

Application of AIS in AtoN Wireless Surveillance System

Chang LIU, Ren-jie LIU, Xiao-fei SHI, Yao-liang HUANG
Information Engineering College, Dalian Maritime University
#1 LingHai Road, Dalian China
maria_315@sohu.com

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ABSTRACT

In China, the traditional method of artificial and periodical cruise is still adopted for the AtoN management, which has brought many disadvantages to the work of the AtoN management, such as non real-time, fallibility, and low efficiency. However, with the rapid development of AIS technique, now AIS equipments have been widely installed on ships, and on the other hand China Maritime Safety Administration (abr. China MSA) is carrying out the scheme of AIS base station network in china, based on which the digital AtoN will develop in the future. According to what have been analyzed above, this paper puts forward a design of AtoN wireless surveillance system based on AIS. The system consists of AIS on AtoN, AIS base station and AtoN management center. It can provide such functions as the information gathering, managing of AtoN and the service of navigation assistance. This paper gives the whole design including the work theory, the hardware structure and the software scheme of the system, and finally gives the simulation software of the AtoN management center. The AtoN wireless surveillance system brought forward by this paper will be more efficient with less repair cost and less work of the supervisors. It will bring revolutionary progress in the navigation aids system in China.

1. Introduction

An Aid to Navigation (abr. AtoN) is a basic equipment of the sea-route for assisting navigation straightly effecting on the safety of shipping. Radar is always the main observation facility for watching and identifying the AtoN of seashore. Along with the rapidly increasing of communication and computer technique the new communication system called AIS(Automatic Identification System) appears. Compared with the current radar the AIS has more advantages such as large information quantity, good real-time, strong anti-jamming and across-obstacle transmission and it will bring revolutionary progress in the surveillance of AtoN.

1.1 Disadvantages of Traditional Management of AtoN

In China the traditional AtoN is often cruise checked artificially and periodically by special maintenance technician.

It depends on personnel range estimation to check the shining appearance and the position drift circumstances of the beacon. The beacon and its storage battery should be examined completely each quarter. This kind of the management mode of AtoN brings a lot of irregularities such as the low credibility, the low efficiency and the bad real-time.

1.2 Feasibility of Applying AIS to the AtoN Management System in China

AIS(Automatic Identification System) works at VHF band and adopt SOTDMA protocol to broadcast information automatically[1]. A shipborne AIS can broadcast its dynamic and static messages and other safety related messages to other AIS ships and the AIS base station. At the same time it can also receive the information automatically from others. Depending on the information from shipborne AIS a base station can make the service and management more effective. Now more and more AIS equipments with improved functions have been installed on the ships, which is a good preparation for the application of AIS to AtoN system. China Maritime Safety Administration (abr. China MSA) began the AIS network of Changjiang port and Zhujiang port in 2003 and finished the AIS base station network of Qiongzhou Strait, Changjing port and Bohai Bay in 2004.

Application of AIS in the AtoN wireless surveillance system has many advantages such as the short development period and the low cost. Normally AIS area can cover all the AtoN system within its coverage. So it is feasible to apply AIS to the AtoN surveillance system.

2. Function of AtoN Wireless Surveillance System Based on AIS

According to a great deal of study on automatic identification system and AtoN, it can be generalized that the function of the system should be information gathering, processing, transmitting and utilizing. Details of the function are as follows.

2.1 Information Gathering

Information gathering is a very important function of the AtoN wireless surveillance system. The AtoN installed AIS can get its position from GPS, and the power voltage, current and the switch status from the controller interface. At the same time from the receiver it can also get the neighboring shipborne AIS information and the remote control order from the AtoN surveillance center.

2.2 Information Management

The maritime administration is required to provide the aids to navigation system with high capability and reliability to help the ship navigation safely. So in this system the surveillance center can supervise each AtoN in real time and collect all the information of the system. By friendly displaying the status of each AtoN on the screen the technician can analyze the work status of each AtoN system. When the malfunction appears the surveillance center will report the alarm message to the related principal in time. Additionally the surveillance center can configure the parameters of each AtoN and classify the information by sort, mainly including the maintenance log, history status, data and communication log of the AtoN, in order to make it convenient to query and print the information.

2.3 Aid to Navigation Service

The function of AtoN is to solve the problem of navigation safety and collision avoiding. Vessels receive the position in real time of AtoN and display it on the electronic chart and then decide the best and the most economical navigation route to avoid the obstacles. The surveillance center can also broadcast the safety related information such as the weather, the visibility and the AtoN drifting status.

3. Design Scheme of the AtoN Wireless Surveillance System

The system consists of AIS AtoN station, AIS base stations, AIS control center and AtoN management department. The AIS AtoN station is an AtoN equipped with an AIS, which is a little different from the shipborne AIS. The AIS base station can cover all the AtoN within its coverage and gather all the position and operation information of the AIS AtoN in real time and then send the information continuously to the AIS control center. The AIS control center will store the AtoN information and create a database for other system. The coverage of an AIS is normally 20 to 25 n mile. In order to manage a large port one AIS base station is not enough to cover the whole water-area. An AIS control center can support several AIS base stations and then establish a regional network to supervise the ship navigation and the aids to navigation status in the whole water-area. The structure of the system is shown as fig.1.

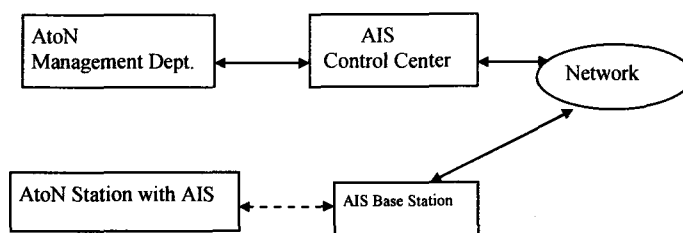


Figure 1. AtoN wireless surveillance system based on AIS

3.1 Operation Theory of the System

The AIS AtoN should form the position information from GPS and the health status of AtoN into a message, which should be broadcasted to the AIS base station. At the same time, ships equipped AIS can also receive the message and then form an electronic sea-route chart. By the network the base station transmits the information of AtoN to the AtoN control center, where the AtoN information should be sorted and then stored into the database and may also be created into statistic chart. When AIS works in an assigned mode, the administrator should inquiry the AIS to get the information of AtoN, and quickly affirm the work status of it. The AIS AtoN can also acute the order to the AtoN from the control center, which can realize the remote control of the AtoN.

3.2 Hardware Design of AIS AtoN Station

Now there is not any special AIS equipment for AtoN. If we apply shipborne AIS to AtoN there may be some waste of resource and cost, because many function of shipborne AIS are not suitable for the AtoN, especially the

bulk and the energy supply. The AtoN is small, so the AIS, equipped on it, should be small and light to avoid the instability of AtoN. And it should also be energy saving, water-repellent and tightly installing. The AIS AtoN station consists of navigation aids, controller, AIS and power supply. The AIS equipped on AtoN generally consists of VHF and GPS antenna, transmitter and receiver, data processor and controller. But there is not a display in the system, which is different from shipborne AIS. The detailed hardware structure is shown as fig. 2.

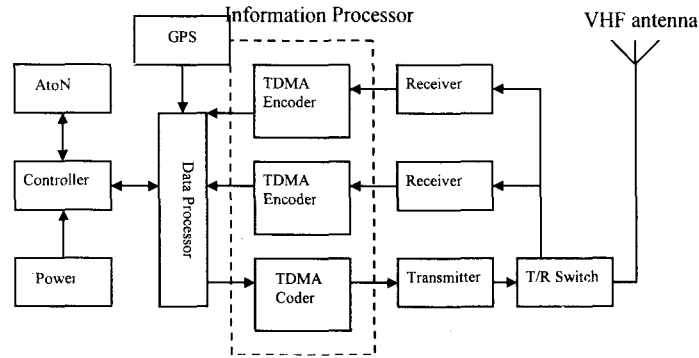


Figure 2. Hardware structure of AIS AtoN

3.3 Main Function of AIS Base Station

3.3.1 Assigning the Operate Modes of AIS AtoN Station

The AIS base station can appoint the operate mode of AIS to get more information of AtoN when it needs. Standard of ITU-RM. 1371-1 recommended that there are three operation modes in automatic identification system, which are autonomous and continuous mode, assigned mode, and polled mode.

The AIS AtoN station operating autonomously should determine its own schedule for transmission of its position and should autonomously resolve scheduling conflicts with other stations. The station operating in the assigned mode should use a transmission schedule assigned by a competent authority's base or repeater station. While the station operating in polled mode should automatically respond to interrogation messages from a ship or competent authority. Operation in polled mode should not conflict with operation in the other two modes.

The three modes are suitable for different conditions. The default mode is autonomous mode. The assigned mode and the polled mode should be used in the management of AtoN.

When operating in polled mode, the AIS AtoN will respond the message 15 about the VHF data link from the base station in the same channel. The message 21 and message 6 should be used for autonomous mode. By polled mode the base station can get the dynamic information and position report of the AtoN within its coverage.

3.3.2 Assigning Transmission Slot

In the busy water-area, the time-slot transmitted may conflict and influence the transmitting and receiving the AtoN information. So in order to supervise the AtoN, the base station should operate in assigned mode by message 16(RECOMMENDATION ITU-R M.1371-1, 2002), including assigning the slot and the report rate.

In assigned mode a certain slot with a parameter called timeout is assigned to the AIS AtoN. Normally the timeout should be 3 to 8. Every frame(in AIS, 1 frame = 1 minute) the timeout will reduce 1. The AIS will not release the slot to switch to autonomous mode until the timeout reduce to zero.

3.3.3 Assigning Report Rate

IALA recommended that the report interval of AIS AtoN is 3 minutes (IALA guidelines on the universal automatic identification system, 2002). When a high-speed ship navigates within the coverage of AIS AtoN, it may not get the information for a long distance in this report interval. So the interval should be 1 minute under this condition.

3.3.4 Broadcasting Remote Control Order

When the control center finds the malfunction of the AtoN, according to the resolving scheme it will automatically form a message (message 6) and send it to the AIS AtoN through the AIS base station.

3.4 Function of System Software

The software installed in AIS control center should be based on ECDIS. The function of it is described as follows.

- (1) Display the information such as the position, work status of AtoN and draw it on the ECDIS.
- (2) Correct the parameters of AtoN and open the backup device.
- (3) Query the detailed information of AtoN
- (4) Dispose the alarm information received from AtoN
- (5) Change the report rate or designed slot of AtoN

Fig.3 gives the information flow chart of the software system.

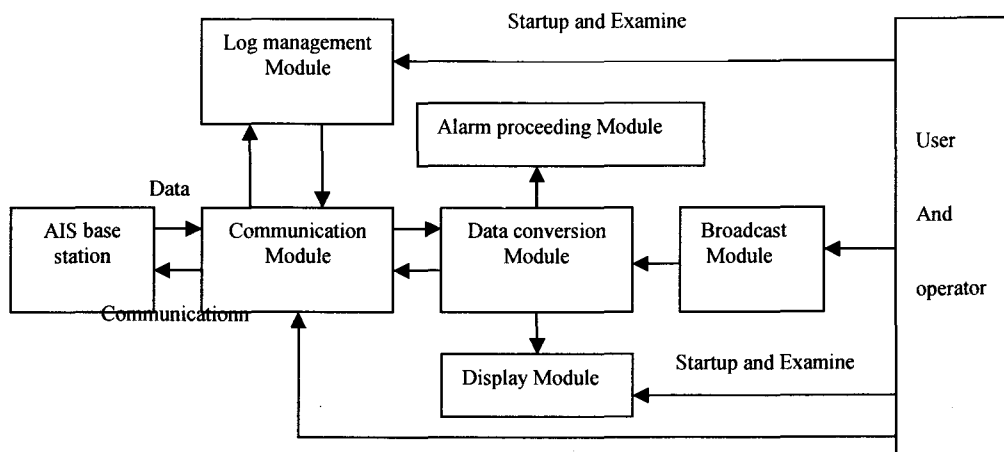


Figure 3. Information flow chart of the software system

The base station broadcasts the VHF message, which has been enveloped in UDP datagram according with IEC-61162-100. The communication module will take out the data from UDP datagram and send it to the data conversion module. Based on the ID code of message in ITU-RM. 1371-1 the data can be encoded and the detailed information, such as position and work status, will be displayed on ECDIS by display module.

4. Results of Software Simulation

4.1 Displaying the position of AtoN

In order to display the information in real time the position of AtoN should be updated in a certain interval, for example, in 3 seconds.

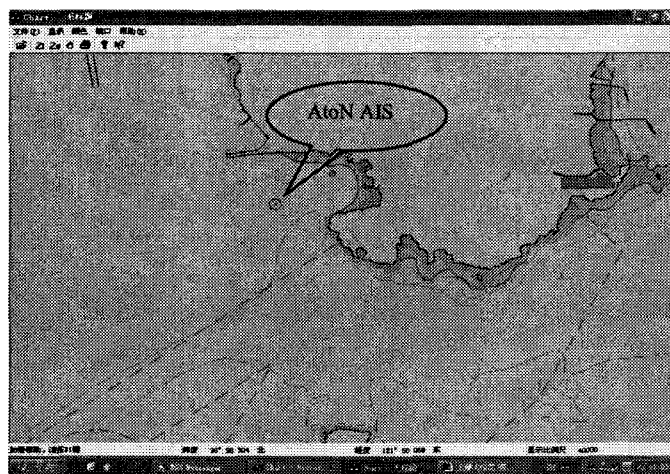


Figure 4. Display of AtoN position information

4.2 Disposing of the alarm

When the malfunction of the AtoN occurs, for example, off its position, the screen will appear alarm message automatically. And then the center can inform the AtoN management dept. in time.

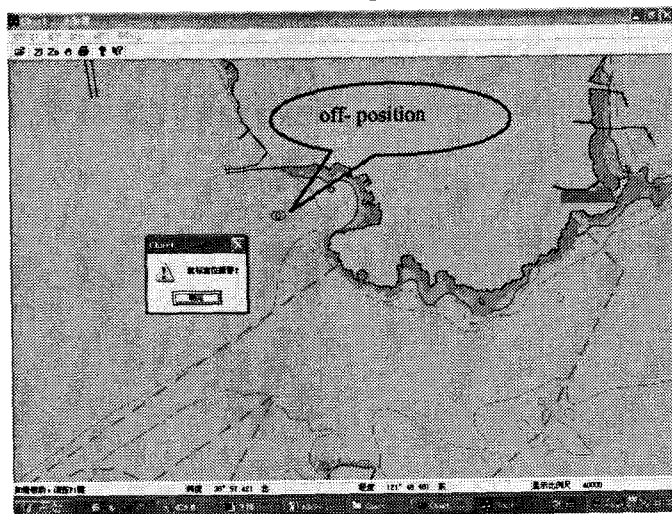


Figure5. Display of AtoN off-position information

5. Conclusion

It is an inevitable trend to develop a digital marine traffic system. Applying AIS into AtoN surveillance system will promote the development of digital marine traffic system in China. And it will also improve the navigation safety and efficiency.

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