

A distributed interactive virtual classroom system

Zhao Xindong¹ Xing Yuelin^{2*} Liu Ling³

¹Jiangsu Provincial Electric Power Science Research Institute

²School of ISE, Shandong University, Jinan 250100

³IGSNRR, Chinese Academy of Sciences, Beijing 100101

xingyl@sdu.edu.cn

Abstract

Interactive Virtual Classroom System (IVCS) is a part of Jiangsu Electric Power Company Network University (JSECNU). This paper describes the architecture and technology of the IVCS, and presents a distributed deployment scenarios of the IVCS based on the enterprise's network architecture, in order to support large-scale user access from different regions. With a central dispatch server, login through a dynamic routing algorithm, the system has the ability to load balancing and nearby Login. The program also supports a disaster recovery mechanism, connection loses caused by failure of any of the distributed servers can be restored within a very short time.

Keywords: IVCS, dynamic routing algorithm

1. Introduction

Jiangsu Electric Power Company is a subsidiary of the State Grid Corporation of China, with branches at 13 cities in Jiangsu province, and about 100,000 employees. As an important part of Jiangsu Electric Power Company Network University (JSECNU), the Virtual Classroom System (IVCS) undertakes a number of teaching tasks, such as online lectures and online discussions. Students scattered across the province can participate

booked courses through IVCS. The system log can be recorded automatically, such as log information of opening a network course, and attendance information of students, to conduct course evaluation and student evaluation.

The application of IVCS provides a web-based virtual teaching space for JEPNU. As a supplement to the original mode of centralized-training, IVCS saves a large number of training resources, reduces training cost, and, increases training efficiency exponentially. Overall technical quality of staffs has been promoted greatly.

2. System architecture

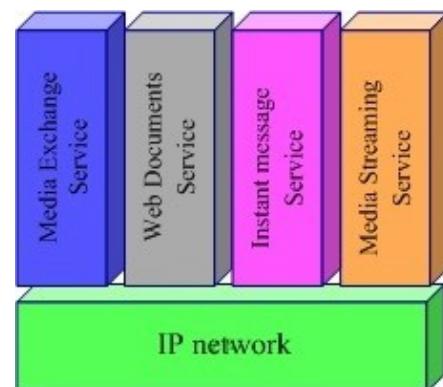


Fig. 1: IVCS Architecture

The IVCS is based on C/S structure, and relies on several services as shown in Fig.1. Media Exchange Service is a real-

time engine to accomplish distribution and synchronization of audio and video streams among clients, such as teacher and active students. Web Document Service is used to complete the conversion, publishing, distribution and synchronization of teaching materials (ppt, xls, etc.). Instant message Service allows teachers and students to exchange through typing. Media Streaming Service provides live and on-demand streaming media capabilities, such as to broadcast videos from teaching resources library, or to replay course videos after class.

The IVCS is tightly integrated with the information platform of JEPCNU. Course information is released through its portal, and is also sent to relevant students via e-mail system. By clicking the course link on the portal or in the email, students can directly launch the client and log into the IVCS. Client software of IVCS will be installed automatically, online automatic update is also supported in order to synchronize software versions with the one on server side.

3. Technology and applications

The IVCS applies VoiceEngine from Global IP Solutions (GIPS)[1] to provide clear and smooth audio service, and H.264 codec to support HD video (720p). The control logic framework in the server system controls the audio/video data stream exchange between the client and server with rtp/rtcp protocol. A modified FEC technique is used to control the impact of network packet loss of audio quality. An independent consultative mechanism is used at each video distribution path (channel) to adjust the video frame rate and compression quality parameters.

In the IVCS, XML technology is applied to achieve a standard Web server-based document management and collaboration system. Through integration with our original Web document annotation tech-

nology, IVCS achieves prominent data collaboration capabilities.

IVCS is based on multi-processor architecture, and can support most of the hardware platform. The design ideas of core thread priority protection and fault-tolerant data stream make the IVCS more stable, and can support 7x24 hours of maintenance-free operation. Efficient design of server software enables a single server to support up to 500 concurrent users and more than 1500 channels of video streams exchanged without affecting the video quality.



Fig. 2: IVCS client screen-shot

As shown in Fig.2, user-lists are shown at each client sides, and teachers can control the display and synchronization of videos, and specify the operation of students who want to speak. Teachers can also play pre-made slides (PPT) on courses, or refer to courseware from a cyber source library, such as web pages, documents, video data, or even share computer application software interface with students. Each student can realize face-to-face communication with teachers, initiating questions through typing or voice, or even displaying his own electronic works.

4. System deployment

In order to support more large-scale network courses, the IVCS consists of a group of master-server clusters and a

number of distributed servers. After being registered to the central master-server, distributed servers can exchange control signal, audio and video with master servers.

4.1. Master-slave cascade architecture

Servers in the framework of the distributed IVCS play different roles. There is one master server, and, many slave servers in this system. A trans-server Distributing cascade conference room (D_{Room}) can be created on multiple servers in a master slave cascade architecture.

As shown in Fig.3, master server is responsible for the state maintenance of the Distributing cascade conference room (D_{Room}). The slave servers response to the commands from primary server, and execute various operations, such as virtual classroom control logic, requesting/distributing of audio, video and data stream.

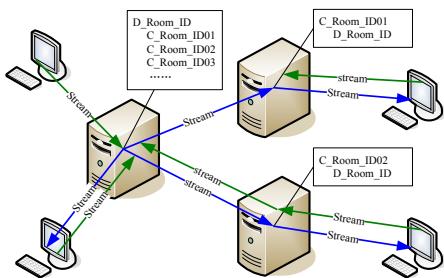


Fig. 3: Streams in a master-slave cascade architecture

4.2. Resource management and scheduling

Distributed servers in IVCS provide various resources, including shared client connection resource, virtual classroom space resources (D_{Room}), shared data resources, and, preset network bandwidth resources.

Scheduling server is responsible for the above-mentioned resources management

and scheduling. After virtual classroom server resources are added to the system, Scheduling server monitors them and maintains the resource-status list. A normally-operated server will be marked as available, while a failed one as not available. In this way, all the resources are monitored, scheduled, and shared throughout the whole system.

Supported with the scheduling server, an administrator can create, freely, a trans-server virtual classroom (D_{Room}), with many available system resources, and realize audio, video and data synchronization through requesting/distributing mechanism built in the cascade architecture.

5. Dynamic resource scheduling

Unified management of system resources is provided by scheduling system, such as management of distributed IVCS, system resources monitoring, D_{Room} management, and other functions.

5.1. Real-time system resources monitoring

Resource-monitoring service provides server-status data, including CPU utilization, memory usage, network utilization, virtual classroom service status, virtual classroom communication port status, connection number, etc. Scheduling server dynamically update list of available resources, under assessment to the monitoring data. Assessment methods are derived from predefined evaluation criteria, or algorithm, which can be updated and revised.

5.2. VC booking algorithm

Virtual classroom (VC) booking algorithm is the key algorithm of IVCS. It is based on system information (resources available, resources location, connection number limit, network bandwidth limit, etc.). A suitable model and resources

needed are appointed for each virtual classroom, according to its booking information (size, time, and user distribution, etc.). Booking algorithms can be updated and revised.

5.3. Dynamic resource routing algorithm

Dynamic resource routing algorithm creates a routing table for each user, based on its current position and available resources list of the system. The routing table includes a primary server and some standby servers that this user can log on. As an access to the system, the routing table needs to be downloaded from the scheduling server, and guides the user to log on. The information of the routing table will be updated automatically, according to the resources list.

The sequence of suggested servers (primary server, 1st standby server, 2nd standby server, and so on) in a routing table is determined by some preset parameters and weights. Default parameters are determined by the relative-position between users' network and the system servers, as well as the load level on system servers. When a user logs on, system will first try to log him to the primary server. If fails, it will try with next suggested standby server. Dynamic resource routing algorithm can guarantee the users log on to the most economical server, thus to maintain low power consumption and reliability of the system.

5.4. Load balancing

In the load balancing algorithm, status of server-resources (such as user number of connections, serving bandwidth, etc.) will be set a warning threshold. Once achieve any threshold, the server will be lowered at its parameter weight accordingly. Thus server selection result from dynamic routing algorithm is affected, server load

and network load are optimized, and system's reliability and stability are improved.

5.5. Disaster recovery

System will monitor the resource status in real-time, update dynamic resource routing tables accordingly and send them to all active virtual classroom clients. If a server fails, the client that is using it will log on the standby server in its routing table, to restore the course. Disaster recovery mechanism makes the distributed IVCS can recovery automatically from server failures. Average time for affected users to recover is less than 15 seconds. Master-server cluster is built by hot standby technology. When a main server breaks down, through a scheduling service, alternate master server can replace it, thus ensure the entire cascade architecture is not affected much. With multi-server collaborative and flexible transparent cascade technology, we are able to build a large-scale virtual classroom system to support thousands of concurrent users.

6. Conclusion

In 2011, Jiangsu Electric Power Company deployed the distributed IVCS. With two master servers, one scheduling server and five distributed servers deployed across the province, the IVCS can support 20 online courses, accommodate 3000 interactive teaching node at the same time. As a new type of corporate-training mode, the IVCS has improved training efficiency greatly.

7. References

- [1] <http://www.webrtc.org/reference/architecture>