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A Study on the Method of IoT-based Navigation Aids Management

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Abstract. Currently, most of the export/import cargoes are processed through maritime transportation. Large-scale and high-speed vessels make maritime transportation more and more complex, which causes frequent maritime accidents. The navigation aids play an important role in reducing such maritime accidents, but their management system is still insufficiently established, thus making it necessary for us to prepare a method for their real-time management and efficient operation. To solve this problem, this study analyzed the problem of current navigation aids management through a literature study and an interview with relevant field experts. As such, it suggests a method of navigation aids management applicable to IoT (Internet of Things) technologies.

Keywords: Internet of Things, Navigation Aids, Navigation Aids Management

1 Introduction

Currently, most export/import cargoes depend on maritime transportation. However, the increase of ship spaces and cargo volumes resulting from the increase of large and high-speed vessels make maritime traffic increasingly complicated[1,2,3]. In addition, subsequent maritime accidents creates increasing large-scaled human/material and environmental damages. Continuous efforts are being made to improve the management of navigation aids that play an important role in reducing maritime accidents and guaranteeing the safety of ships. However, their system has not been firmly established yet.

Accordingly, this study intends to suggest an efficient method for navigation aids management that is applicable to IoT technologies. IoT is an intellectual platform that allows free data communication, information exchange, and mutual communication between humans and things and between things and things through ICT-based intellectualization and networking of things.

This study analyzed the current status of navigation aids management and its system through a literature study and interview with relevant field experts. Moreover, this study suggests application and utilization methods through the development of navigation aids management scenarios and services.

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2 Current Status of Navigation Aids Management

Navigation aids are artificial facilities installed to ensure the safety of ships and maritime transportation with improved navigation efficiency[4]. The major functions of navigation aids are to guarantee the safety of the ships and to prevent large maritime accidents, which are subject to the following two basic conditions. First, they should be always firmly installed at certain places to enable people to easily identify their locations. Second, they should allow people to check their conditions for immediate inspection and use. In other words, people should be able to ignore the navigation aids at normal times or use them immediately as the occasion demands. However, because of the characteristics of their installation and operational environment, it is difficult for them to keep their constant places. The light buoys are sometimes lost because the fastening devices that maintain their places are damaged due to ship collisions and high winds. Further, the light beacons sometimes cannot properly function because they have reached the end of their service lives or because they are damaged even if the light buoys are able to keep their places.

Currently, the management, as well as the repair and maintenance, of the navigation aids are mostly dependent on the "lighthouse and buoy tender," which checks the function of the navigation aids and carries out the management activities such as repair and maintenance. However, this method cannot check the real-time condition of maintenance aids. Moreover, visual observation can create errors in location identification. Recently, a system was introduced to allow an application to check the location of navigation aidsthrough the installation of a GPS or a DGPS receiver[5], or to control and monitor [6] the navigation aids using wire and wireless remote control devices. However, this system is not actively used because of communication problems and high operational costs [7].

3 Service Development for Management of Navigation Aids

3.1 Requirements and Application Scenario

To derive requirements and scenarios for navigation aids management, this study conducted a literature study and an interview with relevant field experts and took in consideration the technological aspects of IoT, including their environmental characteristics.

Most of the navigation aids are fastened at their locations through the installation of sinkers at the seabed. However, they sometimes drift from their location due to high winds and collision, which makes it very hard for managers to identify their location as they have to check each one using their naked eyes. The managers sometimes monitor the location of the buoys by installing a DGPS receiver at the aids, but this can also create problems because of the high installation and operation expenses.

The lighthouse and buoy tender is being used to check the overall functions of the navigation aids and to carry out the repair and maintenance of the aids. However, it

can neither check the condition of the aids on a real-time basis nor take immediate measure in case a problem occurs.

Based on these problems, this study created a scenario by taking in consideration two aspects—1) location management through identification and tracking of navigation aids and 2) equipment management through remote control and collection of state information. First, for identification of the navigation aids, the current exact location of the navigation aids can be identified by identifying the location of each navigation aid that has been installed, as well as by perceiving its movement during its entry into a nearby IoT network, even if it deviates from its normal position. At this time, the manager can directly receive the information that he/she needs from the IoT equipment on the navigation aids or check the location of the lost equipment.

Second, for function control, the movement of the installed navigation aids can be remote-controlled. Using the sensor, the state information related with the movement of the facilities or their function can be collected and delivered to the manager on real-time basis if an abnormal situation occurs. The major information collected includes communication state, lamp state, battery state, brightness, temperature, collision state, etc. Such application scenario works with the process shown in Fig. 1 below.

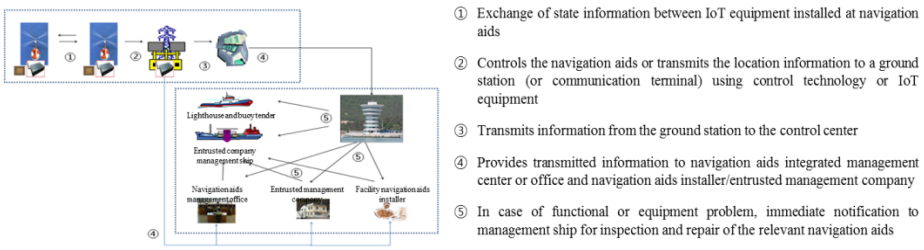

Fig. 1. Application Scenario Process

3.2 Service Functions and Major Contents

For management of the navigation aids using IoT technology, the scenarios and services were developed under the assumption that an IoT equipment or communication terminal is installed at the navigation aids. Through the installation of the IoT equipment, a network can be constructed on coastal waters as an infrastructure that can be used for relevant scenarios or systems such as coastal waters traffic control and management of aqua farm facilities and fishing gears.

IoT-based navigation aids management system, operated under the control of general port facilities control center, can be used for production and utilization of various additional services. Apart from the navigation aids operation and state information collected on real-time basis, various maritime environmental information can be collected and provided through public cloud. A more detailed maritime state and weather information than the present can also be provided through data analysis.

The IoT-based navigation aids management system provided relevant data to a navigation aids integrated management center and a maritime traffic control center. In

addition, it can directly transmit the data to the navigation aids management office, as well as private navigation aids installation companies and entrusted companies, thus allowing them to manage the navigation aids on real-time basis.

4 Conclusion

As a method of real-time management and efficient operation of navigation aids, this study developed application scenarios that used IoT technologies and suggested a system configuration method, as well as other relevant services. Through this method, the time and expense for the repair and maintenance of navigation aids—which can be directly related with large-scaled maritime accidents—are expected to be reduced through the use of IoT technologies that are currently in active development through diverse ways. In addition, the reliability and stability of the navigation aids will be improved as the relevant information can be directly delivered to managers and users of the navigation aids on a real-time basis, thus contributing to the safety of the ships and the prevention of maritime accidents.

As such, this study suggests that a research on the IoT equipment installation and communication network configuration on the navigation aids should be conducted. Moreover, a research on processing, analysis, and utilization of the various data collected through IoT equipment on real-time basis should also be carried out in the future.

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