Online Tutoring through a Cloud-based Virtual Tutoring Center

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Abstract. Online tutoring has gained popularity in recent years, which allows students to get tutoring service from tutors in an online, virtual environment. To support effective online tutoring, an integrated online tutoring system is essential. This paper presents a cloud-based virtual tutoring center that supports online tutoring for college students to complement the tutoring service of physical tutoring centers on a campus. We present the overall architecture of the virtual tutoring center system and show preliminary results of using the virtual tutoring center to provide online tutoring for computer science students.

Keywords: Online Tutoring, Virtual Tutoring Center, Cloud Computing.

1 Introduction

Advances of cloud computing have had major impacts on education, and will continue to influence how educational services are delivered. Examples of cloud computing-enabled educational services are abundant. Cloud computing is one of the key technologies that support Massive Open Online Courses (MOOCs) [1], which represent a new way of delivering classes to students. Cloud computing also makes it possible to set up *virtual computer labs* (see, e.g., [2, 3]), where students carry out labs on virtualized resources remotely through the Internet. These examples motivate developers to explore new ways of using cloud computing to support educational services.

Online tutoring refers to the process for students to get help from tutors in an online, virtual environment. It has grown in importance in recent years and many online tutoring websites have been launched to connect students with tutors through the Internet. As more and more students take online courses and engage in various forms of online learning, it is essential to incorporate technologies and resources to adapt and meet the needs of these students. Online tutoring allows students who cannot make it to campus to receive assistance, without being constrained by the boundaries of the campus. This advantage makes it a great candidate to support the growing trend of online learning. Previous works have studied several issues related to online tutoring, including best practices for online tutoring [4], and effectiveness of online tutoring for college Math courses [5]. The work of [6] studied the role of the tutor in online learning and suggests that online tutors need to have both technical competence and online interaction skills.

To support effective online tutoring, an integrated online tutoring system is important. There are strong interests in the industry to support online tutoring in recent years. Websites such as Skooli, Udemy, Tutorroom.net, and Wyzant provide platforms to allow tutors and students to pair with each other and interact. These platforms focus on open and dynamic online tutoring spaces as they target all users on the Internet. Tools such as Skype and Google Hangouts are also commonly used for online tutoring [7]. Nevertheless, none of these platforms and tools are designed to support online tutoring in a college environment that mimics the physical tutoring centers in college campuses. In this paper, we present a cloud-based virtual tutoring center that supports online tutoring in a college setting and show preliminary results. The virtual tutoring center is installed in a private cloud environment maintained by the Computer Science department at Georgia State University.

2 A Virtual Tutoring Center (VTC) System

An effective VTC system needs to support several essential functions of online tutoring, including managing online tutoring sessions and users and recording data, and providing an engaging platform to support tutor-student interactions. To support tutor-student interaction, we leverage an open source video conferencing system *BigBlueButton* (https://bigbluebutton.org/) and integrate it as part of our VTC system. BigBlueButton offers many of the features that are important for real time tutor-student interaction, including audio and video call, presentation with extended whiteboard capabilities, public and private chat, shared notes, and desktop sharing. In a previous work [8], we developed a collaborative virtual computer lab tool that integrates an early version of BigBlueButton implemented in Flash. The Flash-based BigBlueButton needs web browsers to have Flash support in order to use the system. This often requires students to install Flash on their computers and thus deters students from using the system. To make the VTC system easily accessible for an open group of students, we develop the VTC system using the newer version of BigBlueButton implemented in HTML5. Since HTML5 is supported by all modern web browsers, students can access the system without the need of installing any extra software. The HTML5-based BigBlueButton also brings the advantage of working with mobile devices, and thus makes the VTC accessible through mobile devices.

Fig. 1 shows the software architecture of the VTC system, which includes four subsystems: 1) Users, 2) VTC Management subsystem, 3) BigBlueButton (denoted as BBB) HTML5 clients, and 4) BigBlueButton server. Below we describe each of these subsystems.

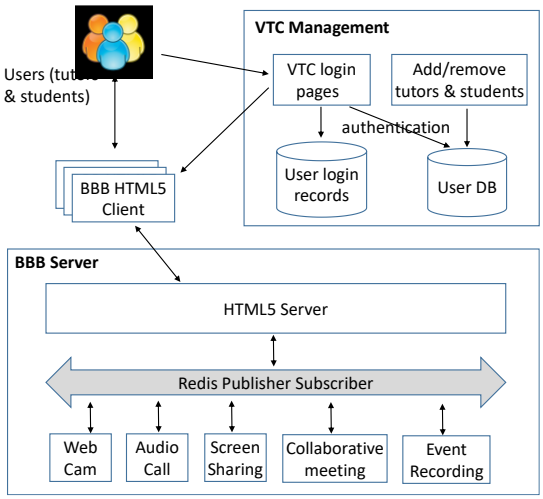

Fig. 1. Architecture of the Virtual Tutoring Center System

2.1 Users

Users are participants of the virtual tutoring center. There are two types of users: students and tutors. Students ask questions and tutors help students. Due to the different roles of tutors and students, they access the VTC in different ways and have different functions available to them. Students enter a tutoring session in the role of *viewer*. As viewers, they can join the video conference, share their webcam, raise their hand, and chat with others. Tutors enter the tutoring session in the role of *moderator*. As moderators, they may mute/unmute others, eject any user from the session, and make any user the current presenter. The presenter can upload slides, control the presentation, and share their desktop. In the current implementation, an online tutoring session can have one tutor and multiple students. Future implementations will support multiple tutors and students, so that students can choose specific tutors for help, and each tutor will interact with their students in a separate breakout room.

2.2 VTC Management

The VTC Management subsystem is in charge of managing the tutoring sessions as well as managing the users and data. This includes providing an interface to start/stop a tutoring session, providing login webpages for users, adding/removing users, and storing data related to the tutoring sessions. Typically, a tutor needs to start a tutoring session so students can join, and end the session after finishing the tutoring. Our implementation also allows a tutoring session to be started in the beginning of a semester and remain open until the end of the semester. With this implementation, students can log in at any time, while tutors are available only in the publically announced tutoring hours. A major function of the VTC management subsystem is to provide a web portal for students to log in to the system to use the online tutoring service. As an example,

Fig. 2 shows the web portal for the CS virtual tutoring center that we implemented in Spring 2020. As can be seen, students need to provide their campus IDs to log in to the system. They also need to select the course for their tutoring questions. A different web portal is provided for tutors to log in that allows the VTC to differentiate tutors from students and assign them different roles.

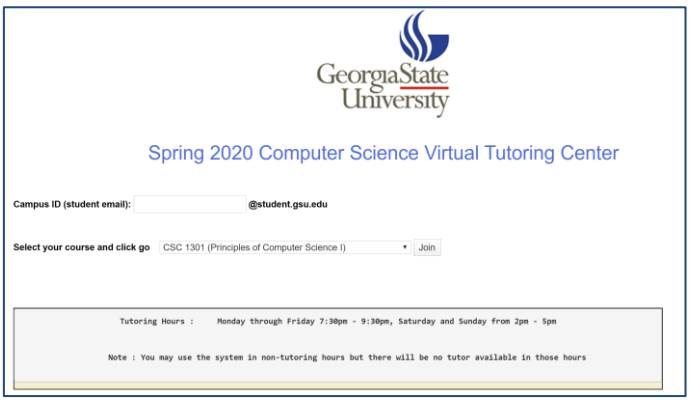

Fig. 2. Web Portal for Students to Use the VTC

The VTC management subsystem is also responsible for user management and data storing. User management handles adding/removing users (tutors and students), as well as supporting the authentication procedure. An administrator (e.g., a faculty) can add/remove tutors and students, whose information is stored in a user database. This user database is checked by the authentication procedure when users try to log in to the system. Data storing deals with storing all the login records in a central database. Each record includes user ID, login date and time, and the course name selected by the student during login. This information is useful for analyzing the usage of the VTC.

2.3 BigBlueButton HTML5 Client

The BigBlueButton HTML5 client is a single-page web application that allows users to interact in a virtual touring session. The HTML5 client is launched after a user clicks the *Join* button on the login page (see Fig. 2) and passes the authentication. It connects with the BigBlueButton server to provide the video conferencing service needed for the tutoring session. Both tutors and students use the HTML5 client to enter the conference. Tutors are identified by displaying the tutor role behind their names. Fig. 3 shows a screenshot of the HTML5 client after logging in to the system. The client window is roughly divided into three regions. The left region lists all the users (there is one tutor and one student in the Fig. 3 example). It also displays the *public chat* and *shared notes* icons. The middle region shows the public chat messages or shared notes depending on which icon is clicked by a user. The right region is the presentation/whiteboard window. It also allows a user to enable/disable audio and video, and for the user who is the presenter to share his/her desktop if needed.

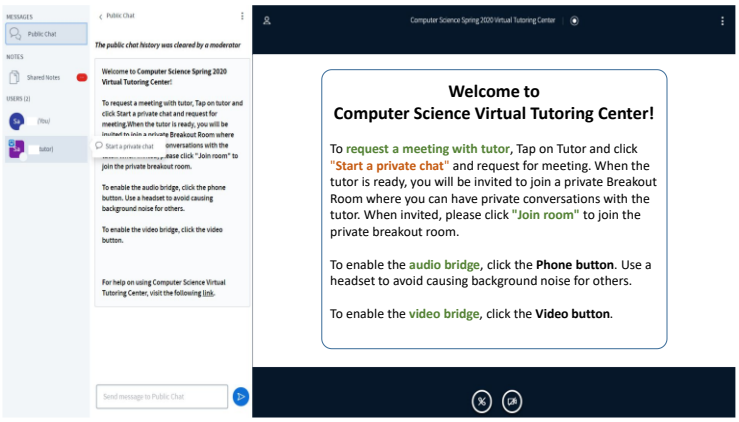

Fig. 3. Screenshot of the HTML5 Client

The HTML5 client offer a set of functions that are useful for student-tutor interaction during a tutoring session. Most of these functions are provided by the BigBlueButton system, including: 1) video and audio conference; 2) public and private chat; 3) shared notes among multiple users; 4) uploading and presenting slides; 5) whiteboard capabilities such as drawing, adding notation, and zooming; 6) desktop sharing; 7) setting up and joining breakout rooms; and 8) conference recording. Furthermore, to facilitate student-tutor interaction in a multi-student environment, we developed a waiting list feature. A student can see how many other students are waiting to talk to the tutor, add himself/herself to the waiting list, and withdraw from the waiting list if needed.

2.4 BigBlueButton Server

The BigBlueButton Server is the back-end software that enables all the video conferencing functions described above. The server runs on Ubuntu 16.04 64-bit and can be installed either from source code or from Ubuntu packages. In our implementation, we install the BigBlueButton server on an Ubuntu instance in a private cloud environment maintained by the department. This configuration allows us to store all the data within the private cloud while allowing students to access the system from the Internet.

An important component of the BigBlueButton Server is the HTML5 server (see Fig. 1), which is responsible for communicating with the HTML5 clients, and for keeping the state of each client consistent with the server. The HTML5 server maintains a database containing information about all meetings on the server as well as each client connected to the meetings. All clients subscribe to the published collections on the server, and updates on the server side are automatically pushed to clients. Within the BigBlueButton Server, Redis Publisher-Subscriber is used to provides a communication channel between different modules/applications running on the server. These functional modules include Web Cam, Audio Call, Screen Sharing, Collaborative Meeting, and Event Recording as illustrated in Fig. 1. Note that the BigBlueButton server can support users connecting from either a Flash or HTML5 client. But in this work we are only interested in the HTML5 clients.

3 Setting Up the CS Virtual Tutoring Center

The Georgia State University Computer Science (CS) department offers free tutoring to core 1000-, 2000-, and 3000-level courses in each semester through a *physical* tutoring center on campus. Students need to go to the tutoring rooms in order to get the tutoring service. In Fall 2019, the tutoring hours of the physical tutoring center were Monday - Thursday from 10am-5pm, Friday 10am–3 pm. In each time slot of the tutoring hours, two or three tutors (recruited senior or junior undergraduate students) were assigned to help answer students' questions. To supplement the physical tutoring service, we launched the CS virtual tutoring center in the middle of the Fall 2019 semester, which offers free tutoring service to students similar as what the physical tutoring center does. Students access the tutoring service through URL http://cstutoring.cs.gsu.edu/ (see Fig. 2). The tutoring hours were Monday - Friday, 7:30pm –9:30pm, Sunday 3pm-5pm. Two students were recruited to work as tutors for the virtual tutoring center. They were assigned different tutoring days so that each day had only one tutor. Since the virtual tutoring center was launched in the middle of the semester, a publicity message was sent to all students through the CS undergraduate listserv. Another message was sent to faculty to encourage them to mention the service in their classes.

4 Results and Analysis

We collected the student login data for the virtual tutoring center from October 14, 2019 (when the VTC was launched) to December 15, 2019 (when the Fall semester ended). Fig. 4 shows the weekly user data in the 9 weeks of the period, where the top figure shows the number of users in all the hours of a week and the bottom figure shows the number of users only in the tutoring hours. The week 11/25-12/01 is the Thanksgiving holiday week and there was no tutoring service provided in that week.

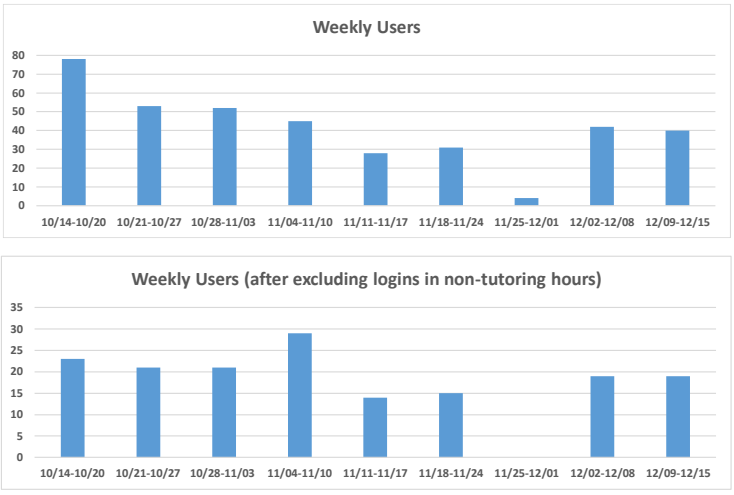

Fig. 4. Weekly Users: (**top**) all logins; (**bottom**) after excluding logins in non-tutoring hours

Comping Fig. 4 (top) and Fig. 4 (bottom) we can see that in each week there were a considerable number of students logged in to the system during non-tutoring hours. This was especially true for the first week when the system was launched, when many students tried the system in non-tutoring hours. To show the usage of the tutoring service, we exclude all the logins in the non-tutoring hours and will analyze only the tutoring-hour data in the rest of this paper. Fig. 4 (bottom) shows that on average there were about 20 students using the tutoring service in each week. Each week has 6 tutoring sessions (see Section 3). This means each session had about 3 student visitors. This number is consistent with what the tutors reported to us.

Fig. 5 shows the number of users broken down based on different days of the week. We can see that Monday had the most users and other days (including Sunday) had about the same number of users. Note that the Monday-Friday tutoring hours are in the night, which is different from the tutoring hours of the physical tutoring center. This data shows that the night and weekend virtual tutoring service is used by students and complements the physical tutoring service.

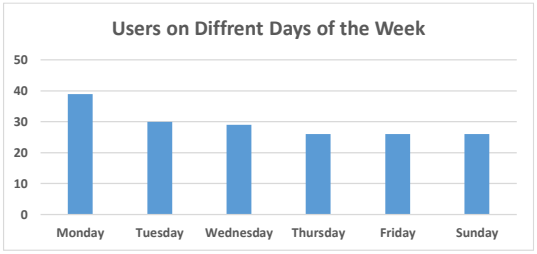

Fig. 5. Users on Different Days of the Week

Fig. 6 shows the number of times of using the virtual tutoring service by individual students, where individual students are represented by IDs not linked to their real identifications. The figure shows that a total of 77 students used the system during the 8 weeks (exclude the Thanksgiving week). The majority of them used the system only once. Nevertheless, there were 17 students used the system at least 3 times, with two of them using the system 9 times. These recurrent users indicate that the system is useful for a group of students as otherwise they would not return to use the system multiple times.

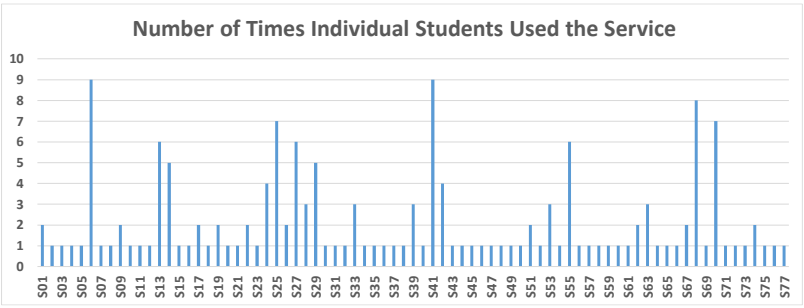

Fig. 6. Number of Times Individual Students Used the Service

The two tutors also reported other useful information that are not reflected in the student login data. First, it was often observed that several students would log in to the VTC together and asked the same questions. This is probably due to that fact that those students were studying together and then decided to join the VTC for the same questions. Second, it was not uncommon for a student to log in to the system and then leave right away as he/she saw the tutor was busy helping other students. This behavior is different from that in a physical tutoring center. How to make students stay or come back in an online environment is an interesting topic for future work.

5 Conclusion

This paper presents a cloud-based virtual tutoring center that supports online tutoring in a college environment. We present the overall architecture of the system and describe how we set up a virtual tutoring center for students in Fall 2019. Preliminary results show that the virtual tutoring center is useful to students and complements the physical tutoring center on campus. Future work includes adding more functions to the system and using the system for more comprehensive evaluation.

6 Acknowledgement

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