

FPGA Implementation of MIMO System using Xilinx System Generator for Efficient Hardware/ Software co-design

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Abstract- To meet rapidly increasing demands for the multimedia services and better quality of service over wireless communication systems, MIMO (Multiple Input Multiple Output) systems have been proposed which promise enhanced system capacity, throughput and data reliability. Moreover, the enormous computational requirements for multimedia data call for use of efficient hardware platforms over and above software platforms. In this work, we implement a transmitter system on hardware test-beds, which is useful in video streaming. We employ the 2*2 Alamouti MIMO technique to develop a transmission system and implement the design on FPGA using Xilinx System Generator (XSG) and AccelDSP (for supporting XSG). The state-of-art design tools and methodology lead to superior performance over traditional approach. This reduces the development time and cost and also enhances the reliability. We discuss the salient features of user-friendly model-based design, which enables creation of reusable models and also provides higher level abstraction. A comparison with traditional design methodology using HDL (hardware description language) shows effectiveness of our approach.

Keywords- FPGA (Field Programmable Gate Array); STBC (Space Time Block Coding); MIMO on FPGA; Xilinx System Generator; AccelDSP; hardware/software co-design; simulation.

1. INTRODUCTION

E-learning and multimedia services to provide online educational material (such as videos, lectures) has been considered a major and fundamental agent of transformation in the realm of distance education. Many institutes have opened their web servers for free lecture-on-demand on several courses (e.g. <http://ocw.mit.edu/index.html>). Also, specialized wireless lecture video streaming servers for distance learning are being setup in various universities. The every-day increasing demands for such vital multimedia services along with the rising expectation of quality for these services render many of the currently used techniques and systems less-useful [1,21]. Existing

multimedia software (even those specialized to digital image processing) do not provide per excellence multimedia data service to the common user, due to a lack of unified on-chip video processing and transmission capabilities.

We propose to utilize the simulation approach for efficient hardware-software co-design, since this approach has been recently gaining a lot of popularity [5, 20, 31]. We implement wireless transmission system over FPGA [13], addressing the need of dedicated hardware system for video data transmission using MIMO (Multiple Input Multiple Output) transmission techniques and using high-level synthesis and design language, and superior design methodologies for effective design. Our work has great significance in making the company managers equipped with technical knowledge required for providing e-learning solutions to masses.

The contributions of our work are as follows:

- (1) We present a solution using FPGA as target platform (instead of software), for implementing algorithms for transmission of educational videos using MIMO over and above SISO (Single Input Single Output) or MISO (Multiple Input Single Output) systems.
- (2) We develop a model of Alamouti MIMO communication technique using STBC over Xilinx System Generator (XSG) using the modelling and simulation capabilities of Simulink.
- (3) We design the hardware using Xilinx System Generator, which offers many advantages over existing implementation platforms. We also perform analysis of various features and design issues for HDL and high-level graphic design language.

The rest of the paper is organized as follows. We first discuss the literature review of on-going work in the area of multimedia communication, MIMO systems, FPGA and its design options and set the stage for the need of

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An FPGA Implementation of MIMO Baseband Systems Yuming Liang,2007 **MIMO Systems** Hossein Khaleghi Bizaki,2011-04-04 In recent years it was realized that the MIMO communication systems seems to be inevitable in accelerated evolution of high data rates applications due to their potential to dramatically increase the spectral efficiency and simultaneously sending individual information to the corresponding users in wireless systems This book intends to provide highlights of the current research topics in the field of MIMO system to offer a snapshot of the recent advances and major issues faced today by the researchers in the MIMO related areas The book is written by specialists working in universities and research centers all over the world to cover the fundamental principles and main advanced topics on high data rates wireless communications systems over MIMO channels Moreover the book has the advantage of providing a collection of applications that are completely independent and self contained thus the interested reader can choose any chapter and skip to another without losing continuity **Nanoelectronics, Circuits and Communication Systems** Vijay Nath,J.K. Mandal,2020-11-17 This book features selected papers presented at the Fifth International Conference on Nanoelectronics Circuits and Communication Systems NCCS 2019 It covers a range of topics including nanoelectronic devices microelectronics devices material science machine learning Internet of things cloud computing computing systems wireless communication systems advances in communication 5G and beyond Further it discusses VLSI circuits and systems MEMS IC design and testing electronic system design and manufacturing speech signal processing digital signal processing FPGA based wireless communication systems and FPGA based system design Industry 4 0 e farming semiconductor memories and IC fault detection and correction **Silicon Systems For Wireless Lan** Zoran Stamenkovic,Gilda Leger,Alberto Bosio,2020-11-27 Today s integrated silicon circuits and systems for wireless communications are of a huge complexity This unique compendium covers all the steps from the system level to the transistor level necessary to design model verify implement and test a silicon system It bridges the gap between the system world and the transistor world between communication system circuit device and test engineers It is extremely important nowadays and will be more important in the future for communication system and circuit engineers to understand the physical implications of system and circuit solutions based on hardware software co design as well as for device and test engineers to cope with the system and circuit requirements in terms of power speed and data throughput Related Link s **MIMO System Technology for Wireless Communications** George Tsoulos,2018-10-03 For broadband communications it was frequency division multiplexing For optical communications it was wavelength division multiplexing Then for all types of networks it was code division Breakthroughs in transmission speed were made possible by these developments heralding next generation networks of increasing capability in each case The basic idea is the same more channels equals higher throughput For wireless communications it is space time coding using multiple input multiple output MIMO technology Providing a complete

treatment of MIMO under a single cover MIMO System Technology for Wireless Communications assembles coverage on all aspects of MIMO technology along with up to date information on key related issues Contributors from leading academic and industrial institutions around the world share their expertise and lend the book a global perspective They lead you gradually from basic to more advanced concepts from propagation modeling and performance analysis to space time codes various systems implementation options and limitations practical system development considerations field trials and network planning issues Linking theoretical analysis to practical issues the book does not limit itself to any specific standardization or research industrial initiatives MIMO is the catalyst for the next revolution in wireless systems and MIMO System Technology for Wireless Communications lays a thorough and complete foundation on which to build the next and future generations of wireless networks

MATLAB Vasilios Katsikis, 2012-09-26 This excellent book represents the second part of three volumes regarding MATLAB based applications in almost every branch of science The present textbook contains a collection of 13 exceptional articles In particular the book consists of three sections the first one is devoted to electronic engineering and computer science the second is devoted to MATLAB SIMULINK as a tool for engineering applications the third one is about Telecommunication and communication systems and the last one discusses MATLAB toolboxes

Recent Trends in VLSI and Semiconductor Packaging T. Vasudeva Reddy, K. Madhava Rao, 2025-05-06 The International conference on Semiconductor Materials packaging AI ML Reconfigurable VLSI architectures for IoT future Communication Technologies SMART 2024 aimed to provide a platform for researchers academicians industry experts and practitioners to exchange ideas present research findings and discuss emerging trends and challenges in the specified fields SMART 2024 sought to foster collaboration innovation and knowledge dissemination by bringing together experts and stakeholders from diverse backgrounds to address key issues and explore new research directions The conference targeted a diverse audience including researchers academicians scientists engineers technologists industry professionals students policymakers and other stakeholders interested in VLSI IoT AI ML communication systems semiconductor packaging hetero architecture devices and Nano materials

Multiple Access Communications Claudio Sacchi, Boris Bellalta, Alexey Vinel, Fabrizio Granelli, Yan Zhang, Christian Schlegel, 2011-09 This book constitutes the refereed proceedings of the 4th International Workshop on Multiple Access Communications MACOM 2011 held in Trento Italy in September 2011 The 21 full papers presented were carefully reviewed and selected from more than 40 submissions They are divided in topical sections on cognitive radio MAC protocols communications theory special session on MAC protocols for WSNs system analysis and scheduling and queuing systems

Massive MIMO Detection Algorithm and VLSI Architecture Leibo Liu, Guiqiang Peng, Shaojun Wei, 2019-02-20 This book introduces readers to a reconfigurable chip architecture for future wireless communication systems such as 5G and beyond The proposed architecture perfectly meets the demands for future mobile communication solutions to support different standards algorithms and antenna sizes and to accommodate the evolution of

standards and algorithms It employs massive MIMO detection algorithms which combine the advantages of low complexity and high parallelism and can fully meet the requirements for detection accuracy Further the architecture is implemented using ASIC which offers high energy efficiency high area efficiency and low detection error After introducing massive MIMO detection algorithms and circuit architectures the book describes the ASIC implementation for verifying the massive MIMO detection In turn it provides detailed information on the proposed reconfigurable architecture the data path and configuration path for massive MIMO detection algorithms including the processing unit interconnections storage mechanism configuration information format and configuration method

DSP for Embedded and Real-Time Systems
Robert Oshana, 2012-10-11 This Expert Guide gives you the techniques and technologies in digital signal processing DSP to optimally design and implement your embedded system Written by experts with a solutions focus this encyclopedic reference gives you an indispensable aid to tackling the day to day problems you face in using DSP to develop embedded systems With this book you will learn A range of development techniques for developing DSP code Valuable tips and tricks for optimizing DSP software for maximum performance The various options available for constructing DSP systems from numerous software components The tools available for developing DSP applications Numerous practical guidelines from experts with wide and lengthy experience of DSP application development Features Several areas of research being done in advanced DSP technology Industry case studies on DSP systems development DSP for Embedded and Real Time Systems is the reference for both the beginner and experienced covering most aspects of using today s DSP techniques and technologies for designing and implementing an optimal embedded system The only complete reference which explains all aspects of using DSP in embedded systems development making it a rich resource for every day use Covers all aspects of using today s DSP techniques and technologies for designing and implementing an optimal embedded system Enables the engineer to find solutions to all the problems they will face when using DSP

[FPGA-based Digital Convolution for Wireless Applications](#) Lei Guan, 2017-01-16 This book presents essential perspectives on digital convolutions in wireless communications systems and illustrates their corresponding efficient real time field programmable gate array FPGA implementations FPGAs or generic all programmable devices will soon become widespread serving as the brains of all types of real time smart signal processing systems like smart networks smart homes and smart cities The book examines digital convolution by bringing together the following main elements the fundamental theory behind the mathematical formulae together with corresponding physical phenomena virtualized algorithm simulation together with benchmark real time FPGA implementations and detailed state of the art case studies on wireless applications including popular linear convolution in digital front ends DFEs nonlinear convolution in digital pre distortion DPD enabled high efficiency wireless RF transceivers and fast linear convolution in massive multiple input multiple output MIMO systems After reading this book students and professionals will be able to Understand digital convolution with inside out information discover what convolution is why it is important and how it works

Enhance their FPGA design skills i.e. enhance their FPGA related prototyping capability with model based hands on examples
 Rapidly expand their digital signal processing DSP blocks to examine how to rapidly and efficiently create DSP functional blocks on a programmable FPGA chip as a reusable intellectual property IP core Upgrade their expertise as both thinkers and doers minimize close the gap between mathematical equations and FPGA implementations for existing and emerging wireless applications

IT Convergence and Security 2017 Kuinam J. Kim,Hyuncheol Kim,Nakhoon Baek,2017-09-03 This is the second volume of proceedings including selected papers from the International Conference on IT Convergence and Security ICITCS 2017 presenting a snapshot of the latest issues encountered in the field It explores how IT convergence and security issues are core to most current research industrial and commercial activities and consists of contributions covering topics including machine learning deep learning communication and signal processing computer vision and applications future network technology artificial intelligence and robotics ICITCS 2017 is the latest in a series of highly successful International Conferences on IT Convergence and Security previously held in Prague Czech Republic 2016 Kuala Lumpur Malaysia 2015 Beijing China 2014 Macau China 2013 Pyeong Chang Korea 2012 and Suwon Korea 2011

Smart Antennas, Electromagnetic Interference and Microwave Antennas for Wireless Communications S. Kannadhasan,R. Nagarajan,Alagar Karthick,Aritra Ghosh,2023-02-16 This book covers all areas of smart antennas electromagnetic interference and microwave antennas for wireless communications Smart antennas or adaptive antennas are multi antenna components on one or both sides of a radio communication connection combined with advanced signal processing algorithms They've evolved into a critical technology for third generation and beyond mobile communication systems to meet their lofty capacity and performance targets It seems that a significant capacity gain is achievable particularly if they are employed on both sides of the connection There are several essential characteristics of these systems that need scientific and technical investigation Included in the book are beamforming massive MIMO network MIMO mmwave transmission compressive sensing MIMO radar sensor networks vehicle to vehicle communication location and machine learning

Reconfigurable Computing: Architectures, Tools and Applications Andreas Koch,Ram Krishnamurthy,John McAllister,Roger Woods,Tarek El-Ghazawi,2011-03-15 This book constitutes the refereed proceedings of the 7th International Symposium on Reconfigurable Computing Architectures Tools and Applications ARC 2011 held in Belfast UK in March 2011 The 40 revised papers presented consisting of 24 full papers 14 poster papers and the abstracts of 2 plenary talks were carefully reviewed and selected from 88 submissions The topics covered are reconfigurable accelerators design tools reconfigurable processors applications device architecture methodology and simulation and system architecture

International Conference on Advances in Engineering and Technology ,hyderabad , *Evolution of Cognitive Networks and Self-Adaptive Communication Systems* Lagkas, Thomas D.,Sarigiannidis, Panagiotis,Louta, Malamati,Chatzimisios, Periklis,2013-06-30 Cognitive networks can be crucial for the evolution of future communication systems however current trends have indicated

major movement in other relevant fields towards the integration of different techniques for the realization of self aware and self adaptive communication systems Evolution of Cognitive Networks and Self Adaptive Communication Systems overviews innovative technologies combined for the formation of self aware self adaptive and self organizing networks By aiming to inform the research community and the related industry of solutions for cognitive networks this book is essential for researchers instructors and professionals interested in clarifying the latest trends resulting in a unified realization for cognitive networking and communication systems

Design and FPGA Implementation of a SISO and a MIMO Wireless System for Software Defined Radio Peng Dong,2009

Ultra-Wideband Radio Technologies for Communications, Localization and Sensor Applications Reiner Thomä,Reinhard Knöchel,Juergen Sachs,Ingolf Willms,Thomas Zwick,2013-03-13

Ultra Wideband Radio UWB earmarks a new radio access philosophy and exploits several GHz of bandwidth It promises high data rate communication over short distances as well as innovative radar sensing and localization applications with unprecedented resolution Fields of application may be found among others in industry civil engineering surveillance and exploration for security and safety measures and even for medicine The book considers the basics and algorithms as well as hardware and application issues in the field of UWB radio technology for communications localization and sensing based on the outcome of DFG s priority funding program Ultra Wideband Radio Technologies for Communications Localization and Sensor Applications UKoLoS

Advanced Applications of Rapid Prototyping Technology in Modern Engineering Md Enamul Hoque,2011-09-22

Rapid prototyping RP technology has been widely known and appreciated due to its flexible and customized manufacturing capabilities The widely studied RP techniques include stereolithography apparatus SLA selective laser sintering SLS three dimensional printing 3DP fused deposition modeling FDM 3D plotting solid ground curing SGC multiphase jet solidification MJS laminated object manufacturing LOM Different techniques are associated with different materials and or processing principles and thus are devoted to specific applications RP technology has no longer been only for prototype building rather has been extended for real industrial manufacturing solutions Today the RP technology has contributed to almost all engineering areas that include mechanical materials industrial aerospace electrical and most recently biomedical engineering This book aims to present the advanced development of RP technologies in various engineering areas as the solutions to the real world engineering problems

Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems Hüseyin Arslan,2007-08-17

Today s wireless services have come a long way since the roll out of the conventional voice centric cellular systems The demand for wireless access in voice and high rate data multi media applications has been increasing New generation wireless communication systems are aimed at accommodating this demand through better resource management and improved transmission technologies This book discusses the cognitive radio software defined radio and adaptive radio concepts from several perspectives

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