

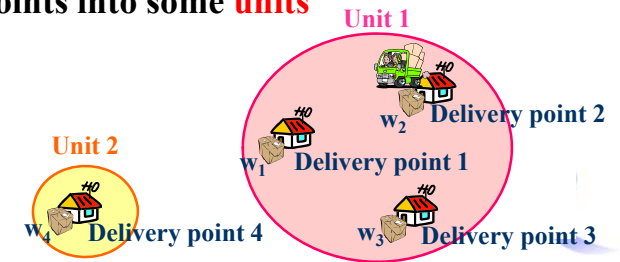
Consideration of the Variety of the Trucks in Vehicle Routing and Cargo Allocation Problem with Minimum CO₂ Emissions

Noriko Otani (Tokyo City University)
Tadayuki Masui (Tokyo City University)



Background

- Reduction of CO₂ emissions from cargo transportation activities
- Delivery of cargos with different weights
 - Shortest route \neq the route with minimum CO₂ emissions
 - CO₂ emissions may decrease by dividing delivery points into some **units**



Purpose

- Previous work [Otani11]
 - The number of trucks owned by a cargo carrier and their maximum loads have not been considered
 - The number of trucks used for delivering cargos is not limited and those maximum loads are uniform

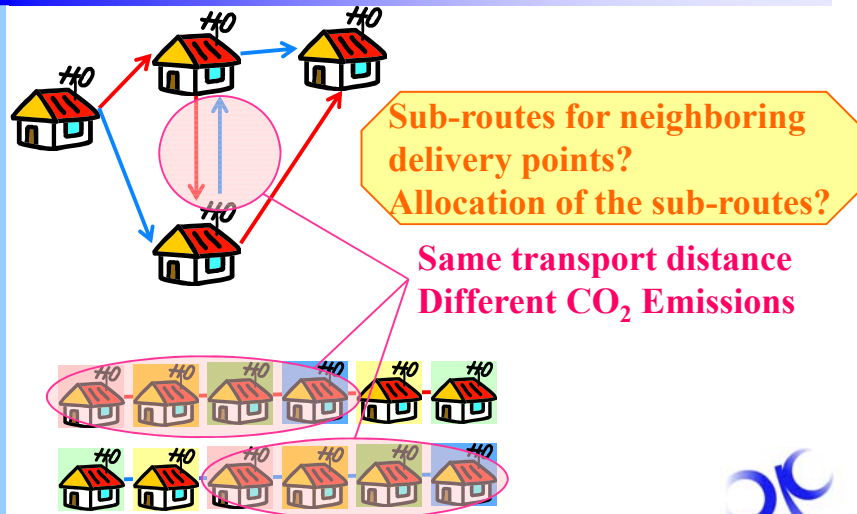


- ◆ Define VRCAP-MCE
- ◆ Propose a method for solving VRCAP-MCE
Vehicle Routing and Cargo Allocation Problem with Minimum CO₂ Emissions

VRCAP-MCE

- An optimization problem that seeks the route and cargo allocation with the minimum CO₂ emission
 - The delivery points are divided into several groups, called “units”
 - The smallest truck among the trucks that can load all the cargo for the unit is used
 - Coexistence of trucks used two or more times and unused trucks should be avoided as much as possible

Characteristics of VRCAP-MCE



5

Characteristics of VRCAP-MCE

- Seek sub-routes for neighboring delivery points that can be components of the optimal entire route.
- Allocate the sub-routes in order to determine the optimal entire route.
- Prepare units and assign trucks to each unit in order to minimize the total CO₂ emissions.

Symbiotic Evolution

6

Symbiotic Evolution

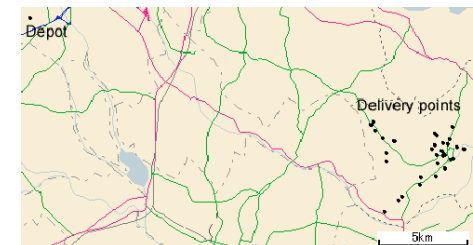
- A kind of evolutionary computation represented by the genetic algorithm
- Teamwork
 - Whole solution = Combination of partial solutions
 - Parallel evolution of two populations
 - Avoid local minimum and find good solution



7

Experiments

- 32 delivery points and the depot
- Number of trucks
 - Using light oil



Data name	Number of trucks		
	light	1 t	2 t
tnum1	0	0	3
tnum2	0	4	1
tnum3	3	5	0
tnum4	3	1	2

8

Experiments

• Cargo weight data

■ possible to be delivered by one 1 t truck

- ◆ *flat-1* ... 31 kg
- ◆ *heavy1-1* ... $w_6=w_{15}=125$ kg, others=25 kg
- ◆ *heavy2-1* ... $w_8=w_{21}=125$ kg, others=25 kg
- ◆ *heavy3-1* ... $w_{13}=w_{29}=125$ kg, others=25 kg

■ should be divided into units

- ◆ *flat-2* ... 186 kg
- ◆ *heavy1-2* ... $w_6=w_{15}=750$ kg, others=150 kg
- ◆ *heavy2-2* ... $w_8=w_{21}=750$ kg, others=150 kg
- ◆ *heavy3-2* ... $w_{13}=w_{29}=750$ kg, others=150 kg

Result for heavy*-1

Data		CO ₂ emission	No. of units	No. of trucks		
Cargo weight	No. of trucks			light	1 t	2 t
heavy1-1	<i>tnum1</i>	37.33	1	-	-	1
	<i>tnum2</i>	33.53	1	-	1	0
	<i>tnum3</i>	33.53	1	0	1	-
	<i>tnum4</i>	33.60	1	0	1	0
heavy2-1	<i>tnum1</i>	37.83	1	-	-	1
	<i>tnum2</i>	33.84	1	-	1	0
	<i>tnum3</i>	33.71	1	0	1	-
	<i>tnum4</i>	33.84	1	0	1	0
	<i>tnum1</i>	37.87	1	-	-	1
		33.73	1	-	1	0
		33.95	1	0	1	-
		33.76	1	0	1	0

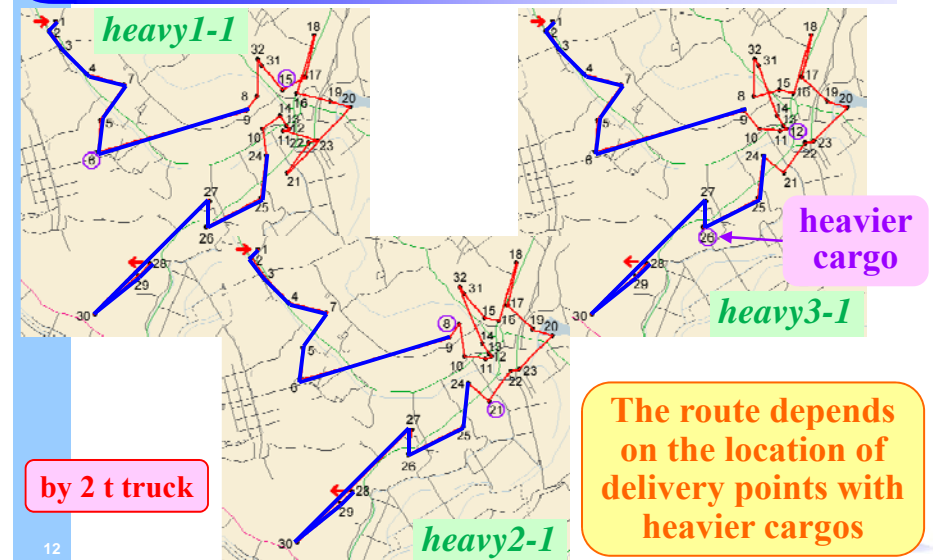
When 1 t truck is available, CO₂ emissions decrease.

Result for heavy*-2

Data		CO ₂ emission	No. of units	No. of trucks		
Cargo weight	No. of trucks			light	1 t	2 t
heavy1-2	<i>tnum1</i>	110.49	4	-	-	4
	<i>tnum2</i>	136.47	5	-	3	2
	<i>tnum3</i>	183.86	8	2	6	-
	<i>tnum4</i>	115.54	4	1	0	3
heavy2-2	<i>tnum1</i>	110.56	4	-	-	4
	<i>tnum2</i>	135.62	5	-	3	2
	<i>tnum3</i>	184.41	8	2	6	-
		115.96	4	1	0	3
	110.49	4	-	-	4	
	137.14	5	-	3	2	
	181.89	8	2	6	-	
	115.46	4	1	0	3	

When two or more 2 t trucks are available, CO₂ emissions decrease.

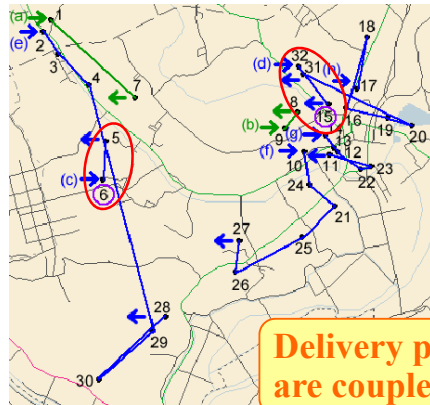
Best route for heavy*-1, *tnum1*



by 2 t truck

The route depends on the location of delivery points with heavier cargos

Best route for *heavy1-2, tnum3*



by light weight trucks

by 1 t trucks

Delivery points with heavier cargos are coupled with their neighbors

The other points are combined with appropriate points to make feasible combinations of cargos

Conclusion

- Define VRCAP-MCE
- Propose a method for solving VRCAP-MCE using symbiotic evolution



Valid route and cargo allocation

- Future works
 - Extend VRCAP-MCE to be more practical
 - Develop a method for solving the extended problem