

Enterprise Architecture for Cloud-based ERP System Development

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Abstract— The cloud computing concept is widely accepted as a new, influential method in the field of information technology. It offers ease of access, flexibility, security, etc. In recent years there are suggestions of making a large number of cloud-based applications; one of them is the enterprise resource planning (ERP). In general, making an ERP accessible through cloud computing offers great benefits regardless of what field may use them, but in order to achieve that level of operation some guidance and assessments are needed. There are numbers of companies who face failure in an attempt of using or even customizing ERP for their company. Enterprise architecture can be used to validate all necessary requirements a company needs to assess before implementing an ERP system, especially a cloud-based ERP system.

Keywords—ERP; Cloud; Enterprise; Architecture

I. INTRODUCTION

Cloud computing has gained respectable reputation around the world since its first introduction. On the last few years, a number of enterprises has adapted some of their resources into cloud. To understand the reason behind this phenomenon, one must understand what cloud-based technology is. In general, cloud computing is defined as a set services or resources that can be accessed by user via the support of Internet [1]. It simplifies accessibility, interoperability, and facilitates the sharing of resources from data to software modules. Enterprises has identified cloud computing as a mean to utilize their IT investments in a more effective and efficient way. On most types of enterprises, cloud computing provides the enterprise with the capability to use or implement flexible and scalable resources without having the computing resources installed directly on consumer's system [2].

Another term that has gained high reputation in the past few years is the application known as enterprise resource planning (ERP). ERP Systems are comprehensive, packaged software solutions designed to integrate the complete range of an enterprise business processes and functions in order to present a holistic view of the business from a single IT and information architecture [2]. For major enterprises, ERP is considered to be a necessity to keep up with the competitors. ERP software is highly configurable to accommodate the diverse needs of users across wide array of sectors.

In recent years, enterprises have utilized these two technologies simultaneously in a form of cloud-based ERP, which incorporate the concept of cloud computing and ERP software as one, which allows users to access ERP modules via internet. It gives the user higher flexibility and accessibility in utilizing the ERP software. In order to utilize this concept, the enterprise in which the user resides must comply with several constraints. The ERP software itself requires the enterprise to customize the ERP so that the software can perform optimally and in accordance to the enterprise business processes.

This paper will present how enterprise architecture can be very useful in managing IT resources within an enterprise by providing the blueprint. The blueprint will then be used to assess many aspects of technicality, with the adaptation and development of cloud-based ERP with multi-tenant concept as the main focus. The purpose of this paper is to give an insight on how enterprise architecture as a discipline can give proper information and assessments about the installation of a cloud-based ERP System.

II. ENTERPRISE ARCHITECTURE AS AN IT BLUEPRINT

A. Background

Enterprise Architecture (EA) has evolved throughout times since it was published by John Zachman in 1987. Approaches to enterprise architecture have appeared in different forms since then. Several dedicated frameworks are invented to assimilate best practices in the field of enterprise architecture [1]. One of the most well-known approaches of designing enterprise architecture is "The Open Group Architecture Framework (TOGAF), which garnered most attention to its contribution towards the enterprise architecture expertise [9]. The development on enterprise architecture discipline is moving forward as the time goes by to seek a common understanding and greater methodological consistency. To build a holistic and integrated view of the enterprise and allow a continually aligned steering of business and IT, a discipline known as enterprise architecture management is used to capture all necessary processes, methods, tools, and responsibilities

In general, enterprise architecture can be considered as a structured and aligned collection of plans for the integrated

representation of the business and information technology (IT) landscape of the enterprise in any given time [9]. The role of enterprise architecture is to develop various frameworks for IT that both facilitate the direction of the business and address main issues of business, including representing interests of stakeholders across enterprise thereby aligning business vision and strategy with IT delivery. The enterprise architecture also has the mission to develop the skills, business principles, standards, and frameworks for each architectural discipline necessary for IT resources within the enterprise to act effectively to achieve the directions set by the executive leadership teams.

B. Enterprise Architecture and IT Development

As of now, IT supports several business strategies and also holds the ability to produce a new strategy. In order to shape business strategies within organizations by utilizing IT, the organization must improve their ability to tap innovation [5, 8]. To make sure the use of IT produces optimum benefits, the alignment between business and IT is a vital part. Business-IT Alignment (BITA) is considered to one of the vital topics of IT management. Alignment is a complex concept involving several different approaches to understand and achieve alignment itself. The approaches that can be used to achieve alignment fall into three categories [5]:

- alignment via “architecture”
- alignment via “governance”
- alignment via “relationship”

The architecture approach utilizes both the software and enterprise architecture techniques in an organization to achieve suitable alignment between IT and business strategy. This alignment can be realized with the use of enterprise architecture by understanding the following [5]:

- Business processes of the organization based on its business goals and requirements.
- Information that will be created, updated, or manipulated within the business processes.
- Application which can save or change the information
- Technology which can support the information.

To organize enterprise architecture into its distinct architectural disciplines, there are six major areas that comprise the specific disciplines, which technically include their governance so that there is a way to measure their objectives’ achievements efficiently. The six major areas generally addressed in enterprise architecture are [8]:

- Business Architecture
- Information Systems Architecture
- Information Architecture
- Control Systems Architecture

- Operations Architecture
- Cross Architecture Disciplines

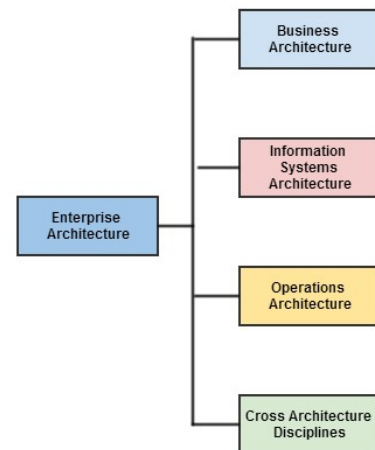


Fig. 1. General Enterprise Architecture Overview

1. Business Architecture

The role of business architecture is to develop business process models, product hierarchies, and business capability models, along with corresponding taxonomies and business definitions [8]:

- Business Process Models
Diagrams that illustrate the flow of steps performed. At high level, it may represent the sequence of department that support a line of business, at low level they may represent steps in how things are done within a particular business capability within a department.
- Product Hierarchies
Taxonomies usually shown in diagrams that illustrate various ways products and services are divided into subtypes and types of products and services by different constituents. of the enterprise.
- Business Capabilities Models
A hierarchy of business capabilities that are similar to a functional decomposition. Starts with the industry that will be break down even further into smaller business capabilities.

2. Information Systems Architecture

The information systems architecture is traditionally known as the enterprise architecture. This architecture provides the architecture on how applications and data architecture are modeled and also on the governance of each architecture discipline. The information systems architecture can be broken down into several architectures [8]:

- Application Architecture

- IT Compliance Architecture
- Reporting Architecture

Architecture regarding the reporting of data processed within business processes inside the enterprise, including business intelligence architecture, data warehouse architecture, big data architecture, and predictive analysis architecture.

- Information Architecture
Comprise of data architecture and data governance architecture. The architecture dimension that model the distribution and the storage architecture of data distributed within the enterprise.
- Life Cycle Architecture

3. Operations Architecture

Operations architecture is the architecture of the operations of IT components in an enterprise. Operations architecture provides the model and the documentation on how operational aspect of enterprise information system architecture operates. The architecture that falls within the operations architecture are [8]:

- Security Architecture
- Network Architecture
- Technical Services Architecture
- Infrastructure Architecture
- System Recovery Architecture.

The general architectures shown above can be defined into other names but same principles across different approaches on enterprise architecture. In TOGAF, the architectures described above are classified into different phases called the TOGAF Architecture Development Model (ADM).

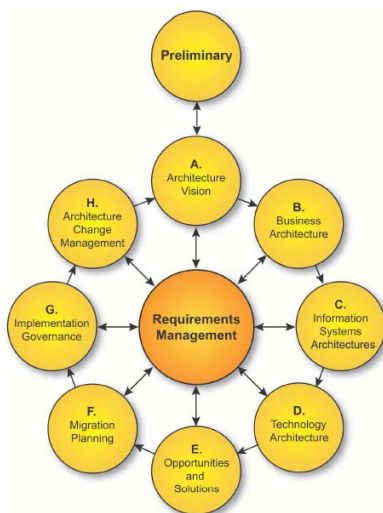


Fig. 2. TOGAF Architecture Development Method [4]

In TOGAF, the architectures shown on (2.1, 2.2, 2.3) are distributed into the phases in the ADM where operations architecture are translated into the technology architecture on the TOGAF ADM [4].

C. Enterprise Architecture and Enterprise Resource Planning

As stated above, enterprise architecture is a blueprint on how an information system within enterprise works. The blueprint starts with the identification of the enterprise's business processes and capabilities creating a business architecture, followed by the architecture of data and applications used to support the processes, and completed by the architecture of technology used to support the operations of the applications and data processed.

On the process of designing the blueprint of the IT architecture, the data which is created on every process in the enterprise is recorded for future uses. Since the business process of the whole enterprise is detailed, the blueprint can be used to customize the ERP that will be used on the enterprise. With this, the chance and expense generated from failed customization can be minimized. The optimal use of enterprise architecture can map the interconnectivity between ERP Modules and the data that is the subject of transaction between processes, making the ERP an actualization of the blueprint provided by the enterprise architecture.

III. ENTERPRISE ARCHITECTURE AND CLOUD-BASED ERP

A. Introduction to Cloud Computing

As stated before, cloud-based application has become a well-known phenomenon on the IT sectors. The flexibility and the ease of access offered are just two of many positive traits obtained by deploying cloud concept. According to NIST, cloud computing is known as a model that is used for convenient, on-demand network access to a pool of configurable computing resources with minimal management effort. The cloud computing model promotes availability and characterized by five essential characteristics (on-demand self-service, wide network access, resource pooling, rapid elasticity, and measured service), three service models (cloud software as a service, cloud platform as a service, cloud infrastructure as a service), and four deployment models (private, public, community, and hybrid cloud) [6].

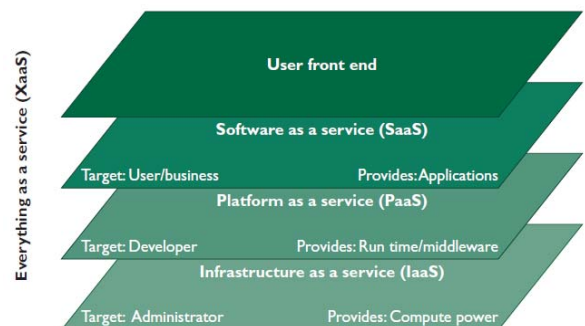


Fig. 3. Cloud Computing Service Models [6]

From the explanation above, a general architecture of a cloud computing can be made. The architecture is composed of the characteristics, the service models, and the deployment models, as shown in figure 4.

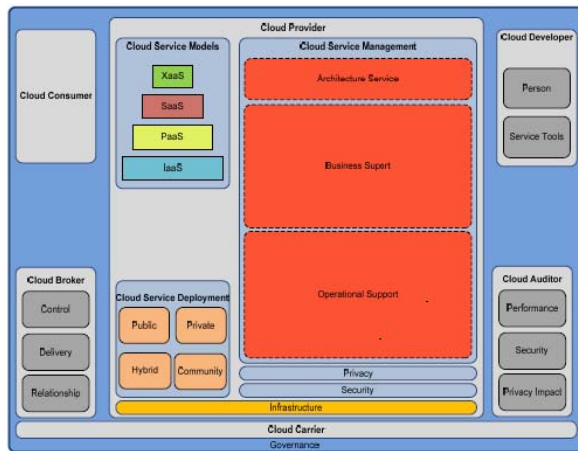


Fig. 4. General Cloud Computing Architecture [7]

B. Cloud-based ERP

Following the statement from the previous part, Cloud-based ERP service model is categorized as cloud software as a service. The normal type of ERP has the system installed on every terminal while the cloud-based ERP allow user to access modules available in the cloud without having to install the ERP itself. This technology allows simpler installation and access of ERP on an enterprise while retaining the integrity and cohesiveness of the ERP system itself.

As stated on part C3, an ERP can also be called an actualization of the blueprint provided by enterprise architecture framework. If the ERP is moved to cloud server, the enterprise architecture of the enterprise is also moved. That's why the technology architecture of an enterprise that utilizes cloud server must provide a technical detail about the cloud-computing concept the enterprise is using. In other words, the enterprise architecture must also state what architecture is used by adapting cloud computing model. The architecture of the enterprise information system on cloud server must work as good, or even better performing than the non-cloud-adapting method. That's why to ensure the ERP can migrate successfully; a blueprint of the enterprise itself can be considered a mandatory requirement.

The notable difference between the orthodox ERP with cloud-based ERP is that cloud-based ERP requires the users to access the system via internet while an orthodox ERP rely mostly on the existence of LAN to operate the ERP within the enterprise. The architecture for the cloud-based ERP is as shown on figure 5.

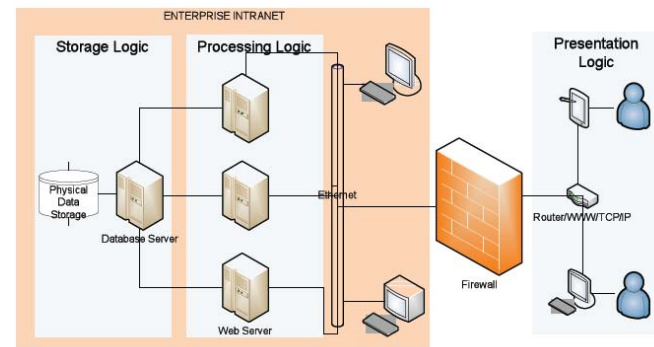


Fig. 5. Cloud-enabled ERP Schematics [10].

From the figure, we can assume that the enterprise intranet is the cloud server which host the storage for data needed in operating the ERP. The user on the other hand, is shown the presentation layer, a layer which acts only as in interface between user and the computer. The above architecture which leaves the user only with an interface while the process and execution logic is done on the cloud can be categorized as a two-tier ERP. The form of transactions that occurs between user and the ERP itself is categorized as an OLTP (Online Transaction Process) which is a class of information system that facilitates transaction-based applications for data entry and retrieval on which the response from the system to the user is done almost immediately.

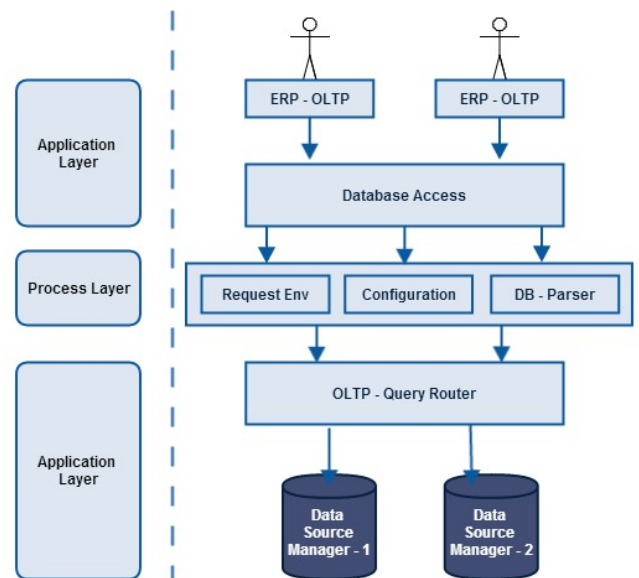


Fig. 6. Online Transaction Process on Cloud-based ERP [11]

As shown in figure 6, the transaction process can be selective in terms which users have the authority to enter or operate which resources. The steps of interaction between users and the applications are as follow:

- User start the application and login to the cloud-server

- If the login is successful, the user will be mapped into a session where each session has its own resources allocated to it depending on the user.
- Each request the user sent to the application layer will undergo encoding/decoding sequence in a type of agreed formats (XML, .csv, etc.) and then exchanged between user and the application via internet.
- The system can validate the input or request sent by user based on pre-determined rules and the governance architecture for every type of relevant requests. This will ensure the compliance on both side of the rules.

C. Multi-tenancy in Cloud-based ERP

Multi-tenancy is a concept in software architecture which is mainly used in cloud-based applications. This architecture provides a single instance of software applications that can be used to serve multiple customers (tenants) at the same time [12]. Multi-tenancy means that while the services provided share a single solution behind the scenes, they have been designed and implemented with the frontlines in mind and are highly configurable to meet specific business needs [13].

The capability to serve many tenants at the same time is done by sharing hardware, infrastructure, data storage, and virtualization. With that being said, the cloud itself needed an architecture where applications which is shared, the network configuration, hardware specifications, and operating system that is used are stated and detailed.

Even though the resources that are available on the cloud server are shared, the availability and the privacy of services used by each tenant must be protected. This means one tenant's needs do not affect other tenant's. In multi-tenant architecture there are four aspects that must be considered, including resource isolation, configuration, security, and scalability [12, 13]. Resource isolation is important since all tenants will share the same infrastructure and code. The second aspect means that in a multi-tenant architecture, the application provided must be highly configurable to meet the user's needs. The security aspect is an issue that must be considered due to sharing of codes and data between multiple tenants. The last aspect concerns the design and implementation of the software in order to satiate conditions for reaching scalable levels.

There are several approaches for the database architecture used in multi-tenant concept; the first one is called Separate Database which is the simplest data isolation model because each tenant's data is stored in separate database. The next approach is called Shared Database – Separate Schema, which hosts all the tenants in the same database instance but each with their own database schema. The last approach is called Shared Database – Shared Schema, which allows tenants to store their data in in the same database and same schema [12].

Configuration is a vital part for any multi-tenant application. Configuration allows SaaS vendors to run single instance software, which supports different tenants with configurable metadata [13]. This aspect provides a mean of configuration to satisfy the tenant's business needs and resolve the issues of different requirements for several tenants who may use the same business domain application. This multi-

tenant design allows sharing resources across multiple tenants, and configuring how the multi-tenant application appears and performs with the ability of differentiating and isolating data, information, configurations, and settings belong to different tenants [12, 13]. Multi-tenant aware application design allows each tenant to customize different parts of the application, and automatically adjusts its behavior during run-time without having to redeploy the application [12].

With the use of multi-tenancy, any tenant can configure the service that they needed from the host to suit their needs while maintaining the integrity and security of their data. In cloud-based ERP context, multi-tenancy can be a very effective concept to deploy. From earlier statements, the blueprint from enterprise architecture can be used to map which ERP modules are necessary and vital for the enterprise. This information can be used to choose which modules should be purchased in order to boost the organization processes. The main reason for this customization by selecting specific modules is mainly financial capability of said organizations. Multi-tenant concept in cloud-based ERP means the provider may offer packages according to each tenants business needs without having to change the software as a whole. This way, every tenant who uses the service of the cloud-based ERP provider can utilize the service based on their organization's preferences without compromising other tenant's business needs.

IV. CORRELATION BETWEEN EA AND ERP

Enterprise architecture assesses multiple elements on a company including its business objectives and resources within that company. Discovering the company's specific traits that give the company the edge on competition is a major requirement in this era, especially if said company has interest in using information system as part of its strategy. Understanding the company's traits and performance within a company, whether it's by segment (department) or as a whole is a very important feat. This information can be used to decide which IS or IT can be utilized to support the growth of said processes or traits. The objective of the IS/IT installation will be to support vital and crucial processes which will bring improvements towards the company as a whole.

ERP as a system can offer improvements and increase the lead on an analytical competition between companies. EA works as a preparation phase before going to implementation phase of the ERP. The most common concept of technology nowadays is the cloud concept which also covers the latest ERP system. By taking advantage of the multi-tenancy concept, a company may use the service of ERP System with greater efficiency in cost to performance ratio.

In steps, EA provides the information about which sectors are performing in a company and also their resources, especially IT Resources. These resources will be the defining factor of which IS can be used based on what the company have or planning what should be provided to fulfil the requirement of the designated IS, such as ERP.

ERP, with multi-tenant architecture implemented in particular, needs proper planning from the company. Terrible planning in ERP implementation usually stems from failure in understanding the company position, traits, and resources.

By using EA to assist ERP implementation planning, the company might have clearer and detailed insight about their whole company. The planning will also determine which module should be implemented in the company and how to customize the module to suit the company needs / business objectives which are stated in most of enterprise architecture planning method.

By using EA in ERP planning, organizations that yearn on using multi-tenant cloud-based ERP to support their business process might get several advantages. First of all, the use of multi-tenant cloud based ERP will reduce the cost of implementation since most of the technical resources are provided by the provider. Besides the stated reason, the use of EA in the planning will ascertain the module and the entire component of the system will be functional without any part proved unnecessary. Another significant advantage that can be taken is the planning of ERP by using EA in conjunction makes sure that the implementation of ERP supports the achievement of the company business objectives, especially in company's strategy or decision making area.

V. CONCLUSIONS

Enterprise architecture is a preferred framework to assist the development of architecture / blueprint creation and can also be considered when measuring the alignment of IT with business in an organization. As long as the enterprise architecture framework follow the general guideline of assessing every detail in enterprise. Each dimensions of architecture can be used as a blueprint before implementing a new IT system.

The architecture framework will create a holistic blueprint of an enterprise which describes how the business processes work within an organization can also be used as a guideline on customizing enterprise architecture framework to suit the organization needs. The application of enterprise architecture in customizing ERP can be considered an actualization of enterprise architecture blueprint.

The cloud-based ERP is proposed to be made by using the multi-tenant architecture. This way, the provider and the tenant who uses the service can obtain maximum benefits while considering financial and other technical factors that act as a constraint from the tenants. Therefore, using a blueprint from

enterprise architecture in conjunction with multi-tenant cloud - based ERP will ensure optimization on the respective tenant.

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