Internet-based integration of multiple ship-handling simulators: an interim report

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1 Background

The research team members of the project include: Shi Chaojian, Hu Qinyou, Huang Zhenmin, Zhang Yi and Yu Lili from Shanghai Maritime University; Adam Weintrit, Przemyslaw Dzuila and Andrzej Bomba from Gdynia Maritime University; Chae-Uk Song from Korea Maritime University; Gyei-Kark Park from Mokpo National Maritime University.

Due to the high expense and risk for the ship handling practice on a real ship, most MET institutions implement ship-handling (SHS) training. With the development of the technology in recent years, SHS has been improved greatly on ship handling model and scene image. However, most of the SHSs are stand-alone facilities and the trainees in the programs usually come from the same country or the same company, which differs from the reality. Navigation is an international activity, and there may be many ships from different countries sailing in the same sea area. Some training institutes having seafarers from different countries or regions trained together as a team, although this method proves to be costly. Integrating SHSs internationally through the Internet is an effective way to solve the problem. On integrated SHSs, cadets and seafarers trained on local SHS can do ship handling and communication practice together with trainees at SHSs in other countries or regions. The integrated training will create a realistic scenario for the trainees and can be performed economically and effectively. The reasons why we need to integrate multiple SHSs internationally are evident:

- To close the gaps between the technical, operational level and methodology between IAMU member universities. It benefits global standardization of simulator training and promotes the exchange and sharing of training experiences.
- To enhance mutual understanding of navigational procedures between cadets and seafarers from different countries. It provides a good platform of intercommunion among cadets with an international background.

- To facilitate communication and Maritime English training. Through the Internet based VHF cadets and seafarers can communicate (using IMO Standard Marine Communication Phrases) in more realistic and diverse situations.
- To extend the application of SHSs. Integrated SHSs provides an excellent training opportunity in virtual twenty-four hour watch-keeping practice for a complete voyage including shift watches. In addition, it is a good supplement to the training on real ships.

Therefore, the internationalization of SHS training will greatly enhance seafarers' technical and operational abilities.

The project "Internet Based Integration of Multiple Ship Handling Simulators" NetSHSs in short, focuses on solving technical problems and developing necessary software and hardware for integrating multiple simulators on the Internet. The necessity of integration of multiple SHSs and its application has being discussed at AGA4 of IAMU 2003, Egypt and the project was granted by IAMU in July 2004.

In this project, we design and realize the platform to integrate multiple SHSs, and compose the relative technology standard. We will describe the relevant specification for the integration of multiple SHSs, and establish the infrastructure for the integration of multiple SHSs according to the technological specification. Standardized guidelines will be provided for the integration of multiple SHSs in IAMU member institutions. A management centre will be set up for managing and coordinating the complete integrated system and a prototype will be built to implement the integration of two or three SHSs from different counties.

2 Methodology

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

There are three advantages in using the MAS to realize the integration of multiple SHSs, they are:

- only small changes on existing SHSs are required;
- the MAS platform can be used as the foundation for the integration of multiple SHSs;
- the integrating SHSs can be easily expanded.

To realize the integration of the SHSs by using MAS technology, we set up a Management Centre as a Server. Five Agents run 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 records information of each Virtual Sea Area (VSA in short) and the SHSs joining it. (3) Visualizer Agent by which the administrators can visually manage the cooperation among several SHSs, (4) Judge Agent which is responsible for deciding whether a SHS can enter or quit a VSA, and (5) Time Agent which records the current time of

each VSA and synchronizes the time of a SHS when the SHS want to enter a VSA.

To implement the interaction between existing SHS and the above Management Centre, a SHS Agent will be built for each SHS. A SHS Agent will take an intermediate role between the SHS and Server. A SHS Agent collects relevant information from the SHS and sends it to the Server, as well as receiving information from the Server and forwarding it to the SHS. Both are in real time.

To realize VHF communication on the Internet, a VHF Agent was built for each VHF terminal. A VHF Agent receives all voice data and channel information, and then forwards them to the SHS Agent. When the VHF Agent receives any voice data from the SHS Agent, it will forward the voice data to the VHF terminal. The communication between the SHS Agent and the Server is taken by IoMSHSs (Integration of Multiple Ship Handling Simulators) protocol. This protocol enables several SHSs to exchange VSA data, ship feature data, voyage information and VHF audio data, etc, through the Server. The IoMSHSs protocol is built on the HTTP protocol. Therefore, IoMSHSs messages can pass through the firewall of the LAN. Figure 1 shows the architecture of the whole system.

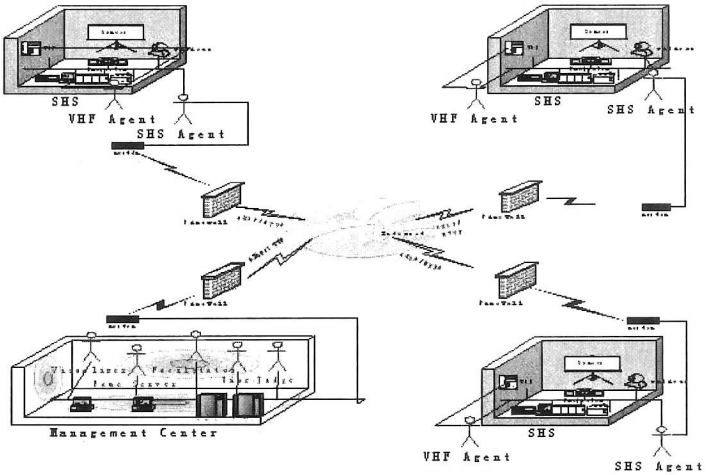

Figure 1: System architecture.

When an SHS starts up, its Agent will register related information to Name Server Agent, such as the SHS name and its network address, the instructor can then select an existing VSA or create a new one. When an SHS enters a VSA, it can exchange its own ship 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 between Agents was established, seafarers can handle the ship, perform watch keeping, and communicate with the trainee at remote SHSs. Moreover, they can communicate via the Internet Based VHF system.

The whole system is mainly composed of two function modules: A Simulator Agent for local ship handling simulator stations and the Management Agent for a central coordinating station. Each agent can respond to the administration/user's inputs through its GUI interface and perform the corresponding tasks. Figure 2 shows the implementation chart of the system.

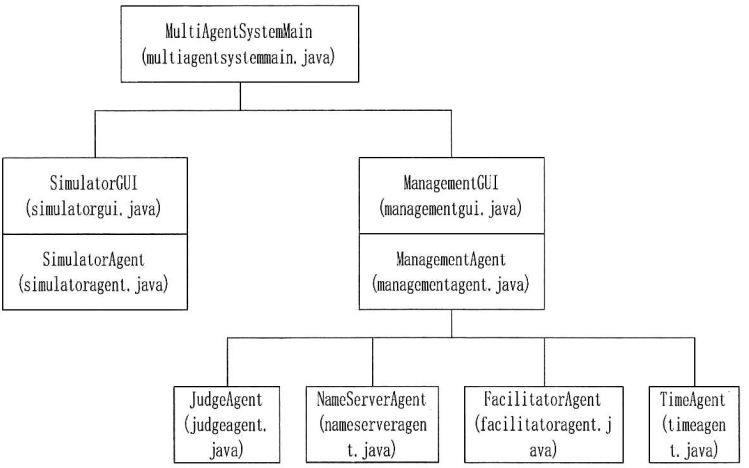

Figure 2: Chart of the system implementation.

3 Implementation of the modules

At present, the frameworks of the SHS Agent, desktop simulator and VHF terminal design have been completed. The work on SHS-Linker Web Server is on going.

3.1 SHS agent

A simulator agent, who has the function of communicating with the system simulator, contacts the simulator. During the runtime of the system, a simulator agent forwards the simulator's data to the Management agent, and then forwards the updated data received from the Management Agent to the simulator, and responds to the Instructor/User's control through its GUI.

As an "Agent" of the simulator, the SHS Agent is in charge of communicating with the Server and delivering relative information.

- Information exchange with the simulator: Collecting the simulator's runtime data, informing the local simulator when remote SHSs enter or

exit the current Virtual Sea Area (*VSA*), forwarding the update information of *VSA* to its simulator.

- Interacting with the Server through the Internet: Acquiring the VSA list from the Server; requesting connection/quitting VSA on the Server or for opening/closing a VSA and receiving the feedback of the Server; receiving and processing the data from the Server.

Supplying an Operating Interface (GUI) for Instructor/User: Through the GUI, Instructor/User could control the Simulator Agent, send commands, get information, and manage local own ships (add or delete own ships).

Through SimulatorGui, a SimulatorAgent can respond to local Instructor's command to connect the system/Internet, register, enquire interactive area list, add or delete the ship, etc. There are two function modules in Simulator Agent Class: the Simulator Manager implements the function that administers the local simulator and communicates with it; and the Management Agent Connector, which implements all interactive action with the Management Agent. Figure 3 shows the block diagram of Simulator Agent.

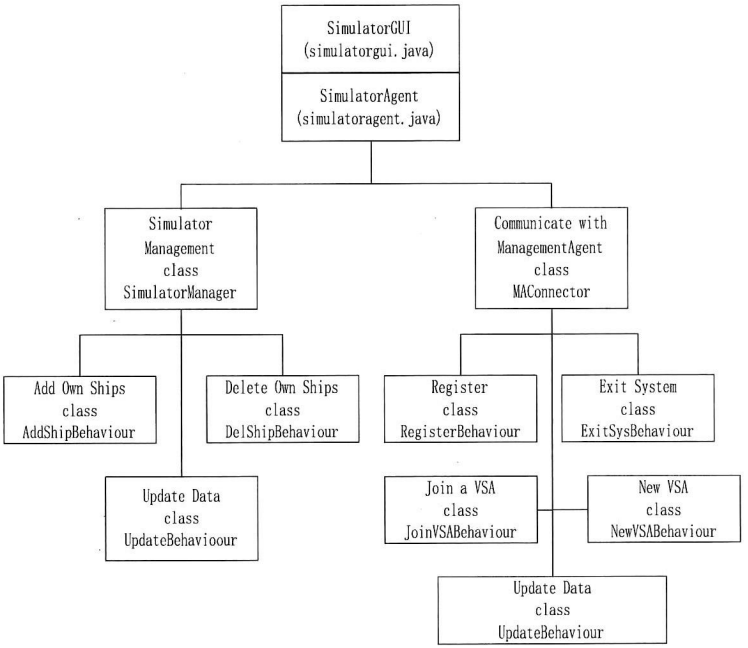

Figure 3: Block diagram of Simulator Agent.

3.2 Desktop simulator

The project focuses on solving technical problems and developing necessary software and hardware for integrating multiple simulators on the Internet. Usually, the real SHS is a complicated facility and the availability is limited, it is

inconvenient to test and debug our program if we use the real SHS directly. On the other hand, we need multiple standalone simulators to set up the multiple SHS environment. It is necessary to develop a simple desktop SHS, which can be used to test or debug the whole system.

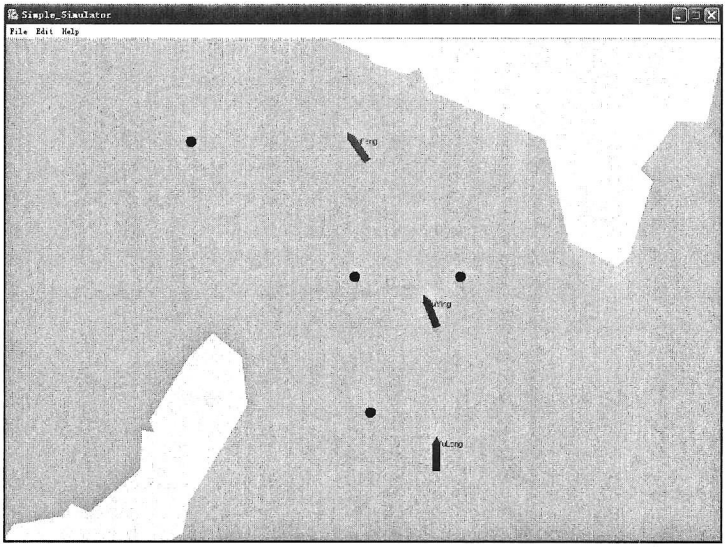

Figure 4: Desk top SHS.

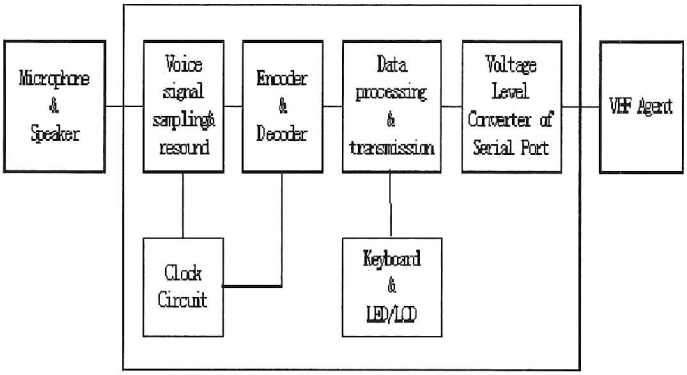

Figure 5: VHF Terminal Architecture.

In order to achieve the aim of substituting the real SHS when testing and debugging, the desktop SHS should include the following functions:

- Showing 2D simulative maritime space based on input data (islands, obstacles) showing 2D ships based on input data.
- Using keyboard control to respond to the user's operation to control the ships speed and course.
- Receiving ship's data from the other SHS in the same virtual maritime space and displaying their movement.
- Calculating and deciding whether there exists any risk of collision among ships, islands, and obstacles. If so, taking suitable action to avoid a collision.

The following modules are included in the desktop SHS:

- Virtual sea area including islands and obstacles;
- Mathematical model of the ship's movement;
- Display panel of simple desktop SHS Context classes.

Figure 4 shows the runtime interface of a simple desktop SHS. This simple desktop SHS has implemented the essential functions of real Ship Handling Simulator.

3.3 VHF terminal

In order to realize a more lifelike simulative environment, the ship-handling simulator should have the function to interact and communicate between multinational ships. The real-time voice communication with the VHF simulation system is an important part of this project.

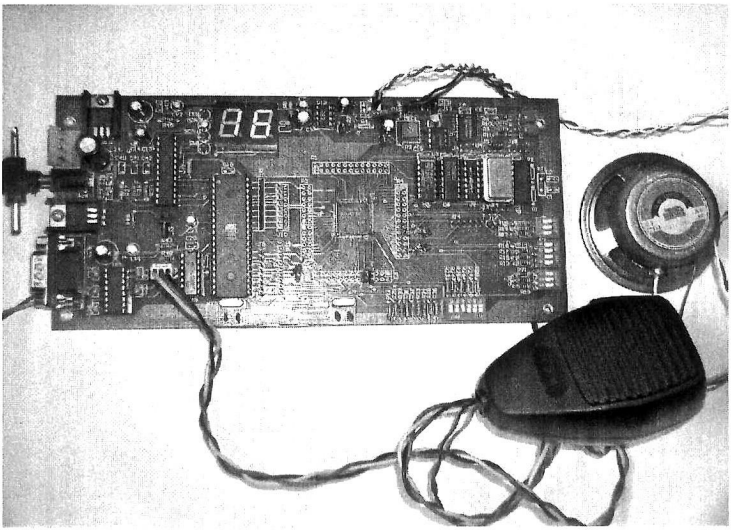

Figure 6: VHF circuit board connection.

The VHF simulation system is based on DSP. The research is focused on the study, selection and experimentation of speech coding algorithms, the design of a hardware circuit, the development of embedded control software, the programming and debugging of the PC's interface and network transmission.

There are two parts of the research work: software design and hardware design of the system. The software design includes PC and microcontroller embedded programming. The hardware design includes the speech data sampling and reconstruction unit, encoder and decoder unit, data processing and transmission unit, clock synchronous unit, keyboard and display unit, and RS-232 converter unit. Figure 5 shows the VHF Terminal Architecture and Figure 6, the VHF circuit board connection

3.4 SHSLinker Web Server

The main purpose of the SHSLinker Web Server is to manage and coordinate the integrated simulators in the system. It also displays the necessary information and provides general functions for monitoring and controlling the running system.

Figure 7 shows a display of administration tools of the SHSLinker Web Server.

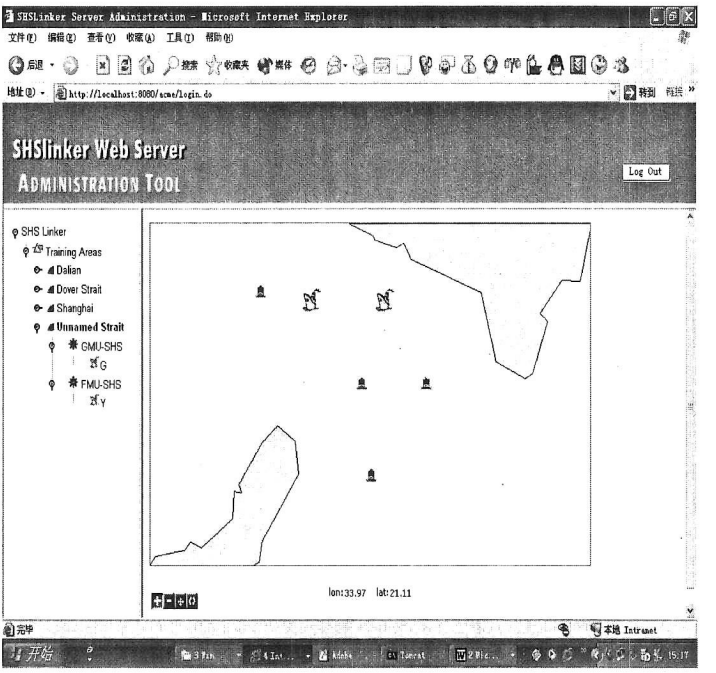

Figure 7: SHSLinker Web Server.

4 Summary

Apart from the Management Agent, all major module frames have been completed, although further refinements are necessary. Interface standards also need further consideration. The status of the project is summarized in the table to the appendix.

Appendix: progress status of the project

Time	Module	Sub-modules	status	Documentation	Participants
Apr.1, 05~ Oct.1, 05	VHF terminal	Voice signal sampling &resound	Finished	General Design for NetSHSs.doc *Implementation report*, N/A	Shi Chaojian Hu Qinyou Huang Zhenmin Zhang Yi Yu Lili Adam Weintrit Przemyslaw Dzuila Andrzej Bomba Chae-Uk Song Gyei-Kark Park
		Encoder &Decoder	Finished		
		Data processing & transmission	Finished		
		Voltage level converter of serial port	Finished		
		Clock Circuit	Finished		
		Keyboard & LED/LCD	Finished		
	VHF agent	Receive Module	Finished	General Design for NetSHSs.doc *Implementation report*, N/A	
		Forward Module	Finished		
	Simple Desktop SHS	Maritime Space Module	Finished	Design & Implementation of Simple Desktop SHS.doc	
		Ship's Movement Calculating Model Module	Finished		
		Ship's Movement Displaying Model Module	Finished		
		Display Panel Module	Finished		
		Context Module	Finished		
	NetSHSs Server	Facilitator Module	Finished	General Design for NetSHSs.doc *Implementation report*, N/A	
		Name Server	Finished		
		Time Module	Under development		
		Judgement Module	Under development		

Time	Module	Sub-modules	status	Documentation	Participants
Apr.1, 05~ Oct.1, 05	SHS agent	SHS Agent Gui Module	Finished	General Design for NetSHSs.doc Design and Implementation of SHS Agent.doc	Shi Chaojian Hu Qinyou Huang Zhenmin Zhang Yi Yu Lili Adam Weintrit Przemyslaw Dzuila Andrzej Bomba Chae-Uk Song Gyei-Kark Park
		SHS Agent Ontology	Finished		
		SHS Agent Interface	Finished		
		Ship Adding Module	Finished		
		Ship Reset Module	Finished		
		Ship Delete Module	Finished		
		Register Module	Finished		
		Deregister Module	Finished		
		New VSA Module	Finished		
		Join-in VSA Module	Finished		
		Data Update Module	Finished		
		Quit VSA Module	Finished		
	NetSHS Website	Index Page	Finished	Introduction to SHSLinker Administration Web Server.doc	
		Log in/out Module	Finished		
		Administer Module	Finished		
		Database Module	Finished		
	SHS Integration	SMU	Under development	N/A	
		GMU	Not start		
		KMU	Not start		
		MMU	Not start		