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An Integrated Vessel Tracking System by Using AIS, Inmarsat and China Beidou Navigation Satellite System

C. Yang, Q. Hu, X. Tu & J. Geng
Merchant Marine College, Shanghai Maritime University

ABSTRACT: As there are more and more Automatic Identification System (AIS) sets have been deployed onboard, it is getting easier for people to trace vessels. Today, many online vessel monitoring services have been developed; however, most of them are based on AIS information. Because the coverage limitation of VHF frequency, which the AIS set works on, is normally no more than 25 nautical miles, so these systems can not track vessels when they are beyond the coverage of the shore-based AIS station. In order to track vessels in all sea areas, we developed a comprehensive vessel tracking system, namely ManyShips, which integrates AIS, Inmarsat and China Beidou navigation satellite system. The running result of the system shows that the Beidou satellite system can track vessels within Asian-Pacific region while the Inmarsat-C station polling service can help people tracking vessels within sea area A3.

1 BACKGROUND

Today, there are more and more base stations have been developed to receive the real-time vessel information and to send them to VTS (Vessel Traffic Service) where this information will be displayed on ECDIS to facilitate traffic monitoring. And the information is very valuable in other area in shipping industry such as ship agent, brokerage, pilotage, salvation, custom inspection, quarantine, and fleet monitoring, etc.[1][2]

However, it is hard for these people access the AIS information field.[3] To satisfy their demand, several live AIS web system have been developed, for example, Lloyds AISLive, NavCom AIS Live, AISLivepool and Tokyo bay live traffic website. All these systems, however, are only based on AIS information which is collected from shore based AIS stations, and their coverage only within sea area A1. We have developed a live AIS web system using Ajax technology[4][5]. But this system can not track vessels when they are beyond the coverage of shore-based AIS stations, because the coverage of the VHF frequency, which the AIS system works on, is normally within sea area A1. Therefore, in this paper we integrate Inmarsat-C polling service and China Beidou Navigation satellite system into the vessel tracking system in order to extend coverage of the system to sea area A3. Once the vessel leaves the sea area A1, that means the position information broadcasted by AIS system can not be received by the shore-based AIS station, the vessel tracking system can use Inmarsat-C polling services or China Beidou navigation satellite system to tracking the vessel continuously.

This paper is organized as follows: in section 2, we briefly introduce the AIS system, Inmarsat-C polling service and China Beidou navigation satellite system; in section 3, we describe the architecture of the vessel tracking system; in section 4 we give out the running results and conclusions.

2 INTRODUCTION

2.1 *The Automatic Identification System*

The Automatic Identification System is an automated tracking system used on vessels and Vessel Traffic Services (VTS) for identifying and locating ves-

sels by electronically exchanging data with other nearby ships or VTS stations. AIS integrates a standard VHF transceiver with a positioning system such as LORAN-C or GPS receiver that can provides information supplements the marine radar, which is the primary method of collision avoidance for water transportation. The AIS provides many important information such as unique identification number, namely Maritime Mobile Service Identification number (MMSI in short), position, course, speed and rate of turn, and can be displayed on a screen or an ECDIS.[6][7][8]

2.2 *The Inmarsat-C polling service*

The coverage of Inmarsat is shown in fig. 1.

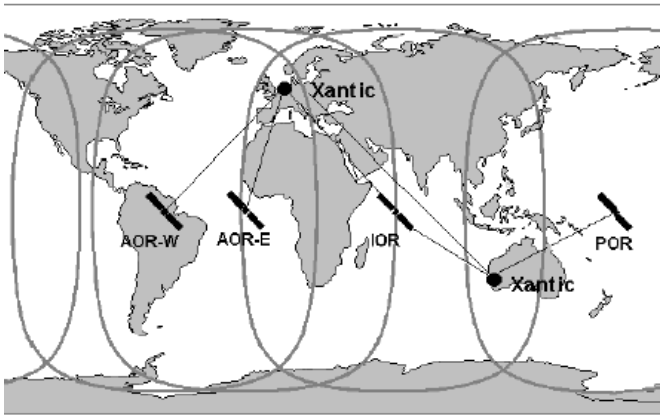

Figure 1[9]. The coverage of Inmarsat.

Data reporting and polling are value added services based on shipborne Inmarsat-C terminal. The data reporting services is intended for transferring small quantities of data (e.g. a position report) from an Inmarsat-C terminal to a predetermined address. This predetermined address could be an internet email address, a telex, a telephone-modem and so on. Data reports make efficient use of the Inmarsat-C system. Data packets limited to a maximum of 256 bits （32 bytes）are transmitted via signaling channels of the Inmarsat-C network. Time and cost are saved by avoiding switching to a messaging channel. Data report can be sent directly from a C-terminal or command with a poll. Most C-terminal can transmit Data Reports manually by means of an operator or be programmed for automatic transmission at pre-set intervals. And the same can be achieved from a remote location (e.g. a fleet management system) by sending a Poll to the C-terminal commanding the sending of Data Report. A Poll is a short command to an individual C-terminal or group of C-terminals initiating some action, controlled by the software of the C-terminal. A fleet manager can ask for data reports, with for instance the position of his ships. Polls can be sent via Internet e-mail. The polling service process procedure is show in fig. 2 and 3.[9]

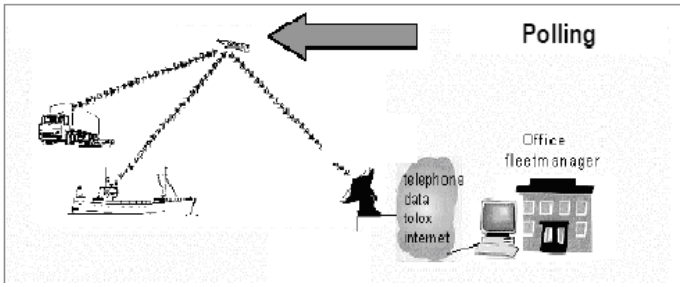

Figure 2. Polling the mobile Inmarsat-C terminals.

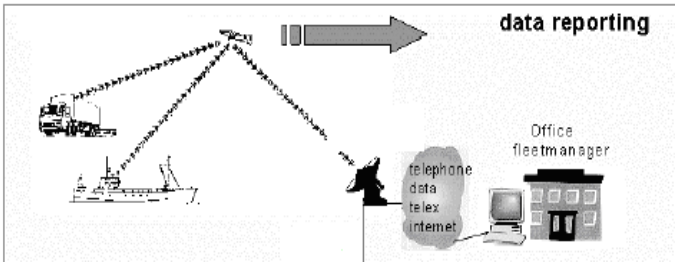

Figure 3. Data reporting from the mobile Inmarsat-C terminals.

2.3 *The China Beidou navigation satellite system*

China Beidou navigation satellite system, which is developed by China stand-alone, is active three-dimensional satellite positioning and communication system. The system can provide positioning and navigation service, time service and communication service. Now it is in its 1st generation stage so the coverage is from 5° N to 55°N, 70° E to 140° E. (See fig. 4) The system consists of satellites, ground earth stations and user side. There are 5 geostationary earth orbit (GEO) satellites and 30 non-GEO satellites. The ground earth stations including control stations, upload stations and monitoring stations. The user side is a receiver which is compatible with GPS, GLONASS and GALILEO. According to the implementation plan of the China Beidou navigation satellite system, it can provide global service at 2020.[10]

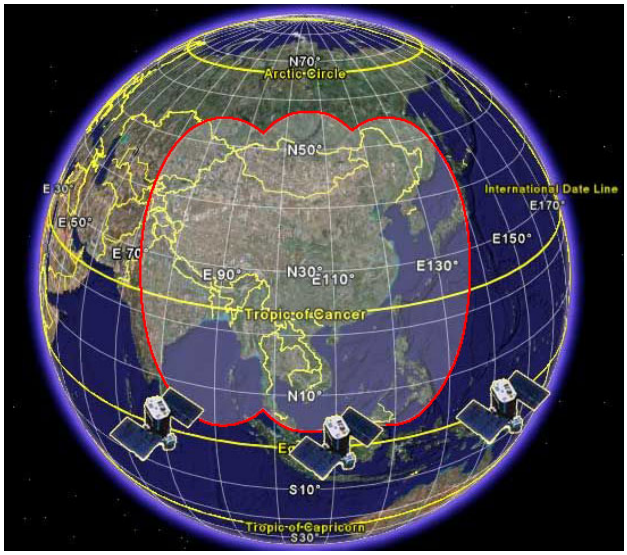

Figure 4. the coverage of China Beidou navigation satellite system.

3 SYSTEM ARCHITECTURE

The vessel tracking system we developed, namely ManyShips, integrates the AIS, Inmarsat-C and China Beidou satellite system. The system architecture is shown in fig.5.

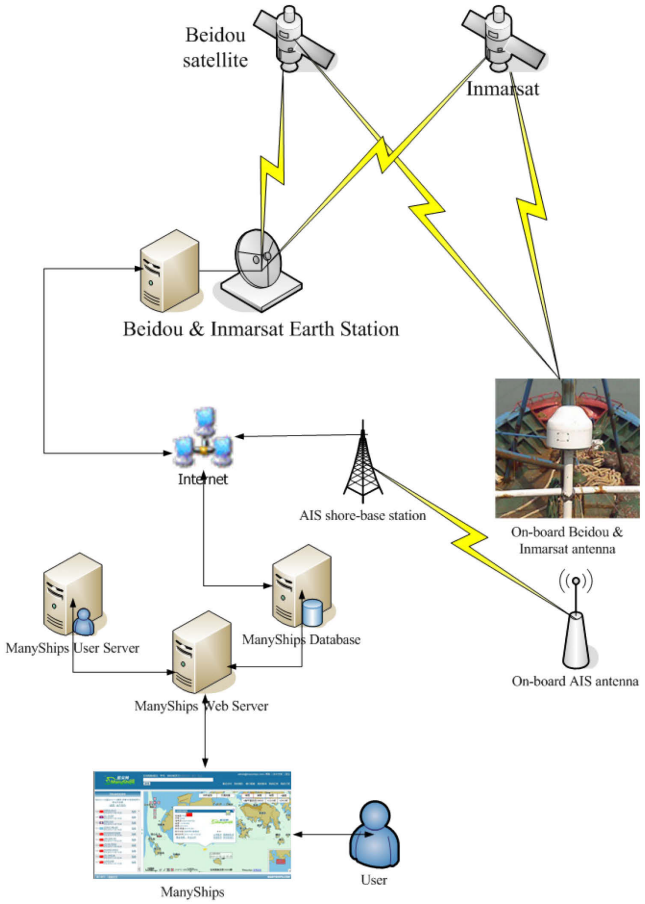

Figure 5. ManyShips system architecture.

When the vessel is navigating within sea area A1, the shore-based AIS station can collect the information broadcasted from the on-board AIS system. Once the vessel is leaving sea area A1, the on-board Beidou satellite antenna can send out the vessel's position information up to the Beidou satellite actively, then the information could be forwarded to the ground earth station and ManyShips system receives it via the Internet finally. Because the Beidou navigation satellite system now only has a regional coverage, so users should send out polling command from ManyShips system to the on-board Inmarsat-C terminals to request data report via the Inmarsat system when the vessel is out of the Beidou coverage.

There is little different between the Beidou satellite report procedure and that of the Inmarsat-C polling report. The on-board Beidou antenna can send out data report up to the Beidou satellite actively and the data report will be pushed to ManyShips system by the ground earth station will the station receiving it from the satellite. So the ManyShips system can locate the vessels continuously when the vessel navigating within the coverage of the Beidou navigation satellite system. While the data report from the on-board Inmarsat-C terminals is initiated when the terminal receives the polling command sent from shore users. The shore users send out an email, whose subject is just the polling command, to the ground earth station, and then the polling command will be uploaded to the Inmarsat system by the station. Also the data report is returned to the users in email format sent by the ground earth station once the data report from the vessels is received.

4 RUNNING RESULT AND CONCLUSIONS

We have deployed many shore-based AIS stations among China's sea line. And these stations can collect the vessels' AIS information when they are navigating within the coastal area. Fig. 6 shows the shore-based AIS stations coverage with the green points stand for the vessels.[11]

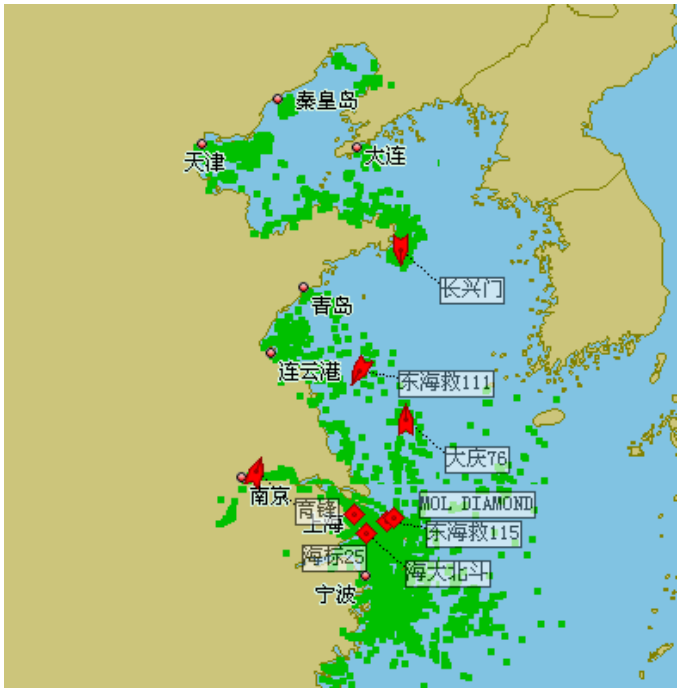

Figure 6. The shore-based AIS stations coverage

A Beidou navigation satellite antenna has been deployed onboard M/V Yu Feng, which sails between Nanjing and Busan. Fig. 7 shows its track when she departures Gwangyang.

All the position information is reported from the on-board Beidou antenna to the ManyShips system every 15 minutes actively.

We have also resisted the Inmarsat-C polling service on M/V QiLinZuo, a vessel that belongs to China Shipping Company and navigating between Shanghai China and European ports where we have not deployed shore-based AIS stations and also out of the coverage of China Beidou navigation satellite

system, so it likes the vessel is navigating in sea area A3. We have sent out several polling commands to the vessel when she is navigating in Aegean Sea. Fig.8 shows the vessel's track which is generated from its Inmarsat-C data reports.

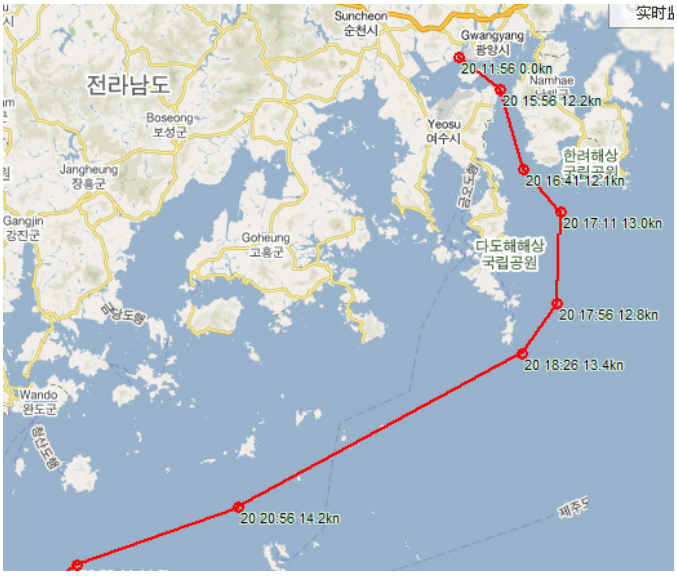

Figure 7. Track information reported from Beidou satellite system.

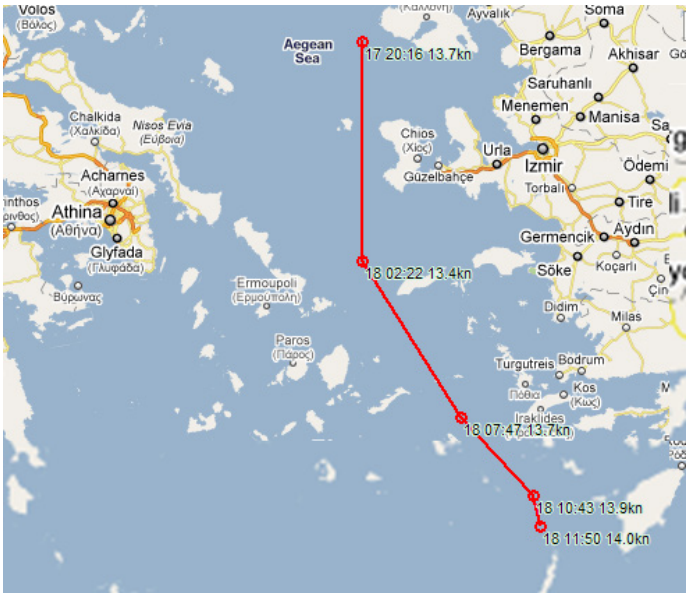

Figure 8. Track information reported from Inmarsat-C station polling service.

The above running results show that the China Beidou navigation satellite system and Inmarsat-C polling service are very important components when developing the integraed vessel tracking system. They can extend the coverage of the ManyShips system from sea area A1 to sea area A3

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