4) Width and SNR_{min}: Some effects regarding corridor width and SNR_{min} are contrary to each other, which complicates drawing general conclusions. For instance, a larger **width** results in more diversity as more nodes participate in each stage, and thus OFDMA can choose better subcarrier allocations. However, since our allocation strategy is “fair”, we assign the same number of subcarriers to each link in a stage. The more links used, the higher is the probability of a link having poor channel conditions, thus limiting the performance of the stage. Regarding $\mathbf{SNR_{min}}$, we encounter a similar trade-off. A large SNR_{min} prevents our algorithm from including bad links in a certain stage, thus improving the performance of OFDMA. Yet, this also affects unipath construction, resulting in better OFDM performance and thus lowering gains. Overall, this limits our gains to about 15%. We address this issue in the practical case, since the aforementioned effects became critical on the SDR testbed.

D. Practical experiments

1) Limitations: The limitations outlined in Section V-C4 had a significant impact on our initial testbed experiments—our OFDMA corridors provided no gains compared to OFDM. Figure 12 depicts a sample of an actual channel measurement from our testbed. We observe two key limitations, namely, (a) the aforementioned fair allocation of subcarriers forces us to use poor links, and (b) the worst subcarrier in a stage imposes the maximum MCS since all subcarriers use the same rate. Although these issues also affected our simulations, they became more critical in practice. The reason is that the channels in our lab feature less reflections than in our simulations, and are thus less frequency selective. Due to the fair allocation strategy, the probability of assigning a poor link to a subcarrier became much larger in the practical case. Still, Figure 12 shows that our testbed does feature significant frequency selectiveness.

2) Implementation changes: To solve the above issues, we adapted the OFDMA allocation mechanism for our practical experiments. To deal with effect (a), we allow each link to get a different amount of resources according to its channel conditions and to the amount of data each node in a stage needs to forward. Further, we counteract (b) by allowing each subcarrier to use a different MCS. We design an allocation mechanism that minimizes the transmission time at each stage.

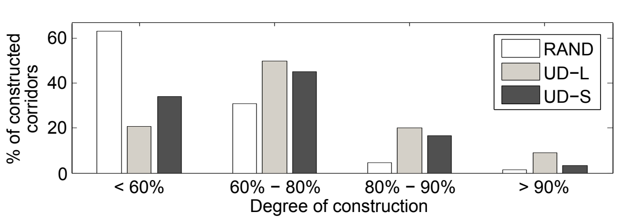

Figure 11. Degree of construction achieved for corridors of width three.

3) Results: Figure 13 depicts the throughput in our testbed of both OFDM and OFDMA for different widths and values of SNR_{min}. We achieve throughput gains mostly between 20% and 50%, which matches the results of related work. According to Section V-A, we conclude that our construction algorithm builds good corridors. Also, these results confirm our observations in Figure 12. The throughput of OFDM varies in each of the three measurements although it does not depend on the corridor width. The reason is that channels in our lab fluctuate slowly during the course of the day, leading to different results for the same SNR_{min}. Still, channels are comparable for each corridor width. We observe that the throughput of OFDM increases with SNR_{min} since this parameter also affects the nodes chosen for unipaths. In contrast, OFDMA achieves similar throughput for all SNR_{min} values. This shows the high degree of flexibility of OFDMA—due to the improved allocation scheme (c.f. Section V-D2), OFDMA becomes highly adaptive, and thus weak links in a stage barely make any impact on it. Regarding corridor width, we observe that throughput decreases slightly with larger stages. The reason is the incurred overhead for *OFDMA operation*, i.e., not the overhead for corridor construction, which is to a large extent independent of corridor width (c.f. Section V-C1). OFDMA exchanges CSI among all nodes of a stage. Hence, the larger a stage, the larger its overhead. For corridors of width four, this overhead even exceeds the gains of OFDMA, resulting in a negative throughput gain. Moreover, Figure 13 illustrates that the diversity available in a corridor of width two already allows for large gains. In other words, the corridor structure does not need to be wide to provide large benefits.

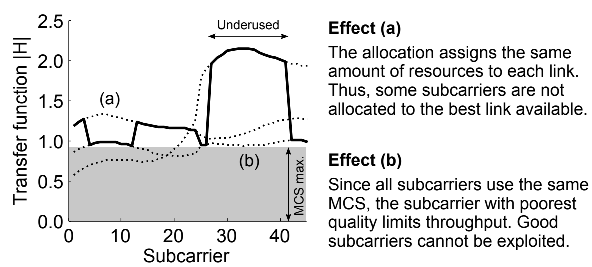

Figure 12. Testbed channels. The thick line is the OFDMA allocation.

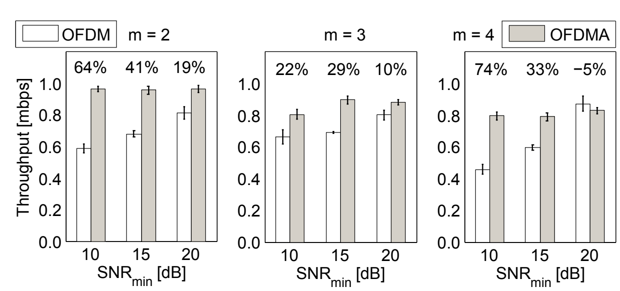

Figure 13. Corridor throughput in practice. Percentages refer to gains.

E. Discussion

In Section I we identified a number of open questions regarding the practicability of corridor construction in WMNs, and our results provide some answers. First, the **construction overhead** of a corridor depends on the length of the corridor, and increases faster per stage than a unipath does per hop. For example, for a corridor of length five, the overhead is about ten times larger than that of a unipath; it consists mostly of control packets conveying neighbor lists. This leads directly to the second issue of compensating for this overhead (**turning point**) before the corridor fails. In our experiments, the slowest scenario needed an average of 16 packets to reach this point. Assuming a packet size of 1500 bytes, a worst-case throughput of 1 mbps, and a corridor length of five stages, 16 packets require 0.96 seconds to reach the destination. Since we consider a range of six meters for our smallest scenario, on average a node needs to move three meters to leave a corridor. Hence, this requires nodes to move at about $3\,\mathrm{m}/0.96\,\mathrm{s} = 11.25\,\mathrm{km/h}$ for the corridor overhead not to compensate, which is significantly larger than the average human speed. This intuitive estimation becomes more beneficial assuming more realistic throughputs, opening doors to using our construction scheme also in outdoor scenarios featuring higher mobility. Still, determining the trade-offs in such a scenario requires further practical experiments. Third, we also study the influence of **topology characteristics**. As expected, dense and connected networks result in better corridors. The less nodes are available, the more often our algorithm has to narrow a corridor. However, similarly to [4], we observe that corridors do not need to be wide to provide large gains, i.e., also sparse networks can benefit from corridors. For OFDMA, we conclude that corridor widths up to three nodes and small $\mathrm{SNR}_{\mathrm{min}}$ values are best. However, $\mathrm{SNR}_{\mathrm{min}}$ should be above a minimum to avoid links with bad channel conditions on all subcarriers. Finally, regarding the **operation of OFDMA**, our practical experiments show that a non-fair allocation of subcarriers to links in a stage enables high adaptability to the channel, which is crucial in wireless communication.

VI. Conclusion

We present an algorithm for corridor construction in WMNs that use Corridor-based Routing, which is a routing paradigm that widens traditional paths to exploit spatial diversity using state-of-the-art PHYs. In particular, we study whether the overhead required to build a corridor structure compensates. We evaluate our algorithm both in simulation and practice using an SDR testbed. To investigate the quality of the resulting corridors, we assess their performance for the case of OFDMA. Our results show that the effort required for corridor construction compensates if the corridor can be used for multiple packets. We analyze the number of packets needed to reach this turning point. Assuming nodes move at human speed, corridors are practicable in all scenarios we consider. We solve practical issues regarding frequency selectivity, and show that our algorithm builds corridors that allow up to 74% throughput gain when using OFDMA.

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