



한국해양수산개발원
KOREA MARITIME INSTITUTE



**Maritime
Transportation
Planning
for Car Carriers**



- 55th Annual Transportation Research Forum -

Maritime Transportation Planning Based on Genetic Algorithm and Its Application

March 13, 2014

**Korea Maritime Institute
Moohong Kang**

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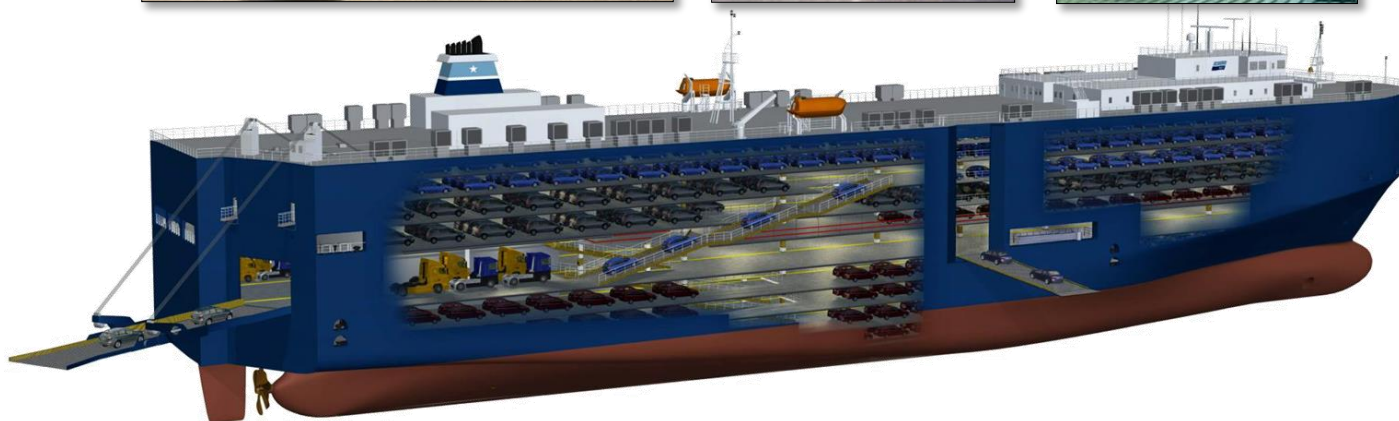
Conclusions

I. Introduction

- 1. Maritime Transportation Problem
- 2. Research Backgrounds
- 3. Research Scope

Major Business of Car Carriers

- Perform a business to transport automobiles to specific areas
- If needed, transport special vehicles like trains, construction equipments, airplanes, etc



Standard Unit of Car Carriers

- Automobiles, trains, construction equipments have a different size
 - To plan a shipment, a standard unit would be needed
- Standard Unit: **CEU** (Car Equivalent Unit, World Standard Unit = 10 CBM(Cubic Meters))

CAR MAKER INFORMATION

Cargo Dimension Detail

Save

Search

Close

Maker Code	HMC	Route	ASNE
Description	HYUNDAI MOTOR	Triff Code	HYUN15
Kind	D (D: Domestic, F: Foreign, S: Swap)		
HD/OT	HD (HD: Hyundai group, OT: Other car)		

D I M E N S I O N

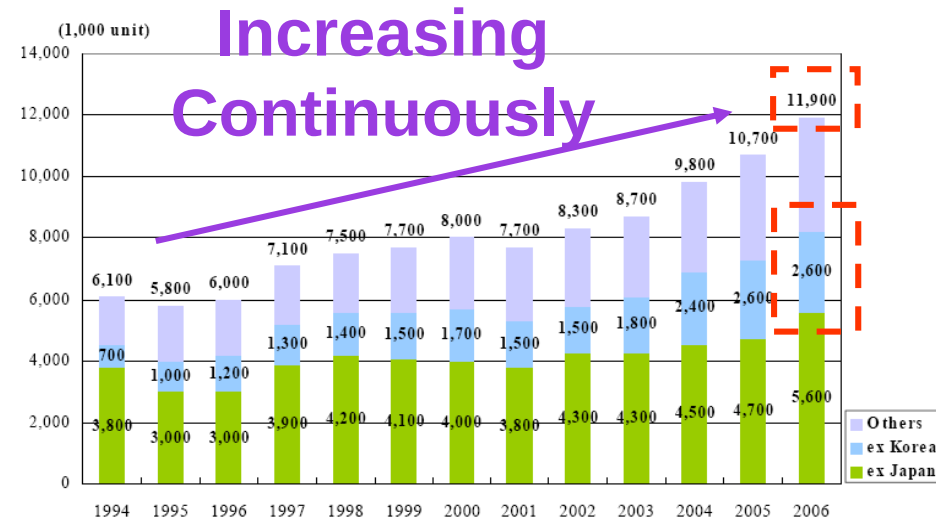
	Length	Width	Height	Weight	AEU	CEU
Standard CEU	4.115 M	1.620 M	1.395 M			
Small passenger	3.495 M	1.495 M	1.615 M	770 KGS	.78	.84
Passenger	4.750 M	1.560 M	1.530 M	1,077 KGS	1.11	1.13
Small truck	5.200 M	1.500 M	1.740 M	1,610 KGS	1.17	1.35
Large truck	8.000 M	2.300 M	2.640 M	2,955 KGS	2.76	4.85
Other	12.100 M	2.490 M	3.290 M	9,500 KGS	4.51	9.91
Static	0.000 M	0.000 M	0.000 M	0 KGS		

Objective of Maritime Transportation Planning

- Transport maximum cargoes with minimum tonnages
- If there is lack of tonnages, charter or build more ships, or carry some cargoes forward to next month

Maritime Transportation Market Growing

- Increasing a transportation planning workload with market growth



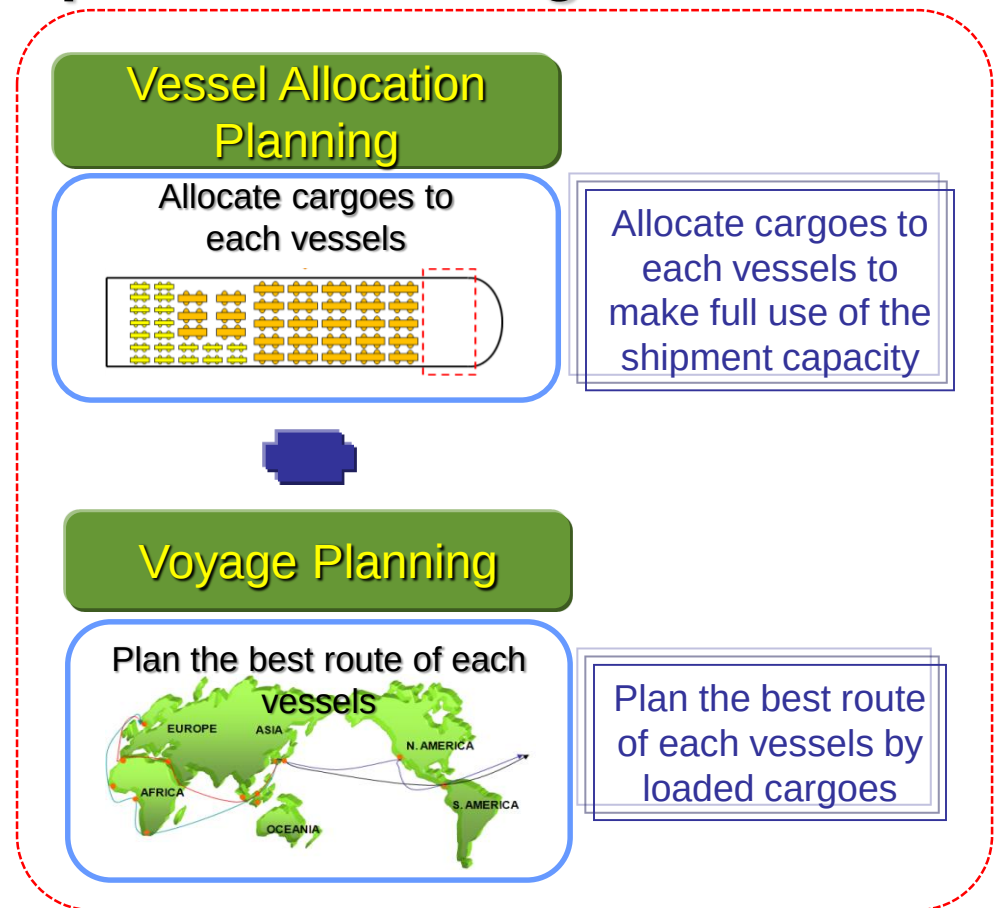
Source : MOL IR

Inefficiency of Legacy Planning Methods

- Planning work has been proceeded through experience of workers by hands

→ To Develop support system and algorithm is needed to plan a maritime transportation systematically and efficiently

Business of Maritime Transportation Planning for Car Carriers



- To plan tonnages is excluded in this research because it is determined by executives

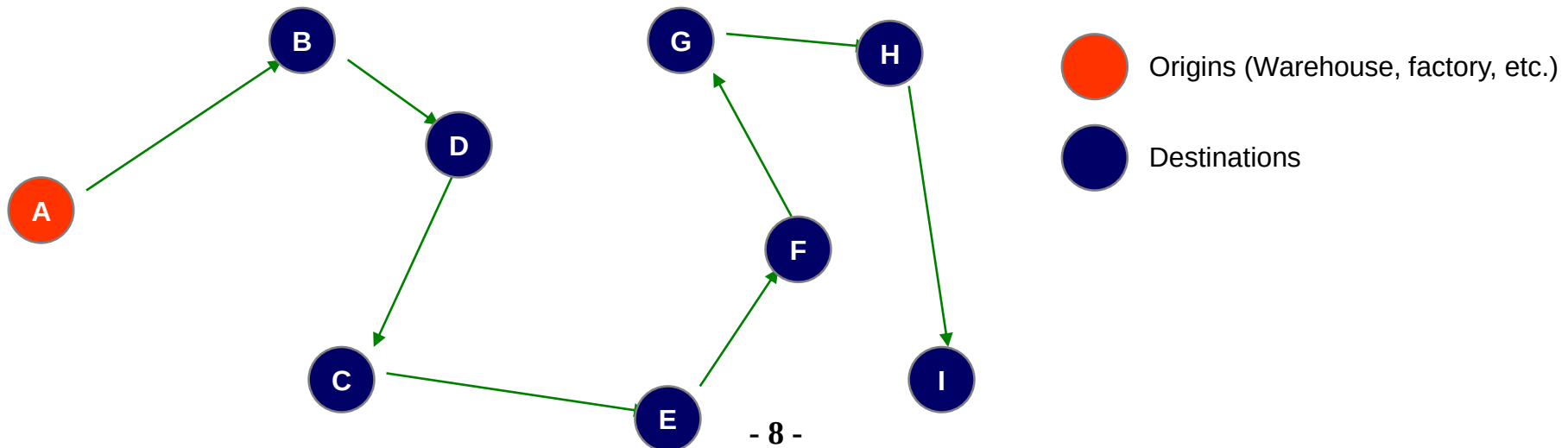
II. Related Research

- 1. Vehicle Routing Problem
- 2. Related Research

■ Outline of Vehicle Routing Problem (VRP)

- The vehicle routing problem (VRP) is a combinatorial optimization and integer programming problem seeking to service a number of customers with a fleet of vehicles
- Proposed by Dantzig and Ramser in 1959, VRP is an important problem in the fields of transportation, distribution and logistics
- The main context is that of delivering goods located at a central

Ex.) In case of Single Vehicle and Single Origin



Kind of VRP

- HVRP(Heterogeneous VRP) : Various Capacity of Vehicles
- ~~VRPMT(VRP Multiple Trips)~~
- ~~MDVRP(Multiple Depots VRP)~~
- VRPTW(VRP Time Windows)
- VRPPD(VRP Pickup & Delivery)
- ~~VRPB(VRP with Backhauls)~~
- ~~SVRP(Stochastic VRP) : Consider stochastic situations~~
- ~~PVRP(Period VRP) : Consider service period of vehicles~~

**How complex is
the maritime transportation
problem of car carriers?**

- Combinatorial Optimization Problem that has many considerations
- Problem of parcel service considers just one day cargoes, but MTP considers monthly cargoes
- In other words, prepared time of each cargoes and vessels is not same in MTP

● Difference from legacy VRP

	<Legacy VRP>	<VRP of this research>																																																						
Cargo Info.	<table> <tr> <th rowspan="2">Dest. (D)</th> <th>Cargo</th> </tr> <tr> <th>1st</th> </tr> <tr> <td>C</td> <td>30</td> </tr> <tr> <td>D</td> <td>50</td> </tr> <tr> <td>E</td> <td>25</td> </tr> <tr> <td>F</td> <td>45</td> </tr> <tr> <td>G</td> <td>40</td> </tr> </table>	Dest. (D)	Cargo	1 st	C	30	D	50	E	25	F	45	G	40	<table> <tr> <th rowspan="2">Dest. (D)</th> <th colspan="5">Cargo Quantity by Periods(G)</th> </tr> <tr> <th>1st</th> <th>2nd</th> <th>3rd</th> <th>4th</th> <th>5th</th> </tr> <tr> <td>C</td> <td>30</td> <td>20</td> <td>15</td> <td>45</td> <td>15</td> </tr> <tr> <td>D</td> <td>50</td> <td>10</td> <td>45</td> <td>20</td> <td>15</td> </tr> <tr> <td>E</td> <td>25</td> <td>15</td> <td>40</td> <td>5</td> <td>35</td> </tr> <tr> <td>F</td> <td>45</td> <td>30</td> <td>30</td> <td>10</td> <td>25</td> </tr> <tr> <td>G</td> <td>40</td> <td>45</td> <td>20</td> <td>10</td> <td>45</td> </tr> </table>	Dest. (D)	Cargo Quantity by Periods(G)					1 st	2 nd	3 rd	4 th	5 th	C	30	20	15	45	15	D	50	10	45	20	15	E	25	15	40	5	35	F	45	30	30	10	25	G	40	45	20	10	45
Dest. (D)	Cargo																																																							
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G	40	45	20	10	45																																																			
Vehicle Info.	<table> <tr> <th>Vehicle (S)</th> <th>Capa.</th> </tr> <tr> <td>V1</td> <td>500</td> </tr> <tr> <td>V2</td> <td>300</td> </tr> </table>	Vehicle (S)	Capa.	V1	500	V2	300	<table> <tr> <th>Vehicle(S)</th> <th>Capacity</th> <th>Arrival Date</th> </tr> <tr> <td>V1</td> <td>500</td> <td>2nd</td> </tr> <tr> <td>V2</td> <td>300</td> <td>4th</td> </tr> <tr> <td>V3</td> <td>200</td> <td>5th</td> </tr> </table>	Vehicle(S)	Capacity	Arrival Date	V1	500	2 nd	V2	300	4 th	V3	200	5 th																																				
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V1	500	2 nd																																																						
V2	300	4 th																																																						
V3	200	5 th																																																						
Problem Size	$S^D \times \sum_{s=1}^S d_s!$	$S^{DG} \times \sum_{s=1}^S d_s!$ d_s is a destination count of vehicle s																																																						

● Genetic Algorithm Application

- Burger et al.(1998) A Hybrid Genetic Algorithm for the Vehicle Routing Problem with Time Windows, LNAI 1418
- Baker et al.(2003), A genetic algorithm for the vehicle routing problem, Com&OR 30

● Tabu Search Application

- Ho et al.(2004), A tabu search heuristic for the vehicle routing problem with time windows and split deliveries, Com&OR 30
- Gribkovskaia et al.(2007), General solutions to the single vehicle routing problem with pickups and deliveries, EJOR 180
- Fallahi et al.(2008), A memetic algorithm and a tabu search for the multi-compartment vehicle routing problem, Com&OR 35
- Haugland et al.(2007), Designing delivery districts for the vehicle routing problem with stochastic demands, EJOR 180

● Simulated Annealing Application

- Osman(1993), Metastrategy simulated annealing and tabu search algorithms for the vehicle routing problem, Annals of Operation Research 41

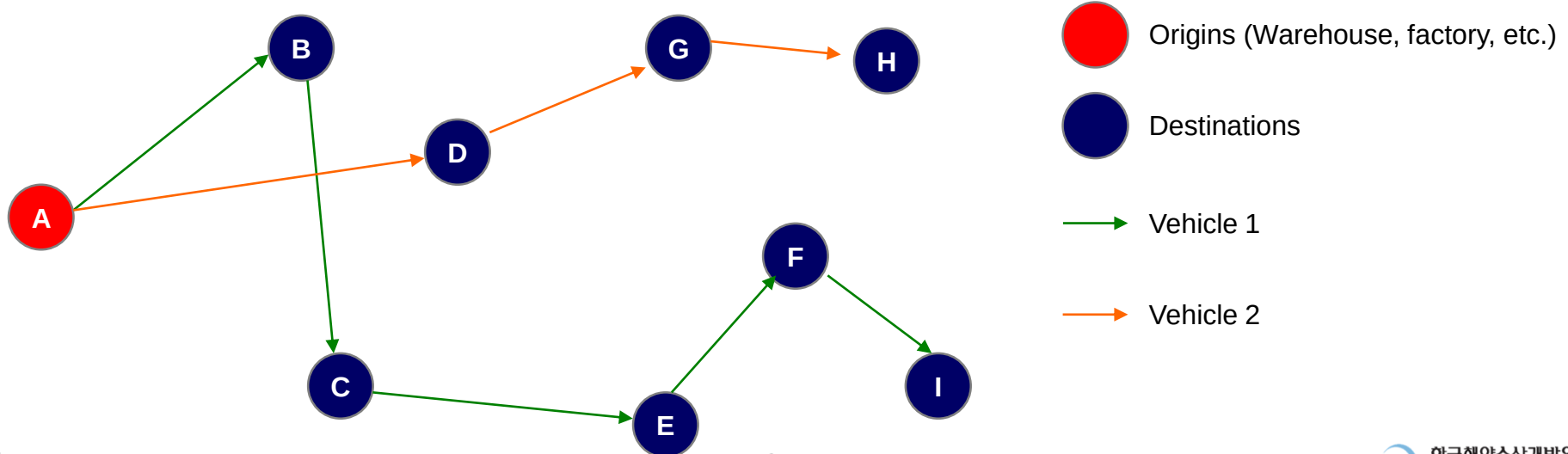
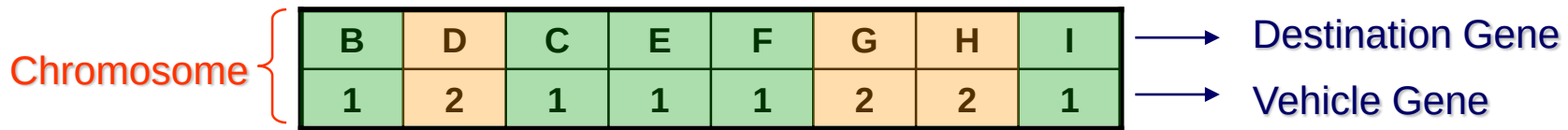
● Ant Colony Optimization Application

- Bell et al.(2004), Ant colony optimization techniques for the vehicle routing problem, Advanced Engineering Informatics 18

III. Development of Genetic Algorithm

Outline of Genetic Algorithm

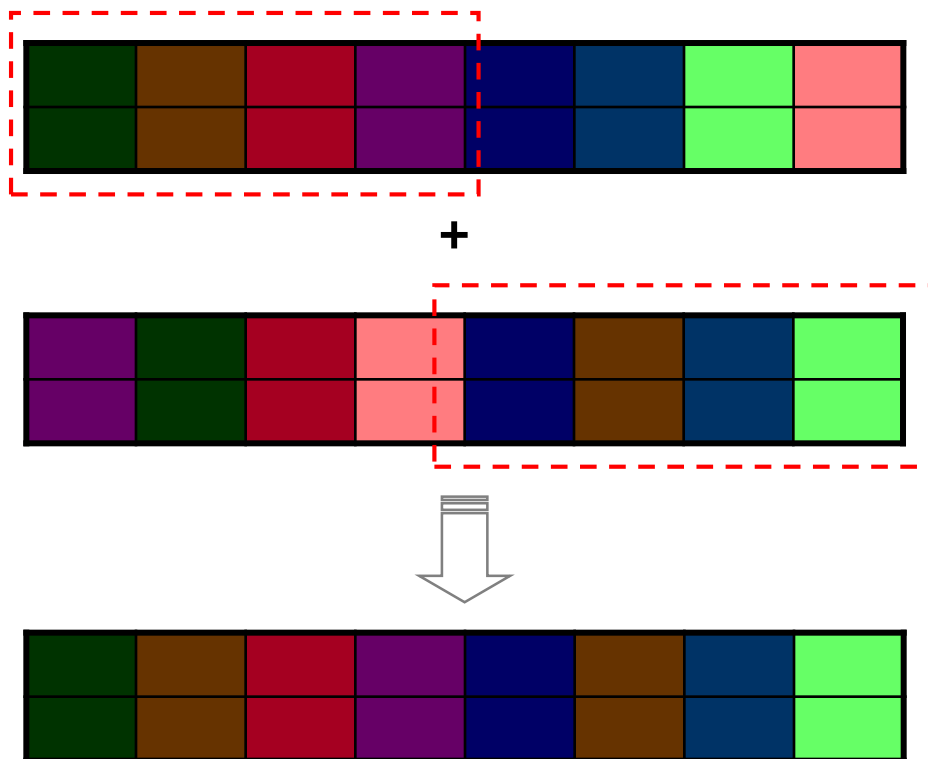
- Start to search from population of solutions
- One solution is called 'chromosome'
- Each of the chromosomes contains genes



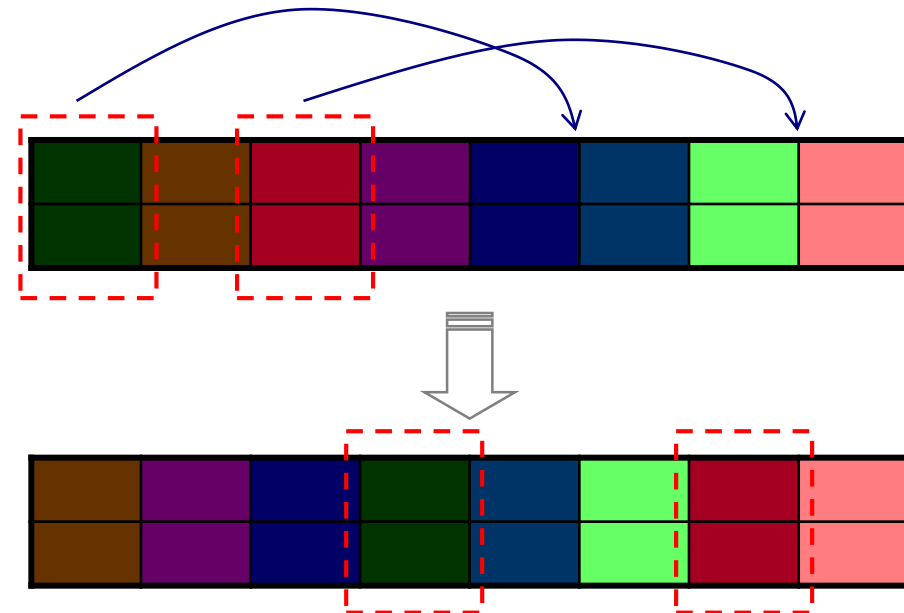
Genetic Operator

- To make a better chromosome, GA uses Genetic Operator like Reproduction, Crossover, Mutation, Elitism

Example of Crossover Operator

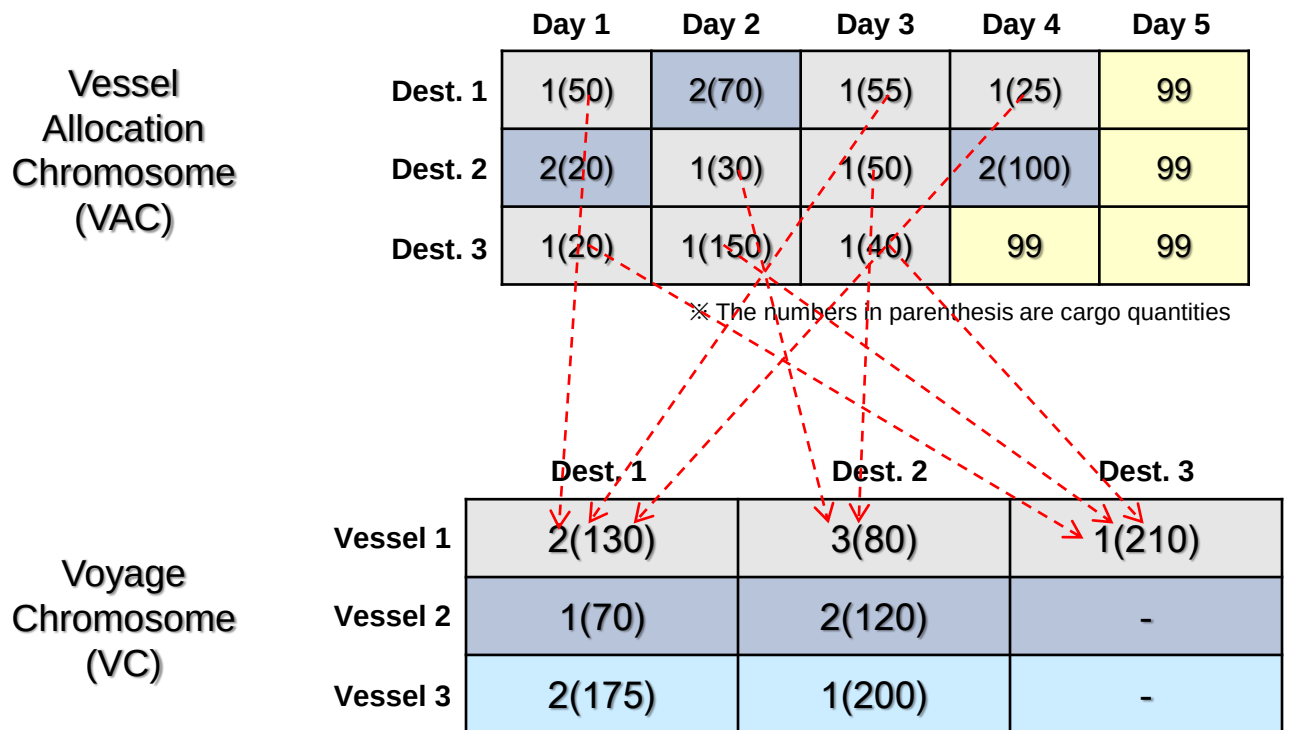


Example of Mutation Operator



Chromosome Presentation

- Vessel Allocation Planning Chromosome: Each of the cargoes is allocated to vessels → Destinations of vessels are determined
- Voyage Planning Chromosome: Visiting order of vessels is determined



※ The numbers in parenthesis are total cargo quantities of each destination and vessel

Method of Initial Solution Generation

Vessel Allocation Chromosome

	Day 1	Day 2	Day 3	Day 4	Day 5
Dest. 1	1(50)	2(70)	1(55)	1(25)	99
Dest. 2	2(20)	1(30)	1(50)	2(100)	99
Dest. 3	1(20)	1(150)	1(40)	99	99

<Random Selection>

	Day 1	Day 2	Day 3	Day 4	Day 5
Dest. 1	1(50)	2(70)	1(55)	1(25)	99
Dest. 2	2(20)	1(30)	1(50)	2(100)	99
Dest. 3	1(20)	1(150)	1(40)	99	99

<Previous Date Comparison Selection by Periods>

	Day 1	Day 2	Day 3	Day 4	Day 5
Dest. 1	1(50)	2(70)	1(55)	1(25)	99
Dest. 2	2(20)	1(30)	1(50)	2(100)	99
Dest. 3	1(20)	1(150)	1(40)	99	99

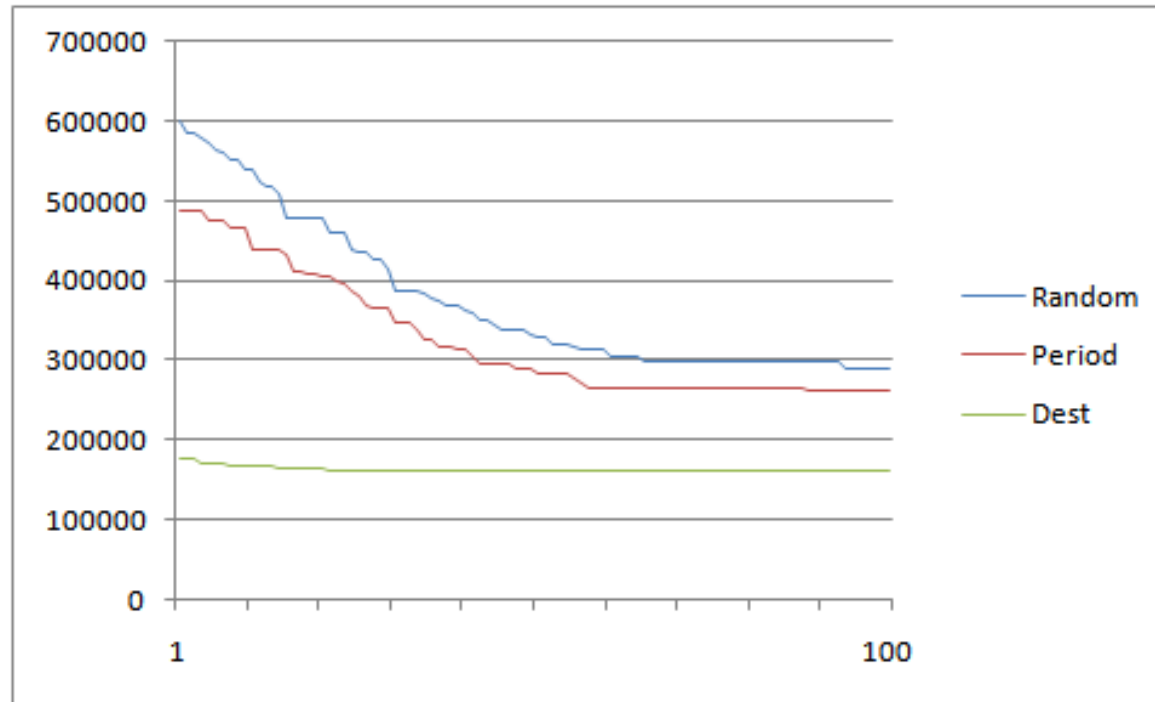
<Previous Date Comparison Selection by Destinations>

MISG of VAG	Minimum S.	Average S.
RS	291,176	365,929
PDCSP	261,207	373,822
<u>PDCSD</u>	<u>160,761</u>	<u>190,921</u>

<Results>

■ Method of Initial Solution Generation (Cont.)

- Vessel Allocation Chromosome



Method of Initial Solution Generation (Cont.)

Voyage Gene

	Dest. 1	Dest. 2	Dest. 3
Vessel 1	2	3	1
Vessel 2	1	2	-
Vessel 3	2	-	1

<Random Allocation>

Distance order
from origin

	2 Dest. 1	1 Dest. 2	3 Dest. 3
Vessel 1	2	1	3
Vessel 2	2	1	-
Vessel 3	1	-	2

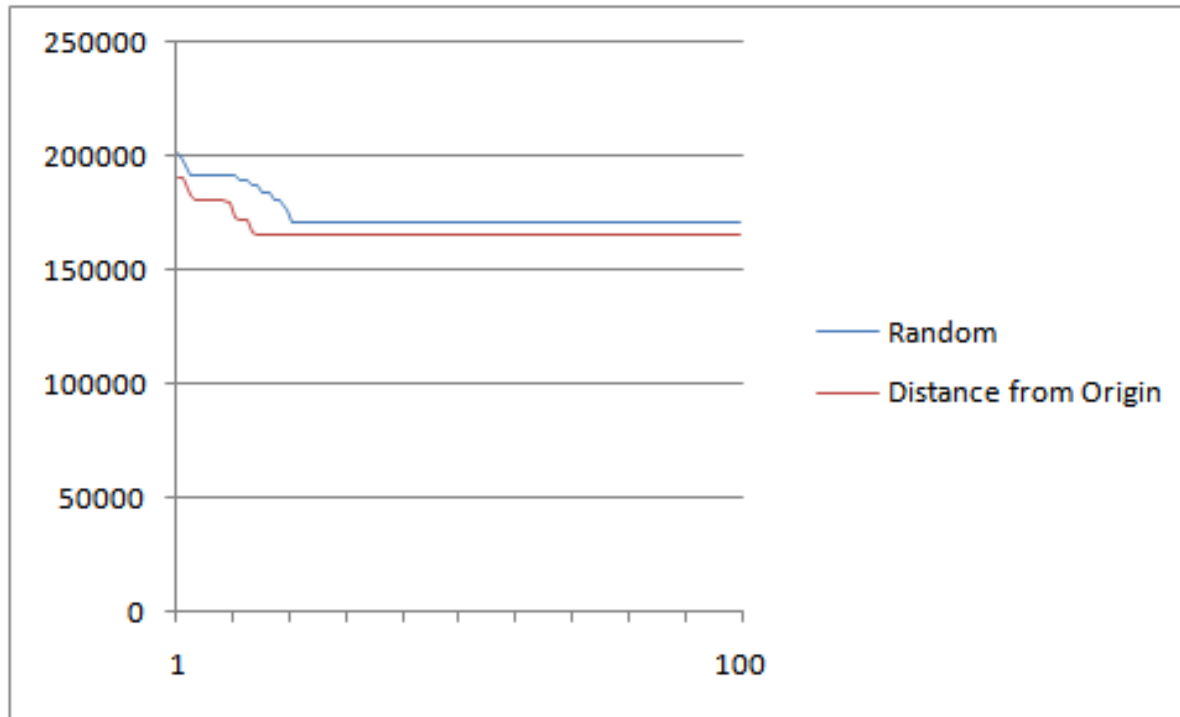
<Allocation by Distance Order from Origin>

MISG of VG	Minimum S.	Average S.
RA	171,210	193,028
ADOO	166,025	194,220

<Results>

Method of Initial Solution Generation (Cont.)

- Voyage Gene



Crossover Operator

Vessel Allocation Gene

		Group 1	Group 2	Group 3	Group 4	Group 5
Parent 1	Dest. 1	1	2	1	3	99
	Dest. 2	2	1	1	2	99
	Dest. 3	1	3	1	99	99
+						
Parent 2	Dest. 1	2	3	3	1	99
	Dest. 2	2	1	2	99	99
	Dest. 3	2	1	2	2	1
↓						
Son	Dest. 1	1	3	1	3	99
	Dest. 2	2	1	1	99	99
	Dest. 3	2	1	2	2	99

<Crossover by cells>

		Group 1	Group 2	Group 3	Group 4	Group 5
Parent 1	Dest. 1	1	2	1	3	99
	Dest. 2	2	1	1	2	99
	Dest. 3	1	3	1	99	99
+						
Parent 2	Dest. 1	2	3	3	1	99
	Dest. 2	2	1	2	99	99
	Dest. 3	2	1	2	2	1
↓						
Son	Dest. 1	2	2	1	3	99
	Dest. 2	2	1	1	2	99
	Dest. 3	2	3	1	99	1

<Crossover 2-points>

		Group 1	Group 2	Group 3	Group 4	Group 5
Parent 1	Dest. 1	1	2	1	3	99
	Dest. 2	2	1	1	2	99
	Dest. 3	1	3	1	99	99
+						
Parent 2	Dest. 1	2	3	3	1	99
	Dest. 2	2	1	2	99	99
	Dest. 3	2	1	2	2	1
↓						
Son	Dest. 1	1	2	1	1	99
	Dest. 2	2	1	1	99	99
	Dest. 3	1	3	1	2	1

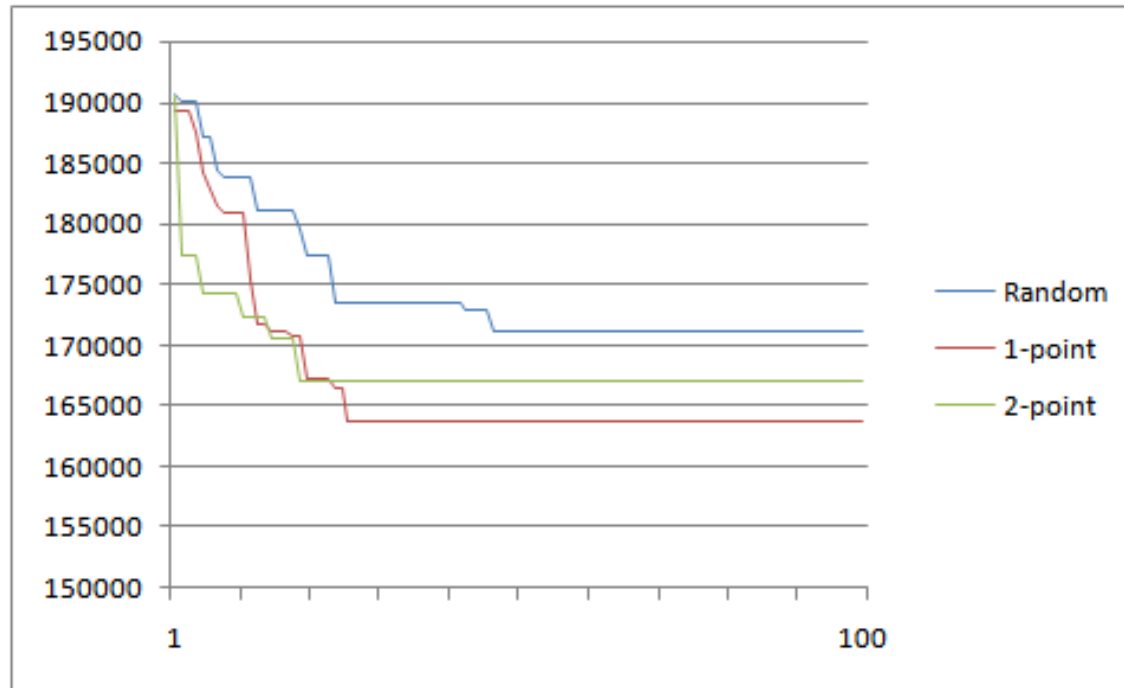
<Crossover 1-point>

CO of VAG	Minimum S.	Average S.
CC	171,072	196,731
C1P	163,736	193,647
C2P	167,035	193,277

<Results>

■ Crossover Operator (Cont.)

- Vessel Allocation Gene



Crossover Operator (Cont.)

Voyage Gene

Parent 1

	Dest. 1	Dest. 2	Dest. 3	Dest. 4	Dest. 5
Vessel 1	1	2	3	-	4
Vessel 2	2	3	-	1	-
Vessel 3	3	-	2	1	4

Mkspan: 178,300

Parent 2

	Dest. 1	Dest. 2	Dest. 3	Dest. 4	Dest. 5
Vessel 1	3	1	2	-	4
Vessel 2	1	3	-	2	-
Vessel 3	1	-	3	4	2

Mkspan: 165,500

>

Son

	Dest. 1	Dest. 2	Dest. 3	Dest. 4	Dest. 5
Vessel 1	3	1	2	-	4
Vessel 2	1	3	-	2	-
Vessel 3	1	-	3	4	2

CO of VG	Minimum S.	Average S.
<u>CFMC</u>	<u>160,032</u>	<u>195,964</u>

<Results>

<Comparison between Father and Mother Chromosome>

Mutation Operator

Vessel Allocation Gene

	Group 1	Group 2	Group 3	Group 4	Group 5
Parent Dest. 1	1	2	1	3	99
Parent Dest. 2	2	1	1	2	99
Parent Dest. 3	1	3	1	99	99



	Group 1	Group 2	Group 3	Group 4	Group 5
Son Dest. 1	1	1	1	3	99
Son Dest. 2	2	1	1	2	99
Son Dest. 3	1	1	1	99	99

<1-point Comparison Mutation>

	Group 1	Group 2	Group 3	Group 4	Group 5
Parent Dest. 1	1	2	1	3	99
Parent Dest. 2	2	1	1	2	99
Parent Dest. 3	1	3	1	99	99



	Group 1	Group 2	Group 3	Group 4	Group 5
Son Dest. 1	1	1	1	3	99
Son Dest. 2	2	1	1	2	99
Son Dest. 3	1	1	1	99	99

<1-point Before Mutation>

	Group 1	Group 2	Group 3	Group 4	Group 5
Parent Dest. 1	1	2	1	3	99
Parent Dest. 2	2	1	1	2	99
Parent Dest. 3	1	3	1	99	99



	Group 1	Group 2	Group 3	Group 4	Group 5
Son Dest. 1	1	1	1	3	99
Son Dest. 2	2	1	3	2	99
Son Dest. 3	1	2	1	99	99

<1-point Random Mutation>

	Group 1	Group 2	Group 3	Group 4	Group 5
Parent Dest. 1	1	2	1	3	99
Parent Dest. 2	2	1	1	2	99
Parent Dest. 3	1	3	1	99	99



	Group 1	Group 2	Group 3	Group 4	Group 5
Son Dest. 1	1	1	1	3	99
Son Dest. 2	2	1	2	2	99
Son Dest. 3	1	1	1	99	99

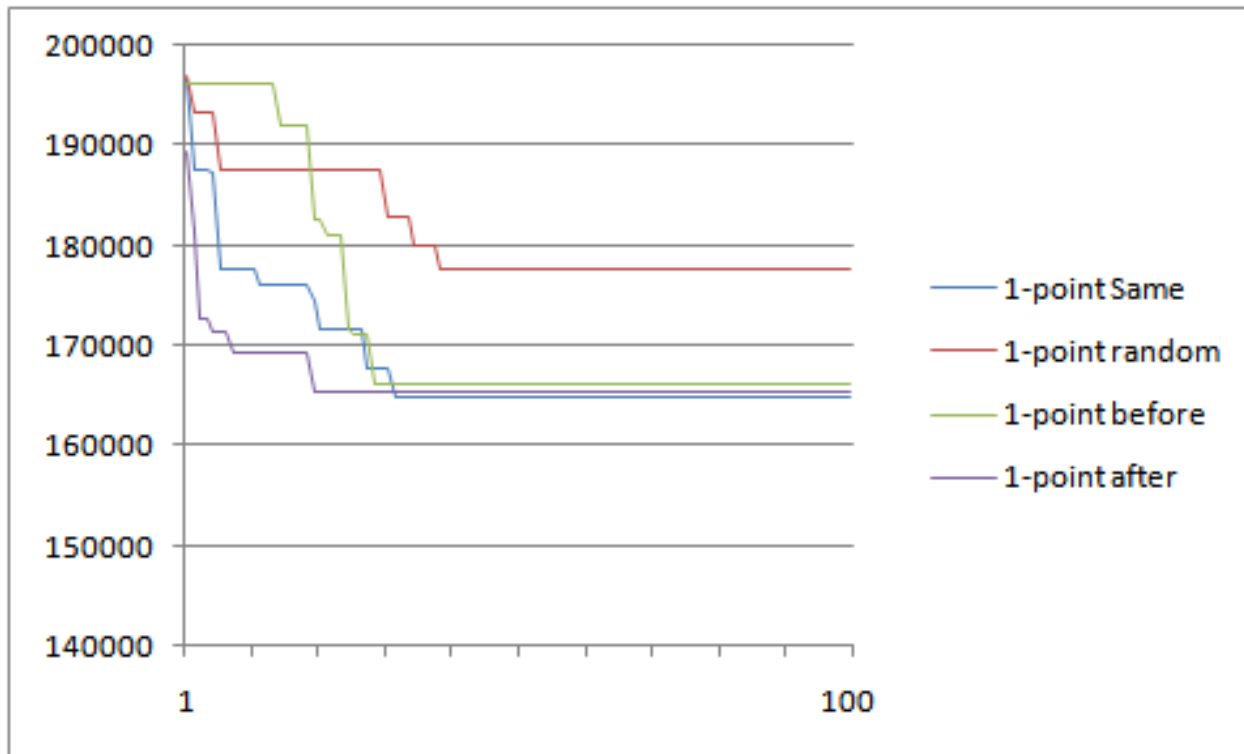
<1-point After Mutation>

MO of VAG	Minimum S.	Average S.
<u>1PCM</u>	<u>164,946</u>	<u>191,279</u>
1PRM	177,757	204,655
1PBM	166,064	197,683
1PAM	165,329	193,230

<Results>

■ Mutation Operator (Cont.)

- Vessel Allocation Gene



■ Mutation Operator (Cont.)

■ Voyage Gene

	Dest. 1	Dest. 2	Dest. 3	Dest. 4	Dest. 5
Vessel 1	2	3	1	-	4
Vessel 2	1	3	-	2	-
Vessel 3	2	-	1	4	3

<Continuous 3-Points Comparison>

	Dest. 1	Dest. 2	Dest. 3	Dest. 4	Dest. 5
Vessel 1	1	2	3	-	4
Vessel 2	2	3	-	1	-
Vessel 3	3	-	2	1	4

<Reproduction>

	Dest. 1	Dest. 2	Dest. 3	Dest. 4	Dest. 5
Vessel 1	2	3	1	-	4
Vessel 2	1	3	-	2	-
Vessel 3	2	-	1	4	3

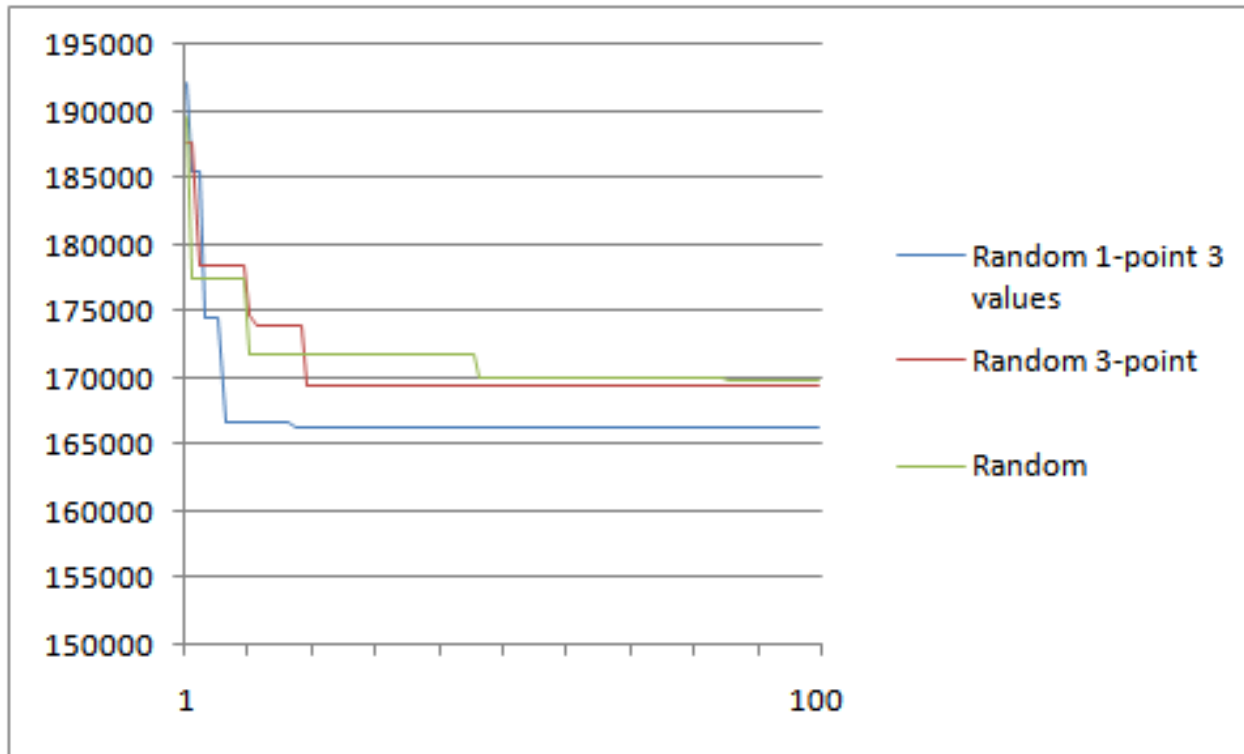
<Random 3-Points Comparison>

MO of VG	Minimum S.	Average S.
<u>C3PC</u>	<u>166,217</u>	<u>194,530</u>
R3PC	169,384	192,503
R	169,844	196,766

<Results>

■ Mutation Operator (Cont.)

- Voyage Gene



Parameter Experiment

- Problem Size: Destination 7, Vehicle 7, Period 31
- Experiment each of the cases for 50 times
- Results of Experiment

Mu. Rate Cr. Rate	0.05		0.1		0.15	
	Min.	Avg.	Min.	Avg.	Min.	Avg.
0.7	160,686	180,893	171,521	185,789	165,246	181,935
0.75	162,650	181,567	165,820	181,508	163,981	181,624
0.8	165,994	181,308	161,352	181,862	160,947	181,179
0.85	165,658	182,337	159,558	180,936	<u>154,543</u>	<u>180,769</u>

Performance Experiment

Comparison Experiment Results with IP Model

Destinations	Vehicles	Periods	IP		GA		
			Best	Time(Sec)	Minimum	Time(Sec)	Approximation(%)
3	3	10	49,062	0.66	49,062	1.98	100
		20	54,995	0.88	54,995	2.43	100
		31	71,832	0.55	71,832	2.87	100
4	4	10	63,939	0.96	63,939	3.56	100
		20	91,381	1.64	91,381	4.11	100
		31	106,969	3.1	106,969	4.9	100
5	5	10	98,752	10.17	99,119	8.42	99.63
		20	99,057	102	99,423	10.21	99.63
		31	101,872	1,310	102,238	12.33	99.64
7	7	10	133,793	18,000	136,624	13.58	97.88
		20	131,768	18,000	134,914	15.81	97.61
		31	146,445	18,000	147,780	21.34	99.10
9	9	10	-	-	173,448	32.1	-
		20	-	-	186,575	41.34	-
		31	-	-	239,836	59.78	-
20	20	31	-	-	980,192	269	-

IV. Application to School Bus Routing Problem

- 1. Introduction of SBRP
- 2. Other Application Area

Definition of a School Bus Routing Problem (SBRP)

- SBRP seeks to plan an efficient schedule for a fleet of school buses where each bus picks up students from various bus stops and delivers them to their designated schools while satisfying various constraints such as the maximum capacity of a bus, the maximum riding time of a student in a bus, and the time window of a school
- SBRP has 5 sub-problems

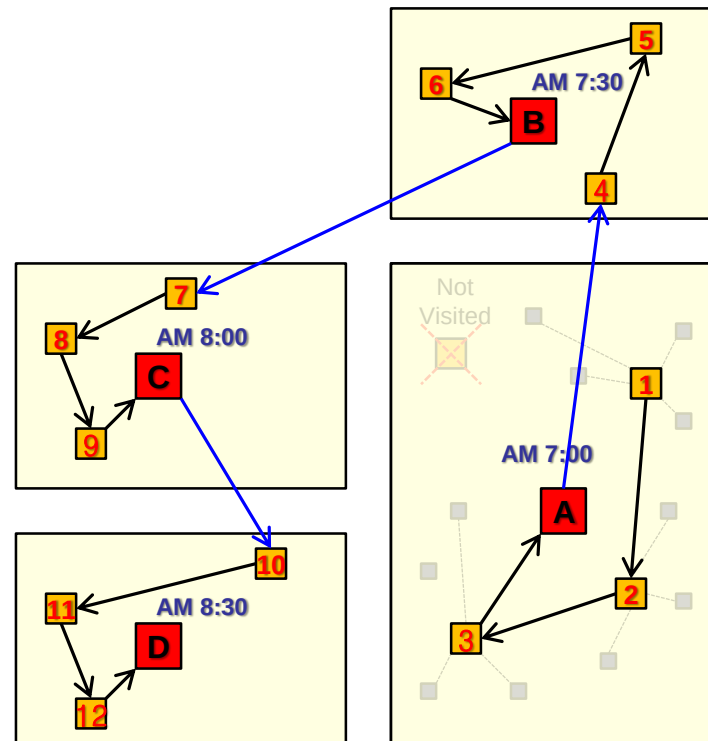
1. Data Preparation

2. Bus Stop Selection

3. Bus Route Generation

4. School Bell Time Adjustment

5. Route Scheduling



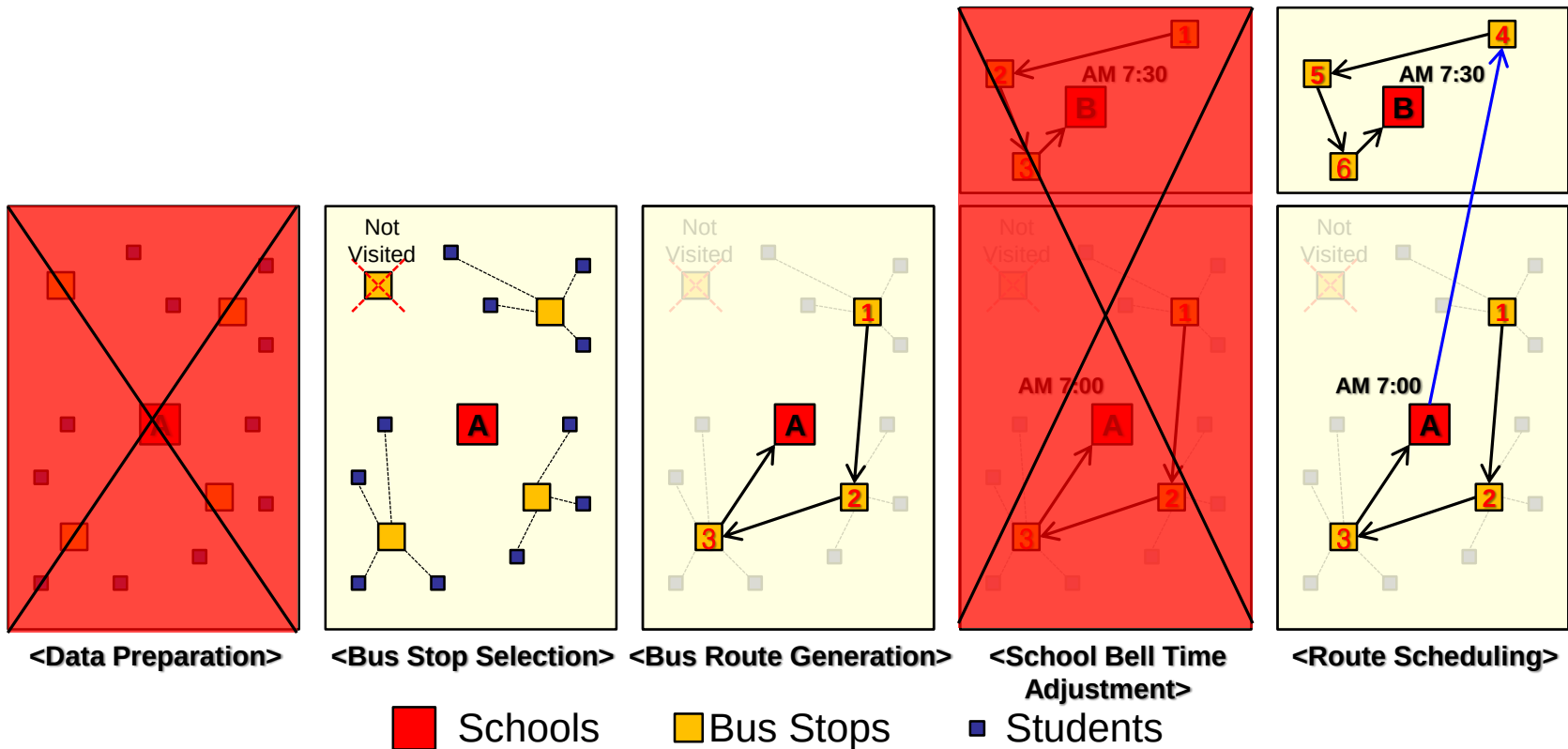
■ Schools

■ Bus Stops

■ Students

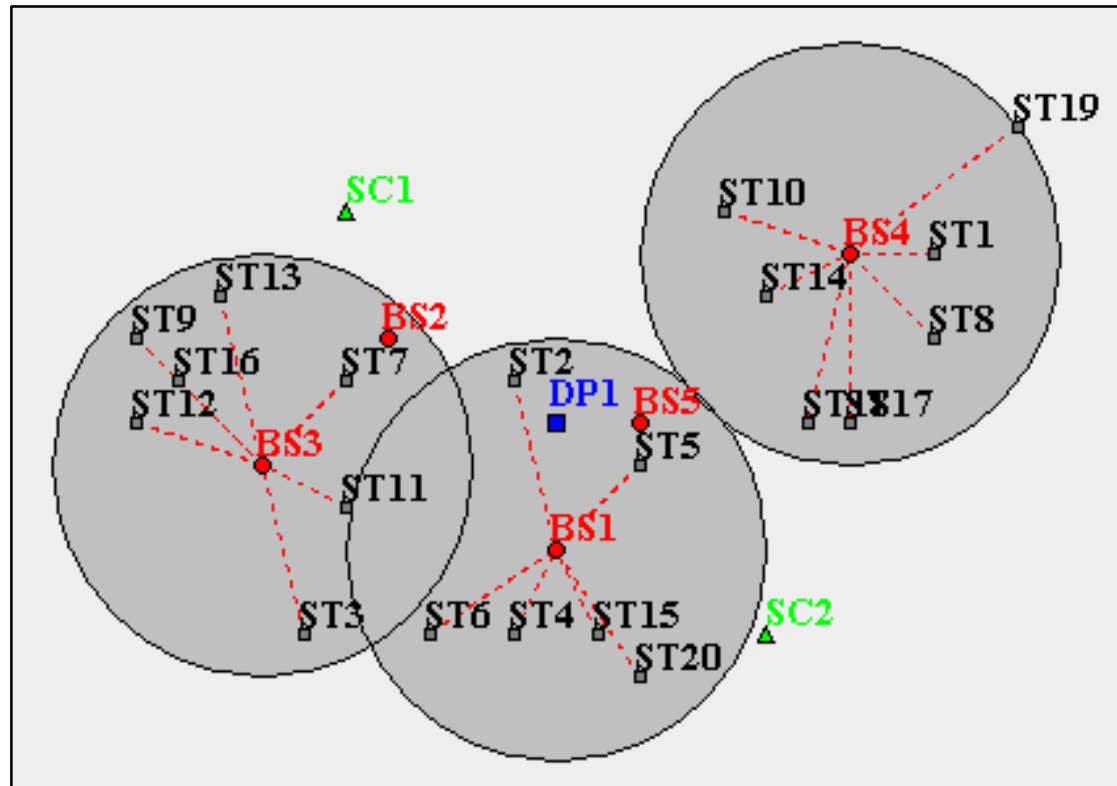
Definition of a School Bus Routing Problem (SBRP)

- We solved Bus Stop Selection, Bus Route Generation, Route Scheduling sub-problems



Bus Stop Selection

- Determine bus stops each students are allocated
- Objective Function: Minimize number of student groups¹⁾
or Minimize students' walking distance



- 1) **Student Groups:**
School groups
allocated by students
of each bus stops

Rule of Bus Stop Selection

Step 1) Allocate students who have only one bus stop in designated walking distance

Step 2) Allocate students who have two or more bus stops in designated walking distance to the nearest bus stop which is already allocated by Step 1 by any student

Step 3) Allocate students who are not allocated by Step 1, 2 to the nearest bus stop in designated walking distance

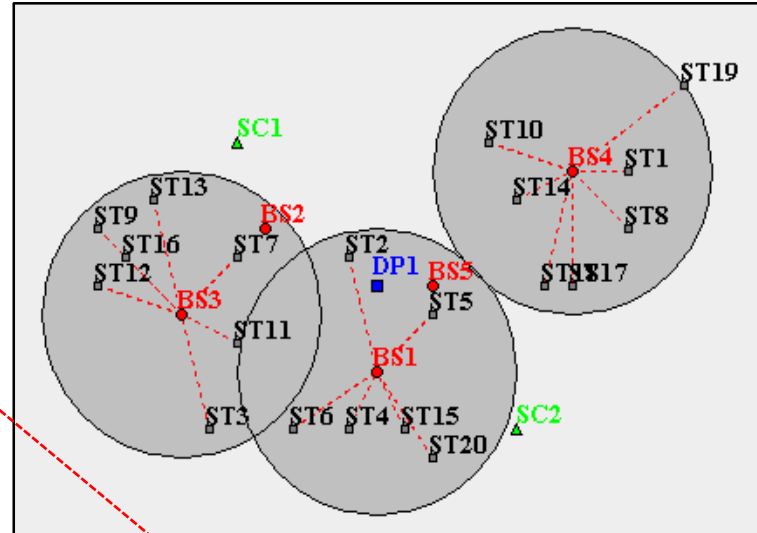
Step 4) Stop

BSS Result

<Table of Allocated Bus Stop Result of Each Student>

Student	School	Allocated Stop
ST ₁	SC ₁	BS ₄
ST ₂	SC ₁	BS ₁
ST ₃	SC ₂	BS ₃
ST ₄	SC ₂	BS ₁
ST ₅	SC ₁	BS ₁
ST ₆	SC ₁	BS ₁
ST ₇	SC ₂	BS ₃
ST ₈	SC ₂	BS ₄
ST ₉	SC ₂	BS ₃
ST ₁₀	SC ₁	BS ₄
ST ₁₁	SC ₁	BS ₃
ST ₁₂	SC ₁	BS ₃
ST ₁₃	SC ₂	BS ₃
ST ₁₄	SC ₂	BS ₄
ST ₁₅	SC ₁	BS ₁
ST ₁₆	SC ₁	BS ₃
ST ₁₇	SC ₂	BS ₄
ST ₁₈	SC ₂	BS ₄
ST ₁₉	SC ₂	BS ₄
ST ₂₀	SC ₁	BS ₁

<Figure of Allocated Bus Stop Result of Each Student>

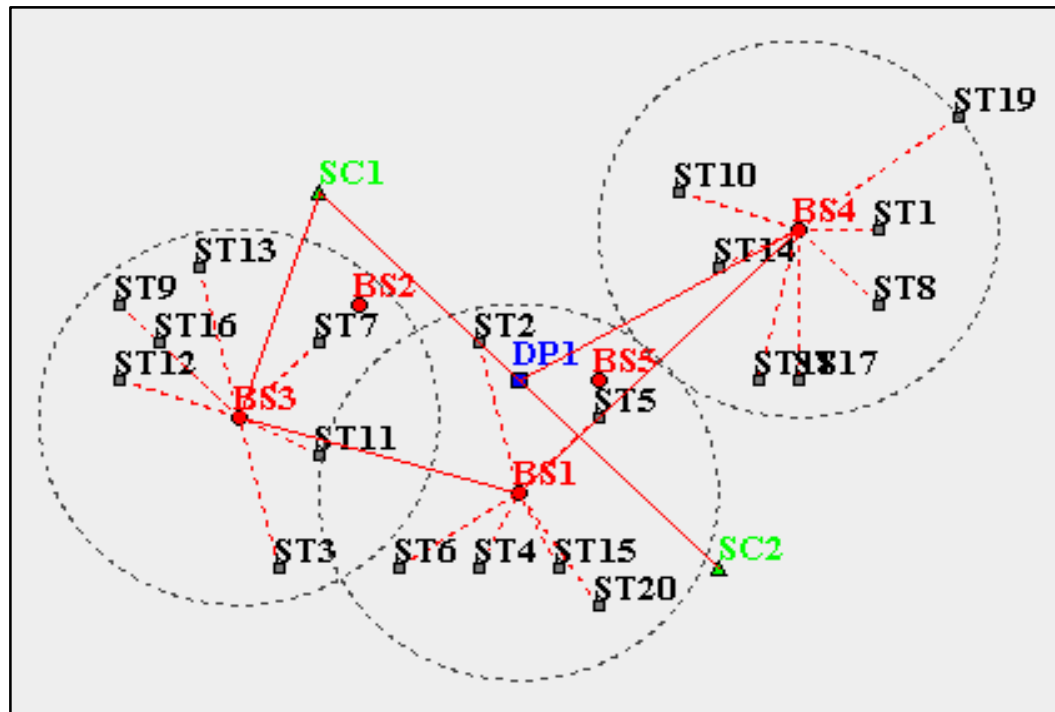


<Student Groups of Each Bus Stop>

Bus Stop	BS ₁	BS ₂	BS ₃	BS ₄	BS ₅
School					
SC ₁	5	-	3	2	-
SC ₂	1	-	4	5	-

● School Bus Routing/Scheduling

- Determine buses each students are allocated, and visiting sequence of each buses
- Objective Function: Minimize Total Bus Travel Distance (TBD)
or Minimize Total Student Riding Distance (TSD)
or Minimize Number of buses used (N)



Genetic Algorithm

- Chromosome Representation
 - Bus Allocation Chromosome
 - Each number means allocated bus number of student groups

	BS ₁	BS ₂	BS ₃	BS ₄	BS ₅
SC ₁	1	1	1	2	2
SC ₂	1	1	1	2	2

- Voyage Chromosome
 - Each number means visiting sequence of bus stops and schools

	BS ₁	BS ₂	BS ₃	BS ₄	BS ₅	SC ₁	SC ₂	SC ₃
B ₁	2	1	3	4	5	7	6	8
B ₂				2	1	3	4	

Genetic Algorithm (Cont.)

- Chromosome Representation (Cont.)
 - Comparison of Chromosome Representation between MTP and SBRP

<Bus Allocation Chromosome>

	BS ₁	BS ₂	BS ₃	BS ₄	BS ₅
SC ₁	1	1	1	2	2
SC ₂	1	1	1	2	2

<Vessel Allocation Chromosome>

	Group 1	Group 2	Group 3	Group 4	Group 5
Dest. 1	1	2	1	1	99
Dest. 2	2	1	1	2	99
Dest. 3	1	1	1	99	99

※ The numbers in parenthesis are cargo quantities

<Voyage Chromosome>

	BS ₁	BS ₂	BS ₃	BS ₄	BS ₅	SC ₁	SC ₂	SC ₃
B ₁	2	1	3	4	5	7	6	8
B ₂				2	1	3	4	

<Voyage Chromosome>

	Dest. 1	Dest. 2	Dest. 3
Vessel 1	2	3	1
Vessel 2	1	2	-
Vessel 3	2	1	-

※ The numbers in parenthesis are visiting orders

Genetic Algorithm (Cont.)

- Chromosome Representation (Cont.)
 - Example of Chromosomes and Result

<Bus Allocation Chromosome>

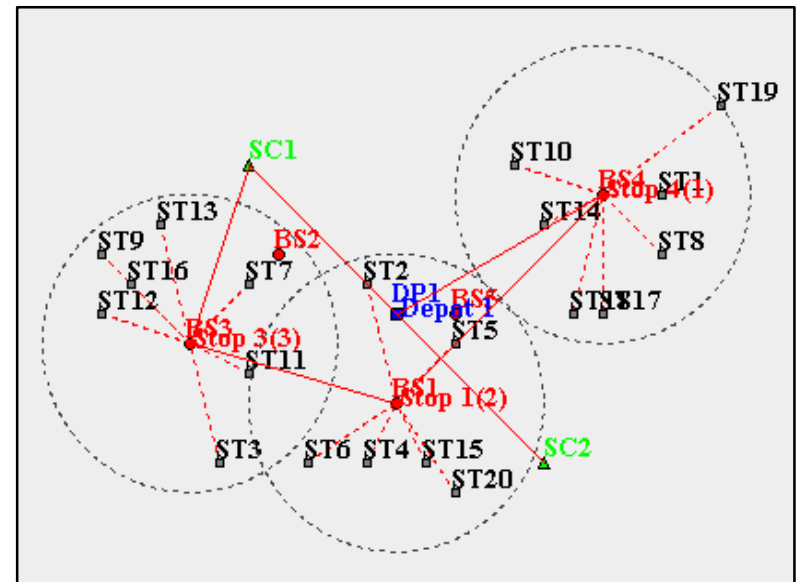
Bus Stop School	BS ₁	BS ₂	BS ₃	BS ₄	BS ₅
SC ₁	B ₁	-	B ₁	B ₁	-
SC ₂	B ₁	-	B ₁	B ₁	-

<Voyage Chromosome>

Bus Stop Bus	Bus Stop			School	
	BS ₁	BS ₃	BS ₄	SC ₁	SC ₂
B ₁	2 nd	3 rd	1 st	4 th	5 th
B ₂	-	-	-	-	-



<Figure of Result of BRS>



Genetic Algorithm (Cont.)

- Genetic Operator
 - Crossover Operator
 - We applied the 2-point crossover operator in this research
 - Mutation Operator
 - We applied the neighborhood search-based mutation operator in this research
- Others
 - Initial Solution Generation
 - Infeasible Solution Repair
 - Seed Selection Method, Elitism

Parameter Test

■ Mutation and Crossover Rate

Mutation Rate \ Crossover Rate	0.05		0.1		0.15		0.2		0.25	
	Min.	Avg.	Min.	Avg.	Min.	Avg.	Min.	Avg.	Min.	Avg.
0.7	97.65	102.32	95.35	102.12	96.44	102.18	96.58	102.10	95.73	101.88
0.75	95.65	102.04	95.33	102.11	97.52	102.47	94.29	101.34	94.05	101.64
0.8	96.62	102.03	97.92	102.56	95.80	101.80	96.22	101.79	95.32	101.77
0.85	97.73	101.60	95.58	101.70	96.89	102.10	98.33	102.21	98.33	101.66
0.9	96.63	101.80	94.09	101.70	98.68	102.25	97.68	102.08	95.53	101.76
0.95	95.48	102.12	93.46	101.71	95.68	101.31	93.80	101.50	96.37	102.02

■ Elitism Size

Elitism Size	Min.	Avg.
10	95.34	100.39
20	92.47	100.20
30	95.04	101.13

Performance Test

- Test the performance test with several size problems

Depots	Schools	Buses	MRT ¹⁾	Result of BSS		Result of BRS with Minimize TBD		
				Student Groups	Bus Stops	TBD ²⁾	N ³⁾	TSD ⁴⁾
1	2	2	3600	6	3	9.14	1	5,017
1	4	3	3600	26	8	31.39	2	38,942
1	5	6	3600	55	18	83.62	5	88,121
2	5	6	3600	55	18	85.16	5	75,916
1	10	12	5400	137	35	227.41	11	285,060
2	10	12	5400	137	35	220.10	11	263,873

1) MRT: Maximum Riding Time

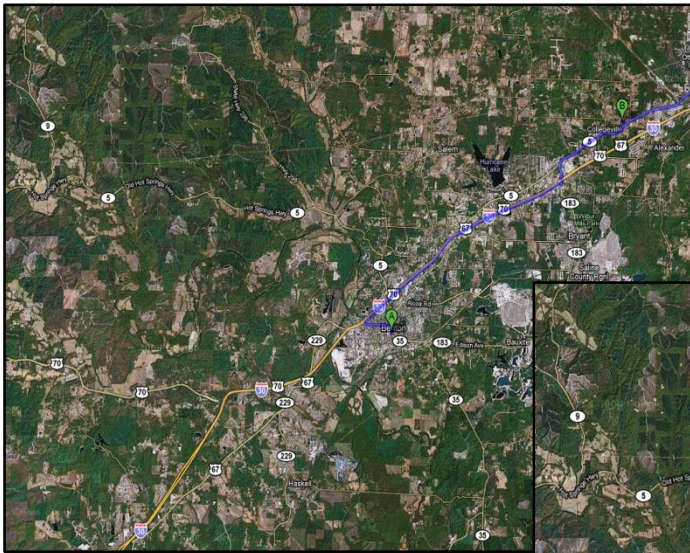
2) TBD: Total Bus travel Distance or time

3) N: Number of Buses in use

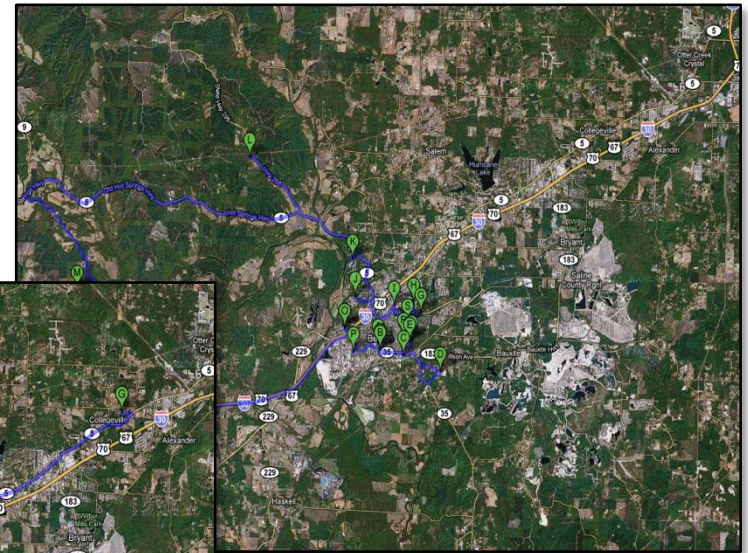
4) TSD: Total Student riding Distance or time

Case Study

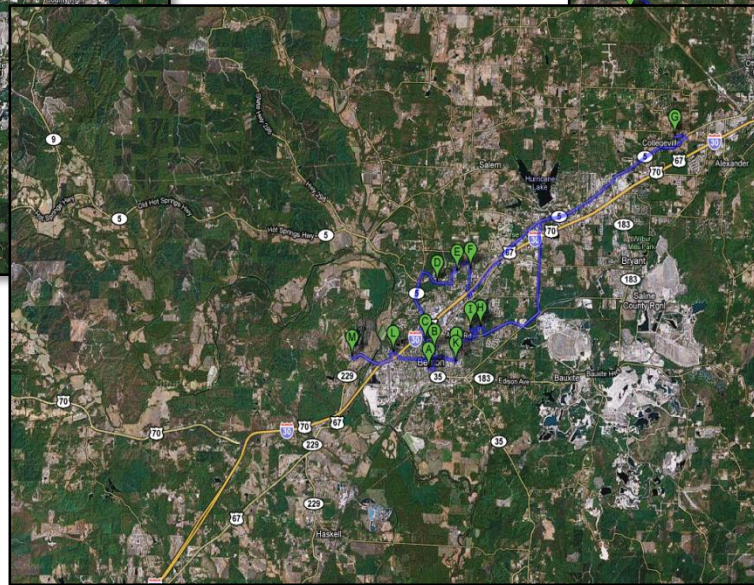
- We applied this algorithm to real problem of B city, A state (3 buses, 26 students, 6 schools)



<Route of Bus 1>



<Route of Bus 3>



<Route of Bus 2>

Case Study (Cont.)

- We could find the results of this algorithm is better than current result.
 - Reduction to 59.8% in case of TBD
 - Reduction to 19.7% in case of TSD

Objective Functions	Minimize TBD	Minimize TSD	Current(Manual)
TBD Value	<u>66.13</u>	~~112.78~~	110.57
TSD Value	46,191	<u>10,568</u>	53,651

- We could know how handwork is inefficient, and confirm the necessity of SBRP research

V. Conclusions

- 1. Contributions
- 2. Other Application Area

- Differently from the general previous studies of VRP or tramper MTP, this study suggested a new problem having the constraint of different preparation time for cargoes and cars
- This study tried to apply this transportation algorithm to inland transportation problem and we could confirm the algorithm can be applied to other domain

● MTP of Trumper Vessels(Container vessel, Bulk vessel)

- It could be applied to MTP of Trumper Vessels that transport non-periodic cargoes

● Truck Transportation Planning of Parcel D2D Service

- It could be applied to TTP of Parcels which have to delivery or pick up every day

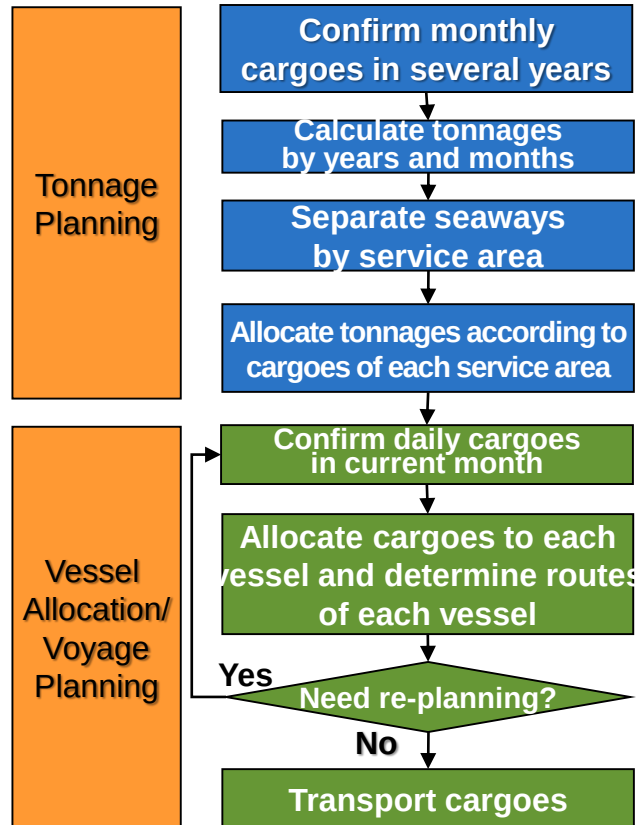




Thank you
for your attention

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Business of Maritime Transportation Planning for Car Carriers



권역	해주	1월	2월	...	12월
미주	HMC	30	22		21
	KMC	25	22		23
	HHC	15	17		24
	Other	10	8		26

NAME	BEI	FROM	TO	CAPA
SUMITOMO 5	2008	2008/3/15	2033/3/15	5,800
SUMITOMO 2	2007	2007/9/15	2032/9/15	5,800
ZODIAC 2	2006	2006/7/20	2022/7/20	4,200
ZODIAC 1	2006	2006/2/20	2022/2/20	4,200

Confirm annual cargo information at Nov. of last year



Group	Current	ROUTE	Frist
AM	AMUE	AS-US. E. C-AS	Over 3999 PCC/PCTC
	AMUW	AS-US. W. C-AS	
	AMCA	AS-C. AMERICA-AS	Over 4199 HSV 60%
	AMCB	AS-CARIB-AS	Over 4199 HSV 60%
	AMLE	CARIB intra service AS-S. A. E. C-AS	E. Brilliance 3350 PCTC

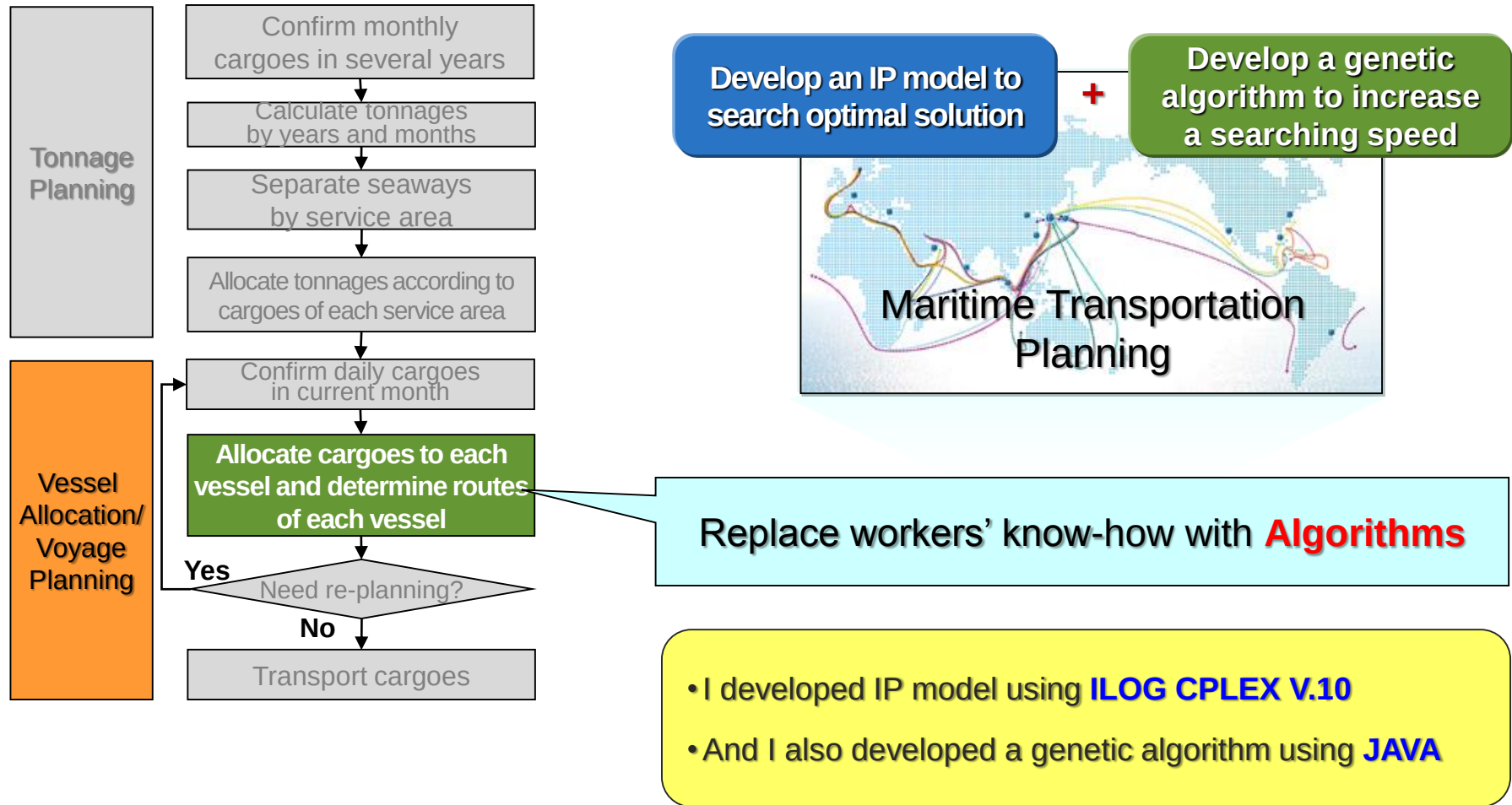


3월									
구분	제품	1일	2일	3일	4일	5일	6일	7일	8일
C1	P1	3	0	4	2	0	0	0	4
C2	P2	5	5	2	0	0	3	1	1
C3	P1	0	1	3	2	3	3	2	2
C4	P3	1	2	2		3	3	3	0

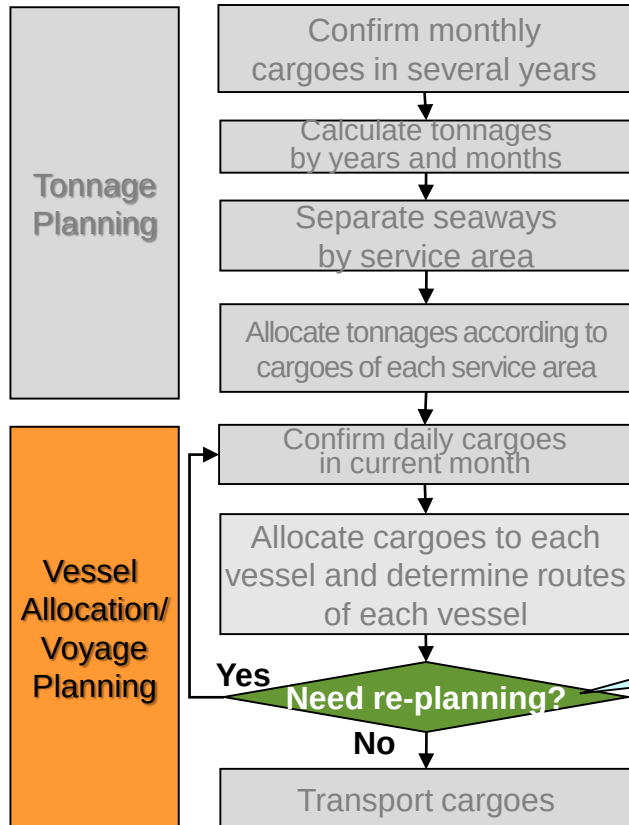
Vessel Allocation & Voyage Planning

Confirm daily manufacturing information at bottom of last month

Development of optimization algorithms for maritime transportation planning



Development of a Decision Support System



Develop an alternative evaluation method

Develop a Decision Support System

The screenshot shows a software interface for a Genetic Algorithm for Car Carriers. It displays a table of results for various destinations (F01 to F09) and a list of routes. The interface includes a search bar and a table with columns for destination, route, and other parameters.

Replace hand-works with **Information System**

• I'm considering to use **MADM(Multi-Attribute Decision Making) methodology** to develop an alternative evaluation method