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Preliminary Evaluation of Passive UHF-Band RFID for Identifying Floating Objects on the Sea

Yasuhiro Sato, Kodai Noma, Kenta Sawada, Kazumasa Adachi, Yoshinori Matruura, Saori Iwanaga

***Abstract*—**RFID system is used to identify objects such as passenger identification in public transportation, instead of linear or 2-dimensional barcodes. Key advantages of RFID system are to identify objects without physical contact, and to write arbitrary information into RFID tag. These advantages may help to improve maritime safety and efficiency of activity on the sea. However, utilization of RFID system for maritime scenes has not been considered. In this paper, we evaluate the availability of a generic RFID system operating on the sea. We measure RSSI between RFID tag floating on the sea and RFID antenna, and check whether a RFID reader can access a tag or not, while the distance between a floating buoy and the ship, and the angle are changed. Finally, we discuss the feasibility and the applicability of RFID system on the sea through the results of our preliminary experiment.

***Keywords*—**RFID, Experimental Evaluation, RSSI, Maritime use.

I. Introduction

RECENTLY, RFID (Radio Frequency Identification) system is used to identify objects such as passenger identification in public transportation system [1] and product identification in stock management [2], instead of linear and matrix barcodes. RFID system consists of three functional components, which are RFID tag, RFID reader and data processor. In contrast to 2-dimentional barcodes, RFID system uses wireless radio waves to identify objects without physical contact or line of sight between the readers and the tags. Moreover, tag managers can store arbitrary information to the tags attached to objects in RFID system. Each object can be uniquely identified by attaching a distinct RFID tag, and multiple RFID tags can be read simultaneously. RFID tag is mainly categorized into two types; active and passive. Since passive RFID tags do not need electric power to operate and are comparatively cheap than the active type, this type is widely adopted in various management systems [3].

Various applications of RFID system have been proposed so far. In [4], authors considered an efficient container management by using RFID technology with passive-type RFID tags. Key advantages of RFID system are to identify objects without physical contact, and to write arbitrary information into RFID tags. These advantages may help to improve maritime safety and efficiency of activity on the sea. For instance, there are lots of aqua-farming rafts in a maritime area, and these rafts are mainly managed by fisheries cooperative association. Generally, holder information of raft is displayed on a physical label attached directly on each raft. To read the label, we need to transfer from a ship to the raft on the sea. If the label can be replaced to a RFID tag, we can read the information from a ship that is away from the label without transferring to the raft. Moreover, these systems can apply not only to aqua-farming rafts but also ships. It is possible that license information and ship information can be managed in RFID tags, because RFID tag can store arbitrary information, the length of which is from 32bits to 64 kbits. The opportunities to transfer to rafts or ships are decreased by using RFID system. As a result, accidents on the sea can be reduced. Furthermore, RFID system can be applied to investigation of flotsams. Since the cost of passive-type RFID tag is comparatively cheap, we can manage many flotsams uniquely and continuously by attaching a passive-type RFID tag to each flotsam. In particular, a huge number of flotsams were generated by the Great East Japan Earthquake, which occurred in March 11th, 2011. Many rescue teams, including the Coast Guard, the Self-Defense Forces and volunteers, have searched the flotsams to find survivors. However, the flotsams generated by the earthquake are too many to search efficiently, and the same flotsam has been checked many times. If we attach a RFID tag, in which the search information is stored, to flotsam already checked, the efficiency of search may be improved. Thus, we consider to apply RFID system to maritime scenes as shown in Fig. 1.

However, usefulness of RFID system for maritime scenes has not been considered in previous works. It is assumed that RFID system is used in a stable environment such as indoor. It is not clarified whether a generic RFID system can be used in an environment such as on the sea. In this paper, we evaluate the availability of a generic RFID system on the sea. We float a buoy with a RFID tag on the sea, and check the availability of RFID tag from RFID reader on a ship. In our experiment, we measure RSSI (Received Signal Strength Indicator) and check whether the reader can access a tag or not, while the distance between the buoy and the ship is varied from 1m to 15m and the angle is varied from 0 to 90.

The paper is organized as follows: The details of our experiment and measurement settings are shown in Section II. The results of our experiment are denoted in Section III. Finally, we conclude this paper in Section IV.

Y. Sato, Y. Matsuura, and S. Iwanaga are with the Faculty of Maritime Safety Technology, Japan Coast Guard Academy, Hiroshima, 737-8512 Japan (e-mail: {sato, matsuura, s-iwanaga}@jcga.ac.jp).

K. Noma is the Faculty of Maritime Science and Technology, Japan Coast Guard Academy, Hiroshima, 737-8512 Japan (e-mail: noma-d6x9@jcga.ac.jp).

K. Sawada and K. Adachi are Regular Course students, Japan Coast Guard Academy, Hiroshima, 737-8512 Japan (e-mail:{g10sawada, g10adachi}@ mitsuishi.ne.jp).

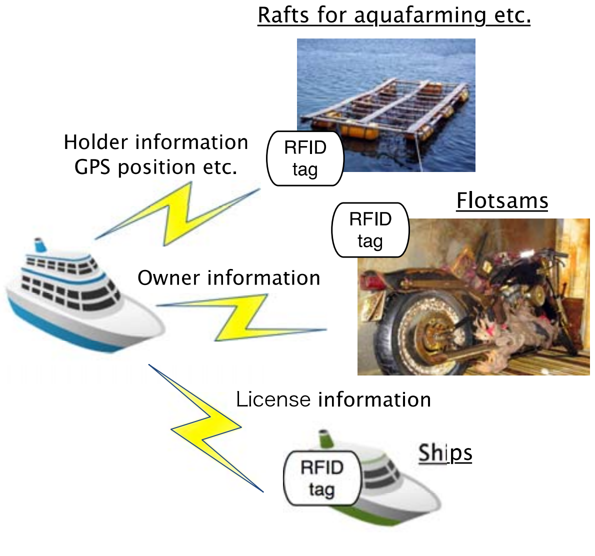

Fig. 1 Applications of RFID system on the sea

TABLE I
SPECIFICATION OF RF-RW311

Frequency	916.8, 918.0, 919.2,920.4 MHz
Power Output	14 ~ 30 dBm
Standards	EPC global C1 G2 (ISO/IEC18000-6 Type C)
Operating Temperature	0 ~ 50 degrees
Dimensions	56 mm x 184.4mm x 212.6 mm

II. EXPERIMENTAL EVALUATION

In this paper, we investigate the feasibility of RFID system on the sea. For that purpose, we measure RSSI between RFID tag and RFID antenna; the tag is attached to a buoy and the antenna is equipped on a ship. In this section, we describe the specification of components of RFID system and the details of our experiment.

A. Specification of RFID Equipment

In our experiment, we use MITSUBISHI RF-RW311 as a RFID Reader-Writer, the specification of which is shown in Table I. The reader connects to a laptop PC, Panasonic CF-32, via a RJ-45 cable. Table II shows a RFID antenna, MITSUBISHI RF-ATCP012, we used in the experiments. We prepare two types of RFID tags: Omni-ID Ultra and AD- 380iL. The specifications of these tags are shown in Tables III and IV. Omni-ID tag is long range and high performance passive-type RFID tag to be used for container management. In contrast, AD-380iL is a label-type tag that is easy to attach to various ID cards. Moreover, we also prepare a handy-type reader-writer, which is MightyCard AT880-RF as shown in Table V.

B. Experiment Settings

Fig. 2 shows the data flow in our experiment. The laptop and the reader are connected each other via a LAN cable, and a dedicated software provisioned by MITSUBISHI is installed into the laptop to measure RSSI between the reader and the tag. Because the software denotes whether the reader can read stored data from tag or not, we also investigate the availability of RFID system.

TABLE II
SPECIFICATION OF RF-ATCP012

Frequency	915.7 ~ 921.5 MHz
Polarization	Circular
Antenna Gain	6 dBi
Operating Temperature	0 ~ 50 degrees
Dimensions	200 mm x 200 mm x 21 mm

TABLE III
SPECIFICATION OF OMNI-ID ULTRA

Frequency	860 ~ 960 MHz
IC	Alien Higgs H3
Standards	UHF EPC Class-1 Gen2
Operating Temperature	-40 ~ 100degrees
Dimensions	210 mm x 110 mm x 21 mm

TABLE IV
SPECIFICATION OF AD-380IL

Frequency	860 ~ 960 MHz
IC	NXP UCODE G2iL
Standards	ISO-18000-C6, EPC Class-1 Gen2
Memory	128 bits
Operating Temperature	-40 ~ 85degrees
Dimensions	50 mm x 30 mm

TABLE V
SPECIFICATION OF AT880-RF

CPU	Marvell PXA320 806 MHz
OS	Microsoft Windows CE 5.0
Frequency	952.2 ~ 953.8 MHz
Polarization	Circular
Standards	EPC global C2 G2 (ISO/IEC18000-6 Type C)
Operating Temperature	-10 ~ 50 degrees
Dimensions	158 mm x 78 mm x 28 mm

We attached two types of RFID tags to a buoy with a floater, which is a definite point to estimate the angle between the antenna and the tag. Fig. 3 shows a photograph of the buoy used in our experiment. The tags are attached to the red- colored buoy, and a yellow-colored floater is the definite point to estimate the angles. Fig. 4 shows a diagram to estimate the angles by using the theorem of cosines. We measure RSSI between the tag and the antenna with changing the distance d_t. At the same time, we measure the distance dv between the antenna and the definite point to calculate the angle θ. The distance d_s between the tag and the definite point is a constant distance, which is 1.45m.

We measured RSSI between the tag and the antenna, and checked the availability from a ship, the engine on which was shut off. As the first step of our experiment, we performed our experiment on the sea on August 3rd, 29th and September 5th, 2013, when the weather was very good and the wave height was 0.5 m, the results of which are described in the next section.

III. MEASUREMENT RESULT

In this section, we describe the results of our experiment. And also show whether RFID system can be actually applied on the sea or not.

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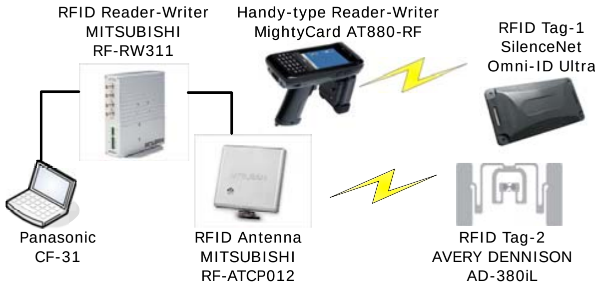

Fig. 2 Data flow in our experiment

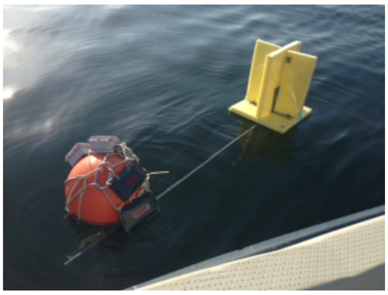

Fig. 3 A red-colored buoy with a yellow-colored floater in our experiment

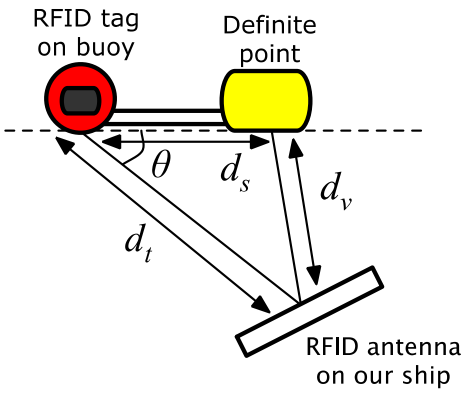

Fig. 4 Diagram of our measurement environment

A. Changing the Distance between the Tag and the Antenna

Fig. 5 shows measured RSSI between the tag and the antenna with changing the distance d_t. From this figure, the value of RSSI is decreased as the distance is getting far away. In case of Omni-ID Ultra, the limit of distance between the tag and the antenna is 10 m that RFID system is available on the sea. In contrast, if the tag is AD-380L, we found that the limit is 4m. These values of the limit are similar to the measurement results on the ground, which we measured before. Thus, we found that RFID system can be utilized enough in outdoor situations when effects by environment factors are vanishingly small.

B. Changing the Angle between the Tag and the Antenna

We next measure RSSI and check the availability in case of changing the angle between the tag and the antenna. To estimate the angle, we set the measurement environment as described in previous section. Fig. 6 shows measured RSSI between the tag and the antenna with changing the angle θ. It is very hard to obtain precise angles due to the ship rolling and undulation. Thus, we measured three times in the same setting, and averaged the measured values. According to the availability check, if the angle is 30◦, RFID system did not work in any case. The results of our experiment denote that waves may degrade the performance of RFID system drastically.

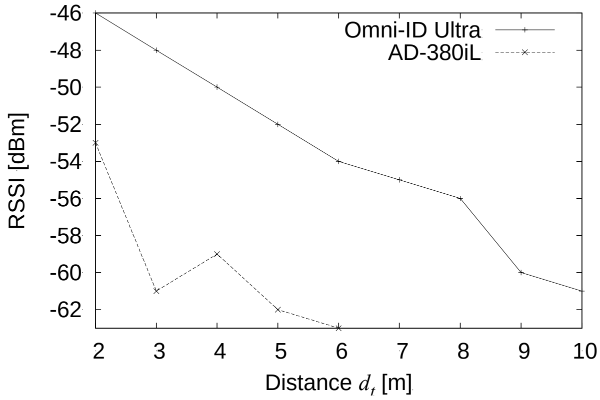

Fig. 5 Relationship between RSSI and the distance d_t

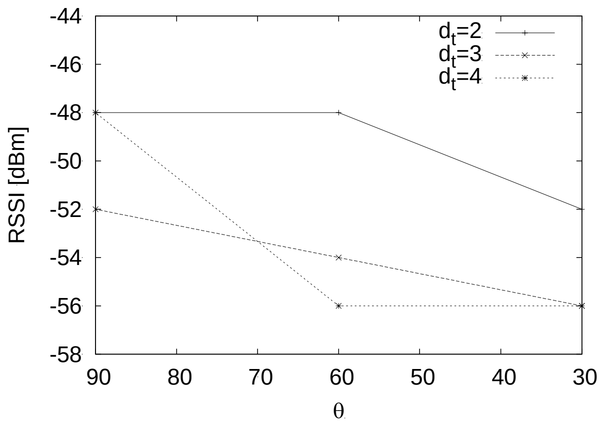

Fig. 6 Relationship between RSSI and the angle

IV. Conclusion

We have studied usefulness of RFID system on the sea. For this, we have measured RSSI between the antenna and the tag, which is attached to a floating buoy on the sea. At the same time, we have checked the availability of RFID system, because we don't know whether RFID system can identify objects by only the value of RSSI. As a result, we have found that RFID system is useful with a strong passive RFID tag even if the tag is 10m far from the antenna on the sea. If the tag is a label-type tag, which is a weak RFID tag, we can use the system until approximately 4m. Moreover, we have measured RSSI with changing the angle between the tag and the antenna. We have clarified that RFID system did not work in any case that the angle is under 30°. We have pointed out the applicability of RFID system on the sea. Although our measurement and evaluation are not enough to apply, this is the first step to operate RFID system on the sea.

REFERENCES

[1] M. hasan, G. Tangim, M. Islam, M. Khandokar, and A. Alam, "RFID-based ticketing for public transport system: Perspective megacity dhaka," in *Proceedings of the 3rd IEEE International Conference on Computer Science and Information Technology (ICCSIT 2010)*, (Chengdu, China), pp. 459–462, July 2010.

[2] A. Bratukhin and A. Treytl, "Applicability of RFID and agent-based control for product identification in distributed production," in *Proceedings of IEEE International Conference on Emerging Technologies and Factory Automation (ETFA 2006)*, (Prague, Czech Republic), pp. 1198–1205, September 2006.

[3] A. S. Bhat, B. Raghavendra, and g. Narendra Kumar, "Enhanced passive RFID based disaster management for coal miners," vol. 2, pp. 476–480, October 2013.

[4] L. Hu, X. Shi, S. Voß, and W. Zhang, "Application of RFID technology at the entrance gate of container terminals," in *Proceedings of the 2nd International Conference on Computational Logistics (ICCL 2011)*, (Hamburg, Germany), pp. 209–220, September 2011.

Yasuhiro SATO received B.E., M.E., and Ph.D. degrees in Information and Communication Engineering from Osaka City University, Osaka, Japan, in 2004, 2006, and 2009, respectively. From April 2009 to September 2009, He was a postdoctoral fellow in the Graduate School of Engineering, Osaka City University. From October 2009 to March 2013, he was a Lecturer of the Faculty of Maritime Safety Technology at Japan Coast Guard Academy, Hiroshima, Japan. Since April 2013, he has been an Associate Professor of the Faculty of Maritime Safety Technology at Japan Coast Guard Academy, Hiroshima, Japan. His re- search work is in the area of modeling and evaluation of network performance. He is a member of the IEEE.

Kodai NOMA received B.E. degrees in Coast Guard from Japan Coast Guard Academy, Hiroshima, Japan, in 2004. From April 2004 to March 2011, He worked in the Ship, Air station and Central organization as a Japan Coast Guard Officer. Since April 2011, he has been an Assistant Professor of the Department of Maritime Science and Technology at Japan Coast Guard Academy, Hiroshima, Japan. His research work is use of RFID at sea.

Kenta SAWADA has been a Regular course student of the Faculty of Marine Engineering at Japan Coast Guard Academy, Hiroshima, Japan since April 2010.

Kazumasa ADACHI has been a Regular course student of the Faculty of Information and Communication Engineering at Japan Coast Guard Academy, Hiroshima, Japan since April 2010.

Yoshinori MATSUURA received B.E. degree in Science from Hiroshima University, Hiroshima, Japan, in 1989. From April 1989 to march 1995, he joined Hitachi Microsoftware Systems, Inc. He received Ph.D. degree in Science from Chuo Uni- versity, Tokyo, Japan in 2002. Since April 2008, he has been a professor of the Faculty of Maritime Safety Technology at Japan Coast Guard Academy, Hiroshima, Japan. His research work is in the area of numerical modeling of nonlinear phenomena. He is a member of the IPSJ and the JSIAM.

Saori IWANAGA is Professor of Department of Maritime Safety Technology at Japan Coast Guard Academy (JCGA) since 2012. She received her B.E. degree in applied chemistry engineering from Utsunomiya University, Japan, in 1994 and her M.S. and her Ph.D. degree in computer science from National Defense Academy, Japan, in 2001 and 2004, respectively. She has worked at JCGA since 2007. She is interested in complex theory, evolutionary games. She is a member of Information Processing Society of Japan and Japan Society for safety Engineering.