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AIS RF Monitoring Service Using Application Specific Message

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Abstract

The AIS is an automatic tracking system used on ships and by vessel traffic services for identifying and locating vessels through electronically exchanging data with other nearby ships and VTS stations. Defining new application specific message has augmented the functionalities and informational content of AIS. This paper proposes RF monitoring service using AIS application specific message. The vessel, which has an AIS RF monitoring device, measures and monitors the sensitivity of the AIS signal transmitted from other nearby ships, AtoN devices and base stations. It can facilitate maintenance of the AIS devices and can also determine the AIS signal strength.

Keywords: *AIS (Automatic Identification System), binary message, ASM (Application Specific Message), service profile*

1. Introduction

The AIS (Automatic Identification System) is an automatic tracking system used on ships and by VTS (Vessel Traffic Services) for identifying and locating vessels through electronically exchanging data with other nearby ships and VTS stations [1, 2].

Application fields of AIS are collision avoidance, vessel traffic services, aids to navigation, search and rescue, accident investigation and binary messages. AIS information supplements marine radar, which continues to be the primary method of collision avoidance for water transport.

There are 27 different types of top-level messages defined in ITU 1371-4 that can be sent by AIS transceivers. AIS messages where the data content is defined by the application are application specific messages. They are the binary messages 6 and 8. The data content does not affect the operation of the AIS. This paper proposes an RF monitoring service profile that can monitor the sensitivity of the AIS signal by using the AIS binary messages. It can facilitate maintenance of the AIS devices and can determine the AIS signal strength.

The remainder of this paper is organized as follows. Section 2 presents an overview of the AIS information and operations. In Section 3, AIS messages are discussed. Section 4 proposes RF monitoring service using AIS application specific message. Finally, this paper is concluded in Section 5.

2. Automatic Identification System

The AIS is an automatic tracking system used on ships and by vessel traffic services (VTS) for identifying and locating vessels through electronically exchanging data with other nearby ships, AIS base stations, and satellites.

Vessels in international voyage weighing more than 300 gross tonnage and vessels in domestic voyage weighing more than 500 gross tonnage is obligated to be equipped with AIS by the SOLAS treaty. The SOLAS (International Convention for the Safety of Life at Sea) is an international maritime safety treaty. It ensures that ships flagged by signatory

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States comply with minimum safety standards in construction, equipment and operation. The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships [3].

Figure 1 shows the concept of the AIS.

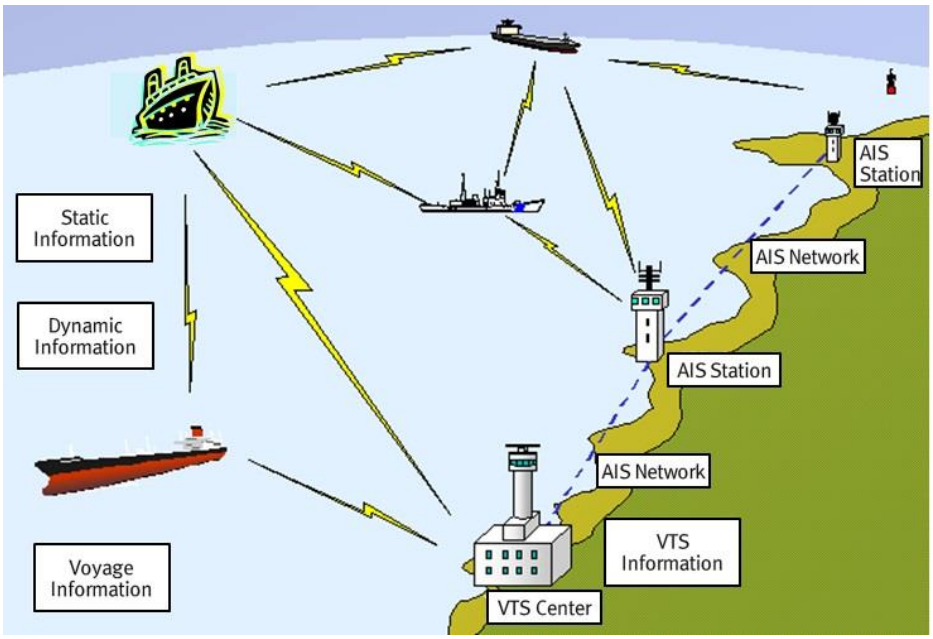

Figure 1. The Concept of the AIS

The original purpose of AIS was solely collision avoidance, but many other applications have since developed and continue to be developed. AIS is currently used for purposes like collision avoidance, fishing fleet monitoring and control, vessel traffic services, maritime security, aids to navigation, search and rescue, accident investigation, fleet and cargo tracking and *etc*.

AIS transceivers automatically broadcast information, such as their position, speed, and navigational status, at regular intervals via a VHF transmitter built into the transceiver. The information originates from the ship's navigational sensors, typically its GNSS (Global Navigation Satellite System) receiver and gyrocompass. Other information, such as the vessel name and VHF call sign, is programmed when installing the equipment and is also transmitted regularly. The signals are received by AIS transceivers fitted on other ships or on land based systems, such as VTS systems. The received information can be displayed on a screen or chart plotter, showing the other vessels' positions in much the same manner as a radar display. Data is transmitted via a tracking system, which makes use of a SOTDMA (Self-Organized Time Division Multiple Access) datalink [2].

Table 1 presents overview of the AIS information.

Table 1. Overview of the AIS Information

Categories	Contents
Static information	- The vessel's MMSI (Maritime Mobile Service Identity) - The name of the vessel - Radio call sign - Type of ship/cargo - Dimensions of ship - Location of positioning system's antenna on board the vessel
Dynamic information	- Position of the vessel - UTC seconds - Course over ground - Speed over ground - True heading - True bearing at own position - Navigation status (at anchor, under way using engine(s), *etc*.) - Rate of turn
Voyage information	- Draft, sea gauge - Destination - ETA (Estimated time of arrival) at destination - Route plan
Text communication	- Navigational data, weather information, *etc*.

The AIS protocol stack is composed of 1 to 4 layers according to the OSI reference model – physical layer, data-link layer, network layer and transport layer.

Figure 2 illustrates the layer model of an AIS station (physical layer to transport layer) and the layers of the applications (session layer to application layer) [4].

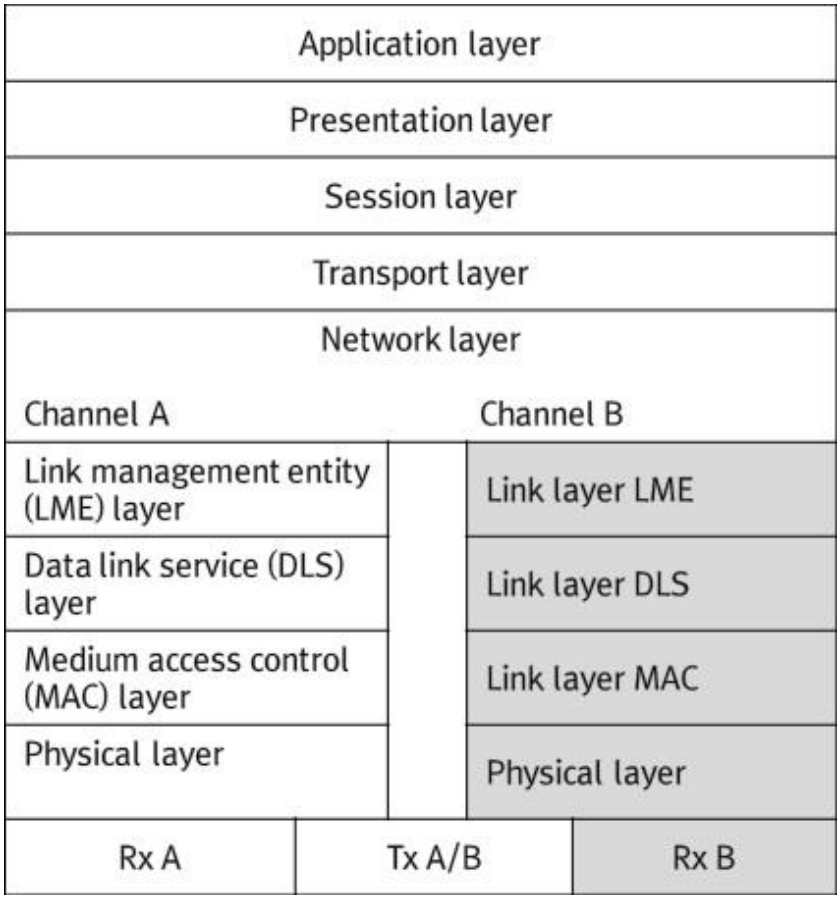

Figure 2. AIS Protocol Stack

The following are responsibilities of AIS layers for preparing AIS data for transmission.

Physical layer:

Convert digital NRZI (Non Return Zero Invented) coded transmission packet to analogue GMSK (Gaussian-filtered minimum shift keying) signal to modulate transmitter.

Link layer:

The link layer is divided into three sub-layers with the following tasks.

LME (Link Management Entity)

– Assemble AIS message bits.

– Order AIS message bits into 8-bit bytes for assembly of transmission packet.

DLS (Data Link Services)

– Calculate FCS (Frame Check Sequence) for AIS message bits.

– Append FCS to AIS message to complete creation of transmission packet contents.

– Apply bit stuffing process to transmission packet contents.

– Complete assembly of transmission packet.

MAC (Media Access Control)

– Provides a method for granting access to the data transfer to the VDL. The method used is a TDMA scheme using a common time reference.

Network Layer:

The network layer is responsible for the management of priority assignments of messages, distribution of transmission packets between channels, and data link congestion resolution.

Transport Layer:

The transport layer is responsible for converting data into transmission packets of correct size and sequencing of data packets [4].

3. AIS Message

Data is transferred using a transmission packet as shown in Figure 3.

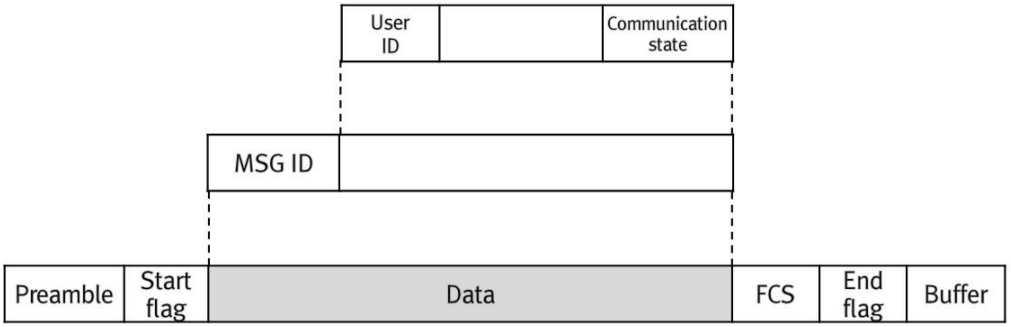

Figure 3. AIS Data-link Layer Frame Format

The AIS Information is included in the data field of the frame and it is transmitted in a given time slot. Therefore, AIS transceivers exchange information with pre-specified data format. There are 27 different types of top-level messages defined in ITU 1371-4 that can be sent by AIS transceivers. The functionalities and informational content of AIS have been augmented by defining new ASM (Application Specific Message) [5, 6]. It is also referred to as binary address, and broadcast messages and multiple content structures can be defined [7, 8].

AIS messages where the data content is defined by the application are application specific messages. The data content does not affect the operation of the AIS. AIS is a mean for transferring the data content between stations. A functional message's data structure consists of an AI (Application Identifier) followed by the application data.

The AI uniquely identifies the message and its contents. The AI is a 16-bit number used to identify the meaning of the bits making up the data content. The AI consists of 10-bit DAC (Designated Area Code) and 6-bit FI (Function Identifier).

The DAC assignments are IFM (International Function Message), RFM (Regional Function Message) and test. DAC 1 to 9 is for IFM, and it is maintained by international agreement for global use. DAC > 10 is for RFM, and it is maintained by the regional authorities affected. DAC 0 is used for test purposes.

It is recommended that DAC 2 to 9 be used to identify subsequent versions of international specific messages and that the administrator of application specific messages based the DAC selection on the MID (Maritime Identification Digit) of the administrator's country or region. It is the intention that any application specific message can be utilized worldwide. The choice of the DAC does not limit the area where the message can be used.

The FI is a 6-bit number assigned to uniquely identify the data content structure within an application under a DAC assignment. Each DAC can support up to 64 applications.

4. AIS RF Monitoring Service

A variety of electronic equipment and systems are built for the safe navigation of ships. The AIS provides the vessel's navigational data such as position, heading, speed and etc. in real time. Recently, maritime service has been developed to provide a variety of services between centers for collecting and utilizing AIS messages and vessels that provide AIS messages.

4.1. Service Scenarios

This paper proposes an RF monitoring service using AIS application specific message. The vessel, which has AIS RF monitoring device, measures and monitors the sensitivity of the AIS signal transmitted from other nearby ships, AtoN devices and base stations. It can facilitate maintenance of the AIS devices and can determine the AIS signal strength. The RF monitoring service consists of a vessel that has monitoring device, other ships and AtoN devices, and base stations. Figure 4 shows the service configuration.

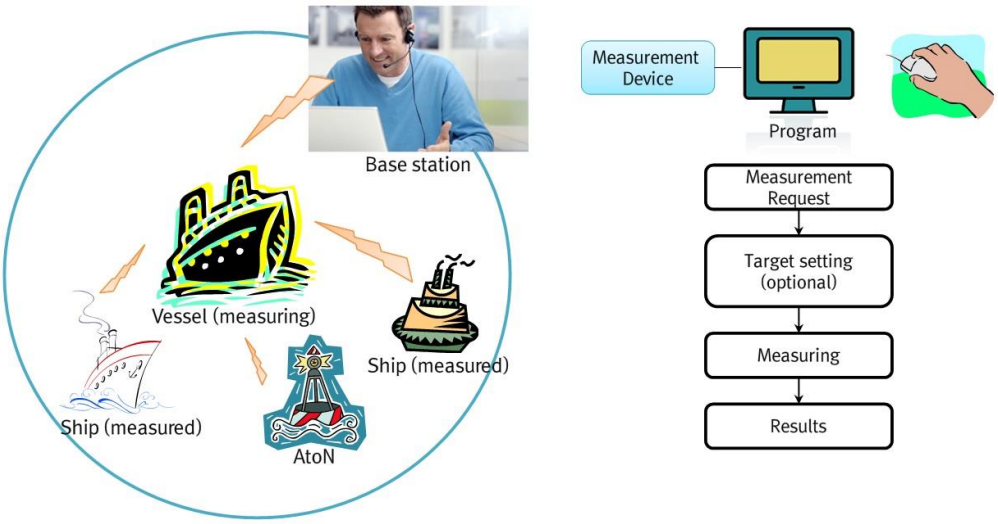

Figure 4. AIS RF Monitoring Service

The RF monitoring equipment of the measuring vessel measures the RF signal strength of the received AIS messages and reports it to the user through the pre-defined data format.

The proposed RF monitoring service is defined by a mandatory service and an optional service. The mandatory service reports the RF signal strength of the messages for the position report from the received AIS messages. The mandatory service scenario is presented in Figure 5.

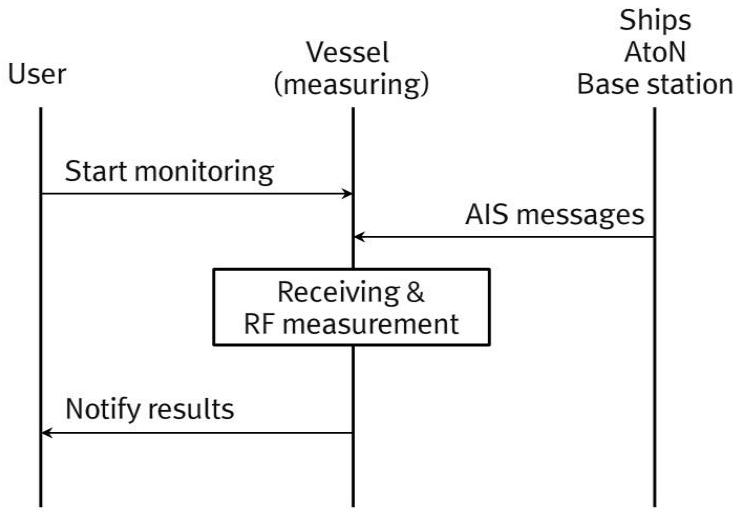

Figure 5. Mandatory Service Scenario

The optional service specifies the target vessel, AtoN devices or base station to be monitored, and transmits the measurement request messages to the target. It receives the response messages form the target and measures RF signal strength. The request and response messages are defined by AIS ASM. Figure 6 shows the optional service.

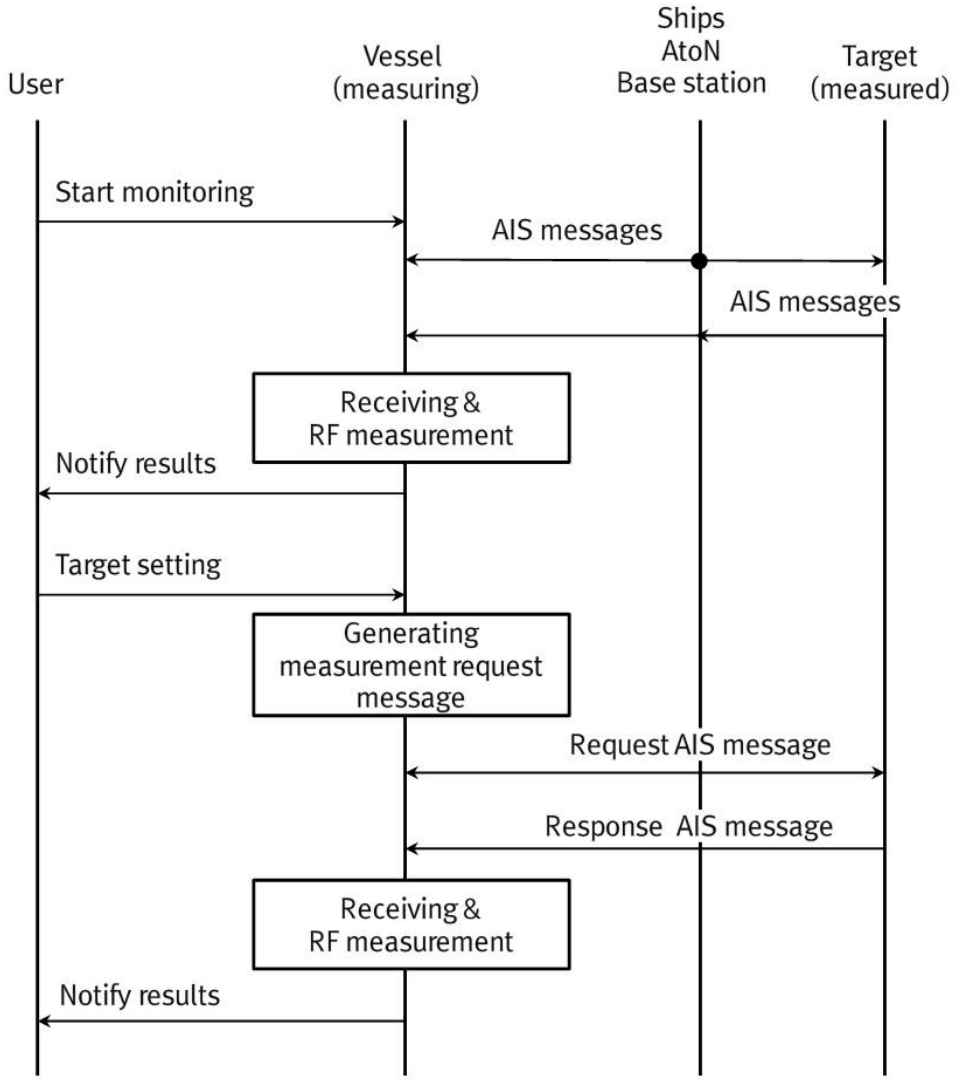

Figure 6. Optional Service Scenario

4.2. Message Formats for RF Monitoring

The messages of RF monitoring service consist of monitoring request messages and monitoring reply messages. Proprietary sentence of NMEA 0183 is applied in transmitting and receiving the RF monitoring messages [9, 10].

The monitoring request message is for requesting an RF measurement result of specified AIS message ID in all received and measured AIS messages. The format of monitoring request message is presented in Table 2.

Table 2. Monitoring Request Message

Parameter	Description
Set of AIS message ID	Message IDs of AIS to be notified

The monitoring reply message is an RF measurement result of the AIS message, which is specified by the monitoring request message. The message format is shown in Table 3.

Table 3. Monitoring Reply Message

Parameter	Description
Sequential ID	Sequential message identifier of received AIS message
Slot number	TDMA slot number of received AIS message
RSSI	RSSI value of received AIS message (dBm)
AIS message	Contents of the received AIS message

5. Conclusions

As well as the AIS is a powerful tool for collision avoidance and safety of ships in water transport, it can also be used as data communication networks between the ships and land. The interest in the use of binary messages that can define the data content by the application has been increasing. This paper proposed an RF monitoring service using AIS application specific message. It can facilitate maintenance of the AIS devices and can determine the AIS signal strength.

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