Journal of
Ship&Ocean
Technology
©SEPTEMBER 2008

SOTECH Vol. 12, No. 3, pp. 26 ~ 35, 2008

A Crew Location Recognition System for a Naval Ship by Applying Ubiquitous Technologies

Jin-Tae Lee[1], Seong Rak Cho and Seong Jeon Kim[2]

[1] Maritime and Ocean Engineering Research Institute, KORDI, Daejeon, Korea
[2] ROK Navy, Warfare Development Group, Chungnam, Korea;
Corresponding Author: ljtprop@morei.re.kr

Abstract

Recognition of real time locations of crews for a naval ship is important, not only for the operation efficiency but also for the safety of onboard crews in the ship. More than 100 crews are dwelling in a modern naval ship and they are involved in various duties. Moreover many visitors come in and out frequently while the ship is moored in a harbor. It sometimes requires considerable time and efforts to find a person for urgent mission. It would enhance the operational efficiency if locations of onboard crews are recognized and monitored in real time.

An active type RFID tag, which has a specific ID number, is distributed to each crew member, which should be carried during his stay in the ship. A number of fixed type RFID readers are to be located at the major passages of the ship, which are connected to the main computer via Local Area Network. The location of a crew would be identified by the ID number of his RFID tag and the location of the RFID reader which detected the RFID tag.

A middleware is needed to process the collected data in the main computer. The data is fed to application softwares, which actually display locations of the concerned crews. The software is coded using GUI (Graphic User Interface) for better user friendliness, which has the function of storing the location history of a crew, and sending warning messages to appropriate persons, if unallowable behavior is detected.

An auxiliary naval ship is selected for an experimental application study of the proposed system. It turns out that the required budget and time for the realization of the system is within the allowable limits. But complementary measures to protect the privacy of onboard crews should be considered and adopted, before the application of the system is realized.

Keywords: ubiquitous technology, location recognition system, crew location, naval ship, RFID, middleware

1 Introduction

Information and Communication Technology (ICT) evolves very rapidly to provide onboard ubiquitous environment even for ocean going ships. Ubiquitous environment is defined as the environment where most machineries and persons on the ship are connected

and supported by a system of networked computers, and are provided with necessary information from the network in real time.

Possible shipboard applications of the emerging ubiquitous technologies are searched for the enhancement of operational efficiency and safety of a ship. Various fields for shipboard applications are suggested and summarized in this paper.

Application of ubiquitous technology for a naval ship is considered particularly promising, since the technology would enhance crew safety and combat readiness of the ship. Possible application fields for naval ships are suggested. Real time recognition of crew locations can be important, not only for the operational efficiency but also for the safety of crews on the ship.

A lot of crews are dwelling in a modern naval ship and they are involved in various duties. Moreover many visitors come in and out frequently while the ship is moored in a harbor. It sometimes requires considerable time and efforts to find a person for an urgent mission. It would enhance operational efficiency of a ship to device an efficient measure to recognize and monitor the locations of onboard crews in real time. A crew location recognition system is suggested for a naval ship in this paper.

An active type RFID tag, which has a specific ID number in its RF chip, is distributed to each crew in a form of attaching badge or hand-carrying key, which should be carried on board the ship. A number of fixed type RFID readers are to be located at the major passages of the ship, which are connected to the main computer via LAN (Local Area Network). As a crew is passing near one of the RFID readers, the reader would communicate with the RFID tag of the crew, and read the ID number remotely. The location of a crew would be identified by the ID number and the location of the RFID reader. The information is transmitted to the main computer via the network.

A middleware is needed to collect and process the data in the main computer. The processed data is fed to application software, which actually displays locations of the concerned crews. The software is coded using GUI (Graphic User Interface) for better user friendliness, which has the function of storing the location history of a crew, and sending warning messages to appropriate persons, if unallowable behavior is detected.

An auxiliary naval ship is selected for an experimental application of the proposed system. A preliminary study shows that the system can be realized by adopting a combined system of wireless communication and wired communication using PLC (Power Line Communication) and the existing LAN system. It turns out the required budget and time for realization of the system is within allowable limits. But complementary measures to protect the privacy of onboard crews should be considered and adopted, before the application of the system is realized.

2 Application of ubiquitous technology for naval vessels

2.1 Ship environment for wireless communication

Ship environment is unfavorable for wireless communication. Most ship structures are made of steel, which blocks transmission of electro-magnetic waves. Wireless communication has severe interference due to reflection of waves. Wave transmission is particularly poor for naval vessels since inboard compartments are subdivided into smaller water-tight compartments, resulted in many smaller compartments compared to those of cargo ships. Moreover all the equipments of naval ships should survive in severe combat environment and meet stringent military specification, and need to get certifications to

survive in vibration and shock tests.

In order to overcome the poor environment, a combined method of wired and wireless communication is suggested to provide shipboard ubiquitous environment. Wireless communication is restrictively used for short distance inside an open space, so that number of gateways is increased in order to be distributed in many enclosed compartments. Collected data through gateway is transmitted by wired communication system, such as LAN (Local Area Network) or PLC (Power Line Communication)

Selection of wireless communication method for a naval ship depends on operational requirements. Comparison of typical wireless communication methods and their characteristics are shown in Table 1. Wireless LAN is advantageous for large data transmission and its adoption would increase because of usability expansion character. Zigbee uses low power to transmit small data, and requires relatively low cost. Since standardization of the protocol is determined by ISO and IEEE, the usage of Zigbee would expand as the need for low cost transmission of small data grows.

A typical ubiquitous system would consist of distributed sensors to collect necessary data in various locations and the wired/wireless communication system for transmitting the collected data to a main computer. A middle-ware would be required, which is running in the main server, for processing the raw data and provide useful inputs to application softwares. Application softwares would be necessary to display the current situations for operators and make decisions for next operation. Usually two way communication would enhance the operation efficiency of the system.

Table 1: Comparison of wireless communication methods

	IEEE Stand.	Freq. (GHz)	Speed (mb/s)	Dist. (m)	Remarks
Wire-less LAN	802.11 b/g/e	2.4 (ISM)	11	50	Large data, Usability expansion, Wi-Fi, VOIP
	802.11a	5.2 (UNII)	54	50	
Blue-tooth	802.15.1	2.4	0.723	10	Short distance, Low power, Home appliance
Zigbee	802.15.4	2.4/ 0.868(EU)/ 0.915(US)	0.250 /0.02 /0.04	10	Low cost, Low power, Small data
CDMA		1.8	Voice	1,000	High price, Voice

ISM : Industrial Scientific Medical

UNII : Unlicensed National Information Infrastructure

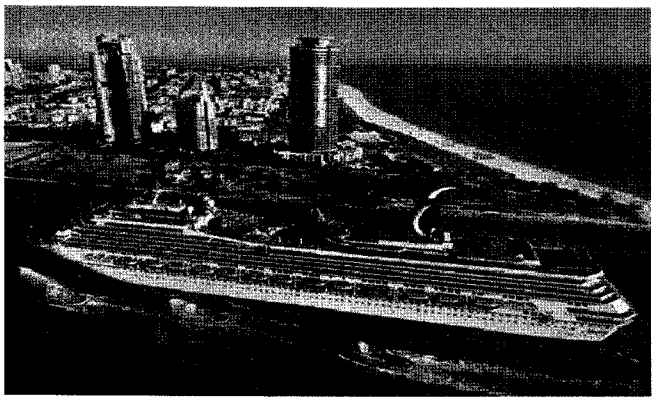

Figure 1: Carnival Valor (GT 110,000 ton, 3,000 passengers, 1,000 crews, put into service in Dec. 2004)

Cruise ship industry already has offered 100% coverage of wireless internet access from bow-to-stem on a cruise ship, providing passengers opportunities to surf the Web, check e-mail. The cruise ship, Carnival Valor as shown in Figure 1, a massive 3000 passenger cruise liner with 110,000 gross tonnages, was put into service in December 2004. The wireless internet system is designed partly by Cisco Systems, has 217 APs throughout the ship and 350 Wi-Fi VoIP phones for passenger and crew usage.

Application of ubiquitous technologies for naval vessels is sought in order to improve operation efficiency and enhance combat readiness. Since the ubiquitous technology is immature and still evolving, applications are limited for experimental applications for demonstration and selective purpose. Possible applications for naval ships are summarized.

2.2 Remote monitoring and distance support for naval Ships

Condition of shipboard machineries and equipments can be remotely monitored by tracking the digitized performance data through the world-wide-web. Engineering performance data of each equipment is continuously collected and health condition of the equipment is monitored, and Condition Based Maintenance (CBM) became possible by accessing the performance data. The Integrated Condition Assessment System (ICAS) is widely adopted in US navy and expected to provide a platform for future fleet support for naval vessels. Figure 2 shows the concepts for future naval fleet support, which is based on remote monitoring.

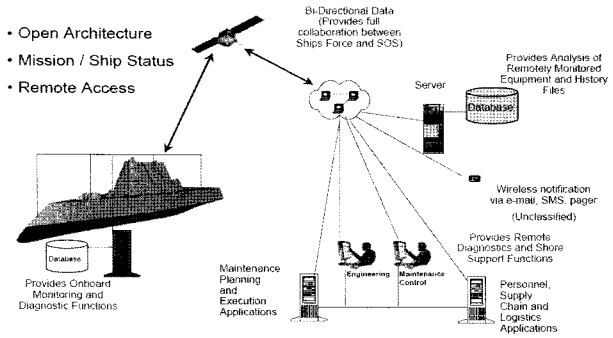

Figure 2: Concepts for future fleet support

2.3 Management of logistics supply

A naval ship needs logistics supply, such as machinery spare parts and ammunitions. The concept of logistics supply management system using RFID is shown in Figure 3. Supply items are registered with RFID tags, as they are manufactured in a factory. Those registered items are monitored as they move to warehouses and ships by using internet service. The logistics supply management system could improve the efficiency for logistic supply and save a lot of man power.

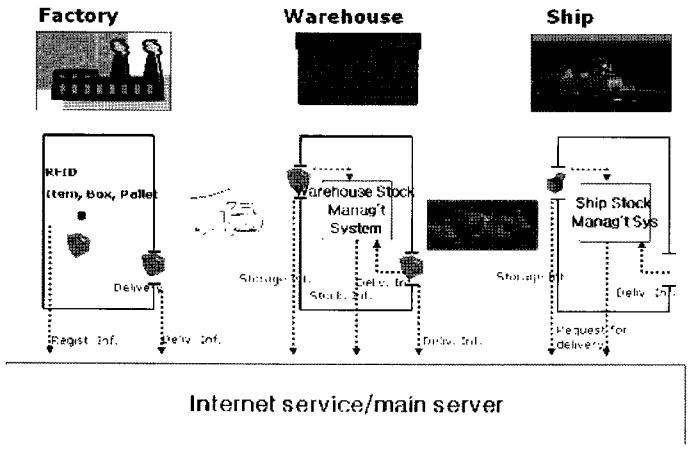

Figure 3: Concept of a logistics supply management system

Target items for logistics supply system for a naval ship might be ammunitions and personal armaments, machinery spare parts and equipments, food and drinking water, regular consumable such as fuels, oils and paints. Not only the efficiency of ship operation is increased, but also the life quality onboard a ship can be increased by proper adoption of the logistics supply management system, so that necessary items are delivered on time.

US navy adopted RFID technology to improve inventory management, where RFID data collection systems do not require line of sight or manual scanning as most bar code-based systems do. The new system also improves the way to find the location of the required part in a warehouse. It may take several hours to find a specific item in a large inventory warehouse. With RFID the mechanic enters the item he needs, scan the reader and immediately receives the location of the item. It is reported 98% of inventory time is reduced by adopting the RFID system for the application of logistical support of naval aircraft squadrons.

2.4 Crew location recognition system

Since a large number of crews are dwelling in a naval combatant ship, location of each crew is not always monitored even in the most critical situation, such as in the combat ready situation. One of the essential procedures during the confirmation of combat readiness is the report of crew muster. Confirmation of predetermined manpower distribution to the appropriate position is an important, but yet time consuming procedure. It would save a lot of efforts of the commanding officer, if location of every crew is monitored and displayed visually, at a screen monitor or in a handy terminal, such as a PDA, in real time.

3 Suggestion of the Crew Location Recognition System for a naval ship

A naval supply vessel is selected for an experimental application study of the crew location recognition system. The ship was relatively old, put into service in 1990, and having length of 130m and displacement of 9,000 ton at full load condition. About 130 persons are dwelling in the ship.

Most communication is delivered by wired telephone, named ASYM, which can be connected to a land based telephone system during moored in a harbor. Sound powered telephone system is used during the combat ready situation, since the system do not require external power and can be communicated even ship power system fails. Interesting features of communication is the usage of personal CDMA mobile phone inside the ship. Since most crews carry mobile phone, communication using the mobile phone is easy way of direct communication between onboard crews. Mobile phone can be used during moored in a harbor and during voyage if the ship is located within 20km of land based antenna. Two external antennas, 3 power amplifiers and 13 internal antennas have been installed during renovation of the ship.

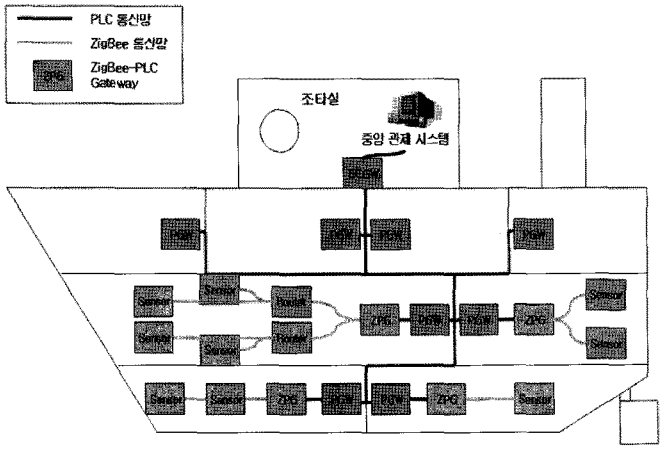

Figure 4: Example of combined system of wireless and wired communication

LAN (Local Area Network) system for the ship has 70 ports with the speed of 100Mbps. It is connected to Navy intranet via land based connector while the ship is moored in a harbor, and connected via satellite during voyage. The system needs to be extended to cover the excluded area in the ship to provide full coverage of communication, such as engine room and open deck area. Open deck area such as stem and stern deck can be covered by using wireless Wi-Fi communication.

PLC (Power Line Communication) is considered as a back-up communication, since power line is supplied to every room and compartment. 110V ac line is selected for PLC since the line is connected to most compartments in the ship. By using PLC no extra extension of LAN system is needed to cover the excluded compartments. Figure 4 shows an example of combined system of wireless and wired communication.

4 Application of the crew location recognition system for a naval ship

4.1 Objects of the system

Recognition of crew location is essential in combat ready situation for effective commandment. The object of the system is to provide the real time locations of crews using the onboard ubiquitous environment. The system can monitor the locations of crews and provide safer environment for crews by sending appropriate warning message if a crew is approaching a hazardous area accidentally.
Missing of a crew is not immediately reported especially if accidents occurred during night time, because mustering is usually reported twice a day in a naval ship. Appropriate actions might be made more effectively if the location of the missing/endangered crew is immediately reported and history of the crew's passage is monitored.

4.2 System structure

Overall conceptual structure of the crew location recognition system is given in Figure 5. Major components of the system can be summarized as:

- Crew ID data: Crew identification data is given as the ID number of the RF tag given to the specific crew. The RFID is carried in a form of attached badge or hand-carrying tag by each crew during his stay in the ship. Crew ID data are read by RF reader or gateway distributed along major entrances in the ship. The location data of gateway and ID number is given to the middleware.
- Hardware:

- Active RFID tag: Each crew should carry the active RFID tag, which can send its own data using its own battery. The tag sends electromagnetic waves encoding the ID data to the nearest gateway or a router to transfer the data to a gateway.
- Router: receive data from a RF tag and transfer the data to other router or gateway.
- Gateway: receive date from RF tag or router, and transfer the data to LAN or Power line.
- LAN: existing LAN (Local Area Network) is used to transfer data from gateways to the main computer where middleware is running.
- PLC (Power Line Communication): The excluded area from LAN connection, such as engine room and deck areas, is connected via power line communication. Power line is used to transfer data to the nearest LAN connector, since every compartment is provided with power line.
- Main computer: All the data are collected at the main computer, which runs middleware and application softwares. A high-end computer is required for stable processing of abundant data, meeting the military specification of shock proof.

- Middleware: All the data including crew ID and location is collected, processed and stored. Time, location and crew rank data are considered for categorizing the events. According to predetermined conditions alarm system can be activated, if necessary. Required data is processed and provided to application softwares.
- Application Softwares: Locations of crews are visually displayed in an easy and efficient way. GUI (Graphic User Interface) can be used to improve user friendliness. Necessary data are fed from middleware, and used to provide effective measures to attain the objects of the system.

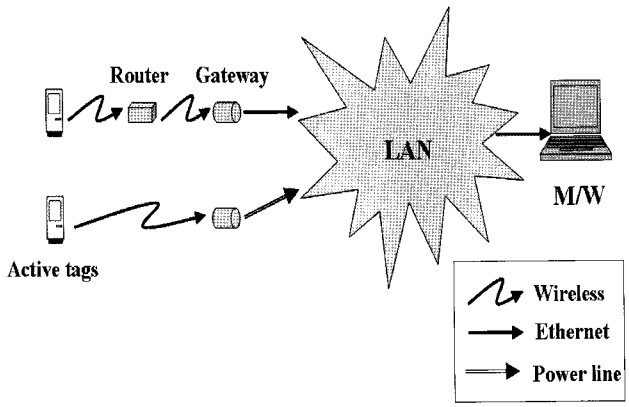

Figure 5: Conceptual structure of the crew location recognition system

4.3 Suggested system and estimated budget

Similar systems have been applied for hospitals and/or factories in land usage. Figure 5 shows an example of RTLS (Real Time Location System) developed for usage in factories and hospitals. RFID tags used for the system are provided as ready-made commodities. Figure 6 shows two types of RF tags supplied by Ekahau.

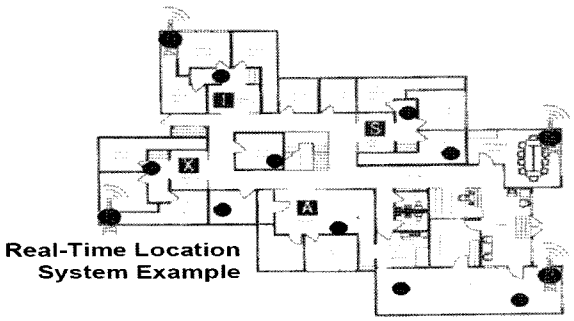

Figure 6: RTLS for land based application (factories and hospitals)

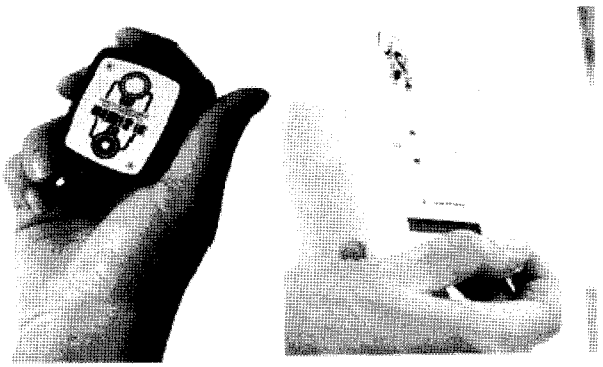

Figure 7: Hand-carry type and necklace type RFID tags

Table 2: Required components for Crew Location Recognition System for a Navy vessel

items	Required no.
Active tag	130
Router	20
Gateway	100
PGW	30
Phase Coupler	5
M/W (PC included)	1
Application S/W	1

PGW: Power line communication GateWay

An experimental application study of the Crew Location Recognition System is performed for the naval ship, in order to confirm the feasibility of the system. Preliminary results of required components for realization of the system are shown in Table 2.

130 active RF tags are required in order to distribute them to all the crew members and visitors. Routers are required to relay data from RF tag to gateways in open stem and stern deck areas. Relatively large number of gateways are required to cover the large number of enclosed compartments. PGW (Power line communication GateWay) and Phase coupler are required to use PLC, in order to cover the excluded area in engine room from the LAN connection.

Estimated H/W price including the middleware and softwares for the system is under the initial budget. It was pointed that complimentary measures to protect the privacy of crew must be made before the system is realized for the ship.

5 Conclusions and Suggestions

Following conclusions and suggestions can be made from the previous study:

- ICTs (Information and Communication Technologies) are evolving very rapidly for land application, and these technologies are maturing for shipboard application, to provide the ubiquitous environment, where most machineries and persons are connected and supported by a system of networked computers
- Possible shipboard applications of ubiquitous technologies, in order to enhance the operational efficiency and safety of the ship, are suggested and summarized. Applications for a naval ship are considered to be effective to provide operational and combat efficiency of the ship.
- A crew location recognition system for a naval ship is proposed, where locations of onboard crews are recognized and monitored in real time, to enhance operational

efficiency and safety of crews.

- An active type RFID tag is distributed to each crew which should be carried during his stay in the ship. ID data in the tag is transmitted to RF readers via electro-magnetic wave and send to main computer via PLC and/or LAN. Middleware and application softwares are required to process and display the crew locations.
- An experimental application study for an auxiliary naval ship shows that required budget and time for realization of the system is within the allowable limit. But complementary measures to protect the privacy of onboard crews should be considered and adopted, before the application of the system is realized.

Acknowledgement

Research works described in the paper was supported by the basic research project of KORDI. Support of ROK navy for the project is acknowledged.

References

KORDI Report. 2007. Development of Ubiquitous-based Key Technologies for Smart Operation of Marine Exploration Fleet.

Lee, J.-T., J.-H. Park, S. R. Cho and D. Lee. 2007. An application of Ubiquitous Technologies for Naval Ships: Crew Location Recognition System. Proceedings of International Conference on Marine Research and Transportation, Ischia, Italy, 51-59.

Park, B., B. Paik, S. Cho and D. Lee. 2007. Enhancing Ship Safety using Ubiquitous Technology. Journal of Ships & Ocean Engineering, **44**.

Lee, D., H. Kim, J.-H. Park and B. Park. 2003. The current status and future issues in human evacuation from ships. Safety Science, **41**, 861-876.

DiUlio, Mike. 2002. Revolutionizing Maintenance through Remote Monitoring via ICAS & Distance Support. DOD Maintenance Symposium.

Webpage: http://www.carnival.com/Ship_Detail.aspx