CIVENG 3C03 Assignment 4

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December 2, 2022

Question 1

(a) The optimal way to move the cranes between old and new sites can be found using the Hungarian method. The setup of the Hungarian method and initial two steps are shown in Figure 1. After the first two steps, optimality is not reached, therefore we find an improved solution in Figure 2 which we discover is an optimal solution. The optimal solution for returning the four cranes to the new sites is shown in Table 1.

Figure 1: Hungarian Method Setup

Old Sites	New Sites			
	A	B	C	D
I	3.5	4.25	6	4
II	4	5.5	5.5	7
III	8.5	9.25	7.5	7.5
IV	5	5.5	6.5	3.75

Old Sites	New Sites			
	A	B	C	D
I	0	0	0.5	0.25
II	0.5	1.25	0	3.25
III	5	5	2	3.75
IV	1.5	1.25	1	0

Old Sites	New Sites			
	A	B	C	D
I	0	0	0.5	0.25
II	0.5	1.25	0	3.25
III	3	3	0	1.75
IV	1.5	1.25	1	0

Figure 2: Hungarian Method Optimal Solution

Old Sites	New Sites			
	A	B	C	D
I	0	0	1	0.25
II	0	0.75	0	2.75
III	2.5	2.5	0	1.25
IV	1.5	1.25	1.5	0

Table 1: Optimal Solution

Old Sites	New Sites
I	B
II	A
III	C
IV	D

(b) The solution is confirmed using Excel Solver in Microsoft Excel. The solution was found to be the same, as seen in Figure 3. The Excel spreadsheet is included with the assignment submission as `question1.xlsx`.

Figure 3: Microsoft Excel Solution

	New Sites				
Old Sites	A	B	C	D	Assigned
I	0	1	0	0	1
II	1	0	0	0	1
III	0	0	1	0	1
IV	0	0	0	1	1
Assigned	1	1	1	1	
Time	19.5				

Question 2

The optimal route for the proposed highway can be determined by expressing the problem as three stages of an unconstrainted Dynamic Programming problem. The detailed analysis of each stage of the problem can be seen in Tables 2, 3, and 4. From the detailed analysis of the problem, we can see the optimal route from City A to City B is A2 $\rightarrow$ B1 $\rightarrow$ C2 $\rightarrow$ D1.

Table 2: Stage 1

S_1	Stage 1			
	D1	D2	$F_{1\text{-min}}$	$D_{1\text{-min}}$
C1	$10 + 15 + 19 = 44$		44	D1
C2	$10 + 5 + 23 = 38$	$19 + 15 + 23 = 57$	38	D1
C3	$10 + 9 + 25 = 44$	$19 + 11 + 25 = 55$	44	D1
C4	$10 + 10 + 21 = 41$	$19 + 18 + 21 = 58$	41	D1

Table 3: Stage 2

S_2	Stage 2					
	C1	C2	C3	C4	$F_{2\text{-min}}$	$D_{2\text{-min}}$
B1	$44 + 10 + 15 = 69$	$38 + 12 + 15 = 65$			65	C2
B2	$44 + 8 + 21 = 73$	$38 + 6 + 21 = 65$	$44 + 10 + 21 = 75$		65	C2
B3	$44 + 4 + 23 = 71$	$38 + 9 + 23 = 70$	$44 + 10 + 23 = 77$	$41 + 9 + 23 = 73$	70	C2
B4		$38 + 8 + 22 = 68$	$44 + 2 + 22 = 68$	$41 + 6 + 22 = 69$	68	C2/C3

Table 4: Stage 3

S_3	Stage 3					
	B1	B2	B3	B4	$F_{3\text{-min}}$	$D_{3\text{-min}}$
A1	$65 + 8 + 10 = 83$	$65 + 7 + 10 = 82$	$70 + 4 + 10 = 84$		82	B2
A2	$65 + 5 + 11 = 81$	$65 + 6 + 11 = 82$	$70 + 9 + 11 = 90$	$68 + 11 + 11 = 90$	81	B1
A3		$65 + 7 + 15 = 87$	$70 + 4 + 15 = 89$	$68 + 2 + 15 = 85$	85	B4

Question 3

(a) The superelevation value, e, used for the design is:

$$\begin{aligned} e &= \frac{v^2}{127R} - f_s \\ &= \frac{100^2}{127(475)} - 0.12 \\ &= \frac{10000}{60325} - 0.12 \\ e &\approx 0.046 \end{aligned}$$

(b) Using Monte Carlo Simulation, the mean and standard deviation of the superelevation needed for the horizontal curve are 0.01258 and 0.03503 (results may vary slightly as the simulation is repeated).

(c) Based on the Monte Carlo Simulation, the probability that the superelevation provided by the deterministic design will be inadequate is 1.74% (results may vary slightly as the simulation is repeated).

(d) It is recommended to use the 95$^{\text{th}}$ percentile as a design value. From the simulation, the 95$^{\text{th}}$ percentile of the required superelevation is 0.07246. Hence, it is recommended to use $e = 0.0725$ as the design value (results may vary slightly as the simulation is repeated).

The Excel spreadsheet is included with the assignment submission as `question3.xlsx`.

Question 3

(a) The probability that less than three busses arrive at the stop in a given hour is:

$$\begin{aligned} P(x < 3) &= P(0) + P(1) + P(2) \\ &= \frac{e^{-m}m^0}{0!} + \frac{e^{-m}m^1}{1!} + \frac{e^{-m}m^2}{2!} \\ &= \frac{e^{-4}4^0}{0!} + \frac{e^{-4}4^1}{1!} + \frac{e^{-4}4^2}{2!} \\ &= \frac{e^{-4}4^0}{0!} + \frac{e^{-4}4^1}{1!} + \frac{e^{-4}4^2}{2!} \\ P(x < 3) &= 0.2381 \end{aligned}$$

(b) The probability that the passenger will wait less than 13 minutes for the next bus is:

$$\begin{aligned} P(h < T) &= 1 - e^{-\lambda T} \\ P(h < \frac{13}{60}) &= 1 - e^{-4 \times \frac{13}{60}} \\ P(h < \frac{13}{60}) &= 0.5796 \end{aligned}$$

(c) The cumulative distribution function of the waiting time at the stop is shown in Figure 4.

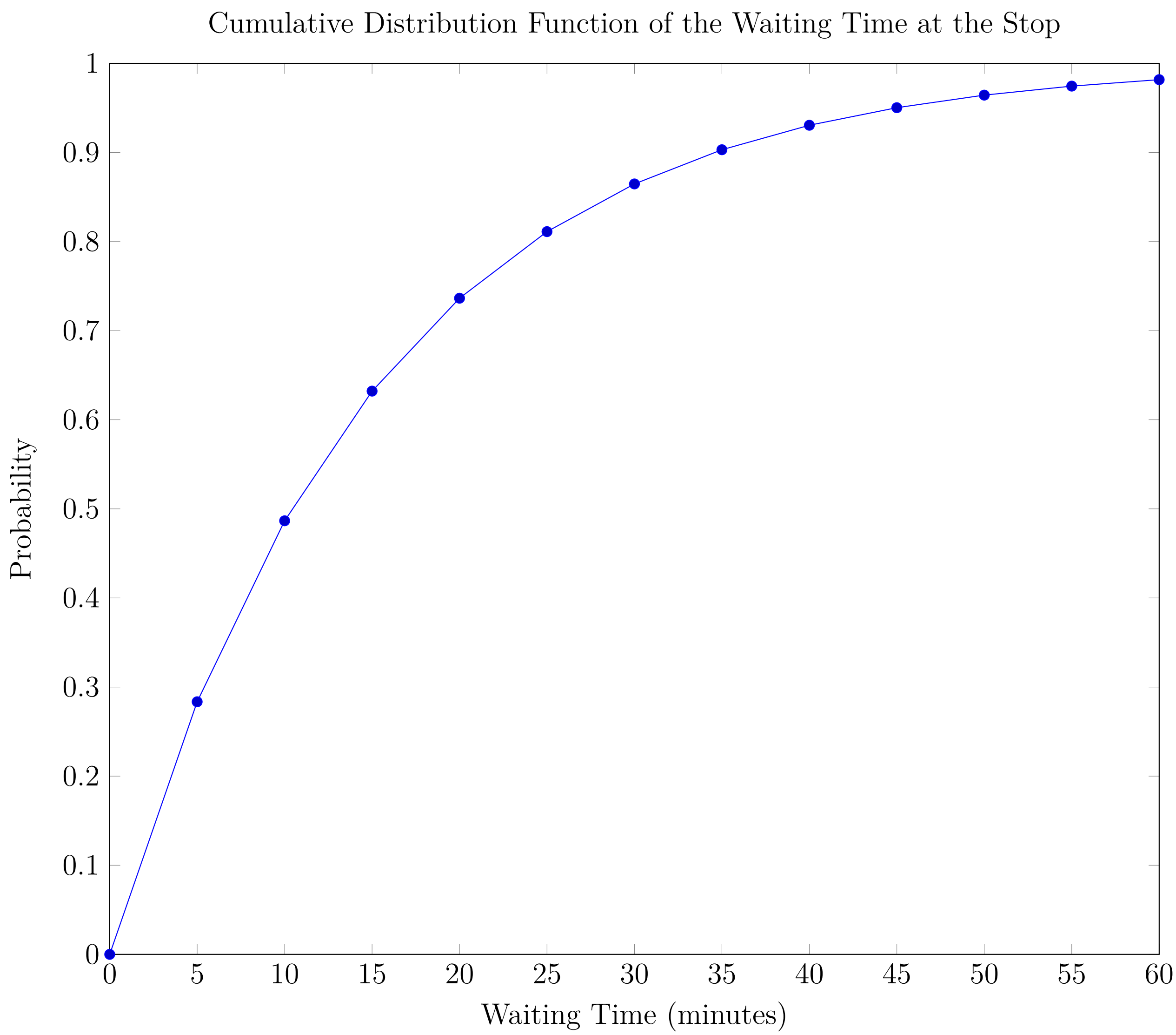

Figure 4: Cumulative Distribution Function of Waiting Time