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Cloud Storage Integration as a Learning Object Repository for Massive Open Online Course

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Abstract

One of the important things on Massive Open Online Course (MOOC) is the availability of the learning content. The availability of the contents are related directly with the capacity and the capability of the storage. Cloud storage has promising capability to create the availability set for MOOC without sacrificing a lot investment for hardware and software. However, numerous cloud storage provider doesn't have a reference model to use the product for MOOC. This paper will discuss the idea to integrate cloud storage as a learning object repository for MOOC. The paper will revisit the learning object concept to design the interface between cloud storage and MOOC. As a result, the paper proposes the integration model between cloud storage and MOOC. The proposed integration is delivered as Application Programming Interface (API) and learning object metadata extraction technique.

Key Words: learning object, MOOC, cloud storage, application programming interface.

1. Introduction

The most used format on MOOC content is multimedia based format. Current MOOC providers such as Khan Academy, Coursera, or Udacity use video to deliver the learning materials. MOOC can be viewed as multimedia text-book for internet-based distance education [1]. The use of multimedia content encourages organizations to invest in infrastructure with sufficient computing and storage. Large-sized video, a lot of users, online access anytime embolden a MOOC must have steadfast infrastructure. However, not all educational organizations who want to implement MOOC has sufficient on premise infrastructure.

The cloud computing arrives to support the flexible infrastructures. The deployment of cloud computing in education will not only relieve the educational institutions from the burden of handling the complex IT infrastructure management activities, but also lead to huge cost savings [2]. One of the reason is a cloud computing is likely to be one of those opportunities sought by the cash-strapped educational establishments in these difficult times and could prove to be of immense benefit (and empowering in some situations) to them due to its flexibility and pay-as-you-go cost structure [3]. Pay-as-you-go provides the opportunity for educational institutions wishing to implement MOOC with very little investment in the beginning.

Organizations can purchase a set of resources for MOOC purposes within a certain period and can terminate it instantly without any up-front losses.

Though, cloud computing has a flexible infrastructure solutions. Most organizations already have an on premise solution that existed before the era of the cloud is present. In other words, organizations should perform the migration or create a new solution for the needs of MOOC. One important question when considering a move to the cloud is whether it makes sense for existing application to migrate to the cloud [4]. Migrating a system to the cloud requires sufficient time, careful planning, and extraordinary risk. Most organizations do not want to migrate because it will interfere with their service and don't have the time to do it. Separating MOOC with institutional e-learning system is the way that many of the selected organizations. The challenge for the organization is the necessity to modify the e-learning system so as to facilitate a large number of users, better storage, and supports the concept of openness that is owned by MOOC.

One of the opportunities to prepare MOOC system is by using the SaaS (Software as a Services) model. SaaS model such as Office 365, Google Apps, or Drop Box provides an opportunity for the organization to be able to extend their existing system by consuming API (Application programming Interfaces) to communicate with the cloud computing resources. This paper focuses on one aspect of integration between cloud computing with the existing MOOC system which the flexible of content storage. This paper proposes an integration model that enables organizations to use cloud-based storage system to the existing MOOC. As a novelty contribution on this paper, the proposed API will adopt learning object metadata as a middleware between cloud storage and existing MOOC. The proposed model is expected to help an organization that is looking for the integration model between cloud-based storage systems and the current MOOC or LMS system.

2. Previous Researches

Cloud storage has been a while as a solution of flexible storage. Using a flexibility of the cloud, cloud storage provides useful, less price, and scalable storage. The usage of the cloud storage has been widely adopt for the backup purposes, file synchronization, and the transactional files exchange. The freemium cloud storage provider such as OneDrive, Dropbox, Google Drive, or Amazon can be used start without investment or pay to nearly $0 per GB. Several researches use the cloud storage to provide flexible infrastructure for e-learning. Table I shows the related researches that use cloud as infrastructure for E-learning. As shown on the Table I, the benefit of cloud storage on e-learning is proven. On the e-learning environment, cloud storage is used for archives purpose, improving files performance, distributed storage, or

as efficient framework.

Table 1. Previous researches on cloud storage for education

Author (Year)	Research title	Contribution
E. Aljenaa, F. S. Al-Anzi, and M. Alshayeji. 2011. [5]	Towards an efficient e-learning system based on cloud computing	Proposing framework namely E-learning as a services that believe in the cloud computing as the next generation of efficient learning
Chen Lixian and Xiao Tong. 2012 [6]	Research on Achieving Cloud Storage Based on Moose FS	The research provides a cloud model for archiving strategy. It is shown that the use of cloud storage have been improved in term of efficiency and performance.
Wilfred W. Li, Richard L. Moore, Matthew Kullberg, Brian Battistuz, Steve Meier, Ronald Joyce, Richard P. Wagner, Tad Reynales, and Qian Liu [7]	Developing Sustainable Data Services in Cyber infrastructure for Higher Education: Requirements and Lessons Learned	The free data storage may offer better network performance for data transfer and synchronization. The research also expect the research data services to be accessible, affordable, reliable, and sustainable.
R. Gopinath and B.G. Geetha [8]	An E-learning System Based on Secure Data Storage Services in Cloud Computing	Focused on distributed data storage security for e-learning system by using effectively auditing mechanism hitches the challenges and distributes erasure-coded data for e-learning web application.

The study was interested in applying cloud storage on MOOC for several reasons:

- Limiting the up-front investment. Using Cloud storage, especially the free one can help the MOOC provider to save the investment for infrastructure and to focus the investment for the quality content.
- Helping scalability of the learning content. MOOC provides a wide variety of courses with a lot of content. A lot of multimedia content causes the hard disk space requirements are becoming increasingly large. Cloud storage has characteristics that support the provision of scalability storage space.
- Accessibility and reliability for the learning content. Many MOOC has a lot of valuable material and content. The content should be accessible and secure from disaster. Cloud storage provides geo redundant that perfect for accessibility and reliability purpose.

However, along the promising integration between cloud storage and MOOC, there are several questions based on the previous researches which are:

- How utilize the free investment cloud storage for existing MOOC in order to provide cost efficient for current MOOC solution?
- How cloud storage easily integrated with the existing MOOC without massive changes on MOOC solution?

Those research questions will be answered and evaluated on this paper through research method that proposed on the next Section.

3. Research Method

Building an acceptable solution should come from a well-known standard. Therefore, the research proposes the solution through several steps which are:

- Evaluating the learning resources standard and storage technology. This step is to assure that the proposed solution comply with the standard.
- Understanding how the cloud storage provider can be integrate with the e-learning or MOOC specifically.
- Proposing integration model between learning resources standard, integration option, and usage scenario on the MOOC.
- Evaluating proposed integration model through MOOC case study. The evaluation is to make sure that the model can be implemented concretely on MOOC.

Based on the proposed research method the integration model will be built and proposed as novelty contribution of this paper.

3.1 Understanding Learning Object Metadata

Learning Object Metadata (LOM) is a metadata standard to describe educational resources which can be re-used or referenced during technology supported learning [9]. Currently, there are three standards that represent the learning object model namely IEEE learning object model (IEEE LOM), IMS Package, and RDF (Resource Description Framework). The IEEE LOM and IMS Content Packaging are currently two major components of the Shareable Content Object Reference Model (SCORM) [10].

The common format of LOM is formed as the Extensible Markup Language [11]. The XML validation for this LOM is represented on the XML namespace namely http://lts c.ieee.org/xsd/LOM. Therefore, any LOM based application profiles should be considered to comply with the namespace for the validation purposes. The sample of LOM based on the standard IEEE Standard 1484.12.3-2005 is shown on the Figure 1.

```
<?xml version="1.0" encoding="UTF-8" ?>
<lom xmlns="http://ltsc.ieee.org/xsd/LOMv1p0"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://ltsc.ieee.org/xsd/LOMv1p0
                         http://www.rdn.ac.uk/oai/lom/lom.xsd">

  <general>
    <title>
      <string>developerWorks : XML</string>
    </title>
    <description>
      <string>
        The XML zone on the developerWorks Web site is designed for
        developers. You'll find tools, samples, standards information,
        education, news and events, and links to XML community forums
```

Figure 1 XML implementation on LOM [12]

The XML implementation of LOM can be reused for any application that understand the XML processing. Furthermore, the LOM idea should be able to model the metadata for simple e-learning design i.e. Quick Instructional Design [13]. Figure 2 shows the XML syntax

that are used to represent the simple e-learning design.

```
<?xml version="1.0" encoding="utf-8"?>
<Curricula id="ICT">
  <Course id="TIF312" name="Object Oriented Programming">
    <Lesson id="1" name="Introduction OO">
      <Topic id="1" name="OO Pillar">
        <LearningObject id="1" type="Document" name="Student Guide" url="http://contoso.com/material/oostudentguide">
        </LearningObject>
      </Topic>
    </Lesson>
    <Lesson id="2" name="OO Analysis and Design">
    </Lesson>
  </Course>
</Curricula>
```

Figure 2 E-learning design on XML

Based on the Figure 2, the XML file will have a curricula tag as a root for the XML file. Inside the curricula tag, the user can fill one or more courses. Each course has more than one lesson. Each lession will have one or more Topic. Each topic will have one or moder learning object. Based on that, the designed XML will not only self described but also provide meaningfull information about the relation between course on a curriculum.

3.2 Cloud Storage Integration Model

Cloud storage provides several options to integrate with the external system. There are two ways to integrate it. The first integration model uses embedded technique that use HTML standard. This option is a common way for consumer to put the files on the external site or web site by simply add embed script on a blog or a social media. The second integration model uses the API (Application Programming Interface). This option is a common way for developer to create a custom solution that use the capability of cloud storage. On this option, developer should write the codes to call the API and package it with the custom solution.

Depending on the system that used MOOC, both approaches is possible to implement. For example on the LMS that supports HTML embed techniques,the cloud storage can be directly applied without the involvement of the developer. However, users need to understand a bit about the syntax of HTML. Figure 3 shows the example of embedding the learning content on a Schoology LMS by using OneDrive storage. On OneDrive, the user can embed the contents as a folder, a downloadable file, or Microsoft Office editor.

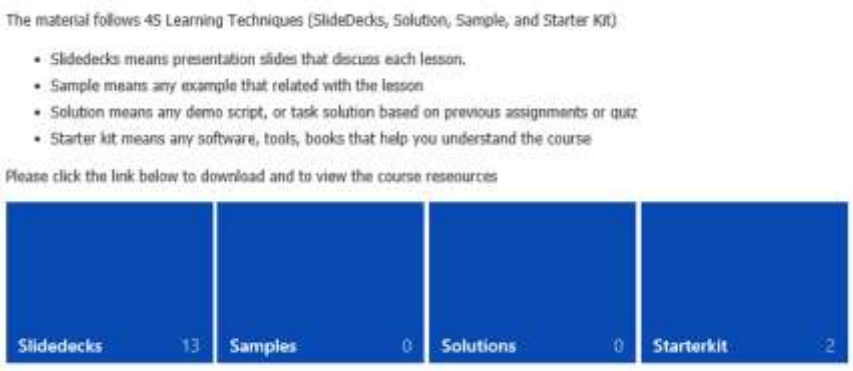

Figure 3 Simple integration model using Embed Technique on OneDrive

The second integration model uses API. On this approach, the developer should register the application to developer site and get the key API. Without the API key, the developer can't call the cloud storage API. The cloud storage API uses the JSON or XML format. Therefore, the developer should build a middleware or custom code that call the API and represent it on the LMS. It means that the developer should modify the code on the existing LMS to make the API call can be executed. The cloud API can be used to manage the directory, manage the files (upload and download), and sharing the files with the users. Table 2 shows the comparison between API technique and embedded technique.

Table 2 Comparison between API technique and embedded technique

Attribute	Embedded technique	API technique
Integration audience	User	Developer
Integration format	HTML	JSON or XML
Requirement of integration for LMS	Support HTML embed object syntax as an input	Support custom code to process JSON / XML
Integration scenario	Limited (Read only)	Full capability (Read, Write, Automate)
Integration complexity	Simple no need changes necessary for the existing system	Need to change the existing code to execute custom code

The proposed integration model of this research is to deliver following scenario:

- The user can reuse the learning resources for repetitive course without reupload or restructure the course content.
- The user can migrate the learning resources from one system to another. As long as the system comply with the proposed integration model.
- The system can utilize the cloud storage API to perform basic course structure manipulation such as create course, create topic, upload-download learning object, and set the permission of learning object

In order to find the integration between cloud storage and learning object metadata. The research make an effort to find the similarity between them. Cloud storage uses file manager model to restructure the files. It means that any files will be stored on a folder model. The folder itself can be represented as a logical relation between files. the hirarchical / tree based structure is a common model on several LMS like Moodle. Both model can be integrated since on file manager model, the user can construct the tree layout. Figure 4 and Figure 5 shows side-by-side comparison between the file manager on OneDrive with tree structure on XML e-learning design.

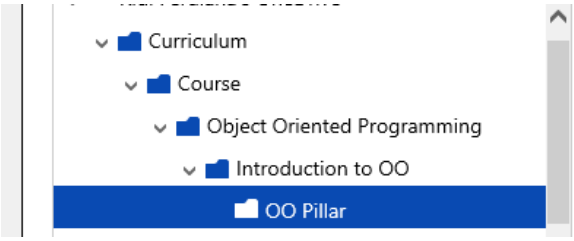

Figure 4 Folder structure on OneDrive

On Figure 4, it is shown that folder structure and learning object metadata structure can be applied as a round trip. It means that the folder structure can be converted into the learning object metadata and vice versa. There are two challenges on this research. The first challenge is how to create the procedures to facilitate the conversion scenario between folder structure and learning object metadata. The second one is how to integrate the conversion model into the usage scenario. The conversion scenario can be supported by creating an API that help the round trip conversion. However, the usage scenario should be fulfilled by understanding the common scenario on the user perspective.

```
<?xml version="1.0" encoding="utf-8"?>
<Curricula id="ICT">
  <Course id="TIF312" name="Object Oriented Programming">
    <Lesson id="1" name="Introduction OO">
      <Topic id="1" name="OO Pillar">
        <LearningObject id="1" type="Document" name="Student Guide" url="http://contoso.com/material/oostudentguide">
        </LearningObject>
      </Topic>
    </Lesson>
    <Lesson id="2" name="OO Analysis and Design">
    </Lesson>
  </Course>
</Curricula>
```

Figure 5 Learning Object Metadata Structure based on folder structure

The common scenario that use storage mechanism is storing the course materials. The course material is uploaded to the cloud storage and then integrated with the existing LMS system. Figure 6 shows the detail of ilustration that represent the common scenario of the cloud storage integration.

As shown on Figure 6, the benefit that can be embraced by following the usage scenario are:

- The user can reuse the existing learning object and course structure for many classes or course. This benefit eliminates re-upload same learning object on different courses.
- The user can update the existing course material on cloud storage and it is reflected directly to the connected course on the LMS / MOOC. This benefits eliminates manual editing on any courses that related with the cloud storage folder.
- The user can get the larger storage than the on-premise storage. For example, OneDrive for Business be able to upload 1 GB / file with unlimited storage for each active user versus with the on-premise limitation between 10 MB – 200 MB.

On the technical point of view, the integration model covers some basic services to facilitate the common usage scenario such as:

- Authenticating service to authenticate and de-authenticate the user within cloud storage services
- Learning object metadata service to import and synhronize the learning object metadata between cloud storage and LMS. The LOM service provides some novelty features such as generating XML metadata based on existing structure, generating feed that can be embedded as RSS standard or JSON format to dislaye the learning material on LMS, and converting between folder structure on cloud storage with the LMS learning object structure.
- File management service to handle basic file management such as upload, download, rename, and delete file.

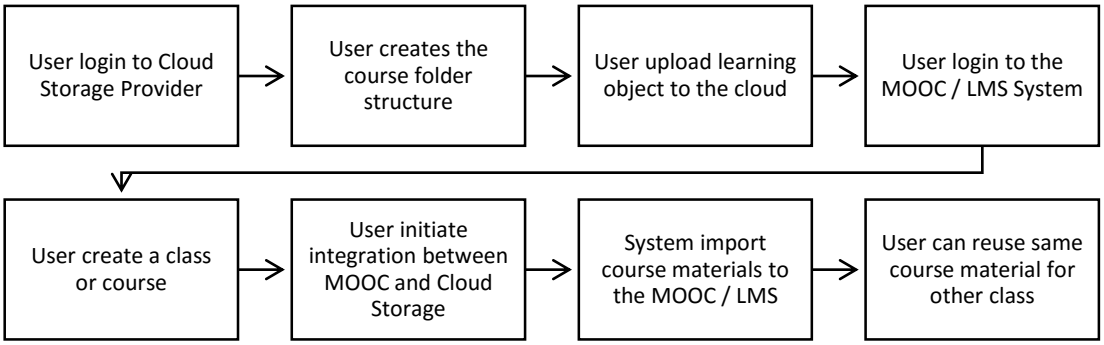

Figure 6 Usage scenario for cloud storage integration

The model will be evaluated through a case study analysis. The case study will implement the proposed integration model into existing LMS. The case study is discussed at the Model Evaluation Section.

3.3 Model Evaluation

The model is evaluated by doing integration project with the existing LMS or MOOC. In order to provide the sufficient result, the evaluation is done through two case studies. The case studies is chosen by several attributes. The attributes are shown on the Table 3. The two case studies should be different on attributes in order to understand the integration effect on two different scenario. The idea of the evaluation is how to implement the model into the existing system and to do analysis the scenario to implement the model. This research neglect the evaluation model on the new system because the new system is an ideal condition to implement the proposed integration model.

The time frame of evaluation is three months. The three months are based on the feedback from the developers on planning session. The evaluation has three main phases namely planning phase (2 weeks), integration phase (6 weeks), and evaluation phase (2 weeks). The evaluation model will answer the research evaluation questions as shown on Table 4. The

research evaluation questions are answered through interviews with the four developers (two developers on each case study). The four developers have similar experience (two years) so that it has same technical capability to do the integration. The result of the evaluation is shown on Table 4.

Table 3 Case study technical specification

Specification Attribute	**Case Study A**	**Case Study B**
System purpose	LMS	MOOC
System development	Custom	Open Source Modification
Web Technology	PHP	ASP.NET
Backend Database	MySQL	SQL Server
Learning Standard Adoption	Learning Object Metadata	Learning Object Metadata
Hosting Model	Cloud Hosting (Azure)	Cloud Hosting (Azure)
Estimated Registered User	6000	20.000
Market Segment	Higher Education	High School
Authentication Model	Custom	Microsoft Account / Live ID

Based on the evaluation interview, it is shown implicitly that both case study has similar difficulty. Although there are some different numbers of change sets and integration man-days, both case study has ability to implement the integration model into the production. There are no significant issues to follow the proposed model since the integration phase that scheduled for 30 days is finished on 17 days and 14 days. Both of them has similar features on the proposed integration model.

Table 4 Evaluation result

Evaluation question	**Case Study A**	**Case Study B**
Possibility to integrate	Yes	Yes
Change sets / Revision	12	9
Integration man-days (max 30 days)	17	14
Implementation scenario	Metadata Generator, Upload and download learning object, learning object player, cloud import	Metadata Generator, Upload and download learning object, learning object player, cloud import

4. Conclusion

Based on the previous section on this paper, the research proposes several conclusions which are.

1. The free cloud storage can be used as an expansion storage for e-learning such a LMS or MOOC by utilizing their API. However, consideration like speed and space should be compared based on the usage of LMS and MOOS.
2. The cloud integration can be done by mapping between folder structures with the course outline on the e-learning. This research contributes an API to map between folder structure and course outline.
3. The idea proposed on this model is to create a middleware that do roundtrip conversion

between folder structure and e-learning course outline. The conversion is facilitated with Learning object concept, XML, and JSON standard.

4. The benefits of the integration are easier to update the course, one storage can be reusable within many courses, and has competitive price on storage unit.
5. The challenges of the integration are the need of time commitment to adopt the API, the additional steps that need to integrate the cloud with the existing e-learning, and the need of codes modification on the host.

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