An Immune-Inspired Algorithm for Vehicle Routing Problem

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25th-27th June, 2019
Royton Sapporo Hotel, Japan

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2019 INTERNATIONAL CONFERENCE ON FUTURE INFORMATION & COMMUNICATION ENGINEERING Vo.11 No.1 목차

Conference Schedule Overview

◉ Registration

- Time : 9:00 ~ 12:00 (26th ~ 27th June, 2019)
- Place : Royton Sapporo Hotel, Japan

◉ Opening Ceremony / Keynote Speech

- Time : 17:00 ~ 18:30 (25th June, 2019)
- Place : Regent Hall, Royton Sapporo Hotel, Japan
- Keynote Speech (Chair. Hee-Cheol Kim)
  Title : ERP Implemetation and Performance Evaluation in Indian Small Manufacturing Enterprises (SMEs)
  Speaker : Srikanta Patnaik(SOA University, India)

◉ Luncheon / Business Meeting

- Time : 12:00 ~ 13:00 (26th ~ 27th June, 2019)
- Place : Royton Sapporo Hotel, Japan

◉ Technical Session

- Time : 9:00 ~ 12:00 (26th ~ 27th June, 2019)
- Place : Crystal Room #1~2, Royton Sapporo Hotel, Japan

ICFICE 2019 25th ~ 27th June, 2019, Royton Sapporo Hotel, Japan		
	26th June, 2019	**27th June, 2019**
Registration Open 09:00 ~		
Technical Session : Oral		
	Crystal Room #1	**Crystal Room #1**
	Session IT-A, SC-A Jong-Wook Jang (Dong-eui University)	**Session IS-A** Hee-Cheol Kim (Inje University)
09:00~ 09:15	**IT-1**	**IS-1**
09:15~ 09:30	**IT-2**	**IS-2**
09:30~ 09:45	**IT-3**	**IS-3**
09:45~ 10:00	**IT-4**	**IS-4**
10:00~ 10:15	**SC-1**	**IS-5**
10:15~ 10:25	**Coffee Break**	
	Session IB-A, NS-A, CA-A Jeong-Wook Seo (Namseoul University)	**Session IB-B, MD-A, DA-A** Dong-Sik Jo (Wonkwang University)
10:25~ 10:40	**IB-2**	**IB-1**
10:40~ 10:55	**IB-3**	**MD-1**
10:55~ 11:10	**IB-4**	**MD-2**
11:10~ 11:25	**NS-1**	**MD-3**
11:25~ 11:40	**CA-1**	**DA-1**

※ IT : IT Fusion Technology / CA : Communication System and Application
NS : Networking and Services / IS : Intelligent Information System
MD : Multimedia and Digital Convergence / DA : Database and Internet Application
SC : Semiconductor and Communication Services / IB : IoT and Big Data

ICFICE 2019 25th ~ 27th June, 2019, Royton Sapporo Hotel, Japan			
26th June, 2019			
Registration Open 09:00 ~			
Technical Session : Poster			
	Crystal Room #2		
	Session IT-B, NS-B, BI-A Dae-Sung Lee (Catholic University of Pusan)		
09:00~ 09:50	**IT-5**	**IT-11**	**NS-5**
	IT-6	**IT-12**	**NS-6**
	IT-7	**IT-13**	**BI-1**
	IT-8	**NS-2**	**BI-2**
	IT-9	**NS-3**	**BI-3**
	IT-10	**NS-4**	
09:50~ 10:00	**Coffee Break**		
	Session IT-C, SC-B, UN-A Chang-Pyo Yoon (Gyeonggi College of Science and Technology)		
10:00~ 10:50	**IT-14**	**IT-20**	**SC-2**
	IT-15	**IT-21**	**SC-3**
	IT-16	**IT-22**	**SC-4**
	IT-17	**IT-23**	**UN-1**
	IT-18	**IT-24**	
	IT-19	**IT-25**	
10:50~ 11:00	**Coffee Break**		

※ IT : IT Fusion Technology / CA : Communication System and Application
NS : Networking and Services / BI : Biomedical Imaging and Engineering
SC : Semiconductor and Communication Services

ICFICE 2019 25th ~ 27th June, 2019, Royton Sapporo Hotel, Japan			
26th June, 2019			
Registration Open 9:00 ~			
Technical Session : Poster			
	Crystal Room #2		
	Session CA-B, SC-C Se-Min Kim (Jeonju National University of Education)		
11:00~ 11:50	CA-2	CA-8	SC-7
	CA-3	CA-9	SC-8
	CA-4	CA-10	SC-9
	CA-5	CA-11	
	CA-6	SC-5	
	CA-7	SC-6	

※ IT : IT Fusion Technology / CA : Communication System and Application
SC : Semiconductor and Communication Services / UN : Ubiquitous Sensor Network

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ICFICE 2019 25th ~ 27th June, 2019, Royton Sapporo Hotel, Japan			
27th June, 2019			
Registration Open 9:00 ~			
Technical Session : Poster			
	Crystal Room #2		
	Session IS-B, IB-C Sung-Hee Woo (Korea National University of Transportation)		
09:00~ 09:50	IS-6	IS-12	IB-9
	IS-7	IS-13	IB-10
	IS-8	IB-5	IB-11
	IS-9	IB-6	IB-12
	IS-10	IB-7	IB-13
	IS-11	IB-8	
09:50~ 10:00	Coffee Break		
	Session IS-C, MD-B, NS-C Young-Woon Woo (Dong-eui University)		
10:00~ 10:50	IS-14	IS-20	NS-7
	IS-15	MD-4	
	IS-16	MD-5	
	IS-17	MD-6	
	IS-18	MD-7	
	IS-19	MD-8	
10:50~ 11:00	Coffee Break		

※ IS : Intelligent Information System / IB : IoT and Big Data
MD : Multimedia and Digital Convergence / NS : Networking and Services

ICFICE 2019 25th ~ 27th June, 2019, Royton Sapporo Hotel, Japan			
27th June, 2019			
Registration Open 9:00 ~			
Technical Session : Poster			
	Crystal Room #2		
	Session MD-C, DA-B Seong-Yoon Shin (Kunsan National University)		
11:00~ 11:50	MD-9	DA-2	DA-8
	MD-10	DA-3	DA-9
	MD-11	DA-4	
	MD-12	DA-5	
	MD-13	DA-6	
	MD-14	DA-7	

※ MD : Multimedia and Digital Convergence / DA : Database and Internet Application

26th June, 2019

Session IT-A : IT Fusion Technology

Session SC-A : Semiconductor and Communication Services

Session Chair : Jong-Wook Jang(Dong-eui University)

09:00~10:15 (Crystal Room #1)

IT-1 : **Design of Vehicle Tracking Systems for Public Safety in Indonesia**
A.M. Ilham, Jin-uk Jung, Kyo-hong Jin, and Min-tae Hwang
(Changwon National University)

IT-2 : **Traceability System for Fire Fighting Equipment using GS1 and EPCIS: Production, Inspection, and Recycling**
Heum Park and Chang Min Park (Youngsan University)

IT-3 : **Proposal of LoRa Network Control System**
Jae-Ung Lee and Jong-Wook Jang(Dong-eui University)

IT-4 : **Performance Analysis & Evaluation of ERP: A Case Study of Indian Small Manufacturing Enterprises**
Bhagyashree Mohanta and Srikanta Patnaik(Siksha 'O' Anusandhan)

SC-1 : **Electrical Characteristic of Monolithic 3D Inverter Consisting of JLFET with Interface Charge**
Tae-Jun Ahn[1,2], Jong Ho Lee[2], Young Baek Kim[2], and Yun Seop Yu[1]
([1]Hankyong National University, [2]Korea Institute of Industrial Technology)

Session IB-A : IoT and Big Data

Session NS-A : Networking and Services

Session CA-A : Communication System and Application

Session Chair : Jeong-Wook Seo(Namseoul University)

10:25~11:40 (Crystal Room #1)

IB-2 : **A CNN data configuration method for Multivariate Time Series IoT Data**
Ji-Soo Kim[1], Chul-Hyun Hwang[2], and Sung-Ock Lee[3]
([1]Kookmin University, [2]Data Maroo co, [3]Global HRD Inc)

IB-3 : **Deep Learning Model Architecture for Rare Event Time Series Prediction**
Ji-Soo Kim[1], Chul-Hyun Hwang[2], and Hyunok Song[3]
([1]Kookmin University, [2]Data Maroo co, [3]DASOMSOFT)

IB-4 : **Analysis of Factors Affecting the Filling rate of each type of daycare center Using Bigdata Technology**
Jeongwon Lee[1], Byungil Jeon[1], Semin Kim[2], Gyujeong Lee[1], and Choong Ho Lee[1]([1]Hanbat National University, [2]Jeonju National University of Education)

NS-1 : **Interference Levels Between Closely Spaced Dual Polarized Geostationary-Satellite Networks**
Wonjun Choi[1] and Jongwon Eun[2]
([1]National Institute of Environmental Research, [2]Namseoul University)

CA-1 : **Asymptotic Stability and Stability Switching for a System of Delay Differential Equations**
Wataru Saito and Ikki Fukuda (Hokkaido University)

Session IT-B : IT Fusion Technology

Session NS-B : Networking and Services

Session BI-A : Biomedical Imaging and Engineering

Session Chair : Dae-Sung Lee(Catholic University of Pusan)

09:00~09:50 (Crystal Room #2)

IT-5 : **A Study of System Design of Automatic Vehicle Passengers Number Count for High Occupancy Vehicle Lanes**
Minyoung Kim and Jongwook Jang(Dong-eui University)

IT-6 : **Branch processing system using WebAssembly and Javascript**
Moon-Hyuk Choi, Jin-Tae Park, Hyun-Gook Kim, and Il-Young Moon (KOREATECH)

IT-7 : **The Utilization of ICT for Support of the Elderly - Based on the Case of Nordic Countries-**
Jin Ah Lee(Catholic University of Pusan)

IT-8 : **A Study on Motion Tracking Method and Moving Path Estimation in Virtual Reality Environments**
Dong-Min Kim, Ji-Yong Lim, Sung-Uk Heo, Gwan-Hyung Kim, and Am-Suk Oh (Tongmyong University)

BI-2 : Rolling Boll System Design with BLE Communication for Pets
Young Bin Kim and Conan K.R. Ryu(Mokwon University)

BI-3 : Auto-segmentation of Intima/Adventitia of the Vessel by Subtracting Different types of Binarization Results
Kwang Baek Kim[1], Jong Hee Lee[1], Hyun Jun Park[2], and Doo Heon Song[3]
([1]Silla University, [2]Cheongju University,[3]Yong-In SongDam College)

Session IT-C : IT Fusion Technology

Session SC-B : Semiconductor and Communication Services

Session UN-A : Ubiquitous Sensor Network

Session Chair : Chang-Pyo Yoon(Gyeonggi College of Science and Technology)

10:00~10:50 (Crystal Room #2)

IT-14 : Simulation Tools to Support the Design of Equipment in Logistics Center
Doo-Jin Park[1], Yong-Seok Choi[2], and Jae-Eun Lee[2]
([1]Tongmyoung University, [2]Sunchon National University)

IT-15 : Design and Implementation of a system for monitoring and controlling farm conditions
Si-Woong Jang and Dong-Hun Jung(Dong-eui University)

IT-16 : Development of Software Education Board Game to improve algorithmic thinking ability
Ji-Yeon Hong(Korea National University of Education)

IT-17 : A Development of Learning Model to Industry Education for Appropriate Technology using Open Source
Semin Kim[1], Jeongwon Lee[2], Byungil Jeon[2], and Choong Ho Lee[2]
([1]Jeonju National University of Education, [2]Hanbat National University)

IT-18 : Development of STEAM-Based Software Education Program
Jeong-Beom Song
(Chungcheongnamdo office of Education Research and Information Institute)

IT-19 : Analysis of Learning Satisfaction in Programming Classes by Types of Programming Language and Tools
Semin Kim[1] and Kangsoo You[2]
([1]Jeonju National University of Education, [2]Jeonju University)

Session CA-B : Communication System and Application

Session SC-C : Semiconductor and Communication Services

Session Chair : Se-Min Kim(Jeonju National University of Education)

11:00~11:50 (Crystal Room #2)

CA-2 : App Inventor Programming Based on Software Engineering
Kie-Sung Oh(Tongwon University)

CA-3 : Development and Effect of Stepwise Simulation-based Communication Education Program for Nursing Students
Hyun-Ju Kim(Catholic University of Pusan)

CA-4 : Automatic Channel Selection of Radio Broadcasting using Bigdata Analysis
O. Bayarmaa[1], Eun kyoung Chae[1], Jeongwon Lee[1,2], and Won jong Park[1]
([1]Euclidsoft, [2]Hanbat National University)

CA-5 : LoRa Class C based Data Collection Speed Improvement Algorithm for Extending LPWA Coverage
Hyuk Kwon, Kyoung-Bog Jin, and Chang-Heon Oh(KOREATECH)

CA-6 : Design of Low Power Operation Algorithm based on LPWA to Continue Localization of Buoys Located in the Ocean
Min-Ho Jeon[1], Hyung-Dong Choi[1], Choon-Sik Yim[1], and Chang-Heon Oh[2]
([1]RCN, [2]KOREATECH)

CA-7 : LPWA 920 MHz Antenna for Subminiature IoT Sensors
Seong-Real Lee(Mokpo National Maritime University)

CA-8 : Theoretical Bound for Sparse Defects in Group Testing Problems
Jin-Taek Seong(Mokpo National University)

CA-9 : An Efficient Radio Communication for Fire Fighting Communication Using DMR(Digital Mobile Radio)
Hyun-Yul An and Chang-Kyu Kim(Dong-eui University)

CA-10 : Design of Automatic Inspection System for Maintenance of Unmanned Security Facility
Chae-young Moon[1], Semin Kim[2], and Kwang-ki Ryoo[1]
([1]Hanbat National University, [2]Jeonju National University of Education)

CA-11 : Use of Web-based Counseling and Psychological test in South Korea
Jisun Park(Catholic University of Pusan)

27th June, 2019

Session IS-A : Intelligent Information System

Session Chair : Hee-Cheol Kim(Inje University)

09:00~10:15 (Crystal Room #1)

IS-1 : **Engine State Monitoring System Using ID Priority Allocation of CAN network**
Hyun Lee(Korea Polytechnic)

IS-2 : **Study on Recognition of Hand Gestures Using Convolutional Neural Network**
Buemjun Kim and Kyounghee Lee(Pai Chai University)

IS-3 : **A Web Server Implementation Providing Tensorflow-based Artificial Intelligence Platform**
Hyun-Jun Park and Kyounghee Lee(Pai Chai University)

IS-4 : **HPC/HC opt-aiNet-based Scheduling**
Arief Zulianto, Kuspriyanto, and Yudi S. Gondokaryono
(Institut Teknologi Bandung)

IS-5 : **An Immune-Inspired Algorithm for Vehicle Routing Problem**
Ayi Purbasari[1], Handoko Supeno[1], and Achmad Nizar Hidayanto[2]
([1]Universitas Pasundan, [2]Universitas Indonesia)

Session IB-B : IoT and Big Data

Session MD-A : Multimedia and Digital Convergence

Session DA-A : Database and Internet Application

Session Chair : Dong-Sik Jo(Wonkwang University)

10:25~11:40 (Crystal Room #1)

IB-1 : **Multi-index Approach to Search Chinese, Japanese, and Korean Text with Elasticsearch 6.6**
Kiju Kim[1] and Youngbok Cho[2]([1]Elastic, [2]Daejeon University)

MD-1 : **Human Activity Recognition Techniques using Deep Learning under Smartphone Acceleration Sensor**
Teuk-Seob Song(Mokwon University)

MD-2 : An Analysis Keyword in SNS Environment Utilizing Big Data
Soo-Tai Nam[1], Seong-Yoon Shin[2], and Chan-Yong Jin[1]
([1]Wonkwang University, [2]Kunsan University)

MD-3 : Analysis of Student Teachers' Requirement of Software Education at National Universities of Education
Young-Sik Jeong(Jeonju National University of Education)

DA-1 : Factors Improving the Performance of IT Investment in Corporates: Focusing on the Moderating Effect of IT Savviness
Moon Junghoon[1], Yoo Sunggoo[1], and Lee Jongtae[2]
([1]Seoul National University, [2]Seoul Women's University)

Session IS-B : Intelligent Information System

Session IB-C : IoT and Big Data

Session Chair : Sung-Hee Woo(Korea National University of Transportation)

09:00~09:50 (Crystal Room #2)

IS-6 : Change of malicious code API call pattern extraction using RNN and LSTM
Young-Bok Cho[1], Ki-Ju Kim[2], Jeong-Ah Ku[1], and Sung-Hee Woo[3]
([1]Daejeon University, [2]Elastic, [3]Korea National University of Transportation)

IS-7 : Drowsiness Preventing System using YOLO
Tan Xujie[1] and Seong-Yoon Shin[2]
([1]Jiujiang University, [2]Kunsan National University)

IS-8 : Improving Text Classification Technique
Liu Xiao-Wen[1], Guangxing Wang[2], Abdur Razzaq Fayjie[3], Hyun-Chang Lee[4], and Seong-Yoon Shin[5]([1]Hebei Normal University for Nationalities, [2]Jiujiang University, [3]Dibrugarh University, [4]Wonkwang University, [5]Kunsan National University)

IS-9 : Performance and energy efficiency analysis of Cache Memory Architecture in GPGPU
Cheol-Won Jo, Seong-Hun Lee, and Kwang-Yeob Lee(Seokyeong University)

IS-10 : Gaussian denoiser: Noise prediction using U-Net with additional skip connection.
Sung-Hun Lee, Cheol-Won Jo, and Kwang-Yeob Lee(Seokyeong University)

IB-13 : On Recommending Additional Speed Cameras for Reducing Accidents Based on Sections and Existing Speed Cameras
Athita Onuean[1], Hanmin Jung[1,2], and Daesung Lee[3]
([1]University of Science and Technology, [2]Korea Institute of Science and Technology Information, [3]Catholic University of Pusan)

Session IS-C : Intelligent Information System

Session MD-B : Multimedia and Digital Convergence

Session NS-C : Networking and Services

Session Chair : Young-Woon Woo(Dong-eui University)

10:00~10:50 (Crystal Room #2)

IS-14 : Adult Access Detection System based on Clothing Information
Seong-Yoon Shin[1] and Hyun-Chang Lee[2]
([1]Kunsan National University, [2]Wonkwang University)

IS-15 : An IoT-Based Object Detection and Alerting System for Livestock Disease Prevention
Wonseok Jung[1], Hyeon Park[2], Se-Han Kim[2], and Jeongwook Seo[1]
([1]Namseoul University, [2]IoT Research Department Electronics and Telecommunications Research Institute)

IS-16 : Comparison of Machine Learning Models for Solar Energy Prediction
Wonseok Jung[1], Young-Hwa Jeong[1], Moon-Ghu Park[2], and Jeongwook[1] Seo([1]Namseoul University, [2]Sejong University)

IS-17 : Particulate Matter Prediction using Recurrent Neural Network
Kyoung-Woo Cho, Yong-Jin Jung, and Chang-Heon Oh
(KOREATECH)

IS-18 : Doppler Radar-based Biometric Measurement System using Spectrum Summation Method
Jong-Sung Lee, Min-Ho Jeon, and Chang-Heon Oh(KOREATECH)

IS-19 : A Review on the Role of Artificial Intelligence (AI) in Psychotherapy & its Feasibility in Real Life Situations
Satyabrata Aich, Sabyasachi Chakraborty, Beom Su Kim, and Hee-Cheol Kim(Inje University)

IS-20 : An Effective Method for Generating Color Images Using Genetic Algorithm
Joo Hyoung Cha and Young Woon Woo(Dong-eui University)

MD-4 : A signaling scheme for the discontinuous reception operations
Sangjoon Park and Jongchan Lee(Kunsan National University)

MD-5 : Analysis of Differences in Learning Flow, Thinking, and Creativity Before and After Participating in Flipped Learning Classes for Engineering
Ockboon Kim, Young-bok Cho, and Hana Yoo(Daejeon University)

MD-6 : AMVP and Merge Candidate Restriction for IBC Mode in VVC
Heeji Han[1], Daehyeok Gwon[1], Hahyun Lee[2], Jungwon Kang[2], and Haechul Choi[1]([1]Hanbat National University, [2]Electronics and Telecommunications Research Institute)

MD-7 : Effects of Virtual Humans on Co-presence
Dongsik Jo(Wonkwang University)

MD-8 : A Comparative Study of Teacher's Recognition for Multicultural Gifted: Korea and Russia
Sung Won Seo(KAIST)

NS-7 : A Study on Event Log Validity Analysis for Detecting Threats by Insiders in Control System
JongMin Kim[1], MinSu Kim[1], and DongHwi Lee[2]
([1]Kyonggi University, [2]DongShin Universiry)

Session MD-C : Multimedia and Digital Convergence

Session DA-B : Database and Internet Application

Session Chair : Seong-Yoon Shin(Kunsan National University)

11:00~11:50 (Crystal Room #2)

MD-9 : Use of Tesla's Columbus egg for Physics Demonstration & Development of Teaching-Learning Materials
Hee-Mok Kim[1] and Chan-Soo Jee[2]([1]KAIST, [2]Kangwon National University)

MD-10 : A Study on specific region detection and recognition based on Transfer-Learning and Data Augmentation
Kwang-Seong Shin and Dong-Sik Jo(Wonkwang University)

MD-11 : Usability evaluation on smartphone app of module kit for DIY smart toy
Hun Choi and Yoo-Jung Choi(Catholic Univ of Pusan)

MD-12 : Forecast Likelihood of Stock Trading Price Based on Big Data Analysis
Soo-Tai Nam[1], Chan-Yong Jin[1], and Seong-Yoon Shin[2]
([1]Wonkwang University, [2]Kunsan University)

An Immune-Inspired Algorithm for Vehicle Routing Problem

Ayi Purbasari[1*], Handoko Supeno[2], and Achmad Nizar Hidayanto[3]

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Abstract

Combinatorial optimization is a problem of finding discrete feasible solutions and its best solution for all feasible solutions. The Travelling Salesman Problem (TSP) and Vehicle Routing Problem (VRP) are the common problems of combinatorial optimization. In VRP, we need to find the optimal set of routes for a vehicle to traverse in order to deliver to a given set of customers. VRP generalises TSP (multi-TSP) and the objective of the VRP is to minimize the total route cost. Many approaches and algorithms proposed by researchers nowdays. In this paper, we propose an Artificial Immune System's algorithm as a promising new VRP algorithm. We use the Clonal Selection Algorithm (CSA) which is an immune-inspired algorithm based on Clonal Selection Principle. This approach is implemented and tested on various dataset of waste transportation In Northern Bandung, West Java, Indonesia. The preliminary results are promising and lead to believe that the Clonal Selection Algorithm is a viable approximation heuristic for the VRP.

Index Terms: Vehicle Routing Problem, VRP, Optimization Problem, Combinatorial Problem, Artificial Immune System, Clonal Selection Algorithm, Immune-Inspired Algorithm, Bio-inpired Algorithms.

I. INTRODUCTION

Vehicle Routing Problem (VRP) is an optimization problem in determining routes with limited vehicle capacity. There is an initial depot and a number of n locations with various demands. A vehicle departs from the initial depot, visits all locations to fulfill requests from each location [1]. The purpose of this problem is to minimize the total distance traveled by the vehicle by arranging the order of places to visit along with when the vehicle will return to fill its capacity again [1].

Basically, VRP can be solved using multi-Traveling Salesperson Problem (mTSP). where a traveling merchant must visit the entire city exactly once, and return to his hometown. At mTSP, there are m traveling traders who each visit a particular city exactly once, and return to the original city [2]. MTSP is a complex problem, namely a difficult problem where there is no solution with a polynomial time to solve it and requires a non-polynomial-time algorithm (NP Problem). In resolving NP problems, the exact approach cannot handle the problem large. The heuristic approach is the choice of solutions, namely a quick approach to get a feasible solution. Artificial Immune System (AIS) [3] is one of bio-inspired computing inspired by the behavior of the immune system that is adaptive and self-organizing. AIS has many roles in the issue of learning, optimization, and

intrusion detection [3]. This paper investigate AIS algorithm to solve VRP with mTSP approach, for Bandung waste transporation. Systematically, this paper contains an introduction, system model and methods, related research, results and conclusions, and acknowledgments.

II. SYSTEM MODEL AND METHODS

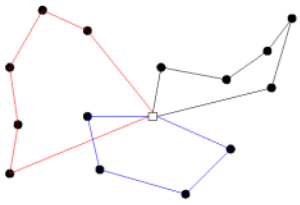

Fig. 1 VRP with 3 vehicles

3.1 VRP and mTSP Solution Approach

VRP is a combinatorial problem which can be seen as an extension of the classic problem Traveling Salesperson Problem (TSP). With the mTSP approach, the solution is obtained by transforming the mTSP into a TSP. The following Fig. 1 is an overview of VRP problems with 3 vehicles. Basically, the VRP problem is to consider the optimal route while taking into account the capacity loading limits.

3.2 Proposed mTSP solutions with AIS

With the mTSP solution approach, the VRP problem can be seen as a mTSP problem with TSP resolution. For the TSP problem itself, there are several solutions that use the immune system-inspired metaheuristic approach. Especially for Traveling Salesperson Problems, AIS was used for the first time by Castro and Von Zuben [4]. Subsequent research was conducted by M. Bakhouya and J. Gaber [5], where the researchers proposed immune based algorithms and compared them with ant colony approaches from other researchers.

This Fig. 2 shows the Clonal Selection Algorithm. By using the AIS approach, the first step in solving the problem of combinatorial optimization is to map the problems and elements contained in AIS [4][6]. Based on the TSP approach, CSA is used to solve the mTSP problem. The first thing to do is the representation of the mTSP problem in the form of the mTSP domain like this Fig. 3 below:

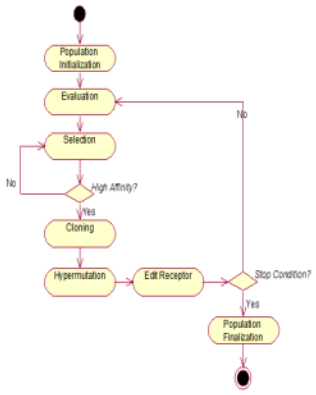

Fig. 2 Clonal Selection Algorithm (CSA)

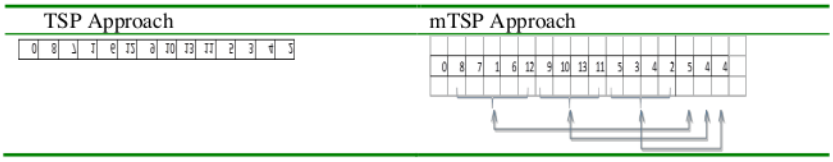

Fig. 3 TSP and mTSP representation of 14 vertices with node 0 as depot [7]

In the case of mTSP this is two-part representation. The first part represents the tour and the second part represents salemen. This shows that the first salesmen were in charge of visiting 5 cities, while the second and third salesmen were in charge of visiting 4 cities.

III. RESULT

A. Experiment Design

We use Java programming language to implement the algorithm with this experiment design:

Dataset	**Waste transportation In Northern Bandung, West Java, Indonesia: Bandung36.vrp and Bandung148.vrp**
VRP parameter:	Numnber of vertices: 36 or 148 Number of salesmen: between 2- 17 and between 2 - 74
CSA parameters	Number of population (N) = 50; Selection size (n) = 10; The value for the cloning factor (β) = 0.1; Value for mutation factor (rho) 2.5;Size for random replacement (d) = 5
Determination of criteria stops	Number of generations (g) = 1000, 10,000, 100,000

B. Experiment Result

This below show the experiment result for dataset Bandung36.vrp.

Table 1 mTSP for North Bandung waste transportation

Number of salesmen	Sub-tour Cost	Total Cost
2	1106 434	1540
3	66 1102 1064	2232
4	885 108 113 1263	2369
5	994 254 222 643 251	2364
6	250 377 42 1260 168 408	2505
7	693 42 106 930 222 40 936	2969
8	72 40 780 206 42 1031 156 222	2549
9	860 66 106 222 168 42 72 40 667	2245
10	42 1043 222 293 108 206 156 543 40 66	2719
11	959 72 40 42 206 147 222 156 66 108 958	2976
12	1007 206 156 42 168 66 222 106 40 146 108 472	2739
13	974 42 423 108 72 40 198 206 156 66 106 476 222	3089
14	206 66 474 156 198 106 685 146 40 222 42 72 108 880	3401
15	601 42 250 803 168 222 106 206 40 198 146 72 156 108 453	3571
16	494 108 168 606 40 66 156 106 222 250 42 146 250 206 72 780	3712
17	222 206 278 40 338 1057 66 106 250 108 198 146 288 168 42 72 156	3741
18	892 206 42 146 108 198 338 66 72 156 250 40 106 290 311 278 222 168	3889

Fig. 4 Best cost for each salesmen (36 nodes)

Fig, 5 result of mTSP for 148 nodes of Bandung waste points.

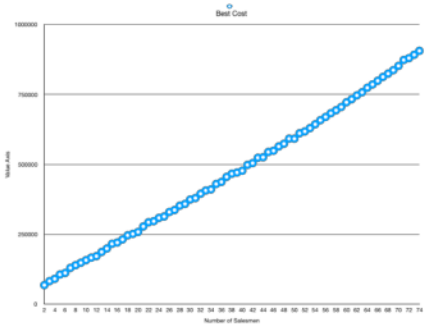

Fig. 5 Best cost for each salesmen (148 nodes)

We can see, the number of salesmen has increased in line with the best costs obtained.The best best cost is obtained for the number of salesmen = 2. This is consistent with the two dataset.

IV. DISCUSSION AND CONCLUSIONS

A. DISCUSSION

In this paper, a clonal selection based algorithm was proposed for solving the VRP with mTSP approach. This algorithm is can show solution for mTSP for Bandung waste transportation dataset. Two dataset in experiments show that the best cost (minimal cost) result from 2 salesmen / driver in VRP. This is because, the cost represent distance between nodes. Actually we need other representation of cost, like capacity of the truck and the time limit as VRP constraint. This is will be future research.

B. CONCLUSION

VRP can be solved by mTSP approach using bio-inspired computation like Clonal Selection Algorithm. This algorithm has been shown the good performance, but has several limitations since the need to define constraint for the VRP constraints.

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