

HOMEWORK 5 - SOLUTIONS

Question 1:

a) Total weighted distance for the current case:

$$= 100 \cdot 35 + 90 \cdot 385 + 120 \cdot 331 + 80 \cdot 394 + 150 \cdot 316 + 110 \cdot 562$$

$$= 218,610$$

b) Use heuristic method to find "good" locations:

- Find the best weighted 1 location

$$\text{Weighted distance of Aydın} = 100 \cdot 126 + 90 \cdot 520 + 120 \cdot 452 + 80 \cdot 477 + 150 \cdot 408 + 110 \cdot 597$$

$$= 278,670$$

$$\text{Weighted distance of Afyonkarahisar} = 100 \cdot 326 + 90 \cdot 212 + 120 \cdot 526 + 80 \cdot 164 + 150 \cdot 100 + 110 \cdot 256$$

$$= 169,680$$

$$\rightarrow \text{Weighted distance of Bursa} = 100 \cdot 325 + 90 \cdot 95 + 120 \cdot 271 + 80 \cdot 152 + 150 \cdot 177 + 110 \cdot 385$$

$$= 151,630$$

$$\text{Weighted distance of Uşak} = 100 \cdot 211 + 90 \cdot 251 + 120 \cdot 621 + 80 \cdot 217 + 150 \cdot 139 + 110 \cdot 367$$

$$= 172,990$$

- Fix Bursa.

- Find the next

	İzmir	Bilecik	Gönuşaklı	Eskişehir	Kütahya	Ankara
Bursa & Aydın	126(A)	95(B)	271(B)	152(B)	177(B)	385(B)
Bursa & Afyonkarahisar	325(B)	95(B)	271(B)	164(A)	100(A)	256(A)
Bursa & Uşak	211(U)	95(B)	271(B)	152(B)	139(U)	367(U)

$$\bullet \text{Weighted distance of Bursa \& Aydın} = 100 \cdot 126 + 90 \cdot 95 + 120 \cdot 271 + 80 \cdot 152 + 150 \cdot 177 + 110 \cdot 385$$

$$= 134,730$$

$$\bullet \text{Weighted distance of Bursa \& Afyonkarahisar} = 100 \cdot 325 + 90 \cdot 95 + 120 \cdot 271 + 80 \cdot 164 +$$

$$150 \cdot 100 + 110 \cdot 256$$

$$= 128,250$$

$$\begin{aligned} \text{• Weighted distance of Bursa \& Uşak} &= 100.211 + 90.95 + 120.271 + 80.152 + 150.139 \\ &+ 110.367 \\ &= 135,550 \end{aligned}$$

"Good" locations according to heuristic method:

Bursa \& Afyonkarahisar

City	Served by Factory in
İzmir	Bursa
Bilecik	Bursa
Çonakkale	Bursa
Eskişehir	Afyonkarahisar
Kütahya	Afyonkarahisar
Ankara	Afyonkarahisar

c) Use enumeration method to find best locations

	İzmir	Bilecik	Çonakkale	Eskişehir	Kütahya	Ankara
Aydın \& Afyonkarahisar	126(Ay)	212(AP)	452(Ay)	144(AP)	100(AP)	256(AP)
Aydın \& Bursa	216(A)	95(B)	271(B)	152(B)	137(B)	385(B)
Aydın \& Uşak	126(A)	251(U)	421(U)	217(U)	139(U)	367(U)
Afyonkarahisar \& Bursa	225(B)	95(B)	271(B)	144(A)	100(A)	256(A)
Afyonkarahisar \& Uşak	211(U)	212(A)	421(U)	144(A)	100(A)	256(A)
Bursa \& Uşak	211(U)	95(B)	271(B)	152(B)	139(U)	367(U)

• Weighted distance of Aydın \& Afyonkarahisar

$$\begin{aligned} &= 100.126 + 90.212 + 100.452 + 80.144 + 150.100 + 110.256 \\ &= 140,600 \end{aligned}$$

• Weighted distance of Aydın \& Bursa = 130,730

• Weighted distance of Aydın & Uşak

$$= 100 \cdot 126 + 90 \cdot 251 + 120 \cdot 621 + 80 \cdot 217 + 150 \cdot 139 + 110 \cdot 367$$

$$= 164,280$$

• Weighted distance of Afyonkarahisar & Bursa = 28,250

• Weighted distance of Afyonkarahisar & Uşak =

$$= 100 \cdot 211 + 90 \cdot 212 + 120 \cdot 621 + 80 \cdot 114 + 150 \cdot 100 + 110 \cdot 256$$

$$= 145,380$$

• Weighted distance of Bursa & Uşak = 135,550

Best locations according to heuristic method:

Bursa & Afyonkarahisar (Some with part b) by chance)

<u>City</u>	<u>Served by factory in</u>
İzmir	Bursa
Bilecik	Bursa
Göndülük	Bursa
Eskişehir	Afyonkarahisar
Kütahya	Afyonkarahisar
Ankara	Afyonkarahisar

Question 2:

a) Travel time matrix:

amb. districts	a	b	c	d	e	f
a	0	2	6	7	11	5
b	2	0	4	5	9	3
c	6	4	0	3	5	5
d	7	5	3	0	4	2
e	11	9	5	4	0	6
f	5	3	5	2	6	0

b) amb. districts	a2b	a2c	a2d	a2e	a2f	b2c	b2d	b2e	b2f	c2d	c2e	c2f	d2e	d2f	e2f
a	0	0	0	0	0	2	2	2	2	6	6	5	7	5	5
b	0	2	2	2	2	0	0	0	0	4	4	3	5	3	3
c	4	0	3	5	5	0	3	4	4	0	0	0	3	3	5
d	5	3	0	4	2	3	0	4	2	0	3	2	0	0	2
e	9	5	4	0	6	5	4	0	6	4	0	5	0	4	0
f	3	5	2	5	0	3	2	3	0	2	5	0	2	0	0
Total:	21	15	<u>11</u>	16	15	13	<u>11</u>	13	14	16	18	15	17	15	15

Optimum solutions: a2d or b2d with total time of 11 min.

c) amb. location	a	b	c	d	e	f
min time that every district is reachable	11	9	6	7	11	6

Min allowable time to cover every district using a single ambulance = 6 min

Optimum solutions: c or f

d) min. number of ambulances s.t. each district is reached in 5 minutes = 2.

i. All optimum solutions:

Construct cover matrix:

amb. dist.	a	b	c	d	e	f
a	1	1	0	0	0	1
b	1	1	1	1	0	1
c	0	1	1	1	1	1
d	0	1	1	1	1	1
e	0	0	1	1	1	0
f	1	1	1	1	0	1

Optimum solutions: a2c, a2d, a2e

b2c, b2d, b2e,

c2f,

d2f,

e2f

ii. Additional measures:

- minimize time to reach every district
- minimize worst time to reach a district
- minimize the number of twice covered districts

		<u>Total Time</u>	<u>Worst Time</u>	<u>Twice Coverage</u>
①	a2c	15	5	b, f
②	a2d	11	4	b, f
③	a2e	16	5	-
④	b2c	13	5	d, f
⑤	b2d	11	4	c, f
⑥	b2e	13	4	c, d
⑦	c2f	15	5	b, d
⑧	d2f	15	5	b, c
⑨	e2f	15	5	c, d

Normalize:

	<u>Total Time</u>	<u>Worst Time</u>	<u>Twice Coverage</u>	
① a2c	0.2	0	0	X
② a2d	1	1	0	
③ a2e	0	0	1	
④ b2c	0.6	0	0	X
⑤ b2d	1	1	0	
⑥ b2e	0.6	1	0	X
⑦ c2f	0.2	0	0	X
⑧ d2f	0.2	0	0	X
⑨ e2f	0.2	0	0	X

② dominates ①

② dominates ④

② dominates ⑥, ⑦, ⑧, ⑨

Non-dominated ones:

②, ③ and ⑤

iii. Score of $a_2 d$: 0.5

Score of $a_2 e$: 0.5

Score of $b_2 d$: 0.5

-All of them are equally preferred.