Study of Quality Service in AIS Gateway System

Mário Assunção and Luis Mendonça

Abstract About 90 % of the volume of world trade is transported by sea via ships, this volume corresponds to about 70 % of world trade in value. Thus, maritime transport must be made on the basis of the highest rates of safety. Global distress communication systems, ship reporting systems, emergency radio beacons, and other technologies have greatly enhanced mariners' safety. Considering this, the paper presents a platform that enables the maritime access information from data provided by the Automatic Identification System (AIS) in a quick way only by using your mobile phone. The developed and made available platform intended as a complement to any existing technology that supports shipping with high safety indices. In this paper the proposed approach is used in two real situations. The results make it possible to understand that the quality of service is good and it can provide relevant information for shipping management.

Keywords Automatic identification system · Maritime transport · Quality of service · Safety of maritime transport

1 Introduction

Maritime transport has contributed effectively to the economic development of Europe, as it enables the business and exchanges between countries. This transport has as main features the cost the safety and the environmental protection. Maritime transport performs effectively and safely power supply as well as the transport of food and raw materials within Europe and worldwide [1]. The maritime transport in Europe and in the world is an important source of employment and income as

M. Assunção · L. Mendonça (✉)
Department of Marine Engineering, Escola Superior Náutica Infante D. Henrique, Paço de Arcos, Portugal
e-mail: luismendonca@enautica.pt

M. Assunção
e-mail: marioassuncao@enautica.pt

P. Garrido et al. (eds.), *CONTROLO 2016*, Lecture Notes
in Electrical Engineering 402, DOI 10.1007/978-3-319-43671-5_67

enhances the participation of various stakeholders in several areas. Maritime transport provides globalization through made business, communications through the contacts between the various countries, the standardization of various entities because only in this way can make contacts and associations and diversification of trade result of contacts and committed business [2]. For all that shipping should be equipped with tools that improve the quality and safety available to its users, the crew and the environment. Maritime transport may involve several vessels with different products and different routes originating specialized transport networks. Specialized transport networks are composed by: ships, ports, factories, terminals and distribution centers. Considering the economic, environmental and safety features the shipping is a possible substitute for other cargo transport [3].

Maritime transport and trade made over the centuries for various locations around the world, have boosted the economic success of the countries involved. Maritime transport has a very high participation in internal and external trade of the European Union, respectively 90 % and 40 %. In terms of the quantities of goods loaded and unloaded values are about 3.5 billion tons each year [4]. The maritime labour is a very difficult profession, security of crews and the use of new technologies will be very important for the development of maritime transport. The sea routes involving Europe are the busiest in the world. So, for safety the monitoring of these routes and monitoring of ships are of great importance to prevent accidents. The development of new technologies and their use in maritime transport is essential for shipping, the trade and the economy can continue to evolve.

Maritime transport and its users can use a navigation protocol adopted internationally in the exchange of information related to navigation, the Automatic Identification System (AIS). This system has several possibilities among which facilitates the vessel traffic management, identifying the ship, its position, its course, its speed, navigation conditions as well as information related to security. AIS receive and shares the information automatically with other ships also equipped with the same system, as well as onshore facilities. The AIS database messages can be used to model the high density of vessel traffic zones for collision avoidance [5]. Also the AIS real time data can be used to aid the target detectors and radars sensors [6] or to help the maritime navigation, environment protection, ports operation [7]. Several AIS Web systems were developed, such AISLive-HIS, ShipAIS or Marine Traffic, to obtain AIS data, although these systems are paid, they present user-friendliness and with no real-time AIS data. Besides systems have been developed to increase the reliability of AIS data [8].

In this paper is proposed the development of AIS with the main objective of the improvement of maritime transport also in concerning safety. One developed and implemented a gateway mechanism that allows the connection of an Android mobile phone to a server that provides real time AIS information received from a VHF-AIS receptor. Hence the information provided by AIS can be used by a greater number of users and improve safety levels. The Quality of Service (QoS) is an issue to get accurate AIS real-time data, therefore is presented a QoS study of the developed AIS gateway system.

The paper is organized as follows. In Sect. 2, the safety of maritime transport is addressed. Section 3 presents the description of the Automatic Identification System and Sect. 4 gives a description of the developed NMEA-AIS gateway system. The measuring of the quality of service is addressed in Sect. 5. The QoS results obtained are shown and discussed in Sect. 6 and conclusions are drawn in Sect. 7.

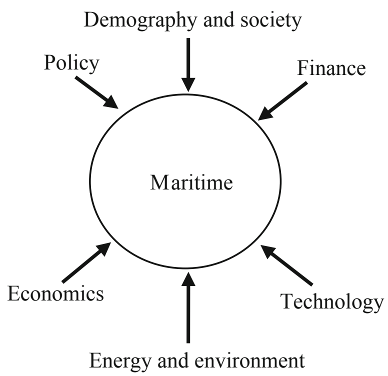
2 Maritime Transport

Considering freight the transportation systems can be done by land, by water or by air. These systems have distinct costs, capacity, speed and time delivery. The transportation system performed by land is normally performed by trucks with more flexibility and operating in many areas. By land the costs transportation for loading and unloading facilities and equipment are very low compared to other modes of transportation however with small capacity in regard to volume and weight. Other disadvantage is the use in some situations of only one driver per truck. Comparing transport by truck to transport by rail this has a more limited network but is more energy efficient. Transport by rail has also the advantage of fast transportation of bulk cargo on long distances however with the disadvantages of longer stops and cargo handling costs. The transportation by aircraft is the fastest however the higher speed implies higher transportation costs.

The maritime transport is slower than transport by land or by air but is cheaper when compared with those freight transport modes. Other advantages of maritime transportation are the ability of shipping bulk cargo and large volume cargo over long distances and the low emissivity gas by what are known as environmentally friendly as compared to other transport modes. Being comparatively favorable the maritime transport, will be important to assess how this transport mode can evolve. The development of maritime transport can be supported in six areas (Fig. 1): policy, demography and society, energy and the environment, technology, economics and finance [9].

The impacts of the technology and its innovation are difficult to quantify. However, the use of new technologies associated with maritime transport has

Fig. 1 Directions of maritime transport



associated advantages with regard to the safety of crew, passengers and cargo as well as the environment. It can thus be seen that technology and innovation make it possible to provide shipping with increasingly important features.

The AIS emerges in maritime transport in order to contribute to improving the quality of services provided based on the need for technological innovation and compliance with the laws that regulate it. In 2000 the International Maritime Organization (IMO) decided to adopt the use AIS on ships for Safety-of-Life-At-Sea (SOLAS), therefore it would be possible to provide information automatically about the ship to other ships and to onshore facilities. After the 31 December 2004 there is the requirement that AIS be installed on ships with the following characteristics: ships on international voyages with gross tonnage less than 300, ships in non-international voyages with gross tonnage less than 500, all passenger ships.

Thus the development of technology related to the AIS, as proposed in this article, may contribute to the improvement of service with regard to maritime transport.

3 Automatic Identification System

Operating AIS enhances communication and sending information from one ship to other ships and onshore facilities as well as receive information from other vessels and onshore facilities. Therefore reduces the risk of collision by providing vessels information allowing the shipping decisions with greater confidence [10]. This can be achieved through an AIS text message relating to security. AIS has enormous potential in many areas but the safety of ships is indeed improved when using this type of system. Some of the AIS features are: provide information, receive information, monitor and control the vessels, assisting in search and rescue and exchange information with onshore facilities. The users of AIS text messages should be aware that this information does not replace the use of other information, according to the rules of international navigation. The use of AIS messages during emergencies should consider that these messages cannot be received, recognized and put into practice by the entities that should receive as with posts Global Maritime Distress Safety Systems (GMDSS). The seafarer should be aware that AIS does not replace other systems should not be used in situations for which is not indicated. AIS should not be used when it is necessary to carry out urgent or instead of GMDSS communications. AIS provides the seafarer the potential to be seen and to be heard by other users of the AIS [11]. The AIS is considered as a complementary system with great features to enhance the quality of maritime transport, but should be used only as a security alert at the available information not eliminating any policy or national or international security procedure and any operational requirement or materials. The seafarer should be aware that the AIS must be in perfect working condition because only in this way the messages exchanged are reliable and can be used without prospects mislead [11]. The use of AIS messages enables the improvement of maritime security can additionally enable the relevant navigation data storage that can certainly help to clarify the cause of some problems that may occur and hence contribute to its future resolution. AIS also has a high importance in the development of risk assessment models [9]. This importance is related to its ability to provide information on the speed and traffic distribution. The AIS information receptors on land are limited. Furthermore the AIS devices do not allow automatic repetitions of an alert. AIS safety messages are transmitted only once, and if the signal is corrupt or there is interference in the transmission, a situation that sometimes occurs with the AIS device, the message may not be received. The seafarer should know the AIS capabilities as well as its limitations [10]. They have been done some studies that enhance the determination of the risk profile of a ship based on the modeling of risk and information provided by AIS. Within the project European Marnis [9] was already set a risk index.

4 NMEA-AIS Gateway System

4.1 Hardware Implementation

AIS data is obtained with existing equipment in Escola Superior Náutica Infante D. Henrique and relate to vessels that move in the Tagus' river. This information is provided on mobile phones and only need to download and install the provided software application.

The National Marine Electronics Association - Automatic Identification System (NMEA-AIS) gateway system is implemented using several technical solutions in interconnected equipment's. The Fig. 2 shows the implemented block diagram. The entry block is the AIS receiver equipment (AIS-3R from Comar Systems) that reads and flood all AIS messages transmitted by AIS Class A and Class B transponders [12]. The digital messages are available in the USB equipment's port (NMEA 0183 format protocol). A server computer is connected to the AIS receiver by the USB port, and a running server application is listening all the incoming USB messages.

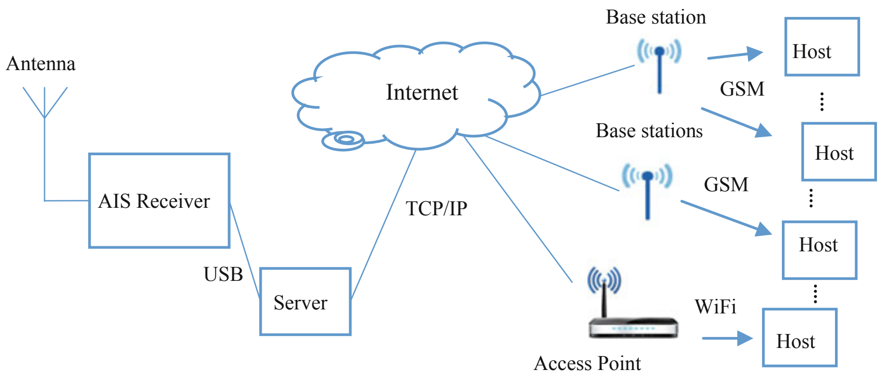


Fig. 2 Block diagram of AIS gateway system

The same application execute a parallel task for listening TCP/IP connections requested from internet by the host clients applications running in mobile equipment, such cell phone or tablet. In each client application the AIS messages are extracted and decoded from the NMEA messages. Additionally the NMEA messages and/or the AIS decoded are locally stored in the client host storage disk or card memory.

4.2 Software Development

In order to implement the NMEA-AIS gateway system two codes software were developed one to run in the server machine and the other to run in the host machine (Android based cell phone). The server software implements the tasks: read USB buffer incoming messages and save to local disk; listening and accept the TCP request connections; and relay the NMEA-AIS messages from USB buffer to the host using the TCP. The host software implements the functions: Establish a TCP connection to the server; save the NMEA-AIS messages in local file; decode the encapsulated AIS message; and show the geographical position of a vessel.

The AIS messages provide the information for traffic analyses and vessels' information. The host client applications are able to decode the AIS messages [13]. The position report messages, type 1, 2, 3, 18 and 19, give the geographical coordinates and the vessel Course Over Ground (COG), among others information. The host application uses the decoded information to map vessels polygon figures in a Google Map™ application window.

5 Measuring the Quality of Service

5.1 QoS System Performance

In order to achieve the overall AIS Gateway system performance a quality of service (QoS) measure has been performed. It is obvious the main goal of the system is to gateway the NEAM messages remotely, so the primary QoS merit figure, is the Packet Loss Rate (PLR) defined in Eq. (1). In this equation the N_{server} represents the number of USB messages transmitted by the AIS receiver and saved in the server, and the N_{host} represents number of the received messages and saved by the host application into the disk memory.

$$(PLR)_1 = \frac{N_{host}}{N_{server}}. \tag{1}$$

Many issues can cause the QoS degradation. In the implemented AIS gateway we identify the follow possible causes for data losses: Communication between AIS receiver and Server: An NMEA message in USB cable has checksum error and is rejected by the server; An NMEA message is corrected buffered in server but the server does not have time to follow up before the next message is written in the buffer. And Communication between Server and Host(s): The TCP packet is sent but it takes a long time to reach the Host; The TCP packet is lost in Internet; The TCP packet had checksum error and was rejected by the Host; The Host take a long time process the received TCP packet compromising the next TCP packet; The Host (mobile) has a week signal connection that affects the delivery time.

The overall QoS is depended on the two bridges communications, first the USB connection between AIS receiver and Server and second the TCP/IP connection between Server and Host(s) over the Internet system. The defined PLR in (1) can be split into two PLR, using the number of messages transmitted in TCP/IP connection, N_{TCP}. These messages are observed with Ethernet sniffer in the server local area network.

$$(PLR)_2 = \frac{N_{TCP}}{N_{server}}. \tag{2}$$

$$(PLR)_3 = \frac{N_{host}}{N_{TCP}}. \tag{3}$$

The subsystems PLRs proposed in (2) and (3) are partial performance indicators the implemented AIS gateway system. So it is possible to differentiate if the Packet Loss Rate is due to the server side or to the host side connections.

5.2 Measuring the QoS

The QoS measurement can be achieved by registering the traffic or the messages in system key points. To do that, text logger were implemented in server at USB buffer and in host applications at decoded TCP messages buffer. Additionally a traffic sniffer logs the TCP connection traffic between server and Internet. With logger text files one can compare the raw NMEA packets in server (N_{server}) with the storage NMEA packets in host (N_{host}). The Eq. (1) gives the overall QoS. Using the number of messages detected in the TCP connection (N_{TCP}) one can calculate subsystem QoS using the Eqs. (2) and (3). Plus the traffic analyser logs the retransmitted packets that occurs due to the traffic congestion, lost packet or host destination unreachable.

5.3 Measuring the Delay Time

The delay time although has not a directly influence in the QoS is somewhat another figure merit of the system. In the logger texts file it was also registered the time for each NMEA packet. In server application it correspond to the instant of read USB buffer, in the host application it correspond to the instant when TCP message are received. The time delay is due mainly to the TCP connection. Although in some instants the Operation System, in server or in host, has to handle other running processes which can cause a significant contribution for the delay time.

6 QoS Results

Two scenarios for QoS measurement were tested for different conditions. In Table 1 is presented the test conditions for each scenario. The first test were short with favourable GSM network conditions. The second test was performed with instability.

GSM network conditions due to mobile movement or base station signal variation.

Using the text files logger for each test condition one obtain the statistical information of the NMEA packets in server (N_{server}) and the storage NMEA packets in host (N_{host}). The Table 2 presents the overall QoS using the Eq. (1). The first test condition has 100 % of QoS and the second test condition has 99.97 %. The USB incoming NMEA messages to the server are similar in the two case study, around 3.7 messages per second.

Notice that even the QoS of 100 % occurred in the first scenario, it was observed 4 retransmitted packets. Three of them are retransmitted once, and one has 3 retransmissions which caused a 2 s delay time. As can see this issue does not affect the overall QoS.

So that we could find the root cause of the 3 losses NMEA packets occurred in the second test scenario, it was observed in the TCP packets traffic analyser logger file that NMEA messages recorded in server logger haven't been sent through the TCP connection. That proves the server application does not gateway the NMEA message for unknown reasons. A possible error cause could be due to big data throughput in USB buffer. The Fig. 3 depicted the USB throughput when the particular instants of failure occur (instant of loss). No big data throughput was observed in the particular instant or the neighbour's instants.

Table 1 also presents the delay time for each scenario. As observed before the first scenario as less than 1 s of delay and a very uniform behaviour. In Fig. 4 is

Table 1 Two scenarios test conditions

Scenario	Mobile position	Move distance	Duration (min)
Fixed host mobile	Indoor	1 m	10
Moved host mobile	Indoor/Outdoor	15 km	97

Table 2 Two scenarios NMEA packets logged and overall QoS

Scenario	N_{server}	N_{host}	QoS (%)	Average delay time (s)	$\langle N_{server} \rangle /s$
Fixed host mobile	1287	1287	100	Less 1	3.77
Moved host mobile	13701	13697	99.97	1,43	3.72

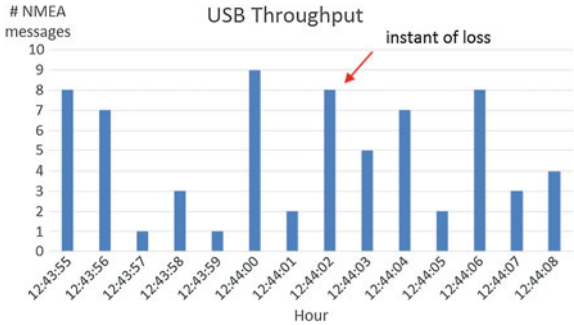


Fig. 3 USB throughput when 1 NMEA message was not sent by TCP (second scenario)

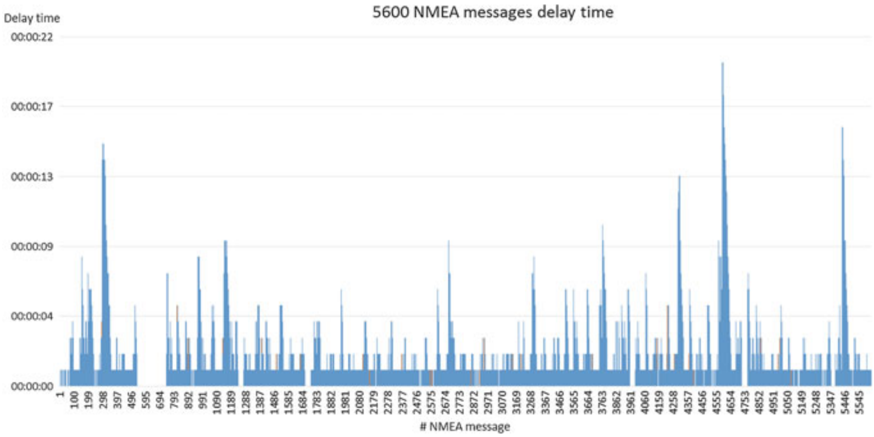


Fig. 4 Delay time for the second scenario test. Presented the first 5600 messages

depicted the delay time for the first 5600 NMEA messages in the second scenario case study. It is important to notice that the QoS in this extracted sample is 100 %. There are several instants where a high delay time occurs and one particular zone where a less than 1 s of delay is observed in the interval [#500, #700]. Since the overall QoS is 100 %, a possible explanation for the observed variation in the delay time is due to the poor network GSM signal conditions and the intermediated Internet equipment's queue.

7 Conclusions

A NMEA-AIS gateway system was implemented to aid the maritime vessel traffic. Technical solutions were developed to relay the NMEA-AIS messages from the VHF AIS receiver to the host mobile equipment connected to the GSM network. It is possible to implement this solution in different host Operation System platforms as long a TCP connection is available.

The developed system was measured in two different conditions scenario to determine its Quality of Service. Since the main connection issue is in the GSM network, the two scenarios are differentiated in cell phone movement characteristics. First it was measured in fixed position, second it was measured in movement condition. Both test conditions scenarios give an excellent QoS, 100 % in the first case and 99.97 % in the second case, which mean a few NMEA-AIS messages are not received in the cell phone.

Deeper analysis to check the root cause for loss NMEA messages allows us to conclude that the problem was in source of the TCP connection because the message wasn't sent. In conclusion the medium that supports the TCP connection over Internet and GSM networks are highly reliable. The AIS server design must be investigated to check the very small intermittent issue.

References

1. http://ec.europa.eu/transport/modes/maritime/index_en.htm. Accessed Dec 2015
2. Maritime Transport Policy, Improving the competitiveness, safety and security of European shipping, European Commission, European Commission, Directorate-General for Energy and Transport, B-1049 Brussels. http://ec.europa.eu/dgs/energy_transport/index_en.htm (2006). ISBN: 92-79-02947-9
3. United States Coast Guard, US Department of Homeland Security, Marine Safety Alert, Assistant Commandant for Marine Safety, Security and Stewardship (2010)
4. Annan, K.: The impacts of globalization on international maritime transport activity: past trends and future perspectives. In: Global Forum on Transport and Environment in a Globalising World. Guadalajara, Mexico, 10–12 Nov 2008
5. Mou, J.M., van der Tak, C., Ligterigen, H.: Study on collision avoidance in busy waterways by using AIS data. J. Ocean Eng. **31**, 483–490 (2010)
6. AIS-based evaluation of target detector and SAR sensors characteristics for maritime surveillance. IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens. **8**(8), 3892–3901 (2015)
7. Riadh, E., Jebali, C., Khaled, G., Ammar, K.: AIS data exchange protocol study and embedded software development for maritime navigation. In: Proceeding of IEEE 28th Canadian Conference on Electrical and Computer Engineering, pp. 1594–1599 (2015)
8. Hu, Q., Chen, J., Shi, C.: Bringing live AIS Information on the web sea charts by using Ajax. In: Proceeding of IEEE 7th International Conference on ITS Telecommunications, pp. 1–5 (2007)
9. Rodrigue, J.-P.: Maritime Transportation: Drivers for the Shipping and Port Industries, International Transport Forum 2010
10. Koldenhof, Y., Folbert, M.: Improving nautical risk modelling with the help of AIS, Marine Research Institute Netherlands Report 113, p. 13, Aug 2011

11. International Maritime Organization: AIS Safety-Related Messaging (2009)
12. Technical characteristics for an automatic identification system using time-division multiple access in the VHF maritime mobile band, ITU-R M1371, 04/2010
13. Maritime navigation and radio communication equipment and systems—Automatic identification systems (AIS)—Part 2: Class A shipborne equipment of the automatic identification system (AIS)—Operational and performance requirements, methods of test and required test results, International Electrotechnical Commission, IEC 61993-2:2012