System Architecture for Green University Resource Planning on Cloud Computing

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Abstract - **This research aimed to study and develop the design of the system architecture for green university resource planning (GURP) on cloud computing. The research was divided into two phases: 1) the design of the system architecture of GURP on cloud computing and 2) the assessment of the system architecture of GURP on cloud computing. The research samples were comprised of 10 experts in the field of the green university and information technology; they were selected using the purposive sampling method. The research tool was used to assess the system architecture of GURP on cloud computing. The tool analysed data by evaluating the mean and standard deviation. The research results showed that the design of the system architecture of GURP on cloud computing was operated in the form of software as a service on cloud computing, which showed the sub-modules operating together within the university context. This research consisted of seven modules. Each of the modules mentioned above were important for developing the system. The 10 experts assessed the system architecture of GURP on cloud computing. The assessment results showed that the system architecture operated at a good level.**

Keywords - **Enterprise Resource Planning, Green University, Cloud Computing, System Architecture**

I. INTRODUCTION

A green university refers to a higher education institution in which a part of the university, or the university as a whole, encourages, manages and participates in mitigating the environmental, economic, social and health problems that arise from resource utilisation, as much as possible. At present, higher education institutions, both in Thailand and elsewhere, are increasingly acknowledging the importance of sustainable and environmentally friendly development [1-8].

In Thailand, the idea of green university development has been extensively used and developed by many higher education institutions. There are 19 universities in Thailand that have passed the assessment carried out by the UI GreenMetric World University Ranking in 2014 [9-10]. The ranking criteria used by the UI GreenMetric World University Ranking 2016 [11] are a global standard, indicating the level of a university's efforts in terms of environmentally friendly management and sustainable development in compliance with the university's policies. The criteria comprise six areas set up by Universitas Indonesia in 2011 [12] showing that the UI GreenMetric World University Ranking is a framework used by each university to assess its operations in terms of green university development and sustainable development, based on the university's policies. Based on the documented research into green university policy, the criteria can be divided into 10 categories: 1) waste; 2) resources; 3) ambient/indoor air; 4) research; 5) energy; 6) landscaping; 7) transportation by bus; 8) corporate social responsibility; 9) regulation compliance; and 10) infrastructure [13-14]. To develop higher education institutions in Thailand, many Thai

universities have begun to use energy and environmental maintenance as a strategic policy and as a way to develop institutions [15-18].

Based on the information mentioned above, the researcher formulated a design for the system architecture of GURP on cloud computing for higher education institutions. The system architecture of GURP will help the university resource planning system to work making it possible to analyse and forecast the future or help support their institution in a sustainable and environmentally friendly approach. The use of this method shows the higher education institution's intent to become a green university.

II. OBJECTIVES

1. To design the system architecture of GURP on cloud computing.

2. To assess the system architecture of GURP on cloud computing.

III. RESEARCH METHODOLOGY

This research was a research and development (R&D) project, which was divided into two phases, as outlined below.

A. Phase 1: was the design of the system architecture of GURP on cloud computing is detailed below.

- **System Analysis and Design**

The design of the system architecture of GURP on cloud computing used the data derived from research, analysis, synthesis and related research, as well as the UI GreenMetric World University Ranking 2014, which has been recognized internationally, which demonstrates the university's commitment to organization executives that are environmentally friendly and sustainable. These measures would conform to university policy [19]. Therefore, the researcher used this measure when developing GURP for education in higher education institutions. The UI GreenMetric was assessed by six criteria.

Fig. 1, illustrates the scope of system operations, which is the use case diagram used in the system architecture of the GURPS on cloud computing.

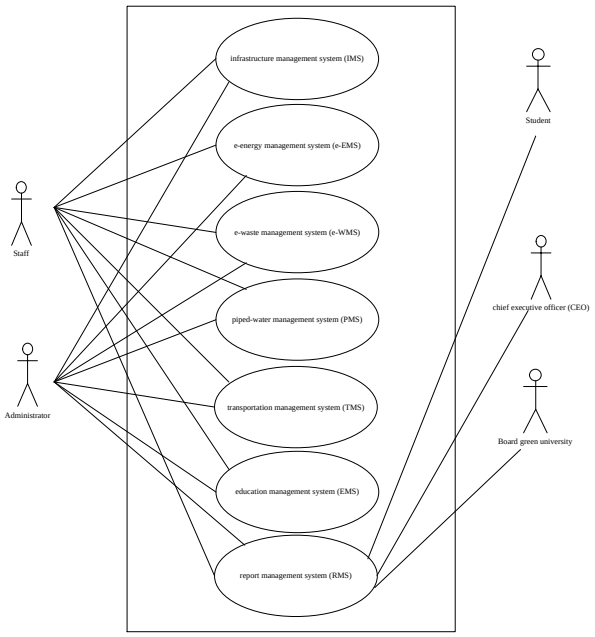

Fig. 1 Use Case Diagram of the System Architecture.

Fig. 1 shows, the use case diagram of the system architecture. It presents the scope of the system's operation and the use case data used in the system, which consists of seven use cases: 1) infrastructure management system (IMS); 2) e-energy management system (e-EMS); 3) e-waste management system (e-WMS); 4) piped water management system (PMS); 5) transportation management system (TMS); 6) education management system (EMS); and 7) report management system (RMS). Moreover, it also shows the access available to those related to the system, as outlined below.

1. **Staff:** this group consists of the users who are allowed by the administrators to access data inside the GURPS. They have the responsibility of inputting the related data into the GURPS.

2. **Administrators:** this group takes responsibility for controlling the whole GURPS by managing the fundamental information and providing/annulling the authority of user groups in the GURPS.

3. **Students:** this group is the students in a university who are given authority by the system to gain an understanding and awareness about information from GURP as appropriate.

4. **Chief Executive Officer (CEO):** this group consists of university executives who can see everything in the system, including follow-up and investigations. The CEO is responsible for facilities and operational support to the information used in the analysis, such as enterprise planning and forecasting decision support.

5. **The Green University Board of Committees:** this group is comprised of the committees who are appointed by the university to achieve a green university ranking. They can access research in order to work according to the operation's plan and can coordinate and facilitate an operation with related institutions, based on the operation's plan.

The system architecture for the GURP on cloud computing shows the overall operational principle of GURP on cloud computing systems through the cloud in the form of software-as-a-service. From the analysis, the researcher found that cloud computing is a technology that can be used in higher education institutions, for example, for educational operations and to support educational services [20-21]. Moreover, this technology helps to develop green universities, as every user can access various information systems using the Internet and administer resource management through network systems and share resources. Therefore, this is an alternative method, as it saves time, reduces management problems, [22-23] and supports resource management in a university in order to exchange information between the university and its subordinate institutions and it helps to increase flexibility in campus management [24], all of which conform to the concept of a green university [14], [25-30].

As shown in Fig. 2, the architecture for GURP in cloud computing consists of three important factors. The principle and relationship between each factor is detailed below.

1. The service requester refers to the GURP system that requests any services that respond to the request of the service requester sent to the service provider. The service requester finds the service that originates from the service brokers and will receive a web service description language (WSDL) document that presents the details of that service. Service requesters thus send parameters to the service provider and have to wait to receive the response result of the service request. The GURPS will extract data from the transaction file of the service provider and store it in the master file database for analysing university resources and research in the RMS.

2. The service broker refers to the service broker that provides the service registry data storage with universal description discovery and integration (UDDI), which allows the service provider to publish his/her own service to benefit the system developer who wants to use the service. The service broker will store WSDL data, allowing the service requester to present the information of that service. When the service requester obtains the information from the WSDL data, they will contact the service provider directly; they do not have to contact the service broker again. To bind the service, the simple object access protocol (SOAP) is used to request the service and, when the service provider receives the result, they will respond to the service requester.

3. The service provider, in this case, refers to the IMS, e-EMS, e-WMS, PMS, TMS, and EMS modules, which have their own service and WSDL document storage. The service provider will promulgate the service through registration and will use the WSDL document deposited with the service broker to let the service requester search for any services they request. This will be stored as a transaction file for use in the transaction processing system (TPS) of the sub-data before being imported into GURPS.

The aforementioned modules in the system architecture of GURP on cloud computing will be important parts of the development of GURPS that shows the sub-modules, which are operated together in a university context. The details are outlined below.

1. **IMS** is the module that manages data, which operates within the university context in terms of total areas of a university, including total building areas, total green areas, total absorbed water areas and the number of staff, professors, academic support staff, and students.

2. **e-EMS** is the module that manages data, which operates within the university context in terms of energy conservation for reducing global warming, alternative energy use policy, consumption, electricity consumption efficiency, and a greenhouse gas emission reduction policy.

3. **e-WMS** is the module that manages data, which operates within the university context in terms of promoting waste segregation projects, deals with toxic waste segregation and ensures that toxic waste is sent to a company, which has a toxic waste disposal certificate. This module also covers organic waste disposal, inorganic waste disposal, wastewater treatment and paper and plastic reduction.

4. **PMS** is the module that manages data, which operates within the university context in terms of water conservation projects and water usage.

5. **TMS** is the module that manages data, which operates within the university context in terms of a number of vehicles on campus and vehicles' gasoline usage. This module also covers the promotion of bicycle usage and a bicycle route policy.

6. **EMS** is the module that manages data, which operates within the university context in terms of the total number of environment-related courses and disciplines, the total amount of environment-related research funds, total number of environment-related publications, the total number of environment-related student clubs in a university and how a university conveys its environment-related information to the public through its website.

7. **RMS** is the module that manages the system report data in terms of a university's energy consumption, a university's budget consumption, and the reduction of a university's paper usage. The module also covers the reporting of the overall image of the university as a green university.

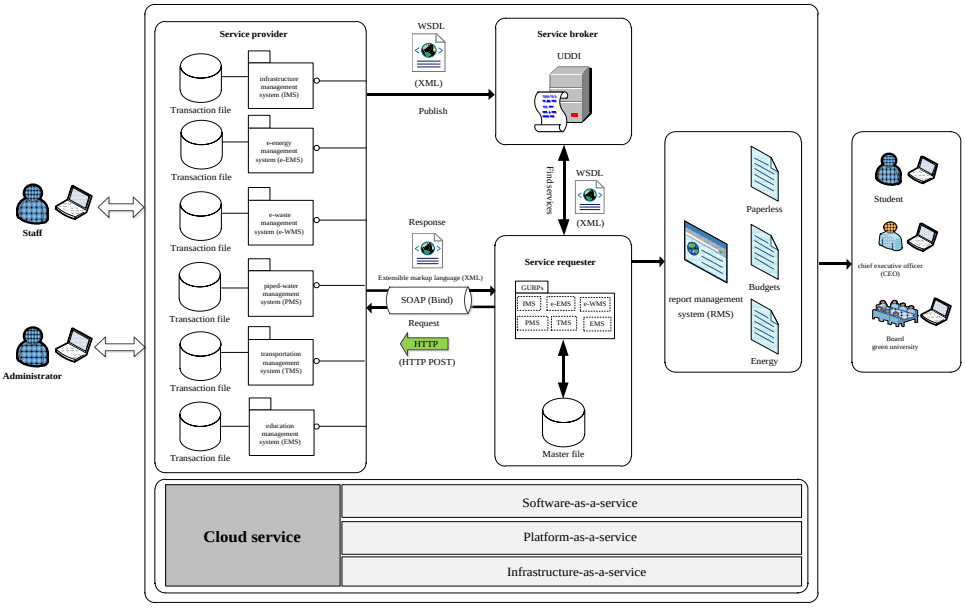

Fig. 2 The System Architecture of GURP on Cloud Computing.

B. The assessment of the system architecture of GURP on cloud computing, which consisted of the following procedures, as listed below.

1. The design of the system architecture was proposed to 10 experts in the field of green universities and information technology. This was so that the researcher could assess and improve the design of the system architecture according to the experts' suggestions.

2. The assessment results of the design of the system architecture were analysed according to the assessment measures by evaluating the mean ($\bar{x}$) and standard deviation (S.D.). The assessment was designed as a five-level rating scale survey, based on the Likert scale.

IV. RESEARCH RESULTS

The experts' assessment results of the system architecture of GURP on cloud computing are summarised below.

TABLE I
THE ASSESSMENT RESULTS OF THE SYSTEM ARCHITECTURE OF GURP ON CLOUD COMPUTING

List of assessment	$\bar{x}$	S.D.	Result
1. The group involved in the system			
1.1 Staff	4.7	0.46	Very good
1.2 Administrator	4.8	0.40	Very good
1.3 Student	4.5	0.81	Good
1.4 CEO	4.7	0.64	Very good
1.5 Green university board of committees	4.6	0.49	Very good
2. The sub-modules that are operated together within the university context			
2.1 IMS	4.6	0.66	Very good
2.2 e-EMS	4.7	0.64	Very good
2.3 e-WMS	4.5	0.81	Good
2.4 PMS	4.4	0.80	Good
2.5 TMS	4.4	0.92	Good
2.6 EMS	4.5	0.81	Good
2.7 RMS	4.4	0.66	Good
3. The operational principle of the system architecture			
3.1 System operation principle via the cloud in the form of software-as-a-service	4.5	0.67	Good
3.2 Suitability of the transaction file storage system	4.8	0.60	Very good
3.3 Suitability of the master file storage system	4.7	0.64	Very good
3.4 Suitability of the cloud system in the form of Extensible markup language web service	4.7	0.64	Very good
3.5 Suitability of the relationship between each sub-operation system	4.5	0.67	Good
4. The system architecture's overall			
4.1 Overall view of the group involved with the system	4.5	0.67	Good
4.2 Overall view of the sub-modules that operate together within the university context	4.7	0.64	Very good
4.3 Overall view of the operational principle of the system architecture	4.5	0.67	Good
4.4 Overall view of the whole system architecture	4.5	0.67	Good

As shown in Table I, the experts' assessment results of the system architecture of the GURP on cloud computing found that the overall image of the system architecture within the overall image of the group involved with the system was rated as good. The overall image of the sub-modules that operate together within the university context was rated as very good. The overall image of the operational principles of the system architecture was rated as good. The overall image of the whole system architecture was rated as good. The assessment results found that the operational principle of the system architecture was rated as good. This shows that the capability of cloud computing can be

effectively used as the centre of the GURPS. This productively integrates the GURPS into an operation that will help to analyse, predict and support future decisions. It can also help a university develop into a green university according to which sustainable development and environmentally friendly concepts the institution implements [14], [20-30].

V. CONCLUSION

The system architecture for GURP on cloud computing was designed to establish a university environment that facilitates education management, energy consumption reduction [31] and environmental conservation, as well as the development of an environmental consciousness and an awareness in students, staff and the community of their responsibilities [32]. The system was designed by using the UI GreenMetric World University Ranking as a standard measurement for the operation [11, 33]. The researcher found that each university had indicators that were modified according to the context, geography, budget, location and internationality. These indicators were used to design the system architecture of GURP on cloud computing, which had a system operation principle of using the cloud in the form of software-as-a-service. The system architecture showed the sub-modules that operate together within the university context. The system architecture consists of seven modules, which are: 1) IMS; 2) e-EMS); 3) e-WMS; 4) PMS; 5); TMS; 6) EMS; and 7) RMS. Each module mentioned above plays an important role in developing the system. Each sub-module conforms to the research of various authors [4-6], [34-38], showing how much the sub-modules operate together, according to the survey conducted in the university environment. Moreover, the system architecture also helps the GURPS conform to the operation. Therefore, this will help university executives to analyse, predict and support their future decisions [39-41]. If universities continuously engage in an environmental management that is suitable for their own contexts and they operate according to the factors for success [18], they will join the green universities that already have effective and sustainable resource management.

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