A Framework for Adopting Hybrid Cloud Computing

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Abstract

The long way it comes, the dynamic change it has, the specialization and transparent nature of its services and the relative advantage it has over the previous computing technologies has provided, cloud computing has attained the maturity level and position where it is now. Security, privacy, trust and location risks are some of the factors that hinder the adoption of cloud computing and it is not well implemented in organizations of developing countries. But the adoption of cloud computing could transform the workflow of organizations to efficient, cost effective and manageable environment. To transform the current working environment to cloud computing environment, it needs to have a sound, comprehensive and agile adoption framework. Its room for keeping the computing and management of sensitive data and applications in house and going public for additional computing requirements, makes the hybrid cloud computing the best fit for construction companies. The proposed hybrid Cloud Computing Adoption framework can support construction companies to determine and understand the contexts they need to consider when adopting cloud computing.

Primary and secondary data are used to develop the proposed adoption framework. On top of that, the National Cloud Computing Policy, Strategy and Roadmap of Ethiopia, Technological, Organizational and Environmental cloud adoption framework was used as a theoretical lens in the study. This paper is proposed to support informed judgment rather than strict robotic rule based implementation. The study findings are believed to help organizations and researchers to understand cloud computing adoption contexts, requirements, to measure their risk, to migrate their services to cloud from all types and to connect and integrate different services as a single system. Future direction and security concerns have been addressed in our framework.

Keywords: Cloud Computing; Hybrid Cloud; Adoption Framework; Security; Privacy; Trust

1. Introduction

Computation power ranges from manual computing to sophisticated cloud computing technologies. The ability to collect, transport, process, store, and access data nearly anywhere in nearly any volume is the far end IT goal of any company [1]. It is described that outsourcing the access of information technology resources and services will have the potential to provide flexible, cost-effective, and proven delivery platform for business and consumer information services [2]. There is still an option to hire local IT infrastructure, but the investment on on-premises is costly and considered as a liability for many companies.

Cloud computing has become a hard core mechanism to have a cost effective and flexible computing environment that can combine and share computational resources. Previously some companies were building and maintaining their computational resources but in recent times, companies and information technology leaders realize the potential benefit in combining and sharing computing resources [3]. According to [4], long term plan for a business without thinking about cloud computing is a mare decision and a cloud-enabled enterprise is able to exploit cloud services to meet its information technology needs easily and effectively.

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to

a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [5]. Cloud computing is the future and survival tool of every data, business, network and everything access to it.

Cloud computing has different deployment models: public cloud, private cloud, and hybrid cloud. Public clouds are run by third parties and applications from different customers are likely to be mixed together on the cloud's servers, storage systems, and networks. Less cost, scalability and availability are some of the benefits of public cloud [6]. Private cloud (or internal cloud) refers to cloud computing on private networks. Private clouds are built for the exclusive use of one client, providing full control over data, security, and quality of service. Private clouds can be built and managed by a company's own IT department or by a cloud provider. Security and privacy are the major benefits of private cloud [3]. Hybrid cloud combines multiple public and private cloud models. Hybrid cloud will give us the ability to secure the institution's critical applications and data by hosting them on the private cloud or in house [7].

There are three types of cloud computing services. These are SAAS (Software As A Service) which focuses on provision of software applications in the cloud, PAAS (Platform As A Service) which focuses on provision of services that enable customers to deploy applications created using programming languages and tools supported by the supplier, and IAAS (Infrastructure As A Service) which refers to services providing computer processing power, storage space and network capacity, which enable customers to run arbitrary software [1, 3, 6].

The construction industry in Ethiopia can be described as the sum of all economic activities related to civil and building works; their conception, planning, execution, and maintenance. The increasing complexity in computation, data storage and system changes enforced the construction industry to have a better computing power that can cope up with the dynamically changing systems [8]. Using cloud computing in the construction industry has strong appeal because of the constant change of workers and frequent setup of new jobsite locations, many workers need better access to company data to aid in timely, well-supported decision making and reporting while working in the field [8]. The increasing requirement of construction companies for smarter, harder and more economical computing power and the booming emergence of hybrid cloud computing for ease, secured, less cost and shared computing power has motivated this study.

The construction industry is now embracing new technology and consuming IT services and solutions at an accelerating rate, needing to acquire more and more computing power, with bigger and faster servers to run the latest business critical applications and data [9]. The major scientific and technological problems of the construction sector in Ethiopia are inadequate planning and programming, nonsystematic way of working, non-conducive system of collection, usage and dissemination of information, low reporting culture and capability, nonstandard pricing and documentation, low capability and capacity in designing and supervising [10]. The current technological problems of the construction companies can be solved through the use of technologies like cloud computing that can facilitate their overall working culture effectively and efficiently [11]. Some IT resources, activities and processes in the construction industry are very sensitive and vital for the wellbeing of the company. They need more security and confidentiality. The company can never compromise for those resources and need to keep them as private as possible.

Hybrid cloud computing is generally best-of-breed that combines the security and comfort level of a private cloud or other on premises computing with the less costly, flexibility and versatility nature of the public cloud. It is possible to merge others with on premises private cloud for high security application

environments to leverage the best of both worlds [12].

The adoption of cloud computing requires a well-defined framework, needs to consider and discuss fundamental changes across the entire organization, requires communication and involvement of stakeholders both outside and within that will support these changes [13]. Currently, to the best of our knowledge, little attention is given to cloud adoption and there is no organized framework for adopting hybrid cloud computing. Technological aspects and processes, current computing capability, external capabilities, internal and external requirements, and frameworks are the central ideas this study considers when developing the adoption framework.

2. Related Work

Several studies have been conducted on cloud computing adoption framework and issues that are affecting cloud adoption process. A general framework for cloud computing adoption in an organization using TOE (Technological, Organizational, and Environmental) conceptual framework is proposed in [14]. The study is conducted using only literature review, in which it lacks real-life exposure and it is only aimed to address the adoption of cloud computing across multiple contexts by proposing a general cloud adoption framework.

A framework to guide companies on adopting cloud computing technologies proposed in [15] is a case study conducted on Kenyan small businesses context. The developed framework doesn't consider the specific requirements of hybrid cloud computing.

The study in [16] proposed hybrid cloud computing framework to optimize e-health activities and it identified privacy, security, interoperability and standards as the factors that influence cloud computing. It appears to be applicable in the health sector and is not adopted for other sectors, because the framework is developed based on the requirements of the health sector.

A framework for the implementation of cloud-based IT services in the construction domain is proposed in [17]. But it is more on the collaboration of construction companies using the cloud and it doesn't describe how to implement cloud based IT services.

Improved cloud computing adoption framework to deliver secure service is proposed in [18] and considered multi-layered security as a suitable security solution. However, the emphasis is on the update on security policy, technologies and techniques used. There is no detailed information from the design to implementation about hybrid cloud computing.

The work in [19] defined a framework for cloud adoption to establish a visual guideline to cloud adoption by considering consumer, provider and integrator as fundamental parties in cloud adoption. However, it is a vendor specific adoption framework that does not have detail on which type of cloud model and for which specific domain.

The hybrid cloud adoption framework proposed in this paper focuses on developing an adoption framework by considering the current internal and external computing capabilities, future requirements, conceptual framework and by making them aware of all the risks and preparedness associated with cloud computing adoption. The contribution of this paper not only raises issues inflicting cloud computing but also provides the aspects to be considered when adopting cloud computing.

3. The Proposed Solution

The proposed adoption framework is developed based on the primary data collected through interview and secondary data through review of literature. The TOE framework developed in [14] is used as a lens to the study and other cloud adoption strategies in [20, 21] are used to keep the alignment of the framework and provide it universality. The proposed framework is shown in Figure 1.

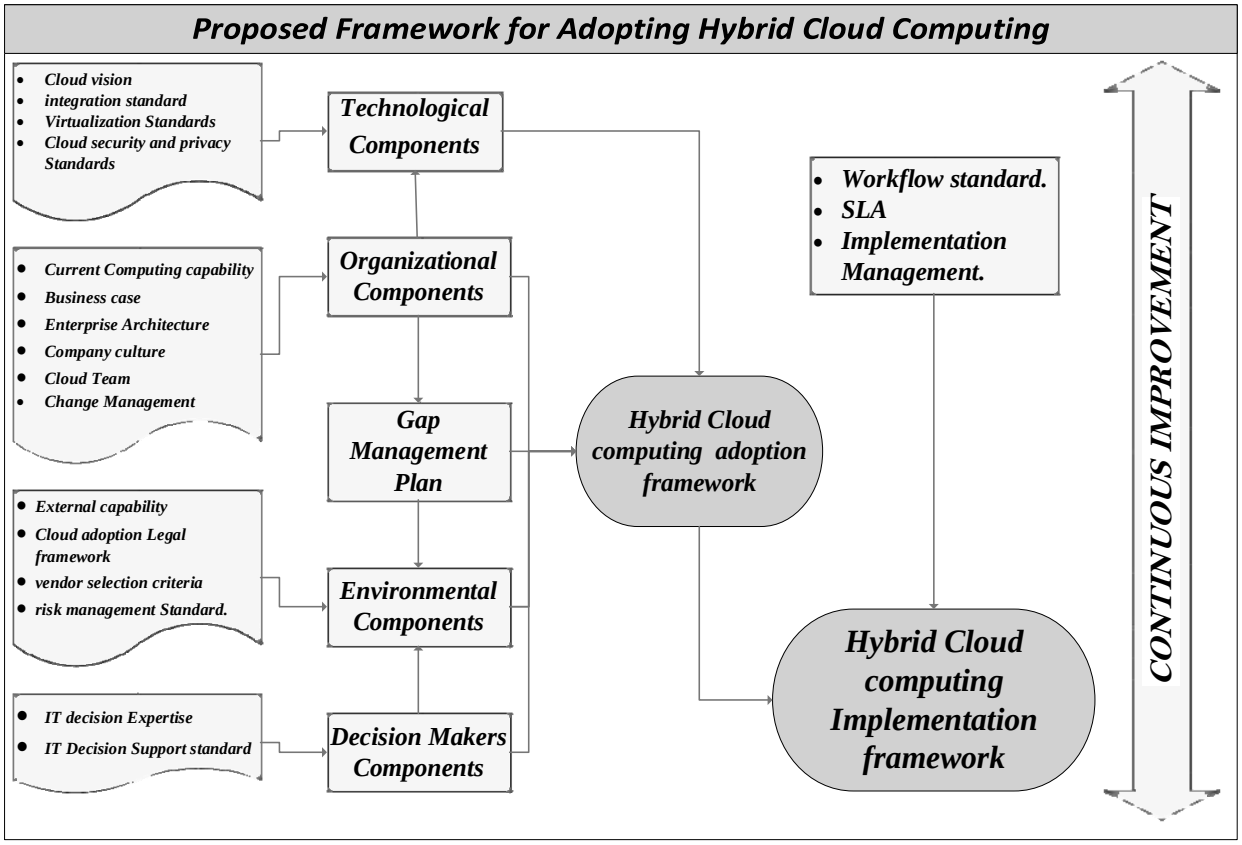

Figure 1: The Proposed Framework for Adoption of Hybrid Cloud Computing

The framework is developed based on the collected source documents, processing them, deriving the output documents and finding the components from the output document through the use of the cloud adoption conceptual framework in [14]. The current way of working and formal procedures for the daily operation, understanding of the business strategy and intents, the intent of IT managers and the identification of the involved stakeholders (internal and external) are some of the critical issues considered. On the other hand, documents that are derived on this process (example, technological, organizational, environmental, human components and adoption framework) are used as input to derive another document.

On the processing step, the collected documents and the identified stakeholders are refined based on the detail aspects of the cloud adoption conceptual framework in [14]. The perceived benefits and attributes of cloud computing, the challenges of cloud computing, the current computing capability of construction companies, the intent of the government and providers, the innovativeness of decision makers, shortfall analysis and implementation techniques are some of the issues that are studied and analysis based on the perspectives described.

The output documents are the documents processed and derived from the analysis of the source document. These documents can be standard, policy, plan, model, enterprise architecture or memorandum that will be an integral part to build its respective components. The derived documents once again can be input documents so as to derive another document through another process.

On the framework/component derivation step, using the derived documents and other inputs, the components are derived and then using the components and other necessary inclusions the adoption framework is developed. The adoption framework and other implementation requirements are used to process and recommend an implementation framework.

Design science research evaluation strategy, called an ex post naturalistic strategy, developed in [22] is used to evaluate the proposed framework. It basically considers the time of evaluation, the nature of the artifact and form of the evaluation. In addition, the quality of the framework is evaluated based on the quality evaluation metrics in [23] and the evaluation result carried out appears to suggest that the framework is reliable and fine grain of the collected data and the specified methodology that will help to adopt hybrid cloud computing.

The proposed adoption framework can provide an insight on how to adopt cloud computing for other sectors that are operating on the same environment. The research can also provide a significant help to researchers, academicians and students who are keen to learn about cloud adoption in construction companies and other sectors in developing countries as well. This is due to the fact that the proposed framework used universal and acceptable tools and techniques to develop the adoption framework.

4. Discussion

From the primary data collected through interview, respondents believe that they need better computing power and they do have a better knowledge about cloud computing. Reliable network, trusted vendor, company culture, government legislation, and skilled manpower are some of the barriers when adopting cloud computing and integrity, interoperability, security, privacy and trust are some of the threats. They believe that refined strategy, cloud vision and frameworks are required to adopt cloud computing. On the other hand, for the problems raised and requirements identified, there is national broadband and national data center expansion plan, standard enterprise architecture, implementation plan, skilled IT expert development plan, strategy alignment plan, IT service outsourcing plan, IT industry development plan, incentives, standardization, consolidation, virtualization, optimization and governance standards for ICT equipment, integration, interoperability, security standards, privacy standards, storage location plans that will support the adoption of cloud computing in the private sector.

Hybrid cloud is the optimal architecture for handling the inevitable complexity of a company's IT infrastructure and it is a catalogue of cloud services that allow the business to select the right cloud service for each application and data [24]. Different computing needs of a company require different security and privacy requirements and cloud deployment models. Sensitive resources where their security should not be compromised need to be kept and managed by a company's in-house computing and the non-sensitive resources can be computed using the public cloud to take its full advantage. The companies had already invested and owned their own ICT facility and resources. Thus hybrid cloud computing will enable them to exploit their current capacity and to go for third party provider for their additional computing requirements. The cloud policy and strategy of the country promotes the adoption of hybrid cloud computing in the time to come (2017-2019). Then it is better for the construction companies to align their cloud strategy with the future plan of the country. Adopting hybrid cloud computing will have a flavor of easy integration of distinct cloud infrastructures and services in the future. Hybrid cloud computing supports heterogeneity, dynamic and open systems, basic VM operation management, flexible scheduling policies, workload monitoring, and defense in depth [25]. Thus, when adopting hybrid cloud computing, construction companies will enjoy those features.

The proposed adoption framework is a step by step guideline that collects the necessary input based on the requirements from internal and external environment, analyses and processes the input based on the methodology selected and derive a formal document that can later be used to develop the adoption framework. Besides the cloud adoption conceptual framework in [14], we kept the framework's alignment using the cloud adoption strategies in [20, 21] at each perspective of the

framework development process. There will exist change on the internal as well as the external environment of the companies, thus the framework has a room for change management. The framework is a beta version and if some special requirement or change occurs, then the framework is open for continuous improvement.

5. Conclusion and Future Work

This paper tried to discuss cloud computing, i.e., a phenomenon changing the way of computing in a dynamic manner. The research has tried to grasp knowledge about cloud computing, its features, benefits and drawbacks and its current status in Ethiopia and the construction companies in particular. The main objective of the paper is to develop the adoption framework of cloud computing in Ethiopian construction companies. To do so we used both theoretical and empirical techniques.

The construction companies are well aware of the benefits of cloud computing and they have the tendency to adopt cloud computing when available. In fact they have a great concern on the security, privacy and trust factors. Based on their requirements hybrid cloud computing is designed in such a way that it matches with their needs. It will place sensitive resources that need special protection and treatment, within the local network by considering the security, privacy and trust requirements of those resources in parallel with the cost, availability, scalability and risk mitigation advantages of public cloud computing paradigm. Various authors figured out that the efficient and effective analysis, development and implementation of a sound and agile framework is one of the most significant factors for the adoption of cloud computing. For that matter we used different strategies, roadmaps, conceptual frameworks and input to develop the adoption framework.

Having its internal and external aspects, the adoption of cloud computing has uncountable benefits for the country in general and the construction companies in particular. In the years to come the Government initiated and promoted the adoption of cloud computing in the private sector which in turn makes the adoption framework a significant resource.

We tried to investigate using the most relative scenario and conditions, and the framework will be generic that will support informed judgment for the construction companies. As technological experience and competence matters, migration to the cloud becomes fairly complicated in the case of construction companies in Ethiopia, thus a proper comprehensive framework is developed in order to minimize the risks, challenges and increase the potential benefits of cloud computing adoption.

The main focus of this study is on the stepwise process of adopting cloud computing by integrating the on-premise IT resources and other external cloud computing environment. Apart from this study, there are other important scenarios that can be a big concern and can support this study.

Virtualization, integration, security, enterprise architecture, cloud architectures, cloud automation, orchestration, communication between different clouds, standardization, cloud control, implementation and other technical and detailed low level studies are some of the future works.

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