International Journal of Advanced Engineering and Applied Sciences 01(01), 12-17, 2016

An Open Access Journal

International Journal of Advanced Engineering and Applied Sciences

www.measpublishing.co.uk/journals/IJAEAS

The Modelling of Collaborative Learning Objects Development Based On Cloud Computing Platform

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Abstract:

The thriving of information and communication technology (ICT) era has made the concept of cloud computing to be the new generation of computing technology that is used in academic and non-academic fields. Academic fields in particular use cloud computing to provide numerous educational services, thereby helping teaching and learning activities to move from traditional approach to a new ubiquitous environment. This is only achieved through the numerous benefits of the cloud platform which consist of seamless collaboration, minimal spending on infrastructure, scalable resources, continuous availability and data security. The focus of this study is specifically to provide a collaborative approach for the development of learning objects to support teaching and learning among school communities. There is increasing need for the collaborative development and management of learning objects that can be used to provide effective learning materials especially for secondary schools. Moreover, the provision of the aforementioned scenario requires a powerful and cost effective platform that can be efficiently implemented. Hence, cloud technology is envisioned as the technological platform with the resources and power to support such demand. A model for the collaborative learning objects development is proposed based on trace matrix concepts. Analysis of the model is then presented using revision maps and matrix diagonal summation process to show the activities involved. This study provides a new collaborative development of learning objects via cloud computing to help schools provide qualitative learning materials, thus supporting knowledge amplification among educational communities.

Article Information:

Keywords:
Learning Objects
Learning Objects Development
Cloud Computing Seamless Collaboration
Modelling Techniques

Submitted: 10 Dec 2015
Revised Form: 15 May 2016
Accepted: 13 June 2016
Available Online:13June 2016

1. Introduction

Learning objects refers to learning and teaching materials that are used by the educational community to acquire knowledge, amplify understanding and progress in life. It is defined formally by the IEEE-LTSC working group (Institute of Electrical and Electronics Engineers-Learning Technology Standardization Committee) as "*any entity, digital or non-digital, which can be used, reused or referenced during technology supported learning…Examples of learning objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology supported learning*" [1-7]. The development of the learning objects is a laborious task that includes addition, edition and deletion of various objects in order to develop and release a complete learning material for learning and teaching purposes [8-16, 26].

The objects are usually texts, images, videos, web pages, documents, audios and animations, which are merged together as single learning objects [17, 26]. Learning objects are believed to increase educational productivity, effectiveness of interaction and quality of teaching among the educational communities. This is usually achieved when appropriate and qualitative educational contents are developed and provided [18]. The author in [6] stated that learning objects are the new alternative for the traditional scholastic materials and instructional systems used in education. It provides suitable educational contents in a proper form to support the educational community. As a result, the consideration for providing learning objects looms tremendously in the academic line leading to many efforts being put in place to develop system models that will create, publish and manage them, hence simplifying its development processes and activities [7]. Moreover, the authors in [2] indicated that learning objects are the current appropriate approach for learning and teaching in both industry and educational arena. However, it is still in infant stage, and it lacks the modelling mechanisms that will define its respective components, actors involved and the collaborative activities needed for its structuration and usage as well as the delivering mode.

In line with the increased efforts for the provision of learning objects, technological platforms are being explored for supporting the tasks and the delivery of the managed learning materials in the most recent times. Specifically, cloud computing that is considered as the next generation for computing technologies and educational services is the new discovery [16, 1]. Paper [19] enumerated certain educational services that are delivered via cloud platform. These services include cloud course module (learning object), cloud classroom, cloud lab, student assignments, on-demand lessons, online evaluation and feedback, e-publications, data sharing and remedial classes. The author in [22] mentioned that cloud computing is a new technological trend that is used in academia to deliver vital educational services for the betterment of education. It is defined by the National Institute of Standards and Technology (NIST) as a "*model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction*" [14, 20]. Some of the advantages of using cloud computing in education include easy educational environment setup, promotion of resource sharing, high reliability and security, seamless collaborative support on education, economic value, continuous availability and scalable computing power [5, 13]. The service of cloud computing is of three models, namely: software, platform and infrastructure service models. They are usually called Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). The services can be deployed to the consumer as public, private, community or hybrid type of cloud model depending on the need. It is mainly characterised based on its on-demand self-service, broad network access, resource pooling, rapid elasticity and measured service [14].

The ability of the cloud computing to provide seamless collaboration can be utilized in the development and management of the learning objects. This is because collaboration helps in providing open, shared and joint atmosphere for teacher development as well as mastering knowledge to a superior magnitude which may be difficult or limited when using individual approaches [3, 11]. The author in [8] stated that *"the process of learning objects development is usually creative, active and collaborative in nature"*. It basically combines the cognitive and communication requirements of the management processes together with that of the social benefits of the collaborative support [25]. This is because education must accept the test of social practice via an effective technological platform in order to generate appropriate educational contents [4]. The authors in [9] indicated that cloud computing can be used to deliver learning object resources based on demand and in real time together with the enormous workloads that can be performed on it. This helps in sustaining a successful implementation of a demanded learning platform.

2. Related Works

The expansion of ICT has changed the way of delivering educational activities and services in the educational arena. Collaborative strategies via ICT platforms in particular are being explored to improve teaching environments, increase knowledge acquisition and provide qualitative learning objects among teachers and learners [11, 27, 25]. It is usually used seamlessly by students, teachers or both. Students use collaboration to support their learning activities, whereas teachers use it for knowledge building. It is also employed by both learner and teacher to provide high interaction during didactic undertakings [15].

The study in [2] proposed a model called Formal Learning Object Model (FLOM) for collaborative development of learning objects as well as the formal identification of the various components involved in constructing them. FLOM model comprised of group model and composition model. The group model identifies the collaborative members in terms of their roles, activities and interactions in the construction of the learning objects, whereas the composition model specifies the various components for developing learning object that can be qualitative and meaningful to the educational communities. The identified components include learning objectives, competencies, prerequisites, educational content and practices. On the other hand, three main players are involved in the collaborative development of the learning objects. They are facilitators who are responsible for offering the learning objects, administrators who perform the management of the learning objects and users, and finally learners who utilise the learning material(s) for knowledge amplification. A model prototype called FLOM-Tool was developed to able the collaborative development processes of the learning objects.

The authors in [15] discussed the design of collaborative learning platform for computer basic course in Shanghai Normal University via cloud environment. Learning modules are provided via Q & A sessions, forums and show cases to help enhance interaction between students and teachers, thereby supporting collective wisdom distribution and collaborative educational activities. The teachers provide projects and learning interest approaches, whereas learners form a team to conduct various joint tasks and open learning. A website was designed to provide the computer courses. The courses are accessed or utilized individually or collaboratively by the learners.

Another study conducted by [25] proposed an analysis approach for collaborative writing topics (learning objects) of students via the use of Google Cloud Docs. The use of the Google cloud docs allows the contents to be added, edited and deleted, as well as saving the number of revisions on the contents. It also saves the identification number of the authors and the timestamp for conducting any activities on the contents. On the other hand, authors collaborate to develop the topic contents. The number of contributions for each of the collaborators on the content is recorded. The study developed three concepts called visualization in order to analyse the collaborative activities. The first visualization is revision map which is used to show the amount of activities performed by the collaborators on the content (addition, edition and deletion). The second visualization process is topic evaluation chart which is utilized to depict the topic(s) created during the development of the content. The third virtualization is topic based collaboration network, which shows the collaboration process of the authors and how they contribute to the content synchronously or asynchronously.

A new collaborative activity system for teaching processes based on cloud technology platform was discussed by [3]. The study provided an insight on how teachers from anyplace and at any time (cloud technology) can utilize computer information transmissions and collaborative efforts to maximize personal knowledge and teacher performance to support educational needs. A virtual team of teachers is created to allow them to interact and collaborate to provide teaching activities in the cloud environment. It is called a network collaborative teaching and research activities, and it is formed using five patterns, namely: expert leading, self-learning, peer-coaching, project research and self-reflection. The expert leading allows a group of more experienced teachers to participate and drag other teachers along in real time or offline, thus supporting universality of collaboration. Self-learning approach is used to provide teaching resources in the form of videos in which the teachers watched and discussed to improve their teaching abilities. Peer-coaching pattern is used to improve the development of the teachers by allowing them to participate in lesson presentation processes via video conferencing and discussion with each other. Project research pattern allows the teachers to jointly discuss and provide updated learning objects that can facilitate teaching activities. Finally, self-reflection is used to enable teachers to reflect on the developed contents as well as the feedback received from reviewers in order to improve the developed contents.

3. Collaborative Development of Learning Objects

A model for the development of learning objects using the cloud computing platform is developed to provide a convenient environment for the collaborative development of learning material(s) from anyplace and at any time to support education. The platform entails five important components, namely: learning objects, learning objects development, collaborators, administrators and delivery platform. These are defined as follows:

1) Learning objects (Learning materials): these are the objects that are amalgamated to form a complete learning object (learning material). It includes texts, videos, audios, graphics and animations.
2) Learning objects development: this is the process in which individual learning objects are incorporated to form a single learning material.
3) Collaborators: these are the participating users (teachers) who work together to develop learning material(s).
4) Administrators: these are the users who are responsible for managing various resources in the model. They grant access to the users and also provide topics (courses) needing learning objects development.

Delivery platform: this is the cloud computing environment that allows the seamless collaboration on the learning objects through continuous availability at anyplace and any time. A public Google Platform as a Service (PaaS) is selected as the environment for the learning object development process.

Figure 1 shows the components of the collaborative learning objects development using cloud technology platform. It consists of collaborators, administrators, leaning objects, learning objects development, learning material and delivery platform. The collaborators are the teachers who team up to conduct the development of the learning objects. The administrators provide courses requiring learning objects development as well managing the users of the platform. The learning objects are the objects that are merged together to form complete learning objects, whereas learning objects development is the task procedure for unifying the learning objects to become a single entity of learning material. The learning material is the end product which can be used in conducting teaching and learning activities, while the delivery platform is the cloud environment that facilitated the availability of the learning objects (learning material) and its various activities via seamless collaboration that can occur from anywhere and at any time.

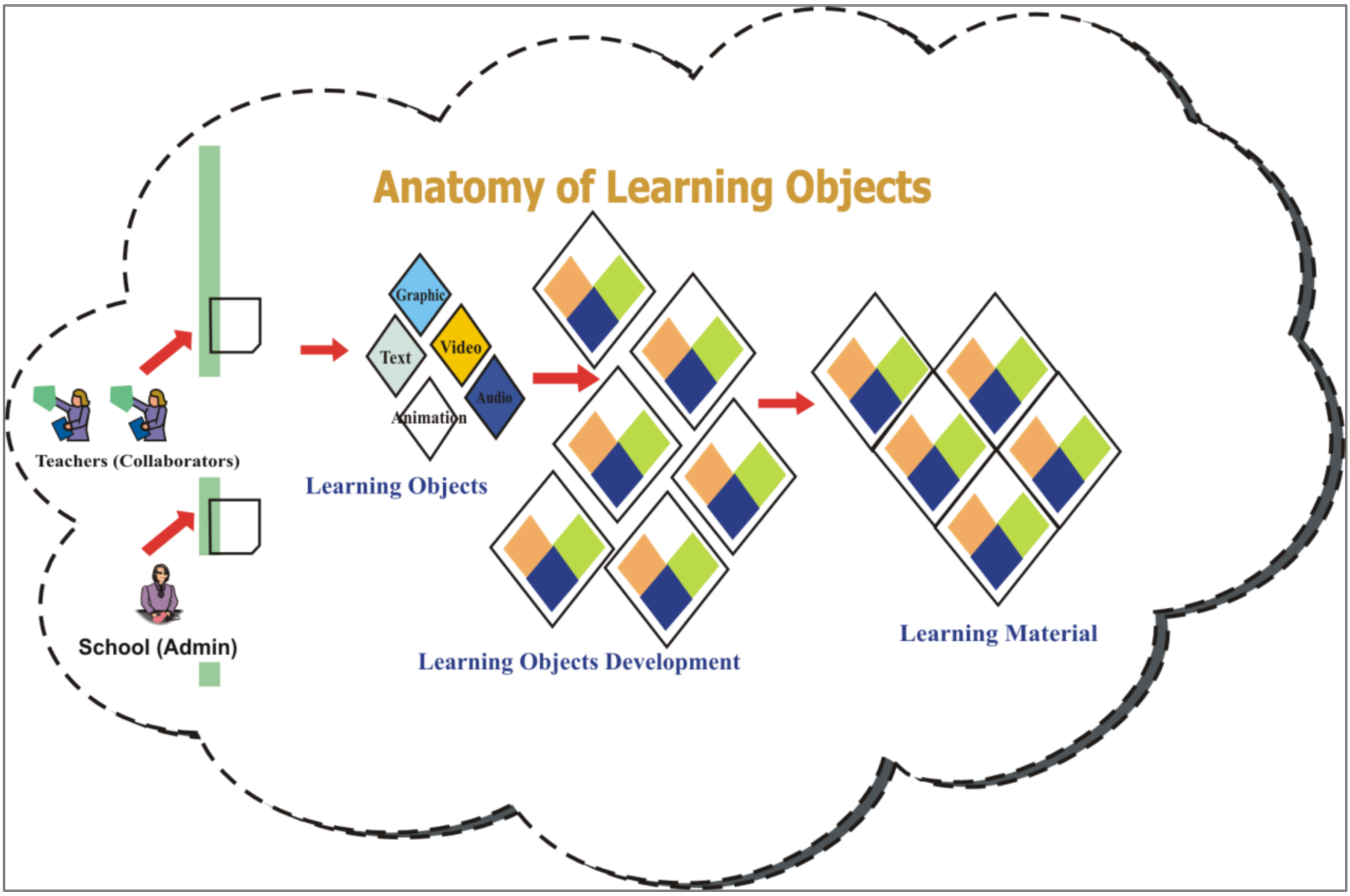

Figure 1: Architeture of Collaborative Learning Objects Based On Cloud Platform

4. Applying Trace Matrix and Low latency

The application of matrices is used in many scientific fields to determine physical representations of different processes. In particular, trace matrix is applicable in the representation of certain processes that can occur as a summation of diagonal square terms [23]. The modelling of the learning objects development requires a phenomenal technique by which all collaborative activities can be summed. Trace matrix allows such approach through summation of the collaborative activities in a diagonal fashion.

On the other hand, the cloud platform serves as the podium that sustained the workloads of the learning objects development in the model. It consists of certain components. These components are data host, servers, bandwidth and virtual machines. There are many cloud podiums in the market. However, some of the available cloud platforms lack the guarantee to provide effective services (low network latency) of these components in dealing with user activities (limited cloud applicability) [10]. Hence, Google cloud, known as Google App Engine (GAE) is selected to support the collaborative learning objects workload. GAE is a Platform as a Service (PaaS) that comprises of thousands of data centre hosts that are interconnected over a powerful and high-speed networked intranet. It is used to process millions of new and old deployed application requests with low delays and persistent high performance capabilities [21, 24].

5. Modeling of Learning Objects

The learning objects development process is modelled using trace matrix technique. The use of the trace matrix approach helps to model the task contributions of each of the collaborators in terms of their respective development activities. The development activities on the learning objects are addition, edition and deletion until a comprehensive learning material is finally completed. Therefore, the following assumptions are made:

- Collaboration occurs when two or more collaborators interact to develop the learning objects.
- There are three development activities that are conducted on the learning objects. These are addition, edition and deletion.
- The process of trace matrix usually determines real number values. However, only positive integer values are considered for the development process of the learning objects.
- The values of the trace matrix are represented diagonally via the summation of the related activities of the learning objects development process.
- The delivery platform has low latency for the smooth performance of the the seamless collaboration.

5.1. Formulating the Collaborative Development of the Learning Objects

Let L_O= Learning objects, L_D= learning Objects Development = {Add, Edit, Delete}= {A, E, D}, $I(L_D)$= Individual Leaning Object Development and $C(L_D)$ = Collaborative Leaning Objects Development.

Based on the properties of trace square matrix, a task entailing entry (T) with $T \in R^{n*n}$ can be computed as:

$$tr(T) = tr(T)_{11} + tr(T)_{12} + \ldots + (T)_{nn}$$
$$= \sum_{k=1}^{n} (\boldsymbol{T})_{kk}$$
$$= \sum_{k} (\boldsymbol{T})_{kk} \qquad (1)$$

Where T: square matrices $\rightarrow \forall R^{n*n}$ represented in a diagonal fashion.

Similarly,

Individual learning objects development (L_{Di}) process entailing addition, edition and deletion tasks with $L_{Di} \in Z^{+\,n*n}$ can be computed by:

$$I(L_{Di}) = (A)_{11} + (A)_{12} + \ldots + (A)_{nn} + (E)_{11} + (E)_{12} + \ldots + (E)_{nn} + (D)_{11} + (D)_{12} + \ldots + (D)_{nn}$$
$$= \sum_{k=1}^{n} (\boldsymbol{A}_{kk}) + \sum_{k=1}^{n} (\boldsymbol{E}_{kk}) + \sum_{k=1}^{n} (\boldsymbol{D}_{kk})$$
$$= \sum_{k} (\boldsymbol{A}_{kk}) + \sum_{k} (\boldsymbol{E}_{kk}) + \sum_{k} (\boldsymbol{D}_{kk})$$
$$= \sum_{k} (\boldsymbol{A} + \boldsymbol{E} + \boldsymbol{D})_{kk}$$
$$= \sum_{k} (\boldsymbol{M}_{Mk})_{kk} \qquad (2)$$

Where L_{Di}: square matrices $\rightarrow \forall Z^{+}$ of learning object development that is represented in a diagonal fashion.

Subsequently, a collaborative learning objects development can be derived when more than one collaborators work together to provide the learning material(s).

Thus,

Suppose that c_1 contribute $C(L_{D1})$ task development, c_2 contribute $C(L_{D2})$ task develepment….c_n contribute $C(L_{Dn})$ tasks and $C(L_{M1}) \leq C(L_{M2}) \leq \ldots \leq C(L_{Mn})$.

Hence,

$$C(L_{Di} + L_{Dj} + \ldots + L_{Dn}) = \sum_{k=1}^{n}(\boldsymbol{L_{Di}})_{kk} + \sum_{k=1}^{n}(\boldsymbol{L_{Dj}})_{kk} + \ldots + \sum_{k=1}^{n}(\boldsymbol{L_{Dn}})_{kk}$$

$$= \sum_k(\boldsymbol{L_{Di}})_{kk} + \sum_k(\boldsymbol{L_{Dj}})_{kk} + \cdots + \sum_k(\boldsymbol{L_{Dn}})_{kk}$$

$$= \sum_k(\boldsymbol{L_{Di}} + \boldsymbol{L_{Dj}} + \cdots + \boldsymbol{L_{Dn}})_{kk}$$

$$= \sum_k(\boldsymbol{L_{Dnk}})_{kk}$$

Where L_{Di}: square matrices → ∀ Z^+ of the seamless collaborative learning object development activities that is represented in a diagonal fashion.

Hence,

$$C(L_D) = \sum_k(\boldsymbol{L_{Dnk}})_{kk} \qquad (3)$$

5.2. Formulating the Delivery Platform of the Learning Objects

The cloud computing is the platform through which the collaborative learning objects development occurs. As such, it is required to deliver smooth performance for the delivery of the learning object activities via low network latency and persistent high performance capabilities of its various components (data centres, servers, virtual machines and bandwidth) given as *CL* in equation 4.

Hence,

$$\textit{Cloud Technology Performance } (T_P) = \frac{\textit{Learning Objects Workloads}(W)}{\textit{Cloud Network Latency }(CL)}$$

$$T_P = \frac{W}{CL} \qquad (4)$$

Where:

T_P= cloud technology performance to deliver the numerous task functions of the model

W= the collaborative learning object development activity workloads conducted in the model

CL= the low latency of the cloud's data storage, servers, virtual machines and bandwidth.

6. Result Analysis

A prototype for the collaborative development of the learning objects model is developed and run on Google App Engine cloud environment. The collaborators who are usually teachers must register with the application in order to access and develop the learning materials. They can login to access the platform and perform their collaborative tasks. Administrators are available to provide the topics for the seamless collaborative development and also grant accessibility to the registered collaborators. The analysis of the collaborative activities is deliberated using the concept of revision map by [25] and the diagonal representation of the processes proposed by [12]. Figure 2 shows the seamless collaborative learning objects development activities of a module in a History subject.

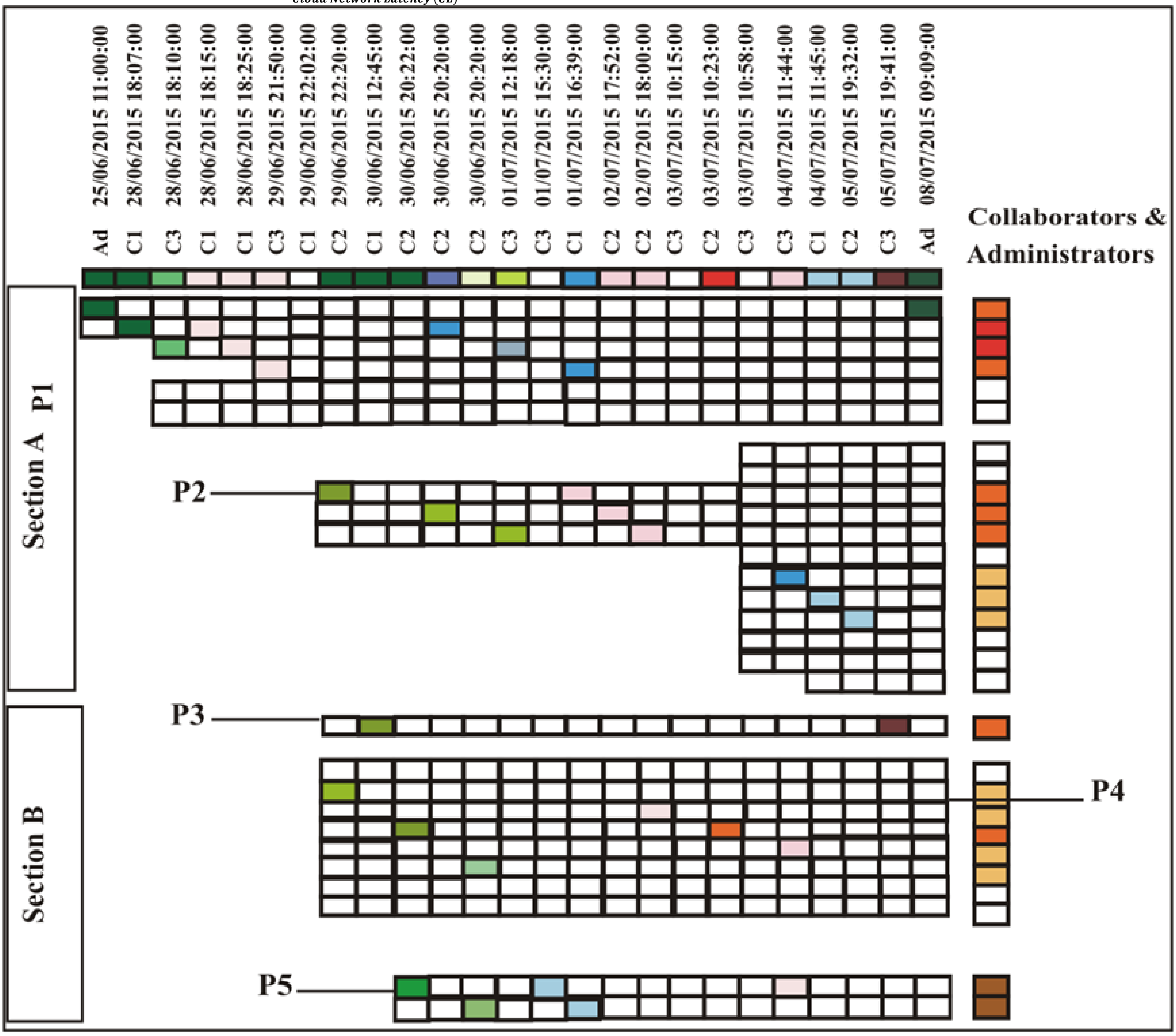

Figure 2: Collaborative Leaning Objects Development Map

Figure 2 shows the contributions of collaborators in developing a leaning objects module. The map can be used to determine the following aspects of the collaborative module management:

i. The number of the collaborators on the module

From Figure 4.1, it is shown that there are three collaborators that participated in the collaboration process (C1, C2 and C3).

ii. The collaborators with the most or least collaborative activities on the module

Here, the process is calculated by finding the weight of contributions for each collaborator and it is given by:

WC_i = (total contribution by C_i/total contributions by C_n)*100

= (C_i/C_n)*100

Where C_i is the contribution by one collaborator and C_n is the total number of contributions by all the contributors.

Hence,

WC1 = (8/24)*100 = 33%

WC2= (8/24)*100 = 33%

WC3 = (7/24)*100 = 29.2%

Thus, C1 and C2 have the most contributions, whereas C3 has the least contributions.

iii. The section of the content that contains the most or least management activities

The section with the most activities can be determined by summing the individual contributions in each section of the content. Section 'A' accumulated seventeen (17) overall number of contributions, whereas Section 'B' has fourteen (14).

iv. The major, medium and least management activity occurrence in the paragraphs

The dark colour rectangles show where the major activities occurred in relation to addition, edition or deletion. P1 has two major activities, P2 has one major activity, P3 has two major activities, P4 has major activity and P5 has none.

The light colour rectangles indicate where medium activities occurred. P1 has two medium activities, P2 has three medium activities, P3 has no medium activity, P4 has two medium activities and P5 has one medium task activity.

On the other hand, the lighter colour rectangles show the minimum tasks activities. Here, P1 has five minimum tasks, P2 has six minimum tasks, P3 has no any minimum tasks, P4 has three minimum activities and P5 has five minimum activities.

v. The time and dates for all the major, medium and minor activities

The date and times for all major, medium and minor task activities are provided in Table 1.

i. Parallel or sequential collaborative management on the module

The date and time indicate the activities that are parallel. C1 and C3 with 28/06/2015 18:07:00 and 28/06/2015 18:10:00 respectively are parallel to each other (occurring on the same time and date), whereas C1 and C2 with 28/06/2015 18:15:00 and 29/06/2015 22:20:00 respectively are sequential to each other (occurring at different time and date).

ii. The paragraph(s) that are completely eradicated

Paragraph (P3) was added on 30/06/2015 12:45:00 by C1 and was entirely deleted from the module on 05/07/2015 19:41:00. This makes P4 to move up to its place, and subsequently P5 becomes paragraph (P4).

Table 1: Date and Time for Tasks Activities

S/N		Date & Time	Activity
1	Ad	25/06/2015 11:00:00	Release of course for collaboration
2	C1	28/06/2015 18:07:00	Major
3	C3	28/06/2015 18:10:00	Medium
4	C1	28/06/2015 18:15:00	Minimum
5	C1	28/06/2015 18:25:00	Minimum
6	C3	29/06/2015 21:50:00	Minimum
7	C1	29/06/2015 22:02:00	None
8	C2	29/06/2015 22:20:00	Major, medium
9	C1	30/06/2015 12:45:00	Major
10	C2	30/06/2015 20:22:00	Major, medium
11	C2	30/06/2015 20:20:00	Major, medium
12	C1	30/06/2015 22:00:00	Minimum, medium
13	C3	01/07/2015 12:18:00	Minimum, minimum
14	C3	01/07/2015 15:30:00	Minimum
15	C1	01/07/2015 16:39:00	Medium, minimum, minimum
16	C2	02/07/2015 17:52:00	Minimum
17	C2	02/07/2015 18:00:00	Minimum, minimum
18	C3	03/07/2015 10:15:00	None
19	C2	03/07/2015 10:23:00	Medium
20	C3	03/07/2015 10:58:00	None
21	C3	04/07/2015 11:44:00	Medium, minimum, minimum
22	C1	04/07/2015 11:45:00	Minimum
23	C2	05/07/2015 19:32:00	Minimum, minimum
24	C3	05/07/2015 19:41:00	Major
25	Ad	08/07/2015 09:09:00	Provide course for usage

7. Conclusions

Cloud technology is the new ICT trend in providing various educational activities and services. This is because it supports educational organizations with low spending, seamless collaboration, efficient facilities, computing availability, service reliability and high secure environments. Currently, seamless collaboration is being explored in the development of learning objects via an efficient technological platform called cloud technology. Cloud computing environment with its nature for providing multidisciplinary and seamless collaboration is employed as possible solution in this study. Specifically, the collaboration allows the provision of appropriate learning objects and amplification of skills for the participants. The results of the analysis show that successful collaborative tasks can be conveniently performed by collaborators via cloud platform from anywhere and at any time to develop learning materials. It also allows the schools (administrators) to determine the collaborative tasks contributed by the developers of the learning materials.

Acknowledgment

The authors would like to extend their appreciation to the Universiti Sultan Zainal Abidin (UniSZA) and Kano State Government for guidance and support throughout the process of this work.

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