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Internet AIS

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Automatic Identification System (AIS) has recently become the leading issue in maritime navigation and traffic management worldwide. The present AIS solution, based on a VHF data communications scheme, provides AIS functionalities for SOLAS (AIS Class A) vessels only in a limited environment defined by radio propagation properties. Here we present a novel approach in AIS development based on current mobile communication technologies. It utilises existing mobile communications equipment that the majority of targetted end-users own and are familiar with. A novel AIS concept aims to offer a transition of AIS data traffic to mobile Internet. An innovative AIS architecture supports AIS data processing, storing and transferring to authorised parties. This enhances not only the operational area, but also provides the global AIS with data transfer security and an improved aids-for-navigation service, with all legally traceable vessels (both AIS Class A and AIS Class B) included in the system. In order to provide the development framework for Internet AIS, a set of essential four use-cases, a communication protocol and the first Internet AIS prototype have been recently developed and are briefly introduced in this article.

KEY WORDS

1. AIS. 2. Internet. 3. GPS. 4. VHF.

1. INTRODUCTION. The Automatic Identification System (AIS) is the latest contribution to the improvement of safety at sea (Sandford, 2004). Required for SOLAS vessels (AIS Class A) (IALA, 2002a, IALA 2002b), AIS:

- provides fast and unmistakeable ship identification at the earliest convenience in order to increase safety at sea
- enables continuous navigation data exchange (ship-to-ship and ship-to-shore)
- serves as an aid-to-navigation.

In order to provide the required functionalities, a dedicated AIS architecture and communications protocol has been developed based on VHF radio communications. Although this serves well for basic requirements, VHF AIS has numerous shortcomings:

- non-SOLAS vessels are not included in the scheme
- VHF AIS has a rather limited coverage

– long-range AIS and AIS Class B are currently unresolved issues
– dedicated AIS networking development is required
– investments in system implementation are considerable
– there is a need for end-user education
– system enhancement opportunities (such as the introduction of new telecommunications services) are rather limited.

Several projects are underway with the aim to provide solutions for at least some of the VHF AIS shortcomings, long-range AIS (Marechal, 2004) and global coverage in particular. Additionally, the issue of AIS data safety is far from being properly specified on the global scale. In order to overcome the limitations of the present AIS solution, we have developed a novel concept of AIS, based on the mobile Internet communications technology. It is important to emphasise that the Internet AIS solution does not compete with currently available VHF AIS, but rather presents a general solution in which VHF AIS and Internet AIS form a synergy that successfully fulfils AIS functionality requirements and provides new value-added services for the marine community.

In this paper we present the general Internet AIS concept together with the description of the Internet AIS architecture and communications protocol. Internet AIS advantages are then compared with sole-means VHF AIS. Several implementation issues are discussed, related to the currently available Internet AIS prototype. The paper concludes by discussing possible future developments of Internet AIS.

2. INTERNET AIS CONCEPT.

The concept calls for an AIS transition towards the Internet. The intention of this transition is to enable seamless and affordable AIS, available for every vessel appropriately equipped with a positioning sensor. The way end-user is connected to the Internet will certainly affect the quality of service. However, the choice of Internet connection is not critical for the service itself. The end-user is offered an opportunity to take advantage of a numerous selection of wireless services to reach the Internet. To that end, Inmarsat or any other satellite communications systems could be used while sailing on the open sea, and public mobile communications systems (GSM, GPRS, UMTS) used whilst in their coverage area (coastal navigation).

Internet AIS does not require special hardware installations for Internet AIS system deployment. It utilises present mobile communications systems as a backbone communications system. Furthermore, end-users are not forced to invest in new equipment or extended education. Emphasis is given on the re-use of devices that end-users are already familiar with (mobile phones, notebooks). Internet AIS provides the way for preparing and exchanging data automatically, with no need for manual interventions from the end-user. However, the end-user (officer on watch or master, for instance) could intervene in order to request or release additional information in relation to vessel's navigation. To support Internet AIS, a dedicated system architecture is developed based on client-server communication concept. End-users can easily utilise existing navigation (GPS/Galileo/GNSS receiver, personal computer with electronic charts, PDAs with appropriate navigation software) and communications equipment (mobile telephones). AIS data sets are to be managed by a

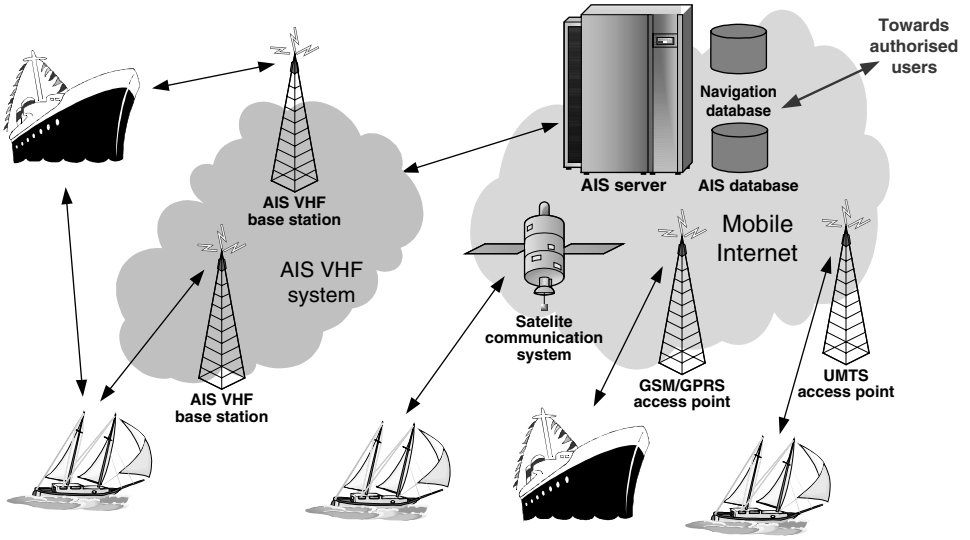

Figure 1. Internet AIS architecture.

network of regional/national servers. Internet AIS architecture allows for the implementation of additional features which are not easily available in standard VHF AIS, such as:

- regional traffic database
- maritime information service
- interfaces towards authorised governmental agencies (navy, police, customs, coastguard).

Finally, Internet AIS can be fairly easily introduced in inland waterways. Such an utilisation would provide the end-users with seamless transition from ocean navigation to river/lake navigation and vice versa. In general, the re-usability of an available network installation and end-user equipment makes Internet AIS an attractive solution for both SOLAS and non-SOLAS vessels, providing a solution for AIS-for-All system as well as global AIS coverage.

3. INTERNET AIS ARCHITECTURE. Internet AIS is based on the mobile Internet, regardless of the way the end-user is connected as in Figure 1. Based on this foundation technology, Internet AIS represents the classic client-server architecture.

The AIS client is located on the vessel and is responsible for:

- Communication with positioning sensors (GPS/Galileo/GNSS receiver, Loran C receiver, etc.) using NMEA-0183 standard
- AIS messages and Internet AIS report preparations
- Communication with regional/national AIS server using dedicated Internet AIS protocol (described in section 4)
- AIS data (message contents) visualisation

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The end-user may choose the most appropriate communications techniques, providing the compromise between quality of service (bandwidth, transmission rate) and cost of service. In general, coastal shipping could use public mobile communications technologies (GSM/GPRS/UMTS), while on the open seas and oceans satellite communications technologies should prevail (Inmarsat, GlobalStar, etc.).

The AIS server in direct Internet contact with the AIS client acts as the regional/national server. It is responsible for:

- Communication with vessels in the geographic area of response
- Collection of AIS-related (position and navigation) information and their storage in related database (AIS database for vessel positions; navigation database for weather data)
- Provision of interface with authorised government agencies for access to selected AIS information
- Integration of VHF AIS in order to achieve unified AIS system.

4. INTERNET AIS PROTOCOL. The Internet AIS data transmissions are organised through AIS reports. An AIS report is an encapsulation of the group of AIS messages, which are to be transferred in a single package. The AIS report exchange between AIS client and AIS server is generally defined by a dedicated Internet AIS protocol. In order to define the protocol, four elementary cases are identified and described by the following sequence diagrams. The AIS message types used are referred to as Mxx, where xx represents the AIS Message type number (for instance, M18 is AIS Message type 18). The standard and extended position reports are sent using AIS M18 and M19 message types, respectively. AIS reports re-transmission includes the AIS reports of neighbouring vessels.

4.1. *Case 1: Standard position reporting*. The AIS report exchange for standard position reporting is shown in Figure 2. Case 1 presents AIS report exchange, when just the standard/extended regularly scheduled position report is to be transmitted. The AIS client is given the next schedule for regular position report.

4.2. *Case 2: Standard position reporting with positioning augmentation*. The AIS report exchange for standard position reporting with positioning augmentation is shown on Figure 3. Case 2 presents AIS report exchange, when the standard/extended regularly scheduled position report is to be transmitted, and a request for differential positioning augmentation is to be fulfilled. The AIS client is given the next schedule for regular position report.

4.3. *Case 3: Standard position reporting with interrogation*. The AIS report exchange for standard position reporting with interrogation is shown on Figure 4. As stated in AIS specifications, AIS Class B vessels can be interrogated and they answer the interrogation with AIS message type 19. Other AIS equipped vessels and authorised government agencies (police, customs, coastguard) are among those who can initiate the interrogation. Case 3 presents AIS report exchange when the standard/extended regularly scheduled position report is to be transmitted and the AIS server interrogates the AIS client. The interrogation answer is given in a form of AIS Message 19. The AIS client is given the next schedule for regular position report.

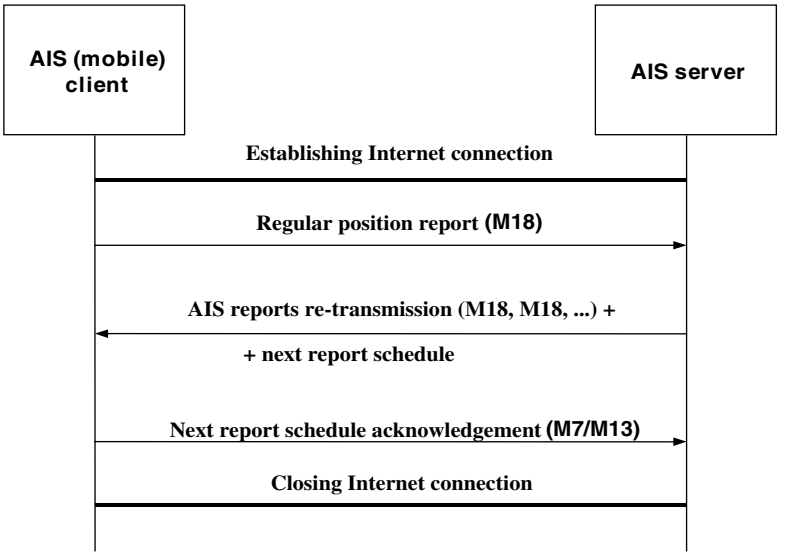

Figure 2. Case 1: Standard position reporting.

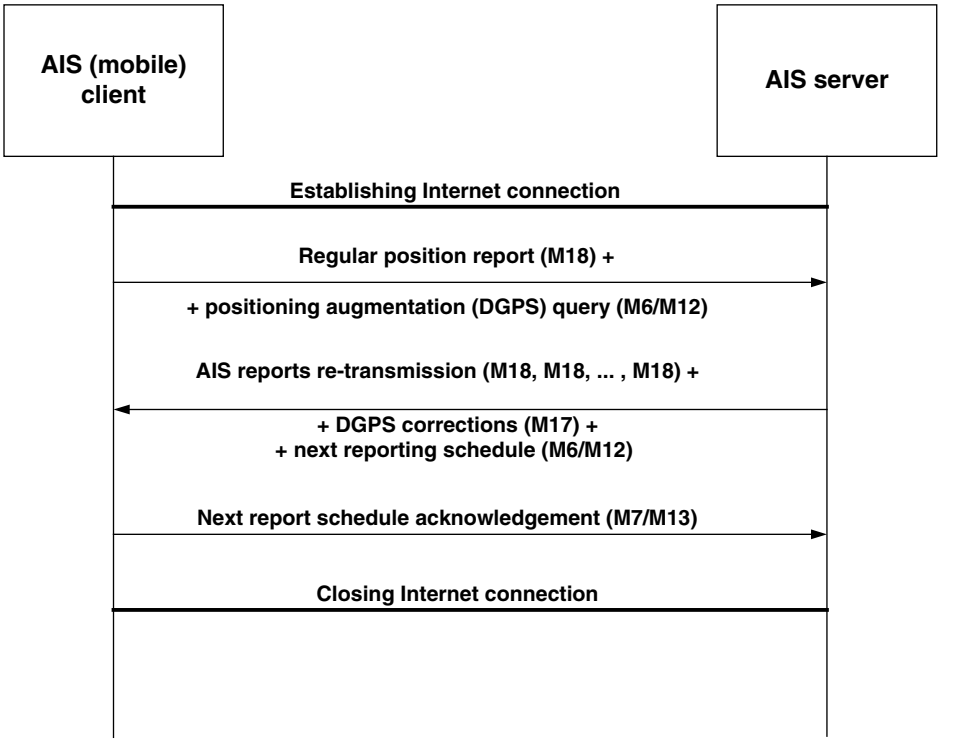

Figure 3. Case 2: Standard position reporting with positioning augmentation.

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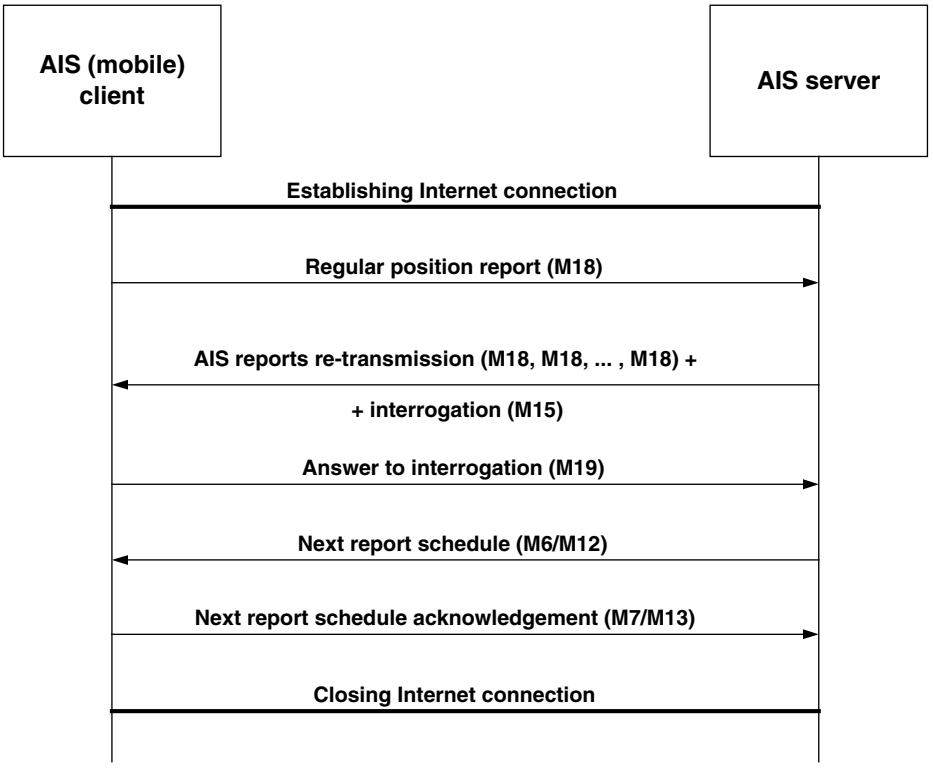

Figure 4. Case 3: Standard positioning reporting with augmentation.

4.4. *UC4: Standard position reporting with safety-related/textual message transmission*. The AIS report exchange for standard position reporting with safety-related/textual message transmission is shown on Figure 5. Case 4 presents AIS report exchange when the standard/extended regularly scheduled position report is to be transmitted and a competent authority wishes to send additional safety-related and/or textual message to the AIS client. The AIS client is given the next schedule for regular position report.

4.5. *Internet AIS report*. The Internet AIS report is aimed to provide the mechanism for AIS message encapsulation, as shown on Figure 6. The Internet AIS sessions presented on Figures 2-5 comprise several Internet AIS reports.

5. INTERNET AIS ADVANTAGES.

The Internet AIS presents numerous advances compared with the current VHF AIS solution. Nevertheless, it does not compete with VHF AIS as a substitute technology but offers integration capabilities.

5.1. *AIS-for-All solution*. Considering the existence of AIS Class A specifications and mandatory service, an interface towards VHF AIS network is opened with the aim to provide data to both VHF AIS and Internet AIS users. This allows development of the AIS-for-All solution, where both SOLAS and non-SOLAS vessels become a part of the system.

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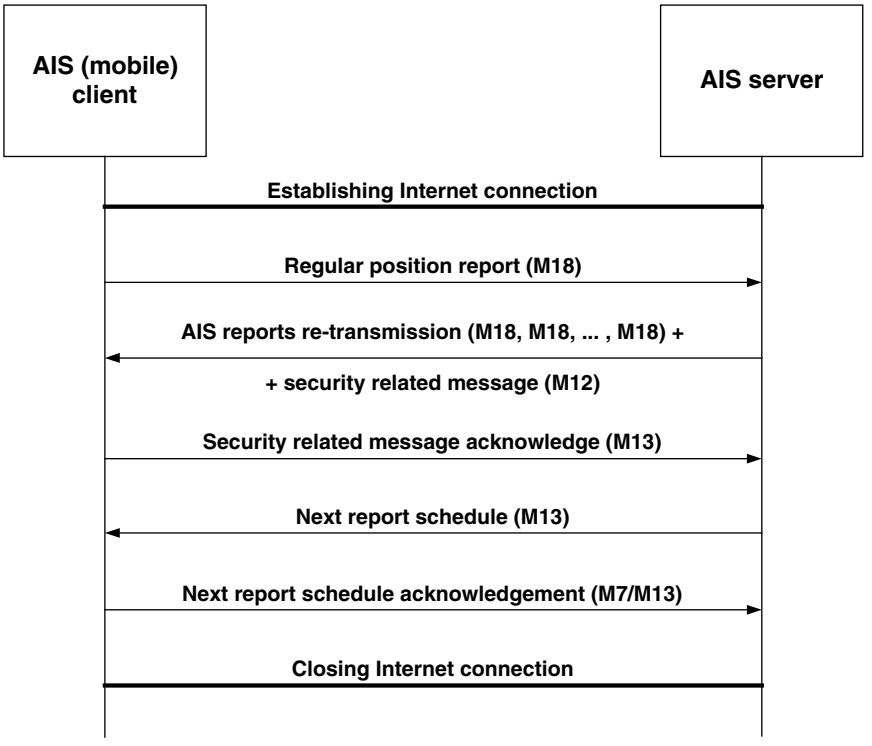

Figure 5. Case 4: Standard position reporting with safety-related/textual message transmission.

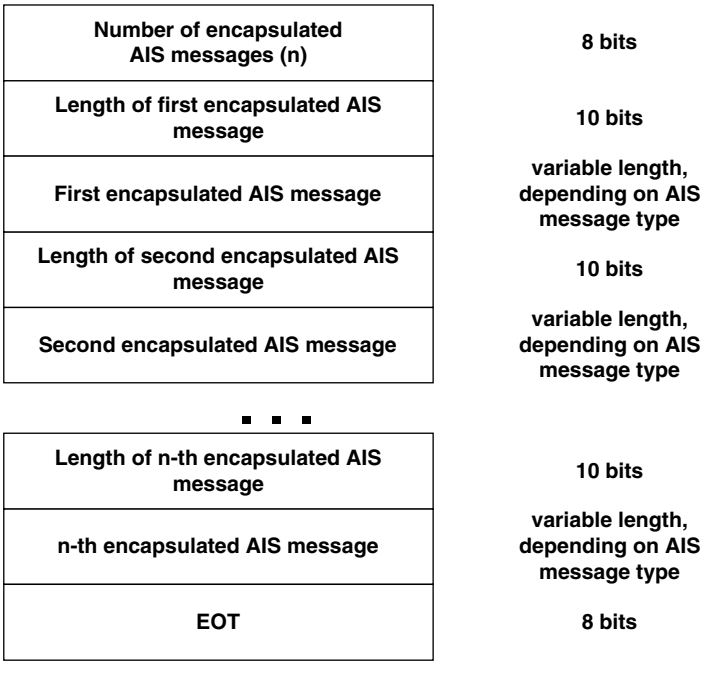

Figure 6. Internet AIS report.

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5.2. *Global AIS*. By utilising mobile Internet regardless of connection mechanism, Internet AIS provides the means of position reporting from every part of the world with any available mobile Internet-supporting network coverage. Flexibility in switching between communications network allows seamless procedure and provides solution for global AIS.

5.3. *Enhanced operation area*. Due to the nature of VHF radio wave propagation, VHF AIS has a rather limited operational area (usually around 25 nm from the transmitting station, but significantly reduced in anchorages and coastal zones with many islands and mountains). Internet AIS provides far better coverage by utilisation of available mobile communications system(s) at the location of the end-user.

5.4. *Enhanced navigation data transfer security*. So far the only mechanism for safe AIS data transfer is the SOTDMA protocol itself. Internet AIS offers advances in data transfer security by implementation of additional security protocols. For instance, the first Internet AIS prototype utilises HTTPS technology for secure data transfer. Further improvements can be gained by including mechanisms for user authorisation and authentication.

5.5. *Improved Aids-for-Navigation service*. Compared with VHF AIS, Internet AIS provides the means for additional navigation-related data delivery, including but not limited to, satellite weather image distribution and frequent up-dates of nautical chart and weather forecasts. These added value services can be initiated either automatically or manually, and generally provide the latest information on demand. Furthermore, utilisation of AIS and navigation databases allows the end-user to request information related to the area in which he/she is planning to travel, instead of being restricted to information about the nearest neighbourhood.

5.6. *Controlled AIS data access for authorised parties*. Government agencies (such as navy, police, coastguard and customs) can be allowed to use selected data from the AIS database for special activities related to national security, criminal investigations, search & rescue (S&R) operations, etc. Data access is provided by utilisation of dedicated interfaces with appropriate authorisation and authentication procedures. At the same time, dedicated agencies could be authorised to publish latest up-dates of navigation information (notices for mariners, up-dates of nautical charts) or issue the announcement related to the S&R operations.

5.7. *Advanced communications services*. Internet AIS successfully overcomes natural broadband limitations of the VHF AIS service, allowing the exchange of a much greater amount of data without noticeable disruption of the service for other AIS users. In that way, a wide variety of data could be exchanged related to both shipping security (for instance, video and pictures of equipment parts that need repair, detailed multimedia description of stranded or wrecked vessels) and commercial usage (fleet management, communications with port authorities and shipping companies). Starting from SMS-like service to transfer of large multimedia files, Internet AIS could seamlessly offer advanced communications services within the same Internet AIS protocol.

5.8. *Security issues*. A number of serious security flaws have been identified relating to VHF AIS (Sandford, 2004; Ramsvik, 2004) they include:

– falsification of AIS data
– creation of "ghost" ships in AIS system
– public availability of AIS data.

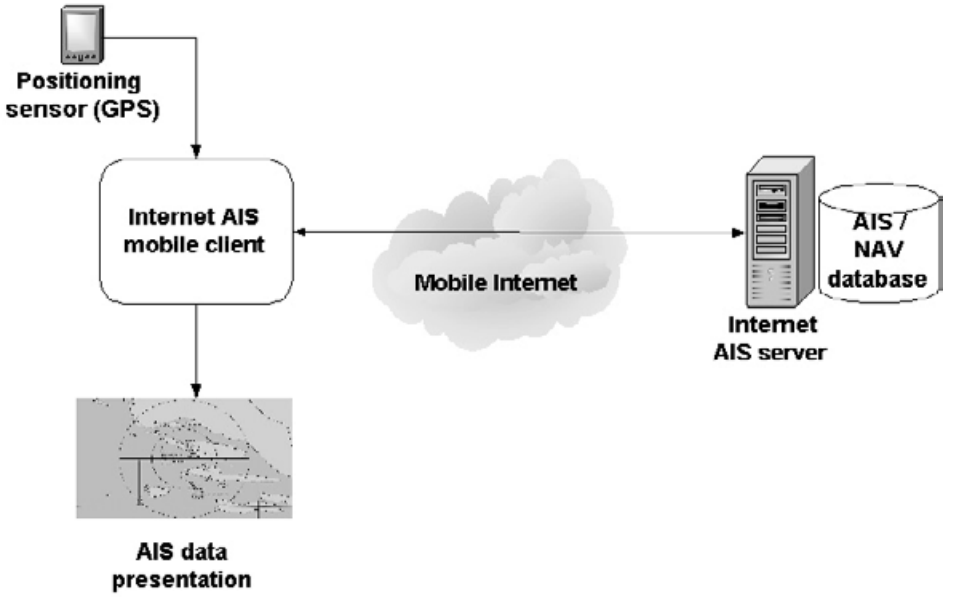

Figure 7. Internet AIS prototype architecture.

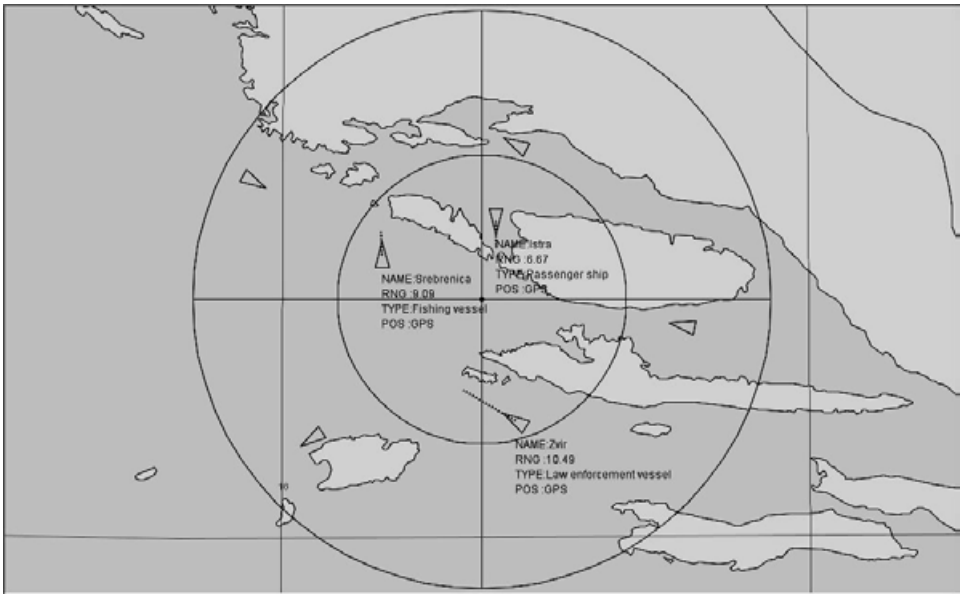

Figure 8. A screen-shot of Internet AIS prototype graphical user interface.

Internet AIS successfully overcomes these flaws by inherent authentication and authorisation procedure that limits falsification of data. AIS messages are encrypted before sending over open interface thus preventing interception and unauthorised access during transmission. Furthermore, AIS data are not publicly

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available and restricted access is available only for registered users and authorised government agencies.

6. OPERATIONAL ISSUES. As stated earlier, Internet AIS can be implemented more easily than a VHF AIS solution. AIS base station installation costs are significantly reduced by use of existing terrestrial and satellite mobile communication networks. Regional/national AIS servers will become responsible for the predetermined geographical areas and additional connection-related information will be deployed in Internet AIS client software for automatic and seamless switching between the geographical areas. In the currently available AIS specification, AIS data are exchanged in small data packets (up to 1008 bits per AIS message), giving rather low data traffic. The current version of Internet AIS prototype utilises HTTPS protocol for AIS data transfer over mobile Internet. This approach adds a considerable amount of data to the initially low AIS data content, extending the costs of the service. Furthermore, mobile communications operators currently have high charging units for data traffic sessions (usually 10 Kb), causing a further increase in the costs of Internet AIS service. A practical solution for this problem would be a suitable agreement between dedicated government agencies and mobile network operators to provide lower charges for AIS data traffic.

A very simple Internet AIS prototype has recently been developed. It provides the standard position reporting functionality (Figure 2) only, and serves as a test-bed for Internet AIS evaluation. The Internet AIS prototype is based on proven communication (GPRS, HTTPS) and software development (Java, OpenMap) technologies. The architecture of Internet AIS prototype and a screen-shot of graphical user interface (simulation of traffic in southern Croatian Adriatic coast) are presented on Figures 7 and 8, respectively.

7. CONCLUSION. Internet AIS presents a novel solution for global AIS and AIS-for-All. While attracting end-users' interest by offering the added value to available equipment and communications technologies, Internet AIS provides the means for inclusion of all vessels in a unique system where navigation data can be exchanged in a seamless and reliable way. In this way, AIS implementation can be gained in full and so provide a considerable improvement in both safety on the seas and efficiency of marine traffic management. The guidelines for future development will be determined during the Internet AIS prototype phase through a comprehensive discussion of Internet AIS implementation issues among the potential users.

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