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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) … 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

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Nearest neighbor (insertion heuristic)

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- **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

Nearest neighbor (example)

- 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	-

Nearest neighbor (example)

To

From	Depot	C1	C2	C3	C4	C5
1 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	-

Nearest neighbor (example)

To

From

	Depot	C1	C2	C3	C4	C5
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	

Nearest neighbor (example)

	From	To: Depot	C1	C2	C3	C4	C5
1	Depot		35	43		33	
	C1		-	47		21	
	C2		47	-		31	
3	C3		42	36		50	
	C4		21	31		-	
2	C5		26	30		45	

Nearest neighbor (example)

	From \ To	Depot	C1	C2	C3	C4	C5
1	Depot		35			33	
	C1		-			21	
4	C2		47			31	
3	C3		42			50	
	C4		21			-	
2	C5		26			45	

Nearest neighbor (example)

	From	To: Depot	C1	C2	C3	C4	C5
1	Depot		35				
	C1		-				
4	C2		47				
3	C3		42				
5	C4		21				
2	C5		26				

Nearest neighbor (example)

	From	To: Depot	C1	C2	C3	C4	C5
1	Depot	-					
6	C1	35					
4	C2						
3	C3						
5	C4						
2	C5						

Nearest neighbor (example)

	Depot	C1	C2	C3	C4	C5
1 Depot	-	35	43	23	33	19
6 C1	35	-	47	42	21	26
4 C2	43	47	-	36	31	30
3 C3	23	42	36	-	50	17
5 C4	33	21	31	50	-	45
2 C5	19	26	30	17	45	-

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

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Thank you!

Questions?

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