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# High Data Rate Scheduling for Underwater Acoustic Communication in Shallow Water

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## 1. Introduction

Underwater acoustic (UWA) communication channels can be characterized by highly time-varying multipath propagation, which causes severe detoration in received acoustic communication signals and reduces the data transmission rate of UWA communication systems [1-2]. Time-varying oceanographic processes produce random channel responses that result in obstacles of succesive data transmission [3-4]. For a communication scenario between one node with a single transceiver and another node with multiple transceivers, however, the time-varying property can be utilized in order to improve the communication reliability of the UWA communication mechnism

In this paper, we propose a selection algorithm that decrease transmission error rate in the time-varying UWA channel. The proposed algorithm transmits data via a channel with the highest receive sound pressure level after measuring that of every channel. In order to provide commiunication error rate of the proposed method, practically measured UWA sound pressure level variations were utilized. The experiment exhibits that the proposed algorithm provide lower bit error rate than that of conventional UWA communication systems.

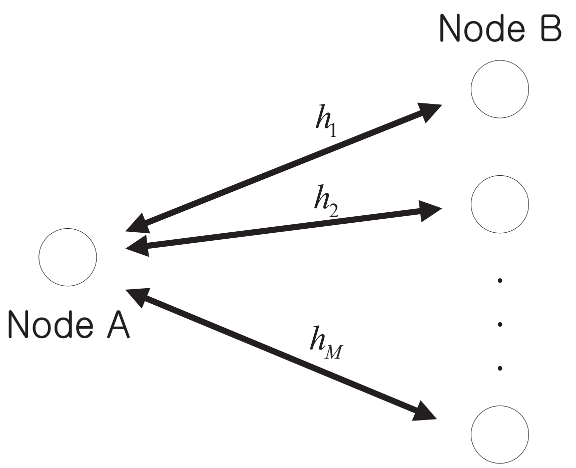


Fig. 1. 1xM communication system

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## 2. Proposed algorithm

Consider that the UWA communication system consists of one node with a single transceiver and another node with M transceivers as dipicted in **Fig. 1**. Once a communication link between node A and B is established, each channel, $\{h_1, h_2, ..., h_M\}$, is linked. Note that channels from the node A to B is equal to channels from the node B to A because of the reciprocity of sound rays. If the UWA communication system adopts duplex method, the node B can obtain sound pressure levels after signal transmission from the node A to B. Then, the node B selects a transmitter which will transmit the data signal based on below equation.

$$\max_i \|h_i\|^2, \tag{1}$$

where $\|\bullet\|$ denotes Euclidean norm, and the square of norm means sound pressure level. Thus, the node B transmits data signal via the transmitter with the highest sound pressure level and does not transmit using other transmitters. If a time goes on, UWA channel varies and the sound pressure level of each trasnmitter varies. Therefore, other trasnmitters have a chance to trasnmit data. This is because UWA channel variation by sea fluctuations.

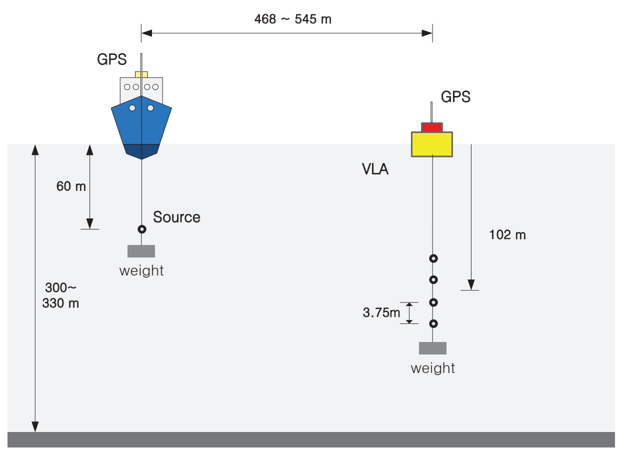


Fig. 2. Experiment configuration

## 3. Sea measurement

In order to demonstrate the transmission performance of the proposed scheme, we utilize rpractical UWA channel statistics measured from sea experiments. **Fig. 2** shows the experimet configuration.

Sea experiments were performed around Donghae-si, Republic of Korea in 2013. As shown in Fig.2,average depths of the transmitter and receivers were 60 and 102 meter, respectively. An average horizontal distance between the source and vertical array was about 500 meter. Note that the distance is not fixed, but varies by drifting during the experments. For UWA communication method, binary phase shift keying (PSK) signal with 6 kHz of carrier frequency and 4 kHz of bandwidth were adopted. In addition, a root raised cosine pulse with roll-off factor 0.25 was applied for a baseband pulse shaping.

**Fig. 3** shows the baseband equivalent channel responses estimated from measured practical experiments. In **Fig. 3**, two time varying dominant rays are observed. The statistics of channel variation are measured from two dominant components of the sound pressure levels. **Fig. 4** exhibits the statistics of the measured sound pressure levels. The magnitude of each dominant ray is distributed with non-zero mean.

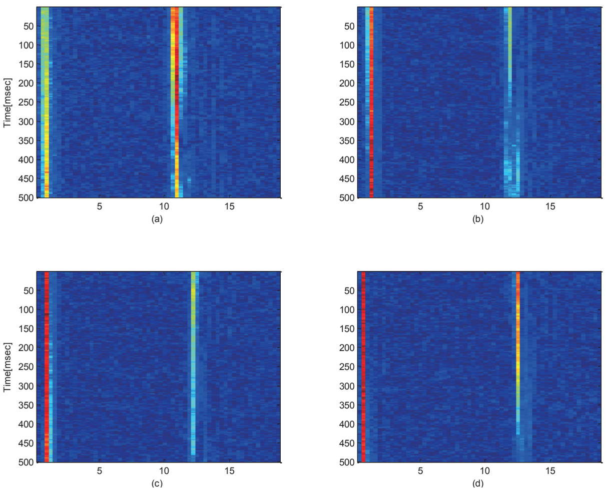

Fig. 3. Estimated equivalent channel responses. (a) $h_1$ (b) $h_2$ (c) $h_3$ (d) $h_4$

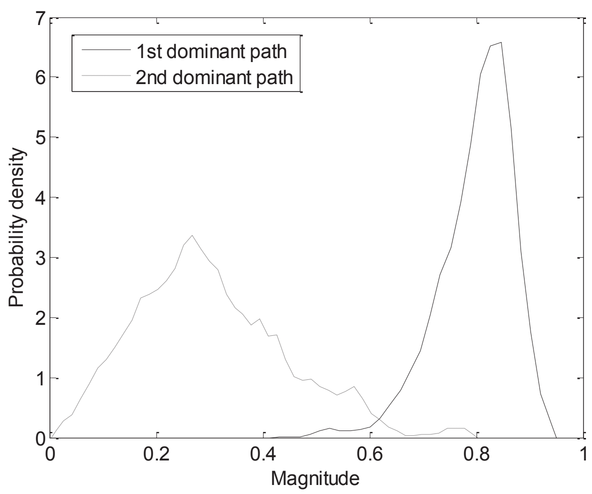

Fig. 4. Statistics of the estimated channel responses

## 4. Performance evaluation

Based on the obtained statistics of the sound pressure levels, the proposed method are tested with computer to calcuate the bit eror performance of the UWA communocation system. The results is demonstrated in **Fig. 5**. The bit error performance of the proposed algorithm is calculated at the node A as the node B changes the number of transmitter from two to four. When the node A utilizes one transceiver with a conventional communication method, the bit error performance is poorer. On the other hand, the bit error performance increases as the number of transmitter increases.

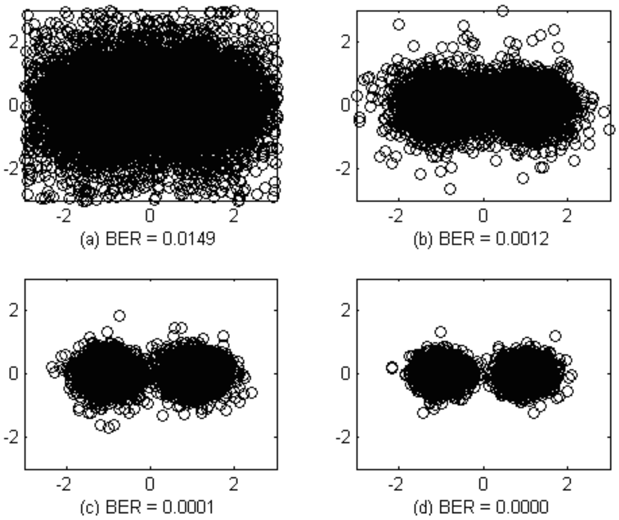

Fig. 5. Simulation result (a) one transceiver (b) 2 transceivers (c) 3 transceivers (d) 4 transceivers

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