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# Field Measurement Data-based Performance Evaluation for Slepian-Wolf Relaying Systems

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***Abstract*—We proposed Slepian-Wolf relaying systems, where the correlation between source and relay is exploited so that the messages received at the relay, even though it contains error, can still help the destination decodes correctly the message transmitted from the source node. In order to assess the practicality in real fields, in this paper we evaluate the performance of the proposed relaying structure with a series of simulation using channel-sounding field measurement data.**

## I. INTRODUCTION AND SYSTEM MODEL

A channel-sounding field measurement campaign are conducted in the city center of Ilmenau, Germany [1]. Since the purpose of this paper is to evaluate the performance in the real field channel environment, we use exactly our structure of [2] as shown in Fig. 1. The source-relay correlation is exploited using an updating function $f_c$ as

$$L^u_{e,D_s,updated} = f_c(\hat{p}, L^u_{e,D_s}), \quad (1)$$

$$= \ln \frac{(1-\hat{p})\exp\{L^u_{e,D_s}\} + \hat{p}}{(1-\hat{p}) + \hat{p}\ \exp\{L^u_{e,D_s}\}}, \quad (2)$$

where $L^u_{e,D_s,updated}$ is the updated extrinsic LLR of $L^u_{e,D_s}$ obtained as the output of $D_s$, the decoder of source node. Here, $\hat{p}$ is the probability of bit error at relay to be estimated at the destination.

In this paper, we evaluate the performance under two scenarios, i.e., narrowband and broadband transmissions as:

- *(I) Narrowband Transmission*: We consider bandwidth of 1 MHz, where according to the measurement data it results in is single path channel. In this scenario, we use exactly the same structure of relaying systems as [2].
- *(II) Broadband Transmission*: We consider bandwidth of 70 MHz, where the channel has 65 paths. The results of channel measurement for some bandwidth parameters settings are shown in Table I. To cancel the inter-symbol-interferece (ISI) in multipath fading channel, we use low complexity frequency domain soft-cancellation with minimum squared error (FD/SC-MMSE) equalization as presented in [3] in addition to the doped-accumulator (D-ACC).

## II. MEASUREMENT DATA SETUP

A top view of the considered urban microcell scenario is shown in Fig. 2. The measurement route has approximately 60 m and was sampled with around 2480 snapshots, corresponding to a distance about 0.03 m between neighboring snapshots.

The transmitter side has a 16-element uniform circular array (UCA) with minimum antenna spacing of half the wavelength. To obtain spatial-temporal observation of the channel, the transmitter was moved at walking speed (about 6 km/h) along the route marked as the dashed line as indicated by Fig. 2.

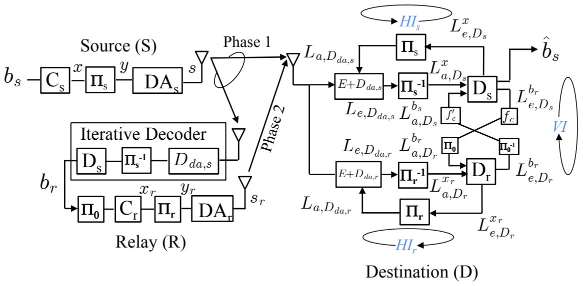

Fig. 1. Structure of the Slepian-Wolf relaying systems [2].

TABLE I
BANDWIDTH VS NUMBER OF MEASURED MULTIPATH COMPONENTS

| BW | Path | BW | Path | BW | Path |
|---|---|---|---|---|---|
| 1 MHz | 1 | 2 MHz | 2 | 5 MHz | 4 |
| 20 MHz | 16 | 50 MHz | 40 | 70 MHz | 65 |

As shown in Fig. 2, the measurement route can be roughly divided into two regions; the first part, the route $A \rightarrow B$, is line-of-sight (LOS) region in front of large open area; the second part, route $B \rightarrow C$, is non-line-of-sight since the transmitter was moved from open place to the the pedestrian street surrounded by building with a height of approximately 10 to 15 m.

To highlight the condition of LOS and NLOS propagation along the measurement route, the power of measurement data shown in Fig. 3 is normalized. As an example, the results of normalization for snapshot 700 and 1700 are shown in terms of channel impulse response (CIR) in Fig. 4. It is found that the signal is very weak in the region of NLOS with difference about 20 dB.

At the receiver side, an 8-element uniform linear array (ULA) antennas with element spacing of 0.4 times wavelength was used. The height of antenna was fixed at 4 m above the ground. The carrier frequency is set at 5.2 GHz. We used oversampling factor of 2, with raised cosine filtering. Roll-off factor is set at 0.5 and the filter delay is 3.

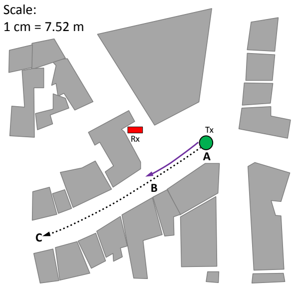

Fig. 2. Overview of measurement route (Tx) and the locations of fixed Rx. A→B: LOS and B→C: NLOS

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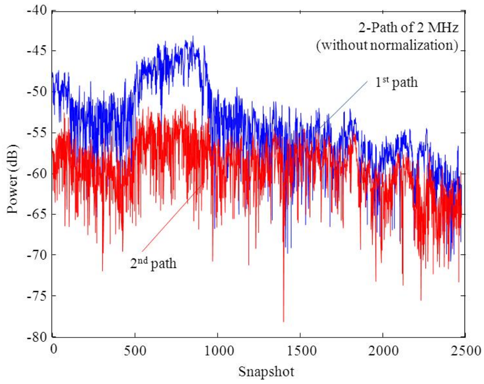

Fig. 3. S-R link with bandwidth of 2 MHz (2-path fading channel) without normalization.

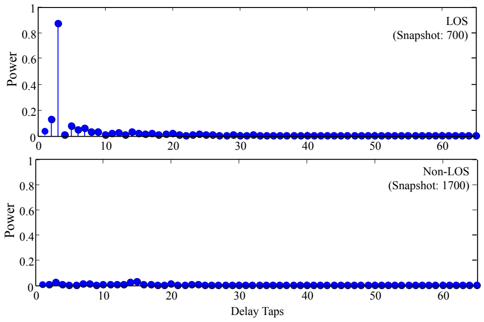

Fig. 4. Channel Impulse Responses (CIR) for S-R link: (a) LOS position (snapshot: 700) and (b) NLOS position (snapshot: 1700).

## III. Simulation Setup and Numerical Results

The coding scheme is exactly the same as our design in [2], i.e., rate-1 doped accumulator followed by memory-1 rate 1/2 non-recursive non systematic convolutional code. However, because in this paper we compare the performance with multipath fading channel, we restrict the block length into 512 which is the same as the fast Fourier transform (FFT) size required by the FD/SC-MMSE equalization. Furthermore, because the page limitation, in this paper we only show the performance where the distances between source-relay, source-destination, and relay-destination are equal as $d_{SD} = d_{SR} = d_{RD}$.

It is important to note that the source-relay (S-R), source-destination (S-D), and relay-destination (R-D) links are assumed as the link obtained from antenna pairs $1 \rightarrow 1, 5 \rightarrow 5$, and $8 \rightarrow 8$ as shown in Fig. 5 with index of 8, 68 and 113, respectively.

It is interesting to evaluate the performance of instantaneous bit-error-rate (BER) snapshot-by-snapshot to observe the performance of structure in LOS and NLOS environment. The numerical results of snapshot-by-snapshot BER are shown in Fig. 6 for Signal-to-noise power ratio (SNR) of 15 dB. Fig. 6 shows that performance of broadband transmission is better and more stable both in LOS and NLOS environment. It shows that our FD/SC-MMSE in this structure can combine all energy path although multipath components are weak.

It is also important here to evaluate the whole performance for other SNR values. Given the channels are randomly selected from snapshot 1 to 2500, we evaluate average BER for SNR 0 dB to 40 dB. The results are plotted in Fig. 7, where we also compare the performance with the case of direct transmission without relay. Given the channel, it is found that the Slepian-Wolf relay systems improves the performance 9.32 dB, while the FD/SC-MMSE equalization for broadband transmission improves the performance by 7.3 dB at BER of $10^{-3}$.

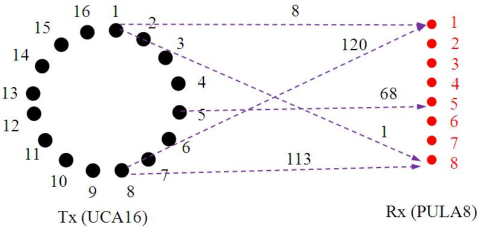

Fig. 5. Antenna setup: Tx (UCA16) and Rx (PULA8).

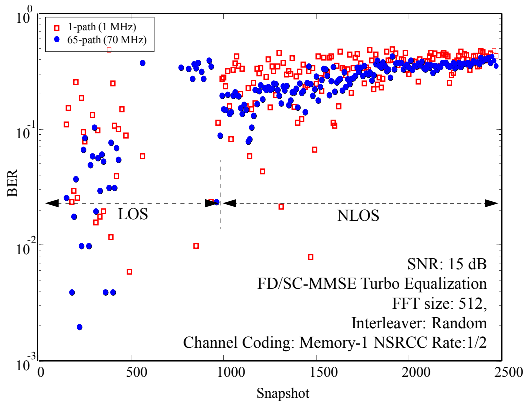

Fig. 6. Snapshot-by-snapshot BER of the proposed relaying systems over single and multipath channels at SNR=15 dB.

## IV. Conclusions

We have evaluated performance of Slepian-Wolf relaying system using channel-sounding field measurement data. We found that the similar tendency on performance improvement is achieved by the proposed relaying systems as presented in [2] and [3], where a stochastic channel model is used.

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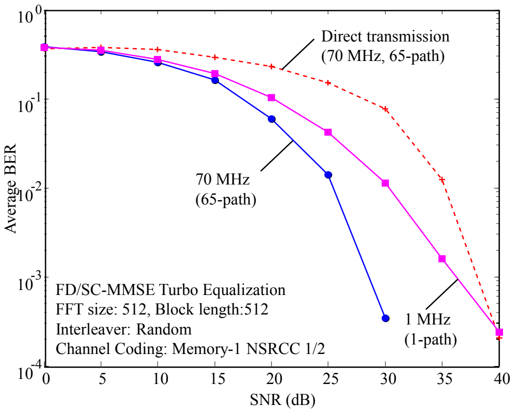

Fig. 7. Average BER given the channel are randomly selected from 2500 snapshots (channel realizations) along the route $A \rightarrow B \rightarrow C$.