Project Number:	IST-026905
Project Title:	Multiple-Access Space-Time Coding Testbed
Project Coordinator:	C.F. Mecklenbräuker
Deliverable Number:	D2.2.1

Title of Deliverable:	VHDL Library of Reference Designs
Public Report:	Top-level Documentation
Workpackage:	WP-2
Nature:	R
Dissemination level:	CO
Editor:	Peter Lüthi
Authors:	see list inside
Contractual Date of Deliverable:	Dec. 31, 2008
Actual Date of Delivery:	Dec. 31, 2008

Abstract:

This deliverable reports on the VHDL reference design library realized within the EU FP6 project MASCOT and the corresponding licensing procedure in order to obtain the library. The library contains four different VHDL reference designs such as sorted QR decomposition, singular value decomposition, lattice-reduction aided precoding using Brun's algorithm, and a K-Best detector.

Contents

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Chapter 1

VHDL Reference Designs

1.1 Accompanying Files

Each reference design consists of the following:

- Documentation in paper form and/or in form of a report
- Golden model written in MATLAB [3]
- VHDL sourcecode of the entire reference design
- Testbench and functional test vectors for simulation
- Compilation script for ModelSim [4]
- Basic synthesis script for Synopsys [5]
- README.txt file

More information about specific MATLAB and ModelSim versions used for the individual designs as well as dedicated simulation requirements can be found in the README.txt file supplied with each reference design.

1.2 Reference Designs

1.2.1 Sorted QR Decomposition

The QR decomposition (QRD) is an important, but often underestimated prerequisite for pseudo- or non-linear detection methods such as successive interference cancellation or sphere decoding for multiple-input multiple-output (MIMO) systems. The ability of concurrent iterative sorting during the QR

decomposition introduces a moderate overall latency, but provides the base for an improved layered stream decoding. This reference design illustrates how an iterative sorted QR decomposition preprocessor for MIMO receivers can be implemented. The presented architecture performs MIMO channel preprocessing using Givens rotations in order to compute the minimum mean squared error QR decomposition and was published in [7].

1.2.2 Singular Value Decomposition

The singular value decomposition (SVD) and the QR decomposition (QRD) are two prominent matrix decomposition algorithms used in various signal processing applications. In the field of multiple-input multiple-output (MIMO) communication systems, the SVD and the QRD are employed for beamforming and for channel-matrix preprocessing for MIMO detection, respectively. This reference design describes a minimum-area matrix decomposition implementation that is programmable to perform QRD *and* SVD with variable precision. The reference design is able to achieve a hardware efficiency of up to 325 k SVDs/s/mm^2 and 1.92 M QRDs/s/mm^2 for complex-valued 4×4-matrices in 180 nm CMOS technology [8].

1.2.3 Lattice-Reduction Aided Precoding using Brun's Algorithm

Lattice reduction (LR) aided multi-antenna broadcast precoding with vector perturbation achieves better error rate performance compared to conventional linear precoding without lattice reduction. This reference design illustrates how Brun's algorithm can be implemented to extend a conventional linear precoder to include lattice reduction with negligible additional silicon area. The reference design also illustrates various architectural optimizations to reduce circuit complexity and a second pipelined implementation illustrates how minor algorithm modifications lead to further complexity reduction [6].

1.2.4 K-Best Detector

From a bit error rate (BER) performance perspective, maximum likelihood (ML) detection is the preferred detection method for multiple-input multiple-output (MIMO) communication systems. However, for high transmission rates a straight forward exhaustive search implementation suffers from prohibitive complexity. The K-best algorithm provides close-to ML BER perfor-

mance, while its circuit complexity is reduced. This reference design shows a high-throughput K-Best architecture and was first published in [9].

Chapter 2

Licensing and Ordering Procedure

The reference designs can be licensed and ordered by filling in the *MASCOT Reference Design License Agreement* [2] according to the following instructions:

- Open the PDF document of the license agreement in a Adobe Reader [1] version 7.x or higher.
- Enter the name and address of your organization on page 1/3 of the license agreement.
- Add name and title of a representative of your institution on page 2/3 of the license agreement.
- Print two copies of the completed license agreement.
- Let the representative of your institution sign both license agreements on page 2/3.
- Send both completed and signed license agreements by mail to:

  ETH Zürich
  Integrated Systems Laboratory
  Dr. Norbert Felber
  Gloriastrasse 35
  CH-8092 Zürich
  Switzerland

- Alternatively, send a scanned copy of the completed and signed license agreement by e-mail to norbert.felber@iis.ee.ethz.ch

After successful license application and license approval, the Integrated Systems Laboratory at the ETH Zurich, Switzerland, will contact the licensee and the reference designs will be made available to the licensee.

Chapter 3

Disclaimer

For liability information, please refer to the *MASCOT Reference Design License Agreement* [2]

Bibliography

[1] Adobe Reader. http://get.adobe.com/reader/.

[2] MASCOT Reference Design License Agreement. http://www.iis.ee.ethz.ch/~mascot/docs/MASCOT_RefDesigns_LicenseAgreement.pdf.

[3] MATLAB - The Language of Technical Computing. http://www.mathworks.com/products/matlab/.

[4] ModelSim simulator offering VHDL, Verilog, or mixed-language simulation. http://www.model.com/.

[5] Synopsys Design Compiler. http://www.synopsys.com/.

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