Internet Based Integration of Multi-Ship Handling Simulators with IP Multicast

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ABSTRACT: IP multicast is a cost-effective method to accelerate data transmission rate and reduce network delay as well. This paper presents an improved IP multicast method to realize the interaction of internet based multi-ship handling simulators. The result of the experiments shows that with the new method, the availability of network resources and compatibility of the systems are tremendously enhanced.

1 GENERAL INSTRUCTIONS

Currently, ship handling simulators have been widely used among maritime education, training and related researches. Though the current systems of ship handling simulators can train interactively on a local area network, the students trained come from the same university or company, which are inconsistent with the actual navigation environment. Navigation is an international activity. Several ships from different countries may navigate in the same water area. Interaction between them will occur in a variety of acts. Therefore, the ship simulators all over the world should be interactive so that the students who come from different countries or regions can manipulate their simulators in the same virtual water through internet. However, with the increase in the number of ship handling simulators, network communication constantly rising, which may result in network communication delay or congestion. Based on the analysis of the data flow system, this paper presents IP multicast method to control the data redundancy and bandwidth occupation. By using such method, the data transmission rate of network system is tremendously increased. Finally, its feasibility is verified by experiments in the real system.

2 IP MULTICAST PRINCIPLE

2.1 *IP Multicast meaning and communication pattern*

IP multicast is a bandwidth-conserving technology that reduces traffic by simultaneously delivering a single stream of information to potentially thousands of corporate recipients. Multicast group members are dynamic, that is, each member can join in or leave the IP Multicast group at any time and each member locates in various independently physical networks.

IP Multicast communication pattern: when a source sends same data to multiple hosts using traditional IP communication, it needs to send data packet to every client. However, when using IP multicast, such source only needs to send data packet to a particular IP multicast group without burdening the source or the receivers while using a minimum of network, resulting in the most efficient delivery of data to multiple receivers. (as shown in figure 1). Currently, applications that take advantage of multicast include video conferencing, corporate communications, computer-supported cooperative work C5CW, interactive Simulation and FTP, etc.
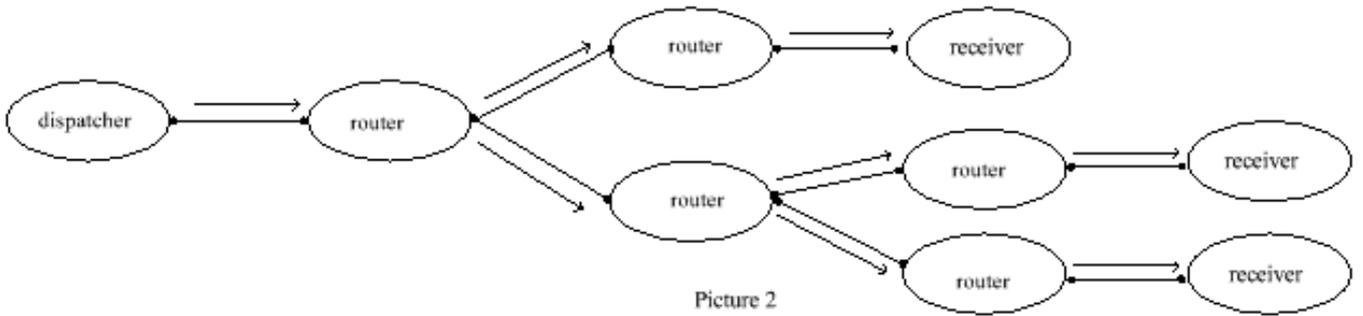
2.2 *IP Multicast addresses*

The Internet Assigned Numbers Authority (IANA) controls the assignment of IP multicast addresses. IANA has assigned the IPv4 Class D address space to be used for IP multicast. Therefore, all IP multicast group addresses fall in the range from 224.0.0.0 through 239.255.255.255.

Addresses in the range from 224.0.1.0 through 238.255.255.255 are called globally scoped addresses. These addresses are used to multicast data between organizations and across the Internet.

Addresses in the range from 239.0.0.0 to 239.255.255.255 are called limited scope addresses or administratively scoped addresses. These addresses are described in RFC 2365, *Administratively Scoped IP Multicast*, to be constrained to a local group or
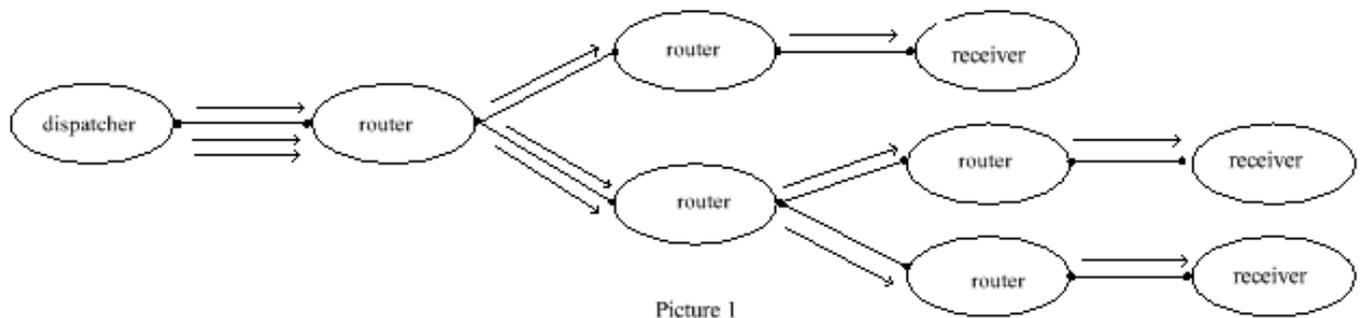
Fig. 1. Multicast group sketch map

organization. Companies, universities, or other organizations can use limited scope addresses to have local multicast applications that will not be forwarded outside their domain.

In multicast communication, two addresses are needed: an IP address and a multicast Ethernet addresses. IP Multicast addresses are representative for a group of receivers. They accept the data, which is sent to the entire group. Because IP packets should be encapsulated in an Ethernet frames, Ethernet multicast addresses are needed. For normal work of Multicast, hosts should be able to receive unicast and multicast data. Thus the hosts need to address a number of IP and Ethernet and Ethernet and IP addresses serve for unicast communications. Ethernet and IP Multicast addresses are used for multicast communication. If the host is not prepared to receive multicast addresses, zero is set for multicast addresses.

2.3 *Multicast system structure*

IP Multicast in communication needs to complete two basic tasks; one is how to add a member to multicast group, the other is how to sent multicast information to each recipient. In order to solve those problems, two basic protocols are introduced: Protocol between the host and router, that is, multicast members management protocol and Protocol between the router and router, multicast routing protocol. Internet Group Management Protocol is IGMP. IGMP protocol, which is used to connect hosts, works between the two routers. IGMP is used to dynamically register individual hosts in a multicast group on a particular LAN.

Hosts identify group memberships by sending IGMP messages to their local multicast router. Under IGMP, routers listen to IGMP messages and periodically send out queries to discover which groups are active or inactive on a particular subnet. IGMP works in the 3rd layer. Router can control the multicast. The second-layer equipment, IGMP Snooping can restrain the distribution of data in 2ed layer of network. Multicast routing protocols running on multicast routers between trees and routing for multicast packets transmitted building.

2.4 *IGMP protocol*

Before the establishment of a multicast routers connection and delivery of multicast group members' information, it must determine whether one or more hosts exist on a local network. Therefore, multicast routers and IP Multicast must use IGMP for information communication between group members. IGMP multicast routers can be used to judge whether there are multicast group members, if there exist members of multicast, multicast router will be added to a specific multicast group and send multicast data to the new adding host. Therefore, IGMP is used to notify router connected directly, adding it into a multicast group IGMP can make the multicast network be dynamic and flexible.

2.5 *IP Multicast routing protocol*

IP Multicast routing protocol is a crucial factor for transmission multicast information flow in routing network. It overcomes bottleneck of single cast

communication model and reduces cost of sending the same data to the several recipients. This is the main reason why IP Multicast application developed greatly. In multicast network, trees for data flow in multicast network should be established according to multicast route protocol data so that a single path can be formed between transmission source and multicast members, ensuring that each data packet was transmitted to the purpose of IP addresses.

3 IP MULTICAST APPLICATION IN INTERNET BASED INTERGRATION OF SHIP HANDLING SIMULATOR

In fact, internet based integration of multi-ship handling simulators is a distributed interactive system composed of several simulators located in different countries or regions through internet. All the training simulator in a virtual sea need exchange information constantly. To ensure the state unification of the simulators in the same virtual water, a high quality of real-time performance is required. Meanwhile, a simulator can join in virtual water and can withdraw at any time. This requires a good scalability and reliability. Taking these demands of the entire system into account, the system must minimize network delay and avoid congestion. UDP and IP Multicast technology can be used to reduce the data packet transmission and improve network data transmission rate.

3.1 *Integration of Internet data flow analysis*

Because the system is based on UDP and IP Multicast, its structure is the tree structure, which can ensure its expansion, flexibility and network data transmission rates. System has a control centre which is responsible for transmitting information, task decomposition, matching and management. Exchanging data between all the simulators and control centre directly affects the reliability of the system or even success. System information is as follows: control centre data to various simulators:

(1) Environmental Information: Virtual waters including the code of the waters, the direction of wind, the velocity of wind, the direction of flow, the flow velocity, day / night, visibility and so on.

(2) Simulator information: Mainly including country, company name, type, and its compatibility.

(3) Ship information: ship's name, call sign, owner, shape, length, breadth, draft, depth, course, speed, longitude, latitude and rate of turn.

(4) Control information: mainly including start and exit of the control centre, start and exit of a simulator, add or delete one model ship on the system and so on.

3.1.1 *The simulator data to the control centre*

(1) Simulator information: Mainly including: country, company name, type, and compatibility.

(2) Ships information controlled by simulator: simulator's name, ship's name, call sign, owner, shape, length, breadth, depth, course, speed, longitude, latitude and rate of turn.

(3) Join in or exit the simulator system information.

When a training simulator wants to join in virtual waters, it will send "join in" information to the control centre (including information simulator). After the success of accession, the simulator regularly sends all vessels and simulator information to control centre. Control centre regularly send the virtual water information to all the training simulators in the same waters to ensure that all simulators is in the same environment. When the control centre received simulator information and the ships which are controlled by this simulator, control centre will send these messages to all the training simulator in the same waters. When the control centre received a simulator's "leaving" information, the control centre will send this message to all other waters in the same virtual training simulator. Other simulators will remove all the ships controlled by this simulator.

3.2 *Data packets and data exchange*

(1) Control Centre is the highest-level multicast communications and is the general control centre of the whole communications network, which occupies a separate group multicast addresses. Control Centre controls the transmission of information and manages all the multicast addresses.

(2) The simulator is the second layer of multicast communications. According to system requirements, all the data exchange are only constrained in the simulators as well as between the control centre in the same waters. So all simulators in the same virtual waters set up a multicast group and shared a multicast address. First of all, simulator data is sent to the control centre (control centre monitor the state of all simulators). Subsequently, the control centre transmits these data to multicast group. Ship Simulator Internet Integration Architecture is shown in the figure 2.

3.3 *Dynamic foundation of the multicast tree*

The control centre adds to pre-defined multicast addresses automatically in procedure initialization. Simulators in the same virtual water are set up to a multicast group.

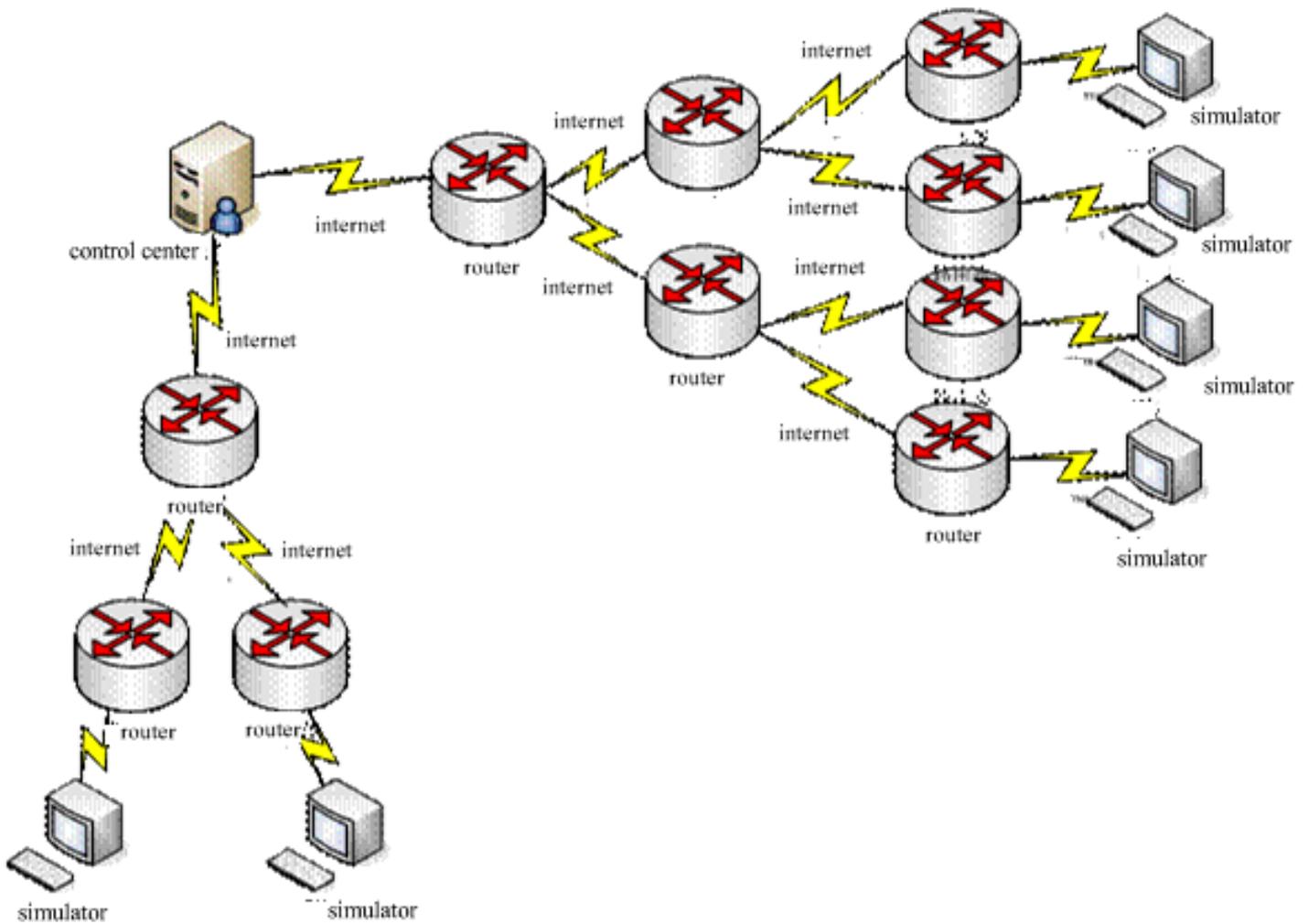After the control centre finish initialization, simulators will be added to the waters. If the

Fig. 2. Ship Simulator Internet Integration Architecture

simulator is the first one to join virtual water, IGMP will assign a multicast group address, the other training simulator can join in this multicast group one by one. The multicast group is dynamic, that is, one can always join in a multicast group and leave. If a multicast group has no simulator, the IGMP will cancel multicast group automatically.

(1) When a simulator wants to join in a virtual area, that is, want to join in a multicast group, This simulator will send a notice to local IGMP multicast routers on the verge of its wish to join in the multicast group.

(2) When the adjacent routers receive the message that a simulator wants to join in a multicast group, this router tracks on the multicast group dynamically. After tracking the multicast group, multicast routing protocol is used to connect the simulator to multicast tree on the edge of the original multicast routers.

(3) When the source and the receiver establish multicast routing, source along multicast routing begin to send data to various recipients.

3.4 *Multicast Communication and the results based on Winsock*

The system apply with the communication and UDP, the control centre relies on JADE3.3 platform, JBuilder9.0 programming tools were used. Terminal simulator uses Winsock based on the Windows platform. VC++6.0 network programming to realize network communication. Process control and multicast data use different socket types. Multicast data and control data are corresponding to two sockets, the collection and sending of data use different port addresses, which can increase the success rate of receiving data. As the using of UDP can not guarantee the quality of communications, related work for handling data error during collecting and sending are disposed in the program. According to the actual operating situation, this method is highly efficient and effectively solves the network congestion. Table 1 contains the actual system contrast results of single cast and multicast.

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Table 1 Data contrast between single cast and multicast

	Average times of the network block	Average delay time of the network	The size of system may withstand the biggest data cast
single cast	10/10h	1.5s	5KB
multicast	1/10h	0.5s	6KB

4 CONCLUSIONS

Results can be seen from the actual operating system. The IP multicast method presented in this paper can effectively decrease the network congestion and highly improve the data transmission rate. An internet based integration of multi-ship simulator is achieved by dynamic allocation of multicast group members. Any simulators can join in or withdraw the virtual water at any time. In the future, we will continue our work to improve error control and transmission reliability.

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