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PAPER

# Development of MOOC Service Framework for Life Long Learning: A Case Study of Thai MOOC

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**SUMMARY** Massive open online course (MOOC) is an online course aimed at unlimited participation and open access via the web. Although there are many MOOC providers, they typically focus on the online course providing and typically do not link with traditional education and business sector requirements. This paper presents a MOOC service framework that focuses on adopting MOOC to provide additional services to support students in traditional education and to provide credit bank consisting of student academic credentials for business sector demand. Particularly, it extends typical MOOC to support academic/ credential record and transcript issuance. The MOOC service framework consists of five layers: authentication, resources, learning, assessment and credential layers. We discuss the adoption of the framework in Thai MOOC, the national MOOC system for Thai universities. Several main issues related to the framework adoption are discussed, including the service strategy and model as well as infrastructure design for large-scale MOOC service.

***key words:*** *massive open online courses, MOOC service framework, credit bank, test bank, e-testing*

## 1. Introduction

Lifelong education using digital material is a global trend in the digital era due to the benefits of time, location, and cost. Massive Open Online Course (MOOC) is now an influential infrastructure for e-Learning in a global scale. MOOC platform is the virtual environment for online learning to support a huge number of learners with no limit on attendance. One of MOOC goals is to establish a standardization learning environment that be equivalent to a traditional classroom [1]–[4].

In Thailand, the national policy to drive lifelong learning was considered to elevate the education of the population. The Thai MOOC project was proposed to perform lifelong learning activity based on the country's culture and environment [5]–[10]. Nevertheless, there are some issues that must be achieved in order for online learning system to reach the national level demand, specifically, 1) the confidentiality protection by applying authentication and verification of learners to guarantee integrity of learner's credential data. 2) the durability of education profiles, credential archives, online learning and assessment materials, i.e., educational programs, certificates, and transcripts, which must be permanently archived. 3) the trustworthiness of an online learning system viewed by the business and job industry, which must be achieved by adopting the standard and reliable procedures and systems.

There are some key components that Thai MOOC platform must provide in order to respond to national demand. The fundamental facilities, the providing services, and the organizational structures are necessary for developing infrastructure and framework. Physical assets are also demanded to deliver sustainable services and data. The main operations are; a) a learning service is the core function to boost up learner's skills. b) a testing service with a reliable assessment tool to prove quality assurance. c) a credential service also collects the learner portfolio to engage in the business section. Besides, the supporting mechanisms are involved to produce the system integrity. Security, privacy issues are major concerns to make a robust system with trust information.

This manuscript introduces the extension framework of the Thai MOOC platform to provide lifelong education with sustainable resources. The framework conceptualizes on usable functions, procedures, and user interface system. This framework focuses on authentication, security, privacy issues to make a robust system with trust information. In addition, the assessment and academic credential issuance mechanism is provided to support traditional education and job application requirements. The social tools are also combined to encourage learning community.

## 2. Review of MOOC Platforms

Several MOOC platforms have contributed and delivered a modern technology for online learning including: edX, Coursera, Khan academy, Udemy, etc. Many research reviews the advantages and disadvantages in several topics such as MOOC research trends, remedial education, instructor roles, data mining, and quality [11]–[14]. Table 1 shows examples of some major MOOC Platforms and their comparision which is investigated by Tsironis et al.[14]. Many research studies suggest that MOOC is mostly appropriate for higher education students, and also after gradua-

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**Table 1** A comparison of MOOC platforms features.

| Topic | edX | Coursera | Khan Acedemy | Udemy | Future Learn | Udacity |
|---|---|---|---|---|---|---|
| Open access | * | * | * | * | * | * |
| Open source | * | | * | | | |
| Video content | * | * | * | * | * | * |
| Discussion board | * | * | * | * | * | * |
| Wiki | * | * | | | | * |
| Social network | * | * | * | | | * |
| Quiz | * | * | * | * | * | * |
| Cerirfication | * | * | * | * | * | * |

tion. Because it needs learners who have high responsibility to manage their participation according to learning goals [2], [3], [15]–[17].

The audiences, pedagogy, and services are some key design criteria to define the learning procedure of a MOOC platform. Each MOOC platform also has different characteristics depend on a goal and a business model. From the user viewpoint, many criteria influencing design of a MOOC platform include satisfaction, interaction, motivation, challenges, communication, and effectiveness.

## 3. The Proposed MOOC Service Framework

The goal of the project is to develop a MOOC service that supports sustainable educational credentials similar to the traditional classroom. The important objective is to deliver a reliable learners' credential data, e.g., academic certificates, for fulfilling the demand of the business sector. Verification and archival of learners' credential data are among keys to make a trustable platform. A scalable service architecture is proposed and implemented to deliver sustainable and reliable services and data. The proposed solution was designed in accordance with the country's educational policies. The details are explained in the following;

### 3.1 Thai MOOC Strategy and Model

Most MOOC platforms mainly focus on self-learning for getting a course certificate. Thus, it usually involves only the learners and educational organizations. However, this is insufficient from the business sector viewpoint, to rely solely on the certificates. Therefore, our framework aims to meet requirements from the learners, educational organizations, and also the business sector. Some important issues are considered to provide a large scale of e-learning system, aka MOOC, to support lifelong education policy of the country. To accomplish the requirements, we define a business model and workflow to obtain an education credential as shown in Fig. 1. There are three stakeholder parts including a) learner/teacher, b) university/institute, and c) organization/company. The stakeholders must collaborate effectively to realize the model. The model describes the rationale of how to create, verify, and deliver a reliable academic certificates corresponding to participant's behaviors in varying roles. Learners gain their knowledge and skills by taking online courses. Education providers increase the number of online students that lead to higher income. They also reduce

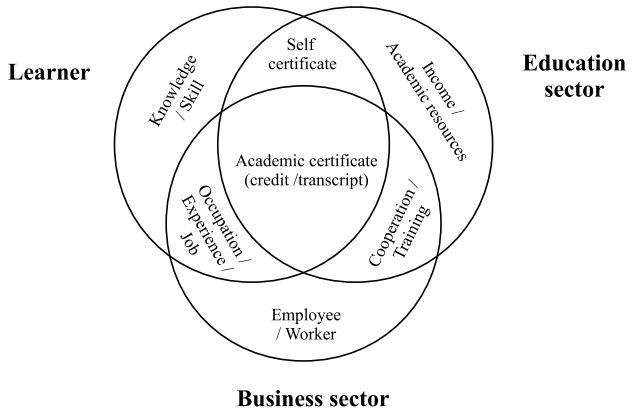



**Fig. 1** Relationship of environment and participants on the business model.

the cost of physical resources. The business sector can directly request education programs and academic credentials of students to the university/institute for collecting information about a graduate applying for jobs.

The academic credential or educational qualification such as program certificate, recorded transcript, and course credits are among the main focuses. Therefore, we define the certificate into two levels, which are self-record and credential record. Figure 2 shows an influential level of a certificate in the conceptual model. A self-record is a basic certification level of the e-Learning platform. Learners who register in online courses and pass enrolled courses, can acquire course certificates. This course certificate is typically not sufficient to apply for a job from a business viewpoint. According to business demand, a credential-record level is compiled for such a purpose. A curriculum or syllabus program is set to gain a reliable certificate. A curriculum consists of a set of courses that associate with the curriculum objective. Learners who need a curriculum certificate or transcript must complete the course certificates via LMS, then make examinations via the e-Testing system. When a learner accomplishes any required course, they will get the curriculum certificate/transcript/course credit as a credential record. The academic credential level is utilized to certify qualification by performing the standard testing process on every related course. The method made reliance on the certificate from the proposed system to enable learner's opportunity to get the right job with the right ability.

Moreover, the validity of user information is the major concern to determine the authenticity of users who are using

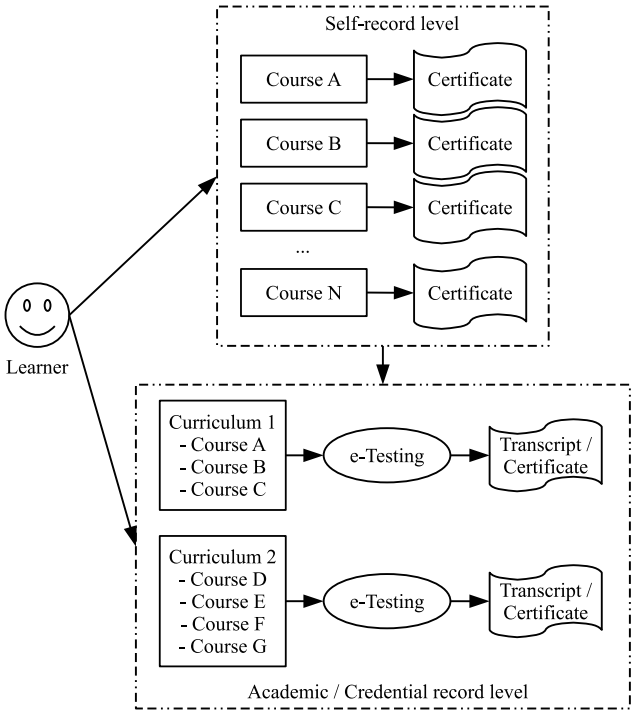



**Fig. 2** Concept design of certificate level.

the system. Authentication and authorization processes are required to access protected resources. Personal data on the national identity card is needed to verify user credentials. Besides, we focus on simplicity, flexibility, efficiency, and ease-of-use factors to reduce the learning curve of users who are not computer literate.

### 3.2 Service Framework Design

In the service framework design, we emphasize many key issues such as privacy issue, trusty certificate, academic guarantee, etc. We use several previous researches as a baseline framework to achieve the requirements and business goals [7], [9]. The proposed design principle is based on the service modularity concept, which makes it easier to maintain and obtain a scalable system. The overall conceptual framework is presented in a layered architecture that characterizes the functions of task interactions as presented in Fig. 3.

The framework can be separated into five layers which are;

1) *Authentication layer* is the common function for providing user's security credentials. We apply the Central Authentication System (CAS) as a single sign-on protocol to permit users access to the system. This process aims to provide trust and verify users who are using the system in all critical functions.

2) *Resources layer* is a repository of educational objects as a digital library to archive education materials such as video clips, images, and other digital assets. We developed the Open Educational Resources (OER) to achieve such a purpose. Any material in OER can be used for developing courses and assessment materials. Moreover, Video Streaming System is also provided to serve on-demand video streaming over the Internet with the good-quality streams to each user's device.

3) *Learning layer* is a facility tool for learning activities. Learning Management System (LMS) and Content Management System (CMS) are both main functions in the layer. This layer supports learners in self-learning procedure until receiving course certificates. This layer not only includes the learning tool, but also the analytics tool which targets at analyzing information about learners, courses, and the system. We use the analytics tool as a feedback mechanism to improve courses and the performance of the system.

4) *Assessment layer* consists of a group of an ecosystem to manage a standardized test for learners who require a grading certificate. An e-Testing system provides testing activities to participants. The testing archive is a repository of testing examinations with various types of tests. Another requirement is a course series that consists of a set of proper courses relating to the certificate. The test set can be assigned to each course in the series. A learner must pass all tests to acquire credits and certificates.

5) *Credential layer* holds education accreditation, and also prescribes skill of education requirements. This layer is used as a front-end to access all test records and information including transcripts, certificates, and portfolios in order to certify learner's abilities in the published profiles. A participant can share his or her information with others depend on the privacy setting.

### 3.3 Academic Credential Approach

Regarding the educational qualification issue, we define an academic certificate level for the learner. The *Assessment layer* and *Credential layer* in Fig. 3 are provided on top of the base MOOC framework. Generally, the baseline MOOC platform provides online courses and grant a course certificate to the learner who passes the enrolled course. The OER system is defined as a central library that contains shared resources for utilizing as learning materials and quizzes such as pictures, videos, etc [7]. However, we allow the OER to be used by the assessment layer as testing resources for the e-Testing system depend on the instructor or teacher who manages testing materials. Similar to the OER, testing resources are shared materials that purposed for the assessment layer. Nevertheless, this module only permits within the assessment layer, while OER takes permission as generally shared resources.

Several modules were developed and utilized to accomplish the learning qualification processes. Details of each module are explained as follows;

*Test Bank* stores testing resources that are used in the e-Testing system. The testing archive is a repository of testing examinations with various types of tests, i.e., interactive multiple-choice, short-answer, gap-fill exercises, etc.. The Test bank is used in managing particular exams that in-

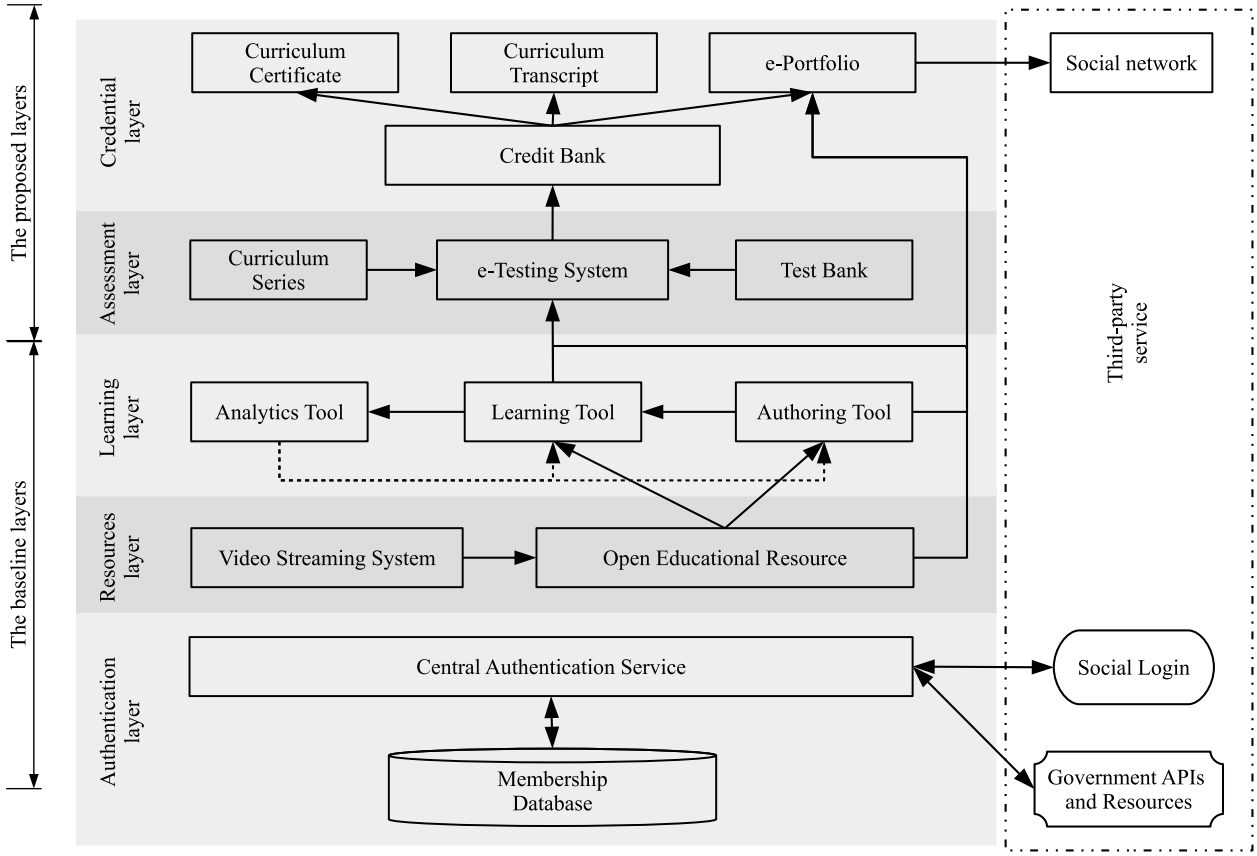



**Fig. 3** Overall architecture system design.

**Table 2** Privacy of test in the Test Bank.

| Mode | Description |
|---|---|
| Private | The test set only accesses and uses by an owner. |
| Public | The test set can be used by any participant who responded to the Test Bank module. |
| Share | The test set can be shared to the MOOC authoring tool. |

tended to measure knowledge, skills, or aptitude in many topics. The privacy mode of the test set is described in Table 2. Furthermore, the test bank allows import of assessments from the Hot potatoes application. This solution allows the participant to use the offline method for creating tests and evaluations.

*e-Testing system* forms a virtual testing environment involving the delivery of examinations and assessments using web-based systems. The system can enable large numbers of concurrent students who are conducting the tests at the same time. The advantage of the e-Testing system is that it can automatically process the test answers and do the grading after the testing is finished immediately.

*Credit Bank* is extremely important since it maintains the learner credentials. The result of testing including grades, scores, transcripts, and certificates, are preserved in the credit bank module. The privacy of data in the credit bank is highly protected. By default, only owner can access its information. Figure 6 shows an example of credential

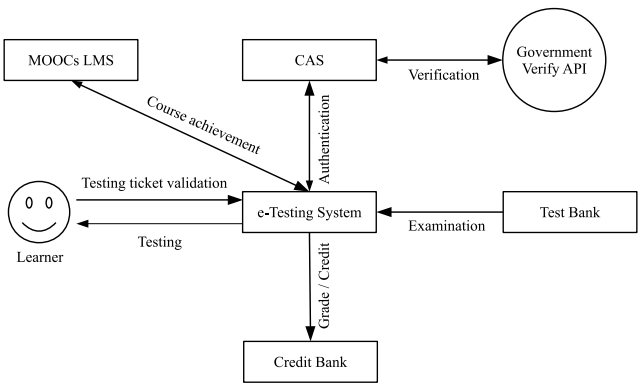



**Fig. 4** Workflow on data verification to perform credential service.

curriculum certificate.

Lastly, all activities and information of participants are collected and summarized by the e-Portfolio module. This module is used to demonstrate the abilities and contributions of the participant in the platform. The module provides activities records of learners in real-time.

Since credential records –such as credits, transcripts, and certificates– are important assets to reach the goal of the platform strategy, then we design the method and workflow to execute credential service as shown in Fig. 4 and Fig. 5. The data flow to access the credential information is shown

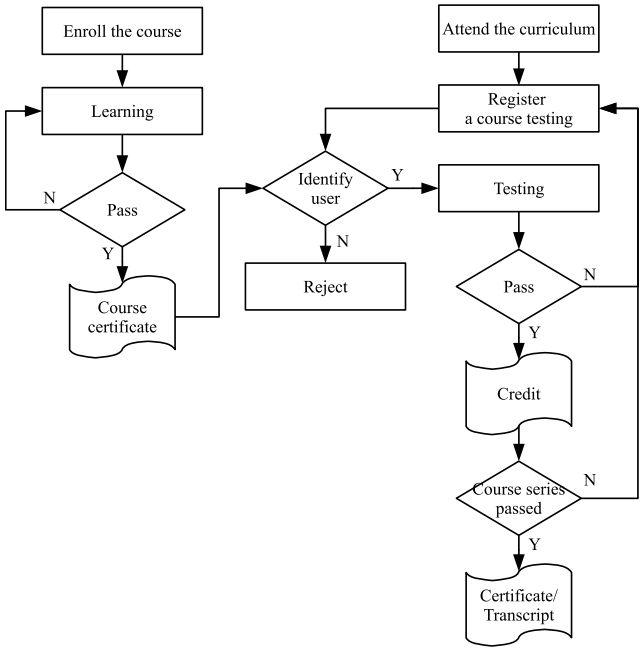



**Fig. 5** e-Testing workflow.


**Fig. 6** An example of credential curriculum certificate.

in Fig. 4. A learner who requires academic credentials must verify the user identity with an identity verification service provided by the government organization. Figure 5 demonstrates a workflow to get credential benefits. A learner must request to enroll courses and pass the courses in LMS. Then, he or she needs to verify the user information to go on curriculum testing on the e-Testing system. Then, they can get a credential certificate and transcript when passing the required courses.

### 3.4 Authentication Policy and Method

*Authentication layer* was initially proposed to the base MOOC framework for centralized user authentication among LMS, CMS, and OER services. Centralized user management allows the system to manage user privileges,

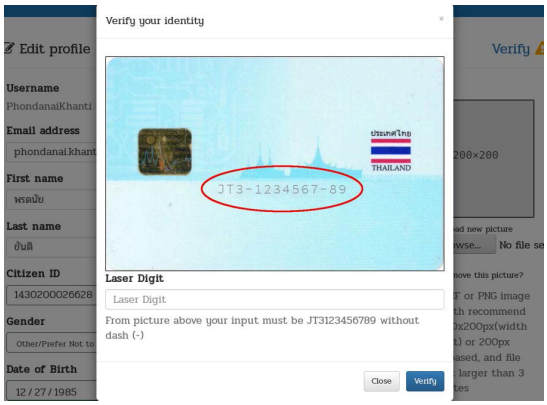



**Fig. 7** An identity verification service provided by the government organization.

**Table 3** Privileged roles and responsibilities in the framework.

| Group | Description |
|---|---|
| Student | A standard privilege that can view course content in LMS. It is a default role for every registered member. |
| Teacher | A privilege to create, edit and run the course in CMS. A teacher is the owner of the course and can invite others to be a course team. Not only the course maintenance, but the examination repository is also organized by the teacher role too. |
| Course team | The role for participants who are assigned to help course owners in the learning activity such as to monitor learners, edit a course, manage quiz, etc. The course team can take responsibility for courses that assigned only. |
| Submitter | A participant who is granted to create, upload, and import educational media to the OER system. |
| Reviewer | The role of a participant who can review and approve educational media in the OER system. They can accept/decline/re-edit/delete resources to keep good quality and correct license declaration. |
| Invigilator | Contributor who takes the duty to manage the on-site testing operation for example; check a testing ticket, arrange a testing room and seat, control testing rule, validate examiner, etc. |
| Executive | The group who can monitor platform information and reports such as overall learner statistics, education trend, etc. |
| Staff | The privileged permission is aiming to operate course contents in CMS and LMS. This role can take full responsibility for the teacher and the course team. Also, grant license to organize examination repository too. |
| Administrator | The person or group who is responsible for system configuration, system maintenance and perform system tools. An administrator can access any module in terms of the system admin. |

authentication, and security [7]. However, it did not cover the demands, roles, and policies of the Thai MOOC model. Thus, we extended and added more functions to the authentication module. Concerning an ease-of-use concept, the seamless user interface of all modules is implemented to reduce the learning curve of participants. A user can do a registration process for all services in one time, and then access to every module with unique credential information.

We also verify user national identify via the API provided by the corresponding government agency. Five fields of user information are requested which are 1) national identity number, 2) name, 3) surname, 4) birthday, and 5) secret code or laser digit of the identity card. Figure 7 demonstrates the verification process. When done with the credential information verification, the learner can pursue processes to get the curriculum certificate through the e-Testing service. The credential credits and grades are archived in the credit bank repository.

Additionally, we introduced more roles of the participants, which are crucial to the main workflows and data integrity. Each user role has different responsibilities for functions and data access which are explained in Table 3.

## 4. Result and Discussion

Initially, we have conducted a pilot project of a MOOC e-Learning system in Thailand, which was collaborated by the Office of Basic Education Commission and many educational organizations. The project aims to perform the sustainable sharing resources repository use for e-Learning systems [7]. The platform adopted the traditional MOOC system deployment with the requirement specifications as described in Sect. 4.2. Therefore, we use the original pilot project as a baseline platform to evaluate and compare with the proposed framework.

### 4.1 Thai MOOC Environment

In this research, the proposed system is the extension phase of the Thai MOOC project, which is organized by the Office of the Thailand Cyber University Project, Office of the Higher Education Commission [18]. The current statistics of the Thai MOOC project is reported in Table 4. The proposed framework including CAS, LMS/Studio, OER, Credit Bank, Test Bank, and e-Testing system are important in providing high-level services and applications. Figure 8 reports the location of learners who access online courses throughout the country.

The infrastructure of the framework is designed based on scalable and replica concepts to ensure data integrity.

**Table 4** Data statistics of the Thai MOOC project

| Topic | Value |
|---|---|
| Active learners | ≈ 268,000 |
| Total courses | 699 |
| Participated universities and organizations | 95 |
| Granted course certificates | ≈ 25,000 |
| Verify users | ≈ 20,000 |
| OER objects (* share with collaboration partner) | ≈ 150,000 |

[1]Update on 10 December 2019

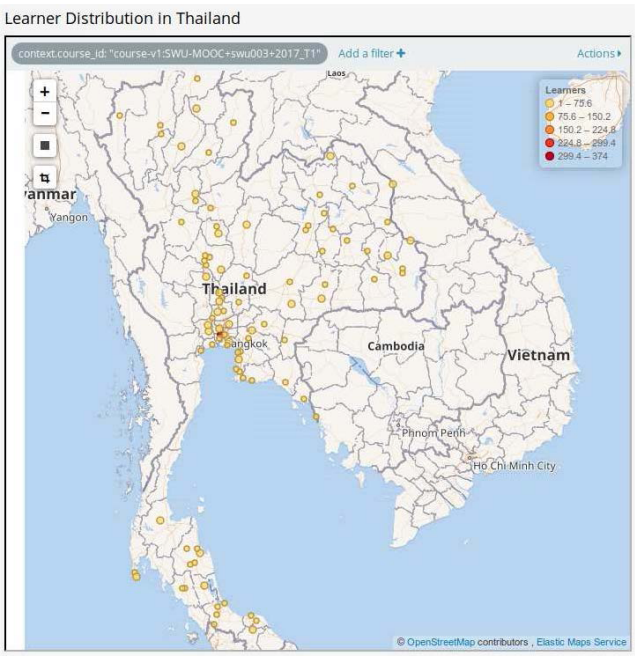



**Fig. 8** Example location of learners who access online course through the internet.

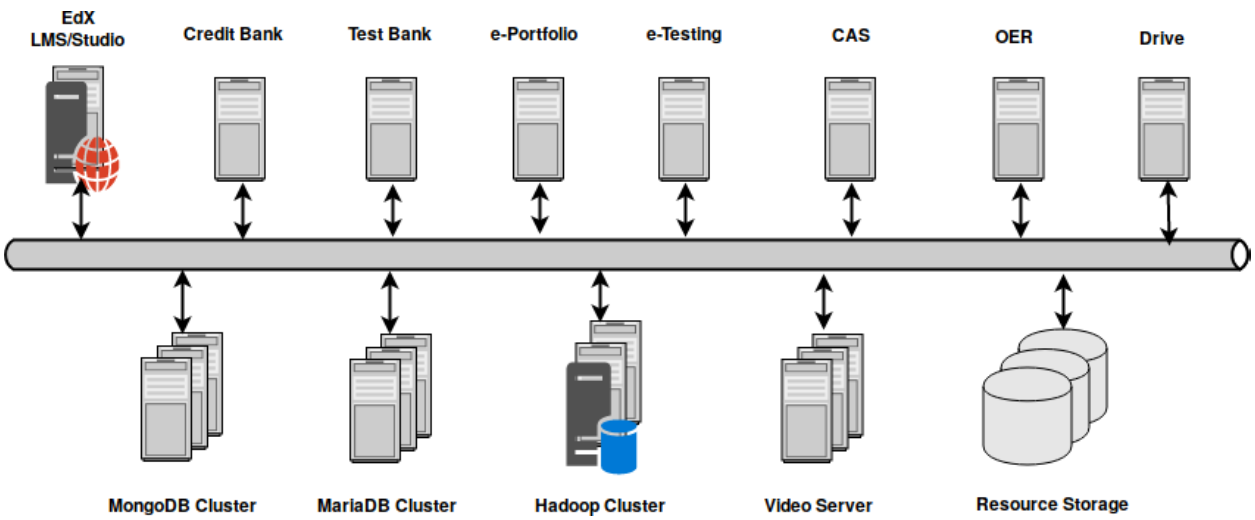



**Fig. 9** Practical ecosystem installation.

**Table 5** Deployment server specifications

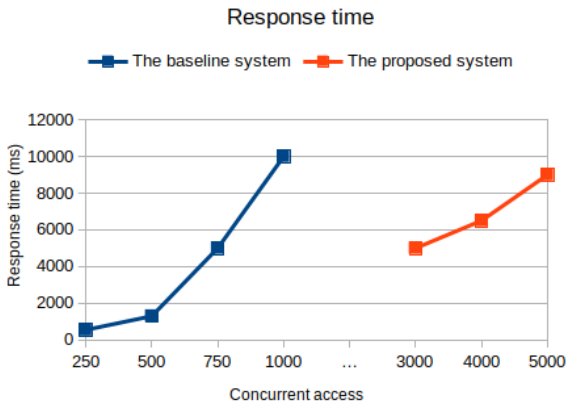
| Service | Cpu (cores) | Memory (GB) | Unit |
|---|---|---|---|
| LMS / CMS | 16 | 32 | 1 |
| MariaDB cluster | 4 | 8 | 3 |
| MongoDB cluster | 4 | 8 | 3 |
| Hadoop cluster / Analytic | 8 | 16 | 3 |
| Video streaming | 4 | 8 | 3 |
| CAS | 4 | 8 | 2 |
| OER | 4 | 8 | 1 |
| Credit Bank | 4 | 8 | 1 |
| Test Bank | 4 | 8 | 1 |
| e-Testing | 4 | 8 | 1 |
| e-Portfolio | 4 | 8 | 1 |

The system was deployed to the cloud resources of the collaborated partners. The framework requires several servers to operate the services as shown in Fig. 9. Each service is hosted in a separate server for scalable application modules regarding the designed architecture. The database cluster and the resource storage are the data aggregation resources serving all applications. Each service is hosted in a separate server for scalable application modules regarding the designed architecture. Details of server specifications are listed in Table 5. Moreover, The file system storage layer, The Ceph File System (CephFS), is implemented as framework storage for sharing data among services [19].

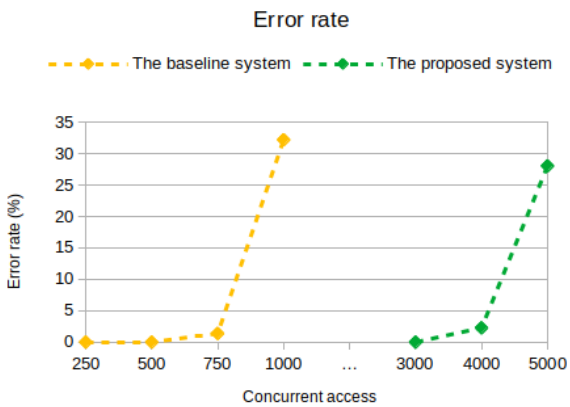
### 4.2 Service Performance Evaluation

One of the goals of the project is to improve system performance of the baseline platform [7]. The baseline system is operating on two VMs, including the OER service, and the MOOC service. Both VMs use Intel(R) Xeon® @2.65 GHz 4 cores and 8 GB of memory. The measurement reports show that the baseline framework can generally support up to 750 concurrent usages. Similar to the baseline platform evaluation setting, we evaluated the system performance by simulating load testing to measure the maximum capacity and other limitations in the learning services. We set scenarios for the load testing process since many privileged roles and responsibilities are defined. The scenario is simulated with an actual workflow of the learner on the testing course. The scenarios for learners include the login process, the course enrollment process, learning process, quiz or exam process, and view the portfolio process. We measured the response time on the client-side and system efficiency on the server-side. The testing course consists of 5 sections, 15 subsections, 30 units, and 5 post-tests of each section. A cycle of learning scenario is done in 800 seconds. The evaluation was conducted for 3,000, 4,000 and 5,000 concurrent connections.

The evaluation results are shown in Fig. 10 and Fig. 11. There are three measurement factors - Response time, Requests per second, and Error rate. The response time is the amount of time a system or functional unit takes to respond to a given request on the client-side. The Requests per second is an actual accession rate (Hits) per second on




(a) Comparison of the response time factor.




(b) An error rate comparison.

**Fig. 10** A system's behavior on anticipated peak load conditions to identify the maximum operating capacity of the platform.

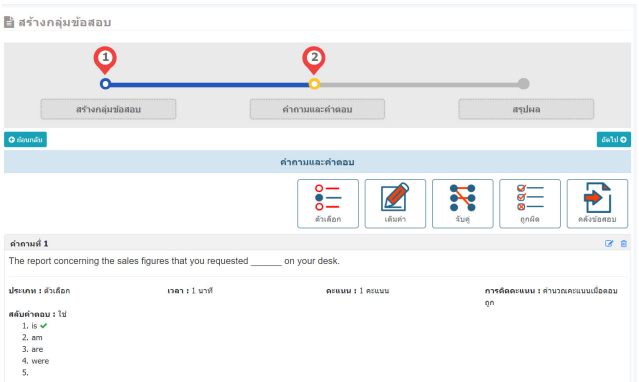



**Fig. 11** An example procedure to manage testing resources on the Test Bank module.

the server-side. The Error rate denotes the percent of requests with errors. This factor reports how many requests failed or resulted in error throughout the test duration. All factors help to identify acceptable workload and limitation of the platform. The results show that the platform can serve up to 4,000 concurrent clients with the acceptable error rate, 2.38 %. When the number of concurrencies is higher, the

error rate will increase. The baseline framework can perform the concurrent usages up to 750 with the error rate of 1.75 %. Therefore, the result shows that the proposed framework can handle more concurrency comparing to the baseline system with similar error rate due to the more optimized infrastructure setting. While the baseline framework can perform the concurrent usages up to 750 with a few errors by request timeout. Therefore, the result reports that the proposed framework can handle more concurrency comparing to the baseline system due to the more optimized infrastructure setting. On the system performance test, the maximum CPU workload is 80 %, memory usage less than 50 %. It was further investigated that the primary cause of error occurred due to the timeout in the course enrollment process. This made a bottleneck and must be improved in order to increase the number of concurrent access.

### 4.3 Discussion

In the proposed MOOC service framework, we emphasize the benefits of online learning to support self-organized and teacher-based actions by centralized content. Several modules are introduced and implemented on top of the baseline platform in order to meet traditional courses and business requirements. Major functions are assessment and credential layers. Test Bank was used to archive the testing repository. Figure 11 shows an example procedure to manage the testing archive. A virtual testing environment, e-Testing system, was involved in conducting the online test event to accomplish the credential record. Figure 12 exams the resourced organization of an e-Testing system. Credit Bank was utilized to maintain the learner's credentials, including transcripts, certificates, etc. An example process of Credit Bank to manage the curriculum was demonstrated in Fig. 13. As the result, Fig. 14 highlights key components and services of the proposed Thai MOOC platform. The approaches of the Thai MOOC platform can be summarized as follows.

*1) Strategy and Model*: this is corresponding to the online course momentum, strategy and business model, particularly for the educational organization and training institution. The adoption of MOOC programs in the course curriculum can help the university to gain more learners, and other participants via the online courses. Then, a combination of online and traditional classroom instruction, the hybrid learning model, is a global trend in higher education.

Due to the academic position of the baseline platform in the business sector viewpoint, an important goal of Thai MOOC is to provide a credential service that can verify and deliver reliable academic certificates for the business sector demand. Also, the platform can increase opportunities for non-academic stakeholders or players such as companies, factories, and training schools to engage in business demand. As a result, the platform can potentially support the new model of education, for example; blended learning, flexibility and high-quality content, lifelong learning, openness, and student-centered learning.

*2) Service and Systemic infrastructure*: Thai MOOC has provided technical and implementation solutions for a large-scale MOOC service. Modular design is applied for the platform by separating sub-systems based on system functionality. The proposed framework requires higher infrastructure specifications comparing to the baseline framework according to the system functionality and work-

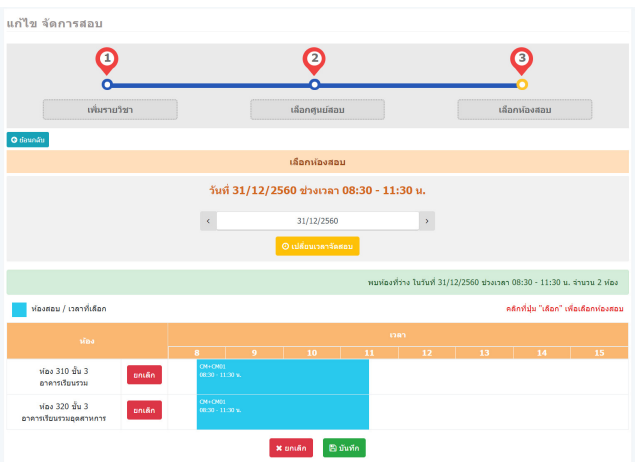



**Fig. 12** An example step to organize the e-Testing resources for operating online testing acquire academic credentials.

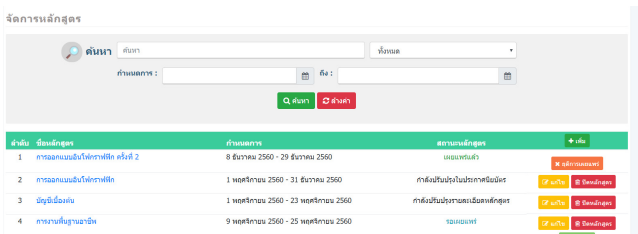



**Fig. 13** An example process of Credit Bank feature using to maintain the curriculum details.

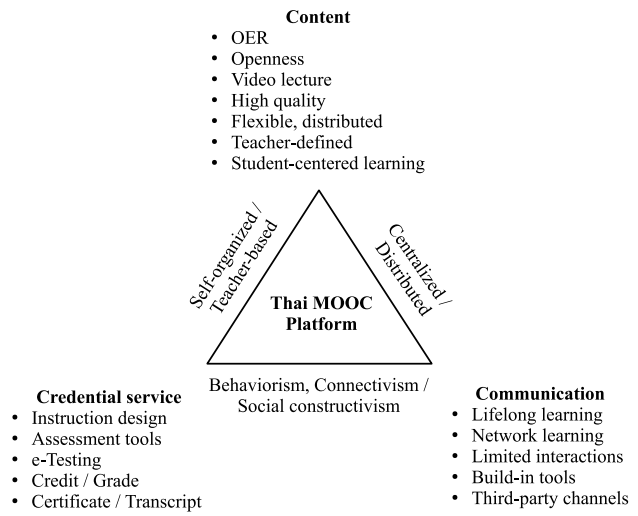



**Fig. 14** A key to drive the Thai MOOC service platform.

load [7]. The infrastructure would allow for a scalable system for long-term maintenance. The system is prepared and operated on a distributed data center instead of a centralized data center. Moreover, a seamless user interface on each sub-application would allow for a good user experience for participants who have limited IT literacy.

With the proposed solution, the framework can response the real business demands. The structure is also close to traditional education, while keep benefiting on anytime, anywhere of the e-Learning system. There are some current limitations which needed to be improved in the future, for examples; 1) foreign learners can not obtain the academic certificates from the Thai MOOC curriculums, since the platform requires user verification with a national ID card. A generic person identification approach should be designed to make the framework more general. 2) The e-Testing event still requires staff to verify examiners before entering the test room. Some automatic verification system of examiners should be designed in the future work.

## 5. Conclusion

In the paper, we present the Thai MOOC platform as a service to support lifelong learning demand. Thai MOOC can be an enabling tool for higher education. Many stakeholders are participating in the project including the educational and business sectors. The strategy and business model are designed to match with the national policy of education. We design and develop a framework based on the service modularity concept. We also present the system architecture in the abstraction layer viewpoints to demonstrate characteristics and interoperation among modules. The system was deployed as an ecosystem for the national MOOC system that is a collaboration with education organizations and universities. Credential information is an important resource which can serve the demand of the business sector in job applications for example; curriculum certificate, transcript, credit, grade, identity credential, etc. In terms of service performance, the evaluation results showed that the proposed framework can provide concurrency load up to 4,000 clients. Future work will include applying Thai MOOC in non-academic sectors such as government and private training agencies.

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