

#### Session 6 (cont.): Vehicle routing problems: heuristics 35E00750 Logistics Systems and Analytics

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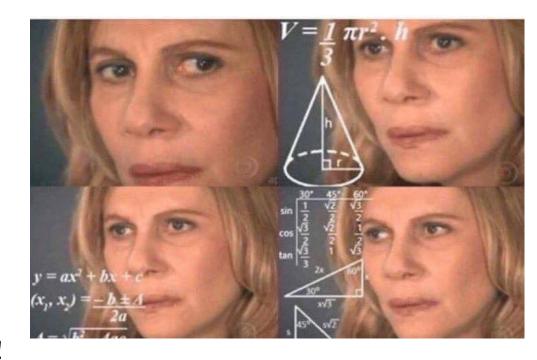
## Solving a TSP to optimality?

- An optimal algorithm would be:
  - Try all combinations and select cheapest
- For TSP, assume n cities:
  - Start in city 1

...

- Second city: (n 1) options
- Third city: (n 2) options

Hence, we have to consider  $(n - 1)(n - 2) \dots 1 = (n - 1)!$ options to find an optimal route connecting all cities



#### **TSP** heuristics

#### Constructive heuristics

- Starts with an empty solution and extends solution step by step until a complete solution is obtained
- Example within this course: nearest neighbor

#### Improvement or exchange procedures

- Start with a (random) solution and repeatedly consider various changes
- Examples: Clarke & Wright savings heuristic
- Examples: simulated annealing, genetic algorithms



## **Heuristics for the VRP**

A VRP may consist of multiple routes. VRP heuristics are thus typically a stepwise process, such as:

#### Cluster-first; route-second

- Step 1: Construct clusters of locations
- Step 2: Solve one TSP per cluster
- Route-first; cluster-second
  - Step 1: Relax constraints on vehicle capacity to build one enormous TSP tour
  - Step 2: Split the enormous tour into feasible routes





# Nearest neighbor (insertion heuristic)

## **Nearest neighbor (insertion heuristic)**

#### • Nearest neighbor (n cities):

- Starting location/city is known
- Select a city from those not visited yet with the min. distance from the last city in the tour
- Continue as long as cities remain unvisited
- You could consider some stopping criterion
  - Total route length
  - Maximum driving time
  - Vehicle (weight/volume) capacity



- The objective is to find the route visiting all customers exactly once in the shortest time
- The route starts and ends at the depot

	Depot	C1	C2	C3	C4	C5
Depot	-	35	43	23	33	19
C1	35	-	47	42	21	26
C2	43	47	-	36	31	30
C3	23	42	36	-	50	17
C4	33	21	31	50	-	45
C5	19	26	30	17	45	-

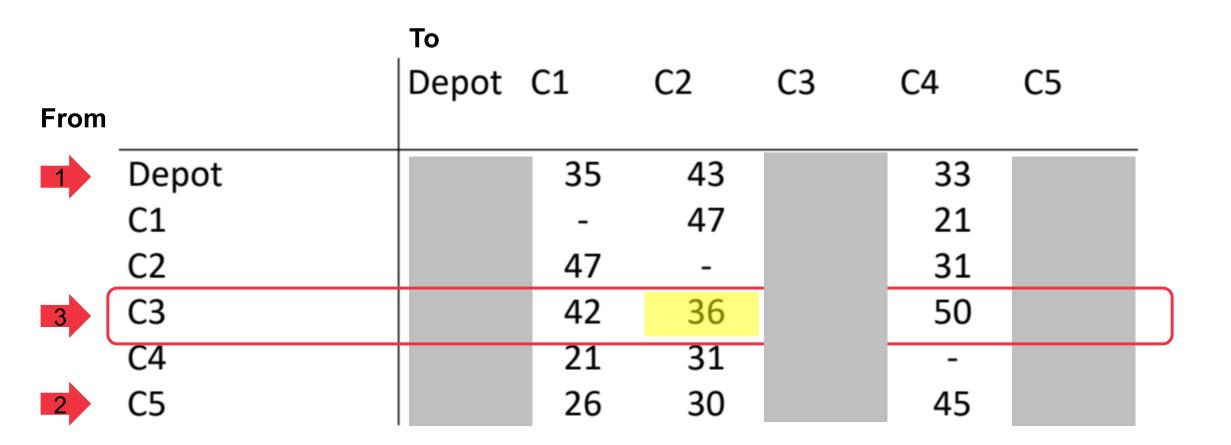


		То					
		Depot	C1	C2	C3	C4	C5
From							
	Depot		35	43	23	33	19
	C1		-	47	42	21	26
	C2		47	-	36	31	30
	C3		42	36	-	50	17
	C4		21	31	50	-	45
	C5		26	30	17	45	-

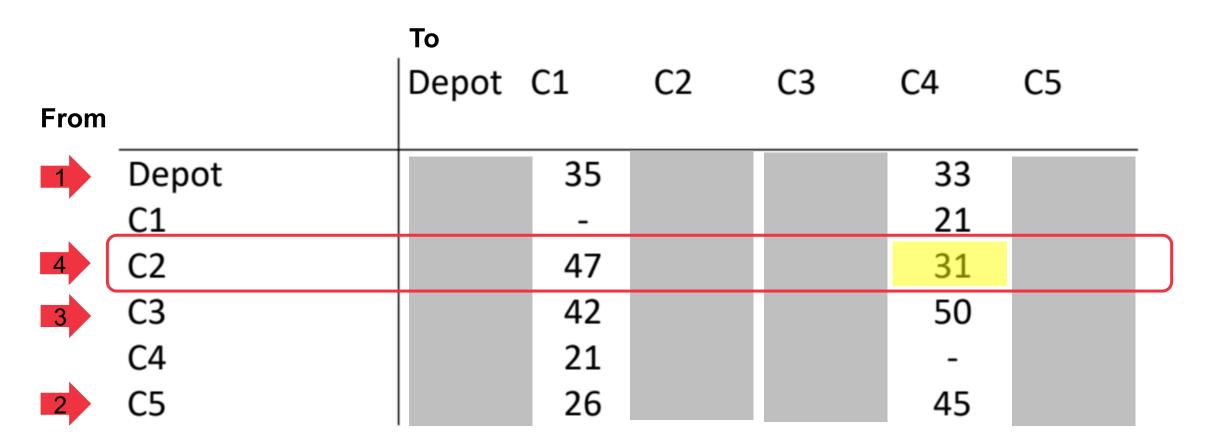


		То						
		Depot	C1	C2	C3	C4	C5	
From								
1	Depot		35	43	23	33		
·	C1		-	47	42	21		
	C2		47	-	36	31		
	C3		42	36	-	50		
	C4		21	31	50	-		
2	C5		26	30	17	45		

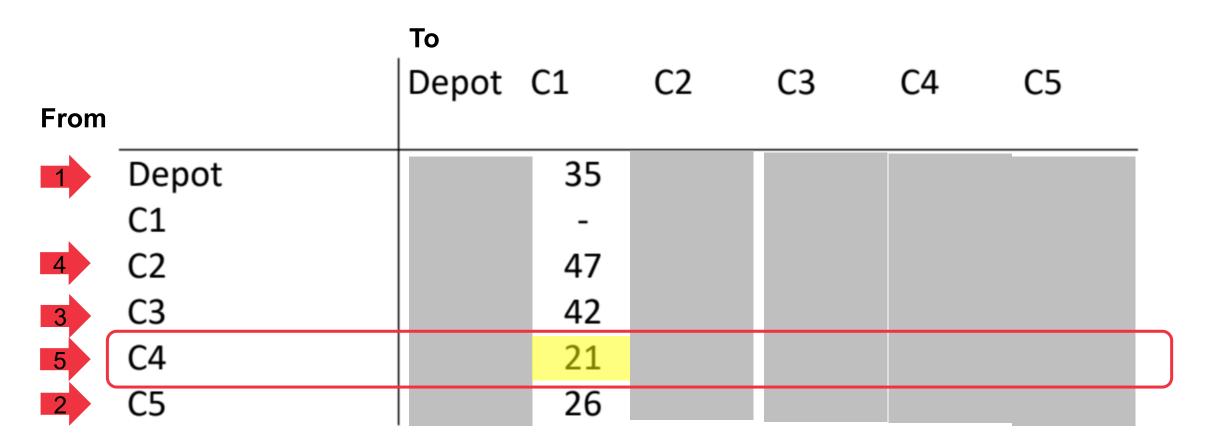




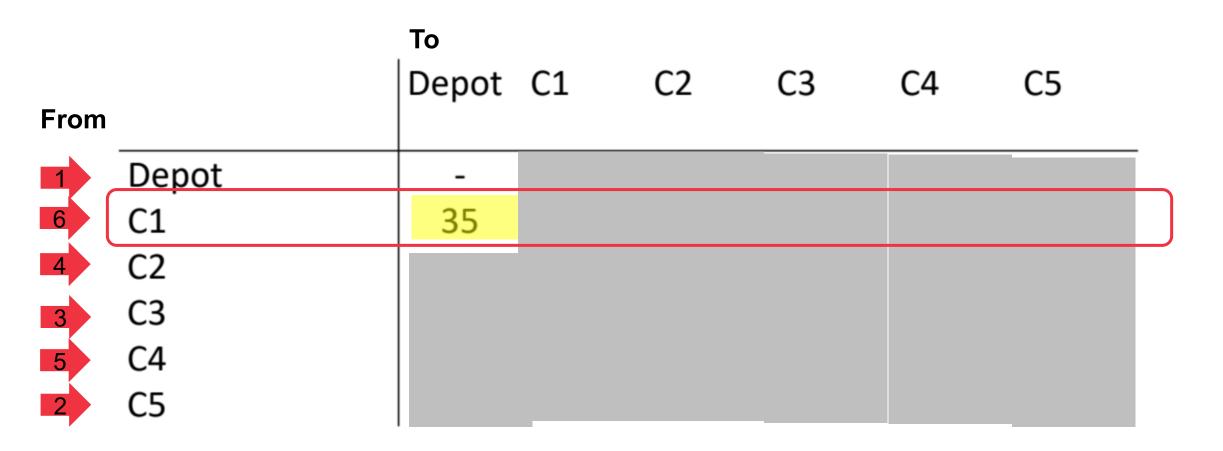














	Depot	C1	C2	C3	C4	C5
➡ Depot	-	35	43	23	33	19
<b>■6</b> → C1	35	-	47	42	21	26
<b>4</b> → C2	43	47	-	36	31	30
<b>-3</b> → C3	23	42	36	-	50	17
<b>-5</b> → C4	33	21	31	50	-	45
<b>-2</b> → C5	19	26	30	17	45	-

- Route: {Depot, 5, 3, 2, 4, 1, Depot}
- Total distance: 19+17+36+31+21+35 = 159



# Thank you!

## **Questions?**

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