2019 4th International Conference on Cloud Computing and Internet of Things （CCIOT 2019）

September 20-22, 2019

Tokyo, Japan

Supported by

Indexed by

Welcome Message from Organizing Committee

It is our great pleasure to invite you to join our international conferences -2019 4th International Conference on Cloud Computing and Internet of Things (CCIOT 2019). This event will provide a unique opportunity for editors and authors to get together and share their latest research findings and results. We look forward to welcoming you at Tokyo, Japan.

We're confident that over the two days you'll get the theoretical grounding, practical knowledge, and personal contacts that will help you build long-term, profitable and sustainable communication among researchers and practitioners working in a wide variety of scientific areas with a common interest in Cloud Computing and Internet of Things.

On behalf of all the conference committees, we would like to thank all the authors as well as the technical program committee members and reviewers. Their high competence, their enthusiasm, their time and expertise knowledge, enabled us to prepare the high-quality final program and helped to make the conference become a successful event.

We truly hope you'll enjoy the conference and get what you expect from the conference.

Organizing Committee

2019.9.2

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Keynote Speakers Introductions

Keynote Speaker I

Prof. Yong Jin Park
University Malaysia Sabah, Malaysia

Prof. Yong Jin Park received B.E., M.E., and Ph.D. degrees in Electronic Engineering from Waseda University, Tokyo. From 1978 to 2010, he was a Professor at Hanyang University, Seoul. He was also a Professor of Waseda University, Tokyo, during 2010-2016. He joined University Malaysia Sabah in 2016, where he is now a Professor of Faculty of Computing and Informatics. In addition, he was a Visiting Associate Professor from 1983 to 1984 in the Department of Computer Science, University of Illinois, Urbana-Champaign, and a Research Fellow at the Computing Laboratory, University of Kent, England, from 1990 to 1991. He joined to deploy Research & Development Network in Korea from the early stage in 1980s. Furthermore, he was one of founding members of the Open Systems Interconnection Association, which promoted standardization activities of communication networks in Korea, and the President from 1991 to 1992. He was the Chairman of the IEEE Seoul Section from 1999 to 2000 and the President of the Korea Institute of Information Scientists and Engineers (KIISE) in 2003. As international academic activities, he was the Director of the Secretariat of the Asia Pacific Advanced Network (APAN) from 1999 to 2003 and the Director of IEEE Region 10 concurrently holding a member of IEEE Board of Directors from 2009 to 2010. He served successively various IEEE committees such as Nominations and Appointment Committee, Conference Committee, Public Visibility Committee, and Ethics & Member Conduct Committee, and is now a member of Life Member Committee, Service Award Committee, Theodore W. Hissey Outstanding Young Professional Award Committee member, and Teaching Award Committee in IEEE as well as IEEE Region 10 Nominations & Advisory Committee. Currently he is a Professor Emeritus of Hanyang University and IEICE fellow. His research interest is the area of Computer Networks, especially Future Internet Architectures.

Keynote Speaker II

Prof. Kuo-Hui Yeh
National Dong Hwa University, Taiwan

Kuo-Hui Yeh (SM'16) is a Professor with the Department of Information Management, National Dong Hwa University, Hualien, Taiwan. He received M.S. and Ph.D. degrees in Information Management from the National Taiwan University of Science and Technology, Taipei, Taiwan, in 2005 and 2010, respectively. Dr. Yeh has authored over 100 articles in international journals and conference proceedings. His research interests include IoT security, Blockchain, mobile security, NFC/RFID security, authentication, digital signature, data privacy and network security. Dr. Yeh is currently an associate/academic editor of IEEE Access, Journal of Internet Technology (JIT), Journal of Information Security and Applications (JISA), Security and Communication Networks (SCN) and Data in Brief (DIB), and has served as a guest editor for Future Generation Computer Systems (FGCS), IEEE Access, Mathematical Biosciences and Engineering (MBE), International Journal of Information Security (IJIS), JIT, Sensors and Cryptography. In addition, Dr. Yeh has participated in the organization committee of DSC 2018, SPCPS 2017, NSS 2016, RFIDsec'14 Asia and RFIDsec'12 Asia, and he has served as a TPC member of 30 international conferences/workshops on information security. He is a Senior Member of the IEEE.

Keynote Speaker III

Prof. Dimitrios Georgakopoulos
Swinburne University of Technology, Australia

Prof. Georgakopoulos is the Director of the IoT Lab at the Digital Innovation Platform of Swinburne University of Technology. Dimitrios came to Swinburne from his roles as Research Director at CSIRO's ICT Centre and Professor at RMIT. He is also currently the Industry 4.0 Program Leader at Swinburne's Manufacturing Futures Research Institute and a CSIRO Adjunct Fellow. Dimitrios has held research and management positions in several industrial labs in the USA, including Telcordia Technologies (where he helped found Telcordia's research laboratories in Austin, Texas and Poznan, Poland), Microelectronics and Computer Corporation, GTE (now Verizon) Laboratories, and Bell Communications Research. Dimitrios is an internationally known expert in IoT, process management, and data management. He has won more than twenty major research awards, produced 200 publications that have been cited 14,500+ times, and attracted significant external research funding ($42M+) from both industry and government in the USA, EU, and Australia.

Keynote Speaker IV

Prof. Latif Ladid
University of Luxembourg, Luxembourg

Founder & President, IPv6 FORUM (www.ipv6forum.org)
Member of 3GPP PCG (Board) (www.3gpp.org)
Founding Chair, 5G World Alliance (http://www.5gworldalliance.org/)
Chair, ETSI IPv6 Industry Specification Group : https://portal.etsi.org/tb.aspx?tbid=827&SubTB=827
IEEE Steering Committee Member: 5G, IoT
Chair, IEEE ComSoC IoT subcommittee
(http://cms.comsoc.org/eprise/main/SiteGen/TC_IOT/Content/Home.html/)
Chair, IEEE ComSoC 5G subcommittee
(http://cms.comsoc.org/eprise/main/SiteGen/TC_5GMWI/Content/Home.html?refer=18312&Site_Name=TC_5GMWI
Vice Chair, IEEE ComSoC SDN-NFV subcommittee:
http://cms.comsoc.org/eprise/main/SiteGen/TC_SDN_NFV/Content/Home.html
Emeritus Trustee, Internet Society - ISOC (www.isoc.org)
IPv6 Ready & Enabled Logos Program Board (www.ipv6ready.org)
World summit Award Board Member (www.wsis-award.org)
Research Fellow @ University of Luxembourg on multiple European Commission Next Generation Technologies IST Projects
Member of 3GPP2 PCG (www.3gpp2.org)
Member of UN Strategy Council
Member of Future Internet Forum EU Member States (representing Luxembourg) Luxembourg, June 2017

Conference Introductions

Welcome to 2019 CCIOT Tokyo conference. This conference is organized by ACM Chapter Singapore. The objective of the conference is to provide a platform for researchers, engineers, academicians as well as industrial professionals from all over the world to present their research results and development activities in Cloud Computing and Internet of Things.

Papers will be published in the following proceeding:

International Conference Proceedings Series by ACM (ISBN:978-1-4503-7241-1), which will be archived in the ACM Digital Library, and indexed by Ei Compendex, Scopus and submitted to be reviewed by Thomson Reuters Conference Proceedings Citation Index (ISI Web of Science).

Conference website and email: http://www.cciot.org and cciot.conference@gmail.com

Conference Venue

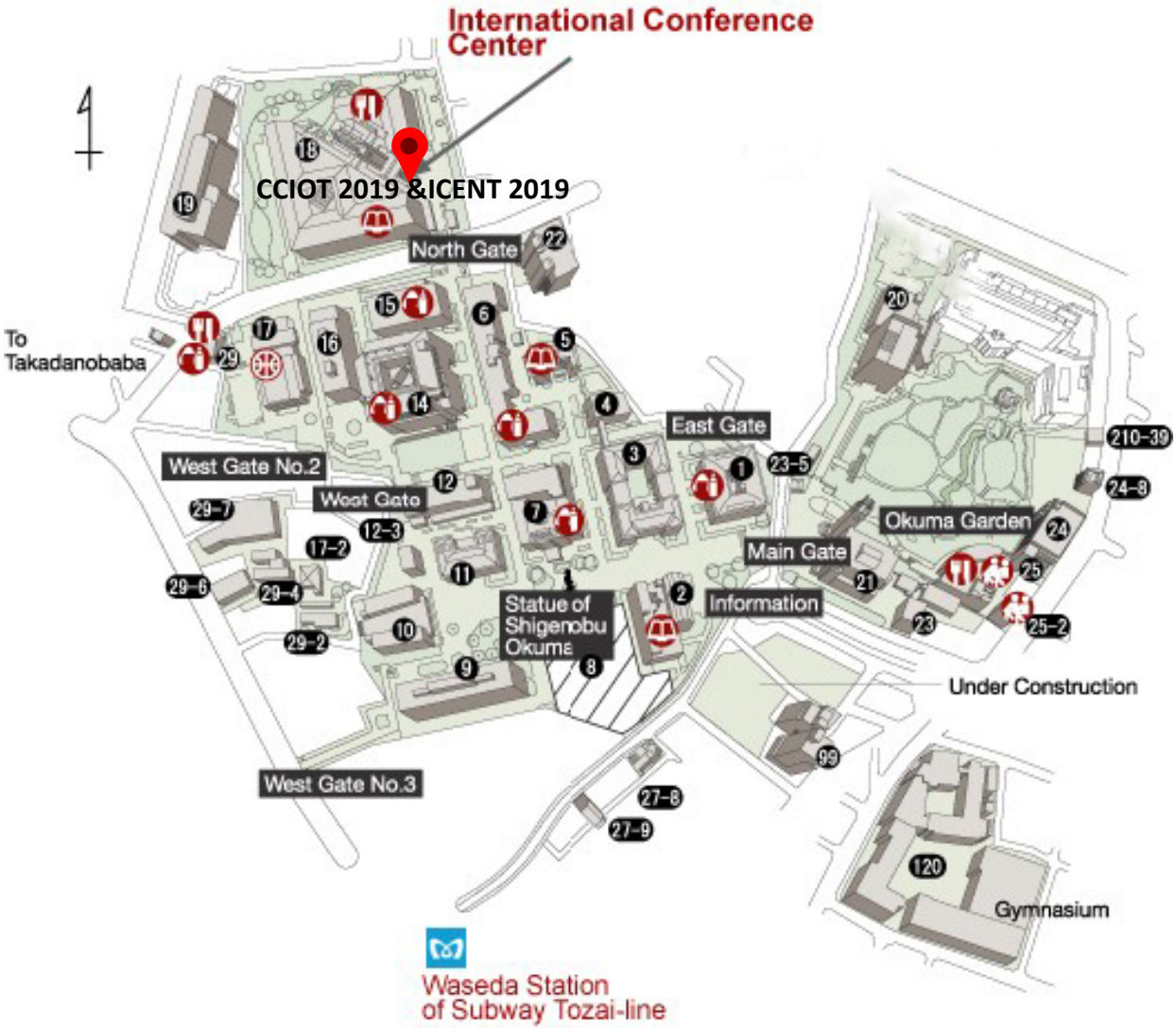
International Conference Center

Waseda University

Address: 1 Chome-20-14 Nishiwaseda, Shinjuku-ku, Tokyo-to 169-0051 Japan, located in the Central Library of WASEDA University

WASEDA University is a private, independent research univercity in central Tokyo. Since 1882 Waseda has tirelessly challenged convention, in favor of progress and innovation.

The conference will be held on Waseda University International Conference Center, which is located on the main campus of the University, near the Waseda station of Subway Tozai-line, or about 3 km northeast of Japan Railways (JR) Shinjuku Station. The JR Shinjuku Station is accessible by either trains or airport limousine buses from the New Tokyo International Airport (Narita) within 2 hours.


International Conference Center
CCIOT 2019 &ICENT 2019
North Gate
To Takadanobaba
West Gate No.2
West Gate
East Gate
Main Gate
Okuma Garden
Information
Statue of Shigenobu Okuma
Under Construction
West Gate No.3
Gymnasium
Waseda Station of Subway Tozai-line

Registration Guide

September 20, 2019 (Friday)

Time: 10:00-16:00

Venue: International Conference Center of Waseda University

Common Research Room 7 (on the Fourth Floor)

Registration Steps

1. Arrive at International Conference Center of Waseda University
2. Inform the conference staff of your paper ID;
3. Sign your name on the Participants list;
4. Sign your name on Lunch & Dinner requirement list;
5. Check your conference kits: (1 conference program, 1 lunch coupon, 1 dinner coupon, 1 receipt, 1 name card, 1 flash disk (papers collection), 1 laptop bag);

Finish registration.

Tips: Please arrive at the conference to upload or copy Slides (PPT) into the laptop room 10 minutes before the session begins.

Note:

(1) The organizer doesn't provide accommodation, and we suggest you make an early reservation.

(2) One Best Presentation will be selected from each presentation session, and the Certificate for Best Presentation will be awarded at the end of each session on September 21, 2019.

(3) One day tour includes lunch but does not include attractions tickets, and participants need to take care of themselves.

Presentation Instructions

Instructions for Oral Presentations

Devices Provided by the Conference Organizer:

Laptop Computer (MS Windows Operating System with MS PowerPoint and Adobe Acrobat Reader)
Digital Projectors and Screen
Laser Sticks

Materials Provided by the Presenters:

PowerPoint or PDF Files (Files should be copied to the Conference laptop at the beginning of each Session.)

Duration of each Presentation (Tentatively):

Regular Oral Presentation: about 13 Minutes of Presentation and 2 Minutes of Question and Answer

Instructions for Poster Presentation

Materials Provided by the Conference Organizer:

The place to put poster

Materials Provided by the Presenters:

Home-made Posters
Maximum poster size is A1
Load Capacity: Holds up to 0.5 kg

Best Presentation Award

One Best Presentation will be selected from each presentation session, and the Certificate for Best Presentation will be awarded at the end of each session on September 21, 2019.

Dress code

Please wear formal clothes or national representative of clothing.

Schedule for Conference

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Title: Trusted IoT Framework
Prof. Kuo-Hui Yeh, National Dong Hwa University, Taiwan</td></tr>
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Morning Session

Morning, September 21, 2019 (Saturday)

Time: 9:00-12:30

Venue: International Conference Center of Waseda University

Conference Room 3 (on the Third Floor)

Opening Remarks (9:00-9:10)

Addressed by Prof. Latif Ladid from University of Luxembourg in Luxembourg

Keynote Speech I (9:10-9:55)

Title: Information-Centric Networking toward IoT Applications

Prof. Yong Jin Park

University Malaysia Sabah, Malaysia

Abstract—Information Centric Networking (ICN) has been being inspired as a promising future Internet architecture. The recent network usage has changed from host-centric to information-centric. ICN accesses information by using its object name, instead of a location address like the current IP network. This revolutionary paradigm also provides content-based security and enables in-network data caching. These features makes ICN promising, not only for content distribution but also to support most IoT applications, which have been developed by various industry areas around the world. This talk includes the background and technological features of ICN as well as the latest research development. It is shown how suitable ICN is to a wide range of IoT applications. Finally, issues and challenges of research areas in ICN-based IoT applications are mentioned.

Morning Session

Morning, September 21, 2019 (Saturday)

Time: 9:00-12:30

Venue: International Conference Center of Waseda University

Conference Room 3 (on the Third Floor)

Keynote Speech II (9:55-10:40)

Title: Trusted IoT Framework

Prof. Kuo-Hui Yeh

National Dong Hwa University, Taiwan

Abstract—The growth of advanced information and communication technologies has led to the tremendous development of IoT circumstances. Traditional approaches for protecting the data by cryptology usually fall short of fulfilling IoT security and privacy requirements. In this talk, we will introduce a trusted IoT framework enabling multiple security techniques, such as secure BLE communication, privacy-aware access control, end-device authentication, and Blockchain-based auditing. First of all, we will present several secure communication schemes for BLE-based smart objects in the IoT. In addition, a user-friendly privacy protocol for users to achieve consents with nearby BLE devices is introduced. Secondly, we will demonstrate the design of a Blockchain-connected gateway for BLE devices. Thirdly, we will give the overview of an ISO/IEC 15408-2 compliant security auditing system with Blockchain as an underlying architecture for data management.

Coffee Break & Group Photo Taking 10:40-11:00

Morning Session

Morning, September 21, 2019 (Saturday)

Time: 9:00-12:30

Venue: International Conference Center of Waseda University

Conference Room 3 (on the Third Floor)

Keynote Speech III (11:00-11:45)

Title: Advances in Industry 4.0 and the Industrial Internet

Prof. Dimitrios Georgakopoulos

Swinburne University of Technology, Australia

Abstract—The Industrial Internet of Things (IIoT) incorporates Internet-connected devices that range from sensors, cameras, and wearables, to smart meters, vehicles, and manufacturing machines. To realize its enormous potential, IIoT must provide solutions for incorporating (i.e., finding and integrating) all these industrial machines, collecting and integrating their data, analyzing IIoT data and distilling high value information, and performing appropriate actions that impact the physical world, as well as doing all these securely, on the move, and in the cloud or edge. In this talk we present an overview of research activities and industrial engagements that are advancing industry 4.0-based-solutions in improving plant productivity, product quality, and just-in time supply chains. We also discuss ongoing fundamental IIoT research in IIoT device/machine discovery, time-bound data analysis, lightweight security, and cyber-physical twins that provide the foundation for generating further research impact.

Morning Session

Morning, September 21, 2019 (Saturday)

Time: 9:00-12:30

Venue: International Conference Center of Waseda University

Conference Room 3 (on the Third Floor)

Keynote Speech IV (11:45-12:30)

Title: 6G: The Terabit Wireless Internet Vision

Prof. Latif Ladid
University of Luxembourg, Luxembourg

Abstract— 6G Vision. Every 10 years a new wireless generation emerges with new requirements and new deployment scenarios not addressed by the previous generation. But the time of generations is getting shorter as we saw from the shift from 4G to 5G. This talk will address the new 6G electromagnetic spectrum requirements, the new research challenges, the new user requirements and their impact. Most data happens in-door and not on the street. Data center, company offices and building, factories and government building produce and consume 80-90% of their data in-house and their wireless bandwidth is limited to Gigabit. To move them to Terabit speed in-door, 6G will look at the Terahertz frequency to address its unexploited spectrum (called the Thz Gap) for new uses and innovations. The vast and enormous cabling spagetti of data center can be replaced by Thz communication to name an example. Very large scale research projects have been awarded around the world with flagship projects such as the 6Genesis project in Finland with the vision to instill interest in research and industry attraction to validate with pilots such a promising new terabit scale wireless technologies. The China MIIT has launched its 6G Program in June 2019 to with working groups to investigate on the Thz communication. The US government has also launched a Thz initiative back in June.

Lunch 12:30-13:30

Oral Presentation Abstracts

Session 1

Tips: The schedule for each presentation is for reference only. In order not to miss your presentation, we strongly suggest that you attend the whole session.

Afternoon, September 21, 2019 (Saturday)

Time: 13:30-15:15

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Yong Jin Park

CC0001 Presentation 1 (13:30-13:45)

A Biometric Smart Card Based Remote User Authentication for Telecare Medicine Information System

Suratose Tritilanunt

Mahidol University, Thailand

Abstract—Telecare medicine information system (TMIS) using authentication protocols as a first defensive line to prevent an unauthorized user to illegally access into a system has been used for many years. Even though in the past decade there were many security researchers proposing some development of authentication scheme, most of them were still susceptible to several kinds of attack. Last year, Quan et al. proposed a secure and efficient biometric smart card based user password authentication scheme that be able to resist against various well-known attacks, for example, off-line password guessing and impersonation attacks. This work demonstrates the attack to figure out that the proposed scheme is still not be able to resist a man-in-the-middle attack. Finally, this work proposes some suggestions to fix vulnerabilities and improve a biometric smart card based authentication scheme for a telecare medicine information system. By presenting an analysis of security and performance, this new development provides a more efficient and secure authentication scheme as well as protects user's credentials at the same time.

Oral Presentation Abstracts

Session 1

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Afternoon, September 21, 2019 (Saturday)

Time: 13:30-15:15

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Yong Jin Park

IC0014 Presentation 2 (13:45-14:00)

Suitability of Blockchains to Enable and Support Network Functions: State of the Art

Befekadu G. Gebraselase, Bjarne E. Helvik and Yuming Jiang
NTNU – Norwegian University of Science and Technology

Abstract—The underlying network infrastructure faces challenges from addressing maintenance, security, performance, and scalability to make the network more reliable and stable. Software-defined networking, blockchain, and network function virtualization were proposed and realized to address such issues in both academic and industry wise. This paper analyzes and summarizes works from implementing different categories of blockchains as an element or enabler of network functions to resolve the limitation. Blockchain as a network function has been proposed to give support to the underlying network infrastructure to provide services that have less lag, are more cost-effective, have better performance, guarantee security between participating parties, and protect the privacy of the users. This paper provides a review of recent work that makes use of blockchain to address such networking related challenges and the possible setbacks in the proposal.

Oral Presentation Abstracts

Session 1

Tips: The schedule for each presentation is for reference only. In order not to miss your presentation, we strongly suggest that you attend the whole session.

Afternoon, September 21, 2019 (Saturday)

Time: 13:30-15:15

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Yong Jin Park

IC0016-A Presentation 3 (14:00-14:15)

Topic Analysis on Online News

Jiang Liang Hou and Yu Pin Cheng

Industrial Engineering and Engineering Management, National Tsing Hua University, Taiwan

Abstract—As a reader wants to know the topic trend of news related to a specific issue, he has to search for the news related to the issue and collect the comments into the statistical applications, such as Excel, etc. After that, the reader has to review all the details to subjectively decide the topics of the news. That is, the reader must spend time retrieving the features of news and subjectively determining the topics of news. In order to solve this problem, this study proposed a Topic Analysis model for online news in order to assist readers accurately and quickly acquire the topics of news related to his interest. Once a reader collects the news based on his interest, he can import the news to the proposed mode and the model will automatically capture six key features of the news. On the basis of the six key features, the topic of news can be determined and visualized display of the distribution of news topics can be generated to assist the reader to efficiently capture the key ideas of the news.

Oral Presentation Abstracts

Session 1

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Afternoon, September 21, 2019 (Saturday)

Time: 13:30-15:15

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Yong Jin Park

CC0002 Presentation 4 (14:15-14:30)

Cost Aware Resource Sizing and Scaling of Microservices

Preyashi Agarwal and J.Lakshmi
Indian Institute Of Science, India

Abstract—Microservices are small, independent, loosely coupled components which provide flexibility, agility, and scalability to an application. While these are aimed for scalability, achieving it needs judicious trade-offs between size, number and cost of provisioning. In this architecture, sizing in both homogeneous and heterogeneous resources plays a key role to balance application performance and resource requirement, as workload demand varies. This paper provides insights where the importance of considering workload characterization to decide a homogeneous or heterogeneous scaling strategy for a microservice is discussed. The work exploits the correlation of workload characterization, predicted workload demand and selection of right-sized microservice to minimize resource costs. Size of microservice is referred with respect to the amount of resources allocated to the microservice. This work also evaluates trade-offs between considering the entire predicted workload demand for resource cost optimization against algorithmic computational complexity and designs a heuristic to reduce such complexity. Evaluation of results demonstrate two important outcomes. Firstly, workload characterization helps to choose between homogeneous or heterogeneous sizing for different microservices. And secondly, by considering workload demand prediction beyond the current scheduling interval, allows to make scaling decision in the current cycle keeping in view whether the demand is going to increase or decrease. The paper also details on how to use the insights of application characterization and workload trend for choosing an appropriate scaling strategy.

Oral Presentation Abstracts

Session 1

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Afternoon, September 21, 2019 (Saturday)

Time: 13:30-15:15

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Yong Jin Park

CC0009-A Presentation 5 (14:30-14:45)

Using IOT to Measure and Manage Shopping Effort in Physical Stores

Raymond Burke[1], Sandeep Chandukala[2] and Øyvind Christensen[3]

1: Indiana University Bloomington, United States; 2: Singapore Management University, Singapore

3: Flow Insights, Norway

Abstract—The extensive product selections, complex and varied promotions, and brand-centric merchandising of many brick-and-mortar stores place demands on shoppers that can reduce the convenience, enjoyment, and productivity of the shopping experience. In order to boost sales revenue and customer loyalty, marketers need to understand how customers engage with product categories, and manage the time and effort required for shoppers to find, evaluate, and choose the desired products. In this presentation, we introduce a new approach for measuring the effort customers expend while shopping in retail stores by tracking the timing and sequence of product interactions and purchase outcomes, much like Amazon Go. We explore the unique insights that can be gained from this analysis by conducting a series of field experiments in four European grocery stores: running a 3-for-2 promotion, featuring recommended products, and reorganizing and labeling shelves. The research reveals that simple changes in product organization can reduce the time and effort expended by shoppers and boost purchase conversion rates, while some brand promotion and merchandising tactics can increase shopping effort and reduce productivity.

Oral Presentation Abstracts

Session 1

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Afternoon, September 21, 2019 (Saturday)

Time: 13:30-15:15

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Yong Jin Park

CC0018 Presentation 6 (14:45-15:00)

Development and HPC Preliminary Testing of a TRM Reactive-transport Model for Solving Potential Environmental Issues

Lukas Vojacek[1], Michal Podhoranyi[2] and Pavel Štrof[3]

1 and 2: IT4Innovations-VSB Technical University of Ostrava, Czech Republic; 3: DHI a.s., Czech Republic

Abstract—The main objective of the study is to develop a reactive-transport model able to utilize HPC resources. The primary purpose is constructing a mathematical representation of a proposed reactive transport system in order to simulate the potential risk of environmental contamination. Additionally, the contribution of the study is not only associated with HPC usage but also with new model features implemented during the developing phase. Overall, the Transport-Reaction Model (TRM) was developed to include complex functionality that is necessary in order to solve specific transport-reaction issues. TRM is based on coupling the PhreeqcRM geochemical library with 2D solute species transport in water on a regular rectangular network of elements. Compared to the other similar models, our model offers a unique feature that is associated with the 2D mesh. This feature represents an innovative component that improved our modelling results. Testing revealed that TRM provides conditions for simulation acceleration up to 16 threads. The further addition of resources to 20 or 24 also speeds up the calculation but decreases the efficiency of the parallel solution. Generally, the TRM is optimally run on 16 threads.

Oral Presentation Abstracts

Session 1

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Afternoon, September 21, 2019 (Saturday)

Time: 13:30-15:15

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Yong Jin Park

CC0019 Presentation 7 (15:00-15:15)

Design, Implementation and Performance Measurement of Raspberry Gate in the IoT Field

Shuting Hu[1], **Hironobu Suzuki[2]**, Yoshiaki Kitaguchi[3], Hiroyuki Ohno[4] and Srinivas Sampalli[5]

1: Dalhousie University, Canada; 2: Universal Shell Programming Laboratory, Japan; 3: Tokyo Institute of Technology, Japan; 4: Kanazawa University, Japan; 5: Dalhousie University, Canada

Abstract—The Internet of Things (IoT) is the third wave of the world's information industry after computers, the Internet and mobile communication networks. In the era of rapid development of the IoT applications, there needs to be more focus on security. To solve the security challenges that are being faced today, the use of a Raspberry Gate is proposed. Raspberry Gate is a small security gateway built using a Raspberry Pi, which is a powerful and an affordable pocket-sized computer. Raspberry Guardian, a human community, that can update information, manage and control IoT devices is implemented. We discuss how Raspberry Gate can be built and managed. Furthermore, we also provide a comparison of Raspberry Gates built with different types of Raspberry Pi models.

Oral Presentation Abstracts

Session 2

Tips: The schedule for each presentation is for reference only. In order not to miss your presentation, we strongly suggest that you attend the whole session.

Afternoon, September 21, 2019 (Saturday)

Time: 13:30-15:00

Venue: International Conference Center of Waseda University – –

Common Research Room 7 (on the Fourth Floor)

Session Chair: Prof. Dimitrios Georgakopoulos

CC0005-A Presentation 8 (13:30-13:45)

Application of the AIoT Architecture on the Large Scale Dynamical Systems Health Monitoring

Wei-Chih Su

National Center for High-performance Computing, National Applied Research Laboratories, Taiwan

Abstract—Vibration of dynamical systems were generated by its moving parts. Violent vibration of dynamical system was caused by its unusually conditions or abnormal running and lead to high damage potential or the machine unexpected shutdown, respectively. In this study, an intelligent diagnosis system for monitoring the health of dynamical systems. This system is integrating the IoT(internet of things) devices for vibration measuring and AI(artificial intelligence)-based vibration analysis technology for accessing its running conditions. The used IoT vibration measurement units have 1k Hz sample rate; +/-4G measurement range; 20-bit digital output. The LSTM neural network was used to check similarity between currently state and initial state (health state). Implementation of AI-based diagnosis approach of dynamical systems via personal and movable AI/BD integration computing platform. This vibration measurement and intelligence monitoring system was mounted on the large scale dynamical systems (such as bridge and wind turbine) for health or condition monitoring and validating the stability of this AIoT system.

Oral Presentation Abstracts

Session 2

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Afternoon, September 21, 2019 (Saturday)

Time: 13:30-15:00

Venue: International Conference Center of Waseda University – –

Common Research Room 7 (on the Fourth Floor)

Session Chair: Prof. Dimitrios Georgakopoulos

CC0010 Presentation 9 (13:45-14:00)

Data Center Environment Monitoring System

Diogo Santos, Bruno Mataloto and **João Ferreira**
Instituto Universitário de Lisboa, Portugal

Abstract—The Internet of things (IoT) is applied to many cases in the smart cities topic. We apply an IoT developed platform using a LoRa communication to a Data Center, to understand temperature behaviour with a concentration of servers and the working behaviour of these server machines. We describe our work of an IoT platform to measure temperature, humidity, and energy consumption in a data centre. Gradient temperature was found in the rack and the increasing temperature is correlated with energy consumption and the backup routines in the night. Our developed approach can be used to understand CPU usage and related temperature and the energy consumption.

Oral Presentation Abstracts

Session 2

Tips: The schedule for each presentation is for reference only. In order not to miss your presentation, we strongly suggest that you attend the whole session.

Afternoon, September 21, 2019 (Saturday)

Time: 13:30-15:00

Venue: International Conference Center of Waseda University – –

Common Research Room 7 (on the Fourth Floor)

Session Chair: Prof. Dimitrios Georgakopoulos

CC0030 Presentation 10 (14:00-14:15)

Comparative Study of Forecasting Schemes for IoT Device Traffic in Machine-to-Machine Communication

Mert Nakip, Baran Can Gul, Volkan Rodoplu and Cuneyt Guzelis
YASAR UNIVERSITY, Turkey

Abstract—We present a comparative study of Autoregressive Integrated Moving Average (ARIMA), Multi-Layer Perceptron (MLP), 1-Dimensional Convolutional Neural Network (1-D CNN), and Long-Short Term Memory (LSTM) models on the problem of forecasting the traffic generation patterns of individual IoT devices in Machine-to-Machine (M2M) communication. We classify Internet of Thigns (IoT) traffic into four classes: Fixed-Bit Periodic (FBP), Variable-Bit Periodic (VBP), Fixed-Bit Aperiodic (FBA), and Variable-Bit Aperiodic (VBA). We show that LSTM outperforms all of the other models significantly in the symmetric Mean Absolute Percentage Error (sMAPE) measure for devices in the VBP class in our simulations. Furthermore, we show that LSTM has almost the same performance in this metric for the FBA class as MLP and 1-D CNN. While the training time per IoT device is the highest for LSTM, all of the forecasting models have reasonable training times for practical implementation. Our results suggest an architecture in which an IoT Gateway predicts the future traffic of IoT devices in the FBP, VBP and FBA classes and pre-allocates the uplink wireless channel for these classes in advance in order to alleviate the Massive Access Problem of M2M communication.

Oral Presentation Abstracts

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Common Research Room 7 (on the Fourth Floor)

Session Chair: Prof. Dimitrios Georgakopoulos

IC0015 Presentation 11 (14:15-14:30)

Dynamic Bandwidth Adjustment for Instant Replay of Live Streams on BitTorrent Networks

Chow-Sing Lin and Hsiang-Yun Chen
Dept. Of CSIE, NUTN 33 Su-Lin St., Sec. 2 Tainan, Taiwan

Abstract—In general, people watching a live streaming program would sit and wait for its broadcasting at the very beginning. However, some of them could not do so and inevitably join in the middle of live program because of unexpected events. This unfortunately results in an incomplete viewing experience, causing viewers to not enjoy the full entertainment value of the live program and general dissatisfaction with the quality of the services. In this paper, we propose the Dynamic Bandwidth Adjustment for Instant Replay of live streams on BitTorrent networks (DBAIR), where in addition to downloading the live content, the surplus bandwidth in a peer is allocated to pre-download broadcasted and pre-defined highlights in order to provide viewers with the ability to watch instant replays of missed live content. In such a system, the length or popularity of a highlight can be used to determine how to allocate the surplus bandwidth needed to download highlights. Once a user decides to watch a certain highlight, if the allocated bandwidth and the pre-downloaded pieces did not provide smooth playback, bandwidth can be sequentially borrowed from other highlights. The order of creditor's law could be decided by considering highlights that are completely downloaded or more popular. The experimental results of the simulation show that the proposed method can reduce the delayed time of the instant replays for the user.

Oral Presentation Abstracts

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Venue: International Conference Center of Waseda University – –

Common Research Room 7 (on the Fourth Floor)

Session Chair: Prof. Dimitrios Georgakopoulos

IC0001-A Presentation 12 (14:30-14:45)

Optimizing the Lifetime of Emerging Low Power Wide-Area Networks

Hamid Al-Hamadi[1], Mohammad Saoud[2], Ing-Ray Chen[3] and Jin-Hee Cho[4]

1 and 2: Kuwait University, Kuwait

3 and 4: Virginia Tech, United States

Abstract—In this paper, we propose and analyze an optimization model to maximize the lifetime of emerging IoT Low Power Wide-Area Networks (LPWAN)s, such as SigFox and LoRa networks. Both SigFox and LoRa have gained popularity by servicing applications requiring long-range transmissions by low-power devices, however no consideration has been given to analyze energy and reliability of these technologies in tandem to achieve quality-of-service (QoS) requirements in the presence of unreliable sensing environments. While increasing the service coverage of LPWAN increases communication reliability with a gateway, it also comes at the expense of increased energy consumption. We formulate the tradeoff between the energy conservation vs. reliability of the LPWAN network as an Integer Non-Linear Programming (INLP) optimization problem such that, under the guidance of an environmental cloud, optimal operational settings in terms of the number of active nodes in the operational area is achieved. Feasibility of our approach is demonstrated along with a discussion of how the methodology can guide in LPWAN implementation projects in unreliable sensing environments.

Oral Presentation Abstracts

Session 2

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Time: 13:30-15:00

Venue: International Conference Center of Waseda University – –

Common Research Room 7 (on the Fourth Floor)

Session Chair: Prof. Dimitrios Georgakopoulos

IC0009 Presentation 13 (14:45-15:00)

MOClusVNF: Leveraging Multi-Objective for Scalable NFV Orchestration

Jing Chen, **Jia Chen** and Renkun Hu
Beijing Jiaotong University, China

Abstract—Network functions virtualization (NFV) is becoming a prevailing design for future Internet by decoupling software implementations of network functions from their hosts or hardware. One crucial issue in NFV is to improve resource allocation problem that saves cost and to improve the flexible management of telecommunications service providers (TSPs). Orchestrating VNFs includes VNFs placement (network-level) and routing of flows (flow-level) through ordered VNFs. The challenge of developing NFV orchestration (NFVO) scheme is to improve utilization of the available network resources while meeting the performance requirements of flows. In this paper, multi-objective clustering based VNF (MOClusVNF) is proposed which can balance the tradeoff between multi-objective including maximizing the number of flows admitted to the network, minimizing the path stretch, and balancing the load among VNF instances (VNFIs). MOClusVNF is proposed to cluster VNFs based on their correlation, and determine whether to launch new VNFI or reuse established VNFI to improve the utilization of VNFIs. Moreover, VNFIs in the same cluster are deployed on the same server or its neighbor servers with one and two hop distance to reduce occupied link bandwidth. Simulation results show that the proposed MOClusVNF can balance the load among NFVIs while maximizing the number of flows admitted to the network. Moreover, the simulation results show the scheme can reduce the occupied link bandwidth utilization by 7.5% comparing with greedy method without violating the service level agreement (SLA) for flows.

Coffee Break 15:15-15:45

Oral Presentation Abstracts

Session 3

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Afternoon, September 21, 2019 (Saturday)

Time: 15:45-17:45

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Kuo-Hui Yeh

CC0017 Presentation 14 (15:45-16:00)

Social Media Data Processing Infrastructure by Using Apache Spark Big Data Platform: Twitter Data Analysis

Michal Podhoranyi and Lukas Vojacek

IT4Innovations-VSB Technical University of Ostrava, Czech Republic

Abstract—Social media provide continuous data streams that contain information with different level of sensitivity, validity and accuracy. Therefore, this type of information has to be properly filtered, extracted and processed to avoid noisy and inaccurate results. The main goal of this work is to propose architecture and workflow able to process Twitter social network data in near real-time. The primary design of the introduced modern architecture covers all processing aspects from data ingestion and storing to data processing and analysing. This paper presents Apache Spark and Hadoop implementation. The secondary objective is to analyse tweets with the defined topic – floods. The word frequency method (Word Clouds) is shown as a major tool to analyse the content of the input dataset. The experimental architecture confirmed the usefulness of many well-known functions of Spark and Hadoop in the social data domain. The platforms which were used provided effective tools for optimal data ingesting, storing as well as processing and analysing. Based on the analytical part, it was observed that the word frequency method (n-grams) can effectively reveal the tweets content. According to the results of this study, the tweets proved their high informative potential regarding data quality and quantity.

Oral Presentation Abstracts

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Afternoon, September 21, 2019 (Saturday)

Time: 15:45-17:45

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Kuo-Hui Yeh

CC0023-A Presentation 15 (16:00-16:15)

User Attributes Inference in Photo Sharing Social Media

Chia-Chi Wu, Lu-An Chen and Jia-Hong Liao

Tamkang University, Taiwan

Abstract—More and more companies find that social media is a direct channel to reach potential customers and a platform to get mult-dimensional customer insight. However, because of the anonymity of social media and the issue of privacy, personal information of social media is usually fragmentary and incomplete. Therefore, even there is rich and diverse data to use, companies still face all kinds of difficulties in collecting, connecting, and analyzing data form social media. In this case, inferring user attributes in social media becomes an important research topic. Most related works extract styled-based features, such as sentence length and emoticons, or content-based features, such as n-grams and LDA topics from user generated corpus, and build classification models with these features. However, besides a photo, a post in an increasingly popular photo sharing social media, such as Instagram, includes only a short message. Therefore, some text-based features cannot be extracted and used. In this study, we propose a method for inferring the gender of users in Instagram. Our method integrated the features extracted from messages and photos, and we expect that the results of this study will contribute to social marketing and social media mining.

Oral Presentation Abstracts

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Time: 15:45-17:45

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Kuo-Hui Yeh

CC0027 Presentation 16 (16:15-16:30)

Cloud Computing Vulnerabilities Analysis

Alin Zamfiroiu[1], Ionut Petre[2] and Radu Boncea[3]

1: National Institute for Research and Development in Informatics; Bucharest University of Economic Studies, Romania;

2: National Institute for Research and Development in Informatics"Lucian Blaga" University of Sibiu, Romania

3: National Institute for Research and Development in Informatics; Politehnica University of Bucharest, Romania

Abstract—Nowadays, cloud computing technologies are the most used. They offer customers great flexibility and also maintenance costs are reduced. Many vendors of cloud computing have appeared on the market for each type of cloud. These solutions still present certain vulnerabilities and work to improve the security of cloud computing technologies. We analyze the main cloud computing solutions, analyze the vulnerabilities identified for these solutions, and also calculate the impact of these vulnerabilities based on the NVD scores. We average the scores for each solution and average for each cloud computing model. This way, we can see the impact of the vulnerabilities identified so far for each cloud computing model.

Oral Presentation Abstracts

Session 3

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Afternoon, September 21, 2019 (Saturday)

Time: 15:45-17:45

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Kuo-Hui Yeh

CC0028 Presentation 17 (16:30-16:45)

Autoencoder-based One-class Classification Technique for Event Prediction

Seung Yeop Shin and **Han-Joon Kim**

University of Seoul, Korea

Abstract—This paper proposes an autoencoder-based one-class classification technique to predict a specific event such as the occurrence of a fire in a specific building. Basically, a binary classification system that uses machine learning to identify fire-risk buildings requires 'positive' fire data and 'negative' non-fire data. However, the fire-risk building data that can be actually obtained have a single class data that includes only the data of the occurrence of the fire and does not include the data of the 'non-occurrence'. In this situation, PU (Positive-Unlabeled) learning which uses 'unlabeled' data can be an effective way of generating the fire prediction model. The autoencoder generates new features from the unlabeled data, with which a predictive model for predicting the fire-risk buildings is built through PU learning.

Oral Presentation Abstracts

Session 3

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Afternoon, September 21, 2019 (Saturday)

Time: 15:45-17:45

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Kuo-Hui Yeh

CC0031 Presentation 18 (16:45-17:00)

Enhanced Inverse Ant Algorithm with Mutable Path Pheromone Concentration

Jaymer Jayoma

Caraga State University, Philippines

Abstract—Inverse Ant Algorithm is an enhanced Ant Algorithm that covers real-world scenarios to avoid stagnation in finding the best path from the source to destination. This is done by incorporating rules and constraints that contributes to pheromone level concentration in the path which is the basis for its decision making on agent's choice of next move. Other modifications like path elimination rule was added to ensure that only short paths were eligible of the selection process of ants' next move as it traverses from the source to its destination. Through the path elimination rule modification the inverse ant algorithm was able to eliminate long distant paths as ants' choice for the next possible move and eventually return choices of shorter paths for the ants' selection process which the inverse ant algorithm with path elimination rule has successfully implemented which resulted to shorter best path and it avoid stagnation as rules and constraints are applied. However, even with its increase in efficiency, the current implementations uses the same pheromone concentration on the path as its initial value and agents deposit the same pheromone cost as agents traverse the path. In addition, the current implement uses the same pheromone evaporation cost overtime in each path which is not the actual defection in the real-world. In order to address this issue a modification is introduced to the current Inverse Ant Algorithm model which uses variable path rules and constraints that mimics real world scenarios in a road traffic network such as car length rules, traffic light delay rule, path speed limit rule, and path pheromone capacity rule. The enhancements made is applied to the current implementation in order to achieve reliability in implementing route optimization and to enhance its performance.

Oral Presentation Abstracts

Session 3

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Afternoon, September 21, 2019 (Saturday)

Time: 15:45-17:45

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Kuo-Hui Yeh

CC0032 Presentation 19 (17:00-17:15)

Revision-Aware Caching for Hybrid Cloud Render Farm

Kyungwoon Cho and Hyokyung Bahn

Ewha Womans University, Korea

Abstract—3D computer graphics are produced by consecutive images and each image is generated by rendering, which is the process of generating a visionary image from a geometric 3D model and various graphic input data such as texture, material, color and light. Render farm is a bunch of networked servers dedicated to render image in a distributed or parallel fashion. The capacity of in-house render farm has an upper bound but a rendering workload in real world tends to highly fluctuate. Thus running overloaded jobs on a remote cloud in a seamless fashion is very useful to build cost-effective rendering infrastructures. However, extending a render farm from a cluster to a public cloud is not straightforward. The most critical obstacle is the shared storage on which all I/O for rendering data occurred. If the storage is shared with off-premises rendering servers, its performance severely degrades. A simple approach to overcome the issue is deploying a separate storage for public cloud. Rendering data is uploaded to or downloaded from public cloud. This kind of configuration is used by most cloud-based rendering services. Despite its simplicity, data synchronization by an explicit data transferring imposes a heavy burden on a user and incurs unnecessary data transmission. A more elaborated data synchronization technique with an on-demand fetch and caching can ease the burden and improve a rendering throughput by exploiting rendering workload characteristics. Our proposed revision-aware caching assumes that a storage in on-premises is a data repository which conducts file-based retrieval and store via an explicit check-in and check-out. It has a revision control and a modified file is a new one with an increased version. Our caching technique can reduce a rendering time by half compared to a legacy uploading method. If input files are partially modified, our scheme will be more efficient.

Oral Presentation Abstracts

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Afternoon, September 21, 2019 (Saturday)

Time: 15:45-17:45

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Kuo-Hui Yeh

CC0033 Presentation 20(17:15-17:30)

Amdalh's Law of Data Compression for Live Migration of Virtual Machines

Kasidit Chanchio

Thammasat University, Thailand

Abstract—Data compression can help improve performance of live migration of Virtual Machines (VM). However, there are many factors involved. This paper presents a novel performance model, namely the Amdalh's Law of data compression in VM live migration, to describe the speedup of VM live migration when used in combination with data compression mechanisms. The model introduces a new factor, the live migration bandwidth, into the speedup calculation of VM live migration with compression capability over regular live migration. Live migration bandwidth represents the data transmission rate of the live migration mechanism. The model shows that the higher the bandwidth the lower the speedup of live migration using data compression. A set of theorems derived from the model are presented. A number of experiments have been conducted to confirm these theorems. In the experiments, QEMU-KVM's pre-copy live migration is used to migrate VMs running several memory-intensive OpenMP NAS Parallel benchmarks with and without data compression. Live migrations are performed over 100 Mbps and 1 Gbps networks. Experimental results confirm the validity of the proposed Amdalh's Law of data compression model.

Oral Presentation Abstracts

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Afternoon, September 21, 2019 (Saturday)

Time: 15:45-17:45

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

Session Chair: Prof. Kuo-Hui Yeh

CC0024 Presentation 21 (17:30-17:45)

Mining Tourist's Perception toward Indonesia Tourism Destination using Sentiment Analysis and Topic Modelling

Herry Irawan, Gina Akmalia and Riefvan Achmad Masrury
Telkom University, Indonesia

Abstract—The significant increase in tourism industry in Indonesia has made the tourism industry as one of the biggest contributors to the country. But still, Bali is the most popular destination among tourists, especially for international tourists. To increase the number of visitors, Indonesia's government has set ten new tourist destinations and introduce as other potential tourism destinations besides Bali. Using internet technology, people tend to search for various tourism information and share their activities on social media or tourism site, such as TripAdvisor. By this abundan source of information that come from user generated content (UGC), the government and tourism provider can take most advantage by using big data technology. This study aims to mine the perception of tourists about destinations from TripAdvisor site. About 2632 comments related to priority destination in Indonesia was mined from TripAdvisor using Parsehub. After preprocessing step, remained 2168 comments that were ready for analysis using Orange.
Findings reveal from sentiment analysis, that most of the sentiments are positive (joy), mean that those tourists had a good experience during their visit. And from topic modelling reveal several important keywords that express which area they are pleased and what things from the services that can be improved.

Dinner 18:00-19:00

Poster session

September 21, 2019 (Saturday)

Time: 10:40-15:50

Venue: International Conference Center of Waseda University – Conference Room 3 (on the Third Floor)

CC0021 Poster 1

A Hybrid Model for Ride-hailing Service Demand Forecasting

Chao Wang[1], Changchang Zheng[2], Xiaodan Lyu[3] and Yibo Xue[4]

1,2 and 4: Tsinghua University, China; 3: Guizhou University, China

Abstract—The accurate prediction of the ride-hailing service demand is important for the improvement of transport capability. Due to the nonlinearity and instability of the time series, the prediction accuracy is not ideal. In this paper, we proposes a hybrid model that combines Discrete Wavelet Transform (DWT), Autoregressive Integrated Moving Average (ARIMA), and Radial Basis Function Neural Network (RBFNN) together, which takes advantage of the good fitting ability of the ARIMA model and the strong nonlinear relation mapping ability of the RBFNN model, and use DWT to decompose the time series in order to isolate the influence of each resolution coefficient to a certain extent. The experimental results show that the proposed model has higher prediction accuracy than the single model such as ARIMA, RBFNN and other hybrid models such as ARIMA-DWT, RBFNN-DWT, RBFNN-ARIMA, SVR-ARIMA-DWT, LSTM-ARIMA-DWT.

CC0029 Poster 2

A Novel Fire Rescue System with Fog computing

Tianhang Luo, Wanggen Wan, Yue Gao,Yuepeng Zhao and Yumei Li

Shanghai University, China

Abstract—Fire is a common disaster in the city, because of its harmfulness, people have paid a lot attention to tackle it. And Fire rescue is one of the urgent tasks that we need to care. Normally, firefighters make the rescue plan by the 2D map, but things cannot be predicted very well without enough information. And because of the interference of fire, the transmission of data can be easily blocked. It is necessary to find a way to make sure that we can get the indoor information in an effective way. In this paper, we propose an IoT framework to serve the building. By using Raspberry Pi to work as the fog server, Arduino to make the sensor, and through BIM to display the situation. The present study considers crowd and environment as the main factors. And given all the information we can make the rescue plan.

One Day Visit

September 22, 2019 (Sunday) 9:00-17:00

1. **(9:00am) Assemble at Waseda University**
2. **(9:00-12:00pm) Morning Visit**

Senso-ji Temple

The Sensoji Kannon temple is an ancient Buddhist temple located in Asakusa, Tokyo, Japan. It is Tokyo's oldest temple, and one of its most significant. Formerly associated with the Tendai sect of Buddhism, it became independent after World War II. Adjacent to the temple is a five-storey pagoda, Shinto shrine, the Asakusa Shrine, as well as many shops with traditional goods in the Nakamise-dori.

Throughout the year you can come across seasonal events held on the temple grounds. Some of the most popular include Asakusa-jinja Shrine's Sanja Festival collaboration event in May, the hozuki (Chinese lantern plant) market in July and the photogenic hagoita decorative paddle market in December.

The history of the temple in an interesting one. Legend says that long ago two fisherman on the Miyato River, the current Sumida River, caught a statue of Kannon —the merciful nirvana achiever— in their net. Despite trying to return the figure to the river multiple times it always came back to them, the leader of the region pointed out its Kannon; so it was enshrined. Although Sensoji Temple was founded in 628 the current crimson building is much more modern, as it was rebuilt after being destroyed in WW2.

Hamarikyu Gardens

Hama Rikyu (浜離宮, Hama Rikyū), is a large, attractive landscape garden in central Tokyo. Located alongside Tokyo Bay, Hama Rikyu features seawater ponds which change level with the tides, and a teahouse on an island where visitors can rest and enjoy the scenery. The traditionally styled garden stands in stark contrast to the skyscrapers of the adjacent Shiodome district.

Meiji Shrine

Meiji Jingu is a Shinto shrine. Shinto is called Japan's ancient original religion, and it is deeply rooted in the way of Japanese life. Shinto has no founder, no holy book, and not even the concept of religious conversion, but Shinto values for example harmony with nature and virtues such as "Magokoro (sincere heart)". In Shinto, some divinity is found as Kami (divine spirit), or it may be said that there is an unlimited number of Kami. You can see Kami in mythology, in nature, and in human beings. From ancient times, Japanese people have felt awe and gratitude towards such Kami and dedicated shrines to many of them. This shrine is dedicated to the divine souls of Emperor Meiji and his consort Empress Shoken (their tombs are in Kyoto).

Emperor Meiji passed away in 1912 and Empress Shoken in 1914. After their demise, people wished to commemorate their virtues and to venerate them forever. So they donated 100,000 trees from all over Japan and from overseas, and they worked voluntarily to create this forest. Thus, thanks to the sincere heart of the people, this shrine was established on November 1, 1920.

Tokyo Tower

Tokyo Tower is a communications and observation tower in the Shiba-koen district of Minato, Tokyo, Japan. At 332.9 metres (1,092ft), it is the second-tallest structure in Japan. The structure is an Eiffel Tower-inspired lattice tower that is painted white and international orange to comply with air safety regulations.

Built in 1958, the tower's main sources of income are tourism and antenna leasing. Over 150 million people have visited the tower. FootTown, a four-story building directly under the tower, houses museums, restaurants and shops. Departing from there, guests can visit two observation decks. The two-story Main Observatory is at 150 metres (490 ft), while the smaller Special Observatory reaches a height of 249.6 metres (819 ft).

5. (17:00) Dissolve in Tokyo Tower

Note

Note