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# Microarchitecture of Network-on- Chip Routers

A Designer's Perspective

 Springer

# Microarchitecture Of Network On Chip Routers A Designers Perspective

**Ensheng Dong**



## **Microarchitecture Of Network On Chip Routers A Designers Perspective:**

**Microarchitecture of Network-on-Chip Routers** Giorgos Dimitrakopoulos, Anastasios Psarras, Ioannis Seitanidis, 2014-08-27 This book provides a unified overview of network on chip router micro architecture the corresponding design opportunities and challenges and existing solutions to overcome these challenges The discussion focuses on the heart of a NoC the NoC router and how it interacts with the rest of the system Coverage includes both basic and advanced design techniques that cover the entire router design space including router organization flow control pipelined operation buffering architectures as well as allocators structure and algorithms Router micro architectural options are presented in a step by step manner beginning from the basic design principles Even highly sophisticated design alternatives are categorized and broken down to simpler pieces that can be understood easily and analyzed This book is an invaluable reference for system architecture circuit and EDA researchers and developers who are interested in understanding the overall picture of NoC routers architecture the associated design challenges and the available solutions

**Recent Trends in Information and Communication Technology** Faisal Saeed, Nadhmi Gazem, Srikanta Patnaik, Ali Saleh Saed Balaid, Fathey Mohammed, 2017-05-24 This book presents 94 papers from the 2nd International Conference of Reliable Information and Communication Technology 2017 IRICT 2017 held in Johor Malaysia on April 23 24 2017 Focusing on the latest ICT innovations for data engineering the book presents several hot research topics including advances in big data analysis techniques and applications mobile networks applications and usability reliable communication systems advances in computer vision artificial intelligence and soft computing reliable health informatics and cloud computing environments e learning acceptance models recent trends in knowledge management and software engineering security issues in the cyber world as well as society and information technology

**3D Interconnect Architectures for Heterogeneous Technologies** Lennart Bamberg, Jan Moritz Joseph, Alberto García-Ortiz, Thilo Pionteck, 2022-06-27 This book describes the first comprehensive approach to the optimization of interconnect architectures in 3D systems on chips SoCs specially addressing the challenges and opportunities arising from heterogeneous integration Readers learn about the physical implications of using heterogeneous 3D technologies for SoC integration while also learning to maximize the 3D technology gains through a physical effect aware architecture design The book provides a deep theoretical background covering all abstraction levels needed to research and architect tomorrow s 3D integrated circuits an extensive set of optimization methods for power performance area and yield as well as an open source optimization and simulation framework for fast exploration of novel designs

**Networks-on-Chip** Sheng Ma, Libo Huang, Mingche Lai, Wei Shi, 2014-12-04 Networks on Chip From Implementations to Programming Paradigms provides a thorough and bottom up exploration of the whole NoC design space in a coherent and uniform fashion from low level router buffer and topology implementations to routing and flow control schemes to co optimizations of NoC and high level programming paradigms This textbook is intended for an advanced course

on computer architecture suitable for graduate students or senior undergrads who want to specialize in the area of computer architecture and Networks on Chip It is also intended for practitioners in the industry in the area of microprocessor design especially the many core processor design with a network on chip Graduates can learn many practical and theoretical lessons from this course and also can be motivated to delve further into the ideas and designs proposed in this book Industrial engineers can refer to this book to make practical tradeoffs as well Graduates and engineers who focus on off chip network design can also refer to this book to achieve deadlock free routing algorithm designs Provides thorough and insightful exploration of NoC design space Description from low level logic implementations to co optimizations of high level program paradigms and NoCs The coherent and uniform format offers readers a clear quick and efficient exploration of NoC design space Covers many novel and exciting research ideas which encourage researchers to further delve into these topics Presents both engineering and theoretical contributions The detailed description of the router buffer and topology implementations comparisons and analysis are of high engineering value

### **Designing 2D and 3D Network-on-Chip**

**Architectures** Konstantinos Tatas,Kostas Siozios,Dimitrios Soudris,Axel Jantsch,2013-10-08 This book covers key concepts in the design of 2D and 3D Network on Chip interconnect It highlights design challenges and discusses fundamentals of NoC technology including architectures algorithms and tools Coverage focuses on topology exploration for both 2D and 3D NoCs routing algorithms NoC router design NoC based system integration verification and testing and NoC reliability Case studies are used to illuminate new design methodologies

*Designing Network On-Chip Architectures in the Nanoscale Era* Jose Flich,Davide Bertozzi,2010-12-18 Going beyond isolated research ideas and design experiences Designing Network On Chip Architectures in the Nanoscale Era covers the foundations and design methods of network on chip NoC technology The contributors draw on their own lessons learned to provide strong practical guidance on various design issues Exploring the design process of the

ICT: Applications and Social Interfaces Amit Joshi,Mufti Mahmud,Roshan G. Ragel,S. Kartik,2024-04-27 This book contains best selected research papers presented at ICTCS 2023 Eighth International Conference on Information and Communication Technology for Competitive Strategies The conference will be held in Jaipur India during 8 9 December 2023 The book covers state of the art as well as emerging topics pertaining to ICT and effective strategies for its implementation for engineering and managerial applications This book contains papers mainly focused on ICT for computation algorithms and data analytics and IT security The work is presented in five volumes

**Network-on-Chip Architectures** Chrysostomos Nicopoulos,Vijaykrishnan Narayanan,Chita R. Das,2009-09-18 2 The Cell Processor from Sony Toshiba and IBM STI 3 and the Sun UltraSPARC T1 formerly codenamed Niagara 4 signal the growing popularity of such systems Furthermore Intel s very recently announced 80 core TeraFLOP chip 5 exemplifies the irreversible march toward many core systems with tens or even hundreds of processing elements 1 2 The Dawn of the Communication Centric Revolution The multi core thrust has ushered the gradual displacement of the computati centric

design model by a more communication centric approach 6 The large sophisticated monolithic modules are giving way to several smaller simpler processing elements working in tandem This trend has led to a surge in the popularity of multi core systems which typically manifest themselves in two distinct incarnations heterogeneous Multi Processor Systems on Chip MPSoC and homogeneous Chip Multi Processors CMP The SoC philosophy revolves around the technique of Platform Based Design PBD 7 which advocates the reuse of Intellectual Property IP cores in flexible design templates that can be customized accordingly to satisfy the demands of particular implementations The appeal of such a modular approach lies in the substantially reduced Time To Market TTM incubation period which is a direct outcome of lower circuit complexity and reduced design effort The whole system can now be viewed as a diverse collection of pre existing IP components integrated on a single die

**Integrated Circuit and System Design. Power and Timing Modeling, Optimization, and Simulation** Rene van Leuken, Gilles Sicard, 2011-01-16 This book constitutes the refereed proceedings of the 20th International Conference on Integrated Circuit and System Design PATMOS 2010 held in Grenoble France in September 2010 The 24 revised full papers presented and the 9 extended abstracts were carefully reviewed and are organized in topical sections on design flows circuit techniques low power circuits self timed circuits process variation high level modeling of poweraware heterogeneous designs in SystemC AMS and minalogic

**Network-on-Chip** Santanu Kundu, Santanu Chattopadhyay, 2018-09-03 Addresses the Challenges Associated with System on Chip Integration Network on Chip The Next Generation of System on Chip Integration examines the current issues restricting chip on chip communication efficiency and explores Network on chip NoC a promising alternative that equips designers with the capability to produce a scalable reusable and high performance communication backbone by allowing for the integration of a large number of cores on a single system on chip SoC This book provides a basic overview of topics associated with NoC based design communication infrastructure design communication methodology evaluation framework and mapping of applications onto NoC It details the design and evaluation of different proposed NoC structures low power techniques signal integrity and reliability issues application mapping testing and future trends Utilizing examples of chips that have been implemented in industry and academia this text presents the full architectural design of components verified through implementation in industrial CAD tools It describes NoC research and developments incorporates theoretical proofs strengthening the analysis procedures and includes algorithms used in NoC design and synthesis In addition it considers other upcoming NoC issues such as low power NoC design signal integrity issues NoC testing reconfiguration synthesis and 3 D NoC design This text comprises 12 chapters and covers The evolution of NoC from SoC its research and developmental challenges NoC protocols elaborating flow control available network topologies routing mechanisms fault tolerance quality of service support and the design of network interfaces The router design strategies followed in NoCs The evaluation mechanism of NoC architectures The application mapping strategies followed in NoCs Low power design techniques specifically followed in NoCs The signal integrity and

reliability issues of NoC The details of NoC testing strategies reported so far The problem of synthesizing application specific NoCs Reconfigurable NoC design issues Direction of future research and development in the field of NoC Network on Chip The Next Generation of System on Chip Integration covers the basic topics technology and future trends relevant to NoC based design and can be used by engineers students and researchers and other industry professionals interested in computer architecture embedded systems and parallel distributed systems *On-Chip Networks* Natalie Enright,Li-shiuan Peh,2022-11-10 With the ability to integrate a large number of cores on a single chip research into on chip networks to facilitate communication becomes increasingly important On chip networks seek to provide a scalable and high bandwidth communication substrate for multi core and many core architectures High bandwidth and low latency within the on chip network must be achieved while fitting within tight area and power budgets In this lecture we examine various fundamental aspects of on chip network design and provide the reader with an overview of the current state of the art research in this field Table of Contents Introduction Interface with System Architecture Topology Routing Flow Control Router Microarchitecture Conclusions **Physical Design for 3D Integrated Circuits** Aida Todri-Sanial,Chuan Seng Tan,2017-12-19 Physical Design for 3D Integrated Circuits reveals how to effectively and optimally design 3D integrated circuits ICs It also analyzes the design tools for 3D circuits while exploiting the benefits of 3D technology The book begins by offering an overview of physical design challenges with respect to conventional 2D circuits and then each chapter delivers an in depth look at a specific physical design topic This comprehensive reference Contains extensive coverage of the physical design of 2 5D 3D ICs and monolithic 3D ICs Supplies state of the art solutions for challenges unique to 3D circuit design Features contributions from renowned experts in their respective fields Physical Design for 3D Integrated Circuits provides a single convenient source of cutting edge information for those pursuing 2 5D 3D technology **The Chip Is the Network** Radu Marculescu,Paul Bogdan,2008-12-24 Addresses the concept of network in three different contexts representing the deterministic probabilistic and statistical physics inspired design paradigms Autonomic Networking-on-Chip Phan Cong-Vinh,2018-09-03 Despite the growing mainstream importance and unique advantages of autonomic networking on chip ANoC technology Autonomic Networking On Chip Bio Inspired Specification Development and Verification is among the first books to evaluate research results on formalizing this emerging NoC paradigm which was inspired by the human nervous system The FIRST Book to Assess Research Results Opportunities Trends in BioChipNets The third book in the Embedded Multi Core Systems series from CRC Press this is an advanced technical guide and reference composed of contributions from prominent researchers in industry and academia around the world A response to the critical need for a global information exchange and dialogue it is written for engineers scientists practitioners and other researchers who have a basic understanding of NoC and are now ready to learn how to specify develop and verify ANoC using rigorous approaches Offers Expert Insights Into Technical Topics Including Bio inspired NoC How to map applications onto ANoC ANoC for FPGAs and

structured ASICs Methods to apply formal methods in ANoC development Ways to formalize languages that enable ANoC Methods to validate and verify techniques for ANoC Use of self processes in ANoC self organization configuration healing optimization protection etc Use of calculi for reasoning about context awareness and programming models in ANoC With illustrative figures to simplify contents and enhance understanding this resource contains original peer reviewed chapters reporting on new developments and opportunities emerging trends and open research problems of interest to both the autonomic computing and network on chip communities Coverage includes state of the art ANoC architectures protocols technologies and applications This volume thoroughly explores the theory behind ANoC to illustrate strategies that enable readers to use formal ANoC methods yet still make sound judgments and allow for reasonable justifications in practice

*Modeling, Analysis and Optimization of Network-on-Chip Communication Architectures* Umit Y. Ogras,Radu Marculescu,2013-03-12 Traditionally design space exploration for Systems on Chip SoCs has focused on the computational aspects of the problem at hand However as the number of components on a single chip and their performance continue to increase the communication architecture plays a major role in the area performance and energy consumption of the overall system As a result a shift from computation based to communication based design becomes mandatory Towards this end network on chip NoC communication architectures have emerged recently as a promising alternative to classical bus and point to point communication architectures In this dissertation we study outstanding research problems related to modeling analysis and optimization of NoC communication architectures More precisely we present novel design methodologies software tools and FPGA prototypes to aid the design of application specific NoCs **Three-Dimensional Integrated**

**Circuit Design** Yuan Xie,Jingsheng Jason Cong,Sachin Sapatnekar,2009-12-02 We live in a time of great change In the electronics world the last several decades have seen unprecedented growth and advancement described by Moore s law This observation stated that transistor density in integrated circuits doubles every 1 5 2 years This came with the simultaneous improvement of individual device performance as well as the reduction of device power such that the total power of the resulting ICs remained under control No trend remains constant forever and this is unfortunately the case with Moore s law The trouble began a number of years ago when CMOS devices were no longer able to proceed along the classical scaling trends Key device parameters such as gate oxide thickness were simply no longer able to scale As a result device static currents began to creep up at an alarming rate These continuing problems with classical scaling have led to a leveling off of IC clock speeds to the range of several GHz Of course chips can be clocked higher but the thermal issues become unmanageable This has led to the recent trend toward microprocessors with multiple cores each running at a few GHz at the most The goal is to continue improving performance via parallelism by adding more and more cores instead of increasing speed The challenge here is to ensure that general purpose codes can be efficiently parallelized There is another potential solution to the problem of how to improve CMOS technology performance three dimensional integrated circuits 3D ICs

*Asynchronous On-Chip Networks and Fault-Tolerant Techniques* Wei Song, Guangda Zhang, 2022-05-10 Asynchronous On Chip Networks and Fault Tolerant Techniques is the first comprehensive study of fault tolerance and fault caused deadlock effects in asynchronous on chip networks aiming to overcome these drawbacks and ensure greater reliability of applications As a promising alternative to the widely used synchronous on chip networks for multicore processors asynchronous on chip networks can be vulnerable to faults even if they can deliver the same performance with much lower energy and area compared with their synchronous counterparts faults can not only corrupt data transmission but also cause a unique type of deadlock By adopting a new redundant code along with a dynamic fault detection and recovery scheme the authors demonstrate that asynchronous on chip networks can be efficiently hardened to tolerate both transient and permanent faults and overcome fault caused deadlocks This book will serve as an essential guide for researchers and students studying interconnection networks fault tolerant computing asynchronous system design circuit design and on chip networking as well as for professionals interested in designing fault tolerant and high throughput asynchronous circuits Network and Parallel Computing Chen Ding, Zhiyuan Shao, Ran Zheng, 2010-09-10 This book constitutes the refereed proceedings of the IFIP International Conference NPC 2010 held in Zhengzhou China in September 2010 The 39 papers presented were carefully selected from 89 submissions The papers are organized in topical sections on Parallelization and Optimization Parallel Algorithms Network CPU and Multicore Cloud and Grid Infrastructure Network on Chip Network and Parallel Computing Ching-Hsien Hsu, Xiaoming Li, Xuanhua Shi, Ran Zheng, 2013-09-12 This book constitutes the proceedings of the 10th IFIP International Conference on Network and Parallel Computing NPC 2013 held in Guiyang China in September 2013 The 34 papers presented in this volume were carefully reviewed and selected from 109 submissions They are organized in topical sections named parallel programming and algorithms cloud resource management parallel architectures multi core computing and GPU and miscellaneous Designing Embedded Processors Jörg Henkel, Sri Parameswaran, 2007-07-27 As we embrace the world of personal portable and perplexingly complex digital systems it has befallen upon the bewildered designer to take advantage of the available transistors to produce a system which is small fast cheap and correct yet possesses increased functionality Increasingly these systems have to consume little energy Designers are increasingly turning towards small processors which are low power and customize these processors both in software and hardware to achieve their objectives of a low power system which is verified and has short design turnaround times Designing Embedded Processors examines the many ways in which processor based systems are designed to allow low power devices It looks at processor design methods memory optimization dynamic voltage scaling methods compiler methods and multi processor methods Each section has an introductory chapter to give a breadth view and have a few specialist chapters in the area to give a deeper perspective The book provides a good starting point to engineers in the area and to research students embarking upon the exciting area of embedded systems and architectures



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