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Dynamic Resource Sharing Model for Information Management in Malaysian Schools

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Abstract: Cloud computing is a technology that delivers a pool of configurable computing resources to the users. The insufficient systems for sharing of resources, poor extended pattern of resource sharing system and inadequate network and computing facilities become an issue in school management. This article discussed a model for resource sharing in Malaysian schools using cloud computing platform. The sharing of resources is modelled based on Multi-Person Prisoner's Dilemma and Peer-Approved incentive mechanism that gives justification to users in the resource utilization. The concept of software as a service is adopted to make the model can be managed in the cloud environment. Based on the proposed model, a prototype is developed and deployed into cloud using OpenStack architecture. The prototype is evaluated using questionnaire instrument that is based on four attributes of usability metrics. The result shows that the model usability achieved 79.28% of effectiveness, 81.35% of efficiency, 91.8% of learnability and 93.18% of satisfaction. The proposed model could save the cost of buying computing and storage infrastructure since all the resources are cloud based.

Key words: Resource management · Gamification · Multi-person prisoner's dilemma · Peer-approved incentive · Cloud computing

INTRODUCTION

The concept of an intelligence school information management has been identified as not only representing a technological innovation for realizing global integration but also as considering the current demand on global issues such as socio economy, application of green technology and smart governance. An intelligence school information management has been characterized as a tool for generating a particular form of spatial innovation that is based on web services, integrated module, involved large data sets and real time information feeding and response.

The Malaysian government always put the first priority on budget allocation for the Malaysian education system. However, student outcomes have not always matched the resources channeled into the system. The government will maintain current levels of this investment for the aspiration to further maximize student outcomes within the budget level. The situation requires funds to be distributed to agencies involved in accordance with the priority needs such as environment and socio-economic.

As stated in Malaysian Education Blue Print 2013-2025, one of the aspirations in Malaysian Education System is efficiency. It requires the ministry and schools to maximize the student outcomes within the allocation budget given by the government. To improve effectiveness in teaching, learning, management and evaluation process, the use of technological innovation that requires a certain investment is cannot be avoided. Therefore, the integrated technology of software, hardware and platform that can be shared by ministries, State Education Department (SED), District Education Office (DEO) and schools must be developed.

Service oriented model (SOM) is a technique that can be used by organization to develop more effective work processes that integrate business functions. It is suitable in organizations that seeking approaches to use ICT

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investments to better support their strategic goals. The adoption of SOM could help organization to improve ICT agility, minimize integration costs and simplify of new applications development [1]. The most popular example of SOM architecture is *web services* technology. A web service is built on open standards that allow connections in business service components, modules, functions and applications more easily regardless of platform or programming language.

Cloud computing is a new technology service that provides several concepts such as distributed application design, virtualization, enterprise IT management and grid application. The main aims of cloud computing is to allow more openness methods in deploying and scaling applications with low investment for hardware, software or platform [2]. This technology refers to flexible network accessible computing resource pools that can be distributed as per user request. The virtualization concept offered in cloud computing technology allows for high availability and safety mechanisms from data lost situation.

Information Management in Malaysian School: In January 2015, the Ministry of Education Malaysia has launched an online system called School Management System (SPS). This system is used by schools, DEO and SED to achieve a single database application for information related to schools, teachers and students. SPS is also aimed at preventing teachers from performing repetitive data entry in multiple systems developed by the ministry. SPS does not include teaching, learning and assessment modules. It can be accessed through the address http://apps4.moe.gov.my/sps and has three modules that are *school management, teacher management* and *student management*.

Currently, Malaysian schools, DEO or SED do not have a specific platform for information sharing of teaching, learning and student assessment materials. The archiving materials in this particular platform helps student to make reference more easily and could be a comprehensive inventory for students to have an alternative learning support. While the management of education such as school administrators, DEO and SED can use the archival material for the purpose of planning, quality improvement and increase the effectiveness of the process of teaching, learning and assessment in schools.

Cloud Technology and Service Oriented Model: The US National Institute of Standards and Technology (NIST) defines cloud computing as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources such as network, servers, storage, applications and services that can be rapidly provisioned and released with minimal management effort or service provider interaction" [3]. Cloud computing offers significant cost savings, efficiencies, flexibility and scalability as well as opportunities for innovative development and delivery of new services [4, 5, 6, 7, 8].

NIST is also divided cloud computing into three service layers: *software as a service (SaaS), platform as a service (PaaS)* and *infrastructure as a service (IaaS)*. Meanwhile, deploying cloud computing can be implemented in four methods: *private cloud, public cloud, community cloud* and *hybrid cloud*.

Some of well-known IT service based enterprises such as Google and IBM Cloud Academy have developed cloud computing platform for serving the education requirements. For instance, Google provides Google Apps for education purposes. It comprises Google Mail, Calendar, Talk, Docs, Sites and Video with zero cost and without advertisement panels. Meanwhile, IBM Cloud Academy provides an educational organization with integrating cloud technologies into their infrastructures, sharing best practices in the use of clouds and collaborating with partners to create innovative cloud technologies and models.

Service Oriented Model (SOM) is a promising paradigm for developing and deploying enterprise software systems. SOM is based on integrating business logic within independent and stateless services that interact through messages using standard communication protocols [1]. The notion of the service application is developed on independent building blocks of components, functions and services. Particularly, SOM based application involved three entities that are *service provider, consumer* and *service broker* [1].

Related Works: In the blueprint Malaysian Education Development Plan 2013 – 2025, the Ministry of Education will ensure that students not only learn using ICT but also can use it in effective ways to improve their learning. Therefore, the Ministry attempts for strengthening basic ICT school infrastructure while introducing ICT solutions well proven in the educational system. Steps taken are include:

- Provide students with the skills and knowledge to learn effectively and live productively in global and digital world.

- Equip all 10, 000 schools nationwide with 4G Internet access and virtual learning platform through 1BestariNet program.
- Provide training for all teachers to apply ICT in teaching and learning.
- Increase the ratio of students to ICT equipment 10:1. This ratio can be reduced further depends on the impact assessment and the availability of funds.
- Leading the way with the delivery of learning using ICT innovations such as distance learning and self-learning content (self-paced).

The education stake holders such as SED, DEO and school management are striving to deliver higher levels of teaching and learning services, but challenged with flat funding to support this effort. A solution that can be taken is to use the vast of databases available to gain a better opportunity in providing services more efficiently. This can be initialized with engaging teachers, subject matter experts and school management with open data initiatives to create innovative information sharing programs. The model that applies advanced analytics and collaboration to the teaching, learning and assessment requirements provides a roadmap to achieve these aims, but the education stake holder IT department is often limited by staff size, skill and budget and is unable to implement the model on their own.

Cloud computing and software as a service can provide the means to acquire data-driven teaching, learning and assessment capabilities that support intelligence school information management. [4] proposed a model for the provision of shared archiving services using cloud computing technology. This archiving as service model is developed based on the Open Archival Information Reference Model. The developed model allows the sharing of functionality and information objects by making them as services at the user application level. The model has been experimented to the Japanese Government and National Archives as an application for Archives and Record Management. The experiment shows that the model provides efficient archiving functionality and improve document life cycle as well as simplify record transfer activities.

Meanwhile, [7] has developed a cloud computing based platform for supporting teaching and learning using a Virtual Computing Lab (VCL) approach and the model is experimented at North Carolina State University State University.

The Gamification Model for Resource Sharing: The gamification model for resource sharing is developed based on the integration of three techniques: *prisoners' dilemma*, *peer-approved incentive* and *application layering*. The prisoners' dilemma and peer-approved incentive techniques managed the resource sharing and its justification in the user's resource utilization process.

Resource Sharing Method: In this model, the multi-person prisoner's dilemma technique is used in order to encourage the users (providers) to share their resources. The multi-person prisoner's dilemma is a game where two players are partners in a crime with each player having two options of either confessing or not confessing [9]. The players are to choose an action simultaneously and at the same time each player wants to maximize his utility.

In the context of resource sharing, users can either choose to share more resources (which is considered as not-preferred option) or to share fewer resources (which is considered as preferred option). The multi-person prisoner's dilemma technique is combined with an incentive mechanism in order to provide justification and encouragement for users to share their resources.

According to [10], there are three incentive mechanism model can be considered in designing information system for sharing resources: *token-exchange, peer-approved* and *service-quality*. The peer-approved model is used to integrate with multi-person prisoners' mechanism for developing the model of cloud based resource sharing in Malaysian school environment.

In this resource sharing problem, several users contrary to prisoner's dilemma that involves two players are considered. Therefore, the following assumptions are made.

- There are N users in the system and each user has at least one resource to share.
- User can either share one resource (preferred alternative) or can decide to share many resources (non-preferred alternative).
- Rating of user is proportional to the number of resources shared by that user.
- The users are categorized into three types: *main-contributor, partial-contributor* and *weak-contributor*.

Let: main-contributor, M_c, be a user that shared at least P resources; partial-contributor, P_c, be a user that shared at most Q resources and weak-contributor, W_c, be a user that shared only R resource or no resource, where the variables P, Q and R can be customized by administrator and P > Q > R.

Suppose that M_{c1} shared d_1 resources, M_{c2} shared d_2 resources, … M_{ci} shared d_i resources where $d \in Z^+$. Thus, $D = d_1 + d_2 + \ldots + d_i$ is the total resources that are shared by main contributors. This condition can be represented by:

$$D = \sum_{k=1}^{i} d_k \tag{1}$$

Suppose that P_{c1} shared e_1 resources, P_{c2} shared e_2 resources, … P_{cj} shared e_j resources where $e \in Z^+$. Thus, $E = e_1 + e_2 + \ldots + e_j$ is the total resources that are shared by partial contributors. This form can be represented by:

$$E = \sum_{m=1}^{j} e_m \tag{2}$$

Suppose that W_{c1} shared f_1 resources, W_{c2} shared f_2 resources, … W_{ck} shared f_k resources where $0 \leq f \leq 1$. Thus, $F = f_1 + f_2 + \ldots + f_k$ is the total resources that are shared by weak contributors. This situation can be represented as:

$$F = \sum_{n=1}^{k} f_n \tag{3}$$

The total resources that are shared in the system is the sum of all the resources shared by users and can be denoted as:

$$G = \sum_{k=1}^{i} d_k + \sum_{m=1}^{j} e_m + \sum_{n=1}^{k} f_n \tag{4}$$

In the proposed model, category of user is calculated based on their contributions. The boundary of main contributor is set to at least P resources in order to encourage user to contribute more into resource database. The variable of P can be customized to accommodate the system requirements. Despite all these restrictions, the system is open and accessible to all users. However, user can access resources available to their category.

Basically, in the initial stage user will be allocated with a space of 10240MB. After a successful registration, the storage space can be expanded to 15GB and user will be given more space as they keep using the application. The utility of each user's category can be denoted as follows:

- Main-contributors are those that shared at least P resources to the system. This group of users can access all the resources. The utility of main contributors is given by:

$$Utility\ M_c = \sum_{k=1}^{i} d_k + \sum_{m=1}^{j} e_m + \sum_{n=1}^{k} f_n \tag{5}$$

- Partial-contributor is the user who share at least Q resources where Q < P. Thus, peer-approved mechanism is applied where users can access resources based on their ratings. This category of users can access all the resources except the last S resources (where S is a variable that can be customized and S < Q. The utility of partial-contributor is given by:

$$Utility\ P_c = \left(\sum_{k=1}^{i} d_k + \sum_{m=1}^{j} e_m + \sum_{n=1}^{k} f_n \right) - S \tag{6}$$

- Weak-contributors are those who shared only R resource or no resource at all. This category of user could access only resources that are shared by other weak-contributors. The utility of this contributor can be signed as:

$$Utility\ W_c = \sum_{n=1}^{k} f_n \tag{7}$$

Application Layering: The implementation of the proposed model is developed based on SOM that emphasize on applying the open data concept. The basic requirement for this concept is to open up publicly owned data and information. The model will provide the transparent platform and enable collaboration between users, providers and related stakeholders. The proposed model adopts the concept of open data in the design and the data stored must be complied with the following principles:

- Complete – the data can be definable and agreed among users.
- Accessible – the data can be accessed by the widest range of users.
- Machine pre-processable – the data must be organized in an agreed structure.
- License free – copyright, patent, trademark etc. is not apply to the available data.

The prototype is implemented by using the concept of SaaS, deployed under OpenStack and private cloud environment. The hierarchy structure of the application

model consists of three layers. These layers are: *Resource Layer, Management Layer* and *Service Layer*. The descriptions of each layer are as follows:

- Resource Layer: The layer consists of all the back-end database and resource pool. It supports for computing power, resource library and storage capability of the resource sharing system.
- Management Layer: The layer responsible for coordination and interaction between the resource layer and service layer for resource sharing. It is responsible for the management of all the system components. The prisoners' dilemma and peer-approved incentive mechanism are incorporated in this layer to handle the resource sharing with its justification.
- Service Layer: The layer provides the description of services offered by the reception that include self-service portal. It allows for resources to be uploaded and downloaded by school management or teachers.

Prototype Framework: The proposed cloud-based students' assessment resource sharing framework consists of three units connected to each other. These units are *client's access unit*, *cloud management unit* and *resource pool unit*. The customers (clients) group consists of a number of system users. Registered users provide their user-id and password to access resources. The cloud management unit coordinates and manages resource(s) access, user login and user registration. Meanwhile, the resource pool unit consists of the system database and resource pool. Figure 1 illustrates the proposed prototype framework.

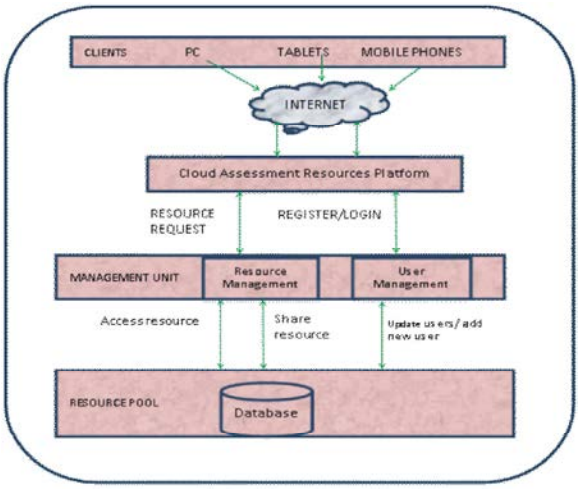

Fig. 1: Prototype architecture

The application prototype consists of five main elements {*data centers, cloud services, service providers, users, Internet*}. Each element plays a specific role in the setting up and implementation of the cloud environment. The framework adapted the concept of Software as a Service using private cloud in the system deployment. The features of software as a service (SaaS) is used to assure that users can access it from any location using smart devices.

Evaluation Results: In this study, the developed prototype is evaluated based on its usability. The usability of the services are measured using quality of service (QoS) metrics suggested by [5] and [11]. A questionnaire has been developed and distributed to 331 school teachers for hands-on evaluation session. Four attributes of usability are used: effectiveness, efficiency, learnability and satisfaction. Each attribute is evaluated based on specific questions with five scales: *strongly disagree, disagree, neutral, agree, and strongly* agree. In the context of developed prototype, the definition of each attribute is as follows:

- Effectiveness is the capability of a prototype to enable user for completing specific task accurately and providing a convenient and interactive interface for user to access.
- Efficiency is the capability of prototype to enable user for completing specific task in a reasonable time and having a set of features to facilitate user in making interaction effectively.
- Learnability is the prototype characteristic that ease the user to accomplish task effectively without specific guidance.
- Satisfaction is defined as data security aspect and reporting quality offered by prototype.

For the effectiveness evaluation, there are five (5) questions are examined (Table 1). Based on the results, more than 68% of respondents agreed with the effectiveness of functional in implementing resource sharing. For all questions involved, the average of service effectiveness of quality metrics measured is 79.28%. Regarding to quality metrics number four (*Enhance ability experience in resource sharing*), percent of respondents agreed with the effectiveness of the prototype is relatively low compared to other quality metrics. This is caused by the respondents still cannot fully adapt to the process flow of the prototype. It is expected that this effectiveness percentage will increase after user having continuous experience and train.

Table 1: Effectiveness

No.	Questions	Respondent feedback (%) SD	D	N	A	SA
1	Allow to use appropriate resources	9.1	10.0	5.4	44.4	31.1
2	Application is accurate and reliable	8.2	8.2	0.3	47.4	36.0
3	Deliver all services at all time	3.3	9.1	0.3	56.8	30.5
4	Enhance ability experience in resource sharing	14.8	13.3	3.3	40.8	27.8
5	Enable to completeness retrieve resources	8.5	10.0	0.0	53.2	28.4

* SD – strongly disagree D – Disagree N – Neutral
A – Agree SA – Strongly agree

Table 2: Efficiency

No.	Questions	Respondent feedback (%) SD	D	N	A	SA
1	Convenient to exchange resources with others	5.4	6.9	0.3	46.8	40.5
2	The effect of resource sharing is convincing and commendable	10.6	2.7	0.0	52.3	34.4
3	The process of uploading and downloading resources is fast and efficient	10.9	13.6	0.0	26.0	49.5
4	Efficient enough to be used and guide users through the process	6.3	9.4	0.0	49.2	35.0
5	Guideline resources are appropriate	14.4	4.2	0.0	29.9	51.4
6	Response time of each process is appropriate	17.8	4.8	4.2	41.4	31.7

* SD – strongly disagree D – Disagree N – Neutral
A – Agree SA – Strongly agree

Table 3: Learnability

No.	Questions	Respondent feedback (%) SD	D	N	A	SA
1	Interface is easy to learn	8.2	3.9	0.0	40.2	47.7
2	Information is properly presented with clear interpretation	8.8	10.6	1.8	48.3	30.5
3	External resources are relevant and informative	0.0	0.0	0.0	44.4	55.6
4	Provide useful contents related to the shared resources	0.0	0.0	0.0	65.3	34.7
5	Provided guidelines are appropriate and sufficient	0.3	2.7	0.3	61.6	35.0
6	All processes are easy to learn and understand	5.7	1.5	5.1	37.8	49.8

* SD – strongly disagree D – Disagree N – Neutral
A – Agree SA – Strongly agree

Table 4: Satisfaction

No.	Questions	Respondent feedback (%) SD	D	N	A	SA
1	Confident to share the resources	4.2	2.7	0.0	24.8	68.3
2	Satisfied with the security and data privacy	6.6	1.5	0.0	47.1	44.7
3	Fonts and style used in interface design are attractive	0.0	2.7	0.0	36.0	61.3
4	The module integration interfaces are interactive and user friendly	5.7	1.8	4.2	45.9	42.3
5	The model of sharing incentive is satisfied	0.0	4.2	0.0	52.6	43.2
6	The model can be easily understand by inexperience users	3.9	0.0	0.0	59.2	36.9
7	The application is very convenience as it can be used at any time and place	7.9	0.0	2.1	44.1	45.9

* SD – strongly disagree D – Disagree N – Neutral
A – Agree SA – Strongly agree

To evaluate the efficiency of the proposed model, six (6) quality metric questions are used. Table 2 tabulates respondent's feedback from the questionnaire given. The result shows that more than 73% of respondents agreed with the efficiency of prototype functions in resource sharing. The average of efficiency quality metrics is 81.35%.

There are also six (6) quality metric questions are used in measuring learnability of the proposed model. Respondent's feedback data is tabulated in Table 3. The result shows that more than 78% of respondents agreed with the learnability of prototype. Besides the friendly interface, the prototype has also provided enough information to guide user in completing tasks. The average for learnability quality metrics is 91.8%.

In a cloud environment, security and data privacy features are very important. Respondent's satisfaction feedback data is tabulated in Table 4. There are seven (7) quality metric questions are used in measuring satisfaction of the proposed model. The result shows that more than 88% of respondents agreed that the prototype has achieved the level of satisfaction. The satisfaction

quality metrics average is 93.18%. This indicates that the respondents are confident and satisfied with the prototype as a resource sharing platform.

CONCLUSION

The issue of resource management, computing facilities, Internet bandwidth and computing services acquisition has become a big concern for Malaysian schools. The article proposed a model for sharing resources among Malaysian schools using SaaS that implemented under private cloud platform. The sharing of resources is modelled based on Multi-Person Prisoner's Dilemma with an incentive mechanism that gives justifications and encouragement for user to participate. Besides that, the service oriented model and open data policy is applied in the prototype development. The proposed model can save the cost and physical space, particularly for the Malaysian Ministry of Education in providing information sharing platform facilities to schools, teachers and students.

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