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Indoor Nearby Channel Condition Estimation System

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Abstract. The proposed channel estimation system is based on the collaboration with nearby users channel estimation information. Channel status condition is inaccurate while the estimating pilot sequence applied is undersized to avoid overloading the system throughput and bandwidth efficiency. In this study, we have tried to ascertain the indoor channel varying conditions by way of nearby users' channel estimated statistics. The distance of the surrounding nearby users has very high correlation to the channel frequency response profile. We have examined the channel profile performance under the proposed nearby channel condition estimations in both line-of-sight (LOS) and non-line-of sight (NLOS) indoor environments statuses.

1 Introduction

Accurate channel condition estimation system is an essential promise to gain well-enough signal transmission performance in modern communication systems. To acquire well established channel estimations information by pilot sequences before transmitting messages, the system may need overwhelming efforts to possess the necessary information, typically a much longer pilot sequence employing adequate bandwidth and more pre-processing time [1], [2]. However, the channel information is usually inaccurate estimate and the longer pilot sequence should moderate the system throughput and bandwidth efficiency.

There are two major distributed classes in channel estimation techniques. The first classification is pilot channel estimation where pilot sequences are inserted prior to the transmitted data [3], [4]. At the receiver part, the recognized pilot streams are evaluated possibly providing channel varying characteristics to gain required channel frequency response information. However, these pilots may consume loads of the transmission data flows and minimize the accessible bandwidth efficiency. The second classification is blind channel estimation scheme where channel condition estimation is acknowledged simply by the received data streams without additional pilot bits [5]. Hence, the bandwidth efficiency is promised but an additional convoluted algorithm is required to channel estimating implementation, where the resulted estimation error is higher than that with pilot channel estimation scheme.

The preliminary notion for this study is to locate sufficient channel varying characteristics at times without depriving system bandwidth efficiency [6], [7]. We then present the implementation of nearby channel condition estimation system as shown in Fig. 1. The channel information is provided by nearby users' pilot sequences estimation process. Therefore, the object (main) user does not need inserting pilot streams to perform channel estimation as that in blind channel estimation scheme.

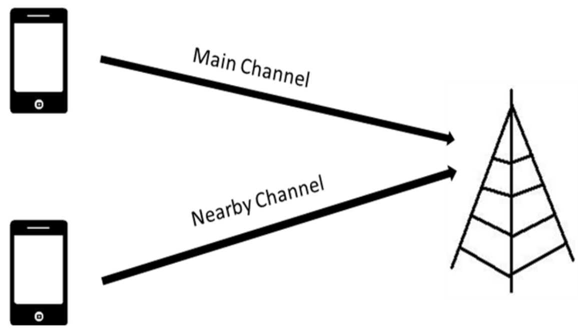

Figure 1. The object channel vs nearby channel estimation

The indoor channel estimation system configuration is described in Section 2. The indoor channel frequency response profiles estimated by nearby users compared with the object user's profiles to examine the consistency within each other are shown in Section 3. Finally, Section 4 gives some brief conclusions.

2 System configurations

Wireless communication channel has been recognized as a varying multipath channel. Data signals transmitted over wireless multipath channel come across refraction, scattering, reflection, and shadowing fading, where the signal power is distorted. The impulse response representation regarding the communication multipath channel is shown as,

$$h_l(t) = \sum_{l=0}^{L-1} a_l \delta(t-\tau_l) e^{j\theta_l(t)} \tag{1}$$

where L is the total number of the transmitted paths, a_l is the amplitude strength for the l^{th} path, τ_l is the delay time for the l^{th} path, and θ_l is the phase deviation for the l^{th} path. After Fourier transformation of (1), we can see the frequency response power profile for the transmitted signal over the occupied frequency band.

$$H(f) = F[h_l(t)] = \int_{-\infty}^{\infty} h_l(t) e^{-j2\pi ft} dt = \sum_{l=0}^{L-1} a_l e^{-j[2\pi f\tau_l - \theta_l(\tau_l)]} \quad (2)$$

To be simplified in this preliminary study, we will examine the frequency response at the experimental channel paths assuming the phase deviation θ_l difference within the nearby channels can be ignored. The frequency response of the object (main) user's channel can be edited to:

$$H_M(f) = \sum_{l=0}^{L-1} a_{Ml} e^{-j2\pi f\tau_{Ml}} \quad (3)$$

The frequency response of the nearby user's channel is:

$$H_N(f) = \sum_{l=0}^{L-1} a_{Nl} e^{-j2\pi f\tau_{Nl}} \quad (4)$$

If the channel frequency response is similar, $H_N(f) \approx H_M(f)$, the nearby channel estimation can be applied to the object user's communication system.

The channel information estimated by nearby users is distributed to the object user's communication system to exclude the pilot sequence used in each transmitted block to improve the bandwidth efficiency. The required channel varying information for active object user is provided by nearby users' pilot sequences estimation process while the nearby users are in idle transmission status. Therefore, the object (main) user can exclude inserting pilot streams to perform channel estimation as that in blind channel estimation scheme. Since nearby users are assumed to be in idle communication status, they may provide longer-enough pilot sequences in each transmission block to better estimate the indoor channel condition variations around very closed areas. In this study, the nearby channel estimation layout is performed in indoor environment. The schematic diagram of the measurement is shown in Fig. 2. The experimental set-up for line-of-sight (LOS) measurement and non-line-of-sight (NLOS) measurement are shown in Fig. 3 and Fig. 4, respectively.

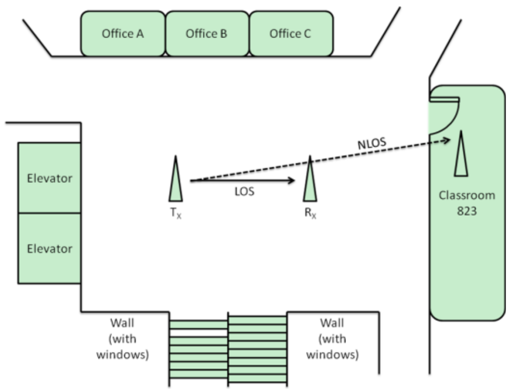

Figure 2. Indoor environment schematic diagram of the measurement

Figure 3. The operation for LOS situation measurement

Figure 4. The operation for NLOS situation measurement

3 Results for system simulations

The indoor channel conditions estimation with line-of-sight (LOS) and non-line-of-sight (NLOS) situations are performed for distance varying from 1 meter to 5 meters, where we have found that the two nearby channels investigated have comparable channel frequency response profile (as shown in Fig. 5 to Fig. 14, for LOS/NLOS distance from 1 to 5 meters, respectively). From simulation analysis, we found that the channel frequency response is very similar when the nearby users' distance is within 1 to 3 meters for LOS/NLOS situations.

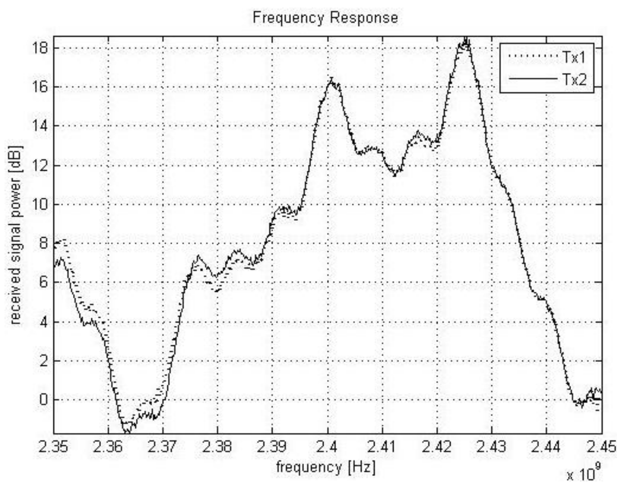

Figure 5. Nearby users' distance: 1m (LOS).

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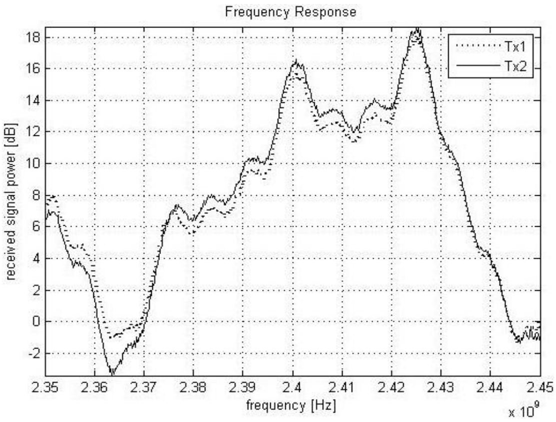

Figure 6. Nearby users' distance: 2m (LOS).

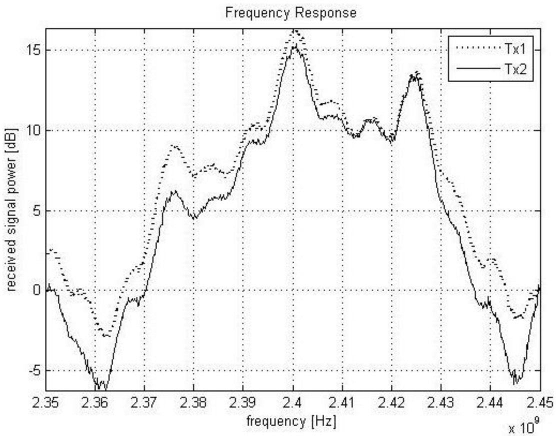

Figure 7. Nearby users' distance: 3m (LOS).

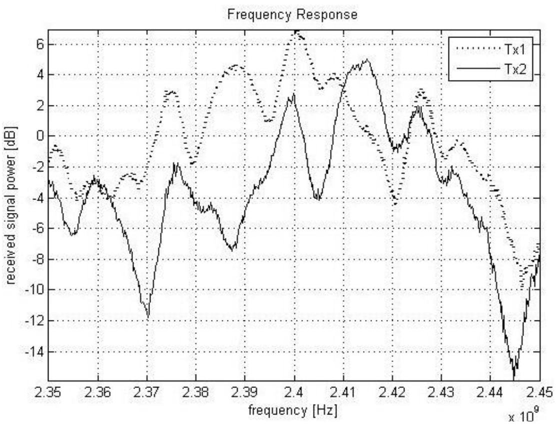

Figure 8. Nearby users' distance: 4m (LOS).

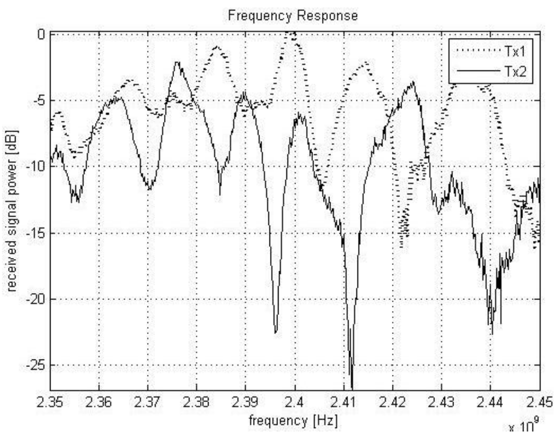

Figure 9. Nearby users' distance: 5m (LOS).

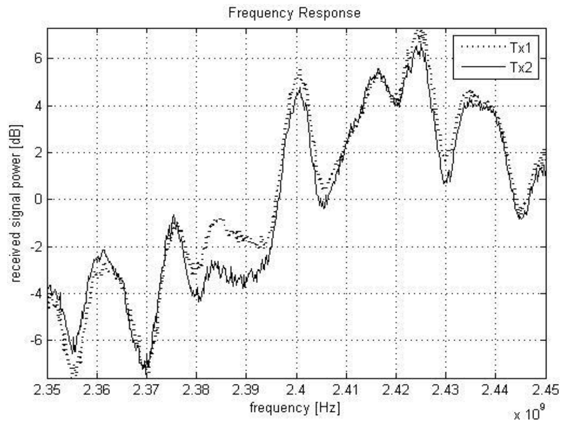

Figure 10. Nearby users' distance: 1m (NLOS).

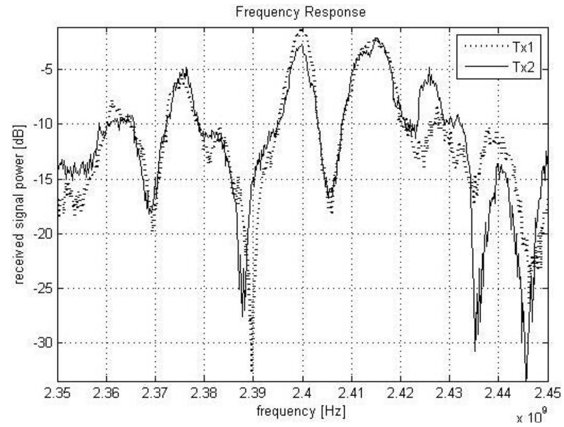

Figure 11. Nearby users' distance: 2m (NLOS).

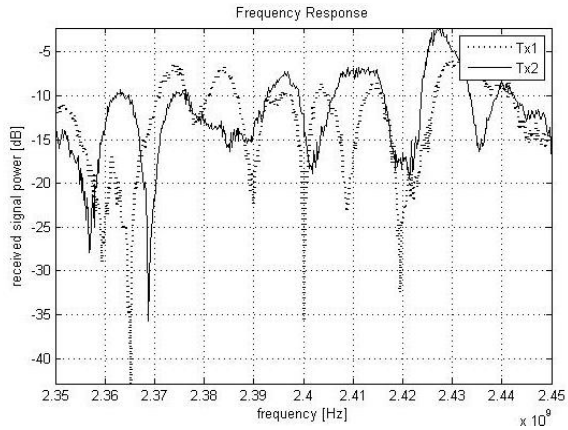

Figure 12. Nearby users' distance: 3m (NLOS).

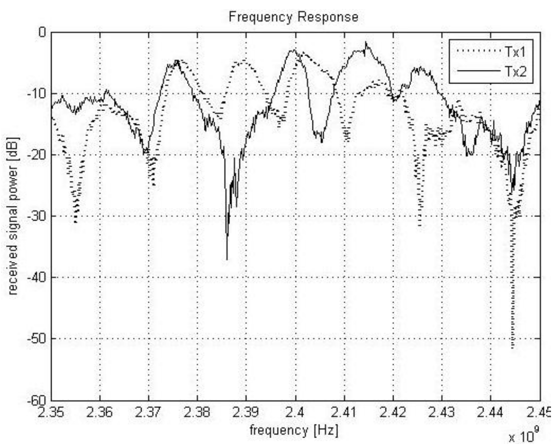

Figure 13. Nearby users' distance: 4m (NLOS).

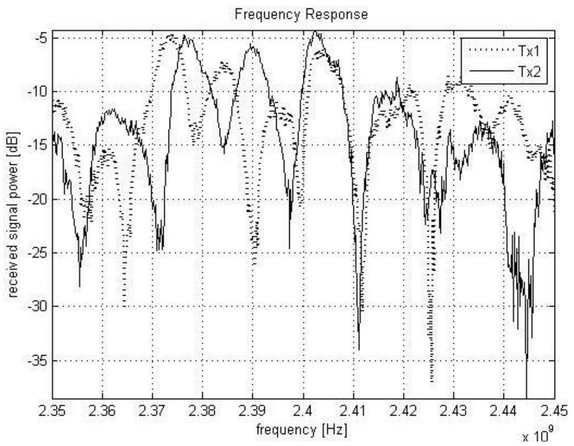

Figure 14. Nearby users' distance: 5m (NLOS).

Table 1. Cross-correlation of frequency response for real/imaginary parts between object and nearby channels (LOS).

Measurement condition	Real Part	Imaginary Part
LOS：1m	$2.2736*10^3$	$4.6769*10^3$
LOS：2m	$1.6197*10^3$	$3.064*10^3$
LOS：3m	$1.1913*10^3$	$1.8672*10^3$
LOS：4m	54.8963	91.274
LOS：5m	14.0308	16.7565

Table 2. Cross-correlation of frequency response for real/imaginary parts between object and nearby channels (NLOS).

Measurement condition	Real Part	Imaginary Part
NLOS：1m	237.4263	588.5835
NLOS：2m	39.3903	64.8906
NLOS：3m	22.4992	34.0363
NLOS：4m	19.8203	24.8906
NLOS：5m	12.4992	22.0363

We have observed the cross-correlation status for channel frequency response between object user's channel and nearby user's channel. Shown in Table 1 (for LOS condition) and Table 2 (for NLOS condition), are the cross-correlation values for both real and imaginary parts, separated distance from 1 meter to 5 meters. For measurement under LOS channel environments, the channel characteristics difference between antennas are quite trivial, even if the distance is about 3 meters, the real part and the imaginary part of the cross-correlation status for channel frequency response are still noteworthy. When the spacing is over 4 meters, the cross-correlation status for channel frequency response will be severe attenuated. For the test channels are NLOS environments, the cross-correlation status for channel frequency response between adjacent channels are decay much faster.

4 Conclusions

These estimated equivalent channel information from the nearby users' channel estimating profile is applicable. The nearby channel estimation system may apply to modern communication systems to gain transmission throughput with satisfactory system performance. By analyzing the real and imaginary parts of the cross-correlation function for channel frequency response of nearby users, we are able to realize the signal power strength and phase deviation over transmission channel at different separation distance. To improve the channel condition information estimation, we may collect surrounding nearby users' channel estimation data, make some statistic combination analysis. The whole transmission system can save the pilot sequence used in each transmitting block to improve bandwidth efficiency.

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