The Comparison of Cloud Migration Effort on Platform as a Service

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Abstract. Platform as a Service offers users to easily and quickly deploy applications in the cloud environment without thinking about the availability of supporting resources for developing the application. However, migrating on-premise applications to cloud vendors still has risks ranging from the compatibility of application technology with the cloud platform to the efforts needed. One obstacle in the adoption of cloud technology is the lack of visibility in planning migration efforts. So this study aims to measure and compare the feasibility of PaaS cloud vendors based on the calculation of the effort required during the migration process through an empirical approach. Specifically, an experiment was carried out by migrating on-premise application to Amazon Elastic Beanstalk, Azure App Service, and Google App Engine. Empirical results show that Azure App Service and Amazon Elastic Beanstalk have similar complexity of effort, while Google App Engine has the highest complexity of effort.

1. Introduction

Cloud computing technology has become popular in recent years due to its advantages compared to traditional computing models. It helps organizations to save most of the costs associated with infrastructure investment, management, and maintenance [1] [2]. Cloud computing provides computing resources on-demand, therefore, cloud users do not need to invest in the future to provide hardware resources and other IT infrastructure [3]. Large organizations see cloud computing as an opportunistic business strategy to stay competitive and meet business goals [4].

Although many organizations have begun to show their interest in cloud computing, there is a lot of ambiguity and uncertainty about the real benefits of this technology for the company [5]. Many companies in the world are facing higher costs and barriers to adopt cloud computing [6]. Migrating internal data and systems to the cloud platform have many risks and challenges. The most critical risk is caused by the technical aspects complexity associated with cloud platforms and the lack of preparation and planning by users [7]. Time is a crucial parameter in cloud migration process. However, the overall time needed to migrate to a new system and environment is difficult to know beforehand. This condition can cause the system to be temporarily unavailable. The length of time needed in the migration process is closely related to the effort that must be passed. Meanwhile, migration efforts themselves are influenced by many factors such as variations in response time of each application, delays, network conditions and even strict requirements on the organization.

The process of adopting cloud computing should be done systematically so that an adoption model is needed. This model is important in analyzing and providing steps in the process of implementing cloud computing. However, until now there has not been any single model that is widely accepted as a cloud computing adoption model [8]. One of the main obstacles to the adoption of cloud computing technology by organizations is the lack of visibility in migration planning and the efforts required [9].
Currently, various types of cloud computing service providers offer a variety of different services, such as Infrastructure as a Service (IaaS), Platforms as a Service (PaaS), and Software as a Service (SaaS) [8] [11]. Therefore, it is difficult for users to choose the appropriate service [10] [2]. The lack of clarity of the above service information from cloud vendors is one of the main reasons why organizations are reluctant to use cloud technology. Among these cloud computing services, migrating applications to the IaaS platform is easier because users have full rights to the virtual machine (VM) granted so users can freely install the operating system and software needed [1]. On the other hand, application migration to PaaS has a higher difficulty than migration to IaaS in terms of effort complexity and cloud environment adoption [12]. Migration efforts to PaaS are more challenging to understand due to platform differences, compatibility of programming languages and databases [13]. Hence, this study tries to compile a comparative model by measuring complexity in cloud migration projects by considering the feasibility of PaaS cloud vendors based on the amount of effort needed.

This paper is presented in the following structure. Part II describes previous research on cloud migration that was carried out. Part III presents the research methodology including the selection of PaaS cloud vendors, experiments setting, and migration measurements. Part IV explains the results obtained and Part V contains conclusions and future work.

2. Related Work

2.1. Critical Factor and Task in Cloud Migration
Avram [6] identified several obstacles faced in the cloud migration process, such as security & privacy issues, connectivity and access, reliability, platform interoperability, cost, configuration changes, and regulatory aspects that apply in related the country. Furthermore, Dutta [7] identified several risks faced by companies when migrating to the cloud system including organizational risk, operational risk, technical risk and legal risk.

Then Vu [1] has successfully identified some essential steps that need to be considered when migrating to IaaS and PaaS services based on the web app migration experiments to the cloud platform. From the experiments on the PaaS service, several effort are needed to modify the on-premise application to fit the configuration on the cloud platform, including programming language compatibility, database compatibility, library compatibility, and data type compatibility, whereas Sheetal [14] examines software quality metrics and their parameters in the application of cloud-based software and proposes a new metric method for evaluating the performance of software that migrates to the cloud. In other studies, Tran [9] has identified essential factors influencing migration to the cloud and proposed several tasks needed to perform cloud migration [3], such as training, configuration and installation, code modification, migration, and testing.

This study focuses on cloud migration technical factors which influence the efforts needed. A group of migration tasks from previous study [3][9] is developed to determine the stages and efforts in the proposed on-premise application migration experiment to Paas cloud vendor.

2.2. Cloud Migration Effort
Several previous studies have been conducted to measure the complexity of migration from each effort in a cloud migration project. Tran [3] examines the estimated size of a cloud migration project by rearranging a software estimation model called Function Point (FP) into the context of cloud migration. The approach taken is to identify cost factors in cloud migration that are influenced by installation configuration factors, database changes, code changes and connection changes. Furthermore Sun [15] examines the estimation of process-based efforts to measure the cloud migration process by assessing the size and complexity of the workload of a cloud migration project. The level of complexity is described and determined by the number of binary software components, the number of configuration items, the dependent factors between configuration items, and the ability of the migration team. In another study, Kolb [13] developed an estimation model by evaluating the cloud migration process on seven cloud provider platforms. Kolb checks the eligibility of migrating native cloud applications between vendor clouds manually. During the process, problems were found regarding the integration of the management interface and environment on the cloud platform. The
results show that there is a big difference between vendors and cloud migration efforts made by the service user configuration.

However, the two studies [3][15] have not considered the feasibility of PaaS cloud vendors based on the value of the efforts made. Thus, this study measure the feasibility of cloud vendors based on the value of the efforts made in the case of on-premise application migration.

The research questions in this paper include:

RQ 1: How to describe the complexity of cloud migration efforts across multiple cloud PaaS vendors?

RQ 2: How to measure and compare the feasibility of PaaS cloud vendors based on the calculation of the effort required during the migration process?

3. Methodology

This study is aimed to measure the feasibility of cloud vendors based on effort complexity in the PaaS cloud migration project. It only focuses on the technical aspects by considering the estimated effort required in the process of migrating on-premise application to the cloud. To achieve these research objectives, a migration experiment is conducted with the research workflow as presented in Figure 1.

3.1. Choosing PaaS Cloud Vendor

Several cloud vendors offer PaaS services, but this study only choose the three largest cloud vendors with public cloud adoption criteria based on [16] with PaaS services, namely:

- Amazon Elastic Beanstalk
  Elastic Beanstalk is intended for developers to deploy code quickly and easily without thinking about supporting infrastructure [17].

- Azure App Service
  Azure App Service offers a platform as a service that allows developers to build secure, mission-critical, and highly scalable web applications [18].

- Google App Engine
  Google App Engine is intended for creating, managing, and hosting web applications and provides automatic scaling for web applications [19].

Although currently, every PaaS cloud vendor supports many application platforms, prior check on service support must been done. Several aspects on each service support need to be considered before migrating on-premise application to PaaS. Three important aspects are compared including programming language support, database and deployment support (See Table.1) [1].

| Support          | Amazon                      | Azure                      | Google                      |
|------------------|-----------------------------|----------------------------|-----------------------------|
| Runtime          | Go, Java, Node.js, Ruby, PHP, Python, Tomcat | .Net core, ASP.Net, Java, Node.js, Ruby, PHP, Python | Go, .Net, Java, Node.js, Ruby, PHP, Python |
| SQL Database     | Amazon Aurora, MySQL, MariaDB, PostgreSQL, Oracle, MSSQL | Azure SQL, MySQL, MariaDB, PostgreSQL, Oracle | MySQL, MSSQL, PostgreSQL, Oracle |
| Deployment Model | AWS CLI, Console (zip upload) | Azure CLI, Console (CI / CD, FTP) | CLI with Cloud SDK |
3.2. Experiment Setup

Experiment is conducted by migrating on-premise applications to several cloud vendors using PaaS services. On-premise applications used in this research is in the form of a web application for Information System for Networking and Facilitation of SMEs (Small Medium Enterprise) in the Magelang District Government, Indonesia. This web app was developed using PHP with the CodeIgniter framework and using the relational database MySQL. The reason for choosing the website is because the LAMP-based system (Linux, Apache, MySQL, PHP) is prevalent to be used by developers.

For reasons to be compared, the web app is manually migrated through the most straightforward steps provided by each cloud vendor. Migrated web apps must work equally in functionality and performance. The cloud migration process is done without any development of new functions from web applications that are migrated. The scope is only in functions where applications that are migrated to the cloud can run normally like on a local server. The overall stages of this experiment includes several technical steps of migration, as presented in Figure 2.

![Figure 2. Migration Steps](image)

3.3. Identification of Migration Task

Several efforts on application migration to the cloud have been classified by some previous studies. The experimental stage in this study is developed from several classification of migration efforts on the Cloud Migration Point model [3]. This study proposes grouping of several migration task to observe in more detail. This grouping aims to ensure uniformity in the comparison of efforts required between cloud vendor PaaS. Some of the migration task variables include:

- **Task 1 (T1) - Prepare On-Premise Resource**
  This task includes every effort needed to prepare on-premises application source files such as accessing, downloading and package resource code and databases.

- **Task 2 (T2) - Installation Tools**
  The migration of on-premise applications to the cloud platform requires software installation efforts to support migration to the intended cloud platform.

- **Task 3 (T3) - Configuring Cloud Resources**
  This task includes every effort needed to configure the environment in the cloud before migrating.

- **Task 4 (T4) - Code and Database Migration**
  This task includes every effort needed to move resources from on-premise to the cloud platform.

- **Task 5 (T5) – Modification Code**
  This effort is related to the code modification needed to match the programming model supported by each cloud vendor. This effort also includes code changes to adjust database access on the cloud platform and several other modifications.

- **Task (T6) – Modification Database**
  This effort is related to database schema changes and query changes caused by differences in the database versions to be migrated.
3.4. Measurement of Migration Effort
The next step of this research is to calculate every effort needed for the migration task at each PaaS cloud vendor. The results of identifying migration task, as determined in section 3.3 are calculated in this section using the specified metrics. The metrics used to measure migration efforts are taken from the framework of measuring application deployments with ISO / IEC Systems and software Quality Requirements and Evaluation (SQuaRE) [20]. This framework is also used [13] to evaluate application installations in PaaS environments with Docker-based migration in native cloud applications. The parameter used is the Deployment Effort by modifying the contained metrics in [13] to be adjusted in the case of the migration of on-premise applications to the PaaS environment, as shown in Figure 3.

Some of the metrics used in measuring the cloud migration process include:

- **Effort of Package Construction (EPC)**
  EPC is the number of steps in the migration task variable (T1) and (T2). This metric consists of several effort before the migration process, such as compiling files from resources on-premises. The tool installation effort is added because migration support tools are needed in the case of on-premises applications.

- **Deployment Step Parameter (DSP)**
  This metric measures certain parameters related to configurations that need to be set on the cloud platform to match user input requirements (T3).

- **Number of Deployment Step (NDS)**
  It includes the number of operations and steps taken to move code and databases on the cloud platform (T4).

- **Effort of Deployment Step (EDS)**
  EDS is a combination of two NDS and DSP metrics, this metric is used to calculate all the efforts needed in completing application deployment on a cloud platform.

\[
EDS = DSP + NDS
\]  

- **Configuration & Code Change (CC)**
  This metric measures how much code and configuration changes in the application to adjust the environment in the cloud (T5) (T6). Each change is calculated using the Line Of Code (LOC) function with application changes consisting of a configuration file, and code file as follows:

\[
CC = \sum_{i=1}^{N_{\text{conf}}} LOC(\text{file}_i) + \sum_{j=1}^{N_{\text{code}}} LOC(\text{file}_j)
\]  

Figure 3. Deployment Metric Frameworks
• Deportment Effort (DE)
  DE is the total amount of all efforts needed during the migration process so that the application can run well on the cloud platform.

\[ DE = EPC + EDS + CC \]  
(3)

4. Research Result
This study has two results, first is the comparison of migration tasks on-premise applications to Amazon Elastic Beanstalk, Azure App Service, and Google App Engine. And the second is the result of measurement of migration efforts in terms of the number of steps using ISO / IEC SQuaRE on several PaaS cloud vendor.

4.1 Migration Task Comparison
In this experiment, the on-premise application was successfully moved to all the previously selected PaaS cloud vendors. The grouping of migration task is done based on the migration task proposed in section 3.3. The grouping of tasks follows the most straightforward steps that have been provided for each cloud PaaS vendor. There are similarities between several stages and efforts in each migration task in each PaaS cloud vendor. The results of our migration experiments with selected vendors are presented in Table 2.

| Task | Amazon Elastic Beanstalk | Azure App Service | Google App Engine |
|------|---------------------------|-------------------|-------------------|
| T1   | - Access / download sources from on-premise - Package source file | - Access / download sources from on-premise | - Access / download sources from on-premise |
| T2   | - Installing remote server tools, Winzip and database management tools | - Installation of FTP Client and database management tools | - Installing Google Cloud SDK |
| T3   | - Create web application resources and configure application environment - Database configuration on Amazon RDS - Create and configure key pair on EC2 and Elastic Beanstalk - Configure SSH access on EC2 | - Create resource and app service configuration - Configuring the APP Credential on the FTP deployment model in Azure - Configuring Azure Database for MySQL | - Create project and Configure cloud resources - Create and Configure instance of Google SQL. Creating a MySQL database in instances - Create and configure buckets with Google Storage |
| T4   | - Upload the zip source file to Elastic Beanstalk - Import a database with MySQL-Workbench into Amazon RDS | - Upload by FTP method on Azure APP Credential - Import a database with MySQL-Workbench | - Upload source files with cloud SDK - Upload SQL database to bucket in Google Cloud Storage - Import a database from Google Cloud Storage |
| T5   | - Change of connection to the new database on Amazon - Changes in the auto load framework configuration that is used - Changes to the configuration on the web server | - Change of connection to the new database on Amazon - Changes in the auto load framework configuration that is used - Changes to the configuration on the web server | - Change of connection to the new database on the Google App - Create and modify app.yaml as app resource descriptor - Creating a configuration file in the form of php.ini |
| T6   | - There are no database changes | - There are no database changes | - There are no database changes |

In our migration experiment to Amazon, there are several services from Amazon that are used, including Amazon Elastic Beanstalk, RDS, EC2, and S3. However, of the few services that require effort in migration only Amazon Elastic Beanstalk to create the environment and Amazon RDS to manage the database. In other cases of migration, some services are used on Azure, such as the Azure App Service for application environment and Azure Database for MySQL. In addition to source code deployment with FTP, Azure has other deployment features with Continuous Deployment (CI / CD) that can cause varying migration task details. While our experiments with Google made use of several
services, including App Engine, Google SQL and Google Storage. Most code modification tasks on Google App Engine are completed by creating app.yaml which functions as an application descriptor and runtime configuration.

The results from Table 2. have answered RQ.1 where the complexity of cloud migration efforts in some cloud PaaS vendors can be described based on the proposed migration task grouping. The more detailed grouping of migration efforts is expected to increase user visibility in planning migration efforts to the PaaS cloud.

4.2 Measurement Result

Table 3. shows the measurement results for each cloud migration effort at several PaaS cloud vendors in the selected metric. Migration efforts measured using ISO / IEC SQuaRE are counted in terms of the number of steps required for each metric attribute. These results answer RQ.2 and show which PaaS cloud vendors have higher effort complexity in terms of number of steps.

| Metric                              | Amazon Elastic Beanstalk | Azure App Service | Google App Engine |
|-------------------------------------|--------------------------|-------------------|-------------------|
| Effort of Package Construction (EPC) | 5                        | 3                 | 2                 |
| Source File Package                 | 2                        | 1                 | 1                 |
| Installation Tools                  | 3                        | 2                 | 1                 |
| The effort of Deployment Step (EDS) | 9                        | 7                 | 7                 |
| Number of Deployment Step (NDS)     | 3                        | 4                 | 3                 |
| Deployment Step Parameter (DSP)     | 6                        | 3                 | 4                 |
| Configuration & Code Change (CC)    | 10                       | 12                | 48                |
| Configuration Change                | 8                        | 10                | 47                |
| Application Code                    | 2                        | 2                 | 1                 |
| Department Effort (DE)              | 24                       | 22                | 57                |

Values obtained from measurement results on each metric indicate different efforts between cloud PaaS vendors. Differences in support and deployment feature variations in each vendor affect the amount of effort required. Table 3 shows some facts related to measurement results, including:

- **Amazon Elastic Beanstalk**
  Migrating to Amazon requires more effort in the EPC metric to create package files from existing source code. Even though the platform has handled the server on EC2, several effort are needed to configure the key pair on EC2 and access SSH, thereby increasing the number of effort on DSP metrics. The number of steps for source code deployment in Elastic Beanstalk is quite simple compared to other vendors by uploading the bundled source code file. For configuration and code changes, it is still necessary to string the connection to the new database, auto load framework settings and configuration on the web server.

- **Azure App Service**
  Azure App Service shows that the number of migration steps is lower than other vendors. Azure app service does not require additional efforts to setup SSH server access. But Azure requires a little more effort than Amazon in metric CC to configure the web server.

- **Google App Engine**
  Google has a large amount of effort in CC metrics, it requires additional efforts to create source code file descriptors so they can be recognized by the platform and to manage runtime configurations. This configuration is made in the app.yaml file and calculated using line of code, causing a lot of effort on the CC metrics. But on the EDS metric, Google has a number of simpler steps in configuring and preparing environment updates in the cloud.

Overall the results of this study indicate the results of the migration task in table 2 can explain the efforts needed during the migration process in each PaaS cloud vendor. Then the results can be used as input to calculate the number of migration attempts using the ISO / IEC SQuaRE quality model and
show the number of different efforts in PaaS each cloud vendor. From the results of these comparisons can be used to provide recommendations for the selection of PaaS cloud vendors based on the number of efforts required.

In addition, currently PaaS cloud vendors have many deployment features that can cause varying details and the number of migration attempts. However, the focus of this research is to measure migration efforts on multiple cloud vendors by using the research attributes that have been determined in the experiment setup and grouping of migration tasks that we propose. So we did not try all the features in the PaaS cloud vendor.

5. Conclusion and Future Works
The conclusions in this paper are:
- The comparison of migration tasks that we obtained from the migration experiments on-premise applications to Amazon Elastic Beanstalk, Azure App Service, and Google App Engine are expected to improve user visibility in terms of planning a migration effort to the PaaS cloud in more detail.
- Modifying the metrics of the application deployment measurement framework with the ISO / IEC SQuaRE quality model, resulting in a number of different steps. Azure App Service (22 steps) and Amazon Elastic Beanstalk (24 steps) have almost the same number of effort and Google App Engine has the highest complexity of effort (57 Steps).
- The difference in deployment features and platform support for each PaaS cloud vendor affects the amount of effort required.

Comparison of on-premise application migration efforts to PaaS cloud vendors is the first step to find out the differences in migration efforts on each cloud vendor. In the next research, an application migration estimation model will be prepared by adding the feasibility of cloud vendors from the results of this research.

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