

Design of Cloud Computing-based Geographic Information Systems for Mapping Tutoring Agencies

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Abstract: Tutoring agencies provides education service for students who needs to enhance study time outside the regular school hours. Students aim to improve academic achievement; thus, it is important to choose the best tutoring agencies. However, prospective students may have informational constraints related to the positions of tutoring agencies, including the nearest location, the institution's reference quality, registration and other information about the institution. Tutoring institutes also have limitations in providing information to prospective students, such as class status, teachers unable to attend, and reminders of students attending tutoring. Mapping of Geographic Information Systems Tutoring is an application that can help tutoring agencies and students using geographic information system technology and cloud computing in terms of data storage media. The functionalities offered in the application are maps to visualize and determine the position of the lessons, packages to register and determine schedules, notifications as reminders and suppliers of information relating to teachers who cannot participate, registration and payment status, payment through the system, feedback in the form of comments and assessments by students to agencies after the end of tutoring.

Keywords: Information Systems; Tutoring Agency; Student; Cloud Computing; GIS (Geographic Information System).

1.INTRODUCTION

Indonesia is a country that applies compulsory education for its citizens for up to 12 years [1]. This must have a positive effect on a country to have a competitive and creative society. The lack of interest for students who want to continue their education not only from schools but through other educational institutions means that students without in-depth studies and only focus on the lessons they receive when they go to school. This is because students are very difficult to find tutoring agencies with the best quality and students have difficulty determining the tutoring program, thus students often forget to attend tutoring activities. These problems can delay one of Indonesia's vision and mission: to develop the nation's intellectual life. The institution that can support compulsory education for up to 12 years through educational channels other than schools is a tutoring agency. Tutoring agency helps students to deepen their knowledge and open their horizons in education by providing out-of-school academic programs. Many tutoring agencies that have the best quality but are less well known because they cannot compete and it is difficult to develop with other agencies that already have big names and quality is not necessarily the best. The tutor agencies that they have developed often find it difficult to tell students if there are teachers who cannot attend and remind students to attend tutoring activities at tutoring agencies.

Research conducted by Hazem A. Al Rekhawi, Samy S. Abu-Naser entitled "Android Applications UI Development Intelligent Tutoring System" explains the design of web-based tutoring systems to teach students the Android application development to

help students overcome the challenges they face. The basic idea of this system is to introduce students to the Android application. This system can handle various problems that are managed directly by the students. A study shows that an Android-based tutoring application has a positive impact on students and users. [2]

A research conducted by Wardatul Jannah, Indah Fitri Astuti, Septya Maharani entitled "Design of Information System on Web-based Tutoring Agency (Case Study: TADICA Tutoring Agency)" states that the web-based tutoring information system is an orientation system for Internet students aiming at a learning system to design the TADICA Tutoring Institute which is accessible via the Internet. Each student can download material or questions, chat or share with other students or administrators via the multimedia chat room and can take the test directly (online). [3]

Utilization of current technology is very necessary to access some very important information, i.e. mobile application, web applications and website-based applications. Cloud Computing is a model in providing convenience to the network access of several users in sharing computing resources as well as data storage media. GIS (Geographic Information System) is a technology that is able to provide location information at a place, making it easier for users to get to the location of a place. Mobile-based applications can facilitate users in accessing information by using a gadget (smartphone) connected to the internet thus users are able to access information via gadget.

Mobile-based applications enable to facilitate the problems

above such as students having difficulty knowing the location of tutoring and enrolling in tutoring agencies, students find it difficult to receive information to remind tutors and teachers are unable to attend, students find it difficult to provide reviews to tutoring agencies. Website-based applications can make it easier for companies or agencies to provide information to the public by accessing the website. The website-based application is able to facilitate the problems above such as tutoring agencies difficulties in providing packages that make it easier for students to see the schedule, agencies are difficult to provide some information such as teachers unable to attend and remind students to tutoring, small and middle scale tutoring agencies difficult to compete with middle and upper agencies. These problems can be solved by creating a system that is certainly different from the research that has been done before and requires a large storage medium so that it is able to manage the problems above hence students and agencies are able to access information and provide information using mobile-based applications and websites and apply GIS (Geographic Information System) feature to view the location of lessons, packages to determine schedules, notifications as reminders of tutoring and information providers, payment through the system, and feedback in the form of comments and ratings. By looking at the problems and features offered above, the system created entitled "Cloud Computing-based Geographic Information Systems for Mapping Tutoring Agencies" is very appropriate to be implemented to students and tutoring agencies.

This research is different with previous researches since it focuses on a cloud-based information system application aimed at mapping tutoring agencies and students using GIS (Geographic Information System) technology to visualize and determine the position of tutoring and cloud computing as the data storage. The functions of the application are the "Package" helps students to decide which subjects and to determine schedules, the "GIS (Geographic Information System)" function in the application helps students to discover the position of the tutoring agencies, the "Notification" function enable students to receive information from the institution and to remind the tutoring schedule and the "Payment" function making it easier for students to make payments.

2. METHODOLOGY

In conducting research, four stages must be carried out as seen in Image 1

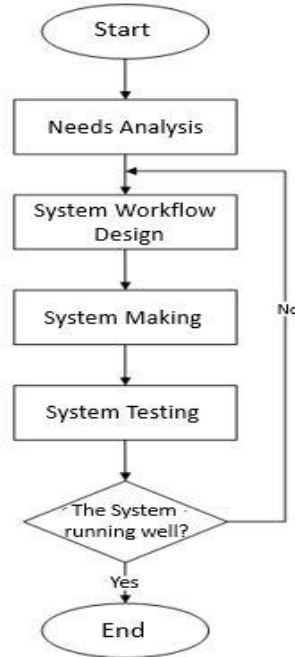


Figure 1. Stages of Research

The first phase of the research is to analyze the needs of both tutoring agencies and students. The analysis phase is the phase to determine the design of the application to meet the needs of both parties. The second phase is the design of the system workflow. The design of the system workflow is such that the system functions properly and according to predetermined procedures. The third phase is the creation of a system, both Android-based and Web-based applications, intended for the administrator and data management guide. The fourth step is to test the system to find errors found in the system and, if there are many errors in the system, it will run a redesigned workflow to correct system errors.

2.1.DFD (Data Flow Diagram) Level 0

Data Flow Diagrams (DFDs) are tools for modeling or displaying systems created to determine the data flow of the system. Data flow diagrams (DFD) describe which processes take place in the system and who involves the users. Data flow diagrams (DFDs) are used in the design and have their respective meanings. There are four data flow diagrams (DFD) symbols, that is, data archives act as a location for storing data, processes, functions to describe which processes are taking place in the system, entities, functions to describe who the user is. The data stream functions to describe where data streams are (data stream). The DFD 0 level in the tutoring mapping information system is shown in Figure 2.

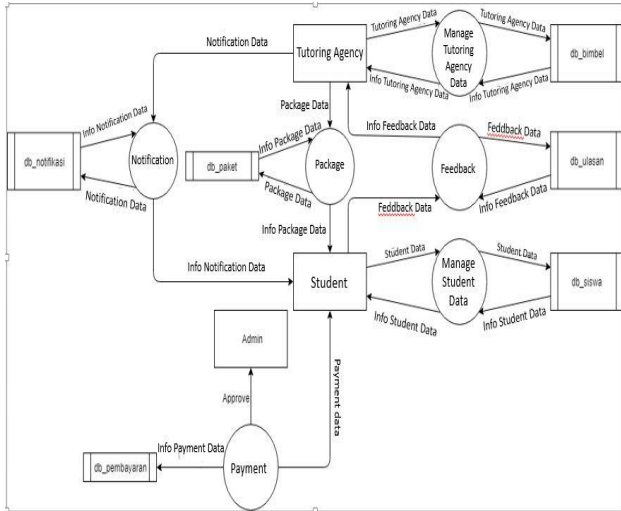


Figure 2. Level 0 DFD

Based on the above image, six processes are performed by the system, i.e. the process of managing student data that can be performed by the tutoring agency of the Geographic Information System for Mapping Tutoring Agencies, the data management process of the tutoring institute can be run by the administrator of the Geographic Information System for Mapping Tutoring Agencies, the packages are created by tutoring agencies and the package registration process involving the students and the tutoring agencies.

Students can register a package at a tutoring institution that can be confirmed directly by the tutoring institution via the application. The next process is the payment process that conducted by the students on the Geographic Information System for Mapping Tutoring Agencies and is confirmed by the admin of Geographic Information System for Mapping Tutoring Agencies, the evaluation or feedback process by students on Android-based applications that can be read by the tutoring agency, the notification process received by the students after receiving the confirmation of registration by the tutoring agency, confirmation of payment by the administrator of the Geographic Information System for Mapping Tutoring Agencies, reminder of tutoring schedule sent by the tutoring agency directly and the notification when the tutor is absent sent by the tutoring agency.

2.2. ERD (Entity Relation Diagram)

ERD is a model used to design a database to describe data relating to the database. The components in the creation of ERD are entities, attributes, relations, and lines.

Entities are objects in the real world that can be distinguished from other objects, such as students, teachers, tutoring agency.

The attributes are part of the entity, for example, the attributes of the student entity are ID, name, address, e-mail, etc. The ID attribute is unique to distinguish students from each other. Each entity must have a unique attribute called a primary key.

Relations are connections between different entities; e.g. relations between students with subjects in which each student can follow multiple subjects and each subject can be followed by several students. The relation can be in a *Many to Many* form. Below is an example of the ERD of the Geographic Information System for Mapping Tutoring Agencies as shown in Image 3.

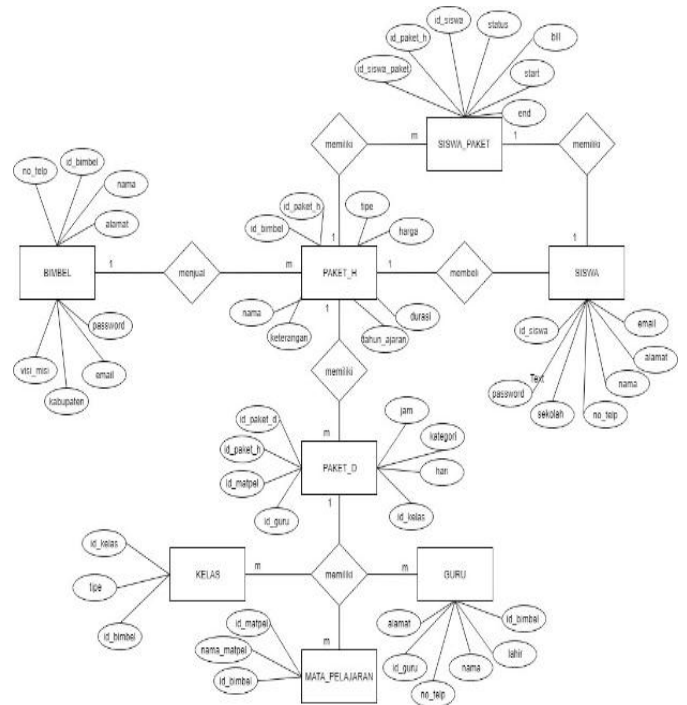


Figure 3. ERD of the Geographic Information System for Mapping Tutoring Agencies

The image above is an ERD (Entity Relations) diagram of the application of the Geographic Information System for Mapping Tutoring Agencies. The tutoring agency and its attributes sell a package called *package H* that have a single relation with many of them. It means that a tutoring agency can sell some packages. The student entity and its attributes can select package H which has *One to One* relation, which means that a student can only complete one transaction when choosing a package. The package H entity has student's package entity and its attributes, which has a *One to Many* relations. It means that a package can have many student's packages. The package H entity also has *package D* entity and its attributes which has *One to Many* relation. It means one package H can have many packages D.

The package D entity has 3 (three) other entities; they are teacher entity, subject entity and class entity. Each of them has *One to Many* relation, which means one package D may have many teachers, classes and subjects.

2.3. PDM (Physical Data Model)

Physical Data Model (PDM) explains how data is stored on a computer by presenting some information such as record formats, record orders, and access paths.

PDM (Physical Data Model) of the Geographic Information System for Mapping Tutoring Agencies has 9 (nine) tables; i.e. *tb_siswa*, *tb_paket_siswa*, *tb_paket_h*, *tb_bimbel*, *tb_paket_d*, *tb_matapelajaran*, *tb_kelas*, *tb_pembayaran* and *tb_guru* which is equipped with data and data types used as well as primary keys and foreign keys that serve as connectors between tables.

2.4. Process of Student's Application

Student's application is an application that will be used by students to choose tutoring agencies and to register packages at

tutoring agencies which has been selected previously. The following is an image of the student's application process.

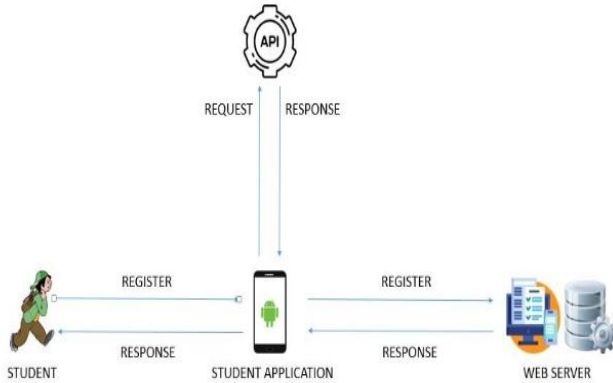


Figure 4. Process of Student's Application

The image above is an illustration of the application process for a student. The student will register first to an Android-based application. The student then will be redirected to a page on which he must enter information when registering. Students who have registered will receive information about the tutoring institution via the application stored in the database. Students can choose tutoring agency in the application and choose packages that are available. The student's application uses the Application Programming Interface (API) to support various application functions, such as using Maps to choose and to show the coordinate and location of tutoring agency while register.

2.5. Process of Tutoring Agency's Application

Application of tutoring agency is an application that will be used by tutoring agencies to sell packages and approve the data of students who wish to register to a tutoring agency. The following is an image of the application process of a tutoring agency.

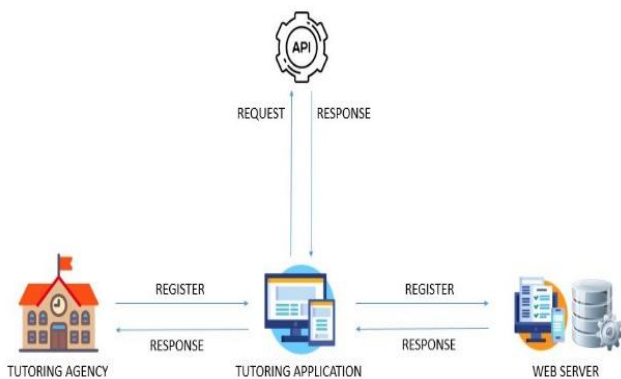


Figure 5. Process of Tutoring Agency's Application

The image above is an illustration of the application process performed by the tutoring agency. The tutoring agency will register first on a web-based application. It will be directed to a page in which its administrator must input certain data while doing registration. The tutoring agency will be directed to pages to create different master data, such as teachers, subjects, classes and packages for applications in the database. Tutoring agency

can create packages after the administrator of the tutoring agency has created personal information such as teachers, classes, and subjects. Tutoring agency can also send some information to students, such as the absent teachers, schedule reminder, and registration status by sending notifications. The application of the tutoring agency uses the Application Programming Interface (API) to support various application functions, such as the use of maps to select and display the coordinate and location of tutoring agency while register.

2.6. Process of Administrator's Application

An administrator application is an application that will be used by the administrator of the Geographic Information System for Mapping Tutoring Agencies to approve data. The following is the image of the administrator's application process.

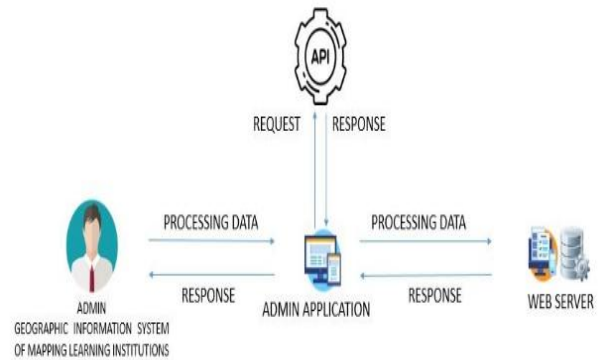


Figure 6. Process of Administrator's Application

The image above is the illustration of the application process performed by the administrator of Geographic Information System for Mapping Tutoring Agencies. The administrator does not need to register first. He then will be directed to the page on which the administrator must approve certain data, i.e. tutoring agencies that want to register, as well as payments made by students through the application. The administrator can send some information about the registration agreement and payment conducted by students by sending notifications. The administrator application uses the Application Programming Interface (API) to support various functions of the application, such as the use of maps to view the location of tutoring agencies.

2.7. System Overview

The research of cloud computing-based geographic information system for mapping tutoring agencies has system overview that can be seen in Image 8.

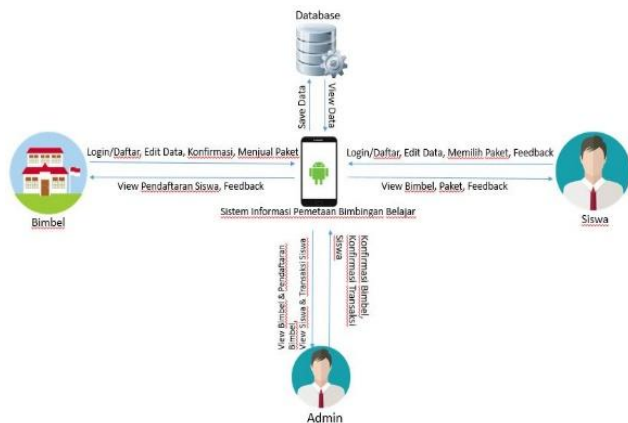


Figure 7. System Overview

Geographic Information System for Mapping Tutoring Agencies is linked to the database as a medium for data storage. Data stored in the form of tutoring data, student data, transaction data, the position of tutoring position data and other data.

The tutoring agencies can register the institution as a user and gain access to the system, change the data, both regarding the addition and deletion of data, confirm that students who want to register with the supervision, sell packages, view student registration and view feedback or student ratings.

The administrator of Geographic Information System for Mapping Tutoring Agencies can only be accessed without registration, verifying the registration of tutoring agencies, and verifying students' payments.

3. LITERATURE REVIEW

The literature review consists of supporting theories used in the research; i.e. website, Cloud Computing, Firebase and GIS (Geographic Information System).

3.1. Website

Website is pages that contain information in the form of text, images, sounds, and dynamic animations, as well as static animations that are found in a series of network pages (links) using the HTTP protocol accessed through a web browser. [4]

3.2. Android

According to Sinuraya, Satoto and Isnanto (2013) Android is a specific operating system for Linux-based devices with middleware, operating systems, and applications. The Android operating system has an open platform function that makes it easier for application developers or producers to create applications based on Android. Android Inc., purchased from Google Inc., was originally used in the development of software for mobile phones. [5]

3.3 Cloud Computing

Cloud Computing is a technology that uses the Internet to centrally manage data and applications, in which every user or user of a computer has the right to access or so-called Login. Cloud computing is a concept for understanding how to create a LAN (Local Area Network) processing framework. There are three delivery models or what is called delivery in Cloud Computing, which is Software as a Service (SaaS), Platform as

a Service (PaaS) and Infrastructure as a Service (IaaS). The deployment of Cloud Computing can be divided into four parts, namely Public Cloud which is wherein a server there are many users, Private Cloud is when there is only a user on the server, Hybride Cloud can be used as Public or Private Cloud and Community Cloud can be used together by companies with the same interests. [6]

3.3. Firebase

Firebase is a Google service that can be used to simplify the development of applications without making substantial efforts. Firebase offers various interesting functions, such as Firebase Remote Config, Firebase Real-time Database and Firebase Cloud Message and Notification.

The application of mapping tutoring agencies uses some of the Firebase features, i.e. Firebase Cloud Message and Notification. Firebase Cloud Message and Notification are features that can provide push notifications and make two-way communication between hardware and can replace Google Cloud Message, which does not have very different characteristics. [7]

3.4.GIS (Geographic Information System)

Geographic Information System (GIS) is a computer-based system to store, to process and to display geographical information. Geographic Information System (GIS) makes it easier for people to find a place where they want to go. GIS (Geographic Information System) is implemented using computer hardware and software that work to verify and collect data, changes, and updates of data, calls and presence and data analysis. [8]

4. BUSINESS PROCESS AND APPLICATION TESTING

The application of geographic information system for mapping tutoring agencies involves various business processes involving the users of the application, in particular students, tutoring agencies and administrators of the application. The business process of the application of geographic information system for mapping tutoring agencies includes registering a tutoring agency and creating packages, student registration, student payments and student feedback to tutoring agencies.

4.1 The Registration and Creation of Packages for the Tutoring Agency

The business process of registering and creating packages in the application requires the administrator of the information system for mapping tutoring agencies.

The following image is the overview of the business process of registering and creating a package of tutoring agencies.

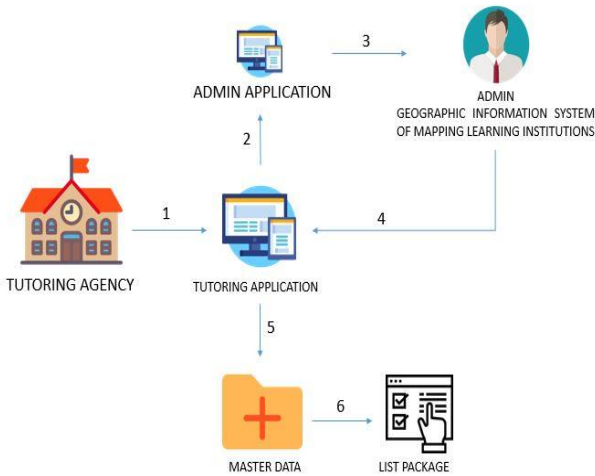


Figure 8. The Registration and Creation of Packages for the Tutoring Agency

The image above is a description of the business process of registering and creating a tutoring’s package. The registration of a tutoring institution in the application involves the administrator of the information system for mapping tutoring agencies. (1) The tutoring agency will register and input information into the application. (2) The registration data of the tutoring agency will be received by the administrator of the application through the administrator’s application.(3) The administrator of the system information for mapping tutoring agency will correct the data sent by the tutoring agency as a requirement to be registered into the application. (4) The administrator will send confirmation on whether the tutoring agency is accepted or not in the form of notifications. (5) The approved tutoring agency can create master data, such as teachers, classes and subjects. (6) The tutoring agency that have successfully created different master data, such as teachers, classes, subjects, the tutoring institute can create a package.

4.2 Student Registration

The business process of student registration on the application involves the tutoring agency. The following is the illustration of the business process of the registration that will be carried out by a student.

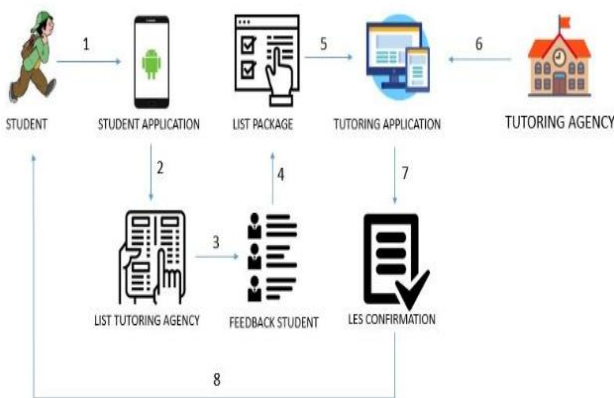


Figure 9. Student Registration

The image above is a description of the business process of the student registration. The process of student registration involves the tutoring agency. (1) Students will register and input information into the application. (2) The student who have registered and logged in to the application can immediately check information and the location of the registered tutoring agency. (3) After choosing a tutoring agency in the application, he can see check the feedbacks from students who have attended tutoring at the chosen tutoring institution. (4) The student then can view and choose some data packages that were previously inputted into the application by the tutoring agency. (5) The package selected by the student will be saved by the tutoring agency. (6) The tutoring agency will verify and decide whether the students can be registered to participate in the tutoring or not. (7) The status of the student who have been successfully accepted by a tutoring institute will change into active tutoring. (8) The tutoring agency will notify and inform the student through the application in the form of notifications.

4.3 Student Payment

The business process of student payment on the application includes the administrator of the information system for mapping tutoring agencies. The following is the illustration of the business processes of student payments.

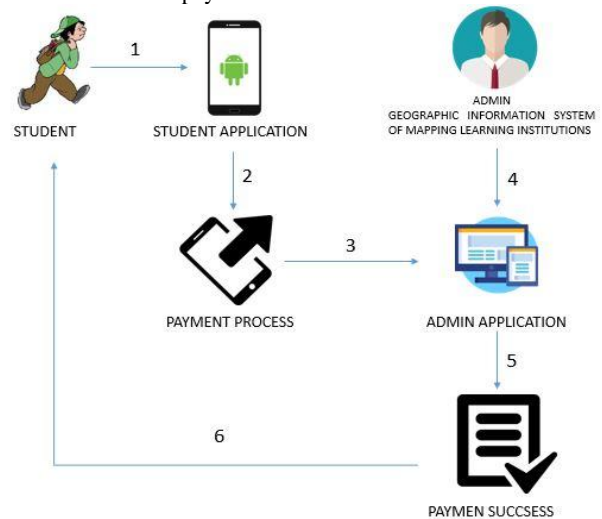


Figure 10. Student Payment

The image above is an overview of the business process of student payment. The student payment involves the tutoring agency. (1) The student accesses the application. (2) The student who have successfully registered in the application can immediately see some tutoring data in the application and make payments directly through the applications. The process requires to input data, such as the name of the banker, the name of the payer, the payment amount and a receipt of the payment. (3) The student who have made payments for the application will appear in the information system of the administrator through the administrator application. (4) The administrator will examine and validates payment data by the student through the administrator application. (5) The payment validation process performed by administrator will change the status of the student payment. (6) The student will receive the notification through the application that explains the payment has been received

4.4 Creating Feedback

The business process of creating feedback on the application includes the students. The following is the illustration of the business processes of creating feedback.

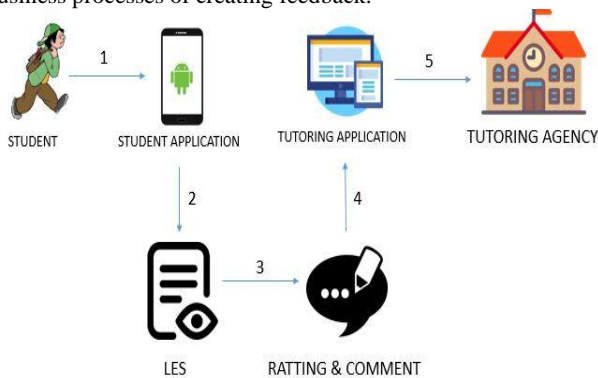


Figure 11. Creating Feedback

The picture above is a description of the business process of creating feedback from students for tutoring agencies. (1) The student will log in to the application. (2) The student who have successfully logged in to the application can immediately see data on the application. (3) The student who have seen some tutoring data and see the duration of tutoring that has completed can directly write feedback in the form of star rating and comments from students towards tutoring agencies. (4) After a review or feedback is made through the application, the data is directly entered in the application of tutoring agencies. (5) The tutoring agencies can directly see the reviews or feedback given by students in the form of star ratings and comments through the application of tutoring agencies.

4.5 Testing the Application

The testing of the information system for mapping tutoring agencies distributed 20 questionnaires with 15 questions each and 20 respondents who answered questions from the questionnaire. Each respondent consists of 10 tutoring agencies and 10 students. The following is the percentage table of 20 questionnaires that have been distributed.

Percentage of 10 questionnaires, each questionnaire has 15 questions distributed to 10 respondents and tutoring has achieved results. The results of the questionnaire included on average 10 interviewees fully agree with what is used as the question on the questionnaire and agree with what is questioned on the questionnaire.

Percentage of the results of the 15 questions addressed to the tutor in the first question, what is the information provided by this application easy to understand? Those who answered strongly agreed by 20% while those who answered agreed 80%. The second question, is the use of menus or application features easy to use? Those who answered strongly agreed at 30% and those who answered agreed 70%. The third question, is this application per the needs of users? Those who answered strongly agreed by 30% and those who answered agreed by 70%. The fourth question, whether this application can be easily learned? Those who answered strongly agreed by 50% and those who answered agreed 50%. The fifth question, is this application easy

to operate? Those who answered strongly agreed by 30% while those who answered agreed by 70%. Question six, can it easily avoid mistakes in using the application? Those who answered strongly agreed by 20% while those who answered agreed by 80%. The seventh question, is the menu display in the application easy to recognize? Those who answered strongly agreed by 20%, while those who answered agreed by 80%.

The eighth question, are you helped with the reminder notification feature as tutor reminders? Those who answered strongly agreed by 50% and those who agreed 50%. The ninth question, are you helped in knowing the schedule with the package features? Those who answered strongly agreed by 50% and those who agreed 50%. The tenth question, are you helped with the feedback feature as a service media? Those who answered strongly agreed by 60% while those who agreed 40%. The eleventh question, are you helped by the location of the tutoring location information feature that functions to see the location of the tutoring? Those who answered strongly agreed by 50% and those who agreed 50%. The twelfth question, are you helped by the notification information that the teacher is unable to attend the application? Those who answered strongly agreed by 80% while those who agreed 20%. The thirteenth question, are you helped by the payment features available in the application? Those who answered strongly agreed by 60% while those who agreed 40%. The fourteenth question, overall are you satisfied with the features provided in this application? Those who answered strongly agreed by 30% and those who agreed 70%. The last question, are you interested in registering this application again? Those who answered strongly agreed by 10% while those who answered agreed by 90%.

Percentage of 10 questionnaires, each questionnaire has the same 15 questions that have been distributed to 10 student respondents. The results of the questionnaire show that on average 10 respondents strongly agree with what is used as a question on the questionnaire and agree with what is questioned on the questionnaire.

Percentage of results from 15 questions addressed to students, i.e. the first question, is the information provided by this application easy to understand? Those who answered strongly agreed by 20% while those who answered agreed 80%. The second question, is the use of menus or application features easy to use? Those who answered strongly agreed by 20% and those who answered agreed 80%. The third question, is this application per the needs of users? Those who answered strongly agreed by 30% and those who answered agreed by 70%. The fourth question, whether this application can be easily learned? Those who answered strongly agreed by 10% and those who answered agreed 90%. The fifth question, is this application easy to operate? Those who answered strongly agreed by 10% while those who answered agreed by 90%.

The sixth question, can it easily avoid mistakes in using the application? Those who answered strongly agreed by 10% while those who answered agreed by 90%. The seventh question is, is the menu display in the application easy to recognize? Those who answered strongly agreed by 20%, while those who answered agreed by 80%. The eighth question, are you helped with the reminder notification feature as tutor reminders? Those who answered strongly agreed by 30% and those who agreed 70%. The ninth question, are you helped in knowing the schedule with the package features? Those who answered strongly agreed by 30% and those who agreed 70%. The tenth question, are you helped with the feedback feature as a service media? Those who

answered strongly agreed at 30% while those who agreed 70%. The eleventh question, are you helped by the location of the tutoring location information feature that functions to see the location of the tutoring? Those who answered strongly agreed by 10% and those who agreed 90%.

The twelfth question, are you helped by the notification information that the teacher is unable to attend the application? Those who answered strongly agreed by 10% while those who agreed 90%. The thirteenth question, are you helped by the payment features available in the application? Those who answered strongly agreed by 10% while those who agreed 90%. The fourteenth question, overall are you satisfied with the features provided in this application? Those who answered strongly agreed by 20% and those who agreed 80%. The last question, are you interested in registering this application again? Those who answered strongly agreed by 20% while those who answered agreed by 80%.

5. CONCLUSION

The application of information system for mapping tutoring agencies can encompass all tutoring agencies in Indonesia. It gives benefits for tutoring agencies in terms of providing information to students, agencies that are small to middle scale tutoring agencies can compete with big agencies. The application also has benefits for prospective students or students such as knowing the location of the institution, getting quality references for the institution, making it easier to register and get other information about the institution.

The Information System for Mapping Tutoring Agencies provides Package features that can be used as commodities sold by tutors. It also applies GIS (Geographic Information System) on the Registration feature and on choosing the most suitable agency based on the location. Moreover, it provides Payment features to facilitate students in making payments to the chosen tutoring agency.

The testing of the application stated that most respondents both students and tutors answered agreed and strongly agreed with what was questioned in the questionnaire. This means that the application is suitable for use and operation.

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Towards the Effective Requirements for Building a Cloud Computing Infrastructure

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Abstract: In order to be competitive enterprises are rapidly changing in terms of technology and moving towards emerging technology trends. Recently cloud computing has emerged as a revolutionary trend and become an integral part of business organizations. However, it is important for organizations to consider a best cloud computing infrastructure that may best fit to the business needs. In this study different types of cloud computing infrastructures have been discussed. The study discusses and analyzes the essential requirements for effective cloud computing infrastructure and concludes the best infrastructure requirements for business organizations before they build a cloud computing infrastructure.

Keywords: cloud computing; requirements; infrastructures; requirements analysis; cloud architecture

1. INTRODUCTION

Organization are adopting information technology at fast pace to be competitive in market. Emerging technologies have forced firms to integrate technology in business processes, but to keep updated with latest technologies is cumbersome. In turn software and hardware become obsolete soon which may affect business performance. Companies consider a viable option using of IT resources and infrastructure from outside of their sites which is more cost effective that prevents from acquiring and maintaining resources. Organizations see flexibility, scalability and availability with appropriate security in cloud services and applications. This is why applications available on cloud are more popular among business organizations due to their immediate availability and cost-effectiveness [1]. Since companies are adopting cloud services so rapidly that extensive study of requirements has become almost irrelevant, consequently infrastructure of cloud services is not implemented properly. Requirements engineering is an essential but complex process that is required among other processes prior implementation of a system [2]. A cloud computing infrastructure can be effective provided requirements have been elicited and understood.

Researchers and practitioners have presented different cloud models and architectures at times. Such model and architectures aim to provide various business solutions. These models and architectures include, a cloud model for mobile platform [3], Google computing model for cost effectiveness [4], cloud model for development of communities [5], hybrid cloud computing model for higher studies [6], cloud architectures related to security [7][8], cloud computing architecture in three layers [9], a cloud architecture for enterprises [10], etc.

1.1 Cloud computing services

Cloud computing services include software, hardware, networking devices, data storages, servers, applications etc. that are available on-demand to any organization. The cloud resources are allocated dynamically to organizations depending on their needs.

1.1.1 Infrastructure as a Service (IaaS)

This service of cloud computing comprised of servers, networking and storage devices. This service allows users to access and manage resources including data, applications and operating systems. Through virtualization resources are integrated or fragmented depending on the demands by customers at times. Nevertheless, users do not manage underlying cloud infrastructure and they can request to the cloud provider for some resources as need arises.

1.1.2 Platform as a Service (PaaS)

This service is available on top of the IaaS, which allows users to access operating systems, develop and deploy user-built applications to the cloud. Clients develop and manage applications and data whereas cloud providers manage operating systems, servers, networking devices, bandwidths, storages etc.

1.1.3 Software as a Service (SaaS)

This service is at top on the services and most widely used among businesses, as clients do not need to install or download any software to run their business processes. Cloud providers manage all software applications and data that prevent clients from worrying about acquiring software, configuration, deployment, security and renewal of licenses etc. Figure 1 shows different services available in cloud

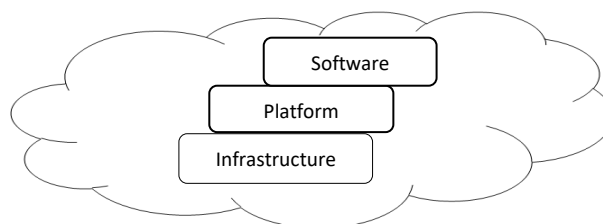


Figure. 1 Cloud services

1.2 Cloud computing models

There are different type of cloud computing models available for clients and clients may select any of the models depending on the resources and services they require.

1.2.1 Public cloud

This cloud computing model provides analogous services and infrastructure to the users including scalable applications, data storages, message services, security and testing services. The servers with resources are shared among multiple customers (i.e. general customers). The cloud service provider maintains the infrastructure.

1.2.2 Private cloud

Organizations provide computing resources and services intended for their specific clients. A secure work space in a well organized manner is provided to the clients (i.e. private customers). The cloud service provider maintains all the resources and infrastructure with quality of service.

1.2.3 Hybrid cloud

This model is composed of a public cloud and a private cloud. In this cloud model physical computing resources available on public cloud are used whereas important data is stored on private cloud. This model provides flexibility to organizations so that they can use resources and deploy data as per needs and costs.

1.2.4 Community cloud

Community cloud model allows various organizations or communities to use shared computing resources, services and self-built datacenters to meet their similar business requirements and objectives [11].

2. COMPONENTS OF CLOUD COMPUTING INFRASTRUCTURE

Cloud infrastructure is a virtual infrastructure that is accessible by internet to a user. Users can access the infrastructure via internet without constructing the infrastructure physically on their premises. The cloud infrastructure consists of various components that are depicted in Figure 2 and discussed in the following section.

2.1 Servers

Since cloud services are shared among different clients, a server is to monitor and compute resource sharing, dynamically allocation of resources, security and services like that.

2.2 Hypervisor

It is a low level program that works like a mainframe operating system or a manager that helps allocation of a resource to multiple clients. It loads an application or operating system and shows it on multiple systems without making physical copy of it.

2.3 Networking

Networking is an essential component of cloud infrastructure as it is used to integrate and provide cloud services over internet. Different virtual resources such as routers,

bandwidth, security firewalls etc. are the parts of networking that clients use and manage them within their organizations or in the cloud.

2.4 Storage

This component of cloud infrastructure helps clients to store their data on physical hardware of the cloud service provider. A storage can be as small as a single system to hundreds of servers linked together to act as storage. Multiple replicas of storage are kept in the cloud and in case, one storage fails to data can be accessed from another storage.

2.5 Cloud management software

In order to support cloud services and manage them effectively and efficiently, a management software consisting of various tools is required. A cloud management software ensures cloud services availability to clients for contract uptime and downtime. The software helps setting up hardware and monitors security and performance of cloud services in order to run system smoothly.

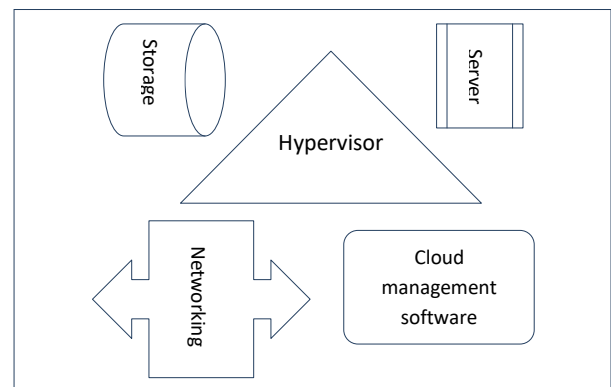


Figure. 2 Cloud infrastructure components

It can be observed that all risk assessment methodologies have some disparities in terms of scope or application. Some of them require expertise and thorough knowledge whereas some methodologies work in combination of generic framework of risk assessment.

3. REQUIREMENTS FOR CLOUD INFRASTRUCTURE

Cloud computing is striking to many business organizations today, but there are some intricacies associated such as integration of software and hardware from multiple companies that make system expensive and hard to build and maintain.

In order to use cloud computing services and perform IT operations for long run it is important that both cloud providers and business organizations clearly understand their need of building cloud infrastructure. Following are the main requirements for building an effective cloud infrastructure.

3.1 Data center management tools

Many data centers host a number of tools that are used for system management, security, customer support and billing etc. As the businesses are rapidly adopting technologies, new trends are emerging. Now data centers and cloud services are being complemented by Edge technology which mainly

focuses on decentralization. Organizations experience huge amount of data with speed which, in turn, affects efficiency as it has to be processed at data centers. Organizations are striving to keep the data at the edge i.e. nearby place where the data is generated [12].

3.2 Resource and service management

Resource management has been a critical issue in cloud services. Clients of cloud services always demand dynamically changing services, which a cloud provider cannot deliver within the limited resources. It is important to meet the customer quality of service requirements [13]. In a data center, its components are virtualized and resources are provided to customer in form of a package. The package which is a service management, consists of applications and services that a customer can deploy and manage through cloud computing provider. In order to provide better and efficient service to customers priorities of resources are set dynamically so that business needs are fulfilled as agreed in service level agreements.

3.3 Security and reliability

Cloud services are delivered to customers who always expect the continuity of the services without any interruption. Researchers and practitioners have reported many security threats and attacks on cloud services [14]. Therefore, there is a need to develop a trust between cloud providers and clients of cloud services. This trust cannot be developed as there are no such rules which can govern both source and destination servers. However, some cloud service providers have started filtering spam mails in messaging services. In order to safeguard privacy in cloud services, cloud providers must manage accessibility, user privileges, credentials etc. [15]. Only authorized users should be allowed to access the cloud services in secure manner.

3.4 User interfaces and developers

Users of client services like to access the service by user friendly interfaces that make cloud services easy to users. Usually users access different cloud applications everyday which may impact on their performance and efficiency. There is no such standard and unified interface that users can use for different type of applications. This unified interface may save operating cost and increase efficiency and productivity. However, self-service interfaces help users to use cloud services easily and effectively.

3.5 Reporting and visibility

Cloud services are successful only when they are managed regularly in terms of performance and efficiency. This requires a continuous report and visibility mechanism to ensure customer service, system performance, billing etc. Data centers need real-time infrastructure visibility and reporting and for this a mechanism should be in place. A visibility monitoring is comprised of machine agent that functions with an app agent. The two agents collect metrics about network, applications and server and determine the reasons of issues among network, applications, hardware etc.

4. CONCLUSION AND DISCUSSION

Cloud services are useful for business organizations and the rapid development in internet technologies more firms are adopting cloud services. However, cloud services should be delivered with proper infrastructure and effective requirements in order to provide customer with effective and seamless services. In this study we have determined effective

requirements for an effective cloud infrastructure encompassing data center and service management tools, security, and monitoring mechanism. If these requirements are adopted and implemented, cloud infrastructure could provide smooth services to users to their level of satisfaction.

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