

Example: Using SDPI Excel for Machine Layout Problems

ISE 453: Design of PLS Systems

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This Example illustrates the use of the machine layout functions in the spreadsheet *SDPI Machine Layout.xls* that you can download from the course webpage.

Solving the Example 1 using EXCEL

Using the same 4-machine SDPI example, the EXCEL function `sdpi` that implements the SDPI heuristic is used. Also, the EXCEL function `RandPerm(N)` is used to construct random N -element assignment vectors.

	Create W						Create D				
Routes =	1	2	3	4			Locations =	X	Y		
	2	4	1	2	3			0	0		
	3	4	1	2	4			10	0		
Flow =	8	5	12					35	0		
								50	0		
Handling Cost =	3	2	1								
	0	46	0	0			D =	0	10	35	50
W =	0	0	34	22				10	0	25	40
	0	0	0	36				35	25	0	15
	22	0	0	0				50	40	15	0
	Find Best Layout										
			Final								
											Cost
			3	4	2	1					3670

Creating the W (weight) Matrix:

To create the W matrix, use the EXCEL function `W(Routes, Flow, Handling Cost)`.

Recall from ISE110 that in order to execute a function across an array you:

- 1) Select the area that the matrix will occupy (in this case a 4x4 range)
- 2) Type the function and then hit **Ctrl+Shift+Enter** simultaneously

Alternately, you can:

- 1) Type the function in one cell and hit **Enter**
- 2) Select the area that the matrix will occupy with the cell that you typed the function in Step 1 being the upper left cell of the selected range and hit **F2**
- 3) Hit **Ctrl+Shift+Enter** simultaneously

fx =w(D64:H66,D68:F68,D70:F70)

C	D	E	F	G	H
	Create W				
Routes =	1	2	3	4	
	2	4	1	2	3
	3	4	1	2	4
Flow =	8	5	12		
Handling Cost =	3	2	1		
W =	70:F70)				
	0	0	34	22	
	0	0	0	36	
	22	0	0	0	

Creating the W matrix

Creating the D (distance) Matrix:

To create the D matrix, use either the EXCEL function;

Dist(Locations, [1 or 2]). The second parameter is entered as 1 or omitted if dealing with rectangular grid and entered as 2 if dealing with open space. Use this when dealing with;

- 1) Rectangular Grid
- 2) Open Space

fx =Dist(K65:L68)

J	K	L	M	N
	Create D			
	X	Y		
Locations =	0	0		
	10	0		
	35	0		
	50	0		
D =	65:L68)			
	10	35	50	
	10	0	25	40
	35	25	0	15
	50	40	15	0

Creating the D matrix with Dist Function

Dijk(Routes). A single route is defined by the starting location, destination location, and the distance between the two. If the route is bidirectional, then a negative sign is associated with the destination location. Use this when dealing with;

- 1) Circular Conveyor
- 2) General Network

The screenshot shows an Excel spreadsheet with two tables. The first table, titled 'Create Distance Matrix', has columns for 'Start', 'End', and 'Distance'. The second table, titled 'Distance Matrix', shows the resulting distance matrix for 5 locations.

Create Distance Matrix			
Locations:	Start	End	Distance
	1	-2	15
	1	-3	60
	1	-4	21
	2	-4	16
	2	-5	39
	3	-5	8
	4	-5	47

Distance Matrix					
	1	2	3	4	5
1	0	15	60	21	54
2	15	0	47	16	39
3	60	47	0	55	8
4	21	16	55	0	47
5	54	39	8	47	0

Creating the D matrix with Dijk Function (not this example)

Finding the Best Layout:

To find the best layout, use the EXCEL function `sdpi(w_matrix, d_Matrix, [1])`. This function uses the weight matrix (W) and the distance matrix (D) calculated above.

- If it is desired to find the best possible layout and cost then choose a horizontal vector ($M+1$) cells in length to accommodate the layout and the cost and omit the third parameter. The function will run for M^2 iterations.
- If it is desired to find multiple iterations' of amount R results, choose an array ($M+1 \times R$) in size to accommodate the layout and the cost of each desired iteration. These layouts and costs are not the best necessarily, just the local minimums found from each of the iterations.
- If it is desired to find a single iteration's layout and cost, choose a horizontal vector ($M+1$) cells in length to accommodate the layout and the cost and set the third parameter of the function to 1.

Formula bar: `=sdpi(D72:G75,K72:N75)`

	D	E	F	G	H		K	L	M	N
W =	0	46	0	0		D =	0	10	35	50
	0	0	34	22			10	0	25	40
	0	0	0	36			35	25	0	15
	22	0	0	0			50	40	15	0
Find Best Layout										
	Final				Cost					
	72:N75)	4	2	1	3670					

Finding the best layout using sdpi function and omitting third parameter

Formula bar: `=sdpi(I11:L14,I16:L19)`

	H	I	J	K	L
W:	0	46	0	0	0
	0	0	34	22	
	0	0	0	36	
	22	0	0	0	
D:	0	10	35	50	
	10	0	25	40	
	35	25	0	15	
	50	40	15	0	
Possible Layouts:					Cost:
<code>=sdpi(I11:L14,I16:L19)</code>					1 3670
3	4	2	1	3670	
1	2	4	3	3680	
1	2	4	3	3680	
3	4	2	1	3670	

Finding multiple layouts using sdpi function by choosing multiple rows and omitting the third parameter

Formula bar: `=sdpi(4:L7,I9:L12,1)`

	H	I	J	K	L
W:	0	46	0	0	0
	0	0	34	22	
	0	0	0	36	
	22	0	0	0	
D:	0	10	35	50	
	10	0	25	40	
	35	25	0	15	
	50	40	15	0	
Possible Layout:					Cost:
<code>=sdpi(4:L7,I9:L12,1)</code>					4 3 3680

Finding single layout using sdpi function by setting third parameter to 1

Solving Example 2 using EXCEL

In this example, a 5×5 matrix \mathbf{W} is created by adding a fifth row and fifth column to the 4×4 matrix \mathbf{W} used in Example 1. The function `dist` is available to determine the (l_p norm) distances between each pair of site locations, and the function `dijk` is available to determine the shortest paths between each pair of site locations. In the function `dist`, the second parameter is used to specify the type of distance: 1, for rectilinear, and 2, for Euclidean distances. `dijk` determines the matrix \mathbf{D} of shortest distances between all pairs of sites.

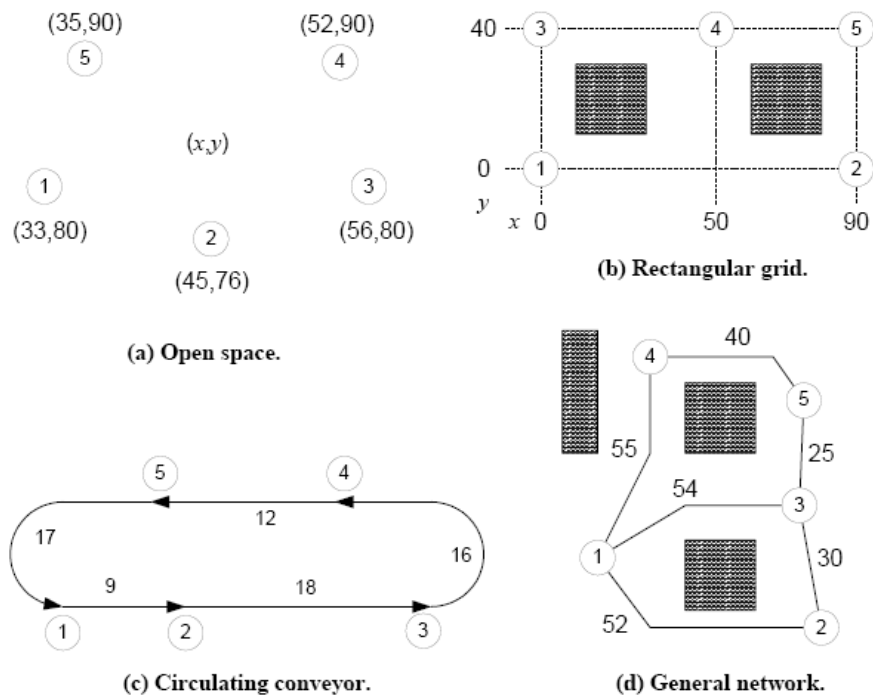


Figure 4.11. Four machine layout scenarios used in Example 2.

=Dist(D94:E98,2)						=sdpi(D86:H90,D101:H105)					
D	E	F	G	H	I	D	E	F	G	H	I
W:						W:					
0	46	0	0	0		0	46	0	0	0	
0	0	34	22	0		0	0	34	22	0	
0	0	0	36	0		0	0	0	36	0	
22	0	0	0	0		22	0	0	0	0	
0	0	0	0	0		0	0	0	0	0	
Locations:						Locations:					
X	Y					X	Y				
33	80					33	80				
45	76					45	76				
56	80					56	80				
52	90					52	90				
35	90					35	90				
D:						D:					
i:E98,2	12.65	23.00	21.47	10.20		0.00	12.65	23.00	21.47	10.20	
12.65	0.00	11.70	15.65	17.20		12.65	0.00	11.70	15.65	17.20	
23.00	11.70	0.00	10.77	23.26		23.00	11.70	0.00	10.77	23.26	
21.47	15.65	10.77	0.00	17.00		21.47	15.65	10.77	0.00	17.00	
10.20	17.20	23.26	17.00	0.00		10.20	17.20	23.26	17.00	0.00	
Best Layout:						Best Layout:					
1	2	3	4	5	Cost: 2184.265	=sdpi(D86:	2	3	4	5	Cost: 2184.265

Distance matrix for scenario (a)

Best layout for scenario (a)

=Dist(L94:M98,1)						=sdpi(L86:P90,L101:P105)					
L	M	N	O	P	Q	L	M	N	O	P	Q
W:						W:					
0	46	0	0	0		0	46	0	0	0	
0	0	34	22	0		0	0	34	22	0	
0	0	0	36	0		0	0	0	36	0	
22	0	0	0	0		22	0	0	0	0	
0	0	0	0	0		0	0	0	0	0	
Locations:						Locations:					
X	Y					X	Y				
0	0					0	0				
90	0					90	0				
0	40					0	40				
50	40					50	40				
90	40					90	40				
D:						D:					
=Dist(L94:	90	40	90	130		0	90	40	90	130	
90	0	130	80	40		90	0	130	80	40	
40	130	0	50	90		40	130	0	50	90	
90	80	50	0	40		90	80	50	0	40	
130	40	90	40	0		130	40	90	40	0	
Best Layout:						Best Layout:					
5	3	1	2	4	Cost: 9320	=sdpi(L86:	3	1	2	4	Cost: 9320

Distance matrix for scenario (b)

Best layout for scenario (b)

=dijk(D121:F125)						=sdpi(D113:H117,D128:H132)					
D	E	F	G	H	I	D	E	F	G	H	I
W:						W:					
0	46	0	0	0		0	46	0	0	0	
0	0	34	22	0		0	0	34	22	0	
0	0	0	36	0		0	0	0	36	0	
22	0	0	0	0		22	0	0	0	0	
0	0	0	0	0		0	0	0	0	0	
Routes:						Routes:					
Start	End	Distance				Start	End	Distance			
1	2	9				1	2	9			
2	3	18				2	3	18			
3	4	16				3	4	16			
4	5	12				4	5	12			
5	1	17				5	1	17			
D:						D:					
=dijk(D121	9	27	43	55		0	9	27	43	55	
63	0	18	34	46		63	0	18	34	46	
45	54	0	16	28		45	54	0	16	28	
29	38	56	0	12		29	38	56	0	12	
17	26	44	60	0		17	26	44	60	0	
Best Layout:						Best Layout:					
3	4	5	1	2	Cost: 2774	=sdpi(D111	4	5	1	2	Cost: 2774

Distance matrix for scenario (c)

Best layout for scenario (c)

=dijk(L121:N126)						=sdpi(L113:P117,L129:P133)					
L	M	N	O	P	Q	L	M	N	O	P	Q
W:						W:					
0	46	0	0	0		0	46	0	0	0	
0	0	34	22	0		0	0	34	22	0	
0	0	0	36	0		0	0	0	36	0	
22	0	0	0	0		22	0	0	0	0	
0	0	0	0	0		0	0	0	0	0	
Routes:						Routes:					
Start	End	Distance				Start	End	Distance			
1	-2	52				1	-2	52			
1	-3	54				1	-3	54			
1	-4	55				1	-4	55			
2	-3	30				2	-3	30			
3	-5	25				3	-5	25			
4	-5	40				4	-5	40			
D:						D:					
=dijk(L121	52	54	55	79		0	52	54	55	79	
52	0	30	95	55		52	0	30	95	55	
54	30	0	65	25		54	30	0	65	25	
55	95	65	0	40		55	95	65	0	40	
79	55	25	40	0		79	55	25	40	0	
Best Layout:						Best Layout:					
3	4	2	5	1	Cost: 6728	=sdpi(L113	4	2	5	1	Cost: 6728

Distance matrix for scenario (d)

Best layout for scenario (d)