantic web and grid computing technologies on collaborative researches, and to provide information for adopting and utilizing these technologies in information systems of Kenyan universities. The objectives of the study were first to establish the use of semantic web technologies for collaborative research in universities and secondly to establish the use of grid technologies for collaborative research in universities in Kenya. In order to achieve the study objectives, a survey research design was employed and involved quantitative as well as qualitative methods of data collection from respondents. Purposive sampling method was used to select the schools of computing and Informatics in five universities in Kenya, and census method to select all one hundred and forty four (144) academic staff members and research scholars from the schools of computing and informatics of the selected universities. Data collection instruments consisted of questionnaires and interviews. Statistical data analysis tool SPSS V21 was used in data analysis. Descriptive statistics and Correlation analysis were computed to determine relationships between the variables under study. Correlation analysis indicated a statistically significant positive correlation between both semantic web technologies ($r = 0.531$, $p<0.01$), grid technologies ($r = 0.466$, $p<0.01$) and collaborative research, implying that these technologies influenced collaborative research. Universities can therefore increase the adoption and utilization of semantic web and grid technologies in order to enhance collaborative research.

Keywords: *Semantic Web, Grid Technology, Collaborative Research, Universities*

1. Introduction

Semantic web and grid technologies have the potential to promote a research attitude in universities by providing access to academic resources such as databases, research journals and repositories, instructional materials developed by research organizations, and information about conferences. These technologies can provide research scholars with opportunities to share academic experiences and exchange research findings throughout the world. Researchers in developing countries have expectations that the spread of high speed broadband networks, the growth of the internet and the continual increase in computing power will enable them use emerging technologies such as semantic web, grid and cloud technologies to enhance collaborative research. Many research projects at university, national or international levels involve researchers from geographically distributed groups, a situation that naturally demands collaboration among researchers who are geographically distributed so that they can focus on tackling shared challenges. This has led to the

emergence of the notion of research collaborations. Distributed computing, the Internet and cloud computing have revolutionized the university landscape, making collaborative research possible and the traditional classroom learning to be complemented by e-learning [1, 2]. In recent years Semantic web and grid computing technologies have become more available in the daily use of academic researchers making collaborative research a real possibility. Collaborative Research refers to scientific collaboration and is a form of interaction that takes place within a social context among two or more scientists that facilitates the sharing of meaning and completion of tasks with respect to a mutually shared, super ordinate goal [3]. The growth of web-based applications has made the web an important educational medium. Emerging web technologies such as social media, blogs, wikis, instant messengers and bookmarks have transformed the web into an interactive space where everyone is allowed to collaborate, create and share information [4]. This study is timely as it is intended to explore the effects of semantic web and grid computing technologies on collaborative researches, and to provide information for adopting and utilizing these technologies in information systems of Kenyan universities. This study intends to provide knowledge to institutions of higher learning to help them take advantage of the enabling capacity of semantic web and grid applications to support collaborative research.

The study sought to evaluate the effects of the Internet, semantic web applications, semantic web services, collaborative and sharing tools, grid components, grid middleware and grid services on collaborative research.

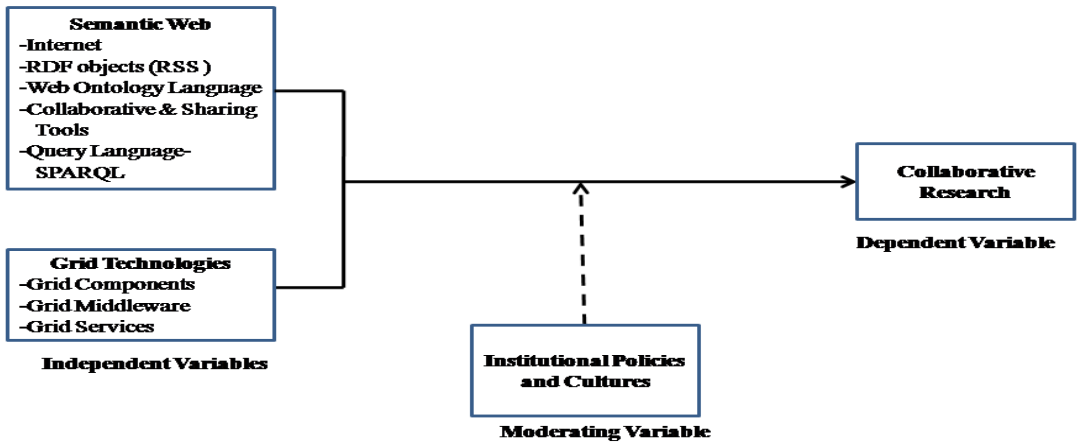

Figure 1: The conceptual Model (Source: Researcher, 2019)

The study posited that these factors have an influence on collaborative research as presented in Figure 1. This study focuses on exploration of the link between the above stated factors as a potential means for investigating semantic web and grid technologies use for academic and collaborative research in universities while being moderated by institutional characteristics.

1.1 Background

African grid computing initiatives focus mainly on technical implementation of grids within institutional intranets, with little investigation being available to measure the effects of amalgamation of semantic web and grid technologies in collaborative research. As a consequence, researchers face challenges related to differences in institutional policies, standards in the computing infrastructure and vendor lock in of systems that limit collaborative researches. An empirical study by [5] revealed that among the challenges significantly affecting grid-computing use for collaborative researches in African

universities are attitudinal and infrastructural issues that impose limitations on implementation. Globalization and cooperation from developed countries is leading to these advanced technologies being infused into developing countries, which have in turn not fully taken up the use of these advanced technologies. Although studies have been done to address the leveraging of these technologies by academic institutions in collaborative research and e-learning in developed countries, what works for the scientific research community in a certain region may not work in the context of another exhibiting different characteristic such as political, social, economic and infrastructural [6]. In Kenya use of semantic web and grid technologies are considered to be still in infancy stages, with the ICTs of universities mainly comprising of fragmented ecosystems, and services provided by different entities presenting interoperability issues. As a consequence, collaborative research supported by computer systems of the universities in Kenya is hampered by inadequate hardware and software resources, inadequate enabling policies and low Internet speeds to fully support collaborative research. There is a knowledge gap within research studies as to how semantic web and grid technologies could contribute to collaborative research in Kenyan public universities. A better level of integration of semantic web and grid technologies is necessary for scientific collaboration

2. Objectives

The purpose of this study was to increase our understanding of how semantic web and grid computing technologies being used in universities affect collaborative research. The study was guided by the following objectives

i) To establish the use of use of semantic web technologies for collaborative research in universities
ii) To establish the use of grid technologies for collaborative research in universities in Kenya

3. Methodology

The study adopted a survey design; involving quantitative as well as qualitative forms of inquiry, implying a positivist epistemological stance. The positivist approach, involving a quantitative and qualitative survey was deemed necessary for purposes of obtaining a broad view of the status and nature of the semantic web and grid technologies in universities in Kenya, and to reveal the influence of these technologies on collaborative research. The target population of this study consisted of all academic staff members in the schools of computing and informatics of the universities in Kenya that have previously used the technologies being researched. The academic staff members of the selected schools are deliberately targeted for their knowledge and understanding of the research areas, and also because they are more likely to provide the relevant and more important information that cannot otherwise be obtained from other schools. The study was conducted as a survey specifically focusing on the following universities; Jomo Kenyatta University of Agriculture and Technology (JKUAT), Meru University of Science and Technology, Masinde Muliro University of Science and Technology (MMUST), Maseno University and The Technical University of Kenya

The respondents of the study were selected through two sampling technique methods comprising of (i) purposive sampling and (ii) census method. According to [11], purposive sampling is a technique widely used in qualitative research for the identification and selection of information-rich cases for the most effective use of limited resources. This involves identifying and selecting individuals or groups of individuals that are especially knowledgeable about or experienced with a phenomenon of interest. This method was used to select the schools of computing and informatics of six universities from the fifty-eight

universities in Kenya. The census method was then used to collect data from all the possible units in the locations of study. This is justified by the fact that the size of the universe was considerably small. In the census method of data collection, all the elements or cases of the field of study area are enumerated. The sample size for this research will therefore be one hundred and forty four (sample Size = 144). For the purpose of achieving the objectives of this study the instruments of data collection that were employed were self-administered questionnaires addressing the objectives of the study as well as interviews.

4. Technology description

Semantic web technologies promote a research attitude among academic members by providing access to academic resources such as databases, research journals and research repositories, instructional materials developed by research organizations, information about conferences and also play an important role in providing opportunities of sharing academic experiences and exchanging findings of research throughout the world [7]. A semantic web is a web that enables automated information access and use based on machine process able semantics of data. Ontologies are the technology at the core of the semantic web and are used for the management of formalized knowledge in the context of distributed systems [8]. The World Wide Web Consortium (W3C) develops standards and recommendations for the web and to ensure the long-term growth on the web. Among these standards are Hypertext Markup Language (HTML), Hypertext Transfer Protocol (HTTP), Extensible Markup Language (XML) and some standards for Linked Data, Ontologies and Queries [9]. Emerging web technologies such as social media, blogs, wikis, instant messengers and bookmarks have transformed the web into an interactive space where everyone is allowed to collaborate, create and share information [10]. According to [12] a grid computing system is a platform that provides access to various computing resources owned by institutions by making a virtual organization. Grid infrastructures are capable of supporting the sharing and coordinated use of resources in dynamic global heterogeneous distributed environments. These include resources that can manage computers, data, telecommunication, network facilities, and software applications provided by different organizations [13; 14]. Systems that support research collaborations can be represented by the amalgamation of web and grid technologies in which grid computing functionalities are incorporated into web based systems. This can achieve the collaborative semantic web based research grid, which essentially is a collection of computational resources on demand to match computational needs of institutions through service matchmaking on the web. The General Portal Framework for e- learning grid proposed by [15] and makes use of Open Grid Computing Environments (OGCE) provided by National Science Foundation Middleware Initiative's (NMI) is an example. Such a semantic web based grid system can also be used to support research collaborations among universities. [16] stated that the Semantic Grid seeks to incorporate the Semantic Web approach into the Grid. They state that as the Semantic Web is to the Web, so is the Semantic Grid to the Grid, and therefore they saw them not as orthogonal activities, but the emerging semantic web infrastructure as an infrastructure for grid computing applications.

5. Developments

Research on the relevance and usefulness of various aspects of semantic web and grid technologies on research collaborations in developing countries like Kenya is limited. Existing literature on the antecedents of semantic web and grid technologies e.g. semantic web and its services and grid services, and their effect on collaborative research are sparse. There is need for a study on the effects of semantic web and grid technologies that is concerned with examining factors that influence use of these technologies in collaborative

research. Semantic web and grid technologies are used in developed countries in support of research and the creation of collaborative technologies. There have been several studies in this area such as Monitoring Research Collaborations Using Semantic Web Technologies by [17]. A study by [18] showed that Semantic Grid technologies can be used to provide enhanced techniques for data collection and use within a grid-enabled environment, thus enhancing the capacity to address substantive social science research. Similarly, in Asia there have been initiatives to set up grid-computing backbone support in China, Japan and Korea. According to [19], the rise of globally distributed computer based workspaces and the advances made in communication technologies have enabled the incorporation of collaboration and knowledge management in information technology systems. In the developing countries, grid computing has emerged as a response to the growing demand for computing resources exhibited by the scientific and researcher communities. For researchers to be able to collaborate and share data with one another efficiently, the underlying IT infrastructures need to be in place because the amount of data produced by research collaborations is rapidly growing making this kind of support important. Recognizing the value of intranet grids therefore will in long run promote collaboration and overall Africa grid connects initiative. South Africa has made significant investments in cyber infrastructure to support collaborative research by the scientific community by starting the South African National Grid Initiative.

6. Results

The analysis, synthesis and presentation of findings were done with the purpose of achieving the objectives of the study. The total number of questionnaires correctly filled and returned being ninety six (n=96) and interview guides being six (6) make a total of one hundred and two (102) out of the cumulative questionnaires administered and interviews conducted. This represented a response rate of 71 percent. [20] observed that a response rate of 50 percent in a survey is adequate.

Factor analysis was conducted to determine whether items should be included or excluded from the measure. It was necessary to examine whether these items have or have no influence using a principal component factor analysis with varimax rotation. The factor semantic web technology was based on six items, while the factor grid technology was based on four items as shown in Table 1.

Table 1: Communalities for the factors affecting collaborative research

	Initial	Extraction
Uniform Resource Identifiers	1.000	.681
RSS Feeds(RDF Objects)	1.000	.533
Web Ontologies	1.000	.695
Query Languages(SPARQL)	1.000	.693
XML	1.000	.621
Linked Data search Engines	1.000	.780
Grid Interface(Toolkit)	1.000	.769
Grid Middleware e.g. web	1.000	.445
Grid groupware	1.000	.601
Grid HW and SW resources	1.000	.509
Extraction Method: Principal Component Analysis.		

Communalities in the data indicated that 44.5% of the variance in the variables has been accounted for by the factor grid middleware. The factor Linked Data search Engines

accounted for 78.0% of the variance in the variables. All the items were retained since they scored more than 0.4 indicating that they all contributed and influenced factor detection.

6.1 The semantic web technologies use for collaborative research in universities

Table 2 below provides some basic descriptive statistics of the semantic web technologies broken down with the mean and standard deviation values of these technologies and whether they are being used for academics and collaborative research. Six items on a Likert scale question were applied to establish the use of semantic web technologies for collaborative research. The respondents were requested to rate items on a five point Likert scale ranging from strongly disagree to strongly and the descriptive results are presented by Table 1.

Table 2: Descriptive statistics for use of semantic web in collaborative research

	N	**Sum**	**Mean**	**Std. Deviation**
Uniform Resource Identifiers	96	403	4.20	0.705
RSS Feeds(RDF Objects)	96	405	4.22	0.684
Web Ontology's	96	399	4.16	0.799
Query Languages(SPARQL)	96	393	4.09	0.822
XML	96	399	4.16	0.772
Linked data search engines	96	279	2.91	0.895

The results show that there is not much variation with regard to the various attributes or items related to semantic web technologies as indicated by the mean scores which ranged from a mean of 2.92 for Linked data search engines to 4.22 for RSS Feeds (RDF Objects). This can be interpreted to mean that all these attributes of semantic web technologies are equally useful in academics and collaborative research. A standard deviation of 0.895 and a mean of 2.91 for Linked data search engines indicate that this is the least used attribute or item of the semantic web technologies in collaborative research. The findings reveal that RSS Feeds (RDF Objects) supported by a mean of 4.22 and a standard deviation of 0.683, Uniform Resource Identifiers supported by a mean of 4.20 and standard deviation of 0.705, Web Ontology's supported by a mean of 4.16 and standard deviation of 0.799 and XML supported by a mean of 4.16 and standard deviation of 0.772 largely determined the use of semantic web technologies in collaborative research. This implied that these five attributes of the semantic web technologies had a significant influence in determining the use of semantic web technologies in collaborative research, while linked data search engines did not.

Table 3 below provides some basic descriptive statistics of the grid technologies broken down with the mean and standard deviation values of these technologies and whether they are being used for academics and collaborative research. Four items on a Likert scale question were applied to establish the use of grid technologies for collaborative research. The respondents were requested to rate items on a five point Likert scale ranging from strongly disagree to strongly and descriptive results are presented in Table 3.

Table 3: Use of Grid Technologies for collaborative research

	N	Sum	Mean	Std. Deviation
Grid Interface (Toolkit)	96	413	4.30	0.651
Grid Middleware e.g. web	96	418	4.35	0.711
Grid groupware	96	401	4.18	0.754
Grid HW and SW resources	96	403	4.20	0.659

The results of grid computing technologies show that there is not much variation with regard to the use of the various items or attributes of the technologies associated with grid computing in collaborative researches as indicated by the mean scores which ranged from a mean of 4.18 for grid groupware to a mean of 4.35 for grid middleware e.g. web. This result like in the case of semantic web technologies can be interpreted to mean that all the items or attributes of grid technologies stated above had a significant influence in determining the use of grid technologies for academics and collaborative research. The standard deviation of 0.754 and a mean of 4.18 for grid groupware indicate that it is the least used of the attributes of grid computing technologies in collaborative research. From the findings, grid middleware had a mean of 4.35 with a standard deviation of 0.711, and grid interface had a mean of 4.30 with a standard deviation of 0.651 which implied that these two attributes largely determined the use of grid computing technologies in collaborative research. The findings also reveal that the grid hardware and software resources which had a mean of 4.20 and a standard deviation of 0.659 also had a significant influence in determining the use of grid computing technologies in collaborative research.

6.2 Pearson Correlation Coefficient of semantic web and grid technologies and Collaborative Research

Correlation analysis was performed to determine the linear relationship between the independent variables i.e. semantic web technologies and grid technologies and the dependent variable i.e. collaborative research, at the universities.

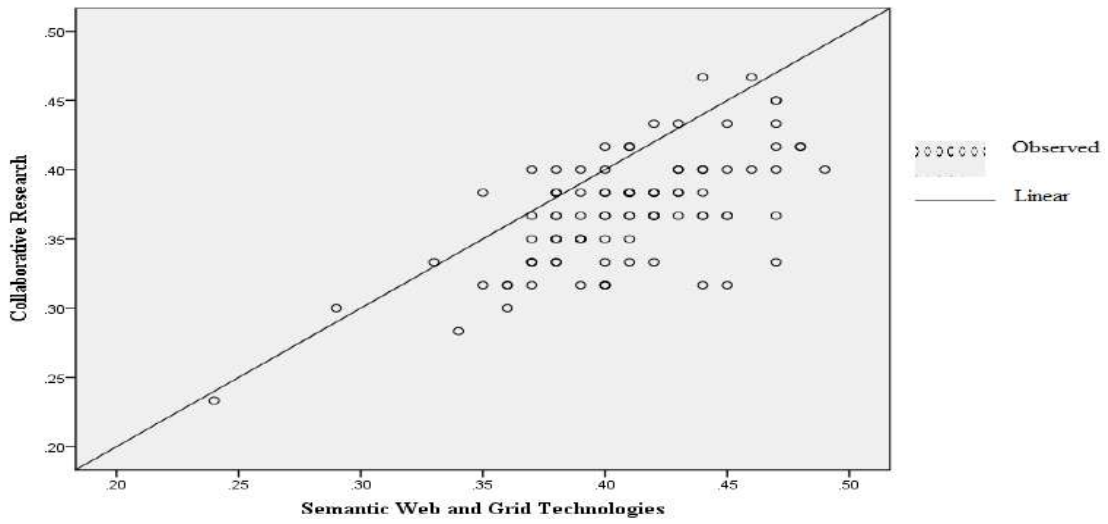

Figure 2: Scatter plot of relationship between semantic web ad grid technologies and collaborative research

The scatter plot reveals a linear relationship between the semantic web and grid technologies and collaborative research as reflected in Figure 2. The scatter plot indicates that the relationship between these two variables is positive and is skewed upward. The results of the Pearson's product moment correlation conducted on the study constructs of semantic web technologies, grid technologies, Institutional Characteristics, and collaborative research are presented in Table 4 below.

Table 4: Correlation of semantic web and grid technologies and Collaborative Research

CORRELATIONS					
		Semantic Web Technologies	Grid Technologies	Institutional Characteristics	Collaborative Research
Semantic Web Technologies	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	96			
Grid Technologies	Pearson Correlation	.096	1		
	Sig. (2-tailed)	.353			
	N	96	96		
Institutional Characteristic	Pearson Correlation	.115	.055	1	
	Sig. (2-tailed)	.263	.595		
	N	96	96	96	
Collaborative Research	Pearson Correlation	.531**	.466**	.065	1
	Sig. (2-tailed)	.000	.000	.526	
	N	96	96	96	96
**. Correlation is significant at the 0.01 level (2-tailed).					

The correlation as depicted in Table 3 shows varied degrees of interrelationships. The correlation reflects a statistically significant positive correlation between semantic web technologies and collaborative research ($r = 0.531$, $p<0.01$). The correlation index for the relationship between semantic web technologies and collaborative research is 0.531, which is between 0.4 and 0.7 implying a positive relationship. A positive and statistically significant relationship is inferred between grid technologies and collaborative research since the correlation was statistically significant ($r = 0.466$, $p<0.01$). A weak and nonsignificant relationship is inferred between institutional characteristics and collaborative research ($r=0.065$, $p>0.05$), implying there is little or no linear relationship between institutional characteristics and collaborative research. The correlation coefficient between semantic web technologies and grid technologies was 0.096 indicating that collinearity would not severely distort the prediction of the dependent variable based on the independent variables. [25] argued that multicollinearity is certain when the correlation coefficient is at a level of 0.9 or higher.

7. Business Benefits

The benefits of collaborative research according to the [21] include the following: i) More scientific results and publications are achieved with less effort, while utilizing fewer resources and these results and publications have a wider geographical reach; ii) Collaboration inspires researchers to apply for and win funding; share proposal writing

skills, research data, equipment and materials; and become more effective at working in teams ; iii) Scientists network and travel across Africa; learn across disciplines, regions and languages; and gain deeper and broader views of their potential as well as challenges of the African continent's; iv) Researchers are able to build expertise in various ways including planning and managing projects, logistics, team coordination, recruitment and training of field staff and field and laboratory activities. [22] argue that ICTs, in particular semantic web and grid technologies are a means of providing opportunities to the younger researchers and those who are not in major universities to collaborate with established researchers and those from prominent universities leading to an increased network of researchers and wider participation. Semantic web and grid computing have the potential to enable the dynamic sharing and aggregation of geographically distributed resources depending on factors which include cost, availability, capability and performance of the resources and user's quality of service requirements [23]. In Kenya KENET, whose membership includes Kenyan institutions of higher learning is a licensed private networks operator recognized by ICANN and AfriNIC as a National Research and Education Network and promotes the use of ICT in institutions of higher learning whilst connecting them to the rest of the world [24]. KENET institutions have so far been provided with affordable and efficient bandwidth [24], meaning that researchers from institutions affiliated to KENET can access resources available globally. This is because the KENET issued digital certificates are accepted on the African Grid and the European Union Grid (EU Grid) where they can have access to enormous computing and storage resources. Successful implementation of semantic web and grid computing may however require redefinition of ownership, copyrights, and licensing, all of which present cultural and legal issues which have to be resolved before adjusting policies and expectations of some of these institutions to integrate with what semantic web and grid technology provides.

8. Conclusions

The study concludes that while semantic web and grid technologies influenced collaborative research, institutional characteristics have little or no effect towards the use of these technologies, especially in support of collaborative research in universities. The study concludes from the findings that the universities can increase collaborative research by increasing Internet availability and encouraging or scaling up the use of various web technologies in academics. Grid technologies were also significant on collaborative research. The results of the data analysis confirmed a significant and positive relationship between grid technologies and collaborative research, implying that these technologies influenced collaborative research. Universities can therefore increase the adoption and utilization of semantic web and grid technologies in order to enhance collaborative research.

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