MASCOT Real-Time 4×4 MIMO-OFDM Testbed

Multi-Antenna Wireless Communication Systems

Degrees of Freedom in Communication Technology

Traditional: Time, Frequency, Code
New: Space

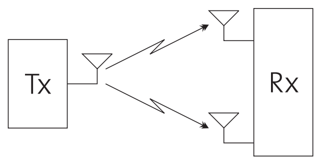
Using multiple antennas at the receiver provides:

Array Gain

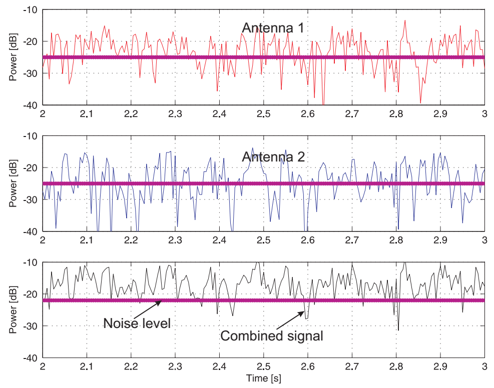
Improves the signal-to-noise ratio at the receiver since the total received signal power is higher.

Diversity Gain

Stabilizes the link by mitigating the effects of fading through multiple antennas.



single-input multiple-output system

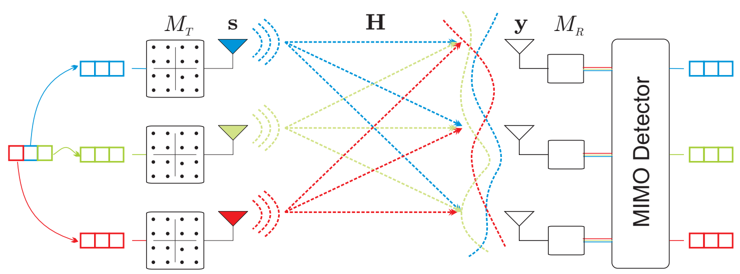


Multiple-Input Multiple-Output (MIMO) Systems

Using multiple antennas at the transmitter and the receiver provides:

Spatial Multiplexing Gain

Multiple data streams can be transmitted *concurrently* and within the *same frequency band*.



System model: $\mathbf{y} = \mathbf{Hs} + \mathbf{n}$

MIMO detection: $\hat{\mathbf{s}} = \mathbf{Gy}$ for instance with $\mathbf{G} = \mathbf{H}^{-1}$

Benefits of MIMO Communication Systems

MIMO technology is a very promising candidate to alleviate performance bottlenecks in wireless communication systems:

- Longer range compared to single-input single-output systems
- Higher throughput at the same overall transmit power expenditure
- Higher spectral efficiency
- Better quality of service (QoS)

Standard	Max. PHY data rate [Mbit/s]	Band-width [MHz]	Number of data subcarriers	Spectral efficiency [bit/s/Hz]
802.11b	11	20	-	0.55
802.11a/g	54	20	48	2.7
MASCOT	216	20	48	10.8
802.11n	600	40	108	15

Practical Design Challenges

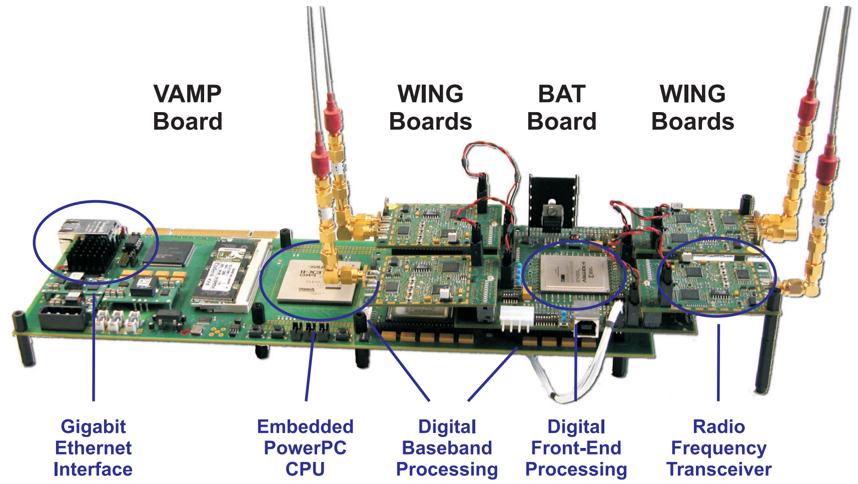
- Higher signal processing complexity
- Increased VLSI design complexity
- Silicon area / manufacturing costs
- Device power consumption

MIMO Research at the Integrated Systems Lab

Approach

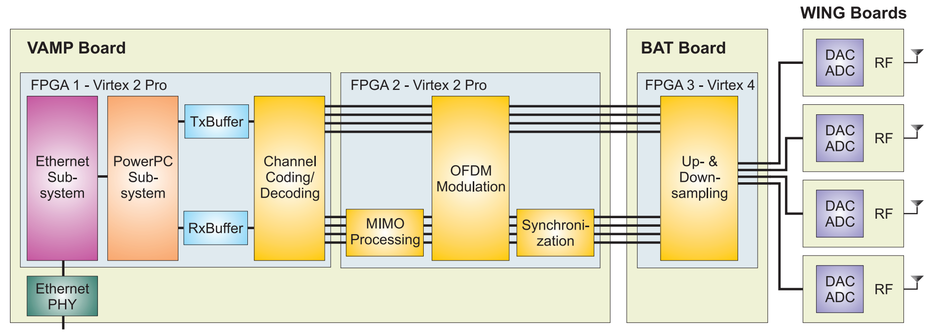
- The key to efficient implementation is **joint optimization of algorithmic and VLSI architectural aspects**.
- We focus on the **VLSI integration** of digital signal processing blocks.
- We use FPGA prototypes for system development and to **assess algorithm performance under real-world conditions**.
- We develop dedicated **application specific integrated circuits (ASICs)** for critical system components.

One Terminal of the MASCOT Testbed



- Polling-based medium access control (MAC) layer implemented on embedded PowerPC RISC CPU operating at 240 MHz.
- MIMO physical (PHY) layer based on IEEE 802.11a/n.
- Complete 2.4 GHz radio frequency (RF) transceiver.
- All boards have been designed at ETH Zurich.

Design Partitioning



Modulation Parameters of MASCOT MIMO PHY

Channel bandwidth	20 MHz
Modulation	BPSK, QPSK, 16-QAM, 64-QAM
Coding	Convolutional rate 1/2, 2/3, 3/4 codes
Number of subcarriers	64 in total: 12 zero tones, 4 pilot tones, 48 data tones
OFDM symbol duration	4 µs
Guard interval	0.8 µs
Subcarrier spacing	312.5 kHz

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IIS MIMO