# Link Selection Algorithm of UWB Communications Considering Fading Statistics

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**Abstract:** This paper presents the link selection algorithm of Ultra Wide Band (UWB) communications considering fading statistics. In this algorithm, UWB devices decide the wireless link considering not only received signal strength but also fading statistics. Fading statistics follows the proposed channel model to the existence of line-of-sight (LOS).

## 1. INTRODUCTION

The Ultra Wide Band (UWB) system has drawn one's interest as a next generation wireless communications. For UWB systems are targeting high data rate in short range, the more access points are needed rather than other communications. For that reason, the advanced link selection algorithm is more emphasized. In this paper, advanced link selection algorithm is suggested. While the conventional link selection algorithm considers received signal strength only, this advanced algorithm determines the wireless link using not only received signal strength but also the fading statistics. Using the proposed fading statistics, the criterion of advanced link selection algorithm is proposed. The detection error and capacity are used for the performance analysis.

## 2. FADING STATISTICS

The distribution of the small-scale amplitudes of UWB is reported as the Nakagami-m distribution [1]. The Nakagami-m distribution is given as

$$p(x) = \frac{2}{\Gamma(m)}\left(\frac{m}{\Omega}\right)^m x^{2m-1}\exp\left(-\frac{m}{\Omega}x^2\right) \qquad (1)$$

where $m \geq 1/2$ is the Nakagami m-factor, $\Gamma(m)$ is the gamma function, and $\Omega$ is the mean-square value of the amplitude. In proposed channel model, the Nakagami m-factors to the environments and existence of LOS path are suggested. The channel parameters of LOS/NLOS are reported in Table 1 with respect to the propagation environments. Empirically, the m-factor is reported to follow the Gaussian distribution, $N(\mu_m, \sigma_m)$ [1].

The simulation scenario is illustrated in Figure 1. There are two access points, one is with LOS path and the other is without LOS path. The UWB device determines wireless link to access point considering received signal strength and fading statistics.

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Table 1. Nakagami m-factor of various channel conditions

| | parameters | Value [dB] |
|---|---|---|
| Residental Environments | | |
| LOS | $\mu_m$ | 0.67 |
| | $\sigma_m$ | 0.28 |
| NLOS | $\mu_m$ | 0.69 |
| | $\sigma_m$ | 0.32 |
| Indoor Office Environments | | |
| LOS | $\mu_m$ | 0.42 |
| | $\sigma_m$ | 0.31 |
| NLOS | $\mu_m$ | 0.50 |
| | $\sigma_m$ | 0.25 |

## 3. PERFORMANCE ANALYSIS

For the noise modeling, we used the Additive White Guassian Noise (AWGN). The AWGN is given by [2]

$$p_{Noise}(n) = N(0,\sigma^2) = \frac{1}{\sqrt{2\pi}\sigma}e^{-\frac{n^2}{2\sigma^2}} \qquad (2)$$

and the fading statistics to AWGN is illustrated in Figure 2. And using this statistics, the average SNR is obtained as (3).

$$(\text{average SNR})_{\text{LOS}} = \frac{E(r_L^2)}{E(n^2)} = \frac{E(r_L^2)}{\sigma^2}. \qquad (3)$$

The performance of this algorithm is analyzed in two parts. The first one is using the detection error concept. When the received UWB signal fades under the noise level, the receiver can not detect the transmitted signal. We defined this case as the detection error. The detection error is shown to the average SNR in Figure 3. And the second one is capacity. The capacity of the fading channel is given by

$$C = \int_\gamma B\log_2(1+\gamma)p(\gamma)d\gamma \ \text{[bits/sec/Hz]} \qquad (4)$$

where $\gamma$ denote the received SNR, $B$ denote the received signal bandwidth and $p(\gamma)$ denote the probability distribution of the received SNR [3]. Using the instantaneous SNR from AWGN statistics and signal statistics, the capacity of each m-factor is shown in Figure 4.

## 4. Conclusion

The advanced link selection algorithm is suggested in this paper. This algorithm determines the wireless link from not only the received signal strength but also the fading statistics. The statistics are distinguished by existence of LOS path. All statistics follow the suggested IEEE 802.15.4a model for standard. Using the concepts of detection error and capacity, the performance analysis is performed.

## References


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[3] A. J. Goldsmith and P. P. Varaiya, "Capacity of fading channels with channel side information," IEEE Tras. on Information Theory, vol. 43, pp. 1986-1992, Nov. 1997.


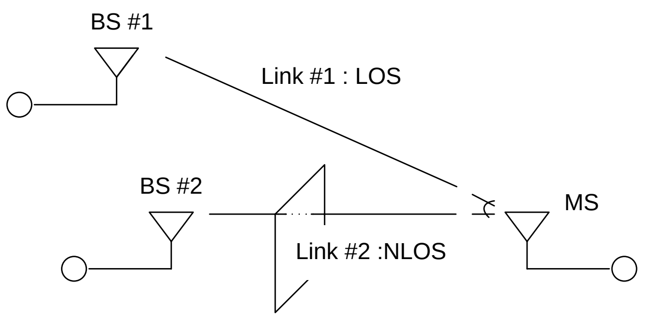


Figure 1. Simulation scenario of a MS (UWB device) and two wireless links (LOS and NLOS)

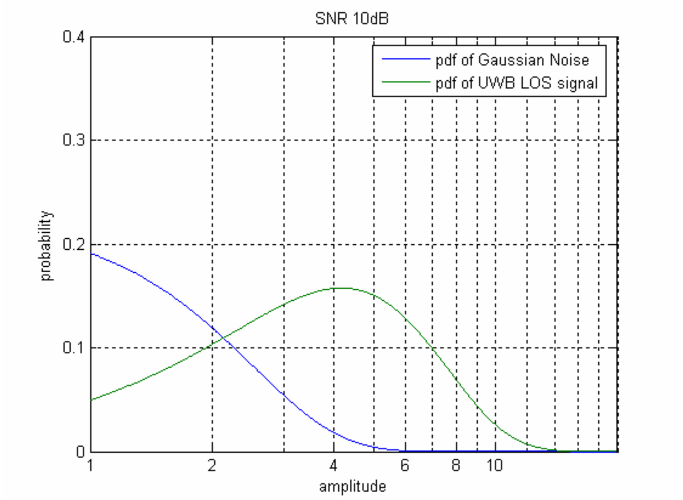


Figure 2. PDFs of Gaussian Noise and UWB LOS signal with SNR 10dB

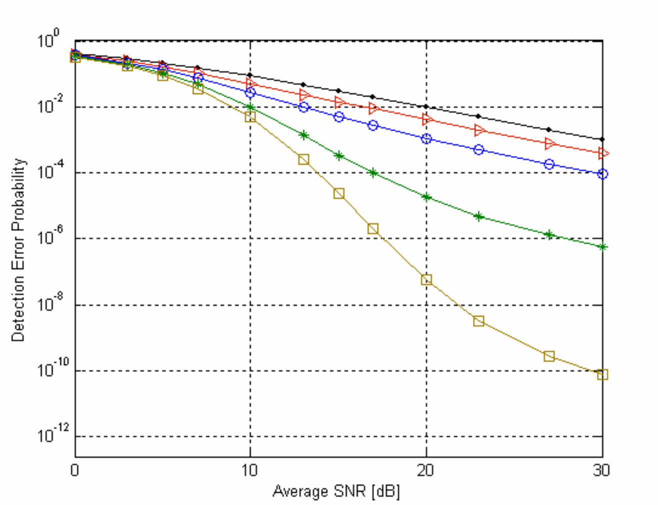


Figure 3. Detection error of various Nakagami m-factors to average SNR

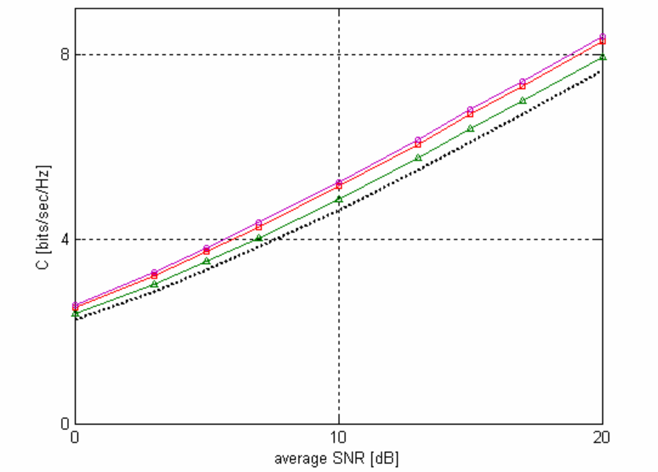


Figure 4. Capacity of various Nakagami m-factors to average SNR