THAM 15.8

Throughput Enhancement for Wireless Communication Systems using the Multiple Antenna Technique MIMO

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Abstract—**One of the main goals in developing next generation wireless communication systems is increasing the data rates. A promising way to achieve this is the combination of Multiple-Input Multiple-Output (MIMO) signal processing with Orthogonal Frequency Division Multiplexing (OFDM). A test system is built in which the OFDM based Wireless LAN standard IEEE 802.11a is extended with MIMO. Initial measurements are performed in a typical office building and successful transmissions up to 162 Mb/s are demonstrated.**

I. INTRODUCTION

Applications, such as the in-home delivery of HDTV signals for entertainment, high-speed computer networks, and hospital communications for medical imaging, drive the need for broadband communication systems. Together with the demand for flexibility, the main goals in developing next generation wireless communication systems are increasing the bit rate (link throughput) and network capacities. Current wireless computer networking products, based on the IEEE 802.11b Wireless LAN (WLAN) standard, deliver 11 Megabits-per-second (Mb/s). Emerging products based on 802.11a and 802.11g achieve rates up to 54 Mb/s. The need for ever-higher transmission speeds, however, will bring us beyond the 54 Mb/s.

A very promising solution is to exploit, besides the time and frequency dimension, also the spatial dimension. For this dimension, information theory research has revealed that the throughput can increase linearly with the number of transmit antennas, especially when the environment provides rich scattering (e.g. indoor environments) [1]. In this paper, we describe the application of this technique, generally referred to as Multiple-Input Multiple-Output (MIMO), and show by measurements that the data rate can be increased. With our MIMO test system (having three transmit and three receive antennas), we demonstrated successful transmissions up to 162 Mb/s in a typical office environment in the license free 5.x GHz band.

II. THE MIMO PRINCIPLE

Consider a wireless communication system with N_t transmit (TX) and N_r receive (RX) antennas. For this system, the MIMO principle is schematically represented in Fig. 1. At the receiver, the channel matrix **H** must be estimated and used in MIMO algorithms [2], [3], [4] to properly detect the in parallel and at the same carrier frequency transmitted signals s_m, with $m = \{1, \ldots, N_t\}$.

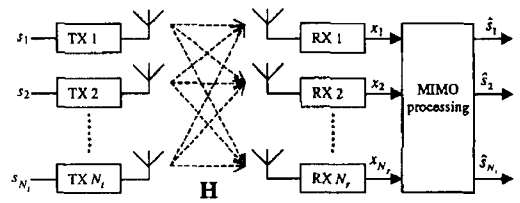

Fig. 1: A schematic representation of a MIMO communication system.

Note that most MIMO algorithms are in general narrowband techniques. The WLAN standards IEEE 802.11a and g, however, are based on a broadband communication technique, i.e. Orthogonal Frequency Division Multiplexing (OFDM) [5]. Since every OFDM subcarrier can be regarded as a narrowband channel, OFDM is extremely suitable for the extension with MIMO. This leads to the promising combination of the data rate enhancement of MIMO with the relatively high spectral efficiency and the robustness against frequency-selective fading and narrowband interference of OFDM. An extra advantage of WLAN systems is that they are mainly deployed in indoor environments. These environments are typically characterized by richly scattered multipath. As explained in [1], this is a good condition for achieving high MIMO capacities.

III. PERFORMANCE EVALUATION

A 3 × 3 MIMO OFDM test system, i.e. having 3 TX and 3 RX antennas, has been built (see Fig. 2). The test system operates in the 5.x GHz ISM band and has a bandwidth of 20 MHz. For reliable reception, synchronization is performed in the receiver. Compared to OFDM, changes have been made to the time and frequency synchronization, channel estimation, and synchronization tracking. An overview of the required changes is given in [6]. For the signal detection, the MIMO algorithm PAC-VBLAST [4] is used. To verify the MIMO OFDM principle, initial Bit Error Rate (BER) and Packet Error Rate (PER) measurements were done with the above described test system in a wing of 12.7 m × 42 m on the third floor of a typical office building. The floor plan, including the RX and 9 TX locations and orientations that were used for the measurements, is given in Fig. 3.

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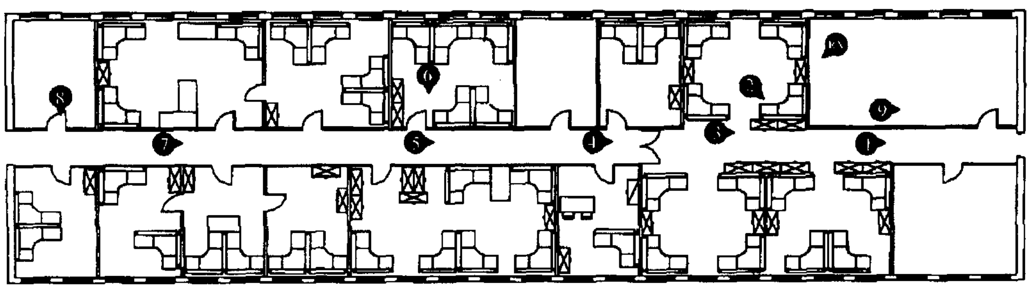

Fig. 3: Floor plan of the office where the measurements were performed, including the RX and TX locations and orientations.

Each TX antenna transmits with an average power of about 50 mW. The memory of the transmitter has a storage capacity of 19 MIMO OFDM data symbols, which was always fully exploited, leading to different packet lengths for different data rates. To obtain an average BER and PER performance, 1000 packets were transmitted per rate. The performance for the positions 1, 3, 4, 5 and 7 is shown in Fig. 4. For the performance of the other locations, the reader is referred to [6].

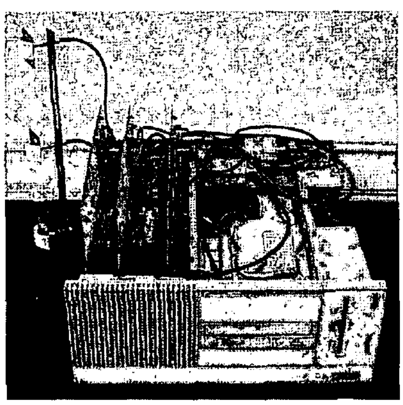

Fig. 2: The receiver of the MIMO test system.

IV. Conclusions

From the results of Fig. 4, it can be concluded that the MIMO technology is suitable to extend wireless communication standards like IEEE 802.11a to higher data rates. As a proof, we performed successful transmissions up to 162 Mb/s in a typical office environment.

Acknowledgment

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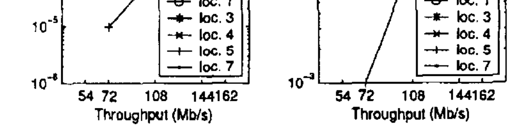

Fig. 4: Measurement results of a 3 × 3 system with PAC V-BLAST detection for the TX locations 1, 3, 4, 5 and 7.