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A Case Analysis of Factors Affecting the Adoption of Grid Technology by Universities

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Abstract: Grid computing is emerging as the foundation upon which virtual collaborations can be built among large organizations with the aim of integrating and sharing computer resources, and thus offering performance speed and resource availability, which is unattainable by any single institutional technology resources. With the level of increase in the number of tertiary institutions in Africa, and the attendant lack of basic information technology resources, the use of grid computing for collaboration purposes would contribute to the enhancement of research, course delivery, course management, and other aspects of institutional development. This paper carries out an empirical study of the possibility of adoption of grid computing as a vehicle for collaboration among tertiary institutions in Nigeria from the perspective of the potential adopters (users) of the systems. This study uncovers challenges to the adoption of grid technology by the tertiary institutions. The key challenges that significantly affect the adoption of grid computing in tertiary institutions are mainly attitudinal (perceived need and perceived benefits). Infrastructural issues (facilitating conditions) also impose limitations on the ability of universities to implement grid computing.

1. Introduction

Advances in Internet and the availability of powerful computers and high-speed networks are changing the configuration and implementation of large scale parallel and distributed computing. These technology advances have allowed us to use distributed resources as a single and powerful virtual machine, leading to what is popularly known as grid computing. In a traditional grid, entities trust each other in a close community, and thus do not make extra effort to hide their identity in communications.

Research-oriented organizations and universities that are involved in advanced research collaboration require the analysis of tremendous amounts of data. Grid Computing provides mechanisms for resource sharing by forming one or more virtual organizations providing specific sharing capabilities. Such virtual organizations are constituted to resolve specific research problems with a wide range of participants from different regions of the world. Grids make a large number of computing resources, data stores, analysis and visualization tools available to analysts and collaborators in a coalition environment for decision support and related applications. Besides the advantage of accessing locally unavailable resources, the Grid is usually also expected to utilize the existing resources more efficiently. Grid computing is not only a mainstream computing paradigm for resource intensive scientific applications but it also promises to become the future computing paradigm for enterprise applications.

In times of global economic slow-down, organizations are increasingly under pressure to cut down their budget. In the past few years, significant amounts of hardware and software have been purchased and installed. Grid computing and server consolidation are two aspects of computing that could assist organizations in reducing their budgets on computing facilities. Server consolidation process focuses on reducing the physical number of computers and moving the workloads/applications running on them to a smaller set of computers, while still maintaining service level objectives. Grid computing tries to utilize the existing computer infrastructure to create a virtual computer that has higher computational power (performance rating) than any single computer. Grid technology can aggregate all the powers from the cpu's of participating organizations to generate a super computing power that will help users to access various types of services simultaneously [1].

Grid computing enables organizations (real and virtual) to take advantage of underutilized resources to meet business requirements while minimizing additional costs. The nature of a computing grid allows organizations to take advantage of parallel processing; making many applications financially feasible as well as allowing them to complete sooner. Grid computing makes more resources available to more people and organizations while allowing those responsible for the IT infrastructure to enhance resource balancing, reliability, and manageability. It has the potential of reducing maintenance cost and improving overall performance without significant hardware changes. It could reduce the complexity of infrastructure and cost of maintenance, as well as increase the efficiency of the utilization of computing resources.

This study focuses on the factors affecting the adoption of grid computing by universities in a developing country context. A number of cooperate organizations (especially in the developed world) have taken advantage of grid computing. As with most technology adoption, developing countries (especially in Africa) have lagged behind. The e-readiness levels of these countries are low [2], and facilitating conditions could hinder the adoption of technology such as grid computing. The rest of the paper is organized as follows: Section 2 presents a review of some relevant literature on grid computing technology and adoption. In Section 3, the framework for the research is presented, while the methodology adopted in the study is described in Section 4. The analysis of data is carried out in Section 5, while the results are discussed in Section 6. Some conclusions are drawn in Section 7.

2. Literature Review

Grid computing is the aggregation of distributed and heterogeneous autonomous computing resources (connected by a network) into one large virtual system. The large-scale virtual system is redistributed as needed by the end users. Examples of the computing resources include: processor, storage, data, hardware, software, telecommunication facilities, and personnel. Grid computing technology dynamically connects remote computers and computing resources over the Internet or a virtual private network. It focuses on increasing computing power, defining computational capabilities and coordinating the sharing of resources and solving problems in multi-level virtual organization [1, 3, 4, 5, 6].

Today, Information and Communications Technology (ICT) resources are deployed in almost all organizations to support their business processes. Many of the organizations have their ICT resources resident and shared within the computer network system of the organization. Collaboration with other organizations with the view of sharing resources is not yet well embraced [3]. Thus there are possibilities of under-utilization of ICT resources in some organizations while some organizations with limited ICT resources may over-use these resources. Grid computing technology is creates a pool of ICT resources and makes it accessible to all connected organizations.

Grid technology is well applied in electric power system where power grid is established. Thus consumers of electricity do not need to know anything about what stays beyond the socket. The consumers can utilize all the electricity they want but this is subject to the agreement with the electricity service provider. Today grid computing has attracted global attention in a variety of application domains ranging from environment, chemistry, aerospace, physics and healthcare systems [1, 7, 8]. Thus in this paper, our focus is on the adoption of grid technology to foster the integration of tertiary institutions in Nigeria in order to have good collaborative learning environment. Our objectives are to establish the grid technology acceptance and adoption level in the tertiary institutions; and the factors that may be responsible for adopting the technology and also factors that may be responsible for rejecting or for poor implementation of the technology.

Grid computing is faced with some development, implementation and management challenges. These challenges have been classified in [3] as: technical, organizational and strategic. Though the vision of grid computing is promising, but the challenges of managing grid infrastructure are daunting. Some of the difficulties include the heterogeneity of devices on the grid; the need to operate in geographically dispersed and complex environments; the unpredictability of system performance and behaviour over time; and the existence of multiple administrative domains. There are also concerns about usage pricing, service-level agreements and network-security issues. A number of authors have attempted to assess the utility of grid computing relative to the technical, organizational, and strategic challenges. For example, [9] measured the efficiency of grid computing for collaborative learning, while the performance, reliability and scalability of grids is assessed in [10, 11, 12, 13]; the improvement of security in grid is discussed in [14, 15]; resource usage policy expression and enforcement in grid computing are presented in [16, 17], while efficient access to many small files in a file system for grid computing is presented in [18]. Efficient anonymity protocol, pricing, accountability, and trust are discussed elsewhere [19, 20, 21, 22], while implementation of system policy derived from the interactions between Service Level Agreements (that is contractual agreements between businesses) and locally specified management rules is presented in [23].

Literatures such as [1, 3, 4, 5, 6, 8, 9, 10, 11, 23, 24] established the adoption of grid computing technology to integrate organizations' resources and expertise in order to help in the delivery of clear business benefits in today's economy (with little upfront cost, pay-per-use utility pricing and scalability as needed). Despite the benefits of grid technology, many organizations are yet to adopt this technology. Some of the factors responsible for the low adoption of grid technology are presented in Table 1.

Table 1 Grid Computing Adoption Factors

Author(s)	Grid Computing Adoption Factors
[25]	Inability of users to understand how grid can fit in their environments. In this way, grid runs the risk of underwhelming users and because grid is still largely undefined, users run the risk of adopting a vision that ultimately remains unfulfilled.
[26]	Factors considered are mainly from the perspective of consumers/users of grid computing service rather than from the perspective of providers/vendors of grid services. For example, the demand for grid computing services, frequency of usage, stage of consumers' line of business. The authors also emphasise that the adoption and utilization of grid computing in an enterprise is a major strategic decision which involves both objective and subjective decision making variables. So, it is not a straight forward objective decision only.
[27]	Complexity of the IT infrastructure required to implement a grid, the complexity of IT integration across heterogeneous environments, enabling grid resources in homogeneous and heterogeneous environments, enabling resources as services to grid partners, and enabling virtualized applications to grid partners, ability of grid technology to deliver increased

	business value. The business issues related to the grid adoption model include key factors, such as leveraging existing hardware investments and resources, reducing operational expenses, creating a scalable and flexible infrastructure, accelerating development time, improving time to market, and increasing customer satisfaction and business productivity.
[28]	Outage (availability), security of computer system and data stored on them, performance measured in terms of communication time between the client computer and the Web server in the grid, compliance to some government regulations regarding the secure storage, privacy, and disclosure of data, harmonizing the functionalities of private grids and resolving possible conflicts, integration of applications and data on multiple public grids, cost of development, implementation and management, and remote administering of computing resources
[29]	Size of the IT resources in the organizations, the organizations' utilization pattern of the resources, sensitivity of the data the organizations are handling, and criticality of work done by the companies.
[30]	Size of the IT department of the organizations, organization management-related innovativeness and organization employee-related innovativeness, open-mindedness of the management and employees of the organizations about new practices, trust (that is trust in the technology itself and trust in the participants in a grid), uncertainties about new technology among individual and also among organizations, and coercive pressure from suppliers, customers, or parent companies can exert pressure on organizations to adopt grid technology.
[31]	Standardization which translate to interoperable, rapidly changing marketplace (this makes it hard to pin down a strict standard).
[1]	Lack of viable business models that can make organizations to gain economically from the grid market.

2.1 Examples of Data Grid in Some Regions/Countries

Despite the challenges associated with grid implementation, a number of successful cases have been recorded. Table 2 provides some examples of grid implementation in a range of regions/countries such as United States of America, United Kingdom, Asian countries [32, 33, 34, 35].

Table 2 Grid Computing Implementation Examples

Region/Country	Data Grid Project	Domain of Application	Purpose of Application
United States	BIRN	Bio-Informatics	Fostering collaboration in biomedical science through sharing of data.
	NEESgrid	Earthquake Engineering	To enable scientists to carry out experiments in distributed locations and analyse data using a uniform interface.
	GriPhyn	High Energy Physics	To provide computational and storage facilities for high-energy physics experiments.
	Grid3	Physics, Biology	To provide a uniform, scalable and managed grid infrastructure for science applications.
	Earth System Grid	Climate Modelling	To integrate computational and data and analysis resources in order to create enabling environment for climate research.
United Kingdom	GridPP	High Energy Physics	To create computational and storage infrastructure for Particle Physics in the UK.
	eDiaMoND	Breast Cancer Treatment	To provide access to distributed databases of mammogram images for medical professionals and researchers.
Japan	BioGrid,	Protein Simulation,	Provision of computational and data infrastructure for medical and biological research.

		Brain Activity Analysis	
Australia	Belle Analysis Data Grid	High Energy Physics	To create computational and storage infrastructure in Australia for physicists involved in the Belle and ATLAS experiments.
Korea	High Energy Physics (HEP) data grid system	High Energy Physics	To construct a system to manage and process HEP data and to support user group (that is high energy physicists).
Global	LCG	High Energy Physics	To create and maintain a data movement and analysis infrastructure for the users of LHC.
	EGEE	High Energy Physics, Biomedical Sciences	Create a seamless common Grid infrastructure to support scientific research in physics and biomedical sciences.
	Virtual Observatories	Astronomy	Infrastructure for accessing diverse astronomy observation and simulation archives through integrated mechanisms.
	Computational Science and Engineering On-line	quantum chemistry, thermodynamics, and fundamental kinetics	Provides the platform for computational scientists to perform research using state-of-the-art tools; query data from personal or public databases, discuss results with colleagues, and access resources beyond those available locally from a web browser; provides an integrated environment for multi-scale modeling of complex reacting systems; allows data to flow from one application to another in a transparent manner.
	Gridbus	e-Science and e-Business	The Gridbus project aims at producing a set of economic Grid middleware services to support e-Science and e-Business applications using the computational Grid service architecture.
	Globus		Globus Toolkit offers a mature basic Grid middleware based on open standards and components. Used to manage, share, and use computational resources across corporate, institutional, and geographic boundaries without sacrificing local autonomy. Used to build further services and high-level Grid frameworks such as Gridbus.
	Sun Grid	High energy and nuclear Physic	The Sun Grid Compute Utility enables customers to purchase computing and storage power as they need it. It provides platform for collaborative research in high energy and nuclear physics.

3. Research Framework

This study utilizes the diffusion of innovation model (DOI), which is presented in Figure 2. The DOI model [36] sees innovations as being communicated through certain channels over time and within a particular social system. Similar to the diffusion of innovation model are the technology acceptance model (TAM) [38] and the theory is the theory of planned behaviour (TPB) [39]. TAM places emphasis on subjective/psychological predispositions and social influences on behavioural intention to adopt a new technology, while TPB identifies three factors that influence consumers' acceptance of new products; namely: attitude, subjective norms and perceived behavioural control.

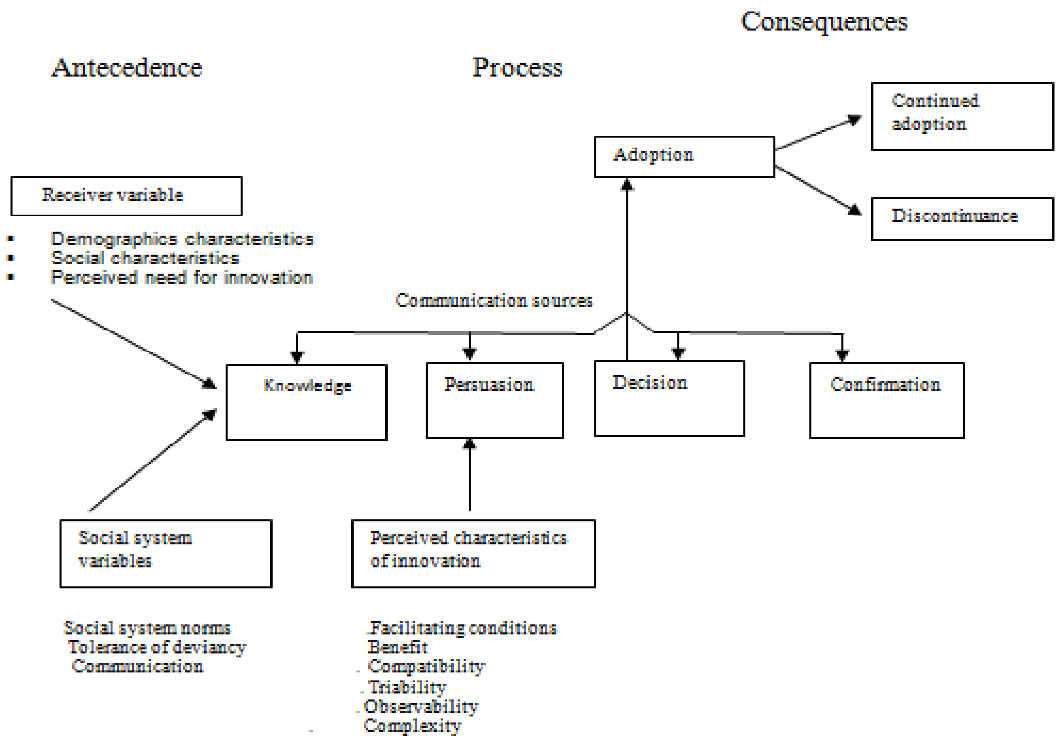

Figure 2: Diffusion of Innovation Model

Diffusion studies have focused on the following five elements: the characteristics of an innovation, which may influence its adoption; the decision making process that occurs when individuals or organizations consider adopting a new idea, product or practice; the characteristics of individuals/organizations that make them likely to adopt an innovation; the consequences of adopting an innovation; and communication channels used in the adoption process. According to [37], the perceived attributes of innovation are:
(a) Relative advantage: The degree to which an innovation is perceived as being better than the idea it supersedes.
(b) Compatibility: The degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters.
(c) Complexity: The degree to which an innovation is perceived as relatively difficult to understand and use.
(d) Triability: The degree to which an innovation may be experimented on.
(e) Observability: The degree to which the results of an innovation are visible to other

The diffusion of innovations theory suggests that the different dimensions of attitudinal belief toward an innovation can be measured. In general, perceived benefits of an innovation is positively related to its rate of adoption [36]. Previous research has also indicated that an innovation with substantial complexity requires more technical skills and needs greater implementation and operational efforts to increase its chances of adoption [40]. Rogers (in [41]) argues that potential adopters who are allowed to experiment with an innovation will feel more comfortable with the innovation and are more likely to adopt it.

The diffusion of innovation theory provided a framework for derivation of the study hypotheses, which are presented in Section 5.

4. Methodology

4.1 Data Collection

The sampling method was random judgment sampling. Fifteen Universities were randomly chosen from a population of 104 Universities in Nigeria. The list of universities was obtained from the National Universities Commission (http://www.nuc.edu.ng/pages/universities.asp). The universities chosen included Federal, State, and private universities. Ten questionnaires were administered to staff of the randomly selected universities using purposeful sampling. The questionnaire was distributed to management (academic and administrative) and information technology staff of the universities. These categories of staff are likely to be responsible for taking decisions on the adoption of major technology facilities.

The data gathering instrument used in the research is the questionnaire. A total of one hundred and fifty questionnaires were distributed to the fifteen universities that constituted the sample for this study. One hundred and two of them were properly filled and used for analysis purposes. This represents 68% response rate. The questionnaire consists of two sections. The first part summarizes demographic information including information on availability of grid computing supporting infrastructure, and implementation of full grid computing. The second section of the questionnaire measures variables relating the diffusion of innovation model that could affect the adoption of grid computing. The items were measured on a five-point likert type scale (extending from 1=strongly disagree to 5=strongly agree).

4.2 Processing

Descriptive statistics were employed in the presentation of data obtained from the first section of the questionnaire. The next part of the analysis involved the use of exploratory factor analysis to reduce the variables into a small number of factors that could have an effect on the adoption of grid technology in universities. The reduced factors were used as explainable factors that can affect the adoption of grid computing. The factor analysis was carried out using the Statistical Package for Social Sciences (SPSS) for Windows Version 17.0. The factors were extracted by principal axis factoring and rotated using Varimax with Kaiser Normalization method to maximize the relationship between the variables and some of the factors. The Kaiser-Meyer-Olkin Normalization (KMO) measure of sampling adequacy indicates the suitability of the application of factor analysis for exploratory purposes (KMO measure = 0.710). The Bartlett's test of Sphericity was used to confirm the adequacy of the sample ($\chi^2 = 1004.762$, $df = 210$). Finally, multiple regression analysis was used to test the hypotheses relating to the factors that affect implementation of grid technology.

5. Data Analysis

The data were collected from university management and information technology (IT) personnel. Table 2 depicts the demographic characteristics of these respondents.

Table 2: Respondents Characteristics

Variable	Value	Percent
Respondents Gender	Male	74.5
	Female	25.5
Respondents Age	≤ 30	40.2
	31-50	52.0
	> 50	7.8
Respondents Department	Administration	15.7
	Academic Department	30.4
	Information Technology	23.1
	Others	30.8
Age of Organization (years)	0-5	44.1
	6-10	22.5
	11-15	14.7
	≥ 16	18.6
Management Level	Senior Management	24.5
	Middle Management	51.0
	Others	24.5
Responsibility for IT facilities decision	Management	21.6
	IT Department	29.4
	Management in conjunction with IT	49.0

Majority of the respondents were males (74.5%) and also less than 50 years of age (92.2%). This gender and age bracket defines the demographics of IT personnel cum management in Nigeria. Most of the IT and management positions are occupied by males, and Nigerian Universities are increasingly employing younger people into management positions. Management staff that were surveyed were mostly Heads/Chairs of departments, Deans of schools, and top academic management] (30.4%). Administrative management constituted 15.7% of respondents, while the information technology staff 23.1%. Most of the sampled universities were new (less than 5 years), pointing to sampling randomness tilting more to newer (private and state) universities. In most of the universities (49.0%), the responsibility of deciding to adopt a major IT facility (such as grid computing) lies with management in conjunction with the IT department.

Table 3 presents the frequency of grid computing training undergone by university staff, while component analysis of grid (and grid related) computing implementation is shown in Table 4. From Table 3, it is observed that most universities (61.8%) never provided any form of training/awareness on grid computing to its staff. This is a reflection of low adoption intention. Table 4 shows that Internet connectivity and security of systems are at fairly above average levels of 3.3235 and 3.2843 respectively on a scale of 1-5, while collaboration among universities is either at an average or below average level. Collaboration is measured in terms of: sharing of educational resources using information and communications technology (3.0882), and computer network based communication (2.8922). Implementation of full grid system is at below average level of 2.6765.

Table 3: Frequency of Training on Grid Computing

	Valid Percent	Cumulative Percent
every 3 months	17.6	17.6
every 6 months	12.7	30.3
every year	7.9	38.2
Never	61.8	100
Total	100.0	

Table 4: Implementation of Grid Related Computing

S/N	Performance Index	Mean	Standard Deviation
1	Connectivity of systems across departments via computer network	3.3235	1.15323
2	Communication between your institution and other institution via computer networks	2.8922	1.21791
3	Sharing of academic resources with other other institutions using information and communication technology	3.0882	1.29051
4	Security of existing institutional network	3.2843	1.17210
5	Implementation of a full Grid system	2.6765	1.31376

Table 5 shows the exploratory factor analysis of variables affecting the adoption of grid computing. Forty variables were initially included in the survey to test the hypotheses relating to the diffusion of innovation model. After three iterations, a total of 19 variables were dropped from the model either due to low communality or non factor loading. Thus 21 variables were included in the analysis. The extraction method found to produce the most meaningful factor structure was principal axis factoring, while varimax rotation with Kaiser Normalization was adopted.

Table 5: Factor Analysis

Factor	**Eigenvalue**	**Variance Explained**	**Variables**	**Factor Loading**	**(α)**
Perceived Benefits	3.356	15.981	Resourcefulness of grid computing	.854	0.862
			Enhancement of job satisfaction	.783	
			Enhancement of motivation and efficiency	.760	
			Essential for the institution	.700	
			Relevance to networking	.488	
Perceived Need	2.340	11.142	Existence of Grid computing in other schools	.704	0.791
			Attitude of management to grid computing	.586	
			Awareness of grid computing	.546	
			Number of participating institutions	.514	
			Training exposure on grid computing	.492	
			Relevance of grid computing awareness	.489	
			Acceptability of grid computing	.426	
Communication	1.788	8.194	Effective means of communication	.797	0.744
			Time Savings	.630	
			Improvement of Communication	.521	

Facilitating Conditions	1.389	6.249	Adequacy of facilities	.779	0.516
			Power supply	.524	
Tolerance of Deviancy	1.721	6.615	Grid computing permits laziness	.813	0.507
			Anxiety about grid computing	.591	
Compatibility	1.389	6.614	Accessibility to other institutions resources	.607	1
Observability	1.083	5.159	Utilization of grid computing in other sectors	.609	1

The twenty one variables loaded on seven distinct factors (Table 5). The factors are indicated, including their eigenvalues, percentage contributions to the variability of data, variables that loaded on each factor, and Chronbach's α values indicating reliability/internal consistency of data. Two factors that had single variables were retained due to the high factor loadings and incompatibility with other factors. Though the eigenvalue rule (engenvalue ≥ 1) was adopted, in factor extraction, the scree plot also pointed to seven factors. Thus the hypotheses were reformulated based on the research framework and factor loadings. The following hypotheses were tested:

H_1 : The perceived benefits derivable from the use of grid computing would be a key factor in the decision to adopt grid computing in universities.
H_2: The perceived need for a facility (such a grid computing) would prompt decision makers to adopt the technology.
H_3: Grid computing would be adopted if it is perceived to enhance inter-institutional communication
H_4: Availability of facilitating conditions such as computing facilities, network infrastructure, and power supply would positively affect a university's ability to adopt grid computing.
H_5: The extent of tolerance to deviancy would significantly influence an organization in deciding to adopt a new technology, which may be a deviation from the known systems.
H_6: The compatibility of a given technology with existing systems would increase the chances of its adoption.
H_7: The adoption of grid computing by Nigerian universities is influenced by the existence of grid computing in other situations (sectors) in the country.

For the purpose of testing the hypothesis, a regression analysis was carried out. Full implementation of grid computing was used as the dependent variable, while the extracted factors constituted the independent variables. The model had a fair predictive ability (R^2 = 0.309). The ANOVA test produced an F value of 6.009 and a significance of 0.000, indicating a significant global influence of the extracted factors on grid computing adoption. The regression statistics is shown in Table 6. The t-values indicate that *perceived benefits, perceived need, and facilitating conditions* have statistically significant predictive capability. In other words, these factors exert a significant influence on the adoption of grid computing by Nigerian Universities. The standardized beta coefficients indicate that the *perceived need* exerts the highest significant influence (β=0.404, t = 4.694, p =*0.00*) followed by *facilitating conditions* (β=.258, t = 2.992, p =.004) *and* lastly *perceived benefits* (β=.213, t = 2.470, p = .015). Thus, H_1, H_2 , and H_4 are supported, while H_3, H_5, H_6 and H_7 are not supported. Therefore, *communication*, *tolerance to deviancy*, *compatibility*, and *observability* do not have significant impact on the adoption of grid computing by Nigerian Universities.

Table 6: Regression Statistics

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.676	.112		23.881	.000
	Perceived Benefits	.295	.120	.213	2.470	.015
	Perceived Need	.586	.125	.404	4.694	.000
	Communication	.023	.127	.016	.182	.856
	Facilitating Conditions	.380	.127	.258	2.992	.004
	Tolerance of Deviancy	-.077	.131	-.051	-.590	.557
	Compatibility	.178	.120	.128	1.484	.141
	Observability	-.052	.132	-.034	-.394	.694

a. Dependent Variable: implementation of full grid

6. Discussion of Results

This paper focuses at determining the factors that significantly impact on the ability of Nigerian Universities to adopt grid technology as a tool for facilitation of collaboration among tertiary institutions. In Table 3, the results show that 61.8% of the universities never make provision for training or create awareness programmes on grid computing for staff and students. In addition, the t-value indicated in Table 6 shows that *users perceived need* (β=0.404, t = 4.694, p =*0.00*) for grid technology is a significant factor for adoption. This corroborates the work of [25], which establishes that the inability of users to understand the concept of grid and how it fits to their work environment prevents them from adopting the technology. The implication is that grid computing is largely undefined and unknown in the Nigerian tertiary institutions.

The poor knowledge of the users about grid equally dampens their perceived various benefits of grid computing in research, teaching, and learning. This is reflected in the results presented in Table 6 with *perceived benefits* having (β=.213, t = 2.470, p = .015). In the real sense, people will like to embrace any technology that they know about its benefits to them. Nigerian tertiary institutions are yet to have a full understanding of the extent to which grid system could facilitate research, teaching/learning and general resource sharing; which could ultimately lead to reduction in expenses for the universities. In [25], poor organizational (consumer) demand for grid services and infrequent usage is attributed to inability of the organizations or consumers to visualize the merits of using grid services.

Our result also shows *facilitating conditions* (β=.258, t = 2.992, p =.004) as another significant factor affecting the adoption of grid technology in the Universities. The availability and stability of electricity and also the adequacy of ICT facilities (e.g. internet access, bandwidth size, software, personal computers, communication cables, and routers), server room ergonomic facilities (e.g. lightings, air conditioner, and furniture), security facilities (like firewalls) are examples of conditions that could facilitate efficient grid connectivity. Our results are in consonance with previous studies [27, 28, 30] that point to facilitating conditions as a key factor in grid technology adoption. A number of these facilitating conditions are currently lacking in Nigeria. The current instability of power supply negatively impacts on the ability of universities to implement a number of ICT related programmes including grid computing.

Our results did not find *communication* to have been a significant influence on grid computing adoption because most respondents did not know much about grid computing and its benefits. The communication aspects of adoption (including the impact of grid on communication) are largely unknown by the potential adopters. In addition, with grid technology largely undefined in the Nigerian tertiary institutions, *tolerance to deviancy* will not be a significant factor to grid technology adoption, because a large population of the people in the institutions are not aware of it. Furthermore, observability and anxiety relating to technology use would be very minimal since there is a very low level of awareness of this technology.

7. Conclusion

Grid Computing is an emerging technology in the private and public sectors, which has the capability of enabling high-performance in environments where emphasis is on agility, resource allocation and optimization. In this paper we examined factors that could likely impact on the adoption of grid technology by universities in a developing economy (Nigeria). Exploratory factor analysis yielded seven distinct factors upon which regression analysis was conducted. The regression statistics indicate that *perceived benefits, perceived need, and facilitating conditions* exert a significant influence on the adoption of grid computing by Nigerian Universities. The standardized beta coefficients indicate that the *perceived need* exerts the highest significant influence (β=0.404) followed by *facilitating conditions* (β=.258) *and* lastly *perceived benefits* (β=.213). Our result shows that *communication*, *tolerance to deviancy*, *compatibility*, and *observability* do not have significant impact on the adoption of grid computing by Nigerian Universities.

A concerted effort by universities to communicate the benefits of grid computing and an improvement in facilities (such as electricity) would greatly facilitate the adoption of grid in Nigerian Universities. Utilization of grid in collaboration would help to distribute computing jobs to many smaller server components based on resource availability and policies. Researchers in these universities could use grid computing to address complex computational challenges. This would reduce the need for very expensive symmetric multiprocessing (SMP) servers for applications that can be split up into smaller commodity type servers. Institutions in Nigeria, especially those with a high level of research intensity need to devote some resources towards inter-university collaboration through grid computing, and make concerted efforts towards educating the university (especially academic) community on the benefits of grid computing in the development of universities. A grid system would offer the following benefits to the universities: 1). Research and other academic jobs can be farmed out to idle servers or even idle desktops. Software policies can be put in place that allow jobs to only go to servers that are lightly loaded or have the appropriate amount of memory/cpu characteristics for the particular application; 2). Due to the modular nature of grid environments very modular, such that if one of the servers/desktops within the grid fail there are plenty of other resources able to pick the load automatically from the point of failure; 3) The grid model has a good level of scalability; thus additional desktops or servers could be added (or removed) easily on the fly. This also facilitates equipment upgrade; 4). With grid configuration, there is the possibility of parallel execution, thus increasing speed of performance.

This study is one of the few additions to the literature on grid computing adoption especially in developing countries. It exposes the impediments to grid computing adoption and offers universities (and government) the opportunity to focus on the improvement of conditions that could enhance grid adoption. The key limitation of this study is the tilt of sampling towards the newer universities. This could affect the results, especially considering the fact that newer universities may not have an elaborate structure for staff education and awareness. It is also observed that two of the seven factors had only one variable loading. While the factors could be retained for factor homogeneity, it could be argued that such factors could increase the level of bias in the regression analysis. An expansion of sample could possibly change the results of the factor analysis, and may produce all multi-variable factors.

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