WebRTC based Remote Collaborative Online Learning Platform

Hyeontaek Oh Sanghong Ahn
JunKyun Choi
Departmant of Electrical Engineering, KAIST,
Daejeon, Republic of Korea
hyeontaek@kaist.ac.kr ancom21c@kaist.ac.kr
jkchoi59@kaist.edu

Jinhong Yang
Department of Information and Communication
Engineering, KAIST, Daejeon, Republic of Korea
sunupnet@kaist.ac.kr

Abstract

Recently, as the number of smart devices increases, the way of digital broadcast contents is changed. This change leads that conventional broadcast media accepts Web platform and its services to provide more quality contents. Based on this change, in education field, education broadcasting also follows the trend. The traditional education broadcasting platforms, which just delivered a lecture in one-way, are utilized the Web technology to make interaction between teacher and student. The conventional education platforms, however, are insufficient to satisfy users' demands for two-way interactions. This paper proposes a new remote collaborative learning platform which able to provide high interactivity among users. Based on new functional requirements from original use case, the proposed platform provides collaborative contents sharing and collaborative video streaming techniques by utilizing WebRTC (Web Real-Time Communication) technology. The implementation demonstrates the operability of proposed system.

Categories and Subject Descriptors K.3.1 [*Computer Users in Education*]: Collaborative learning

Keywords world-wide web, web real-time communication, collaborative learning, e-learning

1. Introduction

Recently, as the number of smart devices (such as web based IPTV, smart TV), the users used many different kinds of devices to consume digital contents [1]. These smart devices contained mobile OS and embedded Web browser, they are able to utilize existing Web services without additional plug-ins or software.

This change leads that conventional broadcast media accepts Web platform and its services to provide more quality contents. Especially, numerous contents are created and consumed through Web, and it affected to content distribution in educational field. The traditional education broadcasting platforms are just delivered a lecture in one-way, which mean students just watched recorded lecture. These platforms utilized Web homepage about lecturer contents to make interaction between lecturer and student. Furthermore, Web based open online course platforms, such as MIT OpenCourseWare[1] or Coursera[2], tried to provide more quality education [2].

However, the conventional online course platforms just provided recorded lecture and lecture homepage for questioning and answering lecture contents among teachers and students although current smart devices now are capable to support more complex interactions, such as real-time questioning, real-time contents sharing etc., for real-time remote collaborative learning.

This paper proposes a new remote collaborative online learning platform which able to provide high interactivity among teachers and students. By analyzing service scenario and user requirements, collaborative online learning platform is proposed ,which can support collaborative learning n-screen interface and collaborative remote video conferencing. To realize real-time user interactivity issues in Web platform, we utilized WebRTC (Web Real-Time Communication) [3] for real-time user interaction. By using WebRTC, the system can create high quality point-to-point or point-to-multipoint connection without installing additional plug-ins.

The rest of paper is organized as follows. Section 2 summarizes previous works on existing online learning system. Section 3 presents system overview of remote collaborative online learning system by analyzing service scenario, user requirements, and functional requirements. Section 4 shows

AWeS '15, April 21, 2015, Bordeaux, France

http://dx.doi.org/10.1145/2749215.2749222

[1] http://ocw.mit.edu/

[2] https://www.coursera.org/

implementation of remote collaborative online learning system by utilizing WebRTC. Finally, Section 5 concludes the paper.

2. Related Work

Conventional Web based e-learning systems can provide educational contents to multiple users, however, these system delivered contents only through PC, so users have limited accessibility. To overcome this issue, u-learning (ubiquitous learning) platform, which provided educational contents to user in anytime at anywhere, is proposed. Web based LMS (Learning Management System) model was proposed to support self-directed learning model through online learning platform [4]. This system provided the way of self-directed learning process, content and method to help student. Also, social learning techniques are used in online learning platform [5].They utilized social network service in real-time video lecture environment to make students focusing in class.

These u-learning systems are able to overcome constraints of time/space for online learning, but they have less consideration about user interactivity. To make user interactivity, some works tried to utilize open source learning platform, called Moodle[3]. To support effective collaborative workspace over Moodle platform, the modified course material management system on Moodle was proposed [6]. Moodle users were able to share various course materials using this system; however, it only supported file sharing (similar to FTP server). Other research focused on Wiki module to make collaborative learning environment [7]. Users are able to upload their opinions or lecture notes in Wiki, and accumulated data are used to make new information for other users. Wiki system was good for learning after school; however, it had limited functionalities for supporting real-time video lecture.

To the authors' knowledge, no previous study focused on user real-time interactivity in remote online learning system. The conventional online course platforms just provided recorded lecture and lecture homepage for questioning and answering lecture contents among teachers and students. This paper proposes new web based remote collaborative online learning platform based on service scenario and functional requirements.

3. Remote Collaborative Online Learning Platform

3.1 Service scenario

The service scenario and new user requirements of remote collaborative online learning system are shown in Fig. 1. Basically, teachers and students are able to do remote collaborative learning service without streaming quality degradation. Users should be able to use multiple devices, and also be able to share their images, and display of their devices in teleconferencing environment. For teacher and student interaction, the real-time notification and quiz function should be available. If a teacher quiz students about lecture material, the question should be sent to students immediately. Also, the answers of students are feedback to the teacher, and the teacher should see the result. This is for keeping students' attention in lecture by real-time notification. If the quiz is for group activity, students should be able to use N-screen based collaborative system to share their ideas and solve given problem. Each student has his/her own device (i.e. tablet PC) for interacting with other students, and they should be able to solve the problem by sharing their own findings or marking the answers. Finally, their activities are feedback to the teacher, and the teacher can improve the quality of lecture by using collected feedback.

3.2 Functional requirements

Based on the service scenario, functional requirements for remote collaborative online learning are analyzed: collaborative learning service interface, n-screen support, and remote video conference.

Collaborative learning service interface consists of collaborative content sharing and social learning features. To support collaborative content sharing function, the learning platform should support content-sharing function regardless the type of users' contents. Also, users should be able to manipulate their on-viewing contents with their collaborators in the real-time, and the result of manipulation should be synchronized among the related users. To support social learning feature, the learning platform should support the linkage to the information in the social network services. Also, user should be able to play the collaborative learning content which is re-organized and personalized, and they should be able to watch the visualized history of content play.

N-screen service is for a collaborative service which uses several devices to provide bi-directional, convergence and personal service [8]. The n-screen service consists of

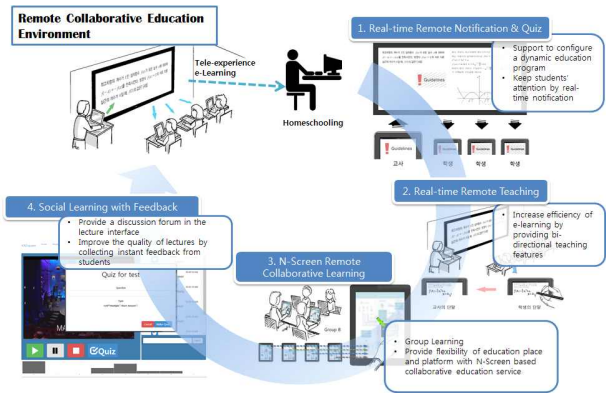


Figure 1. Service scenario and user requirements of remote collaborative online learning

[3] https://moodle.org/

content-view management and access management. To support content-view management, the learning platform should support its content as they fit to users' screen. For access management, the user should be able to access the platform with their web-enabled devices and to be served the same quality of service regardless the type of their web-enabled devices.

Remote video conference consists of streaming control and session control. Users should be able to watch another user's video from his/her camera in the same session, and the platform should support grouping function for each session – a group is a subset of users and supporting video sharing functions for a small conference.

3.3 Service architecture

The remote collaborative online learning platform consists of three major parts: front-end, Application server, and back-end as shown in Fig. 2. Front-end part is divided into user interface and lecture modules. UI manager handle not only general user interface but also organize changed layouts caused by collaborative interaction in n-screen environment. Lecture modules are related to lecture environment.

The application server operates three application modules – collaboration learning elements, content syndicator and session manager. Collaboration learning elements provide functions that make users communicate and interact to each other, such as collaboration canvas, slide show controller and social log management. Content syndicator is a learning management system that deals with lecture video contents, materials and interaction logs in a lecture session. Finally, session manager deals with user accesses and interactions. A lecture is managed in a unit of lecture session, which includes user access log, interaction and communication logs. Back-end manages cloud of virtual machines for supporting overall system.

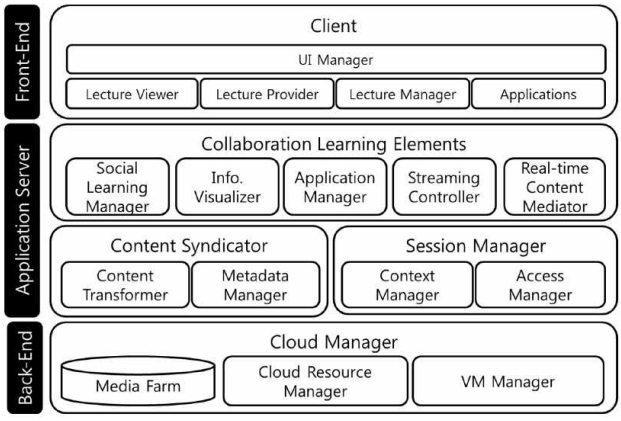


Figure 2. System block diagram

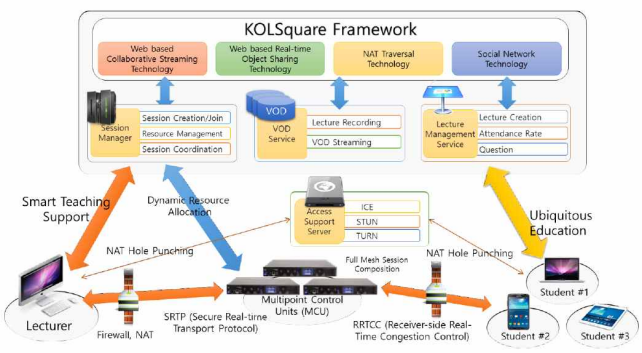


Figure 3. Remote collaborative online learning system architecture

4. Implementation

4.1 Design and network configuration

We configured the system environment composed with a back-end/application server and multi-point control unit (MCU) as shown in Fig. 3. The back-end/application server manages the connections and delivers a lecture service, and it is implemented with Node.js web server and mongoDB system. The MCU is composed with STUN servers and TURN servers for mediating WebRTC connections. A client can access the system via its own web browser, and whole connections are based on HTTP. The client gets three session establishment - a web service session, an application session for dealing interactions in a lecture and a WebRTC session for media streaming with STUN protocol. The instant sessions – an application session and a WebRTC session are established instantly when they are needed for a lecture; they are managed by the session manager module.

It is required to manage the connections between an application server and users, for the performance of interactive functions. A session can represent its user or owner's device, and all interaction in the system is based session-to-session data communication. Especially in the interactive and collaborative learning platform, a user can handle multiple devices at the same time. In this situation, there are multiple device sessions for a user. To manage it efficiently, a layered session model is proposed for user-level management and device-level management. Since all client devices need a WebRTC session for media streaming, we need a method of congestion control in the environment of MCU virtualization for system's scalability. In the proposed system, a key-value based cache as a session store is used for solving this problem and improving the performance of user interactions.

4.2 System flows

4.2.1 Establishment of a lecture session

The system supports many interaction methods between lecturers and students in a lecture, such as lecture video delivery, an instant quiz and an instant lecture feedback by Q button. For this purpose, a lecture needs to be managed as

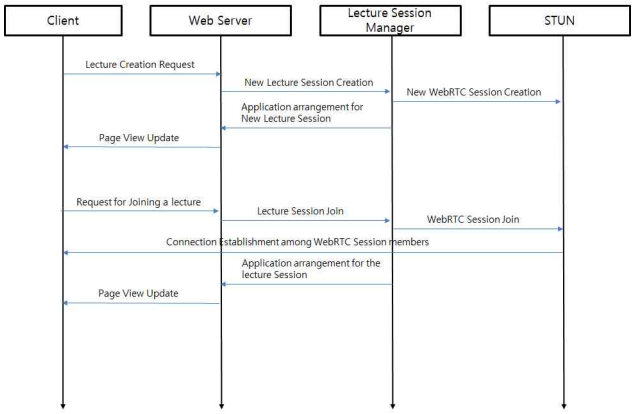


Figure 4. Sequence diagram of creating and joining lecture session

an independent and instant session. Since a media delivery server can be separated from the application server, a WebRTC session for media streaming is managed as a separated from its lecture application session. Fig. 4 describes a process of lecture application session establishment by lecturer client and student clients joining.

4.2.2 Interaction in a lecture session

All users interactions in a lecture is proceeded via the application session of lecture. Inputs from users are transferred to the lecture application session as a kind of user event, via a WebRTC that established between a lecturer and the student. This user event is handled by the event listener functions of application server, and the results are delivered to all student clients which are connected to the same lecture application session. Fig. 5 describes a process of an interaction between teachers and students, as an example of an instant quiz scenario.

4.3 System components

In this section, the detail features of Web-based collaborative e-learning support system are explained. This system can fall into four major components - basic lecture components,

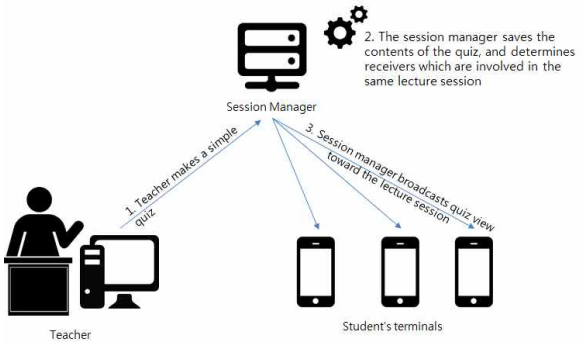
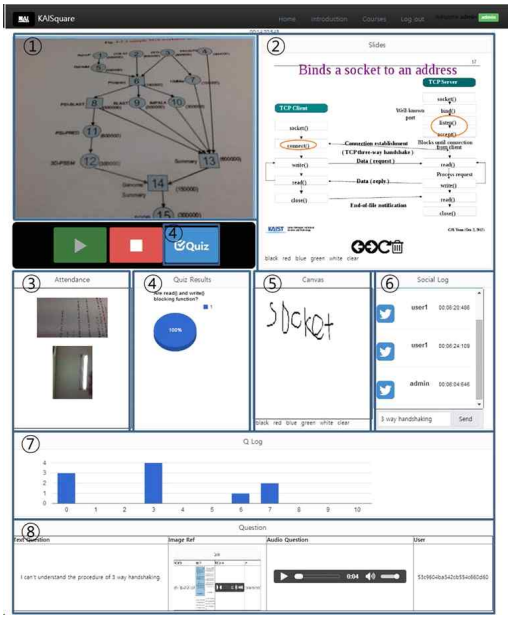
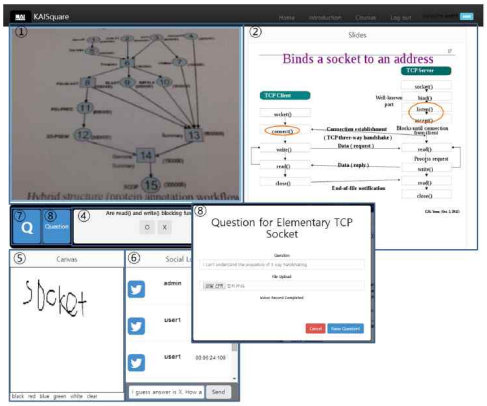


Figure 5. Example of in class interaction: giving a quiz during lecture



(a) Dashboard for teacher



(b) Dashboard for student

Figure 6. Dashboard of remote collaborative online learning platform

interactive quiz and question system, collaborative viewer, and Q feedback system. The details are shown in Fig. 6.

Basic lecture components consist of three parts - lecture video, presentation slide, and student attendance (component ①, ②, ③ in Fig. 6, respectively). Lecture video streaming service is performed over WebRTC channel. The video which is taken by camera can be checked through video in teacher dashboard. Teacher can use presentation slide for teaching students. This part consists of slide show and marker pen. Teacher can write on the presentation to explain detail content, and this activity is synchronized with video streaming, and these video and presentation log are used for VoD. Student attendance list shows students activity through its own camera device which is captured by device API.

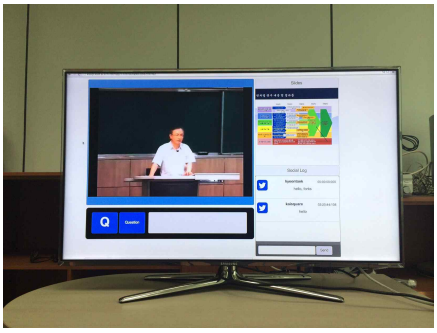


Figure 7. Demonstration of remote collaborative online learning platform on smart TV environment

When a student accesses lecture page, attendance check is automatically performed.

Interactive quiz and question system is shown as component ④ and ⑧ in Fig. 6. The Teacher can push a button for simple true/false or multiple-choice questions. When the teacher makes a question to students, they should answer immediately. After gathering student responses, the results are showed as pie chart. Through this chart, the teacher can easily know student responses. Students also can raise his/her questions about lecture contents. When they make question, they can use text, image and their voice using microphone to ask question. Questions are shown in the dashboard of the teacher, and the teacher can check questions from students.

Collaborative viewer consists of whiteboard and social log parts (component ⑤, ⑥ in Fig. 6, respectively). Whiteboard is implemented using html5 <canvas>. Students can present their opinion by drawing something on the whiteboard. This whiteboard content can be manipulated by multiple students simultaneously. This whiteboard content can be shared among teacher and students. Students can make a group to share their opinion through whiteboard and social log.

The Q feedback interface is shown as component ⑦ in Fig. 6. The Q button in Fig. 6(b) is designed to provide quick feedback to teacher, which is similar to Like button of Facebook in the way that it provides simple feedback method. It gives a chance to raise a question tacitly for students. When students feel confused or have difficulties during a lecture, they can push it to appeal their opinion. This Q log in Fig. 6(a) is directly showed in teacher dashboard to inform teacher. Teacher easily can know how many students feel difficult to understand current lecture contents, so the teacher can change the tempo of the lecture. Fig. 7 shows the implementation and demonstration of the proposed system. We supposed that the runtime environment of students with a TV. Students can use functions that are adaptively enabled for their own device.

5. Conclusion

Today, smart devices are widely used, and this leads that leads that conventional broadcast media accepts Web platform and its services to provide more quality contents. Following trend, educational field is also accecpt Web platform, and many educational contents are distributed through Web. The traditional online learning platforms provided recorded video lectures with simple LMS which supports questioning and answering lecture contents through web board for interaction of teachers and students. However, exisiting online learning platforms are insufficient to provide collaborative learning even if current smart devices now are capable to support more complex interactions, such as real-time questioning, real-time contents sharing etc., for real-time remote collaborative learning. Based on these demands, this paper proposes a new remote collaborative online learning platform which able to provide high interactivity among teachers and students. To realize real-time user interactivity issues in Web platform, we utilized WebRTC for real-time user interaction.

Acknowledgments

This research was supported by The Cross-Department Giga KOREA Project of the Ministry of Science, ICT and Future Planning, Korea [GK14P0100, Development of Tele-Experience Service SW Platform based on Giga Media].

References

[1] S. Kim, and S. Lee, “Web 2.0 and IPTV service,” TTA Journal, no. 111, pp. 76-85, May 2007.

[2] Docebo, “E-Learning Market Trends & Forecast 2014-2016 Report,” Docebo, Mar. 2014.

[3] H. Alvestrand, “Overview: Real Time Protocols for Browser-based Applications – draft-ietf-rtcweb-overview-13,” IETF Network Working Group, Nov. 2014.

[4] J. Choi et al., “An architecture of a learner-centric u-learning”, J. KICS, vol. 36, no. 2, pp. 23-32, Feb. 2011.

[5] J. Yang et al., “Demonstration of smart u-learning system,” in Proc. IEEE Consum. Commun. Net. Conf. 2011 (CCNC 2011), pp. 832-833, Las Vegas, U.S.A, Jan. 2011.

[6] J. Jin et al., “Supporting effective collaborative workspaces over Moodle,” J. IICE, vol. 16, no. 12, pp. 2657-2664, Dec. 2012.

[7] A.H. Silveria Sonego et al., “Use of Moodle as a tool for collaborative learning: a study focused on wiki,” IEEE Revista Iberoamericana de Tecnologias del Aprendizaje, vol. 9, no. 1, pp. 17-21, Jan. 2014.

[8] C. Yoon et al., “Classification of N-screen services and its standardization,” in Proc. IEEE Int. Conf. Adv. Commun. Tech. 2012 (ICACT 2012), pp. 597-602, PyeongChang, Korea, Feb. 2012.