Building Cloud Computing Platform for delivering ERP Services

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This thesis is submitted in partial fulfilment of the academic requirements
For the degree of
Bachelor in Information Technology
In the Faculty of Mathematical Sciences
University of Khartoum

June 2013
As the candidate's supervisor, I have approved this dissertation for submission.

Name: __________________________

Signed: _________________________

Date: ___________________________
Declaration:

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Date: 25 June 2013
Abstract:

Cloud computing software as a service model (SaaS) is the matter of this research document, which is the ability of delivering software's as services through wide network, specifically ERP system in this research that has many respected advantages for business sector. Substantial subjects related to this paradigm have been reviewed, including cloud deployment models and service models, as well it reviews ERP systems from two perspective, traditional ERP and cloud-based ERP showing the advantages and limitations of each model. One ERP system module has been customized in order to be deployed over cloud to observe that business sector advantages. Moreover it reviews today's incentives and triggers to adopt CloudERP. Nonetheless it focuses on showing potentiality and capabilities of cloud (SaaS) model.
الmastkhalef:

يتعمّر هذا البحث حول الحوسبة الساحية وبالخصوص نموذج "البرمجيات كخدمة" الذي فيه يتم تقديم النظم والخدمات للعملاء عبر الشبكة، وتحديد نطاق تخطيط موارد المؤسسات، حيث تم استعراض المواضيع الأساسية ذات الصلة بهذا النموذج بما فيها تمايز الخدمة في الحوسبة الساحية، والتقييمات التي شهدت تطورها بالإضافة إلى الخصائص الأساسية لهذه التقنية.

كما تم استعراض نظام تخطيط موارد المؤسسات وتعريفه ثم مناقشته من جوانب النظم التقليدية والمقدمة عبر الحوسبة الساحية، ويتضمن ذلك تعريف الميزات وارتباط الفئات لكل منها، بالإضافة إلى المحتويات، وعوامل الدافع البيئي تقنية الحوسبة الساحية، وتعريف إمكانيات وميزات نموذج "البرمجيات كخدمة" في دعم ومساعدة قطاع الأعمال، ومن ثم تطبيق رحلة المعرفة وتعميقها بأدوات عملية يتم فيها تقييم السيناريو من حيث النزاهة بمؤشرات التعلم.
Acknowledgement:

First and foremost we thank the almighty Allah for the grace, he bestowed upon us without which this work would not have been possible. We are indebted to our supervisor Ustaz Ahmed Abdalmageed for the outstanding motivation, guidance and support. Last but not least we thank our parents and family who firmly stood by and believed in us.
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Abbreviations:

IT  Information Technology
NC  Node Controller
CC  Cluster Controller
CLC Cloud Controller
AWS Amazon web Services
EC2 Elastic Cloud Computing
WS3 Walrus Storage Services
ERP Enterprise Resource Planning
HR  Human Resource
CRM Customer Relationship Management
VT  Virtualization Technology
PDA Personal Digital Assessment
EUCA LiUtility Computing Architecture for Linking Your Programs to Useful System
S3  Simple Storage Services
XML Extensible Markup Language
SOAP Simple Object Access Protocol
REST Representational State Transfer
Chapter one: Introduction

1.1 Background:

Business and IT worldwide have been strongly demanding computing technologies for the advancement it provides, utilities and advantages modern computing can offer, which is scalable, accessible, flexible and fast responding when demanded. Businesses seek to be responsive to the quick pace of technologies while being less costly [1].

Cloud computing fulfills all of these demands, by presenting a number of services which meets companies different needs such as infrastructure as a service (IaaS) or platform as a service (PaaS) or software as a service (SaaS). Cloud-Computing is defined as “IT resources and services that are abstracted from the underlying infrastructure and provided “on-demand” and “at scale” in a multitenant environment.” [2].

This project covers software as a service Cloud-Computing model in the way it has to be implemented, provided and the way it gains in the business world. SaaS had been defined as “a software distribution model in which applications are hosted by a vendor or service provider and made available to customers over a network, typically the Internet” [3]. One of the services that can be provided over this model is the Enterprises Resource Planning (ERP) system as a service. ERP has been promoted by the American Production and Inventory Control Society (APICS) since 1980 by extending the Manufacturing Requirements Planning (MRP II) operation system to other systems of the company such as finance, marketing, human resources, etc. ERP is defined as “a development objective of mapping all processes and data of an enterprise into a comprehensive integrative structure. Also, ERP can be seen as the key element of an infrastructure that delivers a solution to a business” [4].

The target of this project is to help reduce IT infrastructure, support and management costs to business industry by providing more scalable and elastic IT services with efficient and quick responses when demanded. These are few of the many advantages of software as a service Cloud-Computing model implementation, which will be evident throughout this study.
1.2 Problem Statement:

Companies suffer from high costs of providing IT infrastructure, support, management, and maintenance costs. In spite of that, they do face scalability and accessibility issues. Also, they struggle to achieve the required quality of service and speed of response, which are all essential needs for Small to medium Enterprises (SME's).

SME's are in need for a computing solution that allows for a competitive advantage in the future world of business. The computing utility is needed to avoid seasonal or sudden computing demand as well as reduce risk and costs. Furthermore, computing resources cannot be provided within the small frame for financial or management reasons, hence, a cloud computing solution can be implemented that offers cloud resources for these small frames and let them compete in future world of business.

1.3 Motivation:

Cloud computing can be the solution for many SME's problems: "there are all kinds of areas where the cloud can make a difference for SMEs" [5]. Cloud services provide businesses with stability, accessibility, and ultimately more productivity while at the same time reducing costs. Using cloud to provide ERP system services can have a positive impact on SME's performance. All this potential and capabilities of cloud were considerable motive to conduct this research.

1.4 Methodology:

The research will achieve its objectives and deliver the expected system and solution through obtaining essential knowledge about cloud computing models, acquired from books, websites, conference papers, journals, and researches by others to understand the key concepts of delivering Cloud Services and its key characteristics.

Afterward, a technical implementation will occur, aiming to deliver a computer system where the necessary software and hardware requirements are sought to build the cloud computing environment.

Lastly, the prototype system will be designed and developed, and then testing and evaluated against the aims and objectives behind the research.
1.5 Project Aim:
The aim of this project is providing ERP system services over a cloud environment that supports the business sector and contributes in facilitating business processes for (SME's).

1.6 Objectives:
- Reviewing cloud computing architecture.
- Reviewing the (SaaS) cloud computing model.
- Comparing between traditional ERP and CloudERP.
- Identifying the potentials of (SaaS) cloud computing model in supporting business sector.
- Identifying the capability of presenting a business process module as software over cloud.
- Customizing open source ERP module in order to be deployed over cloud platform.
- Supplying service providers for cloud software service "supply chain".

1.7 Thesis layout:
The outline of this research will be as followed:

Chapter two: Literature review:

This chapter outlines the cloud computing by describing its services and deployment models, its essential characteristics and related technologies. ERP systems has been defined especially the procurement model. Furthermore advantages and disadvantages of CloudERP has been reviewed as well as comparing between traditional and Cloud based ERP.

Chapter three: Requirement Analysis and Design:

This chapter outlines the functional and nonfunctional requirement analysis and the software design throughout the project using the use case, class and deployment diagrams.

Chapter four: Implementation:

This Chapter demonstrates the tools that have been used to implement throughout the project. And the customized model and how it developed.
Chapter five: Conclusion:

This Chapter introduces the results and limitation, future work and recommendations.

1.8 Chapter summary:

Point out previously in this chapter to the necessity of business and IT now days for the advancement it provides and how cloud computing SaaS can fulfill all this demands. problem statement, motivation, methodology and project aim.
Chapter Two: Literature Review

2.1 Introduction:

Since computing technologies had been arisen to the world and proved a significant impact on business sectors, organizations had been spending enormous amounts of money to acquire the required computing resources to set up their own IT infrastructure, which accompanied with various problems and burdens (e.g., management, security, maintenance...etc.). That is until the cloud technology was represented as a cure for these problems.

The previous chapter tried to introduce some important concepts about cloud computing in general, and this chapter will attempt to understand and investigate this research problem, have a full look about cloud computing advantages and disadvantages, it's types and related technologies after that ERP will be defined by revealing its concept and exposing the influence of this enterprise systems in business, consequently comparing between traditional ERP and Cloud ERP.

The below section will define Cloud Computing, its essential characteristics, services and deployment models.

2.2 Cloud Computing:

2.2.1 Definition:

According to National Institute of Standards and Technology NIST 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's interaction. [6]

Cloud Computing compose from five essential characteristics, three service models, and four deployment models, however a borderer explanation for each one of these will be provided in the below section.

2.2.2 Essential Characteristics:

Essential characteristics of Cloud-Computing:
Multi-tenancy:
   It’s the principle where the software architecture should provide a single instance of the software serving multiple clients at the same time without affecting each other’s, or reducing the efficiency.

On-demand self-service:
   The service is available to end users in the way it’s needed with no need for human interaction from service providers side. The on-demand nature of cloud supports the performance and capacity aspects of service-level perspective, and that’s by the maximizing the resources utilization. The Self-service nature of cloud computing helps enterprises to reach an elastic environment that’s respond to business needs and workload.

Broad network access:
   Cloud services are available through enterprise or public network and can be accessed from any location through standard mechanism from user’s devices (e.g., laptops, Personal Data Assistant (PDA’s)… etc.).

Resource pooling:
   Providers physical and virtual computing resources are pooled together to provide services to consumers, assigning and reassigning these resources dynamically according to consumers demand with a multi-tenant model, where they have no control or knowledge about the exact location of the resources.

Rapid elasticity:
   Capabilities needed by consumers can be rapidly and elastically provisioned and provided, sometimes automatically, once the user needs expand the resources are instantly provisioned otherwise it’s automatically released. For consumers cloud resources may appear unlimited.

Measured Service:
   “Cloud systems automatically controlled, monitored, and reported, providing transparency for both the provider and consumer of the utilized service.” [6]

2.2.3 Service Models:
   Cloud computing have many service models which well be categorize in the next sections:
Cloud Software as a Service (SaaS):
This type of model considered to be a very broad market, where there is an open capability of benefiting the available applications and software’s running on a cloud infrastructure by the terms of a commercial agreement between consumers and service provider. These applications can be anything, (the inventory, database processing...etc.). Where a single instance of the software is running on the cloud and serves multiple end users or client organization. In this model both application and data are hosted by the service providers, end user can use the service anytime from anywhere.

Cloud Platform as a Service (PaaS):
This model is an outgrowth for (SaaS) model, where all the required facilities and tools for developing and delivering web-based applications are provided entirely over the internet with no infrastructure resources. Software downloads or installations where burdens for end users. The (PaaS) model have two components, the place on which software can be launched that performs as a platform for the software, and the services being provided. There is many types of services can be delivered via this model to develop, test, deploy, host and manage applications to support application building complete life cycle. End users terminals can only contain an operating system and a web browser since the infrastructure and the application resources are provided by (PaaS), and the data itself can be stored in the cloud.

Cloud Infrastructure as a Service (IaaS):
In this model the organization uses resources from outside, to support its operations, these resources can be network component, virtual servers, storage and databases. An organization typically rents these resources for a fee.

2.2.4 Deployment Models:
This section will describe the Cloud Computing deployment models:

Private cloud:
The cloud infrastructure is dedicated and operated solely for an organization. That is to be used exclusively by the owner who has the ultimate control on it. It may be managed by the organization or a third party and may exist on premise or off premise. This deployment model averts the organization the loss of control and security risks associated with other cloud infrastructure models offering many benefits of cloud in the other hand.
Community cloud:
The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). Also may be managed by the organizations or a third party and may exist on premise or off premise.

Public Cloud:
The cloud infrastructure resources are made available of the general public or a large industry group and it run by third parties. Where consumers don't actually have to possess these resources and can access them on-demand by a web browser simply from any terminal. In public cloud customers applications are probably mixed together in servers, storage systems and networks and end-users may have no knowledge about the exact location of their data. Where their no resource dedication for a specific organization. All resources are shared among cloud provider customers. Public clouds have many security issues that must be considered before implementing this model, one issue could be that commercial cloud provider's access permissions are less controllable and end users may have broad access capabilities.

Hybrid Cloud:
This model provide the capability to extend a private cloud with the resources of a public cloud, that is when the private cloud resources are drained, public cloud resources are leveraged to supplement the internal cloud. This cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain individual entities but are bound together by standardized technology that enables data and application portability. For example the organization can decide which application to stay within the private cloud for security or other considerations, and which can be moved to public cloud.

2.2.5 Related Technologies:
This section will state some of related technologies to cloud computing:

Grid Computing:
A form of distributed computing, where a virtual supercomputer is made up of a cluster networked and interworked computers that performs like a single huge computer used to solve very large problems (e.g., equations to predict weather, mathematical problem, etc.). Grid computing has developed originally for computation-intensive of scientific application.
Utility Computing:

Also termed as (on-demand computing), a pay-per-use billing model where customers acquire the needed resources via a private line or over the internet. Utility-computing role is limited to deliver application infrastructure resources hardware or software. While Cloud-Computing is more advanced and complicated model relates to the way it had been designed, build, deploy and run application, that operate in a virtualized environment, sharing resources and its ability to dynamically interact with its users by expanding or contracting as needed.

Virtualization:

Virtualization is a fundamental technology for cloud computing and can be considered as the backbone of it. It can be defined as "a high-level application that abstracts the physical hardware, forming Cloud-Computing foundation, enables resource pooling capability". [7]

Automatic Computing:

It's self-management capability of systems, overcoming management complexity of computer systems. Cloud Computing has automation feature to handle cloud orchestration complexity. [7]

Computer Cluster

Cluster is a group of closely linked computers, working together forming single computer system in many respects, perform autonomous computing to fulfill a certain task. However, Cloud-Computing is a system working independently that can contain many clusters. [8]

Service Oriented Architecture (SOA):

SOA "is a software architecture for building business application that implements business processes or services through a set of loosely coupled, black-box components orchestrated to deliver a well-defined level of service". [9] Cloud-Computing require many characteristics that must be met in order to use this term, such as elasticity, self-service provisioning, standards based interfaces, and pay- as-you go billing. All these functions require be interpreting and engineering as software. SOA can provide flexibility of software approach to enable Cloud-Computing solution to deliver services.

2.2.6 Major Benefits of Cloud Computing:

In addition to lower expenses, enterprises can benefit from many other primary benefits and utilities associated with cloud computing. These can be summarized as follows:
Costs:
Companies can save the considerable costs associated to computing services that is by adopting cloud, since it released firms from the burden of employing IT staff, providing the hardware and software required, maintenance costs and software licensing item.

Capabilities/Scalability:
This feature of cloud services releases the organization from the boundaries of its infrastructure resources, because the provided resources can be adjusted dynamically in response to the changing workload and required performance parameters, that it expands and contracts to meet different situations.

More Green:
Outsourcing via a cloud solution reduces the environment damage resulted by companies.

Organizational Agility:
By eliminating the purchasing of hardware and software and the need to depreciate these assets, infrastructure is no more an obstacle in organizations way to global expansion. That (SME’s) can acquire the required computing resources and can compete in the market. Moreover with cloud model organizations are more open to change whenever needed with no financial or management burdens.

Collaboration:
Cloud is a supportive environment for global collaboration and group decision making, also with cloud borders are no hurdle for companies expanding since cloud services have no regard for geographical locations.

Focus:
Delegating commodity of infrastructure and services and all the compelling burdens of computing resources, that allows organizations to focus more on their core competencies and to develop products or that can differentiate their organization from other competencies, and further develop capabilities that can differentiate their organizations in the way of performing business.

2.2.7 Cloud computing impact on business environment:
Cloud computing basic concepts and principles are well understood and recognized by most business leaders who have familiarity with Information Technology IT, what can represent confusion is the uncertainty of how cloud will exactly affect their companies, and how to harness its potentials.
A major shift made by cloud in the way that IT services are purchased, and how businesses process information and manage IT, where the enormous investments in dedicating resources and infrastructure are neglected.

Also, cloud computing can have its impact on disrupting entire industries, and it's possible that new business models are produced. Cost reduction and less upfront investment advantages of cloud can dramatically reduce the cost and complexity associated with IT. Cloud-based services can operate at less than half cost compared to another traditional infrastructure [10]. The resulting savings can be enough to disrupt procurement models and enable the development of new markets. Increasing business agility and flexibility offered by cloud can have its influence on companies' scale expansion.

Another serious impact is that new business ideas can be launched in a limited amount of time and with less effort, that with this innovation opportunities opened for all and entry barriers are significantly reduced; the competition map could be redefined and (SME's) are capable of challenging much larger companies and globally. Through these potentials and capabilities cloud computing can disrupt current practices in a wide range of industries, restructure existing business model, and represent new ones.

2.2.8 Impediments to Cloud Adoption:

Security:
Security has been one of the biggest concerns and challenges to cloud computing technology, in hosted clouds option consumers entrust with the responsibility of storing and securing their data to Commercial cloud providers, who offers broad access to end users and access permissions are less controllable, where there is a possibility that many organizations are sharing the same physical resources. Legacy security measures such as firewalls or intrusion detection may not be sufficient in cloud environment and must be duplicated.

Privacy/Compliance:
Cloud computing model have significant implications on end-users privacy, since any kind of information that can be stored in a personal computer can be stored as well in cloud, then privacy or confidentiality questions may arise whenever users try to share these data. Also the location of these data may have its effect of data legal statues since it can be stored in different locations, with
different legislation and laws that may allow the cloud provider to examine its customer's records searching for illegal activities or other matters.

Immaturity of Vendors/Offerings:
Since cloud technology has not been in practice for long, cloud service providers may not yet have developed a strong track record in supporting large production and enough experience in this field.

Risk Mitigation:
It is difficult to determine how well a provider is mitigating data location, loss, or security oriented risks. In fact, some providers have simply gone out of business. [11]

Legacy Application:
Most of legacy organization Core business applications are highly customized, entangled and rigorous in its way of performing business and managing their systems; therefore cloud may have issues in providing such customized services.

The previous sections stated a general description of cloud technology and other related concepts; since this thesis one of its aims to deploy an ERP system over cloud environment we must overview some concepts about ERP systems concepts and functionalities in the next section.

2.3 Enterprise Resource Planning (ERP):
ERP was defined as "a comprehensive, packaged software solution that seeks to integrate the complete range of a business's processes and functions in order to present a holistic view of the business from a single information and IT architecture."[12] Its provide access to different departments and services, via a single computer system, Automatic and coherent work-flow from one department to another, where ERP systems vendors can extend it to provide Business Intelligence functionalities as well.

These systems has various modules like Human Resource(HR) Management, Manufacturing, Sales\Marketing, Warehouse Management, etc. and provides the organization with a unified and single reporting system to analyze the statistics/ numbers/ status etc. in real time, across all the departments. According to ERP suppliers such as SAP, Oracle, PeopleSoft/J.D. Edwards, etc., there is a capability for more than twelve modules to be implemented through ERP.
One of the major benefits of this system is having a single database that is implemented on the back-end to store all the information required by the ERP system and that enables centralized storage back up of all enterprise data. ERP systems provide visibility and hence enable better and faster collaboration across all the departments. Since ERP systems are centralized system that a central security policy can be applied and all transactions and operations can be tracked.

ERP systems can be considered an essential tool for organizations that aims to compete in the global market or even to survive in it.

Since the idea behind this project is to deploy an ERP system over a cloud environment in order to perform a customization process over one of its modules, procurement module was chosen as the implementation part of this project, it will be discussed in more details in this chapter.

2.3.1 Procurement Process:
Which perform the act of buying services and goods, with best prices and quality, the process includes processing and preparation on a demand as well as the end receipt and approval of payment, procurement module functionality can be summarized on the following:

- Allow the employees to send a procurement request.
- Pass the PR through the accounting and technical department.
- Allow the purchase department to send a tender request for suppliers.
- Give suppliers a mechanism for the submission of financial and technical proposals.
- Handle the registration process.
- Allow electronic payment.

2.4 Incentives and triggers to adapt CloudERP:
ERP systems became a key requirement for the survival of businesses and for its acquisition and maintenance and overwrought to manage it and many (SME’s) may not be able to afford it. The above drawbacks and more became trigger factors to adopt CloudERP systems and here are some of these factors:

1. Outward pressure:

Companies are deeply affected by their competitors policies in the general business market that’s include the technological policies because the technology used by the competitors may
represent a real threat for the company by its impact on business performance and cost reduction. Therefore, competitors have considerable impact as a technology adoption trigger factor.

A major pressure factor can be the trading partners such as customers who could have a say in considering the adoption of CloudERP systems. Similarly, suppliers can also be pressurized. Legislative pressure is another factor in which the government, for example, requires companies to adopt a new technology, this is a huge pressure to adopt this technology by the respective sectors, and its so-called new policy enforcement.

2. Pressures from inside the organization:

A considerable demand for CloudERP comes from inside the enterprise, when company suffers from unsatisfactory performance as a result of market uncertainty and competitors innovation, therefore the company needs to upgrade and maintain its technological infrastructure to fix up this situation, and this have its costs. And here comes the CloudERP system as a solution.

Adopting the CloudERP reduces the manual work that creates error-prone results leading to inefficient work.

3. Firm size and structure:

Firm size has a positive relationship with technology adoption, also is the firm structure the more flexible it was, the less difficult it is to implement changes and more open for technology adoption. These firm attributes represent a presumed pull factor for CloudERP adoption.

4. External support:

Many empirical studies considered the external support as another prominent factor [13], which has been defined as "factors outside the control of an organization" [14], these factors provide awareness about the importance of new technologies that are going to be adopted. Such as subsidy by providing incentive, tax exemption which is a cost reduction for SME’s, another one is industry association who provide advices and experiences to reach a better understanding for the shared business environment.
5. **Relative advantages of CloudERP:**

Relative advantages of adopting Cloud ERP are very enticing when it's recognized to, SME's need to gain these benefits through the adoption. These advantages will be discussed in detailed in the previous section.

**2.5 Advantages of CloudERP:**

This section will indicate to some of the advantages when adopting CloudERP:

1. **Cost reduction:**

CloudERP allow companies with small budgets to lower their initial capital costs giving them a chance to enter the market. This benefit is generally considered as having increased relevance for SMEs.

2. **No management burdens:**

CloudERP management efforts are very scant compared to traditional ERP systems. That the service providers are responsible of all management burdens as discussed earlier in this chapter, and to deal with any problems that may occur through effective troubleshooting services.

3. **Improved accessibility, mobility, and usability:**

Besides their inherent features of mobility and accessibility cloud-based ERP and other enterprise applications can usually boast higher levels of user friendliness and usability than other types of ERP [15]. In the meaning of that system can be accessed from any location having the same level of access since it's hosted in a virtualized environment. In the meantime that expanding is a serious concern for companies with traditional ERP, CloudERP relief its users from such concerns.

4. **Access to advanced technology:**

Cloud-based applications often enable access to specialized technology and advanced computing resources that otherwise would have not been accessible to SMEs [16].

5. **Improved business performance:**

With experts handling company system issues, solving its problems that give the company the ability to focus on its core business functions directing all of the effort to achieve its goals.
2.6 Challenges and limitations in CloudERP:

1. Security:

The nature of ERP systems is very sensitive in the meaning of that it deals with critical company data. Security and confidentiality risks are reported to be among the top concerns about cloud-based ERP [17].

2. Privacy:

Privacy in CloudERP is another issue that company data is totally exposed to Cloud Service Providers (CSPs) and company cannot determine who have access to its data.

3. Stability:

Since this service is provided over the internet network downs and outages can occur, which may lead to a loss of productivity among other consequences.

4. Lock-in:

In a general perspective lock in can be considered a serious concern about cloud technology, where many questions arise for example, what if the service terms change, service costs changed, how easily can the user move to another cloud, and is moving out from cloud is easy as moving in. All the previous questions can act as inhibitors to cloud adoption.

According to a published report in November 2009 entitled Cloud Security Risk Assessment, the European Network and Information Security Agency (ENISA) highlighted lock-in as one of the biggest risks involved with cloud computing. "There is currently little on offer in the way of tools, procedures or standard data formats or services interfaces that could guarantee data and service portability," said the report. "This can make it difficult for the customer to migrate from one provider to another or migrate data back to an in-house environment" [18].

The next Table 1 can represent the difference between traditional and cloud ERP:
<table>
<thead>
<tr>
<th>Factor</th>
<th>Traditional ERP</th>
<th>CloudERP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deployment</td>
<td>Local Server</td>
<td>Cloud Server</td>
</tr>
<tr>
<td>Reduced Server costs</td>
<td>Low costs</td>
<td>High costs</td>
</tr>
<tr>
<td>Defining business flow</td>
<td>Defined by ERP developer and business organization Specific.</td>
<td>Define by both ERP developer and Business Organizations.</td>
</tr>
<tr>
<td>Implementation costs</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>On-going costs</td>
<td>Relatively high</td>
<td>Low</td>
</tr>
<tr>
<td>Control over ERP</td>
<td>Easily controlled</td>
<td>Relatively tough to control</td>
</tr>
<tr>
<td>Customization</td>
<td>Not open for business Organization.</td>
<td>Open for business Organizations.</td>
</tr>
<tr>
<td>Support costs</td>
<td>Relatively high</td>
<td>Low</td>
</tr>
<tr>
<td>ERP module update</td>
<td>Costly</td>
<td>Low cost</td>
</tr>
<tr>
<td>Internet needed</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Version Controlling</td>
<td>Complex</td>
<td>Easy</td>
</tr>
<tr>
<td>Integration</td>
<td>Dependent on vendor</td>
<td>Can be supported centrally</td>
</tr>
<tr>
<td>Licensing costs</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 1: Comparison between CloudERP and traditional ERP

2.7 Chapter summary:

In this chapter a definition for cloud computing was provided, previewing its essential characteristics, service models, and its different deployment models. After that related technologies to cloud will be discussed, also the major benefits of cloud computing and its impact on business environment, then Impediments to Cloud Adoption are represented showing cloud shortcomings in meeting business needs.

Another topic discussed in this chapter is ERP system as general and procurement module in more details, comparing traditional ERP systems with cloud-based ERP systems, previewing CloudERP advantages and limitations.
Chapter Three: Requirement Analysis and Design:

3.1 Introduction:

In the previous chapter, a general overview of cloud computing and ERP system were presented, and since the procurement module was chosen to be deployed in the form of Software As A Service (SaaS), a requirement analysis process will be presented, accompanied with a detailed design of the software. The requirement will be previewed from two perspectives:

3.2 Functional Requirement:

3.2.1 Application Requirement:
- Software should allow the employees to send a purchase request.
- Software should allow the purchase department to send a tender request for suppliers.
- Software should provide electronic invoice.
- Software must allow electronic payment.
- Software should perform a supplier evaluation process.

3.2.2 Platform Requirement:
- The billing policy should be pay-per-use.
- Maintenance costs are the service provider's responsibility "cloud provider".
- Needed resources from any size must be assigned to customer whenever needed.

3.3 Non-functional Requirement:
- Availability: that the service should be accessible from anywhere at any time.
- Reliability: that a guaranteed quality of service must be provided according to cloud Service-Level Agreement.
- Inter-operability: to enable applications to be ported easily from one cloud to another and to interoperate with different cloud-based services.
- Compatibility: Cloud application Compatibility means the provided application and user's data will always work the same way regardless of the cloud provider or platform, internally or externally, open or closed.
- Software should be usable for employees with different levels of computer knowledge.
These are the common requirement of purchase system users, the below section will provide an explanation of the procedures followed in purchase process using the necessary diagrams.

3.4 Use case 1:
3.5 Use case 2:

![Diagram of procurement process]

Figure 2: Use case of the procurement process
3.6 Class diagram:

![Class diagram](image)

Figure 3 Class diagram explains the interaction process between system components.
3.7 Deployment diagram:

Figure 4 A deployment model that reflects the scenario with all design components included.
3.8 Chapter summary:

In this chapter a requirement analysis process was conducted in order to define the user requirements, after that a detailed design for the procurement process was represented using two use cases, a class diagram, and a deployment model that clarify the process of providing the software of cloud. The next chapter will discuss the implementation phase of this software in detail, previewing the software architecture, cloud platform component each one with its functions, and all the tools that was used during this process.
Chapter Four: Implementation

4.1 Introduction:

This chapter will introduce you to the tools that we used throughout the project, the criteria behind choosing the tools such as the cloud computing software and the ERP and how they were customized, as well as, how the module was chosen, designed and developed as mentioned in the previous chapter.

4.2 Tools:

The tools used throughout this project are Eucalyptus and Open ERP, which are both open-source software without licensing.

4.2.1 EUCALYPTUS:

Eucalyptus is an open-source cloud-computing tool developed by a research group in University of California: Santa Barbra now supported by Eucalyptus Systems, a Canonical Partner. Eucalyptus stands for Elastic Utility Computing Architecture for Linking Your Programs To Useful Systems. The system is designed to be simple and easily accessible to the user. This system allows users to "start, control, access and terminate entire virtual machines using an emulation of Amazon EC2's SOAP and "Query" interfaces in such a way that users will be able to operate Eucalyptus in the same way as they operated Amazon EC2. [1]

Eucalyptus was chosen for this project because it is fully documented and it has an active online community that can be sought. In addition, according to Daniel Nurmi et al Eucalyptus is considered to be easy to install, highly modular with industry-standard, language-agnostic communication mechanisms encouraging development.

"Eucalyptus provides an EC2-compatible cloud computing platform and S3-compatible cloud storage platform. Eucalyptus has become very popular and is seen as one of the key open source cloud platforms. Since Eucalyptus makes its services available through EC2/S3 compatible APIs, the client tools written for AWS can be used with Eucalyptus as well." [1]

4.2.2 Eucalyptus Components:

Eucalyptus is comprised of the following components:
I. Node Controller (NC):

NC is a Virtualization Technology VT enabled server that operates on every node and it's where VMs are hosted. The NC acts like a mediator between the hypervisor and the OS of the node it's operate on in one side and the cluster controller (CC) in the other side, and that n (available memory, number of cores...etc) of the node and report it to the (CC).

Node controller is responsible for responding to cluster controller's control requests, CC sends runInstance and terminateInstance requests to (NC) in order to control VM instances running on this node. Managing the instance life cycle is done by the NC, that after the authorization is done and the resource availability is confirmed, the node executes the runInstance request in collaborate with the hypervisor the NC makes a node-local copy of the instance image files (the kernel, the root file system, and the ramdisk image), identify a new endpoint in the virtual network overlay and then instructs the hypervisor to boot the instance. To terminate this instance the hypervisor is instructed by the NC to terminate the VM, tear down the virtual network endpoint and clean up all this VM associated files.

II. Cluster Controller (CC)

CC manages one or more NCs and deploys/manages instances on them that it instruct NC to start or terminate instances receiving VM requests and deciding which node to execute it. Also CC is responsible for managing the networking for the instances running on the Nodes under certain types of networking modes of Eucalyptus. CC acts like a mediator between Cloud Controller (CLC) generally CC operates on a cluster front-end machine or any machine with a network connectivity to both nodes running NCs and machine running cloud controller.

The three basic functions of the CC can be previewed as the following:

- Managing the incoming instance run requests by assigning them to a specific NC to execute them.
- Control the Instance virtual network overlay.
- Gather information and Report NCs statues.

A description for how CC operates is that when it receives a set of instances to run, it runs a describeResources operation contacting each NC component and the first NC that have enough free resources receives a runInstance request. When the cloud controller sends a describeResources request to the CC it also sends a list of resources characteristics (cores, memory, etc.) Defining the resource requirement needed by an instance, and in respond for this massage the CC calculates the
number of instances of this specific type can be executed simultaneously on its collection of NCs and report the result back to the cloud controller (CLC).

III. Walrus Storage Controller (WS3):
Walrus can be defined as a data storage service that leverages standard web services technologies (Axis2, Mule) and its interface compatible with Amazon's Simple Storage Service (S3), it works with REST and SOAP interfaces that are also compatible with (S3). Walrus is used by eucalyptus users to stream data into/out of the cloud as well as from instances running on cloud nodes. It also acts like storage for VM images where Root filesystem as well as kernel and ramdisk images which is used to instantiate VMs on nodes can be uploaded to Walrus and accessed from nodes, walrus can be considered as a simple file storage system.

IV. Cloud Controller (CLC):
It's the front end to the entire cloud infrastructure, it provide users with a web interface for managing certain aspects of cloud. CLC can be seen as the component that manages the underlying virtualized resources that comprise the eucalyptus cloud, a description to it that it's a collection of web services that can be grouped by the role it perform into:

- Resource Services: CLC acts like an equalizer of resource allocations (Deciding which clusters will be used for provisioning the instances), that it lets users manipulate VMs properties and networks in on side, and keep monitoring both system component and virtual resources in other side.
- Data Services: govern the data of persistent user and system and present for a configurable user environment for formulating resource allocation request properties.
- Interface Services: provide user-visible interface, expose system management tools providing, and its where the authentication and protocol translation is handled.

4.2.3 Eucalyptus Architecture:
Below the Figure 5 illustrates the architecture of Eucalyptus:
Figure 5: Eucalyptus Architecture
4.3 OpenERP:

Open Source Rapid Application Development (RAD) with OpenObject: Open ERP, Enterprise Management Software, was developed recently under the Affero General Public License (AGPL) license. The software includes Customer Relationship Management CRM, Human Resource HR, Procurement and many other business operations. Open ERP is based in OpenObject, a modular, scalable, and intuitive RAD framework written in Python.

OpenObject is a comprehensive modular toolbox that facilitates quick and easy application design. Features include: integrated Object-Relationship Mapping (ORM) support, template-based Model-View-Controller (MVC) interfaces, a report generation system, automated internationalization, etc.

4.3.1 Python:

"Python is a high-level dynamic programming language, ideal for RAD, combining power with clear syntax, and a core kept small by design." [2]

The Procurement module has then been customized so as to create a ranking system for the different suppliers that are available in the module. The ranking system allocates zero points to each new supplier by default. It then observes the suppliers’ delivering habits, rewarding with points when an early delivery is made and enforcing a penalty when a late delivery is made. This allows for easy ranking between different suppliers using the total point system. Below Figure 4.1 illustrates how OpenERP system displays the list of suppliers organized in terms of points.

Base module: is the kernel of OpenERP, without it nothing will work. It is not possible to change immediately on it, but in our case we did this directly due to time limitation. The other approach is to use inheritance since OpenERP is object oriented based.

Ris_Partner: It is the module of partner in base; the module includes all the relevant data about the partners. OpenERP labeled the customers and suppliers as partners. The partner is given a type Boolean to check in the location file the code

After that remarks have been selected they are arranged in descending order.
OpenERP is divided to a front end and back end. To change the front end view, the Extensible Mark-up Language XML file should be modified. The back end makes use of both PostgresSQL database and Python.

In the view tree, the location path /server/openerp/addons/base/res/res_partner.py has been accessed and a “Ranking” field has been added. The following code has been added.

```python
making _order = "remarks desc"

the filed on line : 155

"remarks": fields.integer('Ranking),
```

adding customized field to the parnter view on
/server/openerp/addons/base/res/res_partner_view.xml

adding field to the tree view: 320

```xml
<field name = "remarks"/>
```

customizing stock.py on /addons/stock/stock.py

editing function action_done on line 846

def action_done(self, cr, uid, ids, context=None):

self.write(cr, uid, ids, {'state': 'done', 'date_done': time.strftime('%Y-%m-%d %H:%M:%S')})
res = self.read(cr, uid, ids, [], context=context
objs = self.browse(cr, uid, ids, context=context
for obj in objs:

    min_date = obj.min_date
    done_date = obj.date_done
    min_date = datetime.strptime(min_date, '%Y-%m-%d %H:%M:%S')
    done_date = datetime.strptime(done_date, '%Y-%m-%d %H:%M:%S')

    if obj.partner_id:
```
days = (done_date - min_date).days
part_obj = self.pool.get('res.partner')
part_remarks = part_obj.browse(cr, uid, obj.partner_id.id, context =

remarks = part_remarks.remarks
if days > 90:
    remarks -= 3
elif days >= 60:
    remarks -= 2
elif days >= 10:
    remarks -= 1
elif days > 0:
    pass
else:
    remarks -= 1

part_obj.write(cr, uid, obj.partner_id.id, {'remarks': remarks}, context =

return True

The figure below, will the custom show the customized field “Ranking” in OpenERP module using dummy variables:
The appendix A will then explore in further detail, using figures, the procurement process in OpenERP.

4.4 Chapter Summary:

In the Chapter all the tools used in implantation through this project had been previewed including Eucalyptus and Open source architecture with a detailed explanation of each of its components, likewise discussing the customization process conducting in this process previewing the ranking system algorithm and code.
Chapter 5: Conclusion:

5.1 Introduction:

The authors of this thesis have looked into Cloud-Computing generally, reviewing its different models with a closer look over the (SaaS) model from business world perspective, which is permanently demanding advance technologies for evolving business practice approaches. Established a cloud (SaaS) model that provides ERP system services, and finally, addressing the values and benefits that can be delivered to cloud users in the business sector.

5.2 Limitation:

The resources that were available through this project were sufficient for implementing only one node controller in landscape business; however, this architecture can be expanded by deploying many node controllers what will have its impact in increasing this architecture processing capabilities and efficiency.

Another limitation is that since Sudan suffers from rigorous embargo, acquiring the required software resources represented an issue during this project, however an open source platforms were used in order to overcome this obstacle.

5.3 Recommendation for future work:

Although the scope of this project was to implement one ERP module, specifically a procurement module, there is a capability for the full ERP package to be deployed and provided over the cloud.

And since Business Sector had been targeted in this thesis, other sectors like Education and Health for example, can be targeted and full functioned over the cloud as well.

Since pay-per-use model is one of primary cloud computing advantages a billing application can be developed and integrated to this project.
5.4 Conclusion:

The thesis has been written in a subjective manner, addressing Cloud-Computing topics, in order that they work together, to deliver general idea about the paradigm. The contribution of this thesis came into many dimensions mainly to give a general view of Cloud-Computing while conducting the approach of delivering Cloud (SaaS) model values to consumers, that is by deploying a customized procurement module, focusing on CloudERP potentials and advantages providing a full comparison between traditional ERP and Cloud ERP.
References:


Bibliography:


Appendix A:

Figure 6: The home page that amperes once local host is opened that shows all the installed modules which are accounting, warehouse and purchase or procurement, all shown since they are related to each other.

![Figure 6]

Figure 7: When purchase button is pressed to complete purchase order figure 2 will be shown.

![Figure 7]
Figure 8: When press on purchase order in left side a history of all previous purchase process will be shown.

Figure 8

Figure 9: shown when press on Create button to select or add a supplier.

Figure 9
Figure 10: supplier field contains a bottom that once it’s pressed it shows the already exist suppliers.

Figure 10

Figure 11: when create button is pressed it gives a screen with number of fields that describe product. If it’s all what needed the “save & close” button is pressed else way “save & now” is pressed.

Figure 11
Figure 12: Enter the relevant data after that press on "save & close" and identify the scheduled date for products delivery.

Figure 13: after that press on "Convert to Purchase order" button to confirm the purchase order.
Figure 14: Then “Save” button is pressed, the invoice can be printed out from this screen by this the client accomplished successfully the purchase order.

Figure 15: The warehouse module will be shown to check if the product arrives at warehouse or not.
Figure 16 shows the process waiting to be fulfilled.

Figure 16

Figure 17 shows that the process is ready to done and press on "Process" button to complete purchase order.

Figure 17
Figure 18: warehouse is checked; if the product has been delivered order fulfillment is reported. Else cancel button is pressed.

Figure 19: Shows the process in warehouse was successfully accomplished the state will change from “available” to “done”
Figure 20: shown when purchase management button is pressed.

Figure 21: this figure shows supplier ranking points.