INTERNET BASED INTEGRATION OF MULTIPLE SHIPHANDLING SIMULATORS

Chaojian Shi

Professor
Shanghai Maritime University
1550 Pudong Avenue
Shanghai 200135, P. R. China
Email: cjshi@shmtu.edu.cn
Tel: +86-21-58855200-2900
Fax: +86-21-58850828

Qinyou Hu

Doctor, Associate Professor
Shanghai Maritime University
1550 Pudong Avenue
Shanghai 200135, P. R. China
Email: qyhu@mmc.shmtu.edu.cn
Tel: +86-21-58855200-2509
Fax: +86-21-58850828

Abstract Shiphandling simulators (SHS) are efficient and useful facilities for training and education of cadets and seafarers. Most of the maritime universities and many maritime training institutes all over the world have installed shiphandling simulators, which play important roles in maritime education and training. However, most of the shiphandling simulators are standalone facilities and the trainees in the training programs usually come from the same country or from the same company, which differs from the real situation. To improve the situation and enhance the application of shiphandling simulators, research has been carried out on internet based integration of multiple shiphandling simulators. A multi-agent based system, including necessary hardware, has been developed. The system consists of a web server linker, local simulator agents and an internet based VHF communication system. With this platform, cadets and seafarers trained on local SHS can conduct shiphandling and communication practice together with trainees at SHSs in other countries or regions. The integrated training on this platform will set up more realistic and versatile scenario for the trainees, and it can be performed effectively and economically.

Keywords system integration; shiphandling simulator; maritime education and training; multi-agent system; internet communication

0 Introduction

It has been well proved that shiphandling simulators (SHS) are efficient and useful facilities for training and education of cadets and seafarers. Because of high expense and risk for the shiphandling practice on real ship, shiphandling simulator training has been carried out in most maritime education and training (MET) institutions. Typical applications includes handling of larger ships, training of bridge resource management[7] or bridge team management, as well as course related training programs such as standard maneuvering tests and collision avoidance scenarios. It is also found useful in maritime English practice for cadets to improve both on-board and external communication skills[8-9]. With the development of the technology in recent years, SHS has been improved greatly on shiphandling model and scene image. However, most of the SHSs are standalone facilities and the trainees in the training programs usually come from the same country or the same company, which differs from the real situation. Navigation is an international activity, and there may be many ships from different countries sailing in the same sea area. There are some training institutes having seafarers from different countries or regions trained together as a team. This method proves to be costly. Integrating SHSs internationally through Internet is an effective way to solve the problem. On integrated SHSs, cadets and seafarers trained on local SHS can conduct shiphandling and communication practice together with trainees at SHSs in other countries or regions. The integrated training will set up more realistic and versatile scenario for the trainees, and it can be performed effectively and economically. The more detail reasons why we need to integrate multiple SHSs internationally were demonstrated in[1].

Internationalization of SHS training will enhance seafarers' technical and operational abilities effectively. In this paper, we report the design and realization of an internet based platform, which is referred to as SHSLinker, to integrate multiple SHSs. A multi-agent based system, including necessary hardware, has been developed. The system consists of a web server linker, local simulator agents and an internet based simulated VHF communication system. The web server linker manages and coordinates the integrated simulators in the system. It also displays the necessary information and provides general functions for monitoring and controlling the system running. The local simulator agent communicates with local simulator and the server linker. The simulated VHF system performs communication functions between simulators linked to the internet. We also compose drafts of relative technical protocols for the integration interface and data exchange.

This paper is organized as follows. In Section 2 of the paper we present the architecture of SHSLinker. The main components of the platform are described in Section 3. Section 4 illustrates the communication protocol between the platform and terminal SHSs. Section 5 presents an experiment to show the usage of the platform. Finally, Conclusion and consideration of future research are offered in Section 6.

1 Architecture

The SHSLinker is based on Multi-Agent System (MAS) technology[2-3] to implement the integration of multiple SHSs from different countries or regions. MAS is one of the mainstream technologies in distributed computing and Computer Supported Collaborating Work (CSCW) area.

There are four advantages to use MAS to realize the integration of multiple SHSs, they are:

- Existing SHSs can be easily adapted to the system.
- Existing software platforms for MAS programming can be employed as the foundation for the integration of multiple SHSs.
- The integrating of SHSs can be easily expanded.
- Agents could adjust the communication according to the available bandwidth.

To realize the integration of the SHSs by using MAS technology, we set up a Management Center as a Server. Three Agents runs in the Server: (1) Name Server Agent which is in charge of recording the names of the active SHSs and their network addresses. (2) Facilitator Agent which record information of each Virtual Sea Area (VSA) and the SHSs joining it. (3) Visualizer Agent by which the administrators can visually manage the cooperation among several SHSs.

To implement the interaction between terminal SHS and the above Management Center, an SHS Agent is built for each SHS. SHS Agent will take an intermediate role between SHS and Server. SHS Agent collects relevant information from SHS and sends it to the Server, as well as receives information from the Server and forwards it to the SHS. Both are in real time.

To realize VHF communication on Internet, we built a VHF Agent for each simulated VHF terminal. VHF Agent receives all voice data and channel information, and then forwards them to SHS Agent. When VHF Agent receives any voice data from SHS Agent, it will forward the data to VHF terminal.

The communication between SHS Agent and the Server is implemented by HTTP protocol so that the communication can pass through the firewall of the LANs.

Fig. 1 shows the architecture of the whole platform.

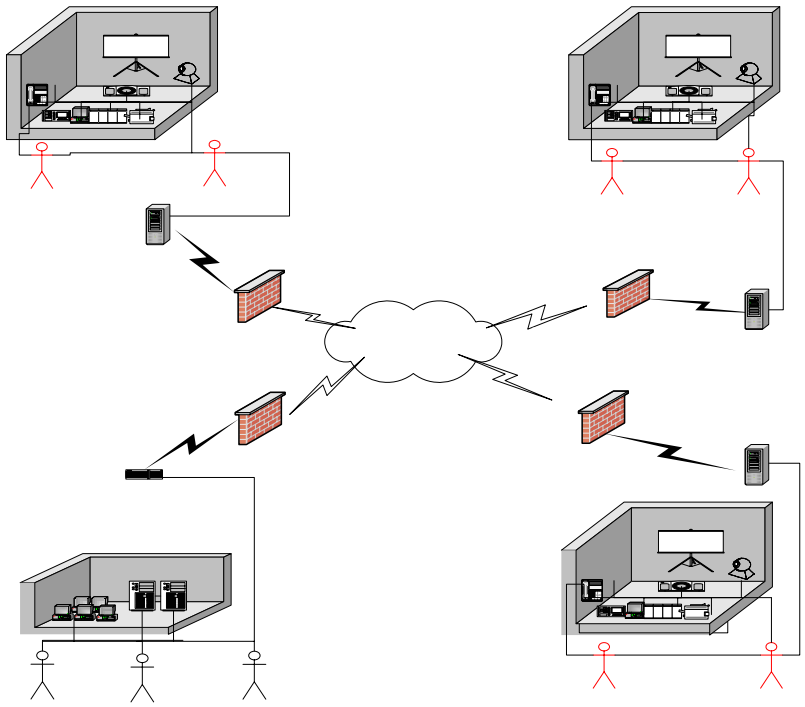

Fig. 1 Architecture of the SHSLinker platform

When an SHS starts up, its Agent will register related information, such as SHS name and its network address, to Name Server Agent, and then the instructor can select an existing VSA or create a new VSA to join. When an SHS enters a VSA, it can exchange ownship data and VHF audio data with other SHSs in the same VSA through the Server. According to the information received, the SHS will create the ship's model and display its movement in the virtual scene.

After the connection among agents has been established, seafarers can handle the ship, perform watch-keeping, and communicate with trainees at remote SHSs. Voice communication can be conducted via Internet based VHF system.

2 Main components

2.1 Facilitator agent

A Facilitator Agent is the agent running on the server for cooperation and communication management. It is active when the system starts up and responds to the request SHS Agents at terminal simulators momentarily. Its main functions include:

Provide VSA creating, joining and quitting service for SHS agents. When an SHS intends to join a running VSA, the Facilitator Agent will check whether the position of the SHS conflict with those of other SHSs in the VSA. If it is, the Facilitator Agent will prevent the SHS from joining the VSA at that moment. Another condition on joining a running VSA is to acquire the acknowledgements from all SHSs operating in the VSA, Facilitator Agent will coordinate and ensure this condition to be met.

Be responsible for forwarding messages among SHS agents properly. SHS data and voice data should be broadcasted among SHS agents in the same VSA.

Provide several data lists to save real time data, for instance, the name of each running VSA, data of navigational environment, number and names of own-ships and real time data of all ships.

2.2 SHS Agent

An SHS Agent plays the role of communicating with local simulator in the system. At the runtime of the system, an SHS Agent forwards local simulator's data to the Facilitator agent, forwards update data received from Facilitator Agent to local simulator, and responds to instructor/user's control.

As an "Agent" of the simulator, the SHS Agent is in charge of communicating with Server and delivering relative information to the simulator. Its main functions include:

Exchanging information with the simulator. Collecting simulator's runtime data, informing local simulator when remote SHSs enter or exit the current VSA, forwarding the update information of VSA to its simulator.

Interacting with the Server through Internet. Inquiring VSA list from the Server, applying for joining/quitting VSA on the Server, or opening/closing a VSA and receiving the feedback from the Server, receiving and processing the update data from the Server.

Supplying a Graphical User Interface (GUI) for instructor/user. Through the GUI, instructor/user could control the SHS Agent, send commands, get information, and manage local ownships (add or delete ownships).

Fig. 2 shows a snapshot of the GUI.

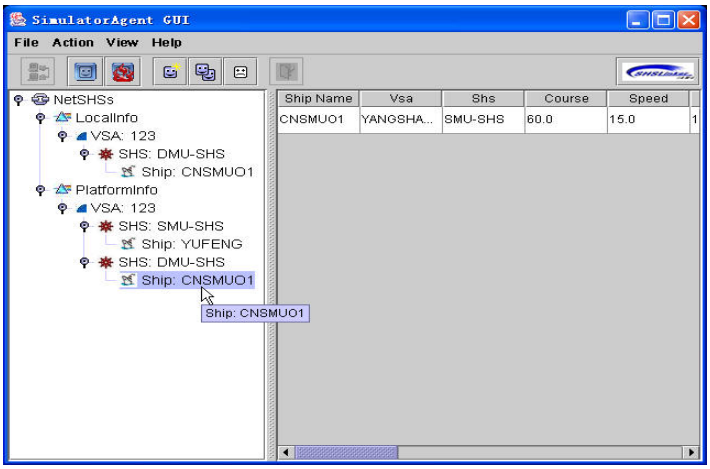

Fig. 2 A snapshoot of the operating GUI

2.3 Simulated VHF terminal

The simulated VHF terminal is used by the trainees for voice communications. Its function and operation are very similar to real VHF set used on board. Since not all VHF terminals used in current SHSs could output digitized voice data, we developed a set of simulated VHF terminal, as shown in Fig. 3. It can be connected to the computer at local SHS, and then linked to the SHSLinker platform.

Fig. 3 Simulated VHF terminal

The architecture of simulated VHF system includes the voice sampling and reconstruction unit, the encoder and decoder unit, the data processing and transmission unit, the clock synchronous unit, the keyboard and display unit, and the RS-232 converter unit. Fig. 4 illustrates its basic architecture.

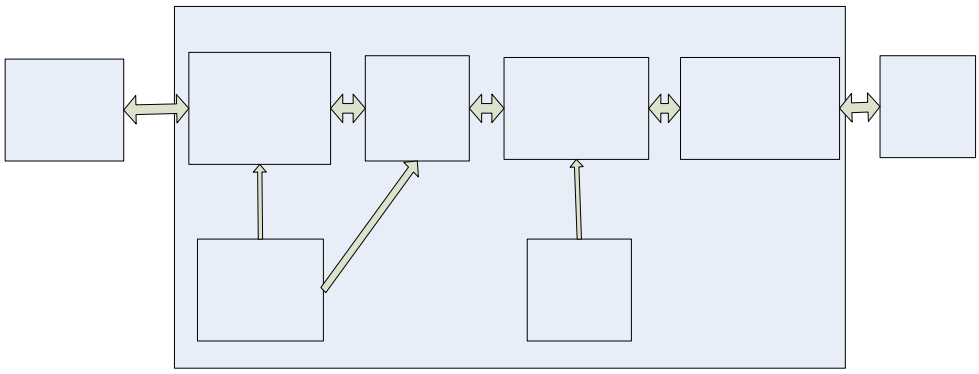

Fig. 4 Block diagram of the simulated VHF terminal

2.4 VHF Agent

The VHF Agent is the functional agent attached to the SHS Agent, and its lifetime relies on that of the latter. Through VHF Agent, SHS Agent can exchange voice data with VHF. The main functions of the VHF Agent includes:

- Receiving channel data and voice data from the VHF terminal;
- Transmitting the received voice data to other VHF terminals in the same SHS and listening on the same channel;
- Converting the voice data to a data type that can be accepted by SHS agent and sends to the SHS Agent for forwarding;
- Receiving and processing the channel data and voice data received by the SHS agent from other SHS Agents or the Facilitator agent, and then transmitting them to the local VHF terminals listening on the same channel.

2.5 Visualizer agent

Visualizer Agent requests the running data of the whole SHSLinker platform from Facilitator Agent and provides a graphical interface to present them. By the Visualizer Agent, the administrator could view the running status of the platform, e.g. the number of SHSs that are connected to the SHSLinker system, the identification of the SHSs, VSAs of those SHSs, the number of vessels running on every VSA, etc.. It also can be used to disconnect an SHS when the administrator feels necessary.

Fig. 5 shows one graphical interface of the visualizer agent.

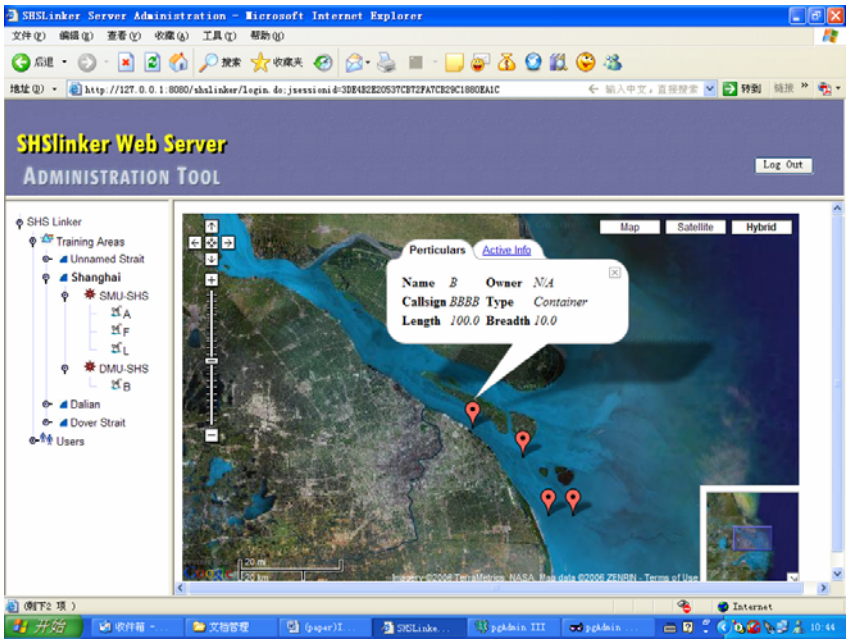

Fig. 5 Graphical interface of visualizer agent

3 Communication rotocol to the local SHS

Through an SHS Agent, a terminal SHS could communicate with and interact with the SHSLinker platform and other SHSs. This Section defines the communicate protocol between the SHS Agent and the terminal SHS. It includes three parts, the first summarized all types of the message, the second explains the structure of each type of message and its interpretation and the final defines the update rate for each type of message. As long as an SHS can receive, interpret, generate and output the messages defined in this platform correctly at required rates, it will be able to be connected to the SHS Agent and to the SHSLinker platform.

3.1 Message types

The communication protocol should implements the following functions.

- Make SHS agent and SHS capable to exchange ship static information and dynamic information;
- Make SHS agent and SHS capable to exchange SHS information and the virtual sea area information;
- Make sure a massage is correctly sent and received.

We defined thirteen types of message for communication between an SHS and an SHS agent. Table 1 shows all of the defined message types, their sender, their receiver and their content.

Table 1 Message types and their interpretations

No.	Type	Sent by	Received by	Reply with	Content
1	SHS	SHS agent	SHS	-	Description of one SHS
2	RSHS	SHS agent	SHS	SHS	Inquiry of the description of the local SHS
3	VSA	SHS agent	SHS	-	Description of a training area
		SHS	SHS agent		
4	STV	SHS agent	SHS	VSA	Inquiry of the current training area of the

					local SHS
5	SSP	SHS agent	SHS	-	The static data of the ships running on the local or remote SHSs
		SHS	SHS agent		
6	RSSP	SHS agent	SHS	SSP	Inquiry of the information of ships on the local SHS
7	SAS	SHS agent	SHS	-	The static data of a newly-added ship on the local or remote SHSs
		SHS	SHS agent		
8	SRS	SHS agent	SHS	-	The static data of a newly- removed ship on the local or remote SHSs
		SHS agent	SHS		
9	SUS	SHS agent	SHS	-	The updated static data of the ships on the local or remote SHSs
		SHS	SHS agent		
10	DSP	SHS agent	SHS	-	The dynamic data of a ship on on the local or remote SHSs
		SHS	SHS agent		
11	DAS	SHS agent	SHS	-	The dynamic data of a new ship on the local or remote SHSs
		SHS	SHS agent		
12	DUS	SHS agent	SHS	-	The updated dynamic data of a ship on the local or remote SHSs
		SHS	SHS agent		
13	VOI	SHS agent	SHS	-	Voice data and channel information
		SHS	SHS agent		

3.2 Message format

The message format defined in our communication protocol is similar to that of AIS message formats[4]. The message type and contents are tailored to the needs of integrated operation of SHSs.

The structure of one of the message type, SSP message, is shown in Fig. 6, as an example. This message provides information about the static data of a ship and is sent to the SHS Agent by the local simulator. The information of the message includes callsign, name, virtual sea area, simulator, length, breath, type, draft, and destination. When a simulator in one virtual sea area practices with other simulators, it sends all ships' static data to its agent at regular intervals. When the SHS Agent receives the message, it will send out the message to all the other simulators so that a ship in all simulators is in the same situation. In this way, a ship's information in the simulator can be updated at regular intervals. All the data of the message is in *char* type.

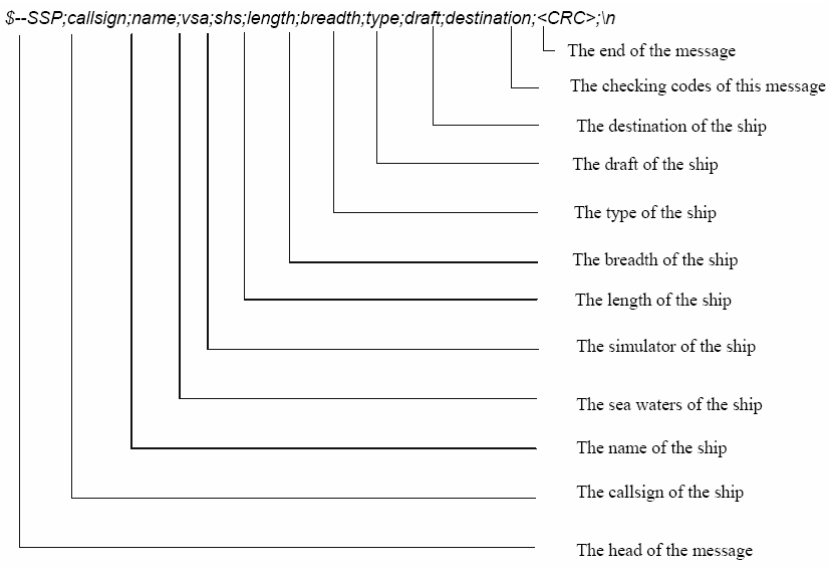

Fig. 6 The format of message SSP

For other message types, interested readers are referred to [5] for details.

3.3 SHS message rates

When the SHS agent starts up, it will inquiry the local SHS of the description, current VSA and the ownships of the SHS, then the SHS will reply the corresponding messages (SHS, VSA and SSP).

When the local SHS connecting to the SHSLinker platform through the SHS agent, the SHS should update the static information of the ships every 6 minutes and update the dynamic information of the ships every second. That is, the local SHS should send message SSP every 6 minutes and send message VOI and DSP every second.

When the instructor of the local SHS adds, removes or changes the static or the dynamic information of a ship, the SHS should send out the corresponding messages (SAS, SRS, SUS, DSP, DAS and DUS) to the SHS agent immediately.

4 Experiments

The SHSLinker platform was developed with Jade[6], which is one of the software platform for developing multi-agent system.

We set up two SHSs in Shanghai Maritime University to test SHSLinker platform. The two SHSs linked via Internet and both are running in Yangshan port. Each SHS has only one own-ship. Fig. 7 to Fig. 10 show the results.

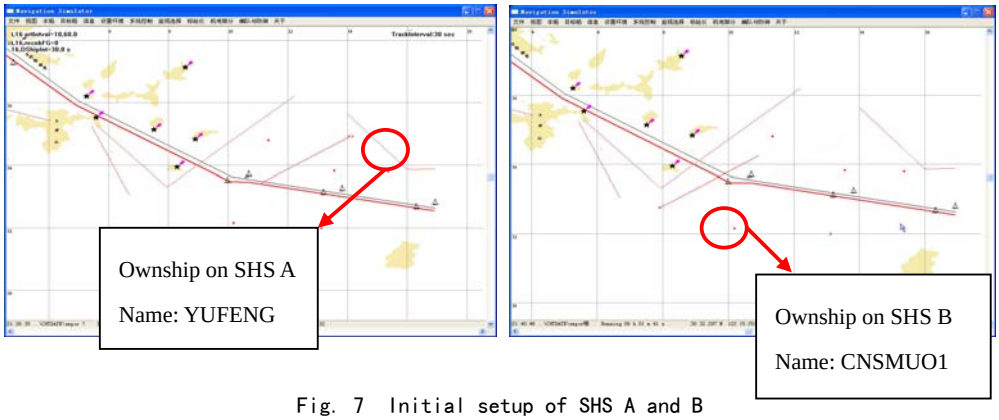

Fig. 7 Initial setup of SHS A and B

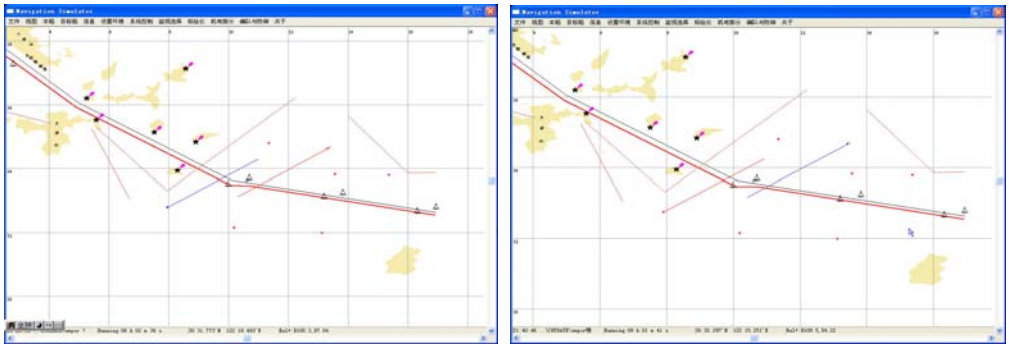

Fig. 8 SHS A and B, when connected by the SHSLinker platform

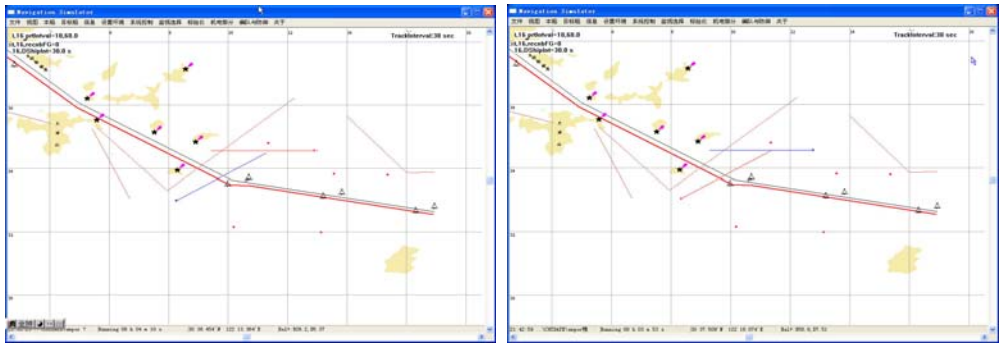

Fig. 9 SHS A and B, when ship "YUFENG" on SHS A changes course to 270

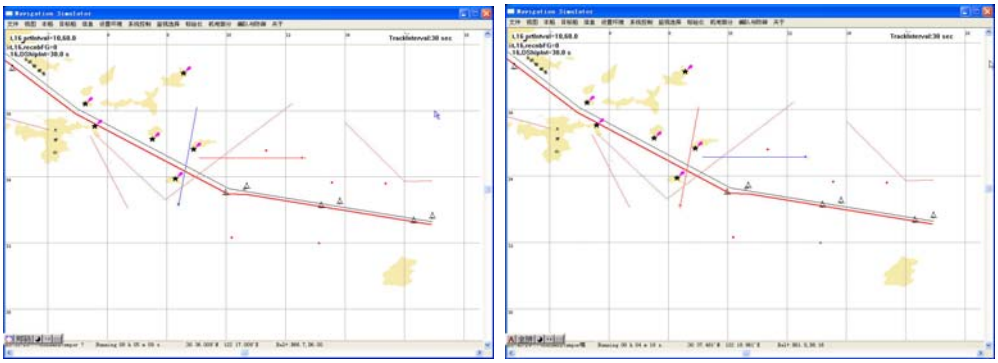

Fig. 10 SHS A and B, when ship "CNSMUO1" on SHS B changes course to 010

5 Conclusion and future work

In this paper, we report the research work of SHSLinker platform to integrate the SHSs from different countries or regions based on Internet. Major modules have been accomplished, and the platform works well when linking several SHSs produced by SMU on the Internet environment. However, further refinery is necessary. First, Interface standards to the SHSs need further discussion among the SHS manufactures and users, and an agreement should be made. Second, an experiment should be done to link the SHSs which are from different countries or regions and produced by different manufactures.

It is worthwhile to link VTS simulators to the platform, thus the trainees could learn how to cooperate with the VTSs to complete their voyages. Moreover, a training assessment or scoring system can be built in the management center to assess the performance of trainees. When they finished their voyage on the integrated platform, they could access the website to see their grades. Building model courses for the integrated training also needs consideration.

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