# Study on Integration of VTS Simulator into Net System of Ship-handling Simulators

Yi Zhang
*Wu-song VTS Centre of Shanghai Maritime Safety Administration, Shanghai, China*
*Merchant Marine College, Shanghai Maritime University, Shanghai*

Jun Ma
*Shanghai Maritime Safety Administration, Shanghai, China*

Chaojian Shi & Qinyou Hu
*Merchant Marine College, Shanghai Maritime University, Shanghai, China*

ABSTRACT: VTS Simulator Training has been a part of VTS operator training program according to IMO/IALA documents. It is a developing direction of VTS simulator to offering a more real-like simulative training as in actual practices. This paper proposed an approach to integrate VTS simulator with Internet system of multiple ship-handling simulators. Utilizing Agent/MAS technology, VTS simulators will play the role of VTS in participating in the interactive simulated training based on Internet. It facilitates a real environment in the VTS training and thus entails better effects.

## 1 BACKGROUND

With the development of VTS around the world, maritime countries and organizations demand more and more from VTS operators and pay at the same time more attention to the training and management thereof. Operators' competence is the key factor in the effectiveness of VTS. Based on the knowledge and experience, VTS operator makes judgments about the situation, coordinates between vessels, organizes the traffic flow, and gives advices to ships. So the personnel's ability exerts a direct effect not only on VTS authority's image but also on ship's safety and environment protection.

The main demands on VTS personnel in accordance with Guidelines for Vessel Traffic Services by IMO (IMO, 1997) are as follows:

- recommend that VTS Authorities be provided with sufficient staff, appropriately qualified, suitably trained and capable of performing the tasks required, taking into consideration the type and level of services to be provided;
- describe the skill and knowledge qualifications required by VTS Operators to provide vessel traffic services.

The main aspects of training for VTS personnel stand as follows: Language; Traffic Management; Equipment; Nautical Knowledge; Communication Co-ordination; VHF Radio; Personal Attributes; Emergency Situations (Maritime and Coastguard Agency, 2001).

Simulator training and assessment for VTS personnel, though a necessary part in the recommendations of IMO/IALA, haven't got enough emphasis.

## 2 CURRENTLY DEVELOPEMENT

At present, many institutions and companies have already developed a variety of VTS simulators, which fully comply with or exceed the international VTS personnel training requirements set by IMO/IALA and have been certified by authorities. There also emerge some institutions which have been authorized to provide VTS simulator trainings. For example, Maritime Research Institute Netherlands, which built VTS simulator in 1998 and got it upgraded in 2003 and further in 2006, has been authorized by the Dutch Ministry of Transport to provide training for Dutch (inland and sea) VTS operators, Dutch pilots as well as foreign VTS operators in cooperation with NNVO (Maritime Research Institute Netherlands, http://www.marin.nl).

For further developing, VTS simulator should offer more real-like situation as in actual practices. In fact, the situation which VTS operator faces is always changing, since different crew of different ship, coming from different countries and hence having different language abilities, culture backgrounds and experiences, will react immediately and differently to the same VTS operator.

Therefore, we propose to integrate VTS simulators into the *NetSHS* (Internet Integration System of Ship-handling Simulators). While playing the role of VTS in *Visual Sea Area* (VSA) in interacting with ships controlled by ship-handling simulators around the world, it implements a real-communication environment for VTS trainees. We state its virtues as follows:

- Apart from evaluating the effects of the training, VTS simulator also promotes the language skills,

the equipment-handling skills as well as the ability to organize the traffic flow, to coordinate between ships and to counteract emergencies of VTS personnel;
- The consistence between the simulate training and the reality in the pattern and environment of VTS enables trainees to adapt quickly later on;
- Trainees' performances and behaviors dealing with ship-handling simulators constitute a feedback from those ships on the service and management of VTS personnel and hence offer a lot of advices for the adjustment and improvement of the current VTS pattern.

## 3 INTRODUCTION OF NETSHS

NetSHS, which we developed in IAMU project, is a original platform for interactive simulation based on the *Multi-Agent System* (MAS) technology in accordance with FIPA standards. In that project, we described related specifications for the integration of multiple *Ship-handling Simulator* (SHS) and established its infrastructure, which enables local seafarers and those in the long distance to receive training together in VSA with interactive communication.

Agent is a problem solving entity relying on hardware, software or both, and its properties including *autonomy*, *sociality*, *reactivity*, *pro-activeness* and so on (Wooldridge & Jennings. 1995). It functions automatically and flexibly in a particular environment to achieve the goal it is designed for.

Several agents composed of Multi-Agent System to solve more complicated problems, communicating each other by its content language and *Ontology* (see Section 4.1.2). In FIPA agent systems agents communicate with one another, by sending messages. Three fundamental aspects of message communication between agents are the message structure, message representation and message transport. The structure of a message is a *key-value-tuple* and is written in an *agent-communication-language* (ACL) based on *Speech-Act Theory*, such as FIPA ACL. The content of the message is expressed in a content-language, such as KIF (Knowledge Interchange Format) or SL (Semantic Language). The messages also contain the sender and receiver names, expressed as agent-names which are unique name identifiers in system. (FIPA, 2000)

In NetSHS, developing based *Jade* platform which is one of MAS, implemented three basic kinds of Agents: *SHS Agent* (SA), *VHF Agent* (VA), and *Facilitator Agent* (FA). The data interface designates one SA and one VA to each ship-handling simulator, the former responsible for exchanging data with local SHS and interacting with FA, while the latter, affiliated to the former, helping it in the management of simulative VHF sets and data exchange. FA, functioning in the server, is the core agent responsible for coordination and communication. It responds to requests from SA, dynamically manages the existing SA in the system, and is in charge of message transmission as well as the decomposition, matching and management of tasks (Zhang et al. 2005).

FA is established at the start-up of the simulative platform. Then SA is set up in every simulator and registered on FA. Simulators need a VSA to perform the simulative navigation. And they can choose to join in an existing VSA or apply to FA for creating a new VSA on the platform. When a SHS enters a VSA, SA exchanges the data of its own ship and VHF audio with those in other SHSs in the same VSA through FA. Then, based on this information, SHSs create the virtual sea surroundings and other ships' model and update them continuously.

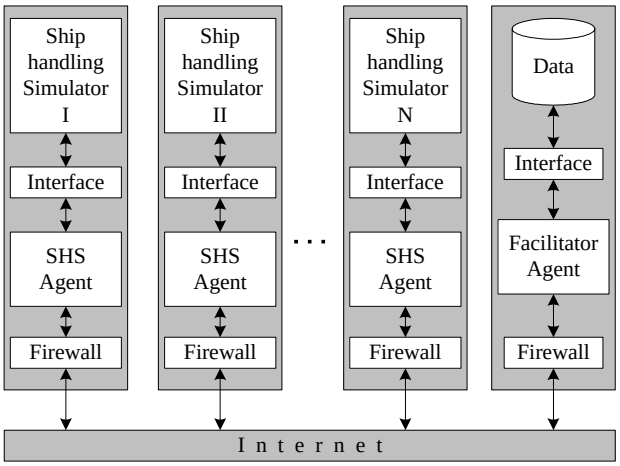


Fig. 1. Structure of NetSHS

## 4 DESIGN OF VTS SIMULATOR INTEGRATION BASED ON NETSHS

According to *IALA Recommendation V-103* (IALA, 1998), VTS simulator training should contain cases of equipment and system in the VTS centre and promote the knowledge and capability (the ability to manage the traffic and to handle equipments) of trainees.

### 4.1 *Simulator Integration*

To integrate VTS simulators into NetSHS, a new type of Agent should be created in the system: *VTS Agent* (VTA). And a VTS Agent and a VHF Agent

should be planted in one VTS simulator.

4.1.1 *Function Definition of VTS Agent*

VTS Agent planted in the VTS simulator is in charge of communication with the FA and local VA:

- Exchange information with VTS: record property of local VTS simulator; notify VTS simulator of some necessary information, i.e. the login and logout information about long-distance ships, or information about a VSA start-up/close; forward the real-time updating information of VSA to local VTS simulator.
- Interact with FA and other Agents via Internet: register on FA; apply for join/quit a VSA; send real-time VHF data to agents; receive and process the long-distance updating information from FA.
- Maintain the data list and update it at all time in running, provide it to display part of simulators;
- Provide simulator's instructor with a visible interface, through which, instructor can operate VTS Agent including making instructions or receiving information.
- Communicate with local VHF Agent.

VTS Agent's lifetime is the period of time from the moment when the agent starts up connecting with NetSHSs to when it exits the system through Internet. It is the whole process of interaction of VTS simulator.

4.1.2 *Ontology of VTS Agent*

Ontology is an important module for successful interaction among agents in MAS. The function of ontology in the system is to reduce or deracinate confusions in conceptions and words so as to obtain a state of sharing (FIPA, 2000). Ontology contains conception, relationship and description about some glossaries.

There are three types of ontology in NetSHS: *System-object Ontology*, *Data-object Ontology*, and *Relational Ontology*. Since what VTS Agent sends is only VHF voice data, corresponding to the those categories in *Data-object Ontology*, what we need is merely small adjustment in *System-object Ontology* and *Relation Ontology*.

(a) System-object Ontology

A new type will be added in the set of System-object Ontology: *VTS*

To facilitate uniform and abstract descriptions of different VTS simulators in the domain, we formulate properties as follows:

Table 1. Property list of VTS Ontology.

| Property | Data's type | Signification |
|---|---|---|
| Name | String | The name of VTS simulator |
| Producer | String | The producer of VTS simulator |
| Owner | String | The owner of VTS simulator |
| Compatible | String | The compatibility of VTS simulator |

(b) Relation Ontology

There are two types of *Relation Ontology*: *Contain* and *Participate*. The involvement of VTS Agent casts an effect on *Participate* and hence renders it necessary to adjust the property set to include the properties of VTS as follows:

Table 2. Property list of Participate Ontology.

| Property | Data's type | Signification |
|---|---|---|
| Vsanickname | String | The nickname of the VSA |
| Shsnames | String | The set of SHS names which join in this VSA |
| Vtsname | String | The name of VTS simulator which join in this VSA |

4.1.3 *Structure Design of VTS Agent*

There are five main functional modules in SA based on its function definitions above: *Data Interface Module* for data exchange with VTS Simulator, *Communication Behavior Module* for interaction with Facilitator Agent, *Display Module* for instructors' interaction, *VHF Interacting Module* for data exchange with simulative VHF set, and *Data Processing Module*(Shi & Hu, 2005.10, Shi & Hu, 2006.10).

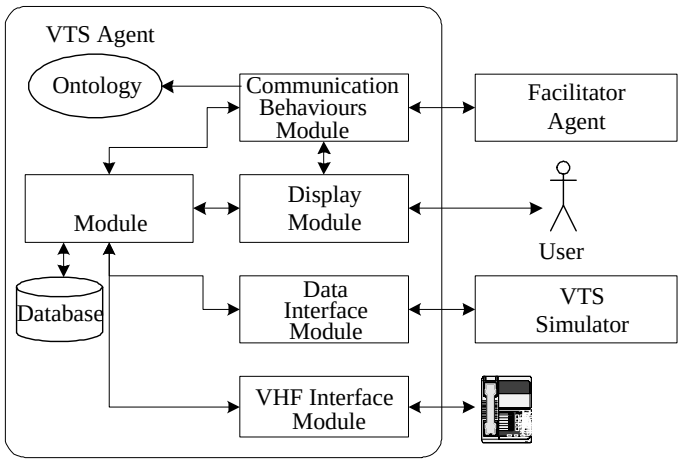


Fig. 2. VTS Agent Structure

*VHF Interacting Module* is actually the VHF Agent of the system. Other modules will be described in detail in the following passages.

(a) Data Processing Module

This module, functioning mainly in the process of the system, processes VHF voice data and the dynamic data of long-distance ships which other modules may invoke at any moment, and saves related historical data for the sake of achievement evaluation of training later on.

(b) Communication Behaviors Module

This module, mainly in charge of the interaction and communication between VTS Agent and Facilitator Agent, sends out local data and receives updated data from long distance. Different from SA, it only sends

VHF voice data.

(c) Display Module (VTS Agent GUI, VTAG)

This module provides related information for instructors, including properties of local VTS simulators and information of the operation in each VSA on the platform, and responds to instructors' commands, including start-up/quit of the system and the command of activating VTS Agent's behaviors.

The commands of the interface are listed as follows:

Table 3. List of commands on VTAG

| Commands | Notes |
|---|---|
| Start | Activate data interface for one time, get current data of VTS Simulator. |
| Register | Activate the behavior of register. |
| Deregister | Activate the behavior of deregister. |
| Join String | Activate the behavior of joining in a VSA. |
| Quit | Activate the behavior of quitting the VSA. |
| Exit | Kill the VTS Agent and quit the integrated platform. |

(d) Data Interface Module

This module's main task is to exchange data with local VTS simulators.

#### 4.1.4 *Design of Interactive Behaviors*

According with the function definition above, VTS Agent performs behaviors as follows in its lifetime:Register; Join in a VSA; Send local data; Receive updated data; Quit the VSA; Deregister.

The behavior design and data structure of message transmission in VTS Agent is basically the same as those in SHS Agent, except that there are only VHF voice data in the message. The time sequence of message sending in VTS Agent is as follows:

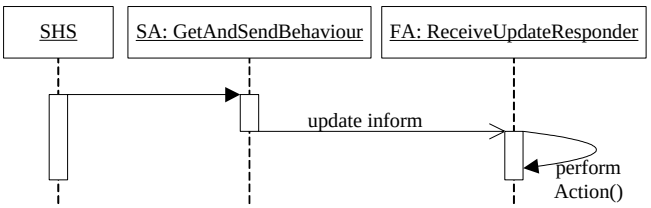


Fig. 3. Time sequence of message from VTS Agent to FA

The content format of the message in the stage of "*update inform"* will be described by VHFData format. The structure of the message is as follows:

Fig. 4. Structure of message in "update inform" action

```
(action
      (agent-identifier   :name    :addresses)
       (Send data (VHFData    :channel    :voice)
       )
```

### 4.2 *Additional considerations in the design*

#### 4.2.1 *Logical rules*

Though similar to SHS, VTS simulator plays a role totally different from that of SHS. Thus, its integration into the NetSHS demands formulation of related logical rules of operation to facilitate its relationship with ships on the virtual platform. For example, it should be stipulated that one VTS for one VSA to avoid multiple VTSs disturbing each other, which means that other simulators playing the role of VTS couldn't join in the VSA if there already exists a VTS.

#### 4.2.2 *Extra Ship-handling Simulators*

In the neighborhood of VTS simulator should also be established some SHS which can join in the NetSHS integration system. For one thing, in addition to VTS simulative training, trainees should also receive training in SHS, so as to familiarize them with nautical language and terms, to strengthen their navigational skills, to broaden their knowledge about how and how much weather, sea and currents affect navigation, to accumulate their experience and hence to promote their overall competence. This is very crucial, since VTS trainees usually have little chance to take part in actual navigation and thus have little opportunity to learn.

For another, based on the logical rules mentioned above, we can create a new VSA and simulated ships using those SHSs in the neighborhood if no VSA is favorable and still carry on the training. To meet requirement of training, there should be enough simulative ships in one VSA. When there is insufficient workload for training, extra SHSs could running several own-ships to actively communicate with VTS trainees, and more virtual ships which be simulated by additional Agents planting in them.

#### 4.2.3 *Further Improvement of NetSHS*

Communication among simulators in NetSHS is satisfied but the system is still original needing further improved. For more practical, the system is to be developed with supportes of global relative institutions for more perfect training and evaluating.

## 5 CONCLUSION

Personnel are the crucial factor in VTS. Without personnel improvement, advanced equipments alone can neither reduce accidents nor effectively organize traffic flow in the water area. Therefore, the construction of VTS is to a large extent the building-up of expertise. Personnel's competence and the management thereon directly determine the effectiveness and advancement of VTS.

VTS simulative training based on NetSHS can create a real environment in training, where trainees operate and interact as in actual practices but make mistakes which only result in disorders or accidents in the VSA.

With the development of simulator, VTS simulator training will be more and more diversified. Because that openning thoughts and technology will be prevailing developing trend gradually, and integration of simulators should be more explored. This paper proposed the integration of VTS simulator into NetSHS as an approach to develop VTS simulative training. And we call for higher participation of experts and designers, more new simulative technology and training methods, and definitely more practices.

## REFERENCES


FIPA. 2000. FIPA ACL Message Structure Specification. Foundation for Intelligent Physical Agents. Available at:http://www.fipa.org/specs/fipa00061/

FIPA. 2000. FIPA Ontology Service Specification. Foundation for Intelligent Physical Agents. Available at:http://www.fipa.org/specs/ fipa00086/

IMO. 1997. Guidelines for Vessel Traffic Services. IMO Resolution A.857(20).

IALA. Standards for Training and Certification of VTS Personnel. IALA Recommendation V-103, 1998.

Maritime and Coastguard Agency. Training and Certification of Vessel Traffic Services Personnel. Marine Guidance Note, MGN 180. 2001.

Maritime Research Institute Netherlands. VTS Simulators, General information & VTS training. http://www.marin.nl

Wooldridge M. J. & Jennings N. R. Intelligent agent – Theory and Practice[J]. Knowledge Engineering Review, 1995, 10(2), 115–152.

Zhang Yi & Shi Chaojian & Hu Qinyou. 2005. Study on Internet Integration of Ship-handling Simulator Based on MAS. Shanghai Maritime University, Master Dissertation.

Shi Chaojian & Hu Qinyou. 2005.10. Internet-based integration of multiple ship-handling simulators: An interim report. 6th Annual General Assembly and Conference of the International-Association-of-Maritime-Universities.

Shi Chaojian & Hu Qinyou. 2006.10. Internet Based Integration of Multiple Shiphandling Simulators. AGA7, Dalian, China.