Implementation of Communication Network Utilizing AIS Technology

Soohong Park, JongNyen Lee, *Member, KIMICS*

Abstract—Automatic Identification System (AIS) is recently introduced to the maritime navigation systems. It is aimed to increase safety of vessels at sea by exchanging information to coastal monitoring stations. This article presents a ship traffic monitoring system by using the AIS information communication system using MS Visual C++. Then, the mobile Internet AIS introduced here is considerably improving and extending AIS functionalities compared to VHF AIS. When each ship is connected to the Internet network through the developed AIS system with her own client ID, all of her AIS information is surely sent to a server at her own base station by processing the information via the Internet network.

Index Terms— Automatic Identification System (AIS)

I. INTRODUCTION

The use of radar technology in marine navigation has led to so called "radar assisted collisions" [1]. This was initially used to describe a problem frequent during the early days of radar technology at which time only a small portion of ships carried radar. Radar undoubtedly gave the mariners a whole new awareness of the traffic situation at night or in heavy fog. In addition, when only a very few merchant ship had radar technology, having radar gave a competitive advantage (at night or in heavy fog) since ships without radar had keep low speed and were unlikely to alter their course quickly. The radar however allowed the mariners to maintain full speed and maneuverability. "Radar assisted collisions" started to occur when more and more mariners got this new sight organ, and they were all following the logic outline above, assuming that others did not have radar technology.

The Automatic Identification System (AIS) is a recent concept introduced in order to increase safety of maritime and river traffic, offer aids-for navigation service and improve traffic control and management. Present AIS solution is based on the VHF data communication scheme. Overview of this solution identified several shortcomings of the system, which will be described in this article. Without AIS, mariners must address each other by referring to their position (i.e. "ship at position XY") when trying to make radio contact [2]. This way of addressing ships often does not yield an answer at all, or even worse, it does yield an answer, but from the wrong ship. Apart of providing a solution to this problem, other objectives behind the introduction of AIS are to "assist in target tacking", "simplify informational exchange", and "provide additional information assist situation awareness. As long as some ships do not have access to the information provided by AIS, there is a danger that those ships will experience a loss of information and, with it, situation awareness. It is tentatively suggested that this problem has been overlooked partly because of a widespread but impoverished model of communication which does not account for the role of side-participant in a conversation [3].

Because of the lack of research and knowledge of the use of AIS, this paper is largely exploratory. The focus has been the use of AIS on the bridge by mariners [4]. In order to overcome identified shortcomings of the VHF AIS system our team has developed Mobile Internet AIS, a novel concept which presents migration of VHF-based AIS to mobile internet by utilization of the most recent mobile communications technologies. The purpose of this article is to introduce Mobile Internet AIS as a complement to VHF-based AIS, enabling both systems to form general solution.

In this article, general AIS concept is presented first, along with a brief review of present VHF AIS solution. Mobile Internet AIS solution is then introduced and described. Also implementation of AIS functionalities in Mobile Internet AIS is addressed. Finally, improvements introduced by Mobile Internet AIS are outlined and possible directions for further Mobile internet AIS development are proposed.

II. AIS CONCEPT

AIS is the latest contribution to improvement of the safety on sea. It is an autonomous and continuous broadcasting system, which allows automatic exchange of shipboard information collected by the vessel's sensors with the other vessels and shore station(s) in related geographic area. In general, the AIS is to provide increased safety on sea, continuous data exchange and

Manuscript received August 8, 2008; revised October 16, 2008.

Soohong Park(Corresponding author) is Professor in the Dept. of Mechatronics Engineering of the Dongseo University, Jurye-dong, Sasang-gu, Pusan, 617-716,Korea (Tel: +82-11-849-1765, Email: shpark@dongseo.ac.kr)

JongNyen Lee is Professor in the Dept. of Mechatronics Engineering of the Dongseo University, Jurye-dong, Sasang-gu, Pusan, 617-716,Korea(Tel: +82-11-849-1764)

Aids-to-navigation.

The following AIS entities are describe, according to:

- AIS class A ship-borne mobile equipment – intended for SOLAS vessels.
- AIS class B ship-borne mobile equipment – intended for non-SOLAS vessels.
- AIS base station equipment – shore-based station providing text messages, time synchronization, meteorological or hydrological information, navigation information or position of other vessels

Communication protocol describes the AIS data exchange between AIS entities. Reports being transferred between AIS entities are created as the sequences of AIS messages as defined as below:

III. VHF AIS

Present AIS solution is implemented as the private communication network utilizing a part of the VHF maritime mobile band. Dedicated AIS architecture and communication protocol has been developed to handle multiple reports at the rapid update rates. It uses the Self –Organizing Time Division Multiple Access (SOTDMA) technology to meet high broadcast rates and handle a large number of AIS clients [5].

The VHF AIS enables direct ship-to-ship communication determined by radio propagation characteristic. In addition, the ship-to-shore communication is accomplished through AIS base station utilization. The AIS base station receives reports issues by AIS client. Base station may retransmit these reports toward all AIS clients in the vicinity, allowing those who were unable to receive AIS reports directly due to radio propagation environment, to acquire the data. Network of regional national AIS base stations can be established in order to provide better traffic monitoring in designed area (AIS networking).

While the VHF AIS meets most of the AIS concept requirements, some of the system shortcomings were observed:

- VHF AIS has limited coverage (up to 25 nautical miles at open seas or less at coastal area due to island and mountains),
- Long-range solution is unresolved issue,
- Incomplete situational awareness because all vessels do not participate in the system,
- System implementation is expensive,
- End-users need education in operating AIS equipment,
- Building of AIS network is complex and expensive task,
- System has limited enhancement opportunities,
- AIS data security is unresolved.

IV. Mobile Internet AIS Station

In order to overcome some of the shortcomings of VHF AIS, our team suggests migration of the AIS to mobile Internet. The means for connection to mobile internet is not crucial for the service itself. The end-user can choose from different wireless solutions e.g. satellite communications system (Inmarsat, Globalstar, etc) or public mobile communications system (GSM/ GPRS/UMTS) [6]. In that way, a public mobile communications system can be used during coastal and marine navigation while a satellite system can be used during open seas navigation. The choice should be governed by availability and cost of the communications service.

A. Mobile Internet AIS Station Architecture

In order to make practical realization of proposed solution, a dedicated Mobile Internet AIS Station architecture is developed based on client-server concept.

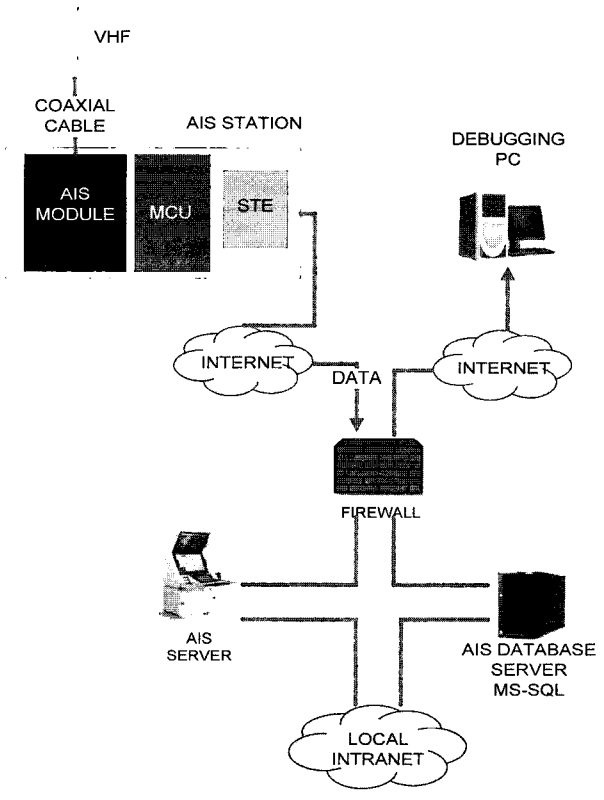


Fig. 1 Mobile Internet AIS architecture

AIS client is a mobile client, located on the vessel search and rescue aircraft or aids-to-navigation equipment.

It is responsible for:

- Collecting positioning data from the appropriate positioning AIS Module,
- Establishing and terminating connection to the AIS station through the mobile internet,
- Reporting data to the AIS server database,

- Receiving information from the AIS server database,

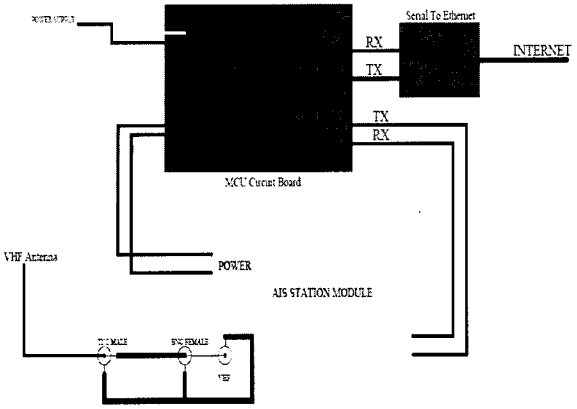


Fig. 2 Mobile Internet AIS Client Architecture

Mobile Internet AIS station is a type of transponder system. If a ship is equipped with AIS station is fitted with an electronic device, the transponder, which transmits signals to, and receive signals from, all other AIS-equipped ships. The transponder consists of a AIS module, microprocessor board, Serial to Ethernet (STE) and VHF antenna which is shown in Fig. 2. The AIS Module is fed with data about ships position and navigational status. This data is sent to microprocessor board, which processes it and send to Server via STE. The communication between AIS module and microprocessor unit is established with standard industrial protocol serial communication RS232.

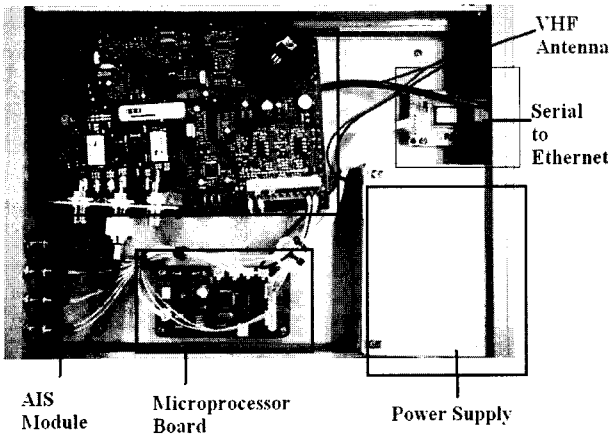


Fig. 3 AIS Station (Client) Hardware Structure

In addition, the AT Command needs to be sent to STE from microprocessor when microprocessor requires sending the AIS information to Server as shown in Fig. 3. Each of the AIS clients has predefined client id and IP address. The AIS station module outputs the data using the standard VDM sentence. The format of the VDM sentence consists of a human readable text part and a binary data part:

!xxVDM,t,n,s,c,binary data,f*hh<CR><LF>

! = Indicates sentence with encapsulated binary data
xx = Talker identified typical 'AI'
t = total number of sentences in message <1-9>
n = this sentence number <1-9>
s = sequential message identifier <0-9> used to identify sentences belonging to the same data transmission
c = AIS channel A or B
f = number of fill I bits 0-5 cannot be null
hh = checksum

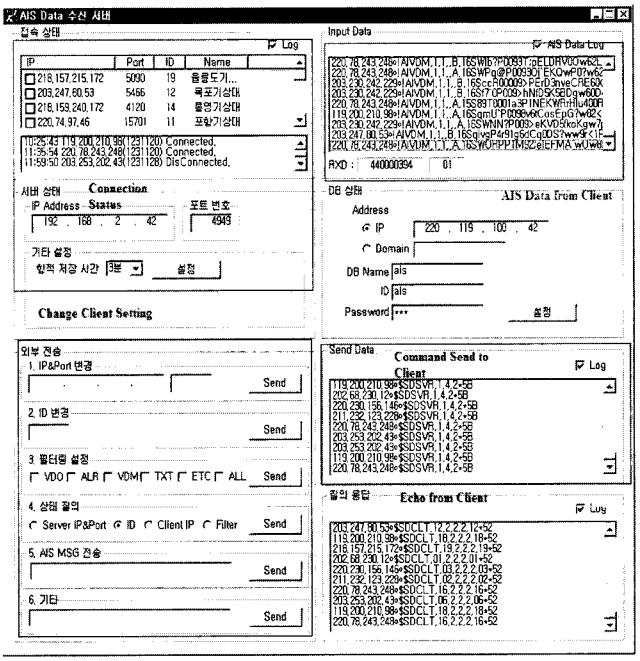


Fig. 4 AIS Client report Receiving Software

The Mobile Internet AIS client consists of AIS Station Module, microprocessor unit and Serial to Ethernet (STE) which is support for connection to communication networks. The Fig. 4 is the Mobile Internet AIS client receiving software. The software is used to monitor, change and query the AIS Client current setting. Another purpose of the software is used for verifying the connection between clients and server. The data from the AIS Client will be saved into Server Database. The Mobile Internet AIS Client eliminates need for expensive and complex equipment, dedicated device for performing AIS tasks. Also need for end-user education in operating such dedicated device is eliminated since user is already familiar with all the devices, their environment (e.g. operating system) and principles of their usage. Below Fig 5 is the firmware flow chart of the AIS Station Client:

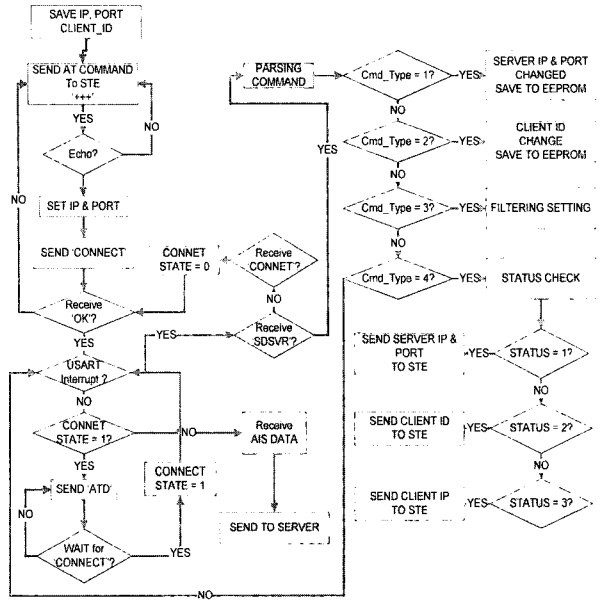


Fig. 5 AIS Station (Client) microprocessor Firmware Flow Chart

AIS server is responsible for monitoring traffic in specific geographic area, making it regional/national server.

It is responsible for:

- Collecting and storing data from all AIS clients (including aids-to-navigation equipment and search & rescue aircrafts) in geographic area of response.
- Mandatory re-distribution of collected data to AIS clients
- Request AIS client id, IP address and the AIS status from server.
- Providing interface to authorized national agencies and VTS.

B. Mobile Internet AIS protocol

The Mobile Internet AIS protocol describes AIS data exchange between AIS client and AIS server.

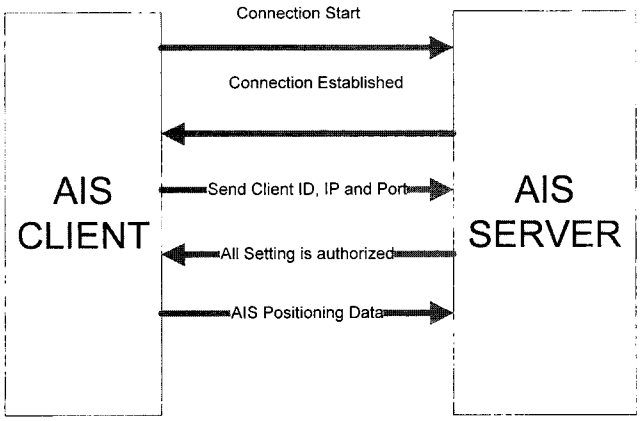


Fig. 6 Communication Session between Client and Server

This use case describes one communications session in which Mobile Internet AIS data is exchanged between AIS client and AIS server as shown in Fig. 6. Session is started when client opens connection to server according to schedule. AIS client prepares and sends standard command which is defined. After AIS server receives the connection established command, it saves data to AIS database.

C. Design and Implementation Ideas

The AIS system is managed by designated national authority, which established the national/regional AIS servers and is responsible for configuration, maintenance and security of servers. National authority should also perform task of initial user registration to the AIS system.

National AIS systems should be integrated in the global AIS system. Such integration can be accomplished through agreements between countries, which should define connectivity of AIS servers, handover between national AIS system and terms of AIS data exchange (e.g. monitoring national vessels on international voyages). End users and national authorities would benefit from increased safety at sea since all vessels are included in the system, while national authorities would also get better insight of naval traffic in national seas and improved monitoring of national vessels on international voyages. Mobile operators would get an increase in data traffic.

V. MOBILE INTERNET AIS STATION FUNCTIONALITIES

The Mobile Internet AIS solution not only offers improvements in required AIS functionalities but also opens possibilities for introduction of new telecommunications services for AIS system (e.g. weather forecasts, satellite weather images, notices for mariners etc.), which will be described.

A. Mobile Internet AIS Station Data message format

Every AIS client communicates with AIS Server using Internet AIS protocol. Direct ship-to-ship communication is not available in the Mobile Internet AIS. Dedicated AIS server replaces that functionality by re-distributing received position reports of the neighbor vessels during every session with AIS clients. A full string of AIS message contains the following information:

1. MMSI (Maritime Mobile Service Identity)
2. Name
3. Call Sign
4. IMO
5. Receive Time
6. Navigation Status
7. Type of ship
8. Position
9. Speed over ground (SOG)

10. Course over ground (COG)
11. Heading (gyro course)
12. Rate of turn
13. Ship Size
14. Draught

B. AIS reception position report

Standard position reports from AIS class A and AIS class B client is transmitted at scheduled time based on speed of the reporting vessel. Upon reception of position report, AIS server determines the instance of the next report. Using this, AIS server can identify vessels not reporting their navigation data at scheduled time. When position or status of the equipment changes, or pre-set limit of parameters monitored by this equipment is exceeded, new report is generated and sent to AIS server. Server can also send interrogation to the AIS Station to change the parameters of the equipment.

C. Long Range AIS Coverage Area

Unlike in the VHF AIS, coverage area in the Mobile Internet AIS is not limited by propagation of radio waves from one source. The long-range AIS solution is achieved by merging different communication system (public networks like UMTS; satellite networks like Inmarsat etc.) in order to get continuous coverage, not interrupted by local geography [6].

The Mobile Internet AIS coverage area is defined by the coverage area of applicable communication networks. Since both public mobile and satellite networks with very good maritime area coverage are used, Mobile Internet AIS presents global solution.

D. AIS Data Communication Technology

Since Mobile Internet AIS station equipment is not expensive and sophisticated, small passenger ships in local traffic and recreational vessels can participate in general AIS system. Almost all vessels are capable of exchange AIS data, which increases navigational security and makes supervision of local marine traffic easier.

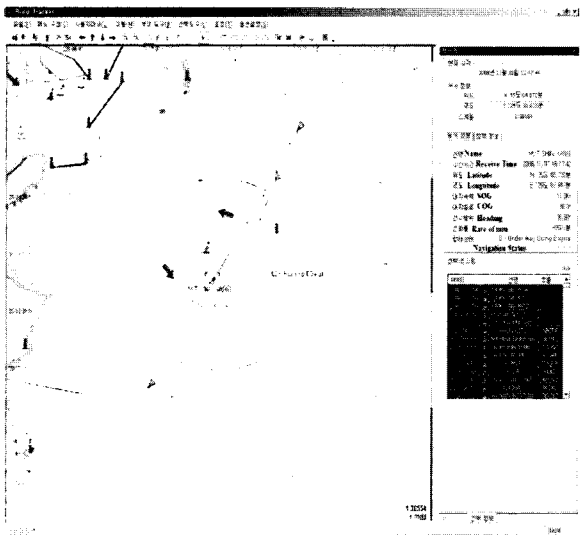


Fig. 7 Monitoring Software at AIS Server side I

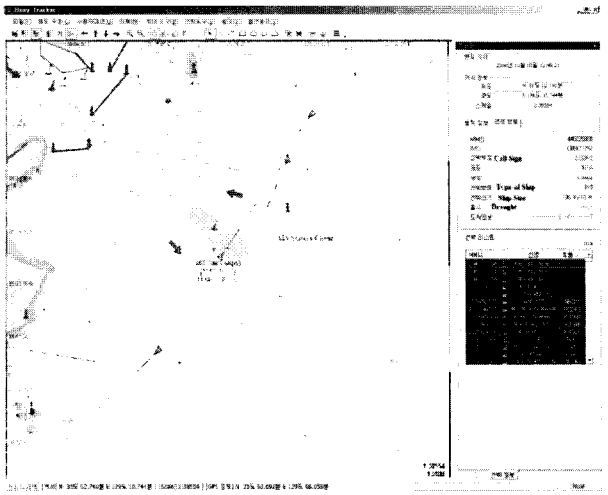


Fig. 8 Monitoring Software at AIS Server Side II

The Fig. 7 and Fig. 8 above are shown the example of AIS Server from a AIS station client report. From the figures, AIS Server can identify the status of the AIS client reports. End user is able to identify the targets and the recognition of collision danger if he is interested.

IV. CONCLUSION

From a technical point of view, Mobile Internet AIS is considerably improving and extending AIS functionalities compared to VHF AIS. At the same time, integration of internet AIS and VHF AIS is also achieved to provide the global AIS and the AIS-for-All. From a political point of view, implementation of the AIS could be a challenging problem. However, once countries agreed on carrying it out, Internet AIS would be just an additional extension to existing systems. A future work for the Mobile Internet AIS will be focused on an application to human-to-machine interface, a synergy effect of VHF AIS and authorized national agency and an implementation to successful business.

ACKNOWLEDGMENT

This work is resulted from the project of human Resources Development for Industrial Demand financially supported by the Ministry of Education and Human Resources Development (MOE) .

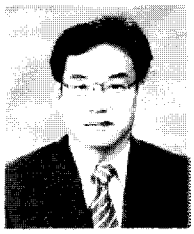
REFERENCES

[1] Belcher, P.A.,"sociological interpretation of the COLRGES", *The Journal of Navigation*, 55, pp. 213-224, 2002.

[2] Cannel, W. P. ,Collision ,"avoidance as a game of co-ordination", *Journal of Navigation,* 34, pp.220-239,1981.

[3] Taylor, W.B.R.," Is there a case for improved communications in order to reduce the risk of

collision of sea?", *Conference Proceedings, Paper 19, Maritime Communication and Control*, 7-8 July 1993.
[4] TRB," *Shipboard Automatic Identification System Display: Meeting the Needs of Mariners.* Transportation Research Board", Special Report 273,2003
[5] Morris, J.," Looking into the future of Hawkeye. U.S. Coast Guard Engineering", Electronics, and Logistics Quarterly, 10 (38), 3-4, 2006.
[6] ITU – RM. 1371 Recommendation,2001.
[7] A.Trangeled, G.Zappa and D.C. Conley, "An Embedded maritime acquisition and control system", NURC report SR-398,2004.
[8] Anonymous, "Technical characteristic for a universal shipborne automatic identification system using time division multiple access in the VHF maritime mobile band," *International Telecommunications Union*, Recommendation ITURM.1371 – 1:98, 2001.
[9] ICAN Marine, "Lloyds uses AIS for court cases," *personal communication*, 2007.
[10] A. Harati-Mokhtari, A. Wall, P. Brooks, J. Wang, J., "Automatic Identification System (AIS): Data Reliability and Human Error Implication," *The Journal of Navigation*, vol. 60:3, pp. 373-389, 2007.
[11] A. Norris, "AIS Implementation – Success or Failure?," *The Journal of Navigation*, vol. 60:1, pp. 1-10, 2006.
[12] Mayer, R. ," The Maritime Awareness Global Network. *Proceedings: The Coast Guard Journal of Safety and Security at Sea of the Marine Safety and Security Counci"l,* 63(3), 47-49. Retrieved January 17, 2006.



Soohong Park (M'2006) is a professor at Mechatronics Department of Dongseo University. He obtained his bachelor, master degrees and Ph.D. from Pusan National University at the year of 1986, 1989 and 1993, respectively. During 1995-1996, he was visit professor at the Beijing Aero & Astronautics University, China. In year 2002-2003, he was visit professor at the Oregon State University, U.S.A.. His main research topics are Control and Unmanned vehicles.

Jongnyun Lee (M'2008) is a professor at Mechatronics Department of Dongseo University. He obtained his bachelor and master degrees from Pusan National University at the year of 1981 and 1985, respectively. He earned Ph.D. degree from University of Arizona at the year of 1992. His main research topics are Control, Robotics and Mutibody Dynamics.