Computer Organization Laboratory

Toshiaki Miyazaki
Professor

Hiroshi Saito
Senior Associate Professor

Peng Li
Associate Professor

Apidet Booranawong
Visiting Researcher

The following researches are progressed in Computer Organization Laboratory:
Toshiaki Miyazaki: has mainly three topics as follows:

- *Die-hard sensor network:* A wireless sensor network that has an autonomous function alternation mechanism among sensor nodes as well as ordinary wireless sensor network capabilities such as automatic network establishment. With this mechanism, we can realized self-organized and maintenance-free sensor network systems. Its applications include surveillance of disaster-hit region, and river and forest monitoring. We are developing not only sensor-node hardware but also protocols equipped to the sensor node.

- *Demand-addressable sensor network:* The aim of this research project is to construct a wide-area sensor network that interprets users' abstract sensing demands. The network then finds the sensors that hold the data which satisfies the demand, mashes up the collected data within the network along with useful information from other systems, and finally enables the user' s terminal to display it in real time. The sensor network itself has an environmental adaptability that allows each sensor node to consider its surroundings and the user-issued requests, and which will then dynamically change its role to actively acquire the desired sensing data autonomously.

- *Custom computing:* A research field to realize a dedicated hardware using programmable logic devices such as FPGAs (Field Programmable Gate Arrays) in order to solve a give problem effectively. We focused on realizing a hardware sorter that performs high-speed sorting of huge amount of data.

Hiroshi Saito:

Our research interests are design automation of asynchronous circuits, design automation of multi/many core systems, and applications of sensor networks.

- Asynchronous circuits are circuits where circuit components are controlled by pairs of local handshake signals instead of a global clock signal. Because of the absence of a global clock signal, asynchronous circuits are low power and low electromagnetic interference compared to synchronous counter parts which use global clock signals. We are developing design support environment to implement asynchronous circuits on Application Specific Integrated Circuits (ASICs) and Field Programmable Gate Arrays (FPGAs), developing a transformation tool from a synchronous register transfer level (RTL) model to an asynchronous RTL model, and designing a low power asynchronous processor.

- Due to the advance of integration technology, current embedded systems consist of multi/many processing cores. This makes possible parallel execution of multiple applications. However, it makes embedded system design complex. To make system-level design easy, we are developing a design support environment for multi/many core systems. In addition, we research on a design technique to reliable multi/many core systems.

- With the advance of sensors and communication modules, the era of Internet-of-Things (IoTs) is reached. In wireless sensor networks, sensor nodes are required to be driven by a battery. To extend the life time of nodes, it is required to realize low power sensor nodes. Therefore, we develop a low power sensor node to be used in wireless sensor networks.

Peng Li:

My research interests mainly focus on wireless communication and networking, specifically wireless sensor networks green and energy-efficient mobile networks and cross-layer optimization for wireless networks. I also have interests on cloud computing, big data processing and smart grid. These topics are studied from two aspects. First, new techniques and approaches will be proposed to enhance network system performance. Prototypes are developed to evaluate their feasibility. Second, new algorithms will be designed and evaluated using advanced theoretical methods, like convex optimization, stochastic optimization, game and auction theories.

Refereed academic journal

[hiroshis-201-031-01:2016] M. Imai H. Saito and T. Yoneda. Task Scheduling Based Redundant Task Allocation Method for the Multi-Core Systems with the DTTR Scheme. *IEICE TRANSACTIONS on Fundamentals of Electronics, Communications and Computer Sciences*, Vol.E100-A(No.7):1363–1373, 2017.

In this paper, we propose a redundant task allocation method for multi-core systems based on the Duplication with Temporary Triple-Modular Redundancy and Reconfiguration (DTTR) scheme.

[hiroshis-201-031-02:2016] N. Jindapetch A. Booranawong and H. Saito. A System for Detection and Tracking of Human Movements Using RSSI Signals. *IEEE Sensors Journal*, Volume:18(Issue:6):2531–2544, 2018.

A device-free human detection and tracking system using a received signal strength indicator (RSSI) for an indoor environment is presented in this paper.

[miyazaki-201-031-01:2016] T. Miyazaki, N. Suematsu, D. Baba, S. Guo P. Li, J. Kitamichi, T. Hayashi, and T. Tsukahara. Demand-Addressable Sensor Network: Toward Large-Scale Active Information Acquisition. *IEEE Sensors Journal*, 16(20):7421–7432, 2016.

A new type of sensor network called the demand-addressable sensor network (DASN) is proposed in this paper. The DASN actively acquires the desired information by addressing user demands and delivers the information to appropriate destinations. This is in contrast to the conventional sensor networks that simply send sensed data to users. The DASN is useful for finding the desired information in a short duration of time from a large amount of sensed data generated by a large-scale sensor network. The DASN is constructed with a demand-addressable network that integrates many on-demand reconfigurable wireless sensor networks (ODRWSN) and other existing information and communications technology systems or services, such as Google Maps and Twitter. In addition to the demand-addressing mechanism, the demand-addressable network has an in-network data combining or mashup mechanism. The mashed up data are displayed on the user terminal using an ordinary Web browser without any requirement to install a dedicated application program. The functions of the ODRWSN can be dynamically customized by injecting roles specified by the user. Thus, the user can actively get the

desired information by customizing the sensor network function. The main application of the DASN is wide-area disaster site monitoring, for which the DASN features outlined above are suitable. In this paper, the concept underlying the DASN, its architecture and implementation, and experimental results are presented.

[miyazaki-201-031-02:2016] K. Wang, T. Miyazaki, S. Guo, and Y. Sun. Anti-Eavesdropping with Selfish Jamming in Wireless Networks: A Bertrand Game Approach. *IEEE Transactions on Vehicular Technology*, PP(99), 2016.

Wireless communications are vulnerable to eavesdropping attacks due to their broadcast nature. To deal with their emerging challenge of physical layer security, in this paper, we study the anti-eavesdropping problem in the presence of selfish jammers, who desire to achieve the maximum profit of themselves. We consider both the single-channel multi-jammer (SCMJ) model and the multi-channel single-jammer (MCSJ) model. We investigate the interaction between the source that transmits secret information and friendly jammer nodes who assist the source by interfering the eavesdropper. This problem is formulated as an oligopoly market consisting of a few firms and a buyer. By modeling the problem as a Bertrand game based on price competition, we obtain the optimal pricing scheme for the friendly while selfish jammers such that the utility of those jammers is maximized. For the SCMJ model, we prove the existence of Bertrand Equilibrium (BE) by deriving a closed-form expression for the optimal price strategy. For the MCSJ model, a closed-form expression for power allocation is derived, based on which a new algorithm is designed to obtain the optimal strategy of jammer. Finally, via simulations, we verify our theoretical analysis.

[pengli-201-031-01:2016] Song Guo 14. Peng Li and Ivan Stojmenovic. A Truthful Double Auction for Device-to-Device Communications in Cellular Networks. *IEEE Journal on Selected Areas in Communications (JSAC)*, 34(1), Jan. 2016.

In this paper, we propose a truthful double auction for D2D communications (TAD) in multi-cell cellular networks for trading resources in frequency-time domain, where cellular users with D2D communication capability act as sellers, and other users waiting to access the network act as buyers. Both intra-cell and inter-cell D2D sellers are accommodated in TAD while the competitive space in each cell is extensively exploited to achieve a high auction efficiency. With a sophisticated seller-buyer matching, winner determi-

nation and pricing, TAD guarantees individual rationality, budget balance, and truthfulness. Furthermore, we extend our TAD design to handle a more general case that each seller and buyer ask/bid multiple resource units. Extensive simulation results show that TAD can achieve truthfulness as well as high performance in terms of seller/buyer sanctification ratio, auctioneer profit and network throughput.

[pengli-201-031-02:2016] Song Guo 13. Huan Ke, Peng Li and Minyi Guo. On Traffic-Aware Partition and Aggregation in MapReduce for Big Data Applications. *IEEE Transactions on Parallel and Distributed Systems (TPDS)*, 27(3):818–828, March 2016.

In this paper, we study to reduce network traffic cost for a MapReduce job by designing a novel intermediate data partition scheme. Furthermore, we jointly consider the aggregator placement problem, where each aggregator can reduce merged traffic from multiple map tasks. A decomposition-based distributed algorithm is proposed to deal with the large-scale optimization problem for big data application and an online algorithm is also designed to adjust data partition and aggregation in a dynamic manner. Finally, extensive simulation results demonstrate that our proposals can significantly reduce network traffic cost under both offline and online cases.

[pengli-201-031-03:2016] D. Baba Peng Li Song Guo J. Kitamichi T. Hayashi Toshiaki Miyazaki, N. Suematsu and T. Tsukahara. Demand-addressable Sensor Network: toward Large-scale Active Information Acquisition. *IEEE Sensors Journal*, 16(20):7421–7432, Oct. 2016.

A new type of sensor network called the demand-addressable sensor network (DASN) is proposed in this paper. The DASN actively acquires the desired information by addressing user demands and delivers the information to appropriate destinations. This is in contrast to the conventional sensor networks that simply send sensed data to users. The DASN is useful for finding the desired information in a short duration of time from a large amount of sensed data generated by a large-scale sensor network.

[pengli-201-031-04:2016] Toshiaki Miyazaki Miao Xie Jiankun Hu Peng Li, Song Guo and Weihua Zhuang. Privacy-preserving Access to Big Data in the Cloud. *IEEE Cloud Computing*, 3(5):34–42, Sept. 2016.

Cloud storage can simplify data management and reduce data maintenance costs. However, many users and companies hesitate to move their data to cloud storage because of security and privacy concerns about third-party

cloud service providers. Oblivious RAM (ORAM) aims to enable privacy-preserving access to data stored in the cloud. This article offers a tutorial on ORAM and surveys recent literature. The authors also study the access load-balancing problem when applying ORAM to big data in the cloud. They propose heuristic algorithms to achieve access load balancing in both static and dynamic deployments.

Refereed proceedings of an academic conference

[miyazaki-201-031-03:2016] T. Hayashi, Y. Watanabe, A. Nakamura, A. Pham, T. Miyazaki, and T. Maeda. A Novel Binary Sequence Zero-Correlation Zone Set Having Suppressed Sub-Peaks and Its Application. In *SICE Annual Conference 2016*, page Fr1D.5, Sep. 2016.

The present paper introduces a novel class of binary sequence set that has a zero-correlation zone (ZCZ). For a ZCZ sequence set, the cross-correlation function and the side lobe of the autocorrelation function are zero for phase shifts within the zero-correlation zone. Binary sequences can be utilized with simple hardware, in comparison with M-ary sequences, real-value sequences, complex-number sequences. Binary sequences are easily applied for ultrasonic imaging. The proposed binary ZCZ sequence set can be generated from an arbitrary M-sequence and a Hadamard matrix of order 2 $ B & K (J. In actual applications), the peak of the correlation function for the phase outside the zero-correlation zone is important. The absolute value of the out-of-phase autocorrelation function of the proposed sequence of length $2\hat{}m + 5\lambda\ \hat{}2$ is less than $2\ \hat{}m + 4\lambda\ \hat{}2$. The applications of the proposed sequence set, including ultrasonic imaging and visible light communication are discussed.

[miyazaki-201-031-04:2016] Toshiaki Miyazaki, Kazuya Anazawa, Yusuke Igarashi, Peng Li, and Song Guo. Resilient Information Management System for Disaster Situations. In *IEEE ICOIN2017*, Jan. 2017.

In this paper, a resilient information management (RIM) system for a network isolated environment after disasters is proposed. Using this system, people can manage and share various types of information including medical information, damaged area and map information, and supply/demand information. A RIM system is realized on a locally and quickly established WiFi network environment. Thus, the RIM system can work even if the Internet and communication network infrastructures collapse. This study introduces the concept of RIM sys-

tem and its implementation-related issues followed by its current status and evaluations.

[miyazaki-201-031-05:2016] T.Miyazaki and N. Akiyama. Formal Approach to Produce Verified Programs for Wireless Sensor Nodes. In *IEEE 10th International Symposium on Communication Systems, Networks and Digital Signal Processing (CSNDSP2016)*, July 2016.

Wireless sensor networks consist of many sensor nodes and their behaviors are often programmable. However, it is hard to check the correctness of a new program for sensor nodes because each node works autonomously. In this paper, a new approach to develop stable programs for wireless sensor nodes is proposed. If the user specifies the sensor node behavior using a language named 'Funclet+', the behavior code is verified by using a formal verification tool. In addition, the code can be translated to a C program and installed on the target wireless sensor nodes directly. Thus, the user can easily develop verified programs for the wireless sensor nodes. After introducing the concept and system overview, its implementation and some experiment results using real sensor nodes are described.

[pengli-201-031-05:2016] Peng Li Qimeng Zang, Hsiang-Yu Chan and Song Guo. Software-defined Data Shuffling for Big Data Jobs with Task Duplication. In *45th International Conference on Parallel Processing Workshop (ICPPW)*, pages 403–407, 2016.

We propose a software-define data shuffling approach by designing a controller and a janitor module to control the data shuffling process. Each task has a janitor that communicates with the controller to request admission permit of sending intermediate results to next-stage tasks. We further propose an online grouping algorithm to reduce the overhead of frequent communication with the controller. The performance of the proposed algorithm is evaluated by extensive simulations.

[pengli-201-031-06:2016] Song Guo Peng Li, Toshiaki Miyazaki and Weihua Zhuang. Online Scheduling of Mobile Stations for Disaster Management. In *IEEE Global Communication Conference (GLOBECOM)*, 2016.

We propose an online algorithm that schedules mobile stations for disaster management tasks with weights in each time slot, without any knowledge of future task arrivals. Our objective is to maximize the total weight of finished tasks under constraints of maximum working capability of mobile stations. We

prove that the performance of proposed online algorithm is no worse than e-1/e of optimal solutions. Extensive simulations are conducted to evaluate our proposed algorithm.

[pengli-201-031-07:2016] Peng Li Huawei Huang and Song Guo. Traffic Scheduling for Deep Packet Inspection in Software Defined Networks. In *IEEE International Conference on Trust, Security and Privacy in Computing and Communication (TrustCom)*, 2016.

We study an integrated proxy allocation and routing determining problem with the objective of minimizing the total delay of flows from ingress switches to DPI proxies. This problem is formulated as an integer linear programming problem that is NP-hard in general. To solve this problem, we design a 2-phase algorithm that can quickly select proxy and find routing paths for incoming flows. Finally, extensive simulations are conducted to evaluate the performance of our proposed algorithm. Some useful parameter setting insights are obtained.

Unrefeered proceedings of an academic conference

[miyazaki-201-031-06:2016] A. Ikeda and T. Miyazaki. Formal Approach to Detecting Deadlocks in Wireless Sensor Networks. In *IPSJ 79th National Convention*, volume 1U-03, March 2017.

[miyazaki-201-031-07:2016] Q. Zang, P. Li, and T. Miyazaki. Uncontacted Indoor Localization Using RFID. In *IPSJ 79th National Convention*, volume 3U-02, March 2017.

[miyazaki-201-031-08:2016] Y. Watanabe, T. Okoshi, M. Ohta, and T. Miyazaki. Graph-based clustering method to extract contexts from heart-rate data. In *IPSJ 79th National Convention*, volume 4U-02, March 2017.

[miyazaki-201-031-09:2016] Y. Maruyama, K. Anazawa, and T. Miyazaki. Practical Localization Method for Seeking Victim$B!G Js Mobile Terminal. In *IPSJ 79th National Convention*, volume 4V-07, March 2017.

The student encouragement award

[miyazaki-201-031-10:2016] S. Adachi and T. Miyazaki. Time-Space Query Using Geohash for Distributed Database. In *IPSJ 79th National Convention*, volume 7T-08, March 2017.

The student encouragement award

[miyazaki-201-031-11:2016] K. Anazawa, P. Li, S. Guo, and T. Miyazaki. Information Management System Used in Network Isolated Environment. In *IEEE student session in 2016 Tohoku-Section Joint Convention of Institutes of Electrical and Information Engineers, Japan*, volume 1A12, Aug. 2016.

The best paper award

[miyazaki-201-031-12:2016] N. Akiyama, A. Ikeda, and T. Miyazaki. Deadlock-free Behavior Definition for Wireless Sensor Nodes Using Formal Verification. In *IEEE student session in 2016 Tohoku-Section Joint Convention of Institutes of Electrical and Information Engineers, Japan*, volume 2A08, Aug. 2016.

[miyazaki-201-031-13:2016] T. Miyazaki. Keynote Speech: Handling Big Data and Information in Disaster Scene. In *The Joint International Conference of Big Data Analytics in Health Informatics 2016 (BDAHI 2016) and the 13th International Conference on Ubiquitous Healthcare (u-Healthcare 2016)*, October 2016.

Research grants from scientific research funds and public organizations

[hiroshis-201-031-03:2016] H. Saito. Grant-in-Aid for Scientific Research (C), 2015-2017.

[miyazaki-201-031-14:2016] T. Miyazaki. Ministry of Education Scientific Research Fund, 2015–2017.

[miyazaki-201-031-15:2016] T. Miyazaki. Strategic Information and Communications R&D Promotion Programme (SCOPE), 2016—2018.

[miyazaki-201-031-16:2016] T. Miyazaki. Cross-ministerial Strategic Innovation Promotion Program (SIP), 2014–2018.

[pengli-201-031-08:2016] Peng Li. A Machine Learning based System for Storing and Processing Big Spatial-Temporal Data, funded by JSPS KAKENHI Grants-in-Aid for Young Scientific Research, 2016.

Academic society activities

[hiroshis-201-031-04:2016] H. Saito, 2017.

Steering Committee of IPSJ-SLDM

[hiroshis-201-031-05:2016] H. Saito, May 2017.

Technical Program Committee of ASYNC 2017

[hiroshis-201-031-06:2016] H. Saito, Sept. 2017.

Publicity Co-chair of MCSoC 2017

[hiroshis-201-031-07:2016] H. Saito, Sept. 2017.

Technical Program Committee of MCSoC 2017

[hiroshis-201-031-08:2016] H. Saito, Sept. 2017.

Technical Committee of FDL 2017

[hiroshis-201-031-09:2016] H. Saito, Mar. 2017.

Technical Committee of SASIMI 2017

[miyazaki-201-031-17:2016] T. Miyazaki, 2016.

Steering Committee Member, IEICE Technical Group for Function Integrated Information System (FIIS)

[miyazaki-201-031-18:2016] T. Miyazaki, 2016.

Steering Committee Member, MCSoC-16 (IEEE 10th International Symposium on Embedded Multicore Systems-on-Chip), Lyon France

[miyazaki-201-031-19:2016] T. Miyazaki, 2014 – present.

IEICE Senior Member

[miyazaki-201-031-20:2016] T. Miyazaki, 2014 – present.

IPSJ Senior Member

[miyazaki-201-031-21:2016] T. Miyazaki, 2012 – present.

IEEE Senior Member

Patent

[miyazaki-201-031-22:2016] T. Miyazaki. Sensor Network System and Data Handling Method in Sensor Network System (Registered JP5943476), Sep. 2016.

Advisor for undergraduate research and graduate research

[hiroshis-201-031-10:2016] T. Urakawa. HOG Feature-based Human Detection using Raspberry Pi and FPGA, University of Aizu, 2017.

Master thesis

[hiroshis-201-031-11:2016] J. Furushima. Design of Low Power Asynchronous MIPS Processors on FPGA, University of Aizu, 2017.

Master thesis

[hiroshis-201-031-12:2016] K. Yoshimi. Design and Evaluation of Asynchronous Circuits with Bundled-data Implementation for ASIC Implementation, University of Aizu, 2017.

Master thesis

[hiroshis-201-031-13:2016] R. Hiramoto. A Detection System for Bears using Raspberry Pi and Convolutional Neural Network, University of Aizu, 2017.

Graduation research

[hiroshis-201-031-14:2016] T. Kudo. Evaluation of Asynchronous Pipelined Controllers using FPGAs, University of Aizu, 2017.

Graduation research

[hiroshis-201-031-15:2016] S. Kunii. Implementation of a Reliable Multi-core System based on the DTTR Scheme on FPGA, University of Aizu, 2017.

Graduation research

[miyazaki-201-031-23:2016] Akihiro Ikeda. Graduation Thesis: Formal Approach to Deadlock-free Wireless Sensor Networks, University of Aizu, 2016.

Thesis Advisor: T. Miyazaki

[miyazaki-201-031-24:2016] Kouta Nakashima. Graduation Thesis: Cascadable FIFO-based Merge Sorter, University of Aizu, 2016.

Thesis Advisor: T. Miyazaki

[miyazaki-201-031-25:2016] Toshihiko Okoshi. Graduation Thesis: Long-term Context Extraction From Time-series Data, University of Aizu, 2016.

Thesis Advisor: T. Miyazaki

[miyazaki-201-031-26:2016] Yuta Watanabe. Master Thesis: A method adopting graph-based clustering to extract contexts from time-series data, University of Aizu, 2016.

Thesis Advisor: T. Miyazaki

Advisor of a student club or circle

[hiroshis-201-031-16:2016] Triathlon Club

Other significant contribution toward university planning, management, or administration

[hiroshis-201-031-17:2016] Member of Academic Affair Committee in the Undergraduate School

[hiroshis-201-031-18:2016] Member of Curriculum Working Group

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

[hiroshis-201-031-19:2016] Joining open campus on August and October

Research achievement that can be used for University-Industry collaboration and its characteristics.(for UBIC's information)

[hiroshis-201-031-20:2016] Electronic design automation tools for asynchronous circuits

[hiroshis-201-031-21:2016] Electronic design automation tools for reliable multi-core systems

[hiroshis-201-031-22:2016] A support system for snow removal using Arduino and sensor network