

Division of Computer Engineering

Adaptive Systems Laboratory



Ben Abdallah Abder-
azek
Professor



Yuichi Okuyama
Associate Professor

Refereed academic journal

- [benab-203-037-01:2017] A. Ben Abdallah Achraf Ben Ahmed. Architecture and Design of Real-Time Systems for Elderly Health Monitoring. *Journal of Embedded Systems*, 9(5):484–494, 2017.
- .
- [benab-203-037-02:2017] Abderazek Ben Abdallah Michael Meyer, Yuichi Okuyama. Microring fault-resilient photonic network-on-chip for reliable high-performance many-core systems. *The Journal of Supercomputing*, 73(4):1567–1599, 2017.
- .
- [benab-203-037-03:2017] Yuichi Okuyama-Abderazek Ben Abdallah Khanh N. Dang, Michael Meyer. A Low-overhead Soft-Hard Fault Tolerant Architecture, Design, and Management Scheme for Reliable High-performance Many-core 3D-NoC Systems. *Journal of Supercomputing*, 73(6):2705–2729, 2017.
- .
- [benab-203-037-04:2017] Xuan-Tu Tran Yuichi Okuyama Abderazek Ben Abdallah Khanh N. Dang, Akram Ben Ahmed. A Comprehensive Reliability Assessment of Fault-Resilient Network-on-Chip Using Analytical Mode. *IEEE Transactions on Very Large Scale Integration (VLSI) Systems*, 25(11):3099–3112, 11 2017.
- .
- [benab-203-037-05:2017] Abderazek Ben Abdallah Achraf Ben Ahmed, Tsutomu Yoshinaga. Scalable Photonic Networks-on-Chip Architecture Based on a Novel Wavelength-Shifting Mechanism. *IEEE Transactions on Emerging Topics in Computing*, 2017.
in press
- [benab-203-037-06:2017] Yuichi Okuyama Khanh N. Dang, Akram Ben Ahmed and Abderazek Ben Abdallah. Scalable Design Methodology and Online Algorithm for TSV-cluster Defects Recovery in Highly Reliable 3D-NoC Systems. *IEEE Transactions on Emerging Topics in Computing*, 2017.
in press

Summary of Achievement

[benab-203-037-07:2017] Abderazek Ben Abdallah Michael Meyer, Yuichi Okuyama. SAFT-PHENIC: a thermal-aware microring fault-resilient photonic NoC. *The Journal of Supercomputing*, 9, 2018.

in press

[okuyama-203-037-01:2017] Yuichi Okuyama Khanh N. Dang, Akram Ben Ahmed and Abderazek Ben Abdallah. Scalable Design Methodology and Online Algorithm for TSV-cluster Defects Recovery in Highly Reliable 3D-NoC Systems. *IEEE Transactions on Emerging Topics in Computing*, 2017.

3D-Network-on-Chips exploit the benefits of Network-on-Chips and 3D-Integrated Circuits allowing them to be considered as one of the most advanced and auspicious communication methodologies. On the other hand, the reliability of 3D-NoCs, due to the vulnerability of Through Silicon Vias, still remains as a major problem. Most of the existing techniques rely on correcting the TSV defects by using redundancies or employing routing algorithms. Nevertheless, they are not suitable for TSV-cluster defects as they can either lead to costly area and power consumption overheads or they may result in non-minimal routing paths; thus, posing serious threats to the system reliability and overall performance. In this work, we present a scalable and low-overhead TSV usage and design method for 3D-NoC systems where the TSVs of a router can be utilized by its neighbors to deal with the cluster open defects. An adaptive online algorithm is also introduced to assist the proposed system to immediately work around the newly detected defects without using redundancies. The experimental results show the proposal ensure less than 2% of the routers being disabled, even with 50% of the TSV clusters defects. The performance evaluations also demonstrate unchanged performances for real applications under 5% of cluster defects.

[okuyama-203-037-02:2017] Xuan-Tu Tran Yuichi Okuyama Abderazek Ben Abdallah Khanh N. Dang, Akram Ben Ahmed. A Comprehensive Reliability Assessment of Fault-Resilient Network-on-Chip Using Analytical Model. *IEEE Transactions on Very Large Scale Integration (VLSI) Systems*, 25(11):3099 – 3112, Nov. 2017.

3D-Network-on-Chips (3D-NoCs) are considered as one of the most advanced and auspicious communication methodologies for future IC designs by exploiting the benefits of Network-on-Chips (NoCs) and 3D-Integrated Circuits (3D-ICs). However, their reliability still remains a major problem due to the

vulnerability of Through Silicon Vias (TSVs). Because most of the existing techniques rely on correcting the TSV defects by using redundancy or employing routing algorithms, the TSV-cluster defect tolerances encounter costly area and power consumption penalties. In order to solve this issue, we propose a highly scalable and low-overhead TSV management for 3D-NoC systems where the TSVs of a router can be utilized by its neighbors and an adaptive online algorithm is also performed to assist. With this proposal, we aim to maintain a graceful performance for 3D-NoCs without the need for redundant links or employing routing algorithms.

[okuyama-203-037-03:2017] Abderazek Ben Abdallah Michael Meyer, Yuichi Okuyama. Microring Fault-resilient Photonic Network-on-Chip for Reliable High-performance Many-core Systems. *Journal of Supercomputing*, 73(4):1567–1599, April 2017.

Photonic networks-on-chip (PNoCs) have emerged as a promising alternative to the conventional metal-based networks-on-chip due to their advantages in bandwidth density, power efficiency and propagation speed. Existing works on PNoCs concentrate on architectures of photonic networks with the assumption that the underlying photonic infrastructure operates correctly and reliably. However, the key optical device in PNoC systems, microring resonators (MRs), is very sensitive to temperature fluctuation and manufacturing errors. A single MR failure can cause messages to be misdelivered or lost, which results in bandwidth loss or even complete failure of the whole system. In this paper, we present a fault-tolerant Photonic Network-on-Chip architecture, named FT-PHENIC, which uses minimal redundancy to ensure accuracy of packet transmission even after faulty microring resonators (MRs) are detected. FT-PHENIC is based on a microring fault-resilient photonic router (FTTDOR) and an adaptive path-configuration and routing algorithm. Simulation results show that FT-PHENIC tolerates MR faults quite well up until around when 20 % of the MRs have failed, and has minimal bandwidth degradation and power drawbacks.

[okuyama-203-037-04:2017] Yuichi Okuyama-Abderazek Ben Abdallah Khanh N. Dang, Michael Meyer. A Low-overhead Soft-Hard Fault Tolerant Architecture, Design, and Management Scheme for Reliable High-performance Many-core 3D-NoC Systems. *Journal of Supercomputing*, 73(6):2705 – 2729, 2017.

The Network-on-Chip (NoC) paradigm has been proposed as a favorable solution to handle the strict communication requirements between the increas-

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ingly large number of cores on a single chip. However, NoC systems are exposed to the aggressive scaling down of transistors, low operating voltages, and high integration and power densities, making them vulnerable to permanent (hard) faults and transient (soft) errors. A hard fault in a NoC can lead to external blocking, causing congestion across the whole network. A soft error is more challenging because of its silent data corruption, which leads to a large area of erroneous data due to error propagation, packet re-transmission, and deadlock. In this paper, we present the architecture and design of a comprehensive soft error and hard fault-tolerant 3D-NoC system, named 3D-Hard-Fault-Soft-Error-Tolerant-OASIS-NoC (3D-FETO). With the aid of efficient mechanisms and algorithms, 3D-FETO is capable of detecting and recovering from soft errors which occur in the routing pipeline stages and leverages reconfigurable components to handle permanent faults in links, input buffers, and crossbars. In-depth evaluation results show that the 3D-FETO system is able to work around different kinds of hard faults and soft errors, ensuring graceful performance degradation, while minimizing additional hardware complexity and remaining power efficient.

Refereed proceedings of an academic conference

[benab-203-037-08:2017] Yuichi Okuyama Abderazek Ben Abdallah, Khanh N. Dang. A Low-overhead Fault tolerant Technique for TSV-based Interconnects in 3D-IC Systems. In *The 18th International Conference on Sciences and Techniques of Automatic control and computer engineering, December 21-23, 2017*. IEEE, 12 2017.

[benab-203-037-09:2017] Yuichi Okuyama Abderazek Ben Abdallah The H. Vu, Ryunosuke Murakami. Efficient Optimization and Hardware Acceleration of CNNs towards the Design of a Scalable Neuro-inspired Architecture in Hardware. In *Proc. of the IEEE International Conference on Big Data and Smart Computing, January 15-18, 2018, Shanghai, China.*, pages 326–332. IEEE, 2018.

[okuyama-203-037-05:2017] Yuichi Okuyama Abderazek Ben Abdallah, Khanh N. Dang. A Low-overhead Fault tolerant Technique for TSV-based Interconnects in 3D-IC Systems. In *The 18th International Conference on*

Sciences and Techniques of Automatic control and computer engineering (STA 2017), 2017.

3D-Network-on-Chips (3D-NoCs) are considered as one of the most advanced and auspicious communication methodologies for future IC designs by exploiting the benefits of Network-on-Chips (NoCs) and 3D-Integrated Circuits (3D-ICs). However, their reliability still remains a major problem due to the vulnerability of Through Silicon Vias (TSVs). Because most of the existing techniques rely on correcting the TSV defects by using redundancy or employing routing algorithms, the TSV-cluster defect tolerances encounter costly area and power consumption penalties. In order to solve this issue, we propose a highly scalable and low-overhead TSV management for 3D-NoC systems where the TSVs of a router can be utilized by its neighbors and an adaptive online algorithm is also performed to assist. With this proposal, we aim to maintain a graceful performance for 3DNoCs without the need for redundant links or employing routing algorithms.

[okuyama-203-037-06:2017] Yusuke Sato Ye Chan Nam Khanh Dang Ben Abdellash Abderazek Shunsuke Mie, Yuichi Okuyama. Real-Time UAV Attitude Heading Reference System Using Extended Kalman Filter for Programmable SoC. In *2017 IEEE 11th International Symposium on Embedded Multicore/Many-core Systems-on-Chip (MCSoc)*, 2017.

We implemented an extended Kalman filter (EKF) hardware for a real-time attitude heading reference system (AHRS). Attitude estimation is an important process for small unmanned aerial vehicle (UAV) control. Small UAVs mounts smaller sensors due to the limitation of space and power. However, effects of noise components in sensor output become large if the size of sensors become smaller. We considered using EKF to reduce effects of noises by sensor fusion. Moreover, real-time and highly accurate attitude estimation is required for an autonomous flight of UAVs. To reduce loads of processors in a real-time calculation of EKF, we implemented a circuit of EKF by C-based hardware design in Programmable SoC. We achieved five times faster EKF processing on FPGA than the processing on ARM Cortex-A9 @677Hz with single core processing.

[okuyama-203-037-07:2017] Yusuke Sato Ye Chan Nam Khanh Dang Ben Abdellash Abderazek Shunsuke Mie, Yuichi Okuyama. Real-Time UAV Attitude Heading Reference System Using Extended Kalman Filter for Programmable SoC. In *2017 IEEE 11th International Symposium on Embedded Multicore/Many-core Systems-on-Chip (MCSoc)*, 2017.

Summary of Achievement

We implemented an extended Kalman filter (EKF) hardware for a real-time attitude heading reference system (AHRS). Attitude estimation is an important process for small unmanned aerial vehicle (UAV) control. Small UAVs mounts smaller sensors due to the limitation of space and power. However, effects of noise components in sensor output become large if the size of sensors become smaller. We considered using EKF to reduce effects of noises by sensor fusion. Moreover, real-time and highly accurate attitude estimation is required for an autonomous flight of UAVs. To reduce loads of processors in a real-time calculation of EKF, we implemented a circuit of EKF by C-based hardware design in Programmable SoC. We achieved five times faster EKF processing on FPGA than the processing on ARM Cortex-A9 @677Hz with single core processing.

[okuyama-203-037-08:2017] Yuichi Okuyama Abderazek Ben Abdallah The H. Vu, Ryunosuke Murakami. Efficient Optimization and Hardware Acceleration of CNNs towards the Design of a Scalable Neuro-inspired Architecture in Hardware. In *Proc. of the IEEE International Conference on Big Data and Smart Computing (BigComp-2018)*, pages 326 – 332, Jan. 2018.

Convolution Neural Networks (CNNs) are responsible for the major discoveries in image classification and they are considered as the core of most current computer vision systems. In the implementation of deep CNN, Field-Programmable Gate Arrays (FPGAs) offer a promising paradigm towards major leaps in computational performance while achieving high-energy efficiency. Although current CNN accelerations on FPGA have demonstrated good performance, one major issue is that previously proposed implementation do not achieve a good balance between latency, precision, and hardware complexity. In order to overcome this problem, this paper proposes a highly optimized FPGA implementation of a CNN, named NASH-CNN (Neuro-inspired Architectures in Hardware for CNN). An application for handwritten digit recognition, based on MNIST dataset, is evaluated. The experiment shows that our implementation achieves better performance/accuracy/complexity balance when compared to previously proposed schemes.

Unrefereed proceedings of an academic conference

[benab-203-037-10:2017] Abderazek Ben Abdallah Kanta Suzuki, Yuichi Okuyama. Hardware Design of a Leaky Integrate and Fire Neuron Core Towards the Design of a Low-power Neuro-inspired

Spike-based Multicore SoC. In *Information Processing Society Tohoku Branch Conference*, 2 2018.

[benab-203-037-11:2017] Abderazek Ben Abdallah Yuji Murakami, Yuichi Okuyama. SRAM Based Neural Network System for Traffic-Light Recognition in Autonomous Vehicles. In *Information Processing Society Tohoku Branch Conference, Feb. 10, 2018*, 2 2018.

[benab-203-037-12:2017] Abderazek Ben Abdallah Ryunosuke Murakami, Yuichi Okuyama. Animal Recognition and Identification with Deep Convolutional Neural. In *Information Processing Society Tohoku Branch Conference, Feb. 10, 2018*, 2 2018.

[okuyama-203-037-09:2017] Yuichi Okuyama Maiko Arakawa and Ben Abdallah Abderazek. Vision-based UAV attitude estimation on Programmable SoC. In *The 43rd PARTHENON technical society workshop*, , December 2017.

For autonomous flight of UAVs, attitude estimation using images from camera is developed. In this research, we proposed vision-based real-time attitude estimation system using FPGA. We applied morphological smoothing for detecting noise and sobel filter for detecting edge. We get the horizon using Hough Transform. We calculate attitude of UAVs from shape of the horizon. However we cannot implement real-time system, we expect to improve it by accessing memory efficiency.

[okuyama-203-037-10:2017] Ben Abdallah Abderazek Yohei Shimmyo, Yuichi Okuyama. Scoring Support System for Assignments of Logical Circuit Design Course. In *The 43rd PARTHENON technical society workshop*, December 2017.

A competitive programming is a competition that participants compete to see who can solve the greatest number of programming tasks whose answers can be specified uniquely in an online judge server. We focus on the online judge system and apply it to the education of logical circuit design. In this study, we propose a system that receives a HDL source code, conducts a simulation of the circuit using the corresponding testbench and determine whether the submitted circuit is correct or not. This system is effective in saving grading time. The effectiveness increases learners' ' motivations and causes increase in the number of new learners. We develop an online judge that judges HDL script conducting simulation and evaluate its effectiveness

Summary of Achievement

[okuyama-203-037-11:2017] Abderazek Ben Abdallah Yuji Murakami, Yuichi Okuyama. RAM Based Neural Network System for Traffic-Light Recognition in Autonomous Vehicles. In *Information Processing Society Tohoku Branch Conference*, Feb. 2018.

[okuyama-203-037-12:2017] Abderazek Ben Abdallah Kanta Suzuki, Yuichi Okuyama. Hardware Design of a Leaky Integrate and Fire Neuron Core Towards the Design of a Low-power Neuro-inspired Spike-based Multicore SoC. In *Information Processing Society Tohoku Branch Conference*, Feb. 2018.

Writing a textbook or technical book

[benab-203-037-13:2017] Abderazek Ben Abdallah. *Advanced Multicore Systems On-Chip: Architecture, On-Chip Network, Design, 1s ed.* Number ISBN-13: 978-9811060915, ISBN-10: 98110609162017. Springer, 2017.

Writing a part of textbook or technical book

[benab-203-037-14:2017] Abderazek Ben Abdallah Khanh N. Dang. *Architecture and Design Methodology for Highly-Reliable TSV-NoC Systems*, chapter Architecture and Design Methodology for Highly-Reliable TSV-NoC Systems. Number ISBN: 978-1-53613-327-12018. Nova Science Publishers, 2018.

Research grants from scientific research funds and public organizations

[benab-203-037-15:2017] Abderazek Ben Abdallah. Development of an Energy-efficient Heterogeneous Spiking Neuro-inspired System for Deep Neural Networks, 2017.

[okuyama-203-037-13:2017] Yuichi Okuyama. Evaluation of an Extension Board Development for Embedded GPU, 505,120JPY, 2017.

Academic society activities

[benab-203-037-16:2017] Abderazek Ben Abdallah, 2017.

Senior Member of IEEE

[benab-203-037-17:2017] Abderazek Ben Abdallah, 2017 2017.

Senior member of ACM

[benab-203-037-18:2017] Abderazek Ben Abdallah, 9 2017.

Steering Committee member and chair of the IEEE 11th International Symposium on Embedded Multicore/Many-core Systems-on-Chip (MCSoc-17) Korea University, Seoul, Korea, September 18-20, 2017 <http://mcsocforum.org/2017/>

[okuyama-203-037-14:2017] Yuichi Okuyama, 2017.

Comittee member

[okuyama-203-037-15:2017] Yuichi Okuyama, 2017.

Committee member

Patent

[benab-203-037-19:2017] Abderazek Ben Abdallah. A fault-tolerant router, an IC having the same, and a method for controlling the fault tolerant router, 2018.

[benab-203-037-20:2017] Masayuki Hisada Abderazek Ben Abdallah, Khanh N. Dang. A TSV fault-tolerant router system for 3D-Networks-on-Chip, 2017.

Advisor for undergraduate research and graduate research

[benab-203-037-21:2017] Nam Khanh Dang. Phd thesis, Graduate School of Computer Science and Engineering, University of Aizu, 9 2017.

[benab-203-037-22:2017] Masaki Yamada. B.s. thesis, CSE, 3 2017.

Summary of Achievement

[benab-203-037-23:2017] Kanta Suzuki. B.s. thesis, UoA, CSE, 3 2017.

[benab-203-037-24:2017] Kosuke Takakuwa. B.s. thesis, CSE, UoA, 3 2017.

Others

[benab-203-037-25:2017] Abderazek Ben Abdallah. Neuro-Inspired Adaptive Manycore SoCs and Applications. Keynote Speech, International Conference on Control, Automation and Robotics, April 22-24, 2017, Nagoya, Japan., 4 2017.

[benab-203-037-26:2017] Abderazek Ben Abdallah. Neuro-inspired Computing Systems and Applications. Keynote Speech, 2018 International Conference on Intelligent Autonomous Systems, March 1-3, 2018, Singapore, 2018.

[benab-203-037-27:2017] Abderazek Ben Abdallah. External reviewer for The Austrian Science Fund (FWF), Austria, 4/2018. External reviewer for The Austrian Science Fund (FWF), Austria, 4/2018, 4 2018.

External reviewer for The Austrian Science Fund (FWF), Austria, 4/2018

[benab-203-037-28:2017] Abderazek Ben Abdallah. External Ph.D. examiner, University of Otago, New Zealand, 2017.

External Ph.D. examiner, University of Otago, New Zealand, 2017

Advisor of a student club or circle

[okuyama-203-037-16:2017] Motorcycle club

Other significant contribution toward university planning, management, or administration

[okuyama-203-037-17:2017] PC-Koshien, preparation of problems.

**Did you participate in Public Lectures, and/or Open Campus?
(Yes or No) If yes, please describe what you did.**

[benab-203-037-29:2017] Abderazek Ben Abdallah, Neuro-inspired Computing Systems and Applications, Keynote Speech, 2018 International Conference on Intelligent Autonomous Systems (ICoIAS 2018), Singapore, March 1-3, 2018 Abderazek Ben Abdallah, Neuro-Inspired Adaptive Manycore SoCs and Applications, Keynote Speech, International Conference on Control, Automation and Robotics, Nagoya, April 22-24, 2017. Abderazek Ben Abdallah, Developing a Mindset for Innovation and Entrepreneurship, 1st ACM Chapter Networking Seminar on Globalization and Innovative Thinking, 2017/11/26, University of Aizu

[benab-203-037-30:2017] Abderazek Ben Abdallah, Neuro-inspired Computing Systems and Applications, Keynote Speech, 2018 International Conference on Intelligent Autonomous Systems (ICoIAS 2018), Singapore, March 1-3, 2018 Abderazek Ben Abdallah, Neuro-Inspired Adaptive Manycore SoCs and Applications, Keynote Speech, International Conference on Control, Automation and Robotics, Nagoya, April 22-24, 2017. Abderazek Ben Abdallah, Developing a Mindset for Innovation and Entrepreneurship, 1st ACM Chapter Networking Seminar on Globalization and Innovative Thinking, 2017/11/26, University of Aizu