The Design of Multimedia Multicast System in Campus Network Based on Three-tier Architecture

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ABSTRACT

Multimedia network technology is one of the most popular technologies in network application development, such as video conference, network classroom and other multimedia services. However, these services have high requirements for network delay and bandwidth. In addition, Facing the future and the "post epidemic era", aiming at the problem of multimedia application on the network, If we use the usual unicast communication, it will inevitably lead to a serious waste of bandwidth, and greatly increase the burden of the server, which is obviously a pair of contradictions with precious resources; if we use multicast communication, we can reduce this contradiction. This paper introduces multicast technology firstly. Secondly, it puts forward the multicast idea of campus network multimedia system: deploy IGMP snooping protocol in switching Ethernet, and combine VLAN technology. Thirdly, it provides a framework of multimedia multicast system on the campus based on MVC pattern. Then it describes the designing solution particularly and development method of the difficulty. By experiment, this system has good maintainability and expandability. In the multicast communication mode, the network traffic does not increase with the increase of the traffic, and obtains a good subjective quality evaluation. Audio / video transfers fluency, the flux of network reduces, and has a shorter transmission delay.

CCS CONCEPTS

• **Networks**; • **Network architectures**; • **Network design principles**;

KEYWORDS

Campus multimedia, LookupDispatchAction, Multicast, IGMP snooping

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1 INTRODUCTION

Multimedia applications require the client to play sound and image smoothly, and the sound and image should be synchronized. Therefore, the delay and bandwidth of the network are very high. But for the precious network resources, this has formed a pair of contradictions. How to use the least time and space to transmit and solve the video / audio service?

Especially, Novel coronavirus pneumonia in schools in 2020 brought 87.9% schools to the world. The novel coronavirus pneumonia has hitherto unknown impact on the world, bringing more risks and uncertainties to mankind. Many colleges and universities around the world have closed their campuses and started online education, Facing the future and the "post epidemic era", with the normalization of epidemic prevention and control, students have returned to the campus, and universities need more refined management, such as: class capacity problems, campus network internal online classes and other issues. During the online class, there are a lot of multimedia data packets about audio and video in the campus network. Multimedia service has a large amount of data, strong delay sensitivity, smooth and synchronous playing of sound and image, so it is necessary for the network. Multicast technology is solve the problem of sending large amount of data and large number of users. Video / audio services using multicast technology, not only can save bandwidth, can further improve the QoS of media, but also can expand the size of session nodes, reduce the burden of the server [7].

According to geographical scope, multicast can be simply divided into IP multicast and LAN multicast. LAN multicast only needs to implement group management protocol which supports dynamic group, and does not need routing protocol. IP multicast needs routing protocols, such as distance vector multi-target broadcast routing protocol (DVMRP), multi-target broadcast open shortest path first protocol (MOSPF), protocol independent multi-target broadcast routing protocol (PIM), etc

According to the ISO/ OSI reference model, it can be divided into application layer multicast, network layer multicast (IP multicast) and data link layer multicast .The deployment of multicast is a system engineering. The application layer, network layer and data link layer need to deploy corresponding multicast. It is not enough to deploy multicast only in the application layer. The network layer must also deploy the corresponding routing multicast protocol. At the same time, the data link layer must also deploy the corresponding layer-2 multicast protocol. As long as one intermediate device is disconnected, multicast cannot be realized. Only in this way can we achieve real multicast and improve the performance of the network.

At present, switching Ethernet technology is widely used in campus network. Although the use of this technology makes the conflict domain significantly reduced, all hosts are still in a large broadcast domain, which is easy to cause "broadcast storm".

2 CAMPUS NETWORK MULTIMEDIA MULTICAST SYSTEM ARCHITECTURE

2.1 Build network environment

Although some systems also use multicast technology to solve "broadcast storm" encountered in multimedia services, in fact, there is no real meaning of multicast, and the processing of multicast data is still the way of broadcasting. Only in the application layer, there is no multicast; in the network layer and data link layer, there are a lot of broadcast packets flowing on the network, which seriously wastes the network Network bandwidth and host resources [1].

Therefore, this paper puts forward the multicast idea of campus network multimedia system: deploy Two-Layer multicast protocol. At present, there are CGMP (Cisco group management protocol), GMRP (GARP multicast registration protocol) and IGMP snooping.

CGMP is a communication protocol used between router and switch. The main working mode is that the router informs the switch of IGMP table information through CGMP message. The CGMP module on the switch will convert the group host in IGMP into group VLAN, and forward multicast data according to this relationship. The advantage of CGMP is that it is easy to implement and the switch does not participate in group management. Its disadvantage is that both routers and switches need to configure CGMP. If CGMP is used, routers and switches need to deploy new protocols, and they must be used together, which is not conducive to multicast expansion of current network topology.

GMRP which depends on the transmission function of GARP (Generic Attribute Registration Protocol), can be used to solve completely two-layer multicast communication. It is a pure two-layer protocol. The host registers the multicast MAC address with the switch through GMRP, and the switch maintains the corresponding table of host Mac and multicast MAC address. The advantage of GMRP is that it does not rely on routers, and can work with IP, IPX or other network layer protocols. It has good scalability, fast forwarding speed, and supports a large number of groups. When using GMRP, the network interface card and layer 2 switch of the host must provide support for GMRP. However, the protocol stack of existing equipment and system does not support GMRP sufficiently, and the traditional multicast software is compiled on the basis of IGMP. If layer 2 multicast is implemented, the migration from IGMP to GMRP is also needed. If there are three layers of multicast, the mapping method between GMRP and IGMP must be provided.

So, without changing the equipment and software of the original host and router, how to provide layer-2 multicast capability and realize seamless connection with the original layer-3 multicast is the main problem we need to solve.

Therefore, this paper deploys IGMP snooping protocol in switching Ethernet.

IGMP snooping, also known as IGMP Listening, refers to LAN switches to listen on IGMP sessions between hosts and routers. When the switch hears the IGMP report of a specific multicast group of a host, it will add the port number of the host on the relevant multicast CAM table. When the switch hears the IGMP leave group message of the host, it removes the port of the host from the CAM table [5], [11], [12].

According to the network environment built by this idea, multicast is realized from application layer, network layer to data link layer, and the network performance is completely improved. The author has tested the multicast packets flowing in the campus network through the Etherpeek protocol analyzer and confirmed this point.

2.2 Architecture software scheme

In order to make the system maintainable, reusable and portable, this paper proposes a software architecture based on MVC mode. MVC is to separate the input, processing and output processes of an application completely according to the model, view and controller processes. An application is divided into three layers: model layer (data persistence layer), view layer (presentation layer) and control layer (business layer). MVC pattern is the first design pattern that separates presentation logic from business logic [2], [3].

In the system architecture scheme, the data persistence layer is mainly responsible for database system, transaction processing and other responsibilities, which can be realized by using hibernate framework; the presentation layer is mainly used to process customer requests and call corresponding logic modules, And the results are returned to the client in the form of dynamic web pages, which can be realized by JSP / struts technology; the business layer is mainly used to realize the specific business logic of the application system, which is the core of the system application, which can be realized by MVC framework (see Figure 1).

With the use of Struts framework, the campus network multimedia multicast system has the characteristics of flexibility, strong scalability and high degree of reuse. Struts are an open source project organized by Apache. The underlying mechanism of struts also uses MVC mode [8], [9], [10]. The action-servlet completes the function of the controller and reads the configuration file (struts-config.xml), initialize the corresponding ModuleConfig object for different struts modules. The controller receives the HTTP request, finds out the action subclass corresponding to the request from ActionConfig, distributes the request to the specific action class for processing, and selects to call the JSP file according to the processing result; if there is no corresponding action, the controller forwards the request directly to the JSP page. Before the controller calls the execute method of the specific action, the action form object will use the parameters in the HTTP request to fill itself, and automatically save these parameters in the Servlet context in the way of JavaBean, so that they can be called by other action objects or JSP [6].

Generally, an action contains only one execute method, which is responsible for executing the corresponding business logic. After the execution, an ActionForward object is returned. The controller forwards the work through the ActionForward object. Generally, the function of getting data and executing business logic is put into specific JavaBeans, while action is only responsible for the control related functions (see Figure 2).

3 REALIZATION OF MAIN TECHNOLOGY OF THE SYSTEM

The main functions of campus network multimedia multicast system are: Teacher Center, student center, multicast center. Teacher

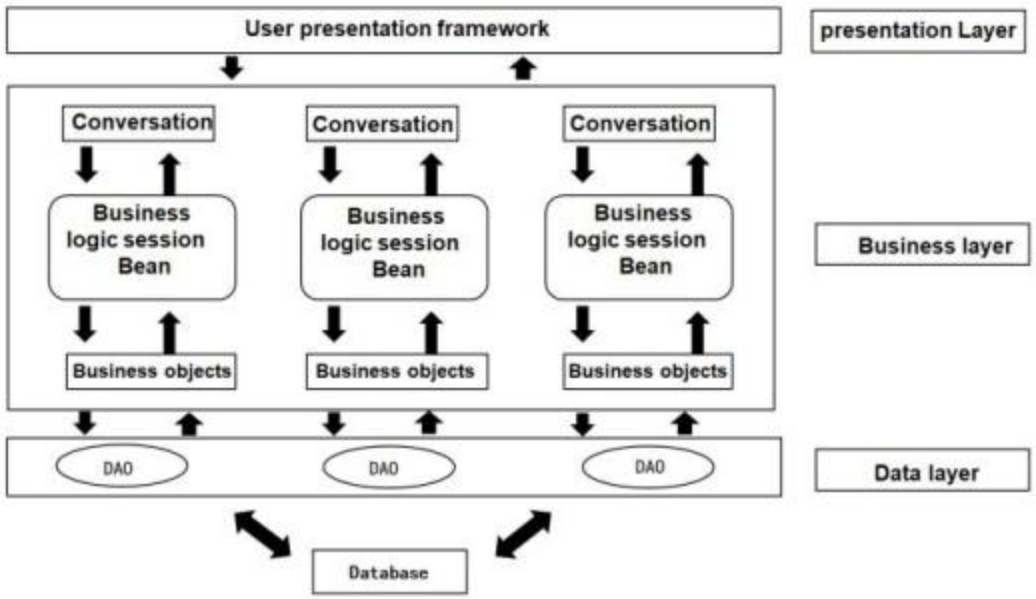

Figure 1: MVC Framework

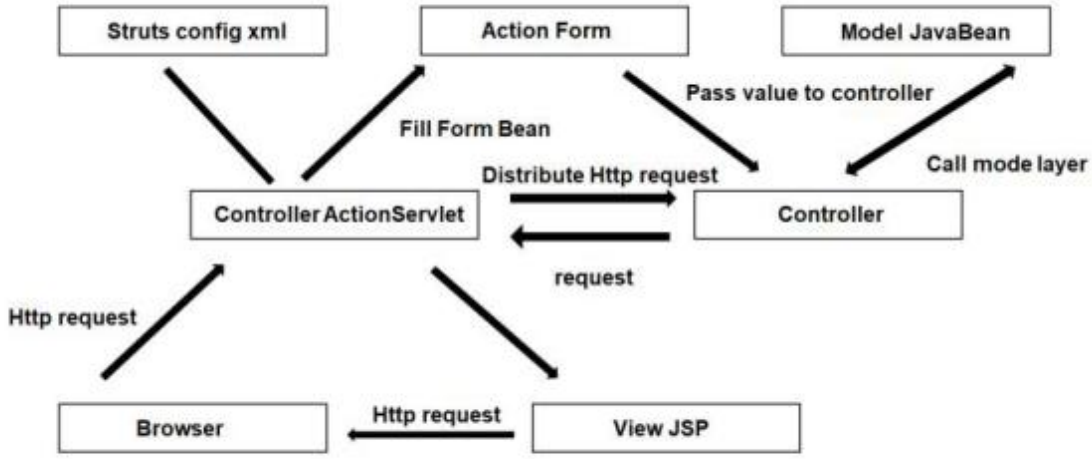

Figure 2: Struts Framework

center and student center mainly complete the registration and management of teacher and student information, and teacher center includes the release of multicast information by teachers (the multicast address is assigned by administrators). Multicast center includes query multicast, join multicast and leave multicast. Query multicast mainly completes random query and condition query of multicast information. Random query means that students can randomly select from the current active multicast after logging in the system. Query by condition means that students can select their own interested courses and teachers' groups after logging in the system. Joining multicast mainly completes the real-time classroom teaching process, including voice, video and text. If students have questions, they can ask teachers online, and teachers can respond immediately. Both joining and leaving multicast are dynamic. Students can join and leave groups dynamically. The stability of the system is not affected by group size (number of students). The web page for querying multicast is shown in Figure 3.

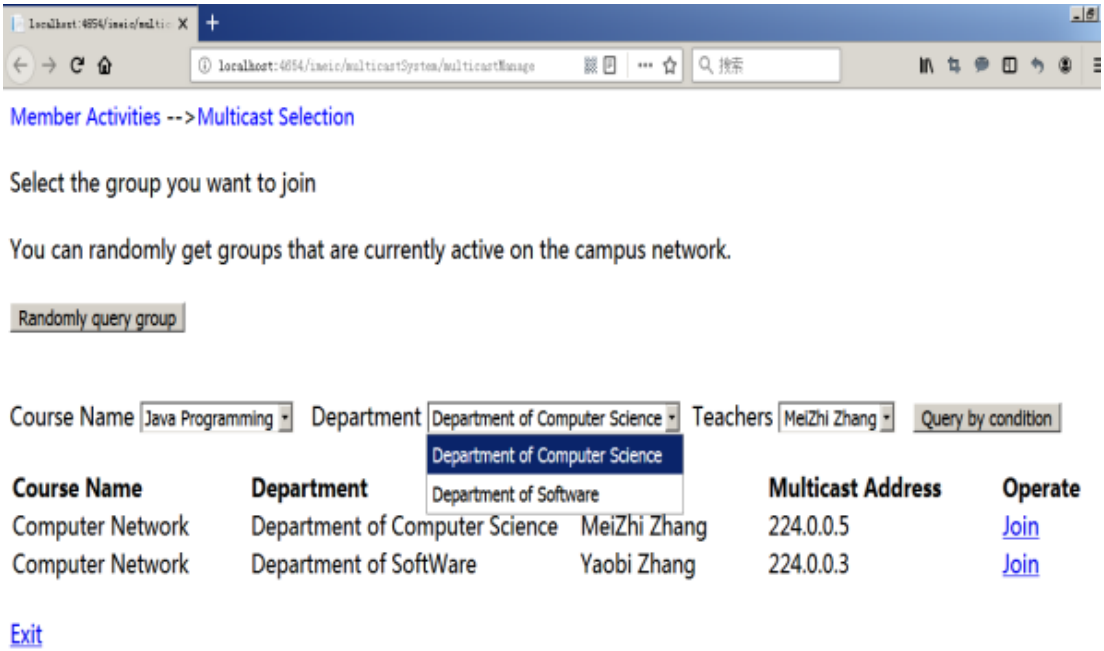

Figure 3: Random query and conditional query of multicast

The page has two functions, one is to query the current active multicast randomly, the other is to query the current active multicast according to the conditions. Therefore, LookupDispatchAction in action is used in the implementation of query multicast. The reference of this technology improves the flexibility and reusability of the system.

The specific implementation process and some codes of query multicast are as follows:

First of all multicastManage.jsp Add:

```
<html:form action$=$ "/member/ multicastManage.do "
 method$=$"post">;
< html:submit name$=$ " method.random "Value $=$" random
 query group "/ >
< html:submit name$=$ " method.condition "Value $=$" query
 groups by criteria "/ >
Note the value of two names:`` method.random "And" method.
condition ".
In Struts- config.xml Add to profile:
<form-bean name$=$"matchForm " type$=$" com.sjtu.web
 .MulticastManage Form"/>
<action name$=$"matchForm" path$=$"/member/
multicastManage" type$=$" com.sjtu.web .
MulticastManageAction" parameter$=$"method" >
<forward name$=$"multicastSuccess" path$=$"/member/
 multicastManage.jsp / >
<forward name$=$"multicastFail" path$=$"/member/
 multicastManage.jsp " />
</action>
```

Please note that the parameter value is "method".

Next, focus on the implementation of MulticastManageAction, which has two functions: random: random query multicast; condition: conditional query multicast.

public class MulticastManageAction extends LookupDispatchAction {public ActionForward random(ActionMapping mapping, ActionForm form, HttpServletRequest request, HttpServletResponse response) throws Exception {

}

public ActionForward condition(ActionMapping mapping, ActionForm form, HttpServletRequest request, HttpServletResponse response) throws Exception {

multicastManageForm matchForm=(multicastManageForm)form;

List members=null;

Try{members=service.multicastQuery(matchForm.getCourse(), matchForm.getTeacher(),matchForm.getDeparment( ));

request.setAttribute("addresss", addresss);

return mapping.findForward("matchSuccess");

}catch(Exceptione){

return mapping.findForward("matchFail"); }}

protected Map getKeyMethodMap() {

Map map=new HashMap();

map.put("method.random", "random");

map.put("method.condition", "condition");

return map;}}

Please note that getKeyMethodMap( ), implements the "method.random" And "method.condition" .The two key values are put into the map, and these values are multicastManage.jsp —the name of the two buttons in.

Table 1: System performance test results under traditional communication mode

Number of student computers		1	5	10	20	50
Server traffic (bps)	DL	168.6K	174.8K	177.4K	169.1K	176.4K
	UL	155.3K	760.4K	1.3M	2.7M	7.1M
Quality evaluation		excellent	good	good	secondary	bad

Table 2: Test results of system performance under multicast communication mode

Number of student computers		1	5	10	20	50
Server traffic	DL	168.1K	171.2K	168.3K	177.3K	169.5K
(bps)	UL	138.5K	153.4K	159.6k	160.4k	189.6k
Quality evaluation		excellent	excellent	excellent	excellent	good

4 EXPERIMENTAL TEST AND CONCLUSION

In order to test the performance of the campus network multimedia system under MVC mode. Du Meter can test the UL (up load), DL (down load) and peak rate of the network ports of the server and client.[4] When testing, the video size is 160 * 120 in the experiment, and the video content is mainly the teacher's head image. MPEG-4 video coding standard is used to compare the traffic of traditional communication mode and multicast communication mode respectively (see Table 1 and Table 2).

It can be seen from table 1 and table 2 :in the traditional communication mode, with the increase of the traffic, the network traffic increases significantly, and the quality of service decreases significantly, while in the multicast communication mode, the network traffic does not increase with the increase of the traffic, and obtains a good subjective quality evaluation. At present, based on MVC mode, multimedia multicast system of campus network runs stably and reliably, and audio / video transmission is smooth and natural.

5 EXPECTATION

With the application of IPv6, multicast technology is an important part of IPv6 system. The multicast address space has reached 1 / 256 of the whole IPv6 address space, and the address management mechanism has a lot of room for development, which also provides a solid guarantee for the maturity of multicast routing technology and multicast management technology.

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