CAPACITATED VEHICLE ROUTING PROBLEM WITH TIME WINDOWS FOR MILK COLLECTION AT KPBS PANGALENGAN

by Tjutju Tarliah Dimyati

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9th INTERNATIONAL SEMINAR ON INDUSTRIAL ENGINEERING & MANAGEMENT

ISIEM

"COLLABORATIVE INNOVATION TOWARDS BORDERLESS INDUSTRIAL AND ECONOMIC SYSTEM"

GRAND INNA MUARA
HOTEL CONVENTION & EXHIBITION
PADANG, WEST SUMATERA, INDONESIA
TUESDAY-THURSDAY, SEPTEMBER 20-22, 2016

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ISSN : 1978-774X

PROCEEDING

9th ISIEM

The 9th International Seminar on Industrial Engineering and Management

Grand Inna Muara Hotel Convention & Exhibition Padang,
West Sumatera, Indonesia, September 20 – 22, 2016

Organized by :

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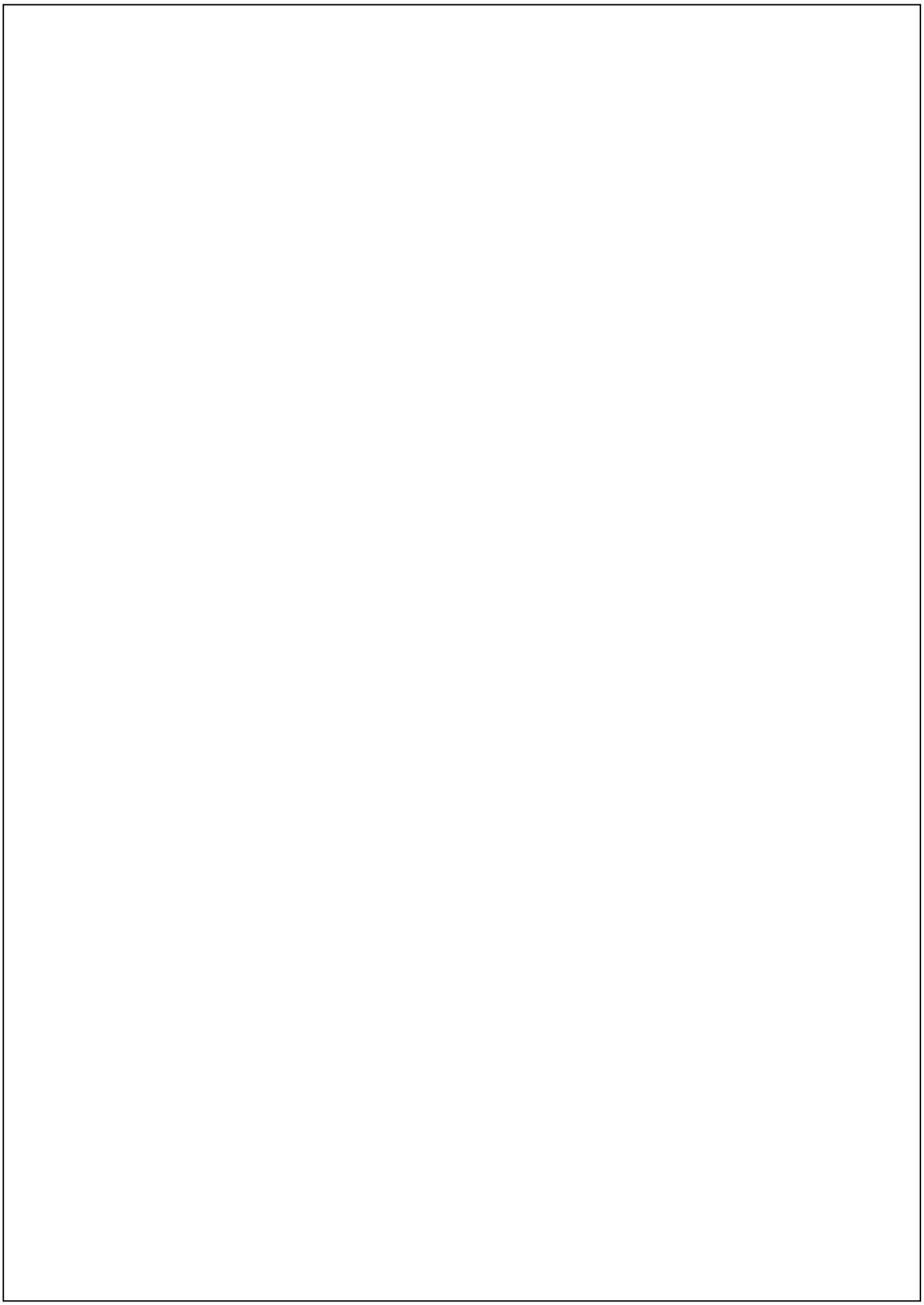

PREFACE

Dear Presenters and Delegates,

On behalf of the Organizing Committee, I am honored to welcome you to the 9th International Seminar on Industrial Engineering and Management (ISIEM). This seminar is organized by the Industrial Engineering Department from eight Universities, namely Trisakti University, Telkom University, Tarumanagara University, Atma Jaya Catholic University of Indonesia, Al Azhar Indonesia University, Esa Unggul University, Pasundan University, and Bung Hatta University.

The theme **"Collaborative Innovation Towards Borderless Industrial and Economic System"** which in accordance with the current economic era, we hope that through the exchange of ideas, experiences and recent progress in Industrial Engineering and Management from academicians, engineers, professionals and practitioners from Universities, research institutions, government agencies and industries be able to help us to deal with future challenges.

We hope that our presenter and delegates will gain many shared ideas and great experiences from this conference and also acquire additional insights from our honorable speakers, **Gursel Ilipinar, PhD** from ESADE Business School – Barcelona, **Profesor Emeritus Dato' Ir. Dr. Zainai Bin Mohamed** from UTM Razak School of Engineering and Advance Technology – Malaysia, **Milko-Pierre Papazoff** from Vice President of French External Trade Counsellor (Malaysian Chapter).

The success of this seminar is due to the hard efforts of many people who we gratefully acknowledge. Special thank to all reviewers, speakers, and presenters, also highly appreciate to the committee for mutual effort and invaluable contribution.

Finally, we hope you will enjoy this conference and the natural beauty of Padang city – Indonesia and see you in the next ISIEM.

Best wishes,

Chair of the 9th ISIEM 2016

Dr. Wisnu Sakti Dewobroto, M.Sc

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18. Ayu Bidiawati J.R, S.T.,M.T.	(Bung Hatta University)

KEYNOTE SPEECH

#1
Prof. Emeritus Dato' Ir. Dr. Zainai Bin Mohamed
UTM Razak School of Engineering and Advanced Technology
UTM International Campus

#2
Gursel Ilipinar, PhD
Innovation Management Expert
ESADE Business School - Barcelona

#3
Milko-Pierre Papazoff
VP of French External Trade Counsellor (Malaysian Chapter)

AGENDA

September 20, 2016

18:00	- 18:30	Registration
18:30	- 19:30	Dinner
19:30	- 19:40	Padang Dance by Bung Hatta University
19:40	- 19:45	Welcoming Speech from Head of Committee ISIEM 9th
19:45	- 20:00	Opening Ceremony by Bung Hatta University Rector
20:00	- 21:00	Keynote Speech # 1 **Prof. Emeritus Dato' Ir. Dr. Zainai Bin Mohamed** **(UTM Razak School of Engineering and Advanced Technology, UTM International Campus – Malaysia)** **Moderator:** Dr. Adianto, M.Sc.
21:00	- 21:15	Photo Session with all participants

September 21, 2016

6:30	- 8:00	Breakfast and Registration
8:00	- 9:00	Keynote Speech # 2 **Gursel Ilipinar, PhD** **(Innovation Management Expert** **ESADE Business School – Barcelona)** **Moderator:** Ir. Wahyukaton, M.T.
9:00	- 10:00	Keynote Speech # 3 **Milko-Pierre Papazoff** **VP of French External Trade Counsellor (Malaysian Chapter)** **Moderator:** Dr. Ir. Syarif Hidayat, M.Eng.Sc, M.M.
10:00	- 10:30	Question and Answer
10:30	- 11:15	Coffee and Tea Break
11:15	- 12:35	Parallel session #1
12:35	- 13:30	Lunch break
13:30	- 16:30	Parallel session #2
15:00	- 15:15	Coffee and Tea Break
18:30	- 20:00	Dinner

September 22, 2016

08:00	- 09:30	Parallel session #3
09:30	- 17:00	City Tour

PARALLEL SESSION

SEPTEMBER 21, 2016 SESSION 1 ROOM 1
Moderator : Dr. Lamto Widodo, S.T., M.T.

Time	Paper	Code	Paper Code
11.15-11.25	**MAINTENANCE PERFORMANCE MEASUREMENT TRANSJAKARTA BUS AT PERUM DAMRI SBU BUSWAY CORRIDOR I & VIII USING MAINTENANCE SCORECARD** Didien Suhardini, Iveline Anne Marie, Amal Witonohadi, Auliandi Fahriditya Putra Jurusan Teknik Industri, Fakultas Teknologi Industri, Universitas Trisakti, Jakarta, Indonesia	IM	110
11.25-11.35	**IDENTIFICATION OF SUPPLY CHAIN PERFORMANCE INDICATORS AND STRATEGIC OBJECTIVES USING THE BALANCED SCORECARD** Dwi Kurniawan, Adela Anggun Pertiwi, Lisye Fitria Industrial Engineering Department, Institut Teknologi Nasional, Bandung, Indonesia	SCM	26
11.35-11.45	**IMPROVEMENT TO QUALITY OF TELECOMMUNICATION SERVICE BY MINIMIZE FAILURE OF SIMKARI APPLICATION DEVICE (A CASE STUDY IN PT DATALINK SOLUTION)** M. Hudori Department of Logistic Management, Citra Widya Edukasi Polytechnic of Palm Oil, Bekasi, Indonesia	QM	79
11.45-11.55	**POSITIONING ANALYSIS FOR HIGHER EDUCATION BASED ON PERCEPTUAL MAPPING USING MULTIDIMENSIONAL SCALING** Hafizh Suharja, Yati Rohayati, Rio Aurachman School of Industrial and System Engineering, Telkom University, Bandung, Indonesia	IM	16
11.55-12.05	**IMPROVING THE SERVICE QUALITY OF DISTANCE EDUCATION USING INTEGRATION SERVICE QUALITY FOR HIGHER EDUCATION AND KANO** Istianah Nedia, Yati Rohayati, Maria Dellarosawati Idawicasakti School of Industrial and System Engineering, Telkom University, Bandung, Indonesia	QM	40
12.05-12.15	**DESIGN OF STANDARD OPERATING PROCEDURE (SOP) OF DESIGN AND DEVELOPMENT OF PRODUCT ACCORDING TO ISO 9001:2015 CLAUSE 8.3 BASED ON RISK BASED THINKING BY BUSINESS PROCESS IMPROVEMENT METHOD AT CV. XYZ** Rindy Aprilina Gita Prastyanti[1], Sri Widaningrum, Heriyono Lalu Faculty of Industrial Engineering, Telkom University, Bandung, Indonesia	QM	52
12.15-12.25	**DESIGN OF NONCONFORMITY AND CORRECTIVE ACTION STANDARD OPERATING PROCEDURE BASED ON INTEGRATED REQUIREMENTS FROM ISO 9001 AND ISO 14001** Rahmah Fadhilah, Sri Widaningrum, Heriyono Lalu Industrial Engineering Department, Telkom University of Engineering, Bandung Indonesia	QM	53

SEPTEMBER 21, 2016 SESSION 1 ROOM 1

Moderator : Dr. Lamto Widodo, S.T., M.T.

Time	Paper	Code	Paper Code
12.25-12.35	**DESIGN AND ANALYSIS PHYSICAL AND LOGICAL SECURITY USING TIA-942 AND ISO/IEC 27000 SERIES IN DATA CENTER OF PDII-LIPI** Mukhlis Anugrah Pratama, Mochammad Teguh Kurniawan, Information System Major, Industrial Engineering Faculty, Telkom University, Bandung, Indonesia	DSS	68

SEPTEMBER 21, 2016 SESSION 1 ROOM 2

Moderator : Dr. Ir. Syarif Hidayat, M.Eng.Sc, M.M.

Time	Paper	Code	Paper Code
11.15-11.25	**INCREASING PRODUCTIVITY WITH OBJECTIVE MATRIX METHOD CASE STUDY ON BUILDING MAINTENANCE MANAGEMENT PIO PT. XXX** R Bagus Yosan, Muhammad Kholil, Winny Soraya Industrial Engineering, Mercubuana University, Jakarta, Indonesia	IM	42
11.25-11.35	**LEAN PROJECT MANAGEMENT TO MINIMIZE WASTE, CASE STUDY : INDARUNGVI PROJECT, PT SEMEN PADANG** Nilda Tri Putri, Sarvina Department of Industrial Engineering, Faculty of Engineering, Andalas University, Padang, Indonesia	QM	38
11.35-11.45	**APPLICATION OF LEAN MANUFACTURING IN THE PRODUCTION OF SPUN PILE USING WASTE ASSESMENT MODEL AND VALUE STREAM ANALYSIS** Syarif Hidayat, Siti Nurlina Industrial Engineering Department, Faculty of Science and Technology, University Al Azhar Indonesia, Jakarta, Indonesia	PS	11
11.45-11.55	**THE IMPLEMENTATION OF CORPORATE SOCIAL RESPONSIBILITY OF STARBUCKS COMPANY** Charly Hongdiyanto Ciputra University, Indonesia	IM	72
11.55-12.05	**A MODIFIED ECONOMIC PRODUCTION QUANTITY (EPQ) WITH SYNCHRONIZING DISCRETE AND CONTINUOUS DEMAND UNDER FINITE HORIZON PERIOD AND LIMITED CAPACITY OF STORAGE** Jonrinaldi, Henmaidi, Nurike Oktavia Department of Industrial Engineering, Andalas University, Padang, Indonesia Master Program of Industrial Engineering, Andalas University, Padang, Indonesia	PS	44
12.05-12.15	**APPLICATION OF VALUE STREAM MAPPING IN THE NVOCC FCL SERVICE PROCESS TO MINIMIZE DELAY IN SUBMISSION OF THE DOCUMENT (A CASE STUDY IN PT YUSEN LOGISTICS INDONESIA)** M. Hudori, Nismah Panjaitan Department of Logistic Management, Citra Widya Edukasi Polytechnic of Palm Oil, Bekasi, Indonesia Department of Industrial Engineering, Sumatera Utara University, Medan, Indonesia	QM	76
12.15-12.25	**WAREHOUSE LAYOUT DESIGN USING SHARED STORAGE METHOD** Alan Dwi Wibowo, Rahmat Nurcahyo, Cut Khairunnisa Department of Agro-Industrial Technology,Universitas Lambung Mangkurat, Indonesia Departemen of Industrial Engineering, Universitas Indonesia,	PS	22

SEPTEMBER 21, 2016 SESSION 1 ROOM 2
Moderator : Dr. Ir. Syarif Hidayat, M.Eng.Sc, M.M.

Time	Paper	Code	Paper Code
	Indonesia		
12.25-12.35	**CABLE CLAMP PRODUCTION CAPACITY PLANNING USING ROUGH CUT CAPACITY PLANNING (RCCP) METHOD (A CASE STUDY IN PT FAJAR CAHAYA CEMERLANG)** M. Hudori Department of Logistic Management, Citra Widya Edukasi Polytechnic of Palm Oil, Bekasi, Indonesia	PS	80

SEPTEMBER 21, 2016 SESSION 1 ROOM 3
Moderator : Dr. Ir. Yogi Yogaswara, M.T.

Time	Paper	Code	Paper Code
11.15-11.25	**DEVELOPMENT OF ONLINE KNOWLEDGE MANAGEMENT CYCLE INDICATORS USING SECI APPROACH: CASE STUDY IN AN ENERGY COMPANY** Aldio Fikri Siddik, Amelia Kurniawati, Umar Yunan Kurnia Septo Hediyanto Industrial Engineering Department, Telkom University, Bandung, Indonesia Information System Department, Telkom University, Bandung, Indonesia	DSS	51
11.25-11.35	**MANAGEMENT INFORMATION SYSTEM FOR ORDER FULFILLMENT: A CASE STUDY** Johanes Fernandes Andry, Halim Agung, Yana Erlyana Faculty Technology and Design, Bunda Mulia University, Jakarta, Indonesia	DSS	3
11.35-11.45	**Risk Factor Analysis of Liquified Natural Gas (LNG) Supply Process Chain in Indonesia** Rahmat Nurcahyo, Farid Akbar, Yadrifil Kampus UI Depok Indonesia	SCM	14
11.45-11.55	**ENHANCING PENDULUM NUSANTARA MODEL IN INDONESIAN MARITIME LOGISTICS NETWORK** Komarudin, Muhammad Reza, Armand Omar Moeis System Engineering, Modeling and Simulation (SEMS) Laboratory, Department of Industrial Engineering, Universitas Indonesia	OR	49
11.55-12.05	**PURCHASING CONSORTIUM SYSTEM USING COMMON REPLENISHMENT EPOCH (CRE) MODEL BY DESIGNING MOBILE INFORMATION SYSTEM FOR SMALL and MEDIUM ENTERPRISES (SMEs)** Yudha Prasetyawan, Imam Baihaqi, Shinta Dewi Industrial Engineering Department, Sepuluh Nopember Institut of Technology, Surabaya, Indonesia Business and Management Department, Sepuluh Nopember Institut of Technology, Surabaya, Indonesia Agroindustrial Technology Department, Universitas Internasional Semen Indonesia, Indonesia	DSS	10
12.05-12.15	**DESIGN E-COMMERCE ANGON BASED ON MARKETPLACE TO INCREASE REVENUE FOR LIVESTOCK'S ACTORS (SELLING MODULE)** Atika Elysia, Irfan Darmawan, Muhammad Azani Hasibuan Department of Industrial Engineering, Telkom University, Bandung, Indonesia	IM	65

SEPTEMBER 21, 2016 SESSION 1 ROOM 3

Moderator : Dr. Ir. Yogi Yogaswara, M.T.

Time	Paper	Code	Paper Code
12.15-12.25	**CONTROL SYSTEMS DESIGN FOR AUTO JUDGEMENT CHECK MACHINE IN ROTOR ASSEMBLY LINE USING PROGRAMMABLE LOGIC CONTROLLER** Syahril Ardi, Moh Faiza Abu Rizal Production and Process Manufacture, Polytechnic Manufacture Astra, Jakarta, Indonesia	PS	31
12.25-12.35	**OPERATIONAL RISK IDENTIFICATION IN ADMINISTRATION SERVICES OF HIGHER EDUCATION** Robby Anzil Firdaus, Rahmat Nurcahyo, Anafi Yuan Septiari, Supriadi Industrial Engineering Departement, Universitas Indonesia, Indonesia	IM	17

SEPTEMBER 21, 2016 SESSION 2 ROOM 1

Moderator : Niken Parwati, S.T., M.M.

Time	Paper	Code	Paper Code
13.30-13.40	**SHELVES RE-DESIGN TO CONSIDER ASPECTS OF ERGONOMICS IN KOPETRI MINI MARKET, KARAWANG** Dene Herwanto, Sukanta University of Singaperbangsa Karawang, Karawang, Indonesia	6	ER
13.40-13.50	**COGNITIVE ERGONOMIC ANALYSIS OF PROFESSIONALS IN INDUSTRIAL DESIGNER APPAREL (Case Study: Designer at PT. Kurnia ASTASURYA)** Erwin M Pribadi, Ari Robiana Rijalah Industrial Engineering Department, Universitas Pasundan, Bandung, Indonesia	13	ER
13.50-14.00	**DESIGN CONCEPT OF WASHING GALLON USING DESIGN METHOD RATIONAL** Antonio Bennarivo Nainggolan, Mira Rahayu, Teddy Syafrizal Industrial Engineering Department, Telkom University, Bandung, Indonesia	56	ER
14.00-14.10	**DESIGNING ERGONOMIC CONVEYANCE TOOLS FOR SULFUR MINERS IN THE IJEN CRATER** Anny Maryani, Dyah Santhi Dewi, Elsa Camelia Harmadi, Pamungkas Dwi Admaja Industrial Engineering Department, ITS Surabaya, Indonesia	61	ER
14.10-14.20	**AUTOMATIC POLARIZING FILTER SYSTEM FOR WELDING MASK** Muhammad Ridwan Andi Purnomo, Riadho Clara Shinta, Rizqi Ramadhani, Ahmad Rizal Yassaruddin, Muhammad Iqbal Sabit Department of Industrial Engineering Universitas Islam Indonesia	47	ER
14.20-14.30	**DESIGN GALLON WASHING TOOLS USING ERGONOMIC FUNCTION DEPLOYMENT METHOD** Bintang Sri Perdana, Mira Rahayu, Teddy Syafrizal Industrial Engineering Department, Telkom University, Bandung, Indonesia	57	ER
14.30-14.40	**ERGONOMIC ANALYSIS FOR THE ARMOURED PERSONNEL CARRIER DRIVER** Halim Mahfudh, Lilik Zulaihah, Reda Rizal Department of Industrial Engineering, Universitas Pembangunan Nasional Veteran Jakarta	91	ER

SEPTEMBER 21, 2016 SESSION 2 ROOM 1

Moderator : Niken Parwati, S.T., M.M.

Time	Paper	Code	Paper Code
14.40-14.50	**APPLICATION OF ANALYTICAL HIERARCHY PROCESS TO CHOOSE CRITERIA FOR MOBILE PHONES** Dessi Mufti, Yesmizarti Muchtiar, Iswanto Industrial Engineering Department, Universitas Bung Hatta, Padang, West Sumatera, Indonesia	83	IM
14.50-15.00	**DESIGNING A PERSONAL SURVIVAL KIT IN FLOOD DISASTERS THROUGH PARTICIPATORY DESIGN APPROACH** Grace Novelia, Johanna Renny Octavia Industrial Engineering Department, Parahyangan Catholic University, Bandung, Indonesia	89	ER
15.00-15.10	**DESIGN IMPROVEMENT FOR POTATOES CULTERY TOOLS "POTTY" USING PRODUCT ARCHITECTURE ANALYSIS** Rahmat Ramadhani Bayu, Dicha Keci Barakin, Rendra Gilang Yuniarto, Muhammad Iqbal Industrial Engineering, Telkom University, Bandung, Indonesia	30	ER
15.10-15.20	**STUDY OF SHAFT POSITION IN GAS TURBINE JOURNAL BEARING** Rizky Arman, Iman Satria Mechanical engineering Dept, Faculty of Industrial Technolgy, Bung Hatta University, Padang, Indonesia	105	PS
15.20-15.30	**APPLICATION METHODS P-C-P TO IMPROVE QUEUE SERVICE QUALITY IN SUPERMARKET CASHIER AT THE PEAK DEMAND CONDITION** Yesmizarti Muchtiar, Muhibbullah Azfa Manik, Emil Endrivon Department of Industrial Engineering, Bung Hatta University, Padang, Indonesia	78	QM
15.30-15.40	**DESIGN E-COMMERCE ANGON BASED ON MARKETPLACE TO INCREASE PURCHASING EFFICIENCY FOR LIVESTOCK'S ACTOR (PURCHASE MODULE)** Pratiwi Galuh Putri, Irfan Darmawan, Muhammad Azani Departemen of Industrial Engineering Telkom University, Bandung, Indonesia	67	IM
15.40-15.50	**DEVELOPING INFORMATION SYSTEM OF LIBRARY ON E-SCHOOL QR-CODE BASED IN 13 NATIONAL HIGH SCHOOL USING EXTREME PROGRAMMING METHODOLOGY** Timbul Prawira Gultom, Nia Ambarsari, Muhammad Azani H. Department of Industrial Engineering, Telkom University, Bandung, Indonesia	71	DSS
15.50-16.00	**USING EDUQUAL AND KANO'S MODEL TO IMPROVE THE SERVICE QUALITY OF TRAINING AND CERTIFICATION PROGRAM** Iftitah Pratomo, Yati Rohayati, Sari Wulandari School of Industrial and System Engineering, Telkom University, Bandung Indonesia	23	IM
16.00-16.10	**DEVELOPMENT DETAIL DESIGN GALLON WASHER USING DESIGN FOR ASSEMBLY (DFA)** Mohamad Walid Anshar Ichsan Shahib, Mira Rahayu, Teddy Sjafrizal Industrial Engineering Department, Telkom University, Bandung, Indonesia	55	ER

SEPTEMBER 21, 2016 SESSION 2 ROOM 1

Moderator : Niken Parwati, S.T., M.M.

Time	Paper	Code	Paper Code
16.10-16.20	**MAKING A PLYWOOD BOAT CATAMARANS MODEL FOR HANDLING OF FLOOD EMERGENCY IN AREAS OF DURI KEPA** Indra Gunara Rochyat, Asnawati, Wahyu Albin Tabrani Product Design Department – Design & Creative Industry Faculty, Esa Unggul University, Jakarta, Indonesia	102	ER
16.20-16.30	**STUDY OF LIFT MARKET THROUGH GAP ANALYSIS** Niken Parwati, Nurhanisa Maysa, Aprilia Tri Purwandari Department of Industrial Engineering, Faculty of Science and Technology, Universitas Al Azhar Indonesia	93	IM

SEPTEMBER 21, 2016 SESSION 2 ROOM 2

Moderator : Inna Kholidasari, S.T., M.T., Ph.D.

Time	Paper	Code	Paper Code
13.30-13.40	**MAXIMUM PROFIT CALCULATION BASED ON THE QUANTITY OF DEMAND VEGATABLES WITH THE SINGLE ORDER QUANTITY METHOD** Annura Minar Gayatri, Nunung Nurhasanah, Ahmad Juang Pratama Industrial Engineering, Faculty of Science and Technology, Univerisity of Al Azhar Indonesia, Jakarta, Indonesia	84	PS
13.40-13.50	**DETERMINING THE INVENTORY POLICY FOR V-BELT USING PROBABILISTIC METHOD** Sukanta, Dene Herwanto University Singaperbangsa of Karawang, Indonesia	7	PS
13.50-14.00	**SYSTEM DYNAMICS BASED BALANCED SCORECARD TO SUPPORT DECISION MAKING IN STRATEGY OF PERFORMANCE IMPROVEMENT (A CASE STUDY IN THE UNIVERSITY)** Linda Theresia, Yenny Widianty, Dawi Karomati Baroroh Department of Industrial Engineering, Institut Teknologi Indonesia, Serpong, Indonesia Industrial Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia	8	DSS
14.00-14.10	**DRUG INVENTORY POLICY PROPOSAL USING PROBABILISTIC METHODS TO INCREASE THE SERVICE LEVEL** Sabila Syafitri Pambudi, Dida Diah Damayanti, Budi Santosa Chulasoh Departemen of Industrial Engineering, Telkom University, Bandung, Indonesia	74	PS
14.10-14.20	**AN AUTOMATED GUIDED VEHICLE SIMULATION THROUGH ROBOTINO TO HELP LEARNING COURSE INDUSTRIAL AUTOMATION** Tatang Mulyana, Haris Rachmat, Prasetia Pramudita Yuliarso Laboratory of Production Manufacturing and Automation, Faculty of Industrial Engineering, Telkom University, Bandung, Indonesia	33	PS
14.20-14.30	**THE IMPLEMENTATION OF ANALYTIC HIERARCHY PROCESS ON THE SELECTION OF SUPPLIER IN START-UP BUSINESS: A CASE STUDY** Ahmad Setyo Irawan, Liliani International Business Management, Universitas Ciputra, Surabaya, Indonesia	27	SCM

SEPTEMBER 21, 2016 SESSION 2 ROOM 2

Moderator : Inna Kholidasari, S.T., M.T., Ph.D.

Time	Paper	Code	Paper Code
14.30-14.40	**OPTIMAL PREVENTIVE MAINTENANCE OF TWO-PHASE MAINTENANCE POLICY FOR LEASED PRODUCT** Hennie Husniah, Andi Cakravastia, Bermawi P. Iskandar Department of Industrial Engineering, Langlangbuana University, Bandung, Indonesia Department of Industrial Engineering, Bandung Institute of Technology, Bandung, Indonesia	28	PS
14.40-14.50	**A SIMPLE MATHEMATICAL MODEL OF TECHNOLOGICAL TRANSFER WITH TWO COMPETING FOLLOWERS (A PRELIMINARY RESULT)** Hennie Husniah, Asep K. Supriatna Department of Industrial Engineering, Langlangbuana University, Bandung, Indonesia Department of Mathematics, Padjadjaran University, Bandung, Indonesia	29	OR
14.50-15.00	**INCREASING PRODUCTIVITY OF PT. XYZ THROUGH THE UTILIZATION OF STANDARD TIME AND THE TWO HANDED PROCESS FOR PANEL BOX PRODUCTION** Arnolt Kristian Pakpahan; Didien Suhardini; Arum Tri Astuti Organizational and Business Development Laboratorium, Industrial Engineering, Faculty of Industrial Engineering, Trisakti University	100	IM
15.00-15.10	**JOB SHOP SCHEDULING AT IN-HOUSE REPAIR DEPARTMENT IN COLD SECTION MODULE CT7 ENGINE TO MINIMIZE MAKESPAN USING GENETIC ALGORITHM AT PT XYZ** Michael Whizo Mayto, Pratya Poeri Suryadhini, Murni Dwi Astuti Industrial Engineering Study Program, Industrial Engineering Faculty, Telkom University, Bandung, Indonesia	99	PS
15.10-15.20	**CAPACITATED VEHICLE ROUTING PROBLEM WITH TIME WINDOWS FOR MILK COLLECTION AT KPBS PANGALENGAN** Tjutju Tarliah Dimyati Industrial Engineering Department, Pasundan University, Bandung, Indonesia	34	OR
15.20-15.30	**AN APPLICATION OF DIFFERENTIAL EVOLUTION ALGORITHM IN SPARE PART LOGISTICS** Said Badrul Nahar , Sakesun Suthummanon, Wanatchapong Kongkaew. Industrial and Systems Engineering, Prince of Songkla University, Songkla, Thailand	109	SCM
15.30-15.40	**DETERMINATION OF FAILURE RISK FOR TRANSFORMER SYSTEM BASED ON CLASSIFICATION TECHNIQUE** Iveline Anne Marie, Anung B Ariwibowo, Docki Saraswati, Amal Witonohadi Faculty of Industrial Technology, Industrial Engineering Department, Trisakti University, Jakarta, Indonesia Faculty of Industrial Technology, Informatics Engineering Department, Trisakti University, Jakarta, Indonesia	90	DSS
15.40-15.50	**INFORMATION SYSTEM STRATEGIC PLANNING BASED ON TOGAF ADM FRAMEWORK IN 1ST REVENUE FUNCTIONS DEPARTMENT OF REVENUE AND FINANCIAL MANAGEMENT BANDUNG REGENCY** Theresia Yudith Dwi Prisila, Yuli Adam Prasetyo, Ridha Hanafi Department of Industrial Engineering Telkom University, Bandung, Indonesia	66	DSS

SEPTEMBER 21, 2016 SESSION 2 ROOM 2

Moderator : Inna Kholidasari, S.T., M.T., Ph.D.

Time	Paper	Code	Paper Code
15.50-16.00	**ANALYSIS & EVALUATION OF PLANT PRODUCTION LAYOUT PT ARKHA JAYANTI PERSADA USING GROUP OF TECHNOLOGY CONCEPT WITH GENETIC ALGORITHM APPROACH** Agung Yugo Ngumboro, Budi Aribowo Majoring In Industrial Engineering, Faculty of Science and Technology, Universitas Al Azhar Indonesia, Jakarta, Indonesia	58	PS
16.00-16.10	**RELIABILITY ANALYSIS AND MAINTENANCE MANAGEMENT EVALUATION OF FLASH BUTT WELDING MACHINE WITH RCM II** Arief Suwandi, Ulia Rahma Industrial Engineering Department of Esa Unggul University, Jakarta, Indonesia	54	PS
16.10-16.20	**CONCEPTUAL FRAMEWORK IN PRINTING PRESS MAINTENANCE DESIGN BY USING DATA MINING** Meldi Rendra School of Industrial and Systems Engineering, Telkom University, Bandung, Indonesia	25	DSS
16.20-16.30	**VARIABLE ANALYSIS OF IMPROVING THE QUALITY OF SERVICE DELIVERY PACKAGE BY USING IMPORTANCE PERFORMANCE MATRIX METHOD AND KANO MODEL** Dwi Novirani, Abu Bakar, Janet Apongtinamba. Industrial of Engineering Institut Teknologi Nasional, Bandung, Indonesia	15	QM
16.30-16.40	**AGGREGATE PRODUCTION PLANNING OF WOODEN TOYS USING MODIFIED PARTICLE SWARM OPTIMIZATION** Adri Fajar Jenie, Syarif Hidayat Department of Industrial Engineering, Faculty of Science and Technology, Universitas Al Azhar Indonesia, Jakarta, Indonesia	111	PS

SEPTEMBER 21, 2016 SESSION 2 ROOM 3

Moderator : Aidil Ikhsan, S.T., M.T.

Time	Paper	Code	Paper Code
13.30-13.40	**IMPLEMENTATION OF CRISP-DM MODEL IN ORDER TO DEFINE THE SALES PIPE LINES OF PT X** Dadan Umar Daihani, Dina Feblian Master Program in Industrial Engineering, Faculty of Industrial Technology, University of Trisakti, Jakarta, Indonesia	59	DSS
13.40-13.50	**HOW ICT ADOPTION COULD AFFECT INDONESIAN SMEs ORGANIZATIONAL PERFORMANCE** Lucy Chairoel, Fuad Salleh, Setyawan Widyarto, Vera Pujani Universitas Dharma Andalas Padang, Indonesia Universiti Selangor, Malaysia Universitas Andalas, Padang, Indonesia	48	IM
13.50-14.00	**STRUCTURAL MODEL FOR SUSTAINABLE CAMPUS ASSESSMENT: A CASE OF ANDALAS UNIVERSITY** Elita Amrina, Insannul Kamil, Nilda Tri Putri, Yunessa Astari Department of Industrial Engineering, Andalas University, Padang, Indonesia.	62	IM
14.00-14.10	**ANALYSIS AND DESIGN ENTERPRISE ARCHITECTURE OF DEVELOPMENT ANALYSIS BUSINESS FUNCTION AT BADAN PERENCANAAN DAN PEMBANGUNAN DAERAH (BAPPEDA) WEST JAVA PROVINCE USING TOGAF ADM FRAMEWORK** Anida Shafa, Yuli Adam Prasetyo, Rahmat Mulyana	69	DSS

SEPTEMBER 21, 2016 SESSION 2 ROOM 3

Moderator : Aidil Ikhsan, S.T., M.T.

Time	Paper	Code	Paper Code
	Information System,Industrial and System Engineering Faculty, Telkom University, Bandung, Indonesia		
14.10-14.20	**ANALYSIS OF EARNINGS PER SHARE BEFORE AND AFTER IPO AND THE STRATEGY (CASE STUDY: COMPANIES PERFORM IPO IN INDONESIA STOCK EXCHANGE YEAR 2013)** Dewa Ayu Jessica Putri, Endang Chumaidiyah, Rita Zulbetti Faculty of Industrial Engineering, Telkom University, Bandung, Indonesia	73	IM
14.20-14.30	**PERCEIVED BARRIERS TO INNOVATION FOR START-UP BUSINESSES** Liliani International Business Management, Universitas Ciputra	81	IM
14.30-14.40	**THE DEVELOPMENT OF TECHNOLOGY READINESS ASSESSMENT FOR COMMERCIALIZATION INNOVATION AND PRODUCT DEVELOPMENT BASED ON DIGITAL BUSINESS ECOSYSTEM** Elfira Febriani, Taufik Djatna Industrial Engineering Department, Faculty of Industrial Technology, Trisakti Univerity, Jakarta, Indonesia Agro Industrial Technology Department, Faculty of Agricultural Engineering and Industry, Bogor Agricultural University, Indonesia	45	IM
14.40-14.50	**DEFINING THE CORPORATE METRICS** **MarsellinusBachtiar** Engineering Faculty, Industrial Engineering Program, Atma Jaya Catholic University of Indonesia, Jakarta	87	IM
14.50-15.00	**A BRIEF REVIEW IN SOME DISSERTATIONS ABOUT BUSINESS INCUBATOR PROCESS FRAMEWORK AND PERFORMANCE IN SOME COUNTRIES** Lina Gozali Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, Kuala Lumpur, Malaysia	37	IM
15.00-15.10	**GREEN DATA CENTER POWER MANAGEMENT DESIGN AND ANALYSIS IN PDII-KPI USING TIA-942 STANDARD** Algadilan Susanto, Mochammad Teguh Kurniawan Information System Major, Industrial Engineering Faculty, Telkom University, Bandung, Indonesia	70	DSS
15.10-15.20	**RELIABILITY BASED PERFORMANCE ANALYSIS OF BASE TRANSCEIVER STATION (BTS) USING RELIABILITY, AVAILABILITY, AND MAINTAINABILITY (RAM) METHOD** Judi Alhilman, Rd. Rohmat Saedudin Industrial Engineering Department, School of Industrial and Systems Engineering, Telkom University, Bandung, Indonesia	35	QM
15.20-15.30	**MEASURING LABORATORY ADMINISTRATION SYSTEM SATISFACTION : A CASE STUDY** Rayinda Pramuditya Soesanto, Amelia Kurniawati, Muhammad Iqbal Industrial Engineering Department, Telkom University, Indonesia	9	IM
15.30-15.40	**THE RELATIONSHIP BETWEEN TEACHING PROCESS AND QUALITY USING THE LINEAR STRUCTURE (LISREL) MODEL IN INDUSTRIAL ENGINEERING DEPARTMENT** Tiena Gustina Amran Trisakti University, Jakarta, Indonesia	98	IM

SEPTEMBER 21, 2016 SESSION 2 ROOM 3

Moderator : Aidil Ikhsan, S.T., M.T.

Time	Paper	Code	Paper Code
15.40-15.50	**ANALYSIS OF LOCAL ELEVATOR COMPANY CORPORATE CULTURE** Syarif Hidayat, Ainun Jariyah, Achmad Chirzun Industrial Engineering, Faculty of Science and Technology, Univerisity of Al Azhar Indonesia, Jakarta, Indonesia	85	IM
15.50-16.00	**FEASIBILITY STUDY OF BUSINESS DEVELOPMENT PT NUSAPATI PRATAMA WITH LEAN STARTUP** Agung Sasongko, Wisnu S Dewobroto, Said Saleh Al-Amry. Trisakti University, Jl. Kyai Tapa No. 1 Grogol, Jakarta Barat, Jakarta, Indonesia	96	IM
16.00-16.10	**PROPOSED MAINTENANCE POLICY AND SPARE PART MANAGEMENT OF GOSS UNIVERSAL PRINTING MACHINE WITH RELIABILITY CENTERED MAINTENANCE, RELIABILITY CENTERED SPARES, AND PROBABILISTIC INVENTORY MODEL** Valinouski Aulia, Judi Alhilman, Nurdinintya Athari S. Industrial Engineering, Faculty of Industrial and System Engineering, Telkom University, Bandung, Indonesia	75	PS
16.10-16.20	**PAYROLL ADMINISTRATION SYSTEM IMPLEMENTATION USING ODOO AT PT.PRIMARINDO ASIA INFRASTRUCTURE,TBK WITH RAPID APPLICATION METHOD** Kevin Rohni Goklas Sinaga1[1] , Wahjoe Witjaksono[2], Faishal Mufied Al-Anshary[3]. Telkom University	64	IM
16.20-16.30	**DEFINING TECHNOLOGY STRATEGY FOR SMALL TO MEDIUM ENTERPRISE WITHIN LEAN AND GREEN MANUFACTURING FRAMEWORK** Yudha Prasetyawan Industrial Engineering Department, Institut Teknologi Sepuluh Nopember Surabaya	107	IM

SEPTEMBER 22, 2016 SESSION 3 ROOM 1

Moderator : Dr. Rina Fitriana, S.T., M.M.

Time	Paper	Code	Paper Code
08.00-08.10	**VALUE PROPOSITION DESIGN AND BUSINESS MODEL GENERATION METHOD USE FOR BUSINESS INNOVATION FEASIBILITY ON THE MICROBIAL FERTILIZER – LAPTIAP BPPT** Wisnu Dewobroto, Bernard Marthin Department of Industrial Engineering, Faculty of Industrial Technology, Trisakti University	97	IM
08.10-08.20	**ENHANCING COMPETITIVENESS OF TEXTILE AND CLOTHING SMALL-MEDIUM INDUSTRIES THROUGH PERFORMANCE MEASUREMENT OF MATERIAL PLANNING USING SCOR METHOD** Nunung Nurhasanah[1], Widya Tanjung Nurcahayanti[1], Meliantika[1], Endang Ripmiatin[2], Mariyatul Qibtiyah[1], Shifa Aini Wulandari[1] [1]Industrial Engineering, Faculty of Science and Technology, Univerisity of Al Azhar Indonesia [2]Informatics Technology, Faculty of Science and Technology, Univerisity of Al Azhar Indonesia	77	SCM

SEPTEMBER 22, 2016 SESSION 3 ROOM 1

Moderator : Dr. Rina Fitriana, S.T., M.M.

Time	Paper	Code	Paper Code
08.20-08.30	**CONCEPTUAL MODEL OF SUPPLY CHAIN MANAGEMENT FOR HIGHER EDUCATION** Fajar Kurniawan Saint Mary's University of Hong Kong	105	SCM
08.30-08.40	**FEEDBACK FROM USERS ON A DESIGN OF WEB-BASED INVENTORY AND PRODUCT ORDERING SYSTEM FOR A UNIFORM MAKER** Gamma Habie Azzaky, Endang Chumaidiyah, Wawan Tripiawan Industrial Engineering Faculty, Telkom University, Bandung, Indonesia	88	DSS
08.40-08.50	**FACTORS INFLUENCING INNOVATION MANAGEMENT PRACTICES IN NIGERIA TEXTILE MANUFACTURING FIRM'S** Mohammed Ndaliman Abubakar Department of Business Admin & Management, The Federal Polytechnic (FPB), Niger State, Nigeria	112	IM

SEPTEMBER 22, 2016 SESSION 3 ROOM 2

Moderator : Dr. Ir. Nofi Erni, M.M.

Time	Paper	Code	Paper Code
08.00-08.10	**BUSINESS INTELLIGENCE SYSTEM MODEL PROPOSALS TO IMPROVE THE QUALITY OF SERVICE AT PT GIA** Rina Fitriana, Johnson Saragih, M. Andika Firmansyah System and Industrial Simulation Laboratory, Department of Industrial Engineering, Faculty of Industrial Technology, Trisakti University, Jakarta, Indonesia	86	QM
08.10-08.20	**WORK RISK ASSESSMENT TOWARDS WOOD FURNITURE PRODUCTION ACTIVITIES USING MANUAL TASK RISK ASSESSMENT METHOD AND RODGERS MUSCLE FATIGUE ANALYSIS METHOD** Cindy Wibisono, Vivi Triyanti Department of Industrial Engineering, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia	4	ER
08.20-08.30	**EXPERIMENTAL DESIGN OF CLASS CHARACTERISTIC FACTORS AGAINST ENERGY EXPENDITURE, MENTAL FATIGUE AND PERFORMANCE USING ANOVA METHOD** Albertus Steven, Vivi Triyanti Industrial Engineering Studies Program – Faculty Of Engineering Atma Jaya Indonesian Catholic University, Jakarta, Indonesia	32	ER
08.30-08.40	**WORKLOAD ANALYSIS OF THE CONTAINER UNLOADING PROCESS WORKER** Lamto Widodo, I Wayan Sukania,Cynthia Kristiani Industrial Engineering Department, Enginering Faculty, Tarumanagara University, Jakarta, Indonesia	1	ER
08.40-08.50	**DETERMINING THE ROUTE FOR SOLID WASTE TRANSPORTATION FROM TPS TO SPA USING VRP – NEAREST NEIGHBOR FOR 10m^3 VEHICLE ON SERVICE AREA SOUTHERN BANDUNG AND EASTERN BANDUNG** Wahyukaton, Anni Rochaeni, Sunarya Industrial Engineering Pasundan University, Bandung, Indonesia Environmental Engineering Pasundan University, Bandung, Indonesia	21	OR

SEPTEMBER 22, 2016 SESSION 3 ROOM 2

Moderator : Dr. Ir. Nofi Erni, M.M.

Time	Paper	Code	Paper Code
08.50-09.00	**STUDY OF LIFT MARKET THROUGH GAP ANALYSIS** Niken Parwati, Nurhanisa Maysa, Aprilia Tri Purwandari Department of Industrial Engineering, Faculty of Science and Technology, Universitas Al Azhar Indonesia, Jakarta, Indonesia	93	IM
09.00-09.10	**PROPOSED DESIGN OF TA*BLE AND SEAT WORK IN AFBRAMEN WORKSTATION USING ULRICH-EPPINGER*** Rino Andias Anugraha, Yusuf Nugroho Doyoyekti Industrial Engineering Study Program, Industrial Engineering Faculty, Telkom University	104	ER

SEPTEMBER 22, 2016 SESSION 3 ROOM 3

Moderator : Andre Sugioko, S.T., M.T.

Time	Paper	Code	Paper Code
08.00-08.10	**DESIGNING PRODUCTION SCHEDULING WITH FUZZY PERT TO SOLVE RESOURCE CONSTRAINTS THROUGH LANG'S ALGORITHM** N. Nurhasanah, W.N. Tanjung, E. Ripmiatin, A. Supriyanto, S.A. Wulandari, C.A. Nurpraja, Meliantika, M. Qibtiyah Department of Industrial Engineering, University of Al Azhar, Jakarta, Indonesia Department of Informatics Engineering, University of Al Azhar, Jakarta, Indonesia	41	PS
08.10-08.20	**PRODUCTION SCHEDULING OF BIG PART AT MACHINING DEPARTMENT IN PT. XYZ** Rizki Wahyuniardi, Wahyukaton, Moch Rifqi Fathoni Industrial Engineering, Pasundan Universitas, Bandung, Indonesia	20	PS
08.20-08.30	**DYNAMIC SIMULATION SYSTEM FOR MAIZE COMMODITIES (CASE STUDY: TUBAN, EAST JAVA)** Christine Natalia, Agustinus Silalahi, Andre Sugioko, Trifenaus Prabu Hidayat, Cavin Natalio Simanjuntak Industrial Engineering, Atma Jaya Catholic University of Indonesia	18	OR
08.30-08.40	**SUPPLY CHAIN ANALYSIS OF CASSAVA AGROINDUSTRY TO IMPROVE NATIONAL FOOD SECURITY** Iphov Kumala Sriwana, Nofi Erni Industrial Engineering, Esa Unggul University, Jakarta, Indonesia	94	SCM
08.40-08.50	**GROUP TECHNOLOGY AND DYNAMIC MODIFIED SPANNING TREE (DMoST) IMPLEMENTATION FOR DYNAMIC CELLULAR LAYOUT PROBLEM** Yogi Yogaswara , Sri Wahyuni Industrial Engineering, Faculty of Engineering, Pasundan University , Bandung, Indonesia	63	OR
08.50-09.00	**USING FUZZY INFERENCE SYSTEM ON PRODUCTION PLANNING CASE STUDY : PANDANUS HANDICRAFT INDUSTRY** Nofi Erni, Iphov Kumala S., Roesfiansjah R., Riya Widayanti Industrial Engineering Department Esa Unggul University Jakarta, Indonesia	103	PS
09.00-09.10	**CRITICALLY ASSESS THE DEVELOPMENT OF GREEN SUPPLY CHAIN MANAGEMENT IN THE FAST MOVING CONSUMER GOODS INDUSTRY** Ilhamsyah Mahendra[1], Elizabeth WIlliamson[2] Glasgow Caledonian University, United Kingdom	**101**	SCM

TABLE OF CONTENT

DSS – Decision Support System and Artificial Intelligence

ER – Ergonomics

ER – Ergonomics

IM – Industrial Management

IM – Industrial Management

OR – Operation Research

OR – Operation Research

PS – Production System

PS – Production System

No	Paper	Title and Author	Page
10	54	RELIABILITY ANALYSIS AND MAINTENANCE MANAGEMENT EVALUATION OF FLASH BUTT WELDING MACHINE WITH RCM II ***Arief Suwandi, Ulia Rahma***	Paper_54
11	58	ANALYSIS & EVALUATION OF PLANT PRODUCTION LAYOUT PT ARKHA JAYANTI PERSADA USING GROUP OF TECHNOLOGY CONCEPT WITH GENETIC ALGORITHM APPROACH ***Agung Yugo Ngumboro, Budi Aribowo***	Paper_58
12	74	DRUG INVENTORY POLICY PROPOSAL USING PROBABILISTIC METHODS TO INCREASE THE SERVICE LEVEL ***Sabila Syafitri Pambudi, Dida Diah Damayanti, Budi Santosa Chulasoh***	Paper_74
13	75	PROPOSED MAINTENANCE POLICY AND SPARE PART MANAGEMENT OF GOSS UNIVERSAL PRINTING MACHINE WITH RELIABILITY CENTERED MAINTENANCE, RELIABILITY CENTERED SPARES, AND PROBABILISTIC INVENTORY MODEL ***Valinouski Aulia, Judi Alhilman, Nurdinintya Athari S.***	Paper_75
14	80	CABLE CLAMP PRODUCTION CAPACITY PLANNING USING ROUGH CUT CAPACITY PLANNING (RCCP) METHOD (A CASE STUDY IN PT FAJAR CAHAYA CEMERLANG) ***M. Hudori***	Paper_80
15	84	MAXIMUM PROFIT CALCULATION BASED ON THE QUANTITY OF DEMAND VEGATABLES WITH THE SINGLE ORDER QUANTITY METHOD ***Annura Minar Gayatri, Nunung Nurhasanah, Ahmad Juang Pratama***	Paper_84
16	99	JOB SHOP SCHEDULING AT IN-HOUSE REPAIR DEPARTMENT IN COLD SECTION MODULE CT7 ENGINE TO MINIMIZE MAKESPAN USING GENETIC ALGORITHM AT PT XYZ ***Michael Whizo Mayto, Pratya Poeri Suryadhini, Murni Dwi Astuti***	Paper_99
17	103	USING FUZZY INFERENCE SYSTEM ON PRODUCTION PLANNING CASE STUDY : PANDANUS HANDICRAFT INDUSTRY ***Nofi Erni, Iphov Kumala S., Roesfiansjah R., Riya Widayanti***	Paper_103
18	105	STUDY OF SHAFT POSITION IN GAS TURBINE JOURNAL BEARING ***Rizky Arman, Iman Satria***	Paper_105
19	111	AGGREGATE PRODUCTION PLANNING OF WOODEN TOYS USING MODIFIED PARTICLE SWARM OPTIMIZATION ***Adri Fajar Jenie, Syarif Hidayat***	Paper_111

QM – Quality Engineering & Management

No	Paper	Title and Author	Page
1	15	VARIABLE ANALYSIS OF IMPROVING THE QUALITY OF SERVICE DELIVERY PACKAGE BY USING IMPORTANCE PERFORMANCE MATRIX METHOD AND KANO MODEL ***Dwi Novirani, Abu Bakar, Janet Apongtinamba***	Paper_15
2	35	RELIABILITY BASED PERFORMANCE ANALYSIS OF BASE TRANSCEIVER STATION (BTS) USING RELIABILITY, AVAILABILITY, AND MAINTAINABILITY (RAM) METHOD ***Judi Alhilman, Rd. Rohmat Saedudin***	Paper_35
3	38	LEAN PROJECT MANAGEMENT TO MINIMIZE WASTE, CASE STUDY : INDARUNGVI PROJECT, PT SEMEN PADANG ***Nilda Tri Putri, Sarvina***	Paper_38
4	40	IMPROVING THE SERVICE QUALITY OF DISTANCE EDUCATION USING INTEGRATION SERVICE QUALITY FOR HIGHER EDUCATION AND KANO ***Istianah Nedia, Yati Rohayati, Maria Dellarosawati Idawicasakti***	Paper_40

QM – Quality Engineering & Management

No	Paper	Title and Author	Page
5	52	DESIGN OF STANDARD OPERATING PROCEDURE (SOP) OF DESIGN AND DEVELOPMENT OF PRODUCT ACCORDING TO ISO 9001:2015 CLAUSE 8.3 BASED ON RISK BASED THINKING BY BUSINESS PROCESS IMPROVEMENT METHOD AT CV. XYZ ***Rindy Aprilina Gita Prastyanti, Sri Widaningrum, Heriyono Lalu***	Paper_52
6	53	DESIGN OF NONCONFORMITY AND CORRECTIVE ACTION STANDARD OPERATING PROCEDURE BASED ON INTEGRATED REQUIREMENTS FROM ISO 9001 AND ISO 14001 ***Rahmah Fadhilah, Sri Widaningrum, Heriyono Lalu***	Paper_53
7	76	APPLICATION OF VALUE STREAM MAPPING IN THE NVOCC FCL SERVICE PROCESS TO MINIMIZE DELAY IN SUBMISSION OF THE DOCUMENT (A CASE STUDY IN PT YUSEN LOGISTICS INDONESIA) ***M. Hudori, Nismah Panjaitan***	Paper_76
8	78	APPLICATION METHODS P-C-P TO IMPROVE QUEUE SERVICE QUALITY IN SUPERMARKET CASHIER AT THE PEAK DEMAND CONDITION ***Yesmizarti Muchtiar, Muhibbullah Azfa Manik, Emil Endrivon***	Paper_78
9	79	IMPROVEMENT TO QUALITY OF TELECOMMUNICATION SERVICE BY MINIMIZE FAILURE OF SIMKARI APPLICATION DEVICE (A CASE STUDY IN PT DATALINK SOLUTION) ***M. Hudori***	Paper_79
10	86	Business Intelligence System Model Proposals to Improve the Quality of Service at PT GIA ***Rina Fitriana, Johnson Saragih, M. Andika Firmansyah***	Paper_86

SCM – Supply Chain Management

No	Paper	Title and Author	Page
1	14	RISK FACTOR ANALYSIS OF LIQUIFIED NATURAL GAS (LNG) SUPPLY PROCESS CHAIN IN INDONESIA ***Rahmat Nurcahyo, Farid Akbar, Yadrifil***	Paper_14
2	26	IDENTIFICATION OF SUPPLY CHAIN PERFORMANCE INDICATORS AND STRATEGIC OBJECTIVES USING THE BALANCED SCORECARD ***Dwi Kurniawan, Adela Anggun Pertiwi, Lisye Fitria***	Paper_26
3	27	THE IMPLEMENTATION OF ANALYTIC HIERARCHY PROCESS ON THE SELECTION OF SUPPLIER IN START-UP BUSINESS: A CASE STUDY ***Ahmad Setyo Irawan, Liliani***	Paper_27
4	77	ENHANCING COMPETITIVENESS OF TEXTILE AND CLOTHING SMALL-MEDIUM INDUSTRIES THROUGH PERFORMANCE MEASUREMENT OF MATERIAL PLANNING USING SCOR METHOD ***Nunung Nurhasanah, Widya Tanjung Nurcahayanti, Meliantika, Endang Ripmiatin, Mariyatul Qibtiyah, Shifa Aini Wulandari***	Paper_77
5	94	SUPPLY CHAIN ANALYSIS OF CASSAVA AGROINDUSTRY TO IMPROVE NATIONAL FOOD SECURITY ***Iphov Kumala Sriwana, Nofi Erni***	Paper_94
6	101	CRITICALLY ASSESS THE DEVELOPMENT OF GREEN SUPPLY CHAIN MANAGEMENT IN THE FAST MOVING CONSUMER GOODS INDUSTRY ***Ilhamsyah Mahendra, Elizabeth WIlliamson***	Paper_101
7	105	CONCEPTUAL MODEL OF SUPPLY CHAIN MANAGEMENT FOR HIGHER EDUCATION ***Fajar Kurniawan***	Paper_105
8	109	AN APPLICATION OF DIFFERENTIAL EVOLUTION ALGORITHM IN SPARE PART LOGISTICS ***Said Badrul Nahar, Sakesun Suthummanon, Wanatchapong Kongkaew***	Paper_109

CAPACITATED VEHICLE ROUTING PROBLEM WITH TIME WINDOWS FOR MILK COLLECTION AT KPBS PANGALENGAN

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ABSTRACT

This research aims to solve a real-life problem faced by KPBS, a regional dairy company in Pangalengan Village of West Java that collects raw milk from farmers to the location of Milk Treatment. In the considered problem, a daily plan is needed to determine a heterogeneous fleet of vehicles that depart from a depot (the factory) and must visit a set of farmers for collection operations within given time window. This problem is known as the Capacitated Vehicle Routing Problem with Time Windows (CVRPTW) which is one of the classical areas of study in Operations Research. In this study the problem will be solved using heuristic method.

Key words: Milk collection, CVRPTW, Operations Research, Heuristic

1. INTRODUCTION

The dairy industry in Pangalengan Village of West Java, Indonesia is organized on the basis of regional cooperative dairy company, named KPBS. Milk collected from the client farmers (*suppliers*) is then delivered by several vehicles with a certain capacity to the location of Milk Treatment operated by the company. In order to maintain the standard quality of milk, each vehicle has to arrive at the location of Milk Treatment within three hours since the milk is picked up from the farmers. In this vehicle routing problem, two kinds of constraints are considered: 1) each vehicle has a limited capacity of collecting milk, and 2) there is time window associated with each farmer, during which the collection operation must be done.

In the considered problem, a daily plan is needed to determine a heterogeneous fleet of vehicles that depart from a depot and must visit a set of farmers for collection operations within given time window, where the collected milk is then delivered to the location of milk treatment for further process. A common objective of the company for this operation is the minimization of the collection cost per kilogram or liter of milk, where the cost of each vehicle route is computed through a system of fees depending on the distance traveled.

In order to achieve this objective, it is needed to group all the suppliers into several clusters i.e., a list of suppliers serviced in sequence by one vehicle in a specific order. Each cluster begins at a factory, collects the milk from the suppliers in turn (this is termed *servicing* the supplier), and finally delivers the milk to the factory. The total milk collected in a cluster cannot exceed the known, upper limit (*capacity*) of the vehicle assigned to that cluster.

The objective of this paper is to determine the minimum number of vehicle routes and the sequence of farmers visited by each vehicle, such that all farmers' milk are collected and all constraints imposed by vehicle capacity, service times and time window are satisfied.

The rest of this paper is organized as follows: Section 2 reviews the related past research in this area. Section 3 describes the data of the problem and the heuristic applied to solve it. Computational results are presented in Section 4, followed by the conclusion in section 5.

2. LITERATURE REVIEW

The capacitated vehicle routing problem with time windows (CVRPTW) is an important problem occurring in many distribution

systems. Basically, the CVRPTW is an extension of the classical CVRP that each customer is associated with a time interval, called a time window. The problem can be described as the problem of designing least cost routes from one depot to a set of geographically scattered points.

Although it is possible to formulate the CVRPTW with a single objective function, most real-world applications involve multiple objectives. Usually, the primary objective is to find the minimum number of vehicles, and the secondary objective is often to minimize the total distance travelled. Other objectives include the minimization of the total schedule time and the minimization of the total waiting time.

During the past few years, numerous papers have been written on generating good solutions for VRPTW. Solomon (1987) is a landmark paper on the VRPTW and is cited by many papers thereafter. It proposes several construction heuristics and provides an extensive computational study of their performance. Tan et al. (2001) investigates various meta-heuristics to solve the VRPTW. This paper implements simulated annealing, tabu search and genetic algorithms to Solomon instances with 100 customers and provides comprehensive results.

Braysy and Gendreau (2005a) reviews and compares classical heuristic methods (route construction heuristics and improvement heuristics) for VRPTW, meanwhile Braysy and Gendreau (2005b) reviews various meta-heuristic algorithms for VRPTW. Russel and Chiang (2006) have used a scatter search metaheuristics to solve the VRPTW. Both a common arc method and an optimization-based set covering model are used to combine vehicle routing solutions.

A reactive tabu search metaheuristic and a tabu search with an advanced recovery feature, together with a set covering procedure are used for solution improvement. Soler et al. (2009) proposed a method to solve, optimally, TDVRP instances that are too small for practical purposes and was likely to experience exponential growth of computational time as a function of problem size. Bettinelli et al. (2011) describes a version where multiple warehouses are considered, using a branch-and-cut-and-price algorithm. These studies clearly demonstrate continuing interest of researchers to solve the problem.

3. PROBLEM STATEMENT

KPBS Pangalengan is a farmer cooperative located in Pangalengan village of Southern Bandung, which is responsible for helping farmers to store and sell milk. Milk collected from the client farmers (suppliers) is then delivered by several vehicles with a certain capacity to the location of Milk Treatment operated by the company.

Because milk is a highly perishable product, the delivery of fresh milk should be sent to the Milk Treatment location within a specific time limit. At the moment, there are 19 registered milk pick-up points (called TPKs) associated with the active member of KPBS Pangalengan, each of which has a certain pick-up demand and time windows as shown in Table 1 below.

Table 1 Data of each pick-up point

Pick-up Point	Pick-up Demand (Liter)	Arrival Time	Departure Time
TPK 1	3.188	05:00	07:30
TPK 2	2.962	05:00	07:00
TPK 3	2.076	05:00	07:30
TPK 4	2.023	05:00	08:00
TPK 5	1.040	05:00	07:30
TPK 6	2.600	05:00	08:00
TPK 7	2.669	05:00	07:00
TPK 8	2.426	05:00	06:30
TPK 9	1.883	05:00	08:00
TPK 10	1.435	06:00	08:30
TPK 11	1.595	05:00	07:30
TPK 12	2.347	05:00	07:30
TPK 13	1.833	05:00	07:30
TPK 14	1.525	05:00	07:00
TPK 15	1.771	05:30	08:30
TPK 16	1.937	05:30	08:00
TPK 17	2.128	05:30	08:30
TPK 18	2.174	05:30	08:30
TPK 19	2.000	05:00	07:00

To conduct the milk collection, the company operates 10 units of vehicle with different capacity, i.e., 2 units of 4.000 liters, 2 units of 4.200 liters, 1 unit of 4.400 liters, 1 unit of 5.400 liters, and 4 units of 6.000 liters. In

order to maintain the standard quality of milk, the vehicles leave the Milk Treatment location to begin a tour and must end the tour at the same location within 3 hours. The distance and average time needed to travel between the milk treatment and pick-up points is shown in Appendix A.

Considering these situations, the problem to solve can be classified as the capacitated vehicle routing problem with time windows (CVRPTW).

The CVRPTW is defined on a graph (N, A). The node set N consists of the set of customers, denoted by C, and the nodes 0 and n+1, which represent the depot. The number of customers $|C|$ will be denoted n and the customers will be denoted by 1,2,…,n. The arc set A corresponds to possible connections between the nodes. No arc terminates at node 0 and no arc originates at node n+1. All routes start at 0 and end at n+1. A cost Z_{ij} and travel time t_{ij} are associated with each arc $(i, j) \in A$ of the network. The travel time t_{ij} includes a service time at customer i. The set of (identical) vehicles is denoted by V. Each vehicle has a given capacity q and each customer a demand d_i, $i \in C$.

At each customer, the start of the service must be within a given time interval, called a time window, $[a_i, b_i]$, $i \in C$. Vehicles must also leave the depot within the time window $[a_0, b_0]$ and return during the time window $[a_{n+1}, b_{n+1}]$. A vehicle is permitted to arrive before the opening of the time window, and wait at no cost until service becomes possible, but it is not permitted to arrive after the deadline. Since waiting time is permitted at no cost, we may assume without loss of generality that $a_0 = b_0 = 0$; that is, all routes start at time 0.

To solve this real-life milk collection problem, the Solomon's insertion heuristic, called *I1* is implemented. A route is first initialized with a seed customer and the remaining unrouted customers are added into this route until its capacity constraint is violated. If unrouted customers remain, the initializations and insertion procedures are then repeated until all pick-up points are serviced. The seed customers are selected by finding either the geographically farthest unrouted customer in relation to the depot or the unrouted customer with the lowest starting time for service.

After initializing the current route with a seed customer, the method uses two subsequently defined criteria $c_1(i, u, j)$ and $c_2(i, u, j)$ to select customer u for insertion between adjacent customers i and j in the current partial route.

Let $(i_0, i_1, i_2, \ldots, i_m)$ be the current route with i_0 and i_m representing the depot. For each unrouted customer u, we first compute its best feasible insertion cost on the route as

$$c_1(i(u), u, j(u)) = \underset{\rho=1,\ldots,m}{optimum} \; c_1(i_{\rho-1}, u, i_\rho),$$

Next, the best customer u^* to be inserted in the route is the one for which

$$c_2(i(u^*), u^*, j(u^*)) = \underset{u}{optimum} \; c_2(i(u), u, j(u)),$$

u unrouted and feasible.

Client u^* is then inserted into the route between $i(u^*)$ and $j(u^*)$. When no more customers with feasible insertions can be found, the method starts a new route, unless it has already routed all customers.

More precisely $c_1(i, u, j)$ is calculated as

$$Z_1(i, u, j) = \alpha_1 Z_{11}(i, u, j) + \alpha_2 Z_{12}(i, u, j),$$

where $\alpha_1 + \alpha_2 = 1$, $\alpha_1 \geq 0$, $\alpha_2 \geq 0$,

$$Z_{11}(i, u, j) = (d_{iu} + d_{uj} - \mu d_{ij}) \; ; \mu \geq 0$$

$$Z_{12}(i, u, j) = b_{ju} - b_j$$

or $Z_{12}(i, u, j) = t_{0u} + t_u + t_{ui} - t_{0i}$

t_{0u}, t_{ui}, and t_{0i} are travel time from the depot to customer u, from customer u to customer i and from depot to customer i respectively, while t_u is the service time at customer u.

d_{iu}, d_{uj} and d_{ij} are distances between customers i and u, u and j and i and j respectively. Parameter μ controls the savings in distance and b_{ju} denotes the new time for service to begin at customer j, given that u is inserted on the route and b_j is the beginning of service before insertion.

The criterion Z_2 (i, u, j) is calculated as
Z_2 (i, u, j) = $\lambda d_{0u} - Z_1 (i,u,j)$, $\lambda \geq 0$.

Parameter λ is used to define how much the best insertion place for an unrouted customer depends on its distance from the depot and on the other hand how much the best place depends on the extra distance and extra time required to visit the customer by the current vehicle.

4. COMPUTATIONAL RESULTS

To solve the problem, the parameters are set arbitrarily as follows, $\mu = 1$; $\alpha_1 = \alpha_2 = 0.5$; and $\lambda = 1$.
Since pick-up point TPK 8 has the shortest time window (see Table 1), it then chosen to be the seed customer in the first iteration, which result the partial route of {0, 8, 0}. After the value of Z_1 and Z_2 computed, it is found that TPK 14 has the minimum value of Z_1 (see Appendix B). Therefore TPK 14 is chosen to be inserted to the partial route, so that the resulted route is {0, 8, 14, 0} with the total demand of 3.951 liters.

It is important to notice that since 10 units of different capacity vehicle are available to perform the milk collection, inserting a pick-up point to a given partial route has to be done by concerning the capacity constraint of a chosen vehicle. In the first iteration, if the vehicle assigned to the route is the one of 4000 liters capacity then there is no more pick-up point can be inserted to the route. The schedule resulted of this iteration is presented in Table 2

Table 2. Schedule of Iteration 1

Pick-up Point	Arrive	Depart	Cumulative Unit (liter)	Cumulative Distance (km)
MT (Depot)		5:00		
TPK 2	5:10	5:25	2.426	3.2
TPK 7	5:34	5:49	3.951	6.2
MT (Depot)	6:02	6:17		10.6

Since unrouted pick-up points remain, the initializations and insertion procedures are then repeated. In the second iteration TPK 2 is chosen to be the seed, followed by TPK 7. As the total pick-up demand of these two TPKs is 6.000 liters, the insertion is stopped which result the route of {0, 2, 7, 0} and the schedule as shown in Table 3.

Table 3. Schedule of Iteration 2

Pick-up Point	Arrive	Depart	Cumulative Unit (liter)	Cumulative Distance (km)
MT (Depot)		5:00		
TPK 2	5:12	5:27	2.962	4.0
TPK 7	5:40	5:55	5.631	8.4
MT (Depot)	6:12	6:27		13.9

All of the above process are then repeated until all pick-up points are serviced. The final solution of the considered problem in this study is shown in Table 4.

Table 4. The final solution

Route	Pick-up Points	Travel Distance (Kilometers)	Capacity Used (liters)
1	0 – 8 – 14 – 0	10,6	4000
2	0 – 2 – 7 – 0	13,9	6000
3	0 – 19 – 12 – 11 – 0	16,6	6000
4	0 – 1 – 13 – 0	27,6	5400
5	0 – 5 – 6 – 3 – 0	34,1	6000
6	0 – 16 – 9 – 17 – 0	47,3	6000
7	0 – 4 – 18 – 0	40,6	4200
8	0 –15 – 0	26	4200
9	0 –10 – 0	48,2	4000

As shown in Table 4, there are 9 routes needed to collect milk from 19 farmers (pick-up points) that will be delivered to the milk treatment location of the factory. It means that the factory has a spare vehicle of 4.400 liters capacity.

5. CONCLUSION

In this study a heuristic is implemented to solve a real-life problem of milk collecting from a set of farmers to the location of Milk Treatment. This problem known as the Capacitated Vehicle Routing Problem with Time Windows (CVRPTW) which categorized as NP-hard problem. The computational result shows that the heuristic in this study is a good heuristic for this problem and the other CVRPTW problems, in terms of its simplicity of implementation.

The main weakness in this heuristic is that there are parameters (μ, α_1, α_2 and λ) that have to be determined arbitrarily. Since these parameters will affect the resulted solution, the only way to find the good solution is to run trial and error all of parameters, which might very time consuming.

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Appendix A The distance (below) and average time needed (upper) to travel between the milk treatment and pick-up points

TPK	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	0	23.1	12	33.6	41.1	32.7	40.2	16.5	9.6	44.7	72.3	23.7	18.3	30.3	13.2	39	55.5	53.1	35.4	14.4
1	7.7	0	13.2	33	40.5	32.1	39.6	21	24.3	49.2	49.2	28.2	31.8	29.4	15.3	43.5	60	57.6	39.9	27.9
2	4	4.4	0	26.4	34.2	25.8	33	13.2	16.8	41.4	62.4	20.4	23.7	23.1	8.1	35.7	52.2	49.5	31.8	19.8
3	11.2	11	8.8	0	11.1	21.6	28.8	26.1	29.4	46.8	82.2	30	33.3	18.9	20.4	41.4	57.6	55.2	37.5	33
4	13.7	13.5	11.4	3.7	0	28.5	31.2	33.6	37.2	54.6	89.7	37.8	40.8	26.4	27.9	45.6	65.4	63	45.3	40.5
5	10.9	10.7	8.6	7.2	9.5	0	7.2	25.5	28.8	46.2	81.3	29.4	34.5	18	19.8	22.8	57	54.6	20.7	32.1
6	13.4	13.2	11	9.6	10.4	2.4	0	32.7	36	41.7	88.8	26.1	31.5	15.3	27	15.6	52.5	50.1	13.2	39.6
7	5.5	7	4.4	8.7	11.2	8.5	10.9	0	9.9	29.4	70.2	8.4	12	11.1	5.7	23.7	40.2	37.8	20.1	9.3
8	3.2	8.1	5.6	9.8	12.4	9.6	12	3.3	0	38.1	73.5	17.1	12.6	19.8	9	32.7	48.9	46.5	28.8	8.7
9	14.9	16.4	13.8	15.6	18.2	15.4	13.9	9.8	12.7	0	98.4	22.5	27.9	28.5	33.9	32.1	19.8	13.5	28.2	32.1
10	24.1	16.4	20.8	27.4	29.9	27.1	29.6	23.4	24.5	32.8	0	77.4	81	78.6	64.5	92.7	109.2	106.8	89.1	77.1
11	7.9	9.4	6.8	10	12.6	9.8	8.7	2.8	5.7	7.5	25.8	0	6.3	11.7	12.9	6.3	6.3	6.3	6.3	6.3
12	6.1	10.6	7.9	11.1	13.6	11.5	10.5	4	4.2	9.3	27	2.1	0	17.1	16.5	22.2	38.7	36.3	18.6	5.4
13	10.1	9.8	7.7	6.3	8.8	6	5.1	3.7	6.6	9.5	26.2	3.9	5.7	0	17.1	22.8	39.3	36.9	19.2	21
14	4.4	5.1	2.7	6.8	9.3	6.6	9	1.9	3	11.3	21.5	4.3	5.5	5.7	0	28.2	44.7	42.3	24.6	12.6
15	13	14.5	11.9	13.8	15.2	7.6	5.2	7.9	10.9	10.7	30.9	5.7	7.4	7.6	9.4	0	42.9	40.5	3.6	26.4
16	18.5	20	17.4	19.2	21.8	19	17.5	13.4	16.3	6.6	36.4	11.1	12.9	13.1	14.9	14.3	0	26.7	39	42.9
17	17.7	19.2	16.5	18.4	21	18.2	16.7	12.6	15.5	4.5	35.6	10.3	12.1	12.3	14.1	13.5	8.9	0	36.6	40.5
18	11.8	13.3	10.6	12.5	15.1	6.9	4.4	6.7	9.6	9.4	29.7	4.4	6.2	6.4	8.2	1.2	13	12.2	0	22.8
19	4.8	9.3	6.6	11	13.5	10.7	13.2	3.1	2.9	10.7	25.7	3.5	1.8	7	4.2	8.8	14.3	13.5	7.6	0

Appendix B The value of Z_1 and Z_2 of iteration 1

i	u	d(i,u)	d(u,0)	d(i,0)	Z11	t(0,u)	t(u,i)	t(0,i)	Z12	Z1	Z2
8	1	8,1	7,7	3,2	12,6	23	24	10	52	32,3	-24,6
	2	5,6	4,0	3,2	6,4	12	17	10	34	20,3	-16,3
	3	9,8	11,2	3,2	17,8	34	29	10	68	43,1	-31,9
	4	12,4	13,7	3,2	22,9	41	37	10	84	53,3	-39,6
	5	9,6	10,9	3,2	17,3	33	29	10	67	42,1	-31,2
	6	12,0	13,4	3,2	22,2	40	36	10	82	51,9	-38,5
	7	3,3	5,5	3,2	5,6	17	10	10	32	18,7	-13,2
	9	12,7	14,9	3,2	24,4	45	13	10	63	43,6	-28,7
	10	24,5	24,1	3,2	45,4	72	25	10	102	73,8	-49,7
	11	5,7	7,9	3,2	10,4	24	6	10	35	22,6	-14,7
	12	4,2	6,1	3,2	7,1	18	4	10	28	17,5	-11,4
	13	6,6	10,1	3,2	13,5	30	7	10	42	27,9	-17,8
	14	3,0	4,4	3,2	4,2	13	3	10	22	12,9	-8,5
	15	10,9	13,0	3,2	20,7	39	11	10	55	38	-25
	16	16,3	18,5	3,2	31,6	56	16	10	77	54,4	-35,9
	17	15,5	17,7	3,2	30,0	53	16	10	74	52	-34,3
	18	9,6	11,8	3,2	18,2	35	10	10	50	34,3	-22,5
	19	2,9	4,8	3,2	4,5	14	3	10	23	13,6	-8,8

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