A Study on Shipborne

Automatic Identification System (AIS)

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Abstract At present the identification of vessels is still depending on the OOW (Officer Of Watch) in VTS (Vessel Traffic Service), which is completed by radar , and also by the combination of VHF radio and VHF direction finder. However, with the development of port transportation and economic, this conventional way of identification can't satisfy more and more request for the information that the VTS needs from the vessels. In such a case, the AIS (Automatic Identification System) precept which is based on STDMA (Self-organized Time Division Multiple Access) technique is put forward by IMO (International Maritime Organization). AIS can automatically provide the information, including own ship's identification, type, position, course, speed, and other information to the appropriately equipped coast station and other ships. At the same time it can also automatically monitor and track the nearby ships similarly fitted with AIS. On the basis of describing the whole comprising and the format of transmission information of AIS, this paper mainly studies the key communication techniques in AIS, such as STDMA protocol, net synchronization and GMSK (Gaussian Minimum Shift Keying) technique, and so on. At last this paper briefly introduces the recommendation decided by IMO on forcing the sea-going ships to fixed with AIS equipments, and it continues with the unexploited potential of AIS if it applies in VTS.

Keywords AIS VTS SOTDMA GMSK Net synchronization

1 PREFACE

The 21th Century is the century belonging to ocean and also the developmental century of the sea traffic "Infobahn". With the reform and opening deeply into our country and the development of our social economy, the carrying trade of vessel traffic gets an unparalleled flourish, and which brings us the problem of the navigation safety. VTS plays an important role in enhancing the safety of navigation, increasing the efficiency of traffic and protecting the environment and so on. It can provide the services such as traffic monitor, information service, navigation consultation, traffic organizing and supporting the combined actions by collecting, dealing with and evaluating the information.

However, in VTS at present the identification of the vessels is still depending on the operator, that is shipping report system. When the vessels enter the appointed area it should report to the VTS center by VHF and then VTS operator will identify the vessels on the VTS information proceeding and displaying terminal. Because this identification scheme mainly rely on manual work and radar to treat with the data, it has several shortages as follows:

(1) The communication among vessels completed by VHF radio by the operator so one vessel can't obtain the encountered one's identity automatically and can't understand in time the other one's intention. For this reason collision accidents often happen.

(2) the radar and ARPA on ship can offer only limited information and their works are often

inflenced by weather, sea-condition and landform, so in bad weather when we need more from them the radar and ARPA can't work efficiently instead.

（3）VTS radar data proceeding subsystem based on port radar signal adopts regular-constant-carrier none-coherence pulse which brings the limitations and it leads the result that the precision, distinguish rate and reliability of tracking dynamic objects all can't be satisfying.

With the development of VTS, the ship-to-ship information and ship-to-shore information to be exchanged become more and more and the VTS center's requirement for information also increases. On this occasion IMO brings forth a new shipborne navigation aid, universal shipborne Automatic Identification System –AIS. This system is the product of the studying by International Maritime Organization（IMO), International Association of aids to navigation and Lighthouse Authorities（IALA）and International Telecommunications Union-Radio communication Sector（ITUR）and it is also called universal radio transponder. Its purpose is to help the vessels all fixed with AIS to exchange their important data such as the current voyage status and manipulate information with other similarly fixed vessels. This system utilizes GPS and modern communication techniques together with computer proceeding to complete automatically the identification of the vessels.

2 A STUDY ON OVERALL PROJECT OF AIS

2. 1 The Comprising of AIS

The system block diagram of AIS is as follows, figure 1:

AIS is a relatively stand-alone system which utilize the advanced communication technique and computer technique according to the fact condition of traffic at sea. The function of each part of the system is as follows:

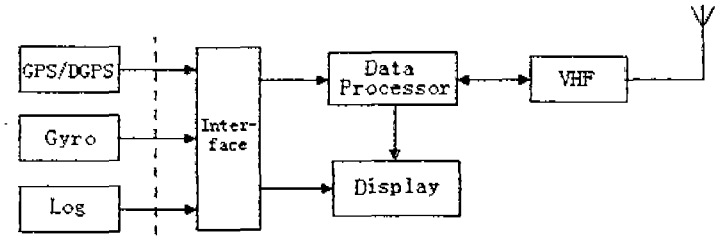

Figure 1 block diagram of AIS

（1）interface circuit : receiving own ship's position of longitude and latitude, UTC from GPS/DGPS and the course over ground form gyro compass and the speed over ground form the log and other signals which are to be conversed into digital signals and to be input the data processor.

（2）data processor: to be used for storing own ship's static data and voyage related data, and for proceeding and storing own ship's dynamic data. And after encoding these data will be send to the transmitter. It also receives the voyage data from other vessels and then decodes and stores them. At last it will send the voyage data of own ship and others to the display. Data processor is the hard core of AIS.

(3) information display: to be used for monitoring the operation of the system and displaying the data and status information as has been said before. But the information display for application may be integrated with radar, ARPA and ECDIS.

(4) VHF transceiver: concluding one transmitter and two receivers and controlled by data processor. It works in VHF CHN 87B, 88B which are two international special channels and transmit or receive automatically the modulated signal (including the navigation information of own ship and other ships) according to the protocol of communication scheme. The frequency bandwidth is 25KHz.

2.2 Types of AIS Messages

All messages related to AIS can be displayed on electronic chart, and its basic message is as follows:

(1) Static messages include: IMO number, call sign and name, length and beam, type of ship and location of position-fixing antenna on the ship (aft of bow and port or starboard of centerline).

(2) Dynamic messages include: ship's position, time in UTC, course over ground (COG), speed over ground (SOG), heading, navigational status and rate of turn.

(3) Voyage related messages include: ship's draught, hazardous cargo, destination and estimated time of arrival (ETA), route plan and short safety related message.

The messages are transmitted in a data packet. A frame equals one minute and is divided into 2250 time-slots. Each slot contains 256 bits. The packet format is as shown in table 1.

Ramp up	Training sequence	Start flag	Data	CRC	End flag	Buffering
8 bits	24 bits	8 bits	168 bits	16 bits	8 bits	24 bits

Table 1 data packet

2.3 Key techniques in AIS

AIS utilizes modern communication and computer proceeding techniques to navigate and monitor the vessels. Communication is the key in AIS. AIS information is transparent to all vessels similarly installed the AIS equipment. And if at pointed area the number of vessels is not known so it requires the system to have a large communication capacity. And this reason brings forth a high requirement for the selection of the communication mode. We are to discuss them separately as follows:

2.3.1 TDMA (Time Division Multiple Access) Technique

The communication system in AIS consists of one base station and many mobile stations. One mobile is used for one user so it is single-channel. But the base station broadcasts its information to all mobiles, which is multiple-channel. Therefore the system is an integration of single-channel and multiple-channel and it should select multiple-channel modes, which is also called multiple access.

At present multiple access includes frequency division multiple access (FDMA), time division multiple access (TDMA), and code division multiple access (CDMA).

FDMA is a relative mature technique and it is easy to be used. But it will generate cross-modulation interference and intermodulation interference, and if multiple channels share the same antenna at the base station, their transmitters will use power combiner. A lot of power will be

lost and much of the power capacity will be endured by combimer. Its main shortage is that the capacity of users is small and if it is used in army its performance of anti-jamming is not very good.

CDMA is a wide-band technique and in fact it is a technique of Direct Sequence Spread (DSS) Its efficiency of spectrum is 10 times that of the analog modulation or FDMA. Each cellular accommodates thousands of users. In addition, CDMA has the performance of anti-multi-path fading. The problems of this technique applied in mobile communication are grievous far-and-near effect and limited treat gain.

TDMA is also a mature multiple access and it is an effective solution to resolve the cross-modulation interference and intermodulation interference among base stations. In TDMA technique the time is divided into periodical frames and then each frame is divided into time-slots. According to the principle of assigning the slots, each mobile can only send messages to the base station at pointed slots in each frame. If it is timed and synchronized, the base station can receive the messages from every mobile with no interference. The capacity of TDMA is times of FDMA and it is easy for TDMA to realize anti-jamming. TDMA system doesn't have the problem of assignment frequency. The allocation and management of time-slots are easier and more economical than that of frequency. The biggest limitation of TDMA in mobile communication is that it should use protected slot and the protected time is related to the communication distance. The long the distance is, the long the protected time is and the more the channels are. However with the channels becoming more and more, the sum of protected slot of every channel will increase. Therefore the data slots have to be compressed in order to increase the speed of transmission, which may bring the troubles such as the spectrum spreading, the power of unit frequency descending, and the S/N descending. With the development of component and communication technique, TDMA technique is employed more and more frequently in the mobile communication system. If the slots are assigned dynamically, the capacity of system will be increased.

AIS works on the sea with the band of each channel being 25KHz in VHF and the number of channels being limited. So if it uses FDMA technique it will not only occupy many channels which will decrease the number of users, but also generate greate intermodulation interference. On the other hand, CDMA technique is not mature enough for application and the cost of the manufacture of the base station's and the mobile's equipments is relative expensive, so it is not fit for AIS system. Therefore TDMA technique is selected.

In AIS there is no difference between main station and sub-station. Each user selects the slot by itself. When the mobile station works automatically and continuously the mobile user broadcast the position and identify the information from the near users with SOTDMA (Self-Organized Time Division Access) address protocol. It can resolve the address conflict without the control by the main station. All users are allowed to select automatically 1~5 slots in one frame and send their information within one selected slot and the left 4 slots are used for spare slots. When some mobile station sends its messages the others should be in the status of receiving, which means that in this kind of communication system the function of the lowest layer is still controlled and organized by the users themselves, which is the signification of the term "self - organized".

The length of one frame equals 1 minute and is divided into 2250 slots. Each slot is 26.67ms. The speed of channel transmission is 9600bps and each slot contains 256bits. UTC from satellite flags the beginning and ending of every frame. The system should be able to handle a minimum

2000 reports per minute, which satisfies the request of VTS for the capacity. The allocation of the slots is as shown in figure 2.

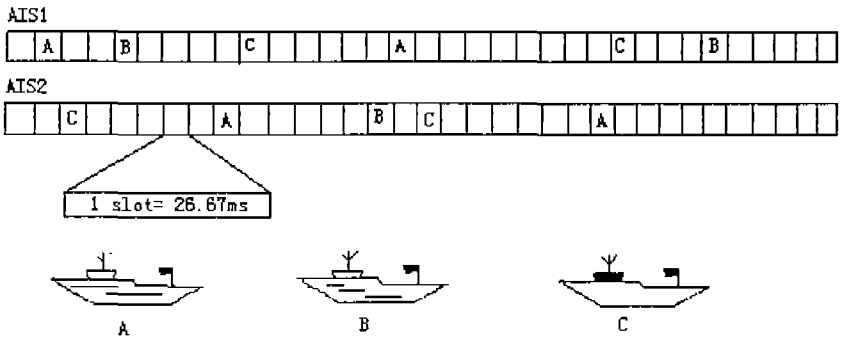

Figure 2 STDMA time slots allocation

2.3.2 Net Synchronization Technique

TDMA system must be accurately timed and synchronized to ensure that the signals from every mobile station will not generate overlap or confusion at the base station and to ensure the mobile stations receive the information from the base station and other mobiles precisely. Net synchronization is the key technique in TDMA system. It will make the whole system transmit, proceed and exchange in an orderly way systematically only when there is a uniform time standard in the entire meshwork. AIS contains several synchronization modes described as below:

(1) Vessels installed AIS equipment mostly use GPS to position and use the UTC to get timing (UTC time is achieved from equipment and in AIS here it mainly refer to the time from GPS receiver). In this way AIS users will be synchronized precisely based on UTC source.

(2) When an AIS user can't obtain the UTC from GPS as its standard source, receiving the information from other users who synchronize to UTC, that is, indirect access to UTC can synchronize it.

(3) Synchronize to the base station or VTS center.

(4) Synchronize to other AIS users. When all users in some area can't receive UTC source and the information from base station and VTS center, these AIS users will synchronize to one of them.

2.3.3 GMSK (Gauss Minimum Shift Key) Modulation Technique

The selection of modulation mode relates to the selection of channel performance and the transmission speed. In AIS it divides one minute into 2250 slots and the length of each slot is 26.67ms. If the speed of transmission is selected as 4800bit/s, 128 bits will be send within one slot, by means of which it can't transmit a piece of whole information about one vessel. Therefore the speed of transmission is selected as 9600bit/s with NRZI code. The modulation mode is selected as frequency modulated Gaussian Minimum Shift Keying (GMSK/FM). The modulation index is 0.5 when the bandwidth is 25KHz and 0.25 when the bandwidth is 12.5KHz.

Minimum Shift Keying (MSK), also named fast shift keying, refers to obtain the orthogonal signal on the condition of the minimum modulation index. For a given frequency band, its transmission bit rate is higher than PSK. In the mobile communication on sea, it is important for the limitation of the power radiation outside the band, the attenuation of which must be above 70~80dB. MSK still can't meet such a critical request and it must be improved by means of

adding a Gaussian lowpass filter before MSK modulation, that is, the Gaussian lowpass filter will be used as the pre-lowpass filter of the MSK modulation. The filter is required to have a narrow bandwidth since it should restrain the power outside the band and at the same time it will ensure the digital signal to be demodulated correctly. According to the difference of bandwidth in AIS it will be selected as 25KHz or 12.5KHz, and at the same time the filter must be sharply cut-off, with a lower over-pulse response, so as to keep the stability of the output pulse and demodulated correctly.

2.3.4 Transmitter RF Attack and Release Time

Because the transmitter should transmit at the two designed channels and the communication mode is simplex, it is required to have a well RF attack and release time and allow transmitter fast keying and 解控. RF attack time should not exceed 1 ms, that is, the time from TX-ON signal until the RF power has reached 80% of the steady state should not exceed 1 ms. And also the time which is call RF release time from TX-OFF signal until the RF power has reached zero should not exceed 1 ms. See figure 3.

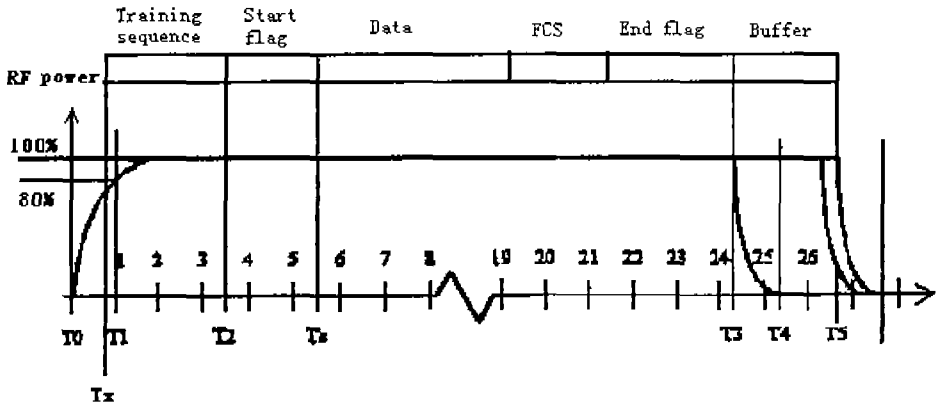

Figure 3 transmission timing

3 CONCLUSIONS

AIS is a universal system. In the NAV42 session the conclusion has been made as follow: in the whole world only one type of AIS should be selected as the system in the future. In November 1998 ITU agreed the suggestion of AIS technique standard. IMO now has passed the resolution about the standardization of universal AIS. The NAV45 session in 1999 agreed the resolution that all merchant ships engaged on international voyages must be forced to install AIS equipment not later than 1 July 2008. The equipments of AIS are now in the course of being studied and developed, among which VTS products of many companies such as German ATLAS and Norwegian NORCNTROL have both been designed and remained the special interface for AIS. At same time many ECDIS manufacturers have produced the ECDIS products with the function of displaying and proceeding the AIS information.

For VTS, AIS will build up its function of monitoring. Each vessel with AIS equipments can achieve other ships' dynamic information through the sensors and store their basic information. According to its own navigation speed it will send continuously and automatically the important data to the VTS center in a regular interval. All AIS targets within VHF radio range will be displayed on the electronic chart of AIS center station. AIS center station will monitor all the ships

fitted with AIS after receiving the information from the ships. And at the same time all ships fitted with AIS can also display the information of the ships around similarly fitted with AIS. Therefore, for VTS the application of AIS can reduce the reliability of the special equipment and increase the flexibility of system. Intellectualized VTS is the direction of development in the future of which AIS will become one of the important constitutes.

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