Interactive Video Platform for E-learning and Remote services

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Abstract

This paper proposes a PC based Interactive Video platform for e-learning and remote services. Recently, multimedia technology has been greatly progressed on content bandwidth and picture quality. Problems used to be solved by face to face meetings, now it may be solved over an Internet video meeting in no time delay. Nowadays, people who need help may use a NB or a smart phone to receive all kinds of help or solutions from all over the world. As the gradually mature of cloud computing technology, the generated large amount of audio and video contents by the aforementioned Internet video meetings, can be readily transformed and saved in a searchable video database, such that the proposed platform can provide further more complete, friendly and useful distance services.

Keywords: *Digital Contents, Cloud computing, Interactive video.*

1. Introduction

During the past decades, human excessively wastes of fossil energy, leading to energy shortages and global warming crisis. The insightful people all working actively advocate energy saving and carbon reduction to slow down the advent of the crisis. In recent years, technology new favorites, multinational business leaders, and senior government officials commonly use video conferencing as a tool to reduce travel, to save time, and to increase meeting efficiency. We believe that the next decades will be the best time to develop Internet methods and solutions to help all the people to do day-to-day activities, and to achieve comprehensive energy conservation and carbon reduction.

During the past few years, Internet multimedia technology has outstanding progressive in picture quality and bandwidth reduction. Through the Internet, people at a remote distance can immersive see and hear each other in a live situation. The need now is to integrate multimedia information and network technology, to construct video platforms, so that people who need help around the world can use a NB or a smart phone, to reach experts to get help for solutions of difficult problems.

The Internet breaks through time and space limitations, many daily activities such as meeting, teaching, and a variety of services used to be performed at a specific time and locations, can be easily performed through video connection and communication at anytime and anywhere. Coupled with the increasingly matured cloud computing technology, large amount of audio and video contents were generated by the aforementioned remote video connection, can be converted into Internet video library, so that Internet users can readily check and use these valuable contents.

During the 2008 U.S. presidential election, President Obama campaigned through video conferencing with voters close contact and played streaming video through YouTube, Justin.tv and other audio-visual platform to promote his own policies and vision. The novel way of using Internet multimedia subverts propaganda vehicles, newspapers, posters, television presentations and advertising campaign way. The network will not only be able to quickly release the information, can also provide some insufficient part of the traditional campaign propaganda. If a candidate wants to interact with voters, the past can only be paraded through the streets and running around to shake hands with voters to listen to the voice of the voters. Now use the Internet to publish information of the campaign, twenty-four hours a day at

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any time to listen to the response of the voters, to greatly expand the level of interaction with voters of various ages. President Obama applied these concepts to interact with voters of different ages, different social status, various living environment to closer distance, eventually get elected overwhelmingly.

We believe that the field of interactive video contact can be used in many types and forms of service applications. Hereby gives a few examples to illustrate.

(1) Agricultural and pastoral assistance: When farming or livestock facing pests and diseases problems, farmers or herders may take on-site photos by a mobile phone and then sent the photos to the interactive video platform to request for help to identify problems and to get solutions. On the other hand, when nearby farmers / pastoralists asked similar questions, it is likely to collect regional timely meteorological or pests disaster reports. District experts may use the received information to submit response strategies, and also to inform other areas for early prevention. This can quickly resolve the difficulties of the farmers and herdsmen, and may also get better understanding of environmental changes in near real-time.

(2) Industry and business services: When equipment or machine failure, in general, a user will notify the vendor to send someone from the field distance away to repair. If on-site personnel may use Internet video devices to take photos or scene video to the vender service departments or stations, then remote maintenance experts can clearly see and hear the situation and condition of the failed equipment over a video screen, and command or instruct on-site people how to fix failed equipment.

(3) Tutoring or teaching assistance: For a long time, a lot of college students in addition to take courses in school, but also work part-time tutoring. If interactive video devices are available at both student and tutor sides, tutor and students may have one-on-one and just like face to face tutoring at anytime and anyplace. Through interactive video connection, learners may quickly and almost immediately achieve tutoring assistance, and tutors may also save lot not necessary trips to reach students.

Interactive video platform, comprehensively applies streaming video and multimedia network communication technologies for distance people without long-distance travel, to query and answer daily life, study and work questions and problems in an energy-saving manners. After difficult problems were solved, the platform will use its video server cluster to edit and to save the problem-solving video contents at Internet AV database for later searching and referencing by many Internet users.

2. Previous works

In this paper, Internet video communication mechanisms are proposed to provide users at distance away, an interactive cooperation method to undertake research and/or assistance to solve problems. As mentioned above, an important function of the proposed platform is the video content transferring method and architecture between users. There are two commonly used architectures for contents transferring: Client-Server architecture, and Peer-to-Peer (P2P) architecture. For example, MSN's messenger chat room uses Client-Server architecture, and Yahoo's Messenger uses P2P way to send information.

The advantage of using client-server architecture is that the information can be centralized and managed by a server to achieve better security control; and its drawback is when the server fails, it is difficult to backtrack and to get lost data back. The advantage of Peer-to-Peer architecture is its capability of dispersing foregoing server, thus the relative reliability of the system will be higher; and its drawback is smoothing audio and video data transmission will be affected when Peer to Peer network bandwidth is lower.

The following are briefings of related literature and commercial available video communication systems: (1) Skype video call, (2) Windows Live Messenger, (3) Co-Life, (4) JoinNet, and (5) GAIA, etc.

(1) Skype Video call [1]**:**

Skype uses P2P technology to provide users real-time high quality audio and video communication. When the dialog parties are connected with smoothly network quality, the Skype sound quality is similar to ordinary telephone. Skype can provide two-party or multi-party video dialogue at the same time. Due to the P2P technology, Skype provides no real-time video recording function. Since storing video contents between the dialogue parties is the major resource that an interactive video platform (IVP) can use to provide Internet users with long-term accumulated useful information from previous communication activities. Some new version of the audio and video server software has been started to provide P2P functionality for more flexibility in audio and video communication services like Skype. In addition, users of Skype video do not allow markings on the video screen to illustrate the designated or important objects.

(2) Windows Live Messenger (MSN) [2]:

MSN is an instant multi-functional messaging (text, speech, and video dialogue) software developed by Microsoft Corporation. MSN uses Client-Server architecture, and handles most of the functions through a

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server, which is very convenient for task management. By going through an authentication procedure, MSN users may use message server (switchboard server) to relay/receive messages. Currently (January 2013), MSN does not provide audio and video recording/playback, focus markers and multi-language text communications.

(3) Co-Life [3]:

Co-Life is developed by the National Center for High-Performance Computing (NCHC) in Taiwan, Co-Life provides: complete network video conference, and public broadcast speech functions. Co-Life uses Client - Server architecture, to provide text, images and video communication between participant users. Co-Life provides whiteboard to help connected users to emphasize key projects, and to mark important items and/or objects. The Co-Life whiteboard can only be applied to a few specific text and/or image formats for interactive communication.

(4) JoinNet [4]:

JoinNet is a on-line meeting software, developed by HomeMeeting to provide users with video conferencing, whiteboard, synchronized web browsing and video conference recordings. JoinNet is designed according to Client-Server architecture, so the clients are not connected to each other, and the meeting server is responsible for text, images and even video exchange between participants. JoinNet uses the whiteboard as the main tool for participants to discuss the text documents, or marking important points between each other.

(5) GAIA[5]:

GAIA (Global Agriculture Information Alliance) was proposed by the Jigga-Dongxi team of National Chiao-Tung University in Taiwan to participate the 2010 Microsoft Imagine Cup competition, and won the first place on the section of **Looking to the future 2020**. GAIA pointed out that in 2020 the use of the Internet cloud computing and mobile phone mobile devices can help 800 million poor small farmers around the world at any time to obtain valuable atmospheric information from satellite, also to consult experts around the world, for information on agriculture, pest, and financial relief programs. Therefor the value of agricultural production can be greatly improved, so as to increase the personal household income, so as to reduce the disparity between the rich and the poor around the world.

We think that the goal of Global Agricultural Information Alliance may use the proposed IVP to comprehensively promote and achieve the desired objectives.

3. IVP design

Figure (3.1) shows how a video network connection can be used to allow remote experts (mentors) commanding/ teaching field personnel (learner) to operate and/or to maintain machinery or equipment. Learners may use a Webcam to take instant video of field devices, instead of just show the video at his computer screen, and also may use the Internet to pass instant video to experts, for the operation or maintenance suggestions and/or solutions for difficult problems.

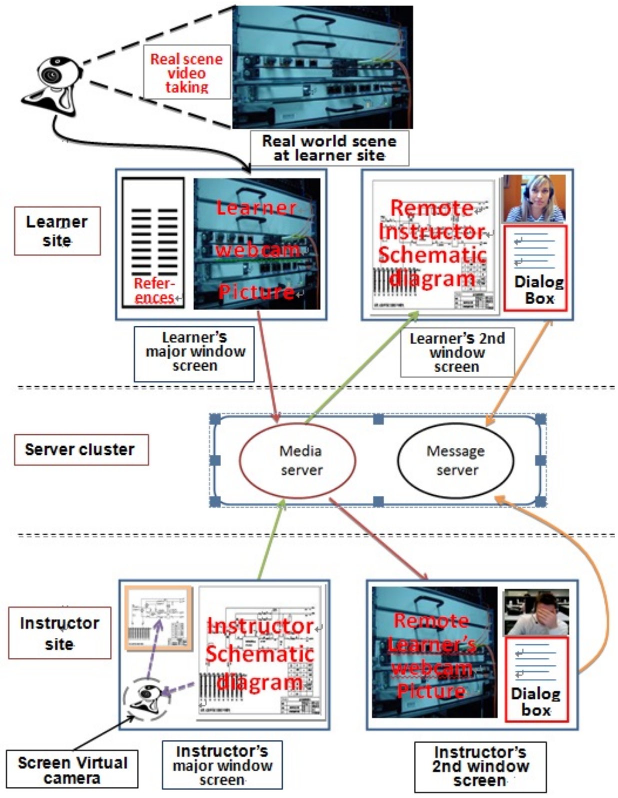

Figure 3.1: The flow diagram of an interactive video platform to be used to allow remote experts (mentors) commanding or teaching field personnel (learner) to operate and/or to maintain machinery or equipment.

In addition, if the instructor wants to show related electronic documents and/or images, or schematic diagrams, he may display these documents at his own screen first, and then use some *virtual screen camera software* [6] to convert these documents into real-time video and to pass to learners' side. Since interaction between teacher and learner has long been recognized as an important mechanism to strengthen communication effects, both instructor or learner may also want to draw simple marks or symbols over the documents displayed at video screens on both site, as shown in Figure (3.2): "⊂⊃" indicates an area or a range to be watched out), "←,↑,→,

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and↓" indicates a focusing point), "╳" means to be deleted, and "___" marks a text segment to be emphasized.

These simple markings can be easily used to remind or to emphases important text items or image objects, so that users at distance away may have a face-to-face like discussing with each other. Additionally, when the platform users have speaking language barrier problems, the platform is also available online translator to provide multi-language translation dialog box to solve the voice communication difficulties. Thus the platform can greatly expand its scope of services to almost everywhere around the world.

Figure 3.2: An example of using pointing marks to indicate a particular item or an image object on a video display screen. For example, users at distance away may use different color markings to tell each other where the "***fan steering gear***" is and how to turn on a "***computer power switch***" respectively.

As mentioned above, we believe that interactive video platform particularly suitable to be used in developing countries. In general, there are a lot of remote undeveloped areas in developing countries, thus interactive video platform can be immediately used to narrow the distance from the people of the metropolitan areas and the remote undeveloped areas, so that the life, education, and industrial and commercial standards of remote areas can be helped and improved rapidly.

4. Architecture of interactive video platform

As shown in Figure 4.1, the interactive video platform (IVP) uses the Client-Server architecture to achieve its structure functionality needs. A user at client-side may set up available video devices first, and may use a browser to connect the IVP for audio and video communicate with other users at the platform. The server clusters at the platform process the video contents from sending users and dispatch the video contents to designated users. The platform contains three types of different function server clusters: Web Server (WBS), Media Server (MDS), and Message Server (MGS).

When there are more and more users at an IVP, its workload will eventually transcend the service capability of a single server. Thus, the server will not be able to deal with the instant needs of users, and cause the users to wait for a long time or unable to get connected to the platform. Eventually, the IVP's service quality is greatly reduced.

Therefore, how to establish a platform for scalability to meet the ever-increasing load, has become an important issue for the architecture design of the platform.

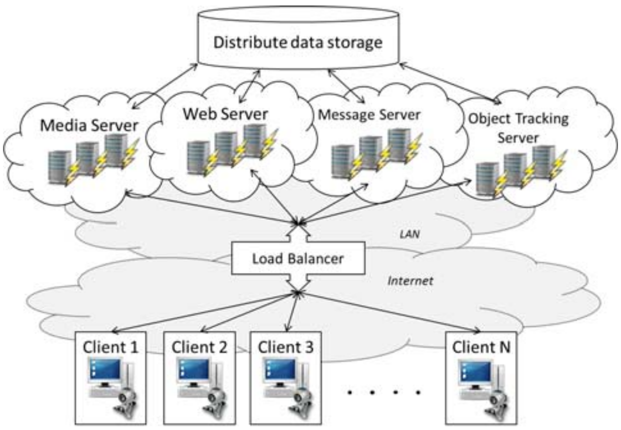

Figure 4.1: The architecture diagram of the proposed interactive video platform (IVP).

Suppose the financial budget to construct and to maintain a server cluster is limited, how to provide high quality services to a large number of users is a topic of concern for cost-effectiveness. Therefore, scalability, availability, and cost-effectiveness are three key points to the design of network based architecture for the proposed IVP. The balanced design considerations of the proposed IVP are summarized as follows.

Web Server (WBS) Design: Web server provides client side users a browser to connect other users and to use various types of server functions available at an IVP. A user, whether to be an expert or not, must be a registered user to use a browser to connect the IVP. In addition to general personal information, e.g., user name, email address, nickname, mobile number, registration at IVP also includes personal interests, skills and expertise level. According to the skills and the expertise level of the on-

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line user, WBS connects associated experts for the on-line user.

Media Server (MDS) Design: Media Server provides users of various video associated functions available at IVP, such as video publishing, sharing to editing, storage, and reuse. Adopting Client-Server architecture for the design of IVP is mainly for the convenience of server-side, to centralize editing and management of audio and video contents and database, and to reduce the workload and hardware requirements of the client-side.

Message server (MGS) Design: Among various interactive processes at the IVP, prompt and clear message communication between users is very important. If there is only video interaction available, it may cause semantic ambiguity or emphasis vague situation between users. Therefore, additional interactive text message communication is added and provided by MGS. The benefits of interactive text message communication are at least three fold: be able to achieve careful expressions of semantics, be able to repeatedly view and read messages, be able to provide multinational language translation. A MGS completes each interactive communication service by linking associated users and experts in a ***discussion chamber***, and is responsible for manipulation and management of each discussion chamber like mechanism. Each of the aforementioned streaming video transfer is also controlled by the mechanism of associated discussion chamber.

In addition to the aforementioned three types of servers, when the loads of an interactive video platform reach its upper limit, the load balance server may add extra servers to enhance the service capabilities, and also the toughness of the server clusters. Thus, the major architecture design goals: i.e., *scalability*, *availability* and *cost-effectiveness* for the proposed IVP can be satisfied.

5. Benchmark and evaluation of IVP server cluster

According to the aforementioned design descriptions, a prototype of the interactive video platform has been implemented at http://140.113.216.64. Basically, the design of IVP needs to provide a web interface, video streaming, discussion rooms, and some other associated functions. Suppose these services are provided by a single server, and when the number of users increases, the host server must gradually to withstand the decline in service quality. Below, we will present how to use cheap PC components and Open source software (e.g., dual-core CPU, motherboard, 4G RAM, SATA-300 7200rpm hard drive, Fedora OS, Apache, the WBS, Adobe FMS and MySQL database) to compose the proposed functional servers. Then, the composed servers are tested and evaluated under different using and working environments. The performance testing results will be important references for the design of the proposed IVP.

The followings are the hardware and software component specifications of the servers to be used in the proposed platform:

- **CPU**: Intel Pentium *Dual E2200* @ 2.20GHz;
- **RAM**: 4GB;
- **Hard Disk**: Seagate ST3160815AS, 160GB SATA-300 7200rpm Hard Drive;
- **OS**: Fedora 11;
- **WBS: Apache 2.0**;
- **MDS: Adobe Flash Media Server 3.5**;
- **DATABASE**: MySQL.

Benchmark of Web servers (WBS):

On the WBS testing, we chose to use Apache Bench (AB) [7] to test the system reaction time under different number of users. Since the response time of most well-known websites, is less than 0.5 second. As shown in Table 5.1, when the number of the on-line users is lesser than 200, there are 90% of users (i.e., 180 users) feel the system response time of about 0.5 seconds. And when the number of Internet users increased to 1000 the average response time of the system is increased to about 1.9 seconds. Thus, if the proposed platform wants to provide the same level of quality of service, it is suggested either to increase the number of WBS, or to enhance performance of the existing WBS.

Benchmark of Media servers (MDS):

The MDS benchmark testing and measuring includes CPU load, hard disk load and network load three parts. The system resource monitoring program -- **iostat** [8] in Linux and 700kbps video streams are used to test and to measure the performance of MDS. The Network load associated with MDS video I/O is estimated by linear interpolation.

Figure 5.1(a) shows the relationship between the CPU load vs. the number of played video clips in a MDS video server. For example, when 20 different video clips are playing in one MDS, the associated CPU idle rate is still as high as 99%. It seems that video playing consumes very small amount of CPU load. As proposed in [9], Adobe Flash Media Server may consume up to 50% of CPU load, when 1000 different video clips are playing at the same time.

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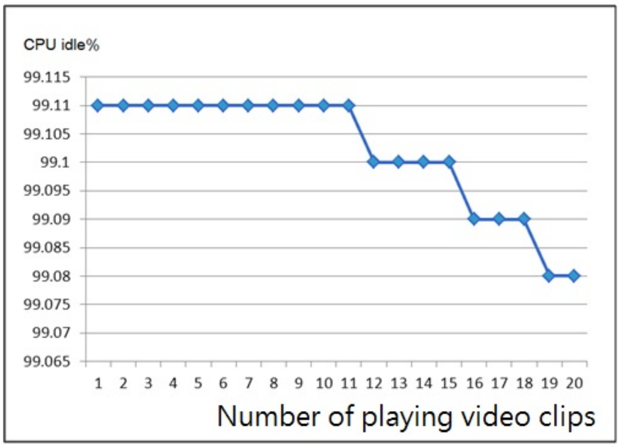
Table 5.1: The Apache benchmark response time (in ms) of the proposed WBS under different number of on-line users.

Response time / % of response users / Number of users	50%	75%	95%	100%	Average response time
1	3	3	3	371	3.450
100	159	177	271	7003	176.715
200	257	368	737	26180	348.594
300	341	444	1099	22792	526.609
400	435	637	1779	43596	709.118
500	418	562	3473	39098	893.391
600	493	794	3578	46094	1070.507
700	402	540	5677	49204	1249.806
800	389	568	5682	49922	1480.069
900	350	712	6608	52564	1633.891
1000	298	448	5543	58450	1929.697

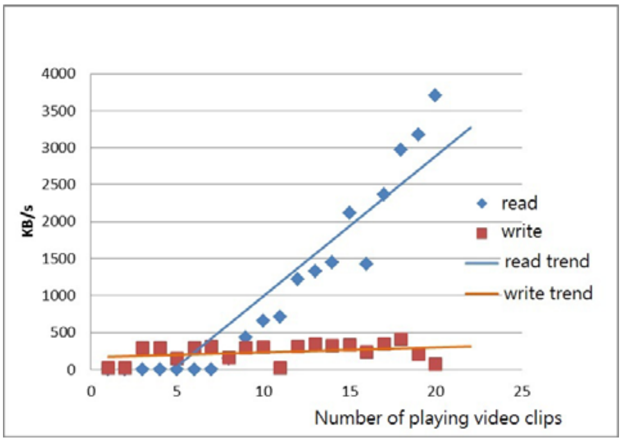
Figure 5.1(b) shows the testing of hard disk I/O workload vs. the number of played video clips. Since the major workload of video playing is disk read, thus the video disk write generates less than 500 KBPS for 20 or less video clips, and this I/O rate may last until all the RAM memory are all used up. On the other hand, the I/O rate of video disk read may be increased in proportion to the number of played video clips. According to the trend of least-squares fitting in Figure 5.1 (b), for each additional video clip playback, the HDD load will be increased by approximately 200 KBPS, thus the following descriptions will only focus on the disk read.

According to the design of Adobe Flash Media Server [10], when broadcasting video streaming, each video clip will be partitioned into 256KB chunks. Therefore, the hard disk I/O capacity is limited by its random access capability of 256KB block. By using the **iometer** [11] to benchmark a hard drive with 256KB chunks, the upper bound of average transfer rate is 35.87MBPS. According to this transfer rate, a hard disk drive could bear 175 playing video clips with 700kbps I/O bandwidth, which generates 130Mbps network load, and consumes10% of CPU load.

In terms of network load, the Adobe flash media server [10] suggests the traffic rate of a single MDS network interface should be controlled to be under 70% of the available network bandwidth, and reserves at least 700kbps bandwidth for each playing video clip to ensure smooth play back video streaming. In the followings, it is suggested that 70% of the total network interface bandwidth is used as the maximum total video streaming flow, which is also used to estimate the number of simultaneous playback of video clips.



(a)



(b)

Figure 5.1: (a) The relational diagram between the numbers of simultaneous playback video clips vs. the CPU load of a MDS; (b) The relational diagram between the read and write bandwidth vs. the number of simultaneous playback video clips of a MDS hard disk drive

Benchmark of Message servers (MGS):

First of all, the relation between multiple discussion chambers vs. associated MGS CPU load is tested. As shown in Figure 5.2, operating multiple discussion chambers occupies only a very small amount of CPU load. The 2nd test is about the relationship between the number of discussion chambers and the number of users in a

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chamber vs. the MGS network traffic flow rates. The test data is a string of English characters of length 50. Suppose 1000 discussion chambers are initiated at the same time, and each discussion chamber contains an average of 20 people, and one character string is sent out per second per chamber, then the needed network bandwidth is approximately 200 KB/Sec. The testing results are shown in Figure 5.3.

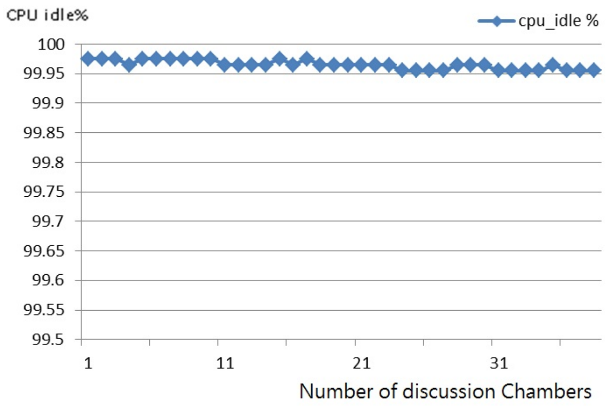

Figure 5.2: The relationship between the MGS CPU load vs. the number of discussion chambers.

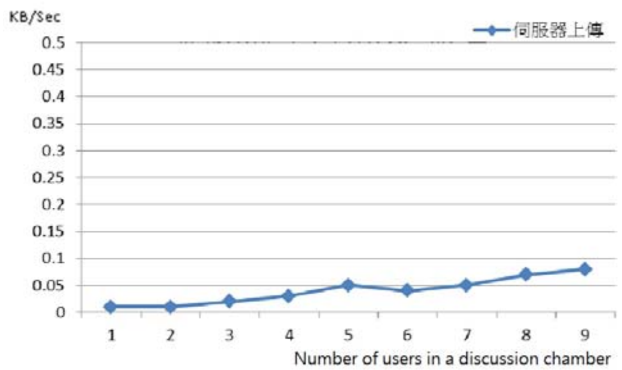

Figure 5.3: The testing results show the relationship between the MGS network traffic flow rates vs. the number of users in a discussion chamber.

6. Conclusions

This paper describes how to use the rapid development of network multimedia technologies [12, 13, 14], to construct an interactive video platform for e-learning and remote services. An Internet user may use a simple PC based video equipment (such as Webcam) to connect the proposed platform to achieve variety of assistance from experts around the world at any time. In the near future, we plan to implement a cloud computing based interactive video platform to test the functional performance, the user friendliness, and the robustness of the network architecture of the proposed video platform. Then, we may build a larger platform to perform real world test and evaluation of e-learning and remote services over Internet.

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