
Organized by
Korean Institute of Industrial Engineers
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PROCEEDINGS
APIEM
APIEMS 2014
The 15th
Asia Pacific Industrial Engineering
and Management Systems Conference
> October 12~15, 2014
> Ramada Plaza Jeju Hotel, Jeju, Korea
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Jeju CVB
Jeju Convention & Visitors Bureau

Message from the APIEMS President

Greeting and a warm welcome to the participants of the 15th Asia Pacific Industrial Engineering and Management Systems Conference. Started in 1998, APIEMS has grown to become the premier conference for industrial engineering and management systems in the region with participants from all around the world. The main theme of this year conference: “Sustainable Industrial Systems and Big Data Management”, is an attempt to address the balance among economic and technical development, social development, and environmental protection in this fast changing world.

I congratulate and thank Prof. Dr. Chi-Hyuck Jun, the conference chair, whose leadership made this APIEMS 2014 conference possible. We are also grateful for the enthusiastic support of APIEMS from the KIIE and the Korea research community.

On behave of the Asia Pacific Industrial Engineering and Management Society, I wish you a successful conference with many thoughtful discussions and debates with old and new friends.

Professor Voratas Kachitvichyanukul
APIEMS President, (2013-2014)
Professor of Industrial & Manufacturing Engineering
Dean, School of Engineering and Technology
Asian Institute of Technology, THAILAND

Message from the General Chair

Welcome to APIEMS 2014 in Jeju City, a beautiful island located at the most south of Korea. It is our great pleasure to organize this conference, which is supported by Korean Institute of Industrial Engineers (KIIE). APIEMS conferences have rapidly emerged as an important forum for exchange of ideas and information about latest developments in the field of industrial engineering and management systems among professionals mostly from Asia-Pacific countries. APIEMS 2014 conference encourages contributors to address the topical theme: Sustainable Industrial Systems and Big Data Management. Papers will represent the latest academic thinking and successful case examples. The wider audience will benefit from the knowledge and experience of leading practitioners and academics in this area.

The conference seeks research contributions from researchers, educators, modelers, software developers, users and practitioners. We hope that you enjoy participating in APIEMS 2014 and staying in Jeju.

Professor Chi-Hyuck Jun
General Chair, APIEMS 2014
Industrial & Management Engineering
POSTECH, Korea

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Keynote Speech

Keynote Speech I
Research Issues in Future Logistics

Oct 13 (Monday) 11:00-12:00

Room: Ramada-1

Chung– Yee Lee
Hong Kong University of Science and Technology, China

Dr. Chung-Yee Lee is Chair Professor/Cheong Ying Chan Professor of Engineering in the Department of Industrial Engineering & Logistics Management at Hong Kong University of Science and Technology. He served as Department Head for seven years (2001- 2008). He is also the Founding and Current Director of Logistics and Supply Chain Management Institute. He is a Fellow of the Institute of Industrial Engineers in U.S. and also a Fellow of Hong Kong Academy of Engineering Science. Before joining HKUST in 2001, he was Rockwell Chair Professor in the Department of Industrial Engineering at Texas A&M University. He worked as a plant manager and also had few years consulting experience in Taiwan. In the past thirty years he has engaged in more than forty research projects sponsored by NSF, RGC, ITF, IBM, Motorola, AT&T Paradyne, Harris Semicon ductor, Northern Telecom, Martin Marietta, Hong Kong Air Cargo Terminal, Hongkong International Terminal, Philips Medical, ...,etc.

His search areas are in logistics and supply chain management, scheduling and inventory management. He has published more than 130 papers in refereed journals. According to an article in Int. J. Prod. Eco. (2009), which looked at all papers published in the 20 core journals during last 50 years in the field of production and operations management, he was ranked No. 6 among all researchers worldwide in h-index.

He received a BS degree in Electronic Engineering (1972) and a MS degree in Management Sciences (1976) both from National Chiao-Tung University in Taiwan. He also received a MS degree in Industrial Engineering from Northwestern University (1980) and PhD degree in Operations Research from Yale University (1984).

Keynote Speech II
Data-Driven Decision Making in Manufacturing: Lessons Learned and Future Opportunities

Oct 14 (Tuesday) 11:00-12:00

Room: Ramada-1

Ronald G. Askin
Arizona State University, USA

Ronald G. Askin, Ph.D., is a Professor of Industrial Engineering and Director of the School of Computing, Informatics, and Decision Systems Engineering at Arizona State University. Professor Askin received his B. S. in Industrial Engineering from Lehigh University followed by an M.S. in Operations Research and PhD in Industrial and Systems Engineering from the Georgia Institute of Technology. He has over 30 years of experience in the development, teaching and application of methods for systems design and analysis with particular emphasis on production and material flow systems. Other interests include quality engineering and decision analysis. He has published over 120 journal and conference proceedings papers in these areas.

Dr. Askin is a Fellow of the Institute of Industrial Engineers (IIE) and serves as Editor-in-Chief of IIE Transactions. He has served on the IIE Board of Trustees, as President of the IIE Council of Fellows, Chair of the Association of Chairs of Operations Research Departments (ACORD) Chair of the Industrial Engineering Academic Department Heads (CIEADH) and President of the INFORMS Manufacturing and Service Operations Management Society (MSOM). He was also General Chair of the 2012 INFORMS Annual Conference. His list of awards includes a National Science Foundation Presidential Young Investigator Award, the Shingo Prize for Excellence in Manufacturing Research, IIE Joint Publishers Book of the Year Award (twice), IIE Transactions on Design and Manufacturing Best Paper Award (twice), the Eugene L. Grant best paper award from The Engineering Economist, and the IIE Transactions Development and Applications Award.

Keynote Speech III
Big Data Management

Oct 14 (Tuesday) 13:00-14:00

Room: Ramada-1

Sungzoon Cho

Seoul National University, Korea.

Sungzoon Cho is currently professor of Industrial Engineering Department, the director of Data Mining Center at Seoul National University (SNU) and a member of Government 3.0 Committee of Korean government. He is on the editorial board of International Journal of Operations Research and Information Systems and International Journal of Cognitive Biometrics. He served as the presi yundai Motors, Hyundai Heavy Industries, POSCO, Daewoo Shipbuilding and Marine Engineering, LG Electronics, Doosan Infracore, SK Hynix, SK Telecommunication and CJ. He advised nine PhDs and 56 Master students. He teaches Data Mining and Computational Intelligence at SNU as well as at firms. He received BS and MS in Industrial Engineering at SNU. He won a Fulbright Scholarship to obtain Masters and PhD at University of Washington in Seattle, US, and University of Maryland in College Park, US, respectively.

Conference at a Glance

Oct 12 (Sunday)		Oct 13 (Monday)		Oct 14 (Tuesday)		Oct 15 (Wednesday)	
		08:00-17:00	Registration	08:00-17:00	Registration	08:00-12:00	Registration
		08:30-10:10	Technical sessions MA	08:40-10:40	Technical sessions TA	08:30-10:10	Technical sessions WA
10:00-18:00	Registration	10:10-10:30	Coffee break			10:10-10:30	Coffee break
		10:30-11:00	Opening addresses : APIEMS President, KIIE President, General Chair			10:30-12:10	Technical sessions WB
				10:40-11:00	Coffee break		
		11:00-12:00	Keynote speech I (Prof. Chung-Yee Lee: Research issues in Future Logistics)	11:00:12:00	Keynote speech II (Prof. Ronald Askin: Data-Driven Decision Making in Manufacturing)		
13:00-17:20	Excursion	12:00-13:30	Lunch	12:00-13:00	Lunch	12:10-13:30	Lunch
		13:30-15:30	Technical sessions MB	13:00-14:00	Keynote speech III (Prof. Sungzoon Cho: Big Data Management)		
				14:00-14:20	Coffee break		
		15:30-15:50	Coffee break	14:20-16:00	Technical sessions TB		
		15:50-17:50	Technical sessions MC	16:00-16:20	Coffee break		
	Registration			16:20-18:00	Technical sessions TC		
				13:00-18:00	Poster Session		
18:00-20:00	Welcome Reception			18:30-21:00	General Reception		

Oct 12 (Sunday)

10:00-18:00	**Registration**
13:00-17:20	**Excursion**
18:00-20:00	**Welcome Reception**

Oct 13 (Monday)

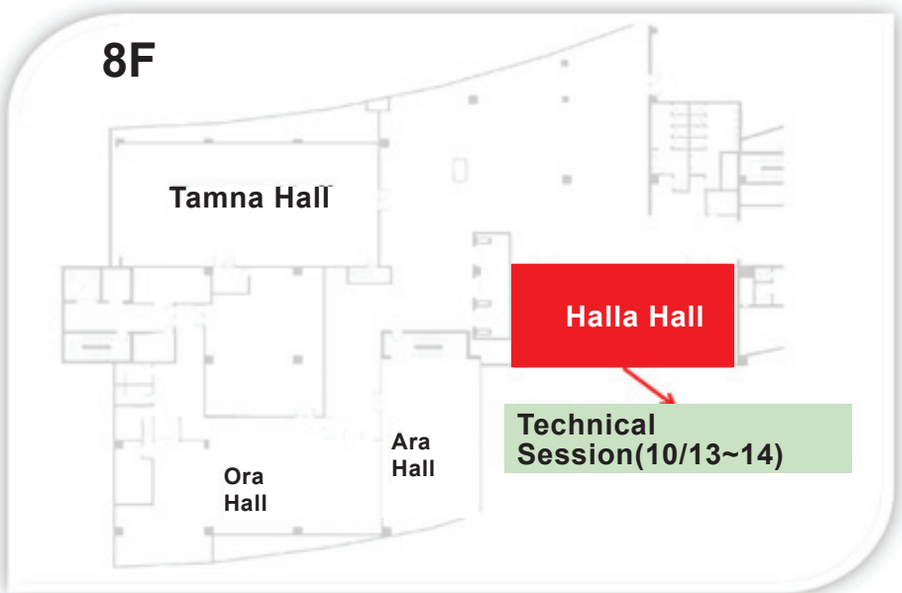
08:00-17:00	**Registration**								
Room	**Mara**	**Biyang**	**Udo**	**Chuja**	**Ramada-1**	**Ramada-2**	**Ramada-3**	**Ramada-4**	**Halla(8F)**
08:30-10:10	**Technical sessions MA**								
	MA1	**MA2**	**MA3**	**MA4**	**MA5**	**MA6**	**MA7**	**MA8**	**MA9**
Session name	Data Mining 1	Management of Technology and Innovations 1	ERP/ E-Business	Service Sciences 1	Quality Engineering & Management 1	Production and Operations Management 1	Metaheuristics	Financial Models & Engineering	Uncertainty Theory (Session I)
Paper #	**528**	**100**	**37**	**54**	**23**	**75**	**42**	**41**	**551**
	207	**111**	**38**	**55**	**28**	**158**	**43**	**146**	**555**
	276	**143**	**352**	**108**	**109**	**211**	**175**	**180**	**556**
	324	**44**	**360**	**215**	**113**	**269**	**353**	**267**	**584**
	296	**97**	**255**	**244**	**226**	**213**	**465**	**273**	
10:10-10:30	**Coffee break**								
10:30-11:00	**Opening addresses: APIEMS President, KIIE President, General Chair**								
11:00-12:00	**Keynote speech I (Prof. Chung-Yee Lee: Research Issues in Future Logistics)**								
12:00-13:30	**Lunch**								
13:30-15:30	**Technical sessions MB**								
	MB1	**MB2**	**MB3**	**MB4**	**MB5**	**MB6**	**MB7**	**MB8**	**MB9**
Session name	Decision Support Systems & Expert Systems	Probability & Statistical Modeling	Ergonomics/ Human Factors 1	Service Sciences 2	Quality Engineering & Managment 2	Production and Operations Management 2	Green Manufacturing/ Management	Transportation	Ergonomics & Welfare Management
Paper #	**173**	**190**	**96**	**322**	**227**	**338**	**417**	**73**	**488**
	254	**299**	**131**	**401**	**228**	**362**	**550**	**91**	**484**
	290	**333**	**305**	**411**	**229**	**394**	**119**	**103**	**530**
	460	**334**	**315**	**479**	**346**	**396**	**156**	**312**	**485**
	116	**3354**	**326**	**504**	**294**	**442**	**342**	**340**	**471**
	538	**450**	**332**	**323**	**307**		**361**	**53**	**505**
15:30-15:50	**Coffee break**								
15:50-17:50	**Technical sessions MC**								
	MC1	**MC2**	**MC3**	**MC4**	**MC5**	**MC6**	**MC7**	**MC8**	**MC9**
Session name	Supply Chain Management 1	Reliability & Maintenance	Ergonomics/ Human Factors 2	Network Optimization	Quality Engineering & Management 3	Simulation 1	Healthcare Systems 1	Optimization Techniques 1	Educational Support System
Paper #	**252**	**118**	**456**	**407**	**325**	**500**	**482**	**374**	**501**
	261	**121**	**359**	**363**	**328**	**196**	**99**	**217**	**562**
	279	**153**	**393**	**268**	**339**	**424**	**112**	**201**	**448**
	280	**320**	**419**	**515**	**346**	**66**	**194**	**169**	**455**
	355	**580**	**449**	**319**	**370**	**179**	**248**	**206**	**154**
	336	**582**	**341**	**142**	**402**			**271**	**507**

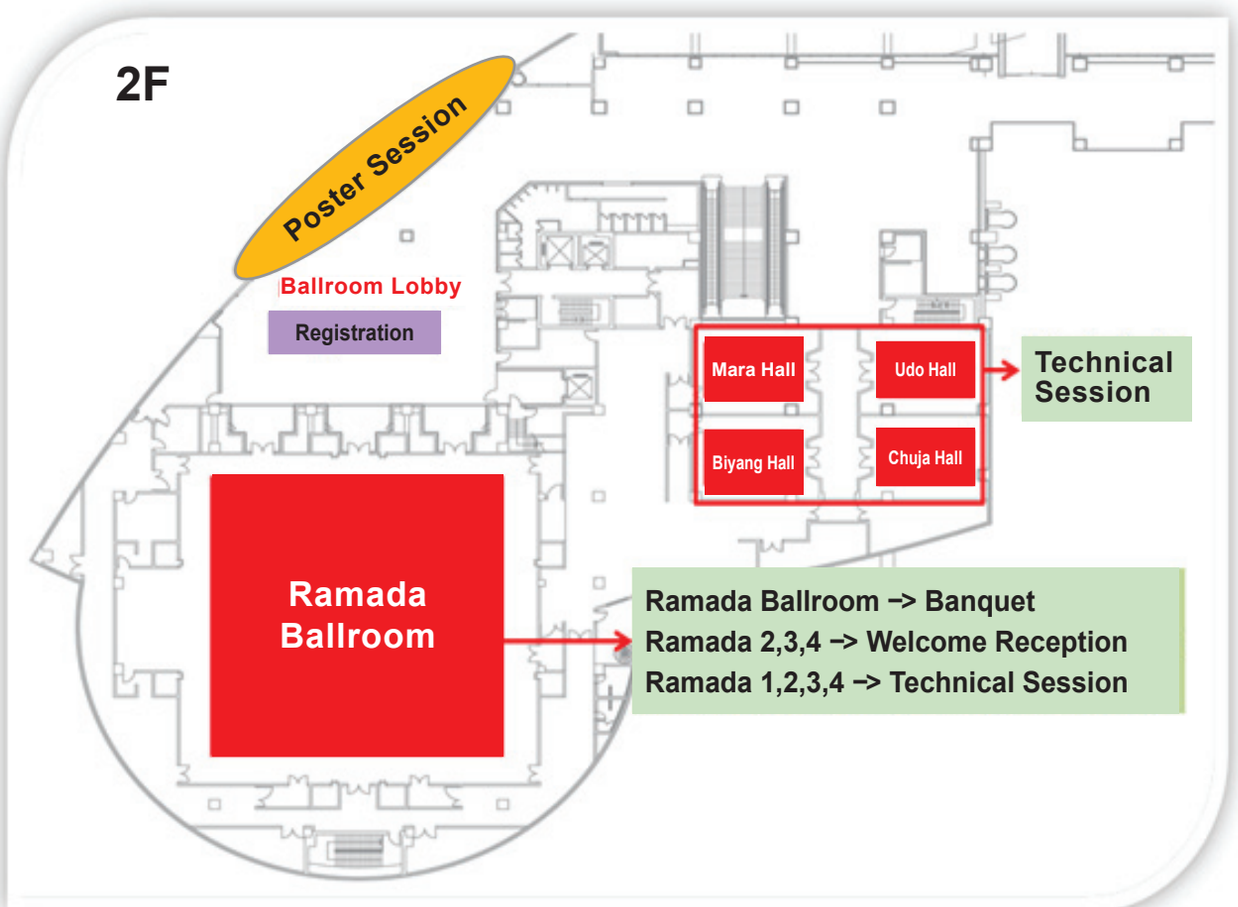
Oct 14 (Tuesday)

08:00-17:00	**Registration**								
Room	**Mara**	**Biyang**	**Udo**	**Chuja**	**Ramada-1**	**Ramada-2**	**Ramada-3**	**Ramada-4**	**Halla(8F)**
08:40-10:40	**Technical sessions TA**								
	TA1	**TA2**	**TA3**	**TA4**	**TA5**	**TA6**	**TA7**	**TA8**	**TA9**
Session name	Supply Chain Management 2	Communication Support	Data Mining 2	Tourism Management/ Topics in IE/MS	Sustainable Management	Simulation 2	Production & Operations Management 1	Logistics Management	Uncertainty Theory (Session II)
Paper #	**50**	**443**	**128**	**472**	**35**	**98**	**282**	**440**	**558**
	59	**535**	**147**	**444**	**114**	**105**	**327**	**477**	**559**
	60	**489**	**203**	**564**	**136**	**221**	**349**	**483**	**560**
	61	**536**	**392**	**15**	**137**	**272**	**431**	**543**	**561**
	130	**480**	**412**	**264**	**291**	**295**	**104**	**344**	**565**
	161	**537**	**216**	**225**	**347**	**356**	**218**	**313**	**428**
10:40-11:00	**Coffee break**								
11:00-12:00	**Keynote speech II (Prof. Ronald Askin: Data Driven Decision Making in Manufacturing)**								
12:00-13:00	**Lunch**								
13:00-14:00	**Keynote speech III (Prof. Sungzoon Cho: Big Data Management)**								
14:00-14:20	**Coffee break**								
14:20-16:00	**Technical sessions TB**								
	TB1	**TB2**	**TB3**	**TB4**	**TB5**	**TB6**	**TB7**	**TB8**	**TB9**
Session name	Supply Chain Management 3	Management of Technology and Innovations 2	Data Mining 3	Scheduling & Sequencing 1	Knowledge & Information Management	Production & Operations Management 2	Healthcare Systems 2	Flexible Manufacturing Systems	Topics in IE/MS
Paper #	**165**	**188**	**437**	**122**	**250**	**49**	**95**	**579**	**575**
	176	**425**	**469**	**233**	**278**	**124**	**106**	**48**	**354**
	208	**317**	**486**	**284**	**445**	**151**	**306**	**62**	**378**
	160	**150**	**502**	**287**	**297**	**187**	**379**	**286**	**212**
	234	**22**	**581**	**309**	**389**	**12**	**76**	**457**	**202**
16:00-16:20	**Coffee break**								
16:20-18:00	**Technical sessions TC**								
	TC1	**TC2**	**TC3**	**TC4**					**TC9**
Session name	Heuristics/Metaheuristics	Inventory Modeling / Artificial Intelligence	Artificial Intelligence	Scheduling & Sequencing 2					Lean Production Management
Paper #	**70**	**381**	**182**	**399**					**542**
	464	**123**	**260**	**405**					**546**
	481	**101**	**490**	**418**					**94**
	520	**318**	**391**	**398**					**545**
	192		**499**	**79**					**547**
13:00-18:00	**POSTER Session**								
Paper #	**47**	**149**	**166**	**204**	**220**	**245**	**253**	**265**	**205**
	365	**366**	**382**	**400**	**414**	**422**	**432**	**435**	**524**
	451	**473**	**487**	**522**	**527**	**491**	**420**	**145**	
18:30-21:00	**General Reception**								

Oct 15 (Wednesday)								
08:00-12:00	**Registration**							
Room	**Mara**	**Biyang**	**Udo**	**Chuja**	**Ramada-3**	**Ramada-4**	**Ramada-1**	**Ramada-2**
08:30-10:10	**Technical sessions WA**							
	WA1	**WA2**	**WA3**	**WA4**	**WA5**	**WA6**		
Session name	Inventory Modeling & Management	SCM and Forecasting 1	Production Design & Management 1	Scheduling & Sequencing 3	Fuzzy Logic	Optimization Techniques 2		
Paper #	**65**	**92**	**117**	**85**	**30**	**125**		
	80	**31**	**162**	**120**	**58**	**69**		
	71	**34**	**198**	**177**	**224**	**288**		
	446	**32**	**222**	**316**	**576**	**577**		
	518	**102**	**249**	**509**		**415**		
10:10-10:30	**Coffee break**							
10:30-12:10	**Technical sessions TB**							
	WB1	**WB2**	**WB3**	**WB4**	**WB5**	**WB6**		
Session name	Industrial Engineering Education	SCM and Forecasting 2	Production Design & Management 2	Scheduling & Sequencing 4	Quality Engineering & Reliability	Lean Manufacturing		
Paper #	**526**	**52**	**283**	**329**	**453**	**129**		
	139	**36**	**348**	**46**	**508**	**371**		
	256	**87**	**350**	**403**	**270**	**553**		
	495	**413**	**93**	**426**	**517**	**110**		
			84	**454**	**421**	**516**		
12:10-13:30	**Lunch**							

Floor Plan


8F
Tamna Hall
Halla Hall
Technical Session(10/13~14)
Ara Hall
Ora Hall


2F
Poster Session
Ballroom Lobby
Registration
Mara Hall
Udo Hall
Biyang Hall
Chuja Hall
Technical Session
Ramada Ballroom
Ramada Ballroom -> Banquet
Ramada 2,3,4 -> Welcome Reception
Ramada 1,2,3,4 -> Technical Session

Detailed Program

MA1 Data Mining 1

Mara, 08:30-10:10

Chair: Kuo-Hao Chang (National Tsing Hua University, Taiwan)

MA2 Management of Technology and Innovations 1

Biyang, 08:30-10:10

Chair: Muh-Cherng Wu (National Chiao Tung University, Taiwan)

MA3 ERP/E-Business

Udo, 08:30-10:10

Chair: Kazuhiko Yasuda (Tohoku University, Japan)

MA4 Service Sciences 1

Chuja, 08:30-10:10

Chair: Kwang-Jae Kim (POSTECH, Korea)

MA5 Quality Engineering & Management 1

Ramada-1, 08:30-10:10

Chair: Ruey Huei (Robert) Yeh (National Taiwan Univeristy of Science and Technology, Taiwan)

MA6 Production and Operations Management 1

Ramada-2, 08:30-10:10

Chair: Daisuke Hirotani (Prefectural University of Hiroshima, Japan)

MA7 Metaheuristics

Ramada-3, 08:30-10:10

Chair: Ching-Jung Ting (Yuan Ze University, Taiwan)

MA8 Financial Models & Engineering

Ramada-4, 08:30-10:10

Chair: Bong-Gyu Jang (POSTECH, Korea)

MA9 Uncertainty Theory (Session I)

Halla(8F), 08:30-10:10

Chair: Jinwu Gao (Renmin University of China, China)

MB1 Decision Support Systems & Expert Systems

Mara, 13:30-15:30

Chair: Hyerim Bae (Pusan National University, Korea)

MB2 Probability & Statistical Modeling

Biyang, 13:30-15:30

Chair: Junghye Lee (POSTECH, Korea)

MB3 Ergonomics/Human Factors 1

Udo, 13:30-15:30

Chair: Mao-Jiun Wang (National Tsing Hua University, Taiwan)

MB4 Service Sciences 2

Chuja, 13:30-15:30

Chair: Chen-Yang Cheng (Tunghai University, Taiwan)

MB5 Quality Engineering & Management 2

Ramada-1, 13:30-15:30

Chair: Shu-Kai Fan (National Taipei University of Science and Technology, Taiwan)

MB6 Production and Operations Management 2

Ramada-2, 13:30-15:30

Chair: Gyu M. Lee (Pusan National University, Korea)

MB7 Green Manufacturing/Management

Ramada-3, 13:30-15:30

Chair: Hsiao-Fan Wang (National Tsing Hua University, Taiwan)

MC1 Supply Chain Management 1

Mara, 15:50-17:50

Chair: Rainisa Heryanto (Maranatha Christian University, Indonesia)

MC1-1 (252)	A Multi-Criteria Selection for Inventory Aggregation Problem under Risk Pooling: A Case Study *Kanokporn Rienkhemaniyom, Nipa Suttachat(King Mongkut's University of Technology Thonburi, Thailand)	607
MC1-2 (261)	A Multi-Objective Closed-Loop Supply Chain Model For Multiple Generations of a Product with Mandatory Product Take-back Justin Contreras(De La Salle University - Manila, Philippines), *Dennis Cruz(De La Salle University, Philippines)	615
MC1-3 (279)	The Proposal of Applying Multi Echelon Inventory to Minimize Supply Chain Total Cost for Soft Drinks *Santoso -, Rainisa Heryanto(Maranatha Christian University, Indonesia)	623
MC1-4 (280)	The Improvement of the Model of Wheat Flour Requirement at Eastern Indonesia by Determining the Number Location of the New Plant *Rainisa Heryanto(Maranatha Christian University, Indonesia), Senator Bahagia(Bandung Institute of Technology, Indonesia)	630
MC1-5 (355)	Coordination of supply chains with risk-averse members under budget constraints *Ilkyeong Moon, Xuehao Feng(Seoul National University, Korea)	638
MC1-6 (336)	A MECE Feature Selection Framework for Yield Improvement in Semiconductor Manufacturing *CHIA-YEN LEE, BO-SYUN CHEN(National Cheng Kung University, Taiwan)	645

MC2 Reliability & Maintenance

Biyang, 15:50-17:50

Chair: Shinya Mizuno (Shizuoka University, Japan)

MC2-1 (118)	DELPHI-AHP BASED METHODOLOGY FOR SELECTING THE OPTIMUM MAINTENANCE STRATEGY FOR SHIP MACHINERY SYSTEMS *Ikuobase Emovon, Rosemary Norman, Alan Murphy(Newcastle University, United Kingdom), Biliaminu Kareem(Federal University of Technology, Nigeria)	653
MC2-2 (121)	Cost Minimization for Achieving a Target Operational Availability of a Warship through Sensitivity Analysis Jinho Lee, *Ki-Hoon Song(Korea Naval Academy, Korea)	661
MC2-3 (153)	Method of Minimizing Costs in Consideration of System Backup Intervals and Expected Costs *Shinya Mizuno(Center for Information Infrastructure, Japan), Naoki Kondo(Shizuoka Professional Training College of Industrial Technology, Japan), Haruki Inoue, Takahiro Hasegawa, Naokazu Yamaki(Center for Information Infrastructure, Japan)	667
MC2-4 (320)	Applied Algorithm for the Optimal Arrangement Problem of a Connected-(r, s)-out-of-(m, n):F System *Toru Omura, Hisashi Yamamoto(Tokyo Metropolitan University, Japan), Tomoaki Akiba(Chiba Institute of Technology, Japan), Xiao Xiao(Tokyo Metropolitan University, Japan)	673
MC2-5 (580)	Interaction in Virtual Reality: A Review *Bereket Woldegiorgis, Chiuhsiang Lin(National Taiwan University of Science and Technology, Taiwan)	680
MC2-6 (582)	The implementation of the mobile-Computerized Procedure System Editor Dae Seung Park, *Yeonsub Jung(Central Research Institute of Korea Hydro and Nuclear Power Co., Korea)	688

MC3 Ergonomics/Human Factors 2

Udo, 15:50-17:50

Chair: Zahari Taha (Universiti Malaysia Pahang, Malaysia)

MC4 Network Optimization

Chuja, 15:50-17:50

Chair: Hsiao-Fan Wang (Universiti Malaysia Pahang, Taiwan)

MC5 Quality Engineering & Management 3

Ramada-1, 15:50-17:50

Chair: Chia-Yu Hsu (Yuan Ze University, Taiwan)

MC6 Simulation 1

Ramada-2, 15:50-17:50

Chair: Pudji Astuti (Trisakti University, Indonesia)

MC7 Healthcare Systems 1

Ramada-3, 15:50-17:50

Chair: Chie-Hyeon Lim (POSTECH, Korea)

MC8 Optimization Techniques 1

Ramada-4, 15:50-17:50

Chair: Shi-Woei Lin (National Taiwan University of Science and Technology, Taiwan)

MC9 Educational Support System

Halla(8F), 15:50-17:50

Chair: Masahide Yamamoto (Kanazawa Seiryo University, Japan)

TA1 Supply Chain Management 2

Mara, 08:40-10:40

Chair: Etsuko Kusukawa (Osaka Prefecture University, Japan)

TA1-4 (61) Optimal Ordering Policy in Dual-Sourcing Supply Chain considering Supply Disruptions and Demand Information 980
Naoki Watanabe, Etsuko Kusukawa(Osaka Prefecture University, Japan)

TA1-5 (130) Research in Supply Chain Management: Issue and Area Development 988
*elisa kusrini(Department of Industrial Engineering, Indonesia), *siti Budijati(Faculty of Engineering, Indonesia), subagyo subagyo(Indonesian Islamic University, Indonesia), nuraini masruroh(Yogjakarta, Indonesia)*

TA1-6 (161) Cold Chain Logistics Development: Analyzing Taiwan Influences in Indonesia Market 996
*James C. Chen(National Tsing Hua University, Taiwan), Janet Chen, Yun-Wei Hung(Industrial Technology Research Institute, Taiwan), *Muhammad Rinaldi Darmawan, Nadia Aulia Arifin, Hsin-Yu Shih(National Tsing Hua University, Taiwan)*

TA2 Communication Support

Biyang, 08:40-10:40

Chair: Sakiko Ogoshi (Kanazawa University, Japan)

TA2-1 (443) Discrimination of Positive / Negative Attitude Using Optical Flow 1003
Yuta Kobayashi(Kanazawa University, Japan), Munehiro Nakamura(Kanazawa Institute of Technology, Japan), Hidetaka Nambo, Haruhiko Kimura(Kanazawa University, Japan)

TA2-2 (535) Development of the support system for facial expression training 1010
Yusuke Amagata, Yasuhiro Ogoshi(University of Fukui, Japan), Sakiko Ogoshi(Kanazawa University, Japan), Tomohiro Takezawa(The National Institute of Vocational Rehabilitation, Japan), Yoshinori Mitsuhashi(Chiba, Japan)

TA2-3 (489) Discrimination of Micro-Expression with Subjective Assessments 1015
Kiyotaka nakashima(Graduate School of Natural Science, Japan), Munehiro Nakamura(Kanazawa Institute of Technology, Japan), Haruhiko Kimura(Graduate School of Natural Science, Japan)

TA2-4 (536) Facial electromyogram (FEMG) analysis of perception and rendering of facial expression 1020
Akira Takahara, Yasuhiro Ogoshi(University of Fukui, Japan), Sakiko Ogoshi(Kanazawa University, Japan), Tomohiro Takezawa(The National Institute of Vocational Rehabilitation, Japan), Yoshinori Mitsuhashi(University of Fukui, Japan)

TA2-5 (480) Text extraction in natural image 1025
Masayoshi Ueno, Hidetaka Nambo, Haruhiko Kimura(Kanazawa University, Japan)

TA2-6 (537) Electroencephalogram activity during imagined imitative learning 1030
Shu Momose(University of Fukui, Japan), Sakiko Ogoshi(Kanazawa University, Japan), Yasuhiro Ogoshi(University of Fukui, Japan), Tomohiro Takezawa(The National Institute of Vocational Rehabilitation, Japan), Yoshinori Mitsuhashi(University of Fukui, Japan)

TA3 Data Mining 2

Udo, 08:40-10:40

Chair: Jong-Seok Lee (Sungkyunkwan University, Korea)

TA3-1 (128) AUC-based C4.5 tree induction for imbalanced data classification 1035
*Jungmin Lee, Sungho Lee, *Jong-Seok Lee(Sungkyunkwan University, Korea)*

TA3-2 (147) Comparison of machine learning classifiers for glaucoma diagnosis using variable selection 1042
*Su-Dong Lee, Jihyung Lee, Heecheon You, *Chi-Hyuck Jun(POSTECH, Korea)*

TA3-3 (203) An iterative random sampling procedure for outlier detection 1049
*Jihyun Ha, Seulgi Seok, *Jong-Seok Lee(Sungkyunkwan University, Korea)*

TA3-4 (392) Development of Knowledge Management for Forecasting in Restaurant Using Association Rule Mining and Regression Analysis 1057
Annisa Khasanah, Agus Mansur, Yasser Ulil Albab(Universitas Islam Indonesia, Indonesia)

TA3-5 (412) Data stream clustering by controlling decision errors 1064
*Jeonghwa Lee, *Chi-Hyuck Jun(POSTECH, Korea)*

TA3-6 (216) The moderating impact of employee's perceived self-efficacy on knowledge sharing intention 1071
Mei-Fang Chen, Ssu-Wei Huang(Tatung University, Taiwan), Pei-Ju Tung(National Chengchi University, Taiwan)

TA4 Tourism Management/ Topics in IE/MS

Chuja, 08:40-10:40

Chair: Hidetaka Nambo (Kanazawa University, Japan)

TA4-1 (472)	Evaluation for painting show of kindergartner on rout bus in Kaga City *Eri Ishikawa, Ayano Kawasaki, Izumi Yamasaki(Kanazawa Seiryo University, Japan), *Takashi Oyabu(Kokusai Business Gakuin College, Japan)*	1077
TA4-2 (444)	Utilization of historical materials and CGM for foreign visitors **Ayako Sawada(Hokuriku Gakuin Junior College, Japan), Taketoshi Yoshida(Japan Advanced Institute of Science and Technology, Japan)*	1084
TA4-3 (564)	The Verification of Mass Customization Systems in the Chinese Market **Bin Fang(Kanazawa Seiryo University, Japan), Akinori Ono(Keio University, Japan)*	1090
TA4-4 (15)	Using SWOT Analysis to Evaluate the Public Procurement in Compliance with SNI (Case Study: Government Agency at Central of Java) **Aries Susanty, Hery Suliantoro, Diana Puspitasari, Diena Novitasari, Nia Budi Puspitasari(Diponegoro Unversity, Indonesia)*	1094
TA4-5 (264)	Designing Variables Quick Switching System with Process Loss Consideration *Yi-Jhen Jian, *Chien-Wei Wu(National Tsing Hua University, Taiwan)*	1100
TA4-6 (225)	A Variables Multiple Dependent State Sampling Plan for Products with Unilateral Specification Limit *Chih-Chieh Chang Chien, *Chien-Wei Wu, Yi-Feng Hung(National Tsing Hua University, Taiwan)*	1105

TA5 Sustainable Management

Ramada-1, 08:40-10:40

Chair: Mei-Fang Chen (Tatung University, Taiwan)

TA5-1 (35)	Sustainable supply chain management in competitiveness environment *Ming-Lang Tseng(Lunghwa University of Science and Technology, Taiwan), *Anthony Shun Fung Chiu(De La Salle University, Philippines), Ming Lim(Derby University, United Kingdom)*	1110
TA5-2 (114)	Sustainable management of Taiwan's semiconductor supply chain **Chi-Tai Wang, Chui-Sheng Chiu(National Central University, Taiwan)*	1119
TA5-3 (136)	The Use of Smart Meter Data to Analyze the Consumption Patterns *Chia-Yu Shen(National Tsing Hua University, Taiwan), *Hsiao-Fan Wang(Hsinchu, Taiwan)*	1124
TA5-4 (137)	Time of Use Electricity Pricing Optimization in a Monopolized Electricity Market *Hsin-Yu Chiang, *Hsiao-Fan Wang(National Tsing Hua University, Taiwan)*	1131
TA5-5 (291)	Modeling and Optimization of Power Storage Strategy of Hybrid Renewable Energy System in Uncertainty Environments *Chi-Kang Su, *Kuo-Hao Chang(National Tsing Hua University, Taiwan)*	1136
TA5-6 (347)	What psychological factors influence the protection motivation of climate change? **Mei-Fang Chen(Tatung University, Taiwan)*	1141

TA6 Simulation 2

Ramada-2, 08:40-10:40

Chair: Udom Janjarassuk (King Mongkut's Institute of Technology Ladkrabang, Thailand)

TA6-1 (98)	Application of Agent-Based Modeling and Simulation for an Outpatient Department in a Hospital **Chumpol Yuangyai(King Mongkut's Institute of Technology Ladkrabang, Thailand), Udom Janjarassuk(Faculty of Engineering, Thailand), Chonnupong Siritan(King Mongkut's Institute of Technology Ladkrabang, Thailand), Kanokporn Rienkhemaniyom(King Mongkut's University of Technology Thonburi, Thailand)*	1147
TA6-2 (105)	Integrated Maintenance and Inventory Optimisation Model for Offshore Assets **Winda Cahyo(Islamic University of Indonesia, Indonesia)*	1154

TA7 Production & Operations Management 1

Ramada-3, 08:40-10:40

Chair: Takayoshi Tamura (Aichi Institute of Technology, Japan)

TA8 Logistics Management

Ramada-4, 08:40-10:40

Chair: Anchalee Supithak (Thai-Nichi Institute of Technology, Thailand)

(344) **Apichit Manee-ngam(Faculty of Engineering, Thailand), Apinanthana Udomsakdigool(King Mongkut's University of Technology Thonburi, Thailand)*

TA8-6 (313) Monitoring Framework for Dynamic Inbound Flows 1264
*Kiyoul Lee(POSTECH (Pohang University of Science & Technology), Korea), Hyunbo Cho(POSTECH (Pohang University of Science & Techonology), Korea), *Mooyoung Jung(UNIST (Ulsan National Institute of Science & Technology), Korea)*

TA9 Uncertainty Theory (Session II)

Halla(8F), 08:40-10:40

Chair: Xiaowei Chen (Nankai University, China)

TA9-1 (558) Towards Uncertain Network Optimization 1270
**Jin Peng(Huanggang Normal University, China)*

TA9-2 (559) Viral Marketing of Multiple-Attribute Products in a Social Network 1271
*Wei Li, *Yaodong Ni(University of International Business and Economics, China)*

TA9-3 (560) Uncertain Logic Controller and Its Applications 1279
**Wei Dai(Central University of Finance and Economics, China)*

TA9-4 (561) Uncertain Random Multilevel Programming 1280
**Hua Ke(Tongji University, China)*

TA9-5 (565) Assets Pricing and Risk Management in Uncertain Market 1281
**Xiaowei Chen(School of Economics Nankai University, China)*

TA9-6 (428) Liquidity Crashes and Robust Portfolio Management 1282
*Seungkyu Lee(Pohang University of Science and Technology, Korea), *Bong-Gyu Jang, Seyoung Park(POSTECH, Korea)*

TB1 Supply Chain Management 3

Mara, 14:20-16:00

Chair: Muhammad Rusman (Hasanuddin University, Indonesia)

TB1-1 (165) Nash Equilibrium Retail Prices in a Planer Duopoly Market 1295
**Koichi Nakade, Akira Kanazawa(Nagoya Institute of Technology, Japan)*

TB1-2 (176) A Proposal of Bargaining Solution for Cooperative Contract in a Supply Chain 1303
**Wakana Kato, Ikuo Arizono(Okayama University, Japan)*

TB1-3 (208) Capacity Planning and Partnership Management 1310
**Cheng-Hung Wu, Wen-Lan Hsu(National Taiwan University, Taiwan)*

TB1-4 (160) A muli-objective facility location problem in congested systems with service level for each facility and competitive environment 1314
**Mahsa Boroushaki(M.Sc. student of industrial engineering, Iran), hasan hosseini nasab(Associate professor, Iran)*

TB1-5 (234) Blood Bank Location Model for Blood Distribution Planning in Makassar City 1323
**Muhammad Rusman(Hasanuddin University, Indonesia), Amrin Rapi(Ministry of Industry of Republic of Indonesia, Indonesia)*

TB2 Management of Technology and Innovations 2

Biyang, 14:20-16:00

Chair: Chih Wang (National Chiao Tung University, Taiwan)

TB2-1 (188) Establishment and development of the innovation-promoting organization for Industry 1328
**Kana Hayase, Nobutaka Odake(Nagoya Institute of Technology, Japan), Takeshi Matsumoto(Osaka Gas Co., Japan)*

TB2-2 (425) Using Innovative Intellectual Property Indicators to Identify National Knowledge Flow Effects 1336
**Chin-Yuan Fan, Chia-Hao Hsu(Science & Technology Policy Research and Information Center, Taiwan), shu-hao Chang(National Applied Research Labs, Taiwan), pin-hua Lin(Zhongli, Taiwan)*

TB2-3 (317) Development of Virtual Organisation Framework Model in Tourism Industry Using Axiomatic Design 1345
*Agus Fauzi, Eny Maftuchah, Nasrullah Setiawan, Bambang Suratno(Universitas Islam Indonesia, Indonesia)

TB2-4 (150) Supporting Technology Foresight for Disruptive Innovation: Keyword-based Visual Analysis for Futuristic Data 1352
Jieun Kim, *Yongtae Park(Seoul National University, Korea)

TB2-5 (22) Combining correspondence analysis with association rule mining to carry out market segmentation and product configuration 1358
*Chih Wang(National Chiao Tung University, Taiwan)

TB3 Data Mining 3

Udo, 14:20-16:00

Chair: Jen-Ying Shih (National Taiwan Normal University, Taiwan)

TB3-1 (437) Comparative Benchmarking Analysis among Fine Jewelry and Costume Jewelry Companies in the Philippines Using Data Envelopment Analysis (DEA) 1366
*Dennis Beng Hui, Emil Fernandez(De La Salle University Manila, Philippines)

TB3-2 (469) A Prediction Method based on Weighted Ensemble of Decision Tree on Alternating Decision Forests. 1375
*Shotaro Misawa, Naohiro Fujiwara(Graduate Student of Waseda University, Japan), Kenta Mikawa(Waseda University, Japan), Masayuki Goto Goto(Waseda University., Japan)

TB3-3 (486) Creating Attractive Digital Signage Content at Universities 1383
*RYO AKAIWA(Aoyama Gakuin University, Japan), RYUJI MAEKAWA, KAKURO AMASAKA(AOYAMA GAKUIN UNIVERSITY, Japan)

TB3-4 (502) A Data Mining Approach for Loan Marketing Response Model 1388
*Jen-Ying Shih(National Taiwan Normal University, Taiwan), Wun-Hwa Chen(National Taiwan University, Taiwan)

TB3-5 (581) The 7-Eleven Rule in the Simulation Output Analysis 1394
*Wheyming Song(professor, Taiwan)

TB4 Scheduling & Sequencing 1

Chuja, 14:20-16:00

Chair: Byung Do Chung (Sungkyunkwan University, Korea,)

TB4-1 (122) A two-stage assembly scheduling problem with makespan minimization 1413
Lulu Hu, *Tsui-Ping Chung, Hongying Shan(Jilin University, China), Chien-Ming Chen(Harbin Institute of Technology Shenzhen Graduate School, China)

TB4-2 (233) Particle swarm Optimization for minimizing electrical consumption for flexible flowshop problem 1420
Krisanarach Nitisiri(Research Unit on Advanced Productivity Improvement and Logistics Management, Thailand), *Kanchana Sethanan(Faculty of engineering. Khon Kaen university, Thailand)

TB4-3 (284) Campaign Planning for Multi-Purpose Batch Plants: A Case Study from the Pharmaceutical Industry 1427
Mao-Kai Hsu, *Kuo-Hao Chang(National Tsing Hua University, Taiwan)

TB4-4 (287) Multi-Jobs Lot Streaming to Minimize the Mean Maximum Completion Time in Multi-Stages Hybrid Flow Shop Scheduling 1434
*Said Syahputra(Institut Teknologi Bandung, Indonesia, Indonesia), Anas Ma'ruf(Indonesia, Indonesia)

TB4-5 (309) Shift-Scheduling Characteristic Identification of Non-Star Hotel Industry in Yogyakarta Indonesia 1442
*Deny Yuniartha(Universitas Atma Jaya Yogyakarta, Indonesia), Ignatius Luddy Indra Purnama(Atma Jaya Yogyakarta University, Indonesia)

TB5 Knowledge & Information Management

Ramada-1, 14:20-16:00

Chair: Minseok Song (Ulsan National Institute of Science and Technology, Korea)

TB5-1 (250)	Mergers and Acquisitions of ICT Firms for Technological Knowledge Sourcing *Yoonjung An, *Yongtae Park(Seoul National University, Korea)*	1449
TB5-2 (278)	Analyzing Service Processes Using Process Mining: A Case Study *Hanna Yang, *Minseok Song(Ulsan National Institute of Science and Technology, Korea)*	1454
TB5-3 (445)	Document Control for Research Reactor Construction by Advanced Nuclear Safety Information Management System **Kook-Nam Park(Korea Atomic Energy Research Institute, Korea), Sung-Kyu Lee(Divi-vision Co., Korea), Seung-Mi Baek(Korea Atomic Energy Research Instituti, Korea), Min-Ho Choi(Korea Atomic Energy Research Institute, Korea), Yong-Se Kwon(Korea Atomic Energy Research institute, Korea)*	1458
TB5-4 (297)	Factors influencing user acceptance of intelligent personal assistants on smart devices *Jihye Park(LG Household & Health Care, Korea), Euiho Suh(Pohang University of Science and Technology, Korea), *Kiwon Lee(Pohang University of Science and Technology (POSTECH), Korea)*	1463
TB5-5 (389)	Prognosis and Survival Prediction of Lung Cancer by Bayesian Network **Shi-Woei Lin, Yu-Wei Chen, Mohammad Jerusalem(National Taiwan University of Science and Technology, Taiwan)*	1471

TB6 Production & Operations Management 2

Ramada-2, 14:20-16:00

Chair: Ivy Mar Lamos (Bulacan State University, Philippines)

TB6-1 (49)	Application of ECRS and Simulation Techniques in Bottleneck Identification and Improvement:A Paper Package Factory **Chompoonoot Kasemset, Prin Pinmanee, Primapun Umarin(Chiang Mai University, Thailand)*	1477
TB6-2 (124)	Assembly line type II problem of sewing lines in garment industry *James C. Chen(National Tsing Hua University, Taiwan), Tzu-Li Chen(Fu Jen Catholic University, Taiwan), Yi-Jhen Lin, *Chun-Ju Lin, Yi-Hsin Hu(National Tsing Hua University, Taiwan)*	1485
TB6-3 (151)	EFFICIENCY AND BETTER PRODUCTION FLOW FOR A MANUFACTURER OF STATUES: AN APPLICATION OF MOTION AND TIME STUDY **Ivy Mar Ramos, Ivy Mar Ramos(Bulacan State University, Philippines)*	1492
TB6-4 (187)	A Genetic Algorithm for Solving Assembly Line Balancing Problem in Footwear Stitching Line *James C. Chen, Tzu-Li Chen, *Chieh-Ying Lin, Chun-Ju Lin(National Tsing Hua University, Taiwan)*	1500
TB6-5 (12)	Pricing, Production, and Channel Coordination with Stochastic Learning *Tao Li(Santa Clara University, United States), *Suresh Sethi(University of Texas At Dallas, United States), Xiuli He(University of North Carolina at Charlotte, United States)*	1507

TB7 Healthcare Systems 2

Ramada-3, 14:20-16:00

Chair: Gino Lim (University of Houston, UnitedStates)

TB7-1 (95)	Construct the Analysis Platform for Evaluating the Static Postural Stability **Chih-Hung Jen(Lunghwa University of Science and Technology, Taiwan), Bernard C. Jiang(National Taiwan University of Science and Technology, Taiwan), Yin-Sung Chen(Yuan Ze University, Taiwan)*	1512
TB7-2 (106)	Recent Advances in Intensity Modulated Proton Therapy Treatment Planning Optimization **Gino Lim, Wenhua Cao(University of Houston, United States), Radhe Mohan(The University of Texas MD Anderson Cancer Center, United States)*	1520
TB7-3 (306)	Developing A Productivity Improving Framework by Overall Equipment Efficiency and An Empirical Study in A Hospital **Chen-Fu Chien, Pei-Chun Chu, Mei-Li Kuo(National Tsing Hua University, Taiwan)*	1526
TB7-4 (379)	An analysis of patients flow in a hospital case study using Simulation model and plant layout	1534

*Patcharaphorn Poobanchao(KhonKaen University, Thailand), *Panitarn Peerapattana(Department of Industrial Engineering Faculty of Engineering of Khon Kean University, Thailand)*

TB7-5 (76) Willingness to pay for BPJS Health Insurance: Findings from an Exploratory Study 1540
Aries Susanty(Lecturer, Indonesia), nia puspitasari(diponegoro university, Indonesia), Purnawan Wicaksono(Lecturer, India), Petty Primatury(Student, Indonesia)

TB8 Flexible Manufacturing Systems

Ramada-4, 14:20-16:00

Chair: Ibrahim Buseif (, Libya)

TB8-1 (579) The Comparison between Perpetual and Periodic-Review Models for Fast-Moving Products in Convenience Store Distribution Center 1547
Yosi Hidayat, Veronica Adelein, Lucia Diawati(Institut Teknologi Bandung, Indonesia)

TB8-2 (48) Using Petri Net (PN) Model for Design Flexible Manufacturing Systems (Prototype FMS's) 1554
Ibrahim Buseif(Staff member, Libya)

TB8-3 (62) New Model of FMS using FTPN with Demand Variability and Machine Breakdown 1561
Muhammad Haris Aziz(University of Engineering and Technology, Pakistan), Erik L.J. Bohez(Asian Institute of Technology, Thailand), Abid Ali, Neelum Iqbal(UET Taxila, Pakistan)

TB8-4 (286) Cellular Manufacturing System Model under Demand Uncertainty 1567
Muhammad Shodiq Abdul Khannan(Universitas Pembangunan Nasional Veteran Yogyakarta, Indonesia), Anas Ma'ruf(Indonesia, Indonesia), Rachmawati Wangsaputra(Institut Teknologi Bandung, Indonesia), sutrisno sutrisno(UPN Veteran Yogyakarta Indonesia, Indonesia)

TB8-5 (457) An iterative production planning approach for flexible semiconductor fabrication 1575
Sun Hoon Kim, Young Hoon Lee, Cheng Yu Hwang, Kee Yong Shin, Ki Yol Nam(Yonsei University, Korea)

TB9 Topics in IE/MS

Halla(8F), 14:20-16:00

Chair: Taufiq Immawan (Islamic University of Indonesia, Indonesia)

TB9-1 (575) A study on relieving electric power shortage by on-site solar power supply 1579
*SangYun Choe, *Jinwoo Park(Seoul National Univ., Korea)*

TB9-2 (354) Preliminary Study for Mapping of Business Process Re-engineering of Batik in Jogja and Solo 1584
Taufiq Immawan(Islamic University of Indonesia, Indonesia)

TB9-3 (378) Evaluation Method of Information Value Applying for Website 1590
GaoYang Liang(Graduate School of Business Administration Daito Bunka University, Japan), Kiyoshi Nagata(Informatics Faculty of Business Administration and Department of Business Studies Daito Bunka University, Japan)

TB9-4 (212) Lean Production in Automotive Parts Industry-A Case Study 1598
*James C. Chen(National Tsing Hua University, Taiwan), Tzu-Li Chen(Fu Jen Catholic University, Taiwan), Kirin Chen, Amy Hung(AXIS-group, Taiwan), *Yu Liang, Chun-Ju Lin(National Tsing Hua University, Taiwan)*

TB9-5 (202) Optimum Humanitarian Relief Logistics for Facility and Stock Location under Time Restriction: Thai Flooding Case Study 1604
WAPEE MANOPINIWES, KEISUKE NAGASAWA, TAKASHI IROHARA(Sophia University, Japan)

TC1 Heuristics/Metaheuristics

Mara, 16:20-18:00

Chair: Ma. Cecilia Buseif (Mapua Institute of Technology, Philippines)

TC1-1 (70) GA-BASED OPTIMAL FACILITY LAYOUT DESIGN: CROSSOVER AND MUTATION PROBABILITY EVALUATIONS 1612
*Maricar Misola(Technological Institute of the Philippines- Quezon City, Philippines), *Ma. Cecilia Carlos(Mapua Institute of Technology, Philippines), Bryan Navarro(Philippine Institute of Industrial Engineers (PIIE), Philippines)*

TC1-2 (464) An Improved Differential Evolution Algorithm for Vehicle Routing Problem: An Application in Mobile Medical Equipment Maintenance Unit 1620
Kanokwan Supakdee(Department of Industrial Management Technology, Thailand), Natthapong Nanthasamroeng(Faculty of Industrial Technology, Thailand), Rapeepan Pitakaso(Metaheuristics for Logistics Optimization Laboratory (MLO), Thailand)

TC1-3 (481) Heuristic for multi-stage capacitated p-median problem with supplier evaluation 1626
Anurak Chaiwichian, Rapeepan Pitakaso(Ubonratchathani University, Thailand)

TC1-4 (520) Heuristic Shift Scheduling forAirport Ground Staff 1633
Kong Weng Lee(UNIMAS, Malaysia), San Nah Sze(Faculty of Computer Science and Information Technology Universiti Malaysia Sarawak, Malaysia), Keat Keong Phang(Faculty of Computer Science and Information Technology Universiti Malaya, Malaysia)

TC1-5 (192) Optimization of Milk Productivity in Dairy Cattles by Genetic Algorithm 1639
Senol Altan(Gazi University, Turkey), Fatih Akturk(Ulsan National Insttute Of Science and Technology, Korea), Emrecan Ozeler(Republic of Turkey Ministry of Food, Turkey)

TC2 Inventory Modeling / Artificial Intelligence

Biyang, 16:20-18:00

Chair: Wisut Supithak (Kasetsart University, Thailand)

TC2-1 (381) Multi-Item Economic Production Quantity Model with the Consideration of Raw Material Inventory Management Costs 1647
Wisut Supithak(Kasetsart University, Thailand), Sasiprapa Limpakan(Kasetsart Uniersity, Thailand)

TC2-2 (123) A Stochastic Programming Model for Vendor Managed Inventory System of an Animal Feed Factory and Farm Network 1654
Thawee Nakrachata-Amon(Faculty of Engineering, Thailand), Supachai Pathumakul(Khon Kaen University, Thailand)

TC2-3 (101) Vender Managed Inventory for Fresh Agricultural Products 1659
Mitsuyoshi Horikawa, Takeo Takeno, Mitsumasa Sugawara(Iwate Prefectural University, Japan)

TC2-4 (318) Vehicle risk assessment in accidents using neural network 1665
*Yuri Castro, *Young Jin Kim, Baek An Sun(Kyung Hee University, Korea)*

TC3 Artificial Intelligence

Udo, 16:20-18:00

Chair: Ronaldo Polancos (De La Salle University, Philippines)

TC3-1 (182) The Study of Tokai Cluster as a Leader of CFRP Industries in Japan 1672
Akihito Zenke, Nobutaka Odake(Nagoya Institute of Technology, Japan)

TC3-2 (260) Agent-based Real-time Scheduling for Smart Household Appliances 1678
*Bobby Kurniawan, *Anggoro Pramudyo, Didik Aribowo(Untirta, Indonesia), Anas Ma'ruf(Institut Teknologi Bandung, Indonesia)*

TC3-3 (391) APPLICATION OF CLOUD-BASED KANBAN SYSTEM IN PROJECT MANEGEMENT 1683
*Chi-Wei Shih, *Chen-Yang Cheng(Tunghai University, Taiwan)*

TC3-4 (490) User's Free Time Estimation When Using Smartphone 1688
kohei Yamamoto(Kanazawa Graduate School of Natural Science and Technology, Japan), Tatsuhito Hasegawa(Tokyo Health Care University, Japan), Haruhiko Kimura(Kanazawa University, Japan)

TC3-5 (499) Earned Value Management considering Milestone Weighting and Dependency Structure Matrix 1692
Ronaldo Polancos(De La Salle University, Philippines)

TC4 Scheduling & Sequencing 2

Chuja, 16:20-18:00

Chair: Hans-Otto Guenther (Seoul National University, Korea)

TC4-1 (399) Improvement of Scheduling n Jobs m Machines Parallel Algorithm to Minimize Makespan 1696
Rifa Arifati(University of Pembangunan Nasional Veteran Jakarta, Indonesia), Aji P.

Gunoto(Universitas Pembangunan Nasional Veteran Jakarta, Indonesia)

TC4-2 (405)	A Batch-scheduling problem to minimize actual flowtime of parts through the shop which has m heterogenous batch processors *Nita Hidayat(Industrial Engineering ITB, Indonesia), Andi Cakravastia, TMA Ari Samadhi(Bandung Institute of Technology, Indonesia), *Abdul Halim(Industrial Engineering ITB, Indonesia)*	1701
TC4-3 (418)	Genetics Algorithm for Hybrid and Flexible Flowshop with Non-Identical Machines and Subcontract Case **Nora Azmi(Trisakti University, Indonesia), Gibtha Fitri Laksmi(Ibnu Khaldun University, Indonesia)*	1707
TC4-4 (398)	Mixed Integer Linear Programming for Un-related Parallel Machine Problems to Minimize Total Earliness and Tardiness - A Case Study of Precision Metal Tools Industry *Chun Hsiung Lai, *Chen-Yang Cheng(Tunghai University, Taiwan)*	1714
TC4-5 (79)	A block planning model for integrated lot sizing and scheduling of continuous casters and hot strip mills in the steel industry **Hans-Otto Guenther(Seoul National University, Korea), Imke Mattik(TU Berlin, Germany)*	1719

TC9 Lean Production Management

Halla(8F), 16:20-18:00

Chair: Kenichi Nakashima (Kanagawa university, Japan)

TC9-1 (542)	Single-period inventory model considering a competitive store and two qualities of the product **Takashi Hasuike(Osaka University, Japan)*	1720
TC9-2 (546)	A Single-Producer Multi-Retailer Integrated Inventory System with Scrap in Production and Shortage in sale **Hitoshi Hohjo, Tomoki Koreeda(Osaka Prefecture University, Japan)*	1728
TC9-3 (94)	Joint replenishment problem with can-order policies under carrier capacity and correlated demands **KEISUKE NAGASAWA, Takashi Irohara(Sophia University, Japan), Yosuke Matoba, Shuling Liu(Fairway Solutions Inc., Japan)*	1733
TC9-4 (545)	Inventory-Production System with Non-Zero Target Inventory **Mohammadreza Parsanejad(Keio University, Japan), Bongsung Chu(Soonchunhyang University, Japan), Hiroaki Matsukawa(Keio University, Japan)*	1741
TC9-5 (547)	A Lean Supply Chain Control Problem with Stochastic Demand **Kenichi Nakashima, Thitima Sornmanapong(Kanagawa University, Japan), Hans Ehm(Infineon Technologies AG, Japan), Geraldine Yachi(nfineon Technologies AG, Japan)*	1746

WA1 Inventory Modeling & Management

Mara, 08:30-10:10

Chair: Nobuaki Ishii (Bunkyo University, Japan)

WA1-1 (65)	A Lot Size-Based Collaborative Demand-to-Supply Management System for Make-to-Order Environment **Nobuaki Ishii(Bunkyo University, Japan), Ko Sakashita, Tetsuo Yamada(University of Electro-Communications, Japan), Masaaki Ohba(Nihon University, Japan), Masayuki Matsui(Kanagawa University, Japan)*	1754
WA1-2 (80)	Reorder Point Determination Considering Customer Service Constraint under Limited Demand Information **Yasuhiko Takemoto(Prefectural University of Hiroshima, Japan), Ikuo Arizono(Okayama University, Japan)*	1762
WA1-3 (71)	Inventory Classification Involving Substitution Rules **ikou kaku, Xinyi Zhang(Tokyo City University, Japan)*	1769
WA1-4 (446)	Reducing Inventory using Inventory Management Models **Sakgasem Ramingwong, Danuchin Anantana(Center of Excellence in Logistics and Supply Chain Management, Thailand)*	1775
WA1-5 (518)	An Approach for Avoiding Information Loss in Managing Product Safety Issue Associated with Suppliers *Muhammad Saad Memon, **Young Hae Lee, Sonia Irshad Mari(Hanyang University, Korea)*	1779

WA2 SCM and Forecasting 1

Biyang, 08:30-10:10

Chair: Kazuhiro Takeyasu (Tokoha University, Japan)

WA2-1 (92)	Forecasting utilizing a Day of the Week Index in the Case of Cafe *Koumei Suzuki, Kazuhiro Takeyasu(Tokoha University, Japan)	1787
WA2-2 (31)	Building BTO System in the Sanitary Materials Manufacturer Under the Improvement of Forecasting Accuracy *Kazuhiro Takeyasu(Tokoha University, Japan), hirotake yamashita(Chubu University, Japan)	1795
WA2-3 (34)	UTILIZATION OF GENETIC ALGORITHM TO IMPROVE FORECASTING ACCURACY ? AN APPLICATION TO THE DATA OF A TUBE AND A CATHETER? *Daisuke Takeyasu(The Open University of Japan, Japan), Kazuhiro Takeyasu(Tokoha University, Japan)	1803
WA2-4 (32)	Optimal operation for green supply chain with quality of recyclable parts and contract for recycling activity *Etsuko Kusukawa(Osaka Prefecture University, Japan), Sho Akizawa(Nara Institute of Science and Technology, Japan)	1811
WA2-5 (102)	A Hybrid Method to Improve Forecasting Accuracy In the Case of Japanese Food Restaurant *Jun Tatebayashi, Kazuhiro Takeyasu(Tokoha University, Japan)	1819

WA3 Production Design & Management 1

Udo, 08:30-10:10

Chair: Philip Ermita (PIIE, Philippines)

WA3-1 (117)	Development a Latex Pillow to Meet Customer Requirements *Nattapong KONGPRASERT(Facluty of Engineering, Thailand)	1827
WA3-2 (162)	BananaNut Paper: REENGINEERING PAPER COMPONENT *Marianne Calayag(Bulacan State University, Philippines)	1834
WA3-3 (198)	An Optimal Modularity for Platform-based Product Family Design of Wind Power Generators *Qingnan Li(University of Southern Denmark, Denmark)	1838
WA3-4 (222)	Composite Board Development: Use of Cardava Banana Peel and Watermelon Rind as Alternative Raw Materials *Philip Ermita(PIIE, Philippines)	1845
WA3-5 (249)	Fairing of High Speed Milling tool-path by Using The Cubic NURBS *Anh Duong, Anh Duong(International University in Vietnam, Viet Nam)	1852

WA4 Scheduling & Sequencing 3

Chuja, 08:30-10:10

Chair: San-Nah Sze (Universiti Malaysia Sarawak, Malaysia)

WA4-1 (85)	Scheduling with multi-attribute setup times on unrelated parallel machines Ching-Jong Liao(National Taiwan University of Science and Technology, Taiwan), *Cheng-Hsiung Lee(Chihlee Institute of Technology, Taiwan), Hsing-Tzu Tsai, Kuo-Jui Wu(National Taiwan University of Science and Technology, Taiwan)	1859
WA4-2 (120)	Scheduling on parallel machines with mold constraints Haidan Zhao, *Tsui-Ping Chung, Hongying Shan(Jilin University, China), Chien-Ming Chen(Harbin Institute of Technology Shenzhen Graduate School, China)	1867
WA4-3 (177)	Transient Period Scheduling of Dual Armed Cluster Tools *Nurhak Aktas, Taesun Yu, Tae-Eog Lee(KAIST, Korea)	1874
WA4-4 (316)	Adaptive Hybrid Genetic algorithm for solving two-stage reentrant flexible flow shop with blocking constraint Chatnugrob Sangsawang, *Kanchana Sethanan(Research Unit on Advanced Productivity	1880

Improvement and Logistics Management, Thailand), Mitsuo Gen(Fuzzy Logic Systems Institute, Japan)

WA4-5 (509) Decision Support System for Order Online Delivery 1888
San-Nah Sze, Bui-Fat Thian, Kang-Leng Chiew(Universiti Malaysia Sarawak, Malaysia)

WA5 Fuzzy Logic

Ramada-3, 08:30-10:10

Chair: Rionel Caldo (Lyceum of the Philippines University - Laguna, Philippines)

WA5-1 (30) Predictive Approach of Assessing the Passing of Engineering Board Courses in Lyceum of the Philippines University-Laguna (LPU-L) Using Fuzzy Logic Technology 1894
Rionel Caldo(Lyceum of the Philippines University - Laguna, Philippines)

WA5-2 (58) Fuzzy Logic Simulation of DC-DC Boost Converter Using Matlab Fuzzy Logic Toolbox 1902
*Rionel Caldo, *Rionel Caldo(Lyceum of the Philippines University - Laguna, Philippines)*

WA5-3 (224) Cost Effectiveness Analysis Comparing Mastectomy versus Lumpectomy with Fuzzy Logic 1908
*Aysun Aktas, *gozde tutuncu(Izmir University of Echonomics, Turkey)*

WA5-4 (576) Fuzzy AHP based Supplier Selection considering the Triple Bottom Line Concept 1914
*Wannimit Khampanya, Tritos Laosirihongthong(Thammasat University, Thailand), *Premaratne Samaranayake(University of Western Sydney, Australia)*

WA6 Optimization Techniques 2

Ramada-4, 08:30-10:10

Chair: Daniel Siek (Chung Yuan Christian University, Taiwan)

WA6-1 (125) Impact of Globalization on Total Factor Productivity of the Manufacturing Sector in Pakistan 1920
Usama Bin Perwez, Muhammad Faseeh Tahir, Aamir Ahmed Baqai(National University of Sciences & Technology, Pakistan)

WA6-2 (69) Optimal Solar Photovoltaic (PV) Penetration in Secondary Distribution Network Using Genetic Algorithm 1929
*Bryan Navarro(Technological Institute of the Philippines, Philippines), *Maricar Misola(Technological Institute of the Philippines- Quezon City, Philippines)*

WA6-3 (288) Numerical Analysis of Three Rookies Assignment Optimization in Limited-Cycled Model with Multiple Periods -the case of Erlang Distribution 1937
Peiya Song, Xianda Kong, Hisashi Yamamoto(Tokyo Metropolitan University, Japan), Jing Sun(Nagoya Institute of Technology, Japan), Masayuki Matsui(Kanagawa University, Japan)

WA6-4 (577) Optimal Ordering Policies under a Progressive Interest Scheme with Supplier's Quantity Discount 1945
*Gary Chen, *Daniel Siek, Hui Wee(Chung Yuan Christian University, Taiwan)*

WA6-5 (415) An analysis on the influences of flat pricing for unlimited voice callings: the aspects of MNOs and consumers in Korea 1951
SEONGJUN LEE, SAESOL CHOI(Electronics and Telecommunications Research Institute, Korea)

WB1 Industrial Engineering Education

Mara, 10:30-12:10

Chair: Young Jae Jang (KAIST, Korea)

WB1-1 (526) Solution Based Learning: A New Approach in Product Design and Development Andragogy 1957
Risdiyono Risdiyono(Islamic University of Indonesia, Indonesia)

WB1-2 (139) A study for making standardized-work tables suited for enterprises of the engineering / metalworking industry 1962
Masahiro Shibuya(Tokyo Metropolitan University, Japan), Kenichi Iida(Hokkaido Research Organization, Japan), Koki Mikami(Hokkaido University of Science, Japan)

WB1-3 (256) "Implementation of methods and solutions for improving statistical thinking of non-English speaking students studying in Industrial Engineering field" 1967
Huy Nguyen, Huy Nguyen, Huy Nguyen(International University - Vietnam National University

HCMC, Viet Nam)

WB1-4 (495) Industrial Engineering Education using KAIST LEGO Manufacturing Systems (KLMS) 1975
Young Jang, Vina Yosephine(KAIST, Korea), Sun Kyung Oh(Korea Advanced Institute of Science and Technology, Korea), Sukhyun Cho, Kiryong Kyeong(KAIST, Korea)

WB2 SCM and Forecasting 2

Biyang, 10:30-12:10

Chair: Kazuhiro Takeyasu (Tokoha University, Japan)

WB2-1 (52) Improving Forecasting Accuracy in the Case of Intermittent Demand Forecasting 1983
*Daisuke Takeyasu(The Open University of Japan, Japan), *Asami Shitara(Tax Corporation Arknet, Japan), Kazuhiro Takeyasu(Shizuoka City, Japan), Asami Shitara(Tax Corporation Arknet, Japan)*

WB2-2 (36) Reformation of Production System Based Upon Demand Forecasting 1991
*hirotake yamashita(Chubu University, Japan), *Kazuhiro Takeyasu(Tokoha University, Japan)*

WB2-3 (87) A Hybrid Method to Improve Forecasting Accuracy with An Application to the Data of Bread 1999
Yuki Higuchi(Setsunan University, Japan), Hiromasa Takeyasu(Kagawa???Junior???College, Japan), Kazuhiro Takeyasu(Tokoha University, Japan)

WB2-4 (413) EXTENDED OPTIMAL REPLACEMENT POLICY FOR A TWO-UNIT SYSTEM UNDER CUMULATIVE DAMAGE MODEL 2006
Shey-Huei Sheu, TZU-HSIN LIU(Providence University, Taiwan), ZHE-GEORGE ZHANG(Western Washington University, United States)

WB3 Production Design & Management 2

Udo, 10:30-12:10

Chair: Masahiro Arakawa (Nagoya Institute of Technology, Japan)

WB3-1 (283) The Implementation of Affective Based Product Design in Small Enterprise Manufacturers 2007
Imam Widodo, Tio Sampurno(Islamic University of Indonesia, Indonesia)

WB3-2 (348) A Study of Product Design Using Parts and Parts Structures Characterized by Reviews on Internet 2012
Masahiro Arakawa, Eriko Katou(Nagoya Institute of Technology, Japan)

WB3-3 (350) Derivation of design freeze sequence using Bayesian network framework 2018
*Jihwan Lee, *Yoo Hong(Seoul National University, Korea)*

WB3-4 (93) Investigation of PLA/PCL biocomposite scaffolds fabricated via SVM rapid prototyping 2025
*Kanokporn Kamonchit, *Thittikorn Phattanaphibul(Kasetsart University (Sriracha Campus), Thailand)*

WB3-5 (84) Assessment of an ERP Graphical User Interface Design Related to Human Cognition 2031
Grace Lorrain Intal, Catherine Briones(Mapua Institute of Technology, Philippines)

WB4 Scheduling & Sequencing 4

Chuja, 10:30-12:10

Chair: Katsumi Morikawa (Hiroshima University, Japan)

WB4-1 (329) Simulation-based outpatient appointment scheduling with the aid of clearing function 2040
Katsumi Morikawa, Katsuhiko Takahashi(Hiroshima University, Japan), Daisuke Hirotani(Prefectural University of Hiroshima, Japan)

WB4-2 (46) Flexible Jobshob Scheduling Model Considering Production Cost and Tardiness Cost Simultaneously 2048
Devy Sari, Anas Ma'ruf(Institut Teknologi Bandung (Bandung Institute of Technology), Indonesia)

WB4-3 (403) Batch Scheduling for a Single Machine with Forgetting Effect to Minimize Total Actual Flow Time 2055
*Rinto Yusriski, *Sukoyo -(Bandung Institute of Technology, Indonesia), T.M.Agung Samadhi(Institut Teknologi Bandung, Indonesia), Abdul Halim(Industrial Engineering ITB, Indonesia)*

WB4-4 (426) Integrating Batch Production and Maintenance Scheduling on a Deteriorating Machine to Minimize Production and Maintenance Costs in Just in Time Environment 2061

*ZAHEDI *(INSTITUT TEKNOLOGI BANDUNG, Indonesia), TMA Ari Samadhi, Suprayogi .(Bandung Institute of Technology, Indonesia), *Abdul Halim(Industrial Engineering ITB, Indonesia)*

WB5 Quality Engineering & Reliability

Ramada-3, 10:30-12:10

Chair: Rionel Caldo (Lyceum of the Philippines University - Laguna, , Philippines)

WB6 Lean Manufacturing

Ramada-4, 10:30-12:10

Chair: Daniel Siek (Chung Yuan Christian University , Taiwan)

POSTER Poster Session

Halla(8F), 13:00-18:00

Chair: (,)

Application of Particle Swarm Optimization for the Capacitated Team Orienteering Problem

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Abstract. The capacitated team orienteering problem (CTOP) is one of important transportation problem that can be faced by any organization. In this problem, there are several location or being called vertex. Each vertex has specific score, which will be collected if the vertex is visited by any transportation vehicle. The transportation time between two vertices are defined. There are time and capacity constraints of transportation vehicles, indicates by *T* and *Q*, respectively. The CTOP objective is to find the path of several transportation vehicles visiting some selected vertices in order to maximize total collected score within the constraint of *T* and *Q*. Various algorithms, such as branch and price, variable neighborhood search, and bi-level filter and fan, have been proposed for solving the CTOP. While the particle swarm optimization (PSO) has been applied to solve similar problems of CTOP such as team orienteering problem (TOP) and team orienteering problem with time windows (TOPTW). This paper tries to apply the PSO for solving the CTOP. The computational results show that the proposed PSO algorithm is able to obtain 47 best known solutions of 130 benchmark problems.

Keywords: Capacitated Team Orienteering Problem, Particle Swarm Optimization, Solution Representation, Computational Method, Metaheuristics

1. INTRODUCTION

The capacitated team orienteering problem (CTOP) is a problem for determining several paths of transportation vehicle in order to maximize total collected profit by visiting some customer through the paths with some restrictions. As defined in earlier research, i.e. Archetti et al. (2009), the CTOP can be formally defined as follow. Let us consider a set of visiting points $V = \{1, 2, \ldots, n\}$ represent potential customers, plus a depot indexed by 0. Let $G=(V,E)$ be an undirected graph where G is the set of vertices and E is the set of edge. m identical vehicles of capacity Q are stationed at the depot. A non-negative demand d_i and a non-negative profit p_i is associated with each customer i, whereas $p_0 = d_0 = 0$. A symmetric travel time t_{ij} is associated with each edge $(i, j) \in E$. Each vehicle starts and ends its tour at the depot (vertex 0), and can visit any subset of customers with a total demand that does not exceed the capacity Q. The profit of each customer can be collected by one vehicle at most. A subset of the potential customers available has to be selected, in order to maximize the total collected profit while satisfying, for each vehicle, a time limit T on the tour duration and the capacity constraint Q.

This problem is one of important transportation problem that can be faced by any organization besides the orienteering problem (OP), team orienteering problem (TOP), traveling salesman problem (TSP), and vehicle routing problem (VRP). All of these problems are concerned with the transportation of vehicle(s) to visit some customers. Regarding to the customers to be visited, the TSP and VRP are required all customers to be visited, while the OP, TOP, and CTOP are not need this requirement. Regarding to the number of vehicles, the OP and TSP are problems with single vehicle, while the TOP, CTOP, and VRP are problems with more than one vehicles. Regarding to the capacity of vehicle(s), the OP, TSP, and TOP are not including vehicle capacity as constraint, while the CTOP and VRP include vehicles capacity as their constraints. More detail reviews on these problems can be found in Guttin and Punnen (2002), Golden et al. (2008), and Vansteenwegen et al. (2011).

Similar with TOP, the CTOP is also an NP-hard problem, hence some exact and heuristics approaches had

been proposed in the past for solving the CTOP. For solving the CTOP, Archetti et al. (2009) proposed an exact method, which is branch-and-price method, and three metaheuristics, which are variable neighborhood search, and two variations of tabu search: tabu feasible and tabu admissible. Tarantilis et al. (2013) proposed a heuristics called bi-level filter and fan method for solving the CTOP. They proposed slow and fast version of the method, based on the number of iterations used in the method.

Since PSO has been successfully applied for solving other problems that are related to CTOP, such as VRP (Ai and Kachitvichyanukul, 2009; Kuo et al., 2012; Tlili et al., 2013) and TOP (Dang et al., 2013; Ai et al., 2013), therefore, this paper tries to solve the CTOP by using a PSO algorithm. The rest of this paper is organized as follows: Section 2 describes the PSO for solving the CTOP. Section 3 presents the computational result, and the last section concludes the paper and gives suggestions for further research.

2. PROPOSED PSO ALGORITHM

Kennedy and Eberhart (1995) proposed the Particle Swarm Optimization (PSO), which is a population-based stochastic optimization technique, by mimicking the physical movement of individuals in the swarm as searching mechanism of optimal solution. In the PSO, the capability of solution searching is included in the properties of a group of particles, which are called position and velocity. A multi-dimensional-space particle position represents an alternative of problem solution. Velocity of particle is the driver of particle movement from one position to another. By moving to other position, another alternative of problem solution is evaluated.

For driving the movement of particles, PSO also imitates two important behaviors of the swarm organism, which are the cognitive behavior and the social behavior. The cognitive behavior is defined as the tendency of particle moving towards the best position ever visited by the particle, which is usually called personal best or pbest. While the social behavior is defined as the tendency of particle moving towards the best position ever visited by all particles in the swarm, which is usually called global best or gbest. The movement of particle in certain period of time is driven by three different directions that are: 1) follow its own way, 2) go towards its personal best position, and 3) go towards its global best position.

In general, the algorithm of PSO can be formally defined as follow:

1. initialization of particles, their position and initial velocity,
2. decode particles into problem solutions,
3. evaluate the quality of particles, based on their corresponding objective functions,
4. update pbest value,
5. update gbest value,
6. update velocity and position for each particle,
7. if the stopping criterion, i.e. maximum number of iteration, is reached, stop. Otherwise return to step 2.

Following this algorithm, the best problem solution is represented by the global best at the end of iteration. The details of PSO can be found in several textbooks, among others are Kennedy and Eberhart (2001) and Clerc (2006). In this research, a variant of PSO called GLNPSO is used, including the computational library called ET-Lib (Nguyen et al., 2010). This algorithm, similar with other metaheuristics techniques, is actually independent from the problem being solved. In other word, this algorithm can be applied on various problem types. In the PSO methodology, we have to define specific particle representation and decoding method in order to apply PSO for solving specific problem. Particle representation is the definition on how the particle represents the problem, while decoding method is the definition on how the particle can be translated into problem solution. The following subsections define the solution representation and the decoding method for applying PSO for solving the CTOP.

2.1 Particle Representation

Based on Ai et al. (2013), particle with dimensions represents a CTOP solution with vertices, in which each particle's dimension corresponds to each vertex, i.e. dimension 1 represents vertex 1, dimension 2 represents vertex 2, and so on. Particle position is assigned to be a real number and represents a priority of vertex on the decoding method. The smaller the position of particle, the higher the priority of the corresponding vertex. Later on the decoding steps, each vertex is evaluated to be inserted into the solution paths based on its priority. Figure 1 illustrates a representation of CTOP with 7 vertices and its conversion process to priority of vertex.

dimension	1	2	3	4	5	6	7
position	0.52	2.69	1.03	0.15	1.94	3.17	1.29

sorted position	0.15	0.52	1.03	1.29	1.94	2.69	3.17
vertex no.	4	1	3	7	5	2	6
priority	1	2	3	4	5	6	7

Figure 1: Solution representation of CTOP with 7 vertices and its conversion to priority of vertex.

2.2 Decoding Method 1

The first decoding method is a simple procedure, in which each vertex, one by one based on the priority of vertex, is evaluated to be inserted in the last sequence of each vehicle tour, starting from the first vehicle. If the insertion complies with tour duration and capacity constraints, then the vertex is placed on the sequence. Otherwise, the vertex is evaluated to be inserted to the subsequent tour. If the vertex cannot be inserted to any available tours, it implies that the vertex is decided not to be visited. Figure 2 illustrates tours construction following the first decoding method.

2.3 Decoding Method 2

The second decoding method requires more effort than the first one. Instead of evaluating insertion in the last sequence of each tour, this method is evaluating all possible sequence in each existing tour for inserting vertex, one by one based on the priority of vertex. At last, the vertex is being inserted into a sequence in certain tour that satisfies tour duration and vehicle capacity constraints and provides the smallest additional time. Additional time is defined as the difference between the tour duration before and after a vertex is inserted to the tour. Figure 3 illustrates tours construction following the second decoding method.

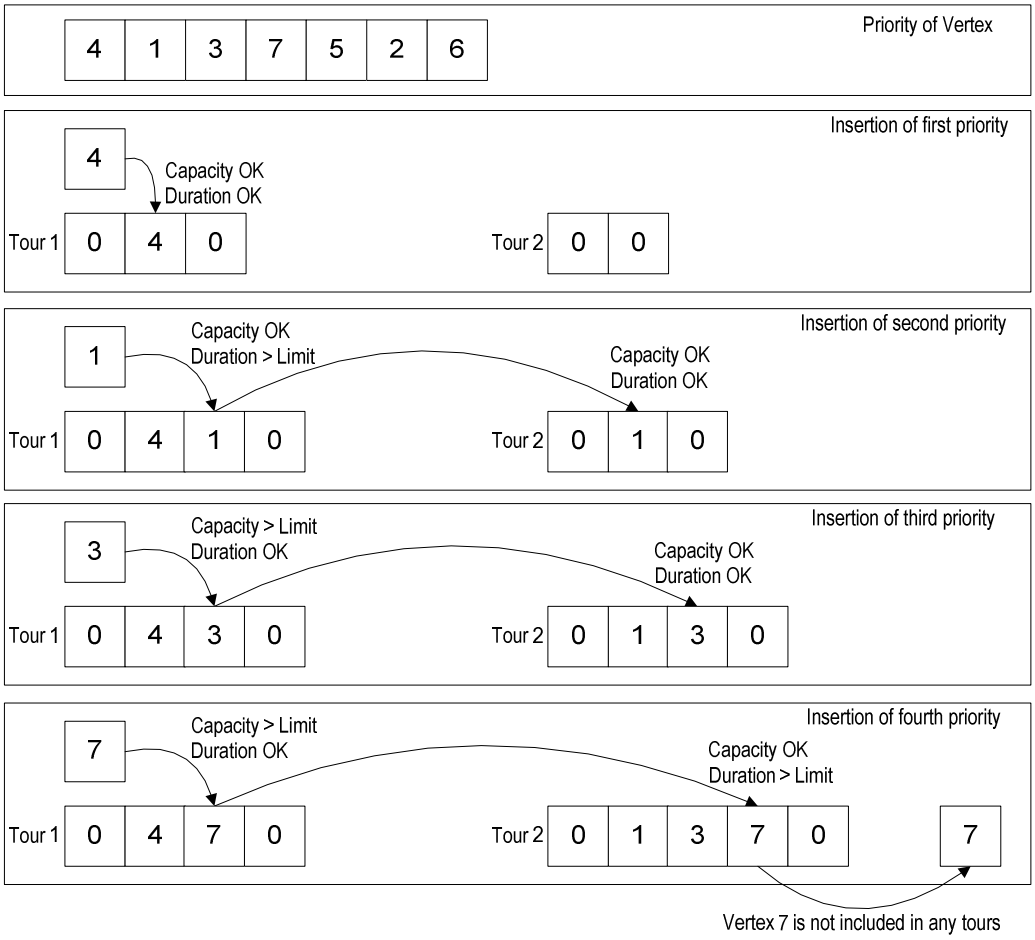

Figure 2: Illustration of tours construction in decoding method 1

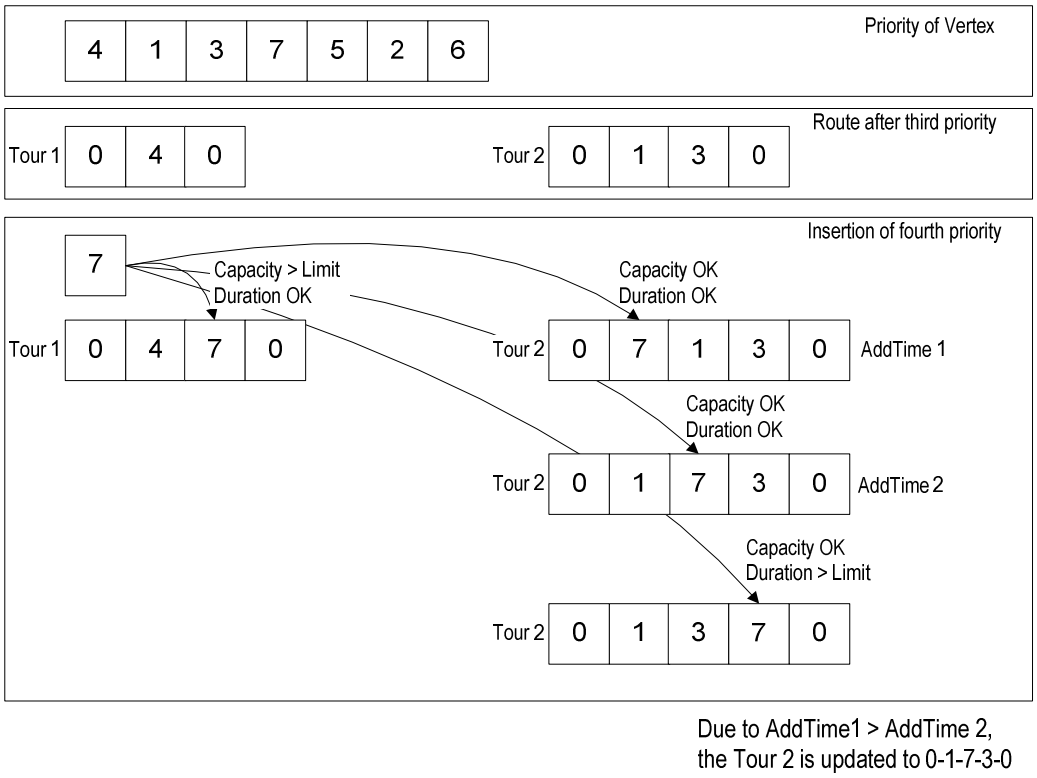

Figure 3: Illustration of tours construction in decoding method 2

3. COMPUTATIONAL EXPERIMENTS

The proposed PSO algorithm for CTOP is implemented using C# language assisted with a PSO computational library called ET-Lib (Nguyen et al., 2010). The ET-Lib uses a PSO variant called GLNPSO that has three different social behavior terms called global best, local best, and nearest neighbor best with its corresponding acceleration constant (c_g, c_l, and c_n), i.e. the movement of particle in this variant is following these equations:

$$\omega_{lh}(\tau+1) = w(\tau)\omega_{lh}(\tau) + c_p u\left(\psi_{lh} - \theta_{lh}(\tau)\right) + c_g u\left(\psi_{gh} - \theta_{lh}(\tau)\right) + c_l u\left(\psi^L_{lh} - \theta_{lh}(\tau)\right) + c_n u\left(\psi^N_{lh} - \theta_{lh}(\tau)\right) \quad (1)$$

$$\theta_{lh}(\tau+1) = \theta_{lh}(\tau) + \omega_{lh}(\tau+1) \quad (2)$$

where τ is iteration index, l is particle index, h is dimension index, u is uniform random number in interval [0,1], $w(\tau)$ is inertia weight in the iteration τ, ω_{lh} is velocity of particle l at the dimension h in the iteration τ, θ_{lh} is position of particle l at the dimension h in the iteration τ, ψ_{lh} is personal best position (pbest) of particle l at the dimension h, ψ_{gh} is global best position (gbest) at the dimension h, ψ^L_{lh} is local best position of particle l at the dimension h, and ψ^N_{lh} is nearest neighbor best position of particle l at the dimension h.

The computational experiments are conducted using Archetti et al. (2009) CTOP benchmark data set, which consists of three sets of problem. The first data set or called the original set, which originally taken from Christofides' VRP benchmark data set, consists of 10 problem instances. By modifying the number, capacity, and time limit of vehicles, the second data set are generated consist of 90 different problem instances. While the third data set is generated by modifying the number of vehicles only, which are 30 different problem instances are included in this data set. Therefore, 130 different problem instances are involved in the computational experiments.

A simple experimental design is applied here to select PSO parameters setting. We are varying the value of acceleration constants (c_p, c_g, c_l, and c_n) among the values of 0, 1, 2; number of particles (L) between the values of 30 and 50; and number of iteration (T) between the values 200 and 500. Using the problem case p09 in the original set to compare the statistical results in term of solution quality and computational time, we concluded that these settings are the best: c_p=1, c_g=1, c_l=1, and c_n=1, L=30, and T=500.

All the test instances are run on a computer with an Intel Core 2 Duo @ 2.40 GHz CPU and 2 GB RAM. For

each instance, 10 replications of the PSO algorithm runs are conducted.

An experiment is conducted to compare the performance of the Decoding Method 1 and Decoding Method 2 by applying both method for the original set. The best result of obtained from each decoding method are compared in Table 1. It is shown that the Decoding Method 2 is able to find better (higher) profit for four instances (p09, p10, p15, and p16) than Decoding Method 1. While both methods are resulting the same profit for the other instances. It is implied that the Decoding Method 2 is better than Decoding Method 1. Therefore, only the Decoding Method 2 is applied in the subsequent computational experiments.

Table 1: Comparison of profit obtained by each decoding method on original set

Problem Instance					**Profit**	
No.	***n***	***m***	***Q***	***T***	**DM 1**	**DM 2**
p03	101	15	200	200	1409	1409
p06	51	10	160	200	761	761
p07	76	20	140	160	1327	1327
p08	101	15	200	230	1409	1409
p09	151	10	200	200	1674	*2058*
p10	200	20	200	200	2890	*3048*
p13	121	15	200	720	1287	1287
p14	101	10	200	1040	1710	1710
p15	151	15	200	200	2035	*2129*
p16	200	15	200	200	2920	*3070*

Table 2 presents the comparison of the Decoding Method 2 results with the Branch & Price of Archetti et al. (2009) over the original set. All the profit obtained by each methods are presented under the *P* column. The BK column shows the best known solution of each corresponding instances obtained by any other methods, after Archetti et al. (2009). The CPU column shows the computational time of each method in seconds. In the Branch & Price results, the sign '–' indicates that the computational time is exceeded 3600 seconds and the algorithm is terminated at that time limit. The percentage deviation of a method (*P*) from its correspondence best known solution (P_{BKS}), which is indicated as %*D*, is calculated by following equation:

$$\%D = \frac{P_{BKS} - P}{P_{BKS}} \times 100\% \quad (3)$$

Table 2: Comparison of profit obtained by each decoding method on original set

	BK	**Branch & Price**			**PSO with DM 2**		
No.	***P***	***P***	**CPU**	**%*D***	***P***	**CPU**	**%*D***
p03	1409	1409	41	0	1409	5.89	0
p06	761	761	2	0	761	1.84	0
p07	1327	1327	2	0	1327	3.67	0
p08	1409	1409	17	0	1409	5.23	0
p09	2064	1164	–	43.6	2058	7.96	0.29
p10	3048	1735	–	43.08	3048	13.3	0
p13	1287	1287	21	0	1287	5.98	0
p14	1710	1710	1082	0	1710	3.84	0
p15	2159	2159	1866	0	2129	9.25	1.39
p16	2968	588	–	80.19	3070	13.5	-3.44
Average		1355		16.69	1821		-0.18

It is shown in Table 2 from the %*D* column for PSO that there are one negative value, 7 zero values, and 2 positive values. Negative value of %*D* indicates that the PSO result is outperformed existing best known solution, zero value of %*D* indicates that the PSO result is similar with existing best known solution, and positive value of %*D* indicates that the PSO result is worse than existing best known solution. To have a single criteria for comparison, the average of %*D* is also calculated. Based on this criteria, we can easily conclude that the PSO with DM 2 is able to provide better result than Branch & Price method.

The results of PSO with DM 2 over three data set are summarized in Table 3. It is shown that PSO is able to solve CTOP with results that are very close to the existing best known solution, i.e. the average percentage deviation for all data set is less than 1%. The proposed PSO is also able to provide 47 among 130 solution of instances that are similar with its corresponding best known solution. In addition, the PSO is able to result one solution of instance, which is p16 in the original set, outperforming its existing best known solution.

Table 3: Summary of PSO results

Data Set	Original	Second	Third
Average %*D*	-0.18	0.60	0.73
Average CPU (s)	7.04	3.98	8.32
%*D* = 0	7	37	3
%D < 0	1	0	0

4. CONCLUDING REMARK

This paper is successfully presented that PSO is also able to solve the CTOP, especially using proposed Decoding Method 2. The computational results show that the proposed PSO algorithm is able to obtain 47 best known solutions of 130 benchmark problems and to improve 1 best known solution, while in average the percentage deviation for all data set is less than 1%.

ACKNOWLEDGMENT

The authors express thanks to High Performance Computing Group at Asian Institute of Technology, Thailand, for providing the Object Library for Evolutionary Techniques (ET-Lib) version 1.0 used in the preparation of this paper.

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