AIS Simulator and ITS Applications

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Abstract – *Automatic Identification System (AIS) is a system that enables ships to exchange information about ships and navigation, such as position, course, speed, name etc. automatically by VHF radio. The system is expected to contribute the improvement of marine traffic control and safety. In some congested waterways excessive transmission of AIS is a potential problem since the planning stage. In this study, we have developed a system that simulates AIS communication in real or simulated marine traffic considering the movement of each ship with some applications using it.*

Keywords – *AIS, VTS,marine traffic, simulator, VHF Radio*

1. INTRODUCTION

Safety in congested waterways is a quite big issue, where traffic volume reaches to a certain extent. Automatic Identification System (AIS) is expected to be one of the powerful tools to improve the safety. However, it is not yet clear how it improves the safety and how it meets the difficulty in high density traffic in terms of transimission capacity.

The amount of the transmission is greatly affected by changes in positional relations among the ships and their speeds and courses, since AIS is a communication network organically and dynamically depending on the situation. For accurate estimation of AIS transmission volume, situations of all the ships sailing in the area have to be taken into consideration.

Hasegawa[1][2] develops the simulation system called Marine Traffic Simulator to create a realistic marine traffic flow, and use it for various researches such as to improve the safety of the marine traffic[3], and to assess the influence of the development in bay areas, etc.

In this paper the authours propose a new application related to such researches: AIS Simulator which simulates AIS communication considering the movement of each ship in real navigation records or in simulated marine traffic flow generated by Marine Traffic Simulator.

2. MARINE TRAFFIC SIMULATOR [1]

Marine traffic simulator is a simulation system to create realistic marine traffic based on the data given statistically. It has three sub-systems. One part is ship dynamics sub-system where each ship's movement is calculated by a mathematical model. The second is captain's dicision-making sub-system where operator's decision-making process such as changing course or avoiding other ships are processed by an expert system. The last is traffic generation sub-system where ship generation and deletion are done according to the statisitc data given. As the generation is done for each OD (origin and destination) route for ship arrival time, type of ship, speed and manoeuvring characters. So there is no pre-determined ship motion. If there is no obstacle ships around the own ship, she will navigate according to the given OD-route, including waypoints. However, if there are any other ships interfering her navigation, the captain will judge her avoidance manoeuvre based on the International convention of avoiding collision and his experience. Fig.1 is a snapshot of Marine traffic simulator where over 400 ships are sailing..

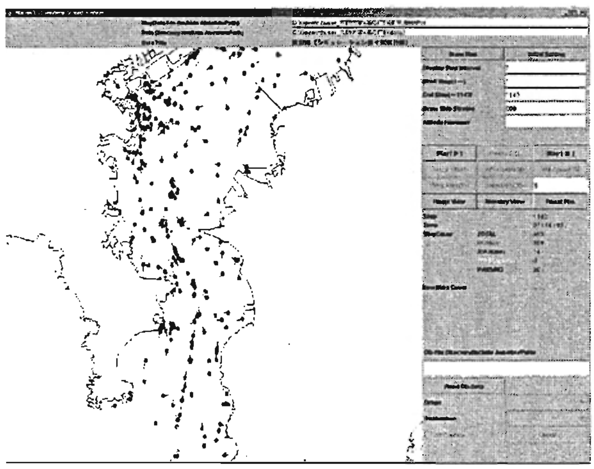

Fig. 1 A snapshot of Marine Traffic Simulator in Tokyo Bay[1]

3. SYSTEM STRUCTURE OF AIS SIMULATOR

AIS Simulator is constructed as shown in Fig. 2, and runs in the following three stages:

-To simulate AIS communication.
-To output simulation results to the database
-To display the status changes of AIS communication visually with the GUI:

- Slot map window
- Navigation status window

Each stage is processed as follows.

First, AIS simulator takes in the analysis result data from Marine Traffic Simulator, or real navigation records collected by Tokyo Bay MARTIS (Tokyo Bay Traffic Advisory Service Center) as navigation record data, and simulate AIS communication.

Second, the processed data are recorded in the output database, and can be utilized for further analysis.

Third, the analysis result stored in the database is displayed into slot map window and navigation status window graphically.

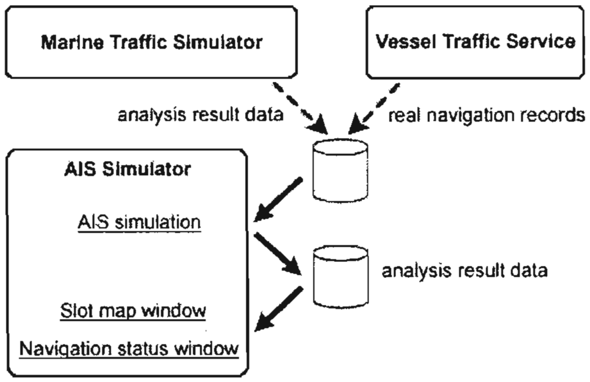

Fig.2 The system struccture of AIS Simulator

4. DEVELOPMENT OF AIS SIMULATOR

4.1. AIS Protocol

According to the Recommendation ITU-R M.1371-1[4] the following protocols are fully installed: *i.e.* RATDMA, ITDMA, SOTDMA and FATDMA. The ships use RATDMA, ITDMA and SOTDMA, and the on-land stations use RATDMA, ITDMA and FATDMA depending on the situation. The messages types sent by the ships are as follows.

Msg.1 Position report (Dynamic information)
Msg.5 Static and voyage related data (Static information)
Msg.5 Static and voyage related data (Voyage related information)

and the ones sent by the on-land stations are as follows:

Msg.4 Base station report
Msg.8 Binary broadcast message
Msg.14 Safety related broadcast message

The interval between the messages is also determined according to the Recommendation ITU-R M.1371-1.

AIS is classified into two kinds, *i.e.*, Classes A and B, according to the kind and the size of a ship. In AIS Simulator each ship is categorized into either Class A or B according to her tonnage. Althogh the AIS protocol is different between Classes A and B, the main difference is the reporting intervals. They are shown in Tables 1and 2.

Table1. Class A shipborne mobile equipment reporting interval [4]

Ship's dynamic conditions	Nominal reporting interval
Ship at anchor or moored and not moving faster than 3 knots	3 min (1)
Ship at anchor or moored and moving faster than 3 knots	10 s (1)
Ship 0-14 knots	10 s (1)
Ship 0-14 knots and changing course	3 1/3 s (1)
Ship 14-23 knots	6 s (1)
Ship 14-23 knots and changing course	2 s
Ship >23 knots	2 s
Ship >23 knots and changing course	2 s

Table2. Class B shipborne mobile equipment reporting interval [4]

Platform's condition	Nominal reporting interval
Class B shipborne mobile equipment not moving faster than 2 knots	3 min
Class B shipborne mobile equipment moving 2-14 knots	30 s
Class B shipborne mobile equipment moving 14-23 knots	15 s
Class B shipborne mobile equipment moving >23 knots	5 s

4.2. Slot map Window

The main screen of the simulator is shown in Fig.3.

At the center of the main screen, the cells representing 4500 timeslots are displayed. The slots occupied are marked on a specified ship and they change dynamically in time. In the original window the status of each slot is represented with different color. But here in Fig. 3, it is represented with different mark: a triangle mark for a slot used by the own ship, a circle mark for one where a garble occurs, a square mark for one where a conflict occurs and black rectangular mark forone used by other ships.

On the right side of the main screen, the controller of the simulator is located. Users can choose arbitrary ship to be displayed and start/stop the slot map animation. The state of the slot map such as the number of used slots and garble rate are also displayed beneath the controller.

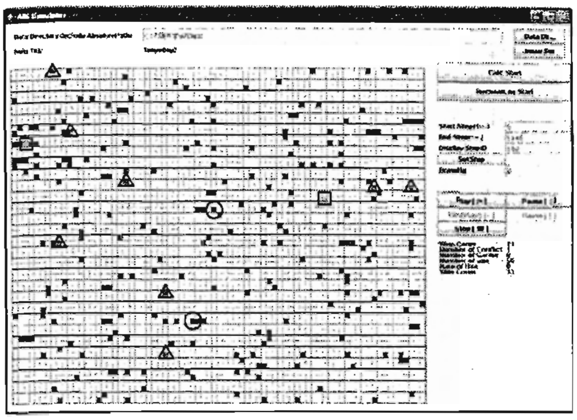

Fig.3 A sample output of AIS Simulator

4.3. Link with Marine Traffic Simulator

The slot map window shown in the previous sub-section seems to be found useful to understand the dynamic usage of slots. However, it is just for a specified ship in the area. It is still necessary to improve the system to show the AIS communication status in the area globally or statistically. The combination of Marine Traffic Simulator system and AIS Simulator system is an idea to realize it..

In the navigation status window, we can see the movement of each ship and in the slot map window, we can see the dynamic movement of a specified ship's AIS slot map. Users can easily choose an arbitrary ship graphically. Fig.4 is a sample output.

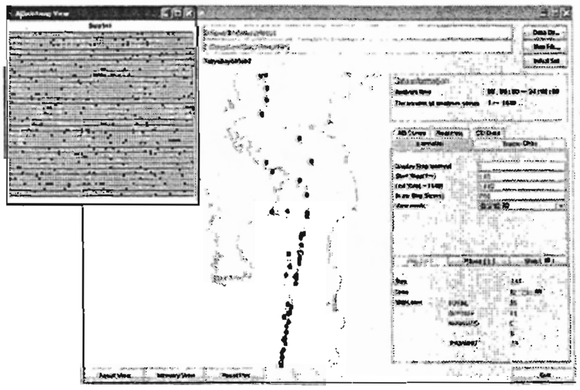

Fig.4 A sample output of combined Marine Traffc Simulator and AIS Simulator.

A dot on the map in the main screen represent each ship respectively, and the its color stands for the current state of the communication. Combining these two systems we can easily understand how and where AIS slot garbles and conflicts take place in the area visually.

. SIMULATION

Assuming the date when all the ships are equiped with AIS, two kinds of simulations were carried out in order to estimation what AIS slot garbles and conflicts would take place quantatively. One is the case using real navigation records collected during 00:00 -23:59 on Nov.11 , 2003 by Tokyo MARTIS (Tokyo Bay Traffic Advisory Service Center). The averate number of ships existing in an hour is 60.4, and the peak number is 87. The other is the case using simulated marine traffic generated by Marine Traffic Simulator where the average number of ships in an hour is 400.8 and peak is 727. For these two cases the garble rate is compared based on the area where the garbles frequently occur (Figs.5 and 6).

In Figs. 5 and 6 garble rates is illustrated in a different colour (in the original window) depending on its rate on the position where each ship exists. There is no ships where garble rate exceeds 5% in the simulation using real navigation records. However, there is an area (dotted-cicle in Fig. 6) where garble rate exceeds 5% in the simulation using Marine Traffic Simulator. In Fig. 7 slot share rate is illustrated in a different colour (in the original window) depending on its rate on the position where each ship exists. The areas where high garble rate is observed coincide with the area of high slot share rate.

These simulaations demonstrate how it will be useful to estimate garble and conflict rate in AIS communication not only in their quantity but also in their distribution. We may utilize this revised AIS Simulator for future Vessel Traffic Service and on-land AIS stations planning and development.

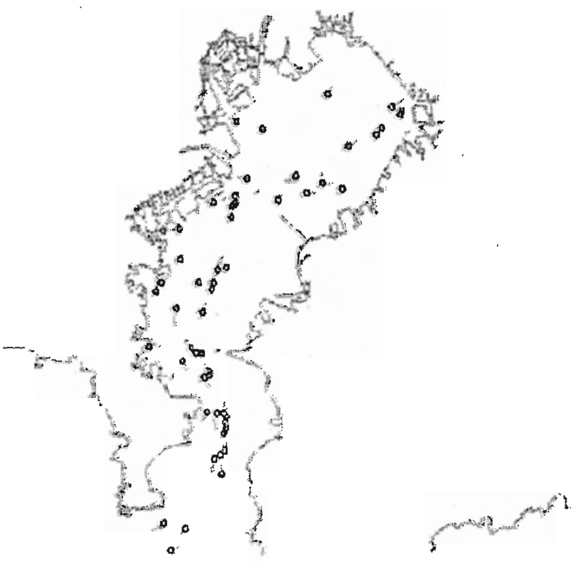

Fig.5 AIS garble rate distribution estimated using real navigation records (60 ships existing at this moment, in Tokyo Bay).

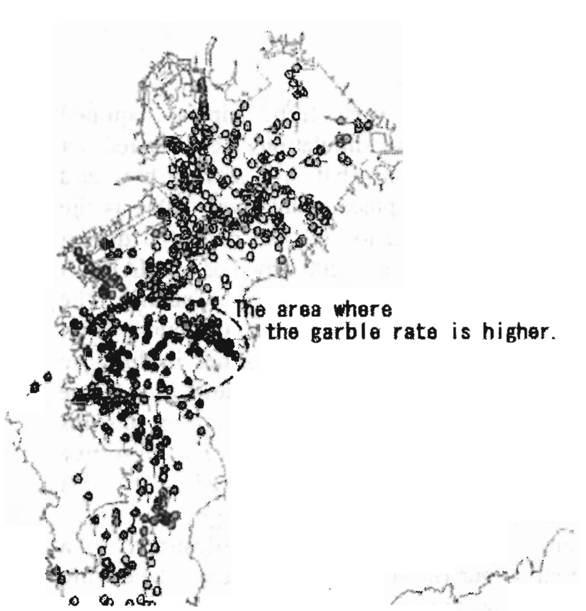

Fig.6 AIS garble rate distribution estimated using Marine Traffic Simulator (659 ships existing at this moment, in Tokyo Bay, and area of over 5% is circled by dotted line).

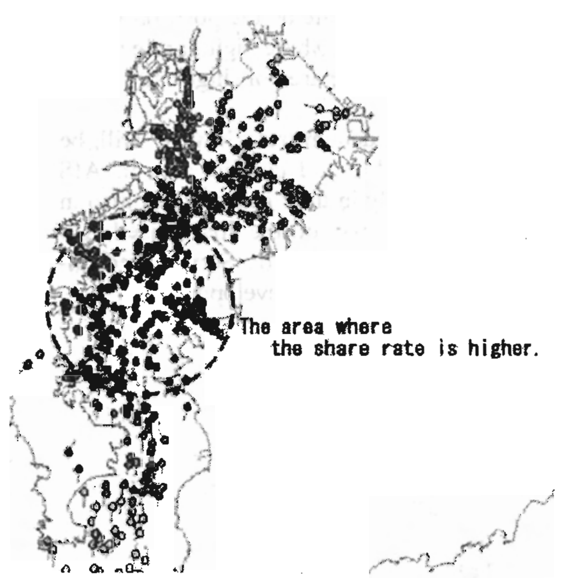

Fig.7 AIS slot share rate distributuion estimated using Marine Traffic Simulator (659 ships existing at this moment, in Tokyo Bay, and area of over 40% is circled by dotted line).

6.CONCLUSIONS

AIS Simulator was developed and demonstrated to show its prosperous aspects. Conclusions can be drawn as follows.

(1) AIS Simulator is proposed and developed to demonstrate its effectiveness.

(2) Combining slot map window and navigation status window, AIS communication status is dynamically and visually observed.

(3) Slot share rate, garble rate and conflict rate etc. can be statistically analyzed and illustrated visually.

(4) Combining AIS Simulator and Marine Traffic Simulator, it is easily to predict future marine traffic situation. The system can be utilized to plan VTS and on-land AIS stations and to assess the influence of various waterway-area development projects.

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