An OFCDM System in Ship and Yard Area Network

Junyoung Jun and Seongjoo Lee

***Abstract*—Ship and yard area environments contain materials mainly composed of metals, which also are applied to the interior structures. Such environments embody air channels characterized by several multipath propagation delays and long maximum delay time. Channel models for ship and yard area network are proposed, and existing communication systems Zigbee, Wifi, and Wibro are evaluated in the channel models. The existing systems such as orthogonal frequency division multiplexing (OFDM) and code division multiple access (CDMA) are combined to produce different variations of orthogonal frequency and code division multiplexing (OFCDM) for experimentation and application. The performance of proposed OFCDM was experimented in ship and yard area network environments.**

***Index Terms*—OFCDM, ship and yard area network, SYAN, OFDM, CDMA, channel model.**

I. Introduction

Due to increasing international trade, there has been an increasing amount of communications in environments such as ships, yards and harbors, and domestic shipbuilders have been putting tremendous amounts of efforts in developing high-tech construction techniques. Wireless communication and Ubiquitous Sensor Network (USN) are most actively utilized in ship construction yards with main yard as a center of communication. Ship and Yard Area Network (SYAN) is the most actively researched subject among other IT technology researches for shipyards [1]. Wired or cable network may be utilized for such environments, but it is too expensive and difficult to maintain, especially in cruise ships or digital ships. However, the priority lies in establishing an appropriate channel model in shipyard environments before researching or selecting any wireless SYAN communication method. Metallic nature of ships and their structures hinder and reflecting Radio Frequency (RF), causing several multipath propagation delays and severely weakened signals that creates no-signal areas. The objective of this paper is to apply channel environments modified for SYAN communication and to evaluate the performances of the existing methods Wi-Fi, Wibro, and Zigbee [2]-[4]. Another purpose is to evaluate the performance of the proposed OFCDM communication systems, the combinations of OFDM and CDMA, in SYAN environments [5]-[8].

The remaining parts of this paper are composed as follows. In Section II, we explain the architecture of the ship and yard environment and SYAN channel model is proposed. We propose OFCDM system which has three versions in Section III. The results of the proposed system in SYAN channel model are shown in Section IV. In the last section, conclusions are reached.

II. SYAN Communication Channel Model

SYAN differs from regular channel environments in that they are sealed and contain metallic structures needed for operations, both of which factors are notorious for hindering signals [1]. Metallic structures cut off and reflect RF and this result in multipath propagation and long delay time due to the reflected signals. A channel environment resembling that of downtown city centers is substituted for the Wibro system in order to satisfy the condition of long delay time. Downtown city centers satisfy the condition of long delay time because the signals must travel through large, high buildings in city centers. It also possesses a certain amount of multipath propagation due to densely locate buildings, but it is not as significant as that in SYAN environments [9]. Thus, a channel environment resembling those of interior factories environment is applied to Wibro channel environment [10]. Factory environment is applied because of its desirable characteristics similar to those of shipyards for containing metallic structures that create multipath propagations [9], [10].

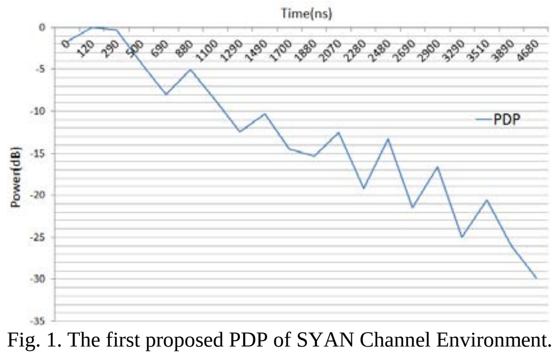

Fig. 1. The first proposed PDP of SYAN Channel Environment.

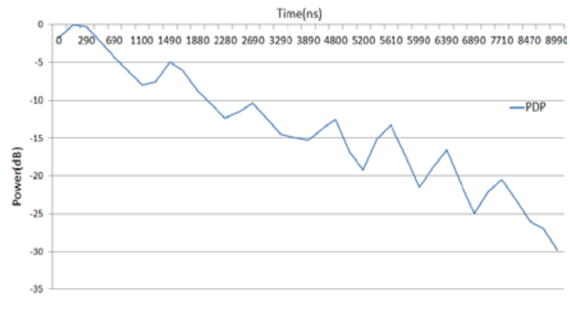

Fig. 2. The second proposed PDP of SYAN Channel Environment.

To Fig. 1 indicates Power Delay Profile (PDP) of SYAN communication channel which is proposed in this paper. Fig. 2 shows the second proposed channel, with longer maximum

Manuscript received June 18, 2015; revised August 24, 2015.

Junyoung Jun and Seongjoo Lee are with the Department of Electrical Engineering, Sejong University, Seoul, Korea. (e-mail: jdancor@itsoc.sejong.ac.kr, seongjoo@sejong.ac.kr).

doi: 10.18178/ijiee.2016.6.1.584

delay time and more multipath propagation compared to the former channel.

III. Proposed OFCDM

Before OFCDM is a combination of OFDM and CDMA, where CDMA is grafted on OFDM system [11], [12], Models OFCDM I and OFCDM II are proposed according to CDMA's spreading and code matching techniques, and models OFCDM I and OFCDM II are combined to produce model OFCDM III [5]-[8].

A. OFCDM I Model

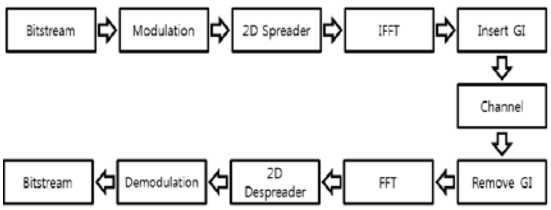

Fig. 3. Model I OFCDM block diagram.

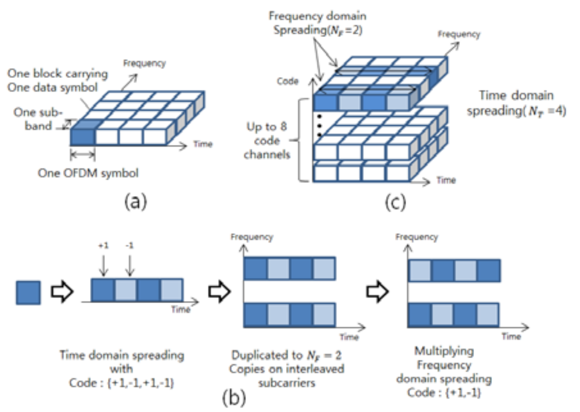

Fig. 4. 2D Spreader of model I OFCDM.

As indicated in Fig. 3, model OFCDM I is a model where Two-Dimensional (2D) spreader and 2D de-spreader blocks of the CDMA functions are added on the existing OFDM communication system. 2D spreaders expand the time and frequency of data. A symbol of OFDM from transmitter indicated in Fig. 4(a) is spread 4 times in terms of time using time code and spread 2 times in terms of frequency using frequency code as shown in Fig. 4(b). Consequently, Fig. 4(c) shows the data is expanded 8 times in terms of time and frequency. Finally, IFFT of OFDM is applied and sent.

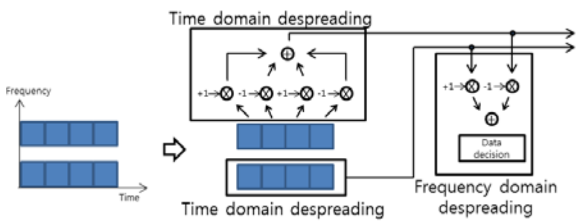

Fig. 5. 2D despreader of model I OFCDM.

In the receiver, 2D spreader combines the data using time code, and executes final decision of the combined data using the frequency code to print data as indicated in Fig. 5.

Performance is improved by increasing data's SNR by using the method above of expanding the data in terms of time and frequency from in the transmitter, and combining data in the receiver.

B. OFCDM II Model

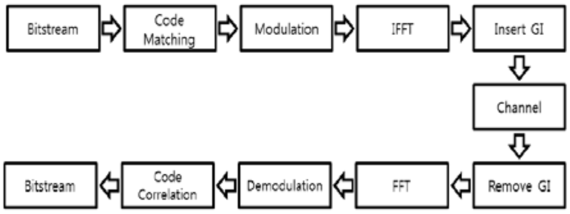

Fig. 6. Model II OFCDM block diagram.

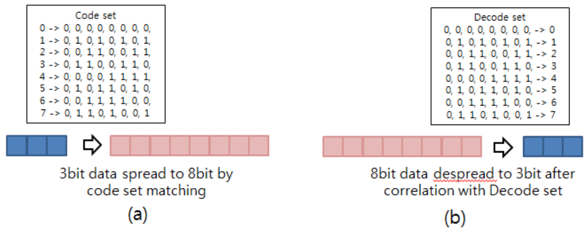

Fig. 7. Model II OFCDM (a) Code matching (b) Decode matching.

As indicated in Fig. 6, model OFCDM II is a model where code matching and code correlation blocks are added on the existing OFDM communication system. Fig. 7(a) shows the process of incoming 3bit data being matched and expanded to 8bit code set. The code set refers to Walsh Code. After this is sent, Fig. 7(b) indicates that the receiver correlates the incoming data with the decode set and recovers the data to a specific 3bit data.

C. OFCDM III Model

The proposed models OFCDM I and II may be combined to produce model OFCDM III indicated in Fig. 8. The transmitter expands the data using the code matching and expands them through 2D spreader in time and frequency with modulation before finally sending. The receiver combines data through 2D de-spreader, processes the SNR-enhanced data through demodulation, and increases performance by recovering data via code correlation.

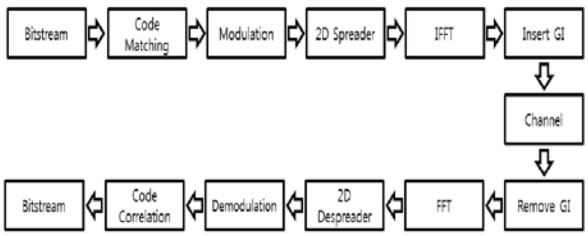

Fig. 8. Model III OFCDM block diagram.

IV. Implementation Results

The proposed SYAN channel models presented above used the existing communication systems Zigbee, Wi-Fi and Wibro and was evaluated with BER measurement [2]-[4].

Fig. 9 is the BER performance results graph of the three communication system from the first proposed SYAN channel model. The analysis is that Wi-Fi and Wibro communication BER only improve in environments with 30dB or above. On the other hand, Zigbee did not show improvements in environments with SNR of 15dB or above.

Fig. 10 is the BER performance results graph of the second proposed SYAN channel model. This was done in the channel environment with longer maximum delay time compared to the first channel. Unlike the first result, this second result showed unimproved performances of Wi-Fi, as Zigbee did in the first channel. Additionally, Wibro system showed properly improved results only after 5dB increase. It is shown that each system's BER curve falls downward only when both channels embody good SNR. Thus, it can be concluded that all three communication methods are significantly influenced by SYAN environment's multipath propagation and delay time.

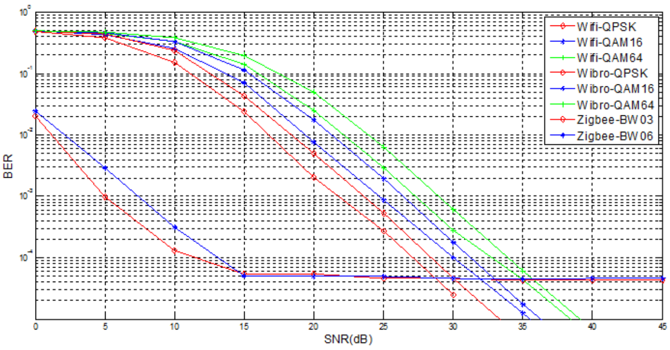

Fig. 9. Performance graph of the existing communication systems of the First Channel Model.

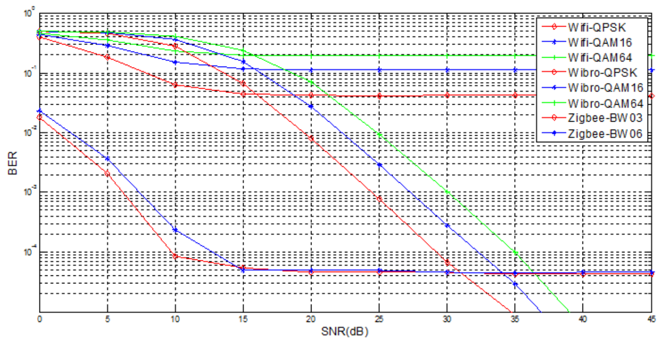

Fig. 10. Performance graph of the existing communication systems of the Second Channel Model.

The performance of the modulation systems of proposed OFCDM communication systems is shown in Fig. 11, 12, 13 and 14. First SYAN Channel Model that was experimented with the proposed OFCDM system show in Fig. 11 and 12. Second SYAN Channel Model resulted in Fig. 13 and 14. In the Figure legend, Ver. 1 and 5 are Model I. Ver. 2, 6, 7 and 8 present Model II. Ver. 3, 4, 9 and 10 show Model III.

The proposed techniques show better performances with larger spreading factors. For Model I, expansion in either time or frequency does not make any difference, but the scale of spreading factor matters. It can be seen that Model I has better performance compared to Model II. However, even better performance is shown when both models are combined to form Model III. Since a larger factor of Model II improves performances, it can be seen that correlation performances are better with larger SNR. Proposed SYAN Channel models are small difference in proposed OFCDM system performance. In conclusion, the proposed OFCDM communication method had more improved BER than those of Wi-Fi, Wibro and Zigbee.

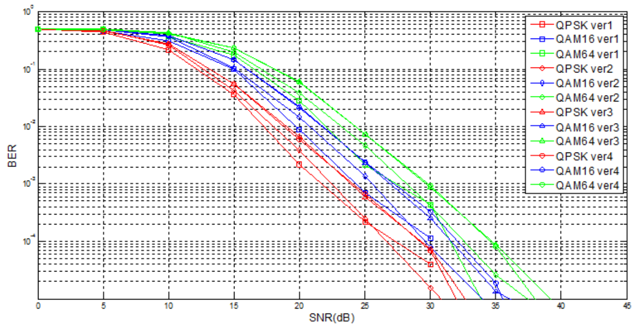

Fig. 11. OFCDM performance with spread factor 4 in SYAN channel model I

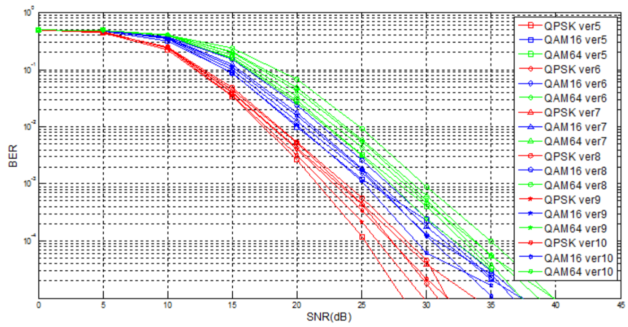

Fig. 12. OFCDM performance with spread factor 8 in SYAN channel model I.

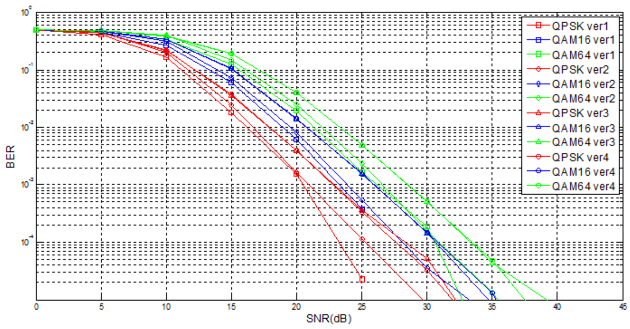

Fig. 13. OFCDM performance with spread factor 4 in SYAN channel model II.

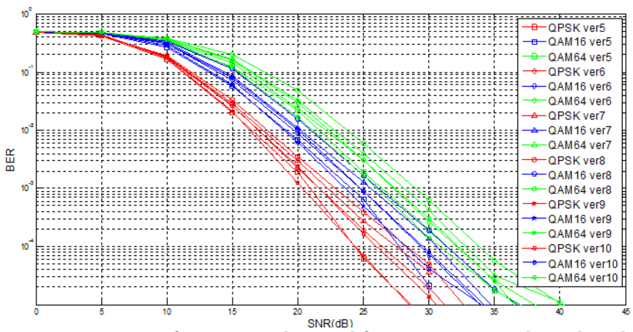

Fig. 14. OFCDM performance with spread factor 8 in SYAN channel model II.

V. Conclusion

This paper presented channel environments and algorithm for communication in SYAN areas usually comprised of metallic materials and structures. SYAN presented environments consisting metallic structures that resulted in several multipath propagation delays and severely weakened signals. SYAN channel environments were applied to existing communication methods Zigbee, Wi-Fi, and Wibro, and the results showed that communication was difficult with these existing methods. Thus, OFDM and CDMA were combined to form three different versions of OFCDM communication methods to be proposed in SYAN channel environments for performance results. The proposed OFCDM showed improved BER compared to those of the existing communication methods.

ACKNOWLEDGMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MOE) (No.2013R1A1A2064733) and also by R&D program funded by IITP & MSIP (B01261510760001002, "Development of non-powered technology combined with ambient RF energy harvesting and Backscatter data transfer"), and CAD tools are supported by IDEC in Korea.

REFERENCES

[1] C. Myeongsoo and J. Mina, "Ship to shore maritime communication for e-navigation using IEEE 802.16e," *ICT Convergence*, Oct. 2013.

[2] W. Andrew and C. Ember, "Commercial applications of wireless sensor networks using zigbee," *IEEE Communications Magazine*, April 2007.

[3] H. Jun and X. Gouliang, "Beyond co-existence: exploiting WiFi white space for zigbee performance assurance," in *Proc. the* IEEE *International Conference, OCT*, 2010.

[4] L. Seungque and P. Namhun, "The wireless broadband (Wibro) system for broband wireless internet services," *IEEE Communications Magazine*, July 2006.

[5] Z. Yiqing, "OFCDM: a promising broadband wireless access technique," *IEEE Communication Magazine*, pp.38-49, 2008.

[6] Z. Yiqing, "Downlink transmission of broadband OFCDM system part i: hybrid detection," *IEEE TCE*, vol.53, 2005.

[7] C. Benjye, "Adaptive load balancing MDP-based approach of two-dimensional spreading for VSF-OFCDM in 4G next-generation cellular communications," *IEEE Transactions on Vehicular Technology*, vol. 58, no. 3, 2009.

[8] S. Olonbayay and H. Rohling, "Comparison between coded FODM-TDMA and OFDM-CDMA systems," in *Proc. International OFDM Workshop*, 2004, vol. 9.

[9] M. Cheffena, "Industrial wireless sensor networks: Channel modeling and performance evaluation," *EURASIP Journal on Wireless Communications and Networking*, p. 297, 2012.

[10] L. Rami *et al*. "Outdoor radio channel measurements at 2.35 GHz for WiBro systems," *VTC-2005-Fall*, vol. 3, pp 1737-1741, Sept. 2005.

[11] M. S. Timothy and C. C. Donald, "Robust frequency and timing synchronization for OFDM," *IEEE Transaction on Communication*, vol. 45, no. 12, Dec. 1997.

[12] H. Shinsuke and P. Ramjee, "Overview of multicarrier CDMA," *IEEE Communications Magazine*, Dec. 1997.

Youngjun Jun was born in Suwon, Korea, in 1989. He received his B.S. degree in information and communication engineering from Sejong University, Seoul, Korea, in 2014. He is working for an M.S. degree at Sejong University. His current research interests include SoC design for touch screen device and wireless communication.

Seongjoo Lee received his BS, MS, and PhD degrees in electrical and electronic engineering from Yonsei University, Seoul, Korea, in 1993, 1998, and 2002, respectively. From 2002 to 2003, he was a senior research engineer at the IT SoC Research Center and the ASIC Research Center, Yonsei University, Seoul, Korea. From 2003 to 2005, he was a senior engineer in the Core Tech Sector, Visual-Display Division, Samsung Electronics Co. Ltd., Suwon, Korea. He was a research professor at the IT Center and the IT SoC Research Center, Yonsei University, Seoul, Korea from 2005 and to 2006. He is currently an associate professor in the Department of Information and Communication Engineering at Sejong University, Seoul, Korea. His current research interests include SoC design for high-speed wireless communication systems and image processing systems.