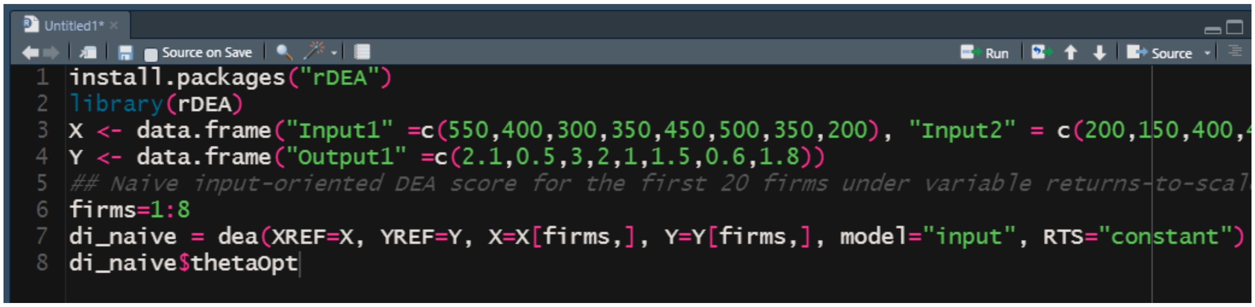
BEMM462 – Final Assessment

Project 1

a. In the given problem, the inputs to be considered are the person-days, CPU time in hours and the estimated profit in million pounds. On the other hand, the output is the result that is the information regarding the which projects to prioritize and which ones to not.

This is because using the DEA analysis the process is taking into consideration the available resources and its main aim is to compare the projects and chose the project with the highest profit to resource inputs ratio. In the considered example although the estimated earnings may seem as an output, it is taken as an input for analysis. This is because the estimated earnings are a theoretical measure and may differ based on the changes in the other inputs, that is, number of days and the CPU time. The main aim of the organization is to reduce the inputs as much as possible and enhance the output on the other hand. The other inputs considered are the CPU time and the Person – days. These two parameters are the effort put in the projects to obtain the results. Hence, it is self-explanatory to choose them as the inputs.

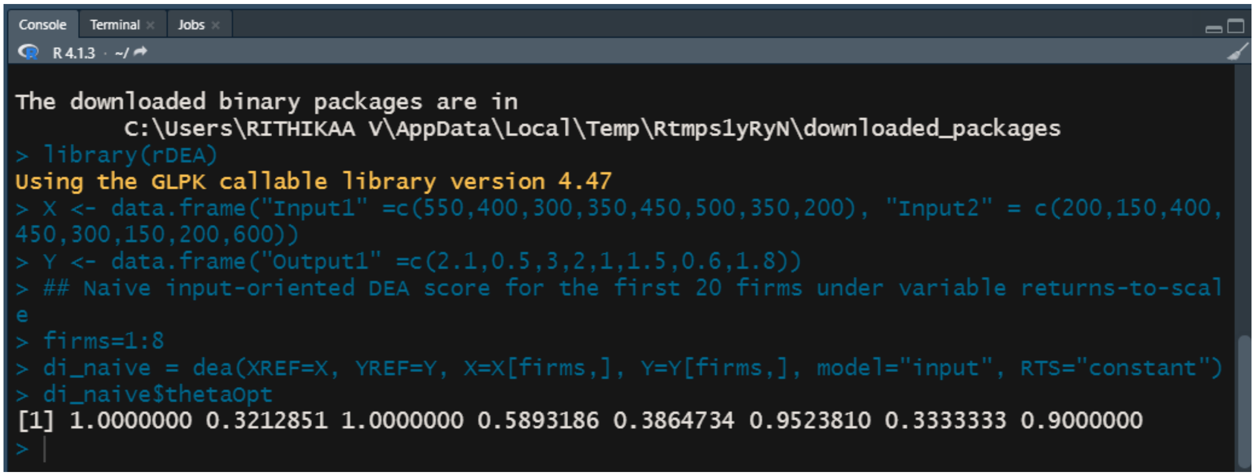
b. The DEA model or the frontier analysis is a method used to estimate the productive efficiency and project prioritization. It uses the data provided from the problem to evaluate the productivity of a system by considering the various input and output combinations.
In the given problem, as explained in the a. subdivision, all the given parameters are considered as the inputs and hence the ideal DEA model here is an input-oriented model. Hence, the analysis of the given problem using R is shown below:



```r
install.packages("rDEA")
library(rDEA)
X <- data.frame("Input1" =c(550,400,300,350,450,500,350,200), "Input2" = c(200,150,400,4
Y <- data.frame("Output1" =c(2.1,0.5,3,2,1,1.5,0.6,1.8))
## Naive input-oriented DEA score for the first 20 firms under variable returns-to-scal
firms=1:8
di_naive = dea(XREF=X, YREF=Y, X=X[firms,], Y=Y[firms,], model="input", RTS="constant")
di_naive$thetaOpt
```

Figure 1 – DEA using R

Output:



```
The downloaded binary packages are in
        C:\Users\RITHIKAA V\AppData\Local\Temp\Rtmps1yRyN\downloaded_packages
> library(rDEA)
Using the GLPK callable library version 4.47
> X <- data.frame("Input1" =c(550,400,300,350,450,500,350,200), "Input2" = c(200,150,400,
450,300,150,200,600))
> Y <- data.frame("Output1" =c(2.1,0.5,3,2,1,1.5,0.6,1.8))
> ## Naive input-oriented DEA score for the first 20 firms under variable returns-to-scal
e
> firms=1:8
> di_naive = dea(XREF=X, YREF=Y, X=X[firms,], Y=Y[firms,], model="input", RTS="constant")
> di_naive$thetaOpt
[1] 1.0000000 0.3212851 1.0000000 0.5893186 0.3864734 0.9523810 0.3333333 0.9000000
> 
```

Figure 2 – DEA output - efficiency

From the above output we can summarize that,

PROJECT	EFFICIENCY	COMMENT
1	100%	This project has the maximum efficiency and is highly capable of producing the exact value of what is provided as input. Hence, it is highly efficient.
2	32.13%	Very low efficiency – it is an inefficient project.
3	100%	This project has the maximum efficiency and is highly capable of producing the exact value of what is provided as input. Hence, it is highly efficient.
4	58.93%	Very low efficiency – it is an inefficient project.

5	38.64%	Very low efficiency – it is an inefficient project.
6	95.24%	This project has good efficiency with a few losses. It can be considered efficient.
7	33.33%	Very low efficiency – it is an inefficient project.
8	90%	This project has good efficiency with a few losses. It can be considered efficient.

c. I would recommend the project 1 and 3 as they have 100% efficiency. This means that the chances of obtaining the maximum profit with the minimal use of input resources (person days and the CPU time in this case) is possible when investing in these projects compared to others.

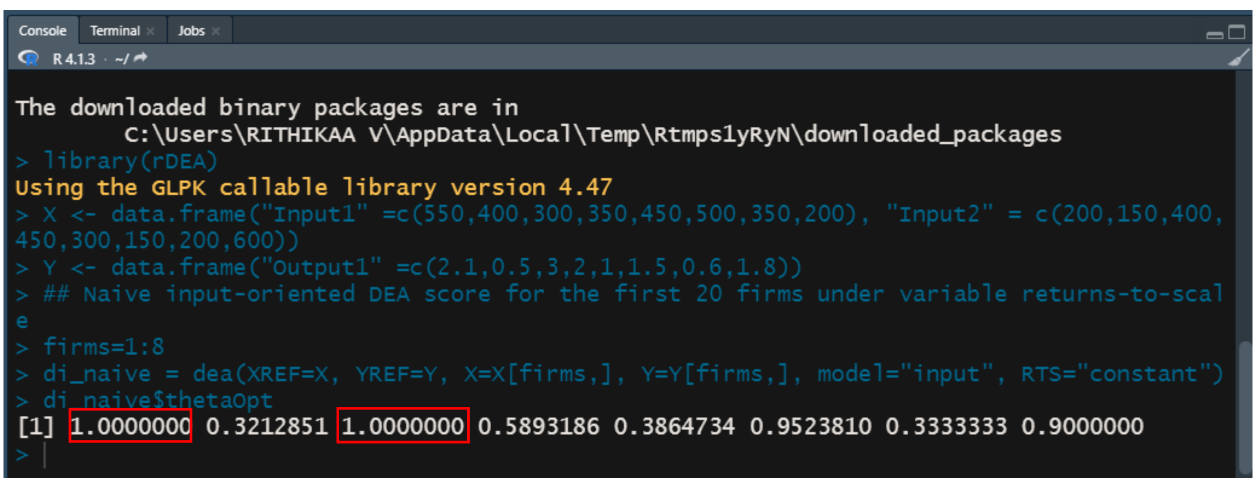


Figure 3 – Most efficient projects

d. In the given problem apart from the DEA methodology other theories can be applied. For instance, the same problem can have an output-oriented approach. In this case the input is the output is the estimated profit, CPU hours and the person days.

on the other hand, more input parameters can also be taken into consideration to arrive at more precise results. For instance, the financial resources invested, type of project, duration of the project, external factors influencing the profit such as competitors, risk or threat if any etc., can be included in the inputs. Further, instead of indicating the efficiency through the generated profit alone, it can be expressed as a measure of various other parameters such as growth of the company sue to the project or increase or decrease in the market share of the organization etc.

e. Every industry with any type of product will have basic parameters such as the finance invested, time spent and the number of people working in a particular project as the basis of any evaluation. On the other hand, the main output parameters would be the profit generated from the projects in the form of sales or services provided. Further, during the planning phase of any project the competitors, market size and risk factors are considered. To ensure that the projects from the various industries are comparable, the above-mentioned parameters should be evaluated in the preliminary stage. Further, it is important to study any similar projects and ask for expert opinion. Also, to make sure that the various projects are comparable, it is important to fix a particular analysis tool so that the results can be easily compared to derive meaningful insights.

Project 2

a. To find the monthly assignment plan for the factories, the optimal solution is defined as below. Using the sum function the sent and received quantities are defined. The total cost is defined using the SUMPRODUCT function.

	A	B	C	D	E	F
1						
2	Factory	Steel	Iron	Capacity		
3	1	200	500	2000		
4	2	800	400	1500		
5	3	500	1000	2500		
6	Demand	3200	1000			
7						
8	Optimal Solution					
9	Factory	Steel	Iron	Sent		
10	1			0		
11	2			0		
12	3			0		
13	Received	=SUM(B10:B12)				
14						
15	Cost	0				
16						

Figure 4 – Formulation of transportation matrix

A	B	C	D	E	F
Factory	Steel	Iron	Capacity		
1	200	500	2000		
2	800	400	1500		
3	500	1000	2500		
Demand	3200	1000			
Optimal Solution					
Factory	Steel	Iron	Sent		
1			0		
2			0		
3			0		
Received	0	=SUM(C10:C12)			
Cost	0				

Figure 5 – Calculating the Sent and Received Quantity

A	B	C	D	E	F
Factory	Steel	Iron	Capacity		
1	200	500	2000		
2	800	400	1500		
3	500	1000	2500		
Demand	3200	1000			
Optimal Solution					
Factory	Steel	Iron	Sent		
1			0		
2			0		
3			0		
Received	0	0			
Cost	=SUMPRODUCT(B3:C5,B10:C12)				

Figure 6 – Calculating the cost

Using the excel solver the total cost and the optimal assignment for each factory is identified.

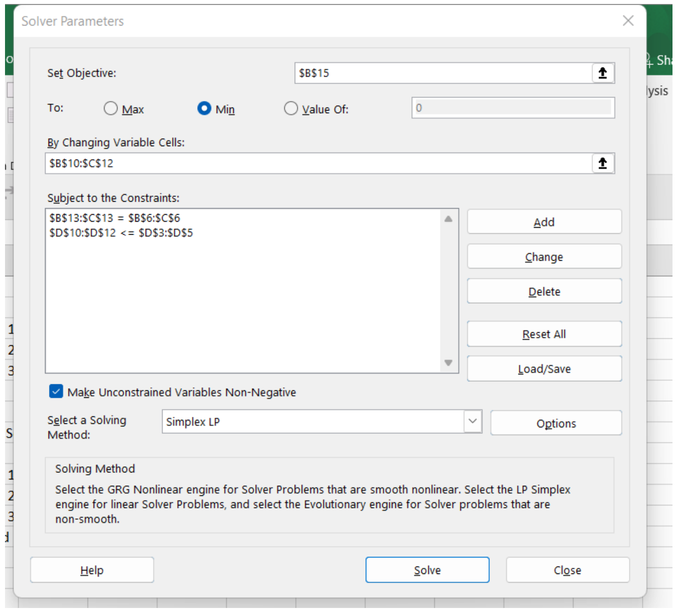


Figure 7 – Finding the optimal assignment using Solver

Solving this gives the below solution:

	A	B	C	D
2	Factory	Steel	Iron	Capacity
3	1	200	500	2000
4	2	800	400	1500
5	3	500	1000	2500
6	Demand	3200	1000	
7				
8	Optimal Solution			
9	Factory	Steel	Iron	Sent
10	1	2000	0	2000
11	2	0	1000	1000
12	3	1200	0	1200
13	Received	3200	1000	
14				
15	**Cost**	**1400000**		

Figure 8 - Solution

Hence, the factory 1 has to ship 2000 tons of steel, Factory 2 needs to ship 1000 tons of iron and factory 3 has to ship 1200 tons of steel to meet the demand with a minimal possible cost of GBP 1400000.

b. Eliminating the factory 3, the revised transportation matrix and the solver are shown below:

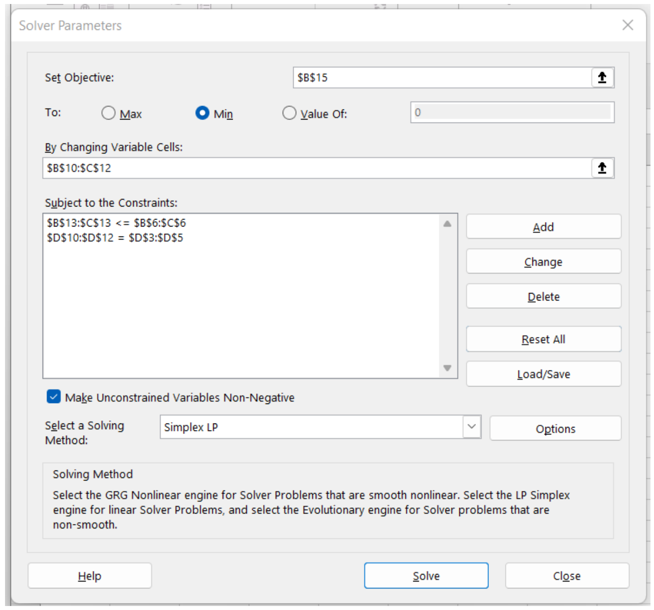
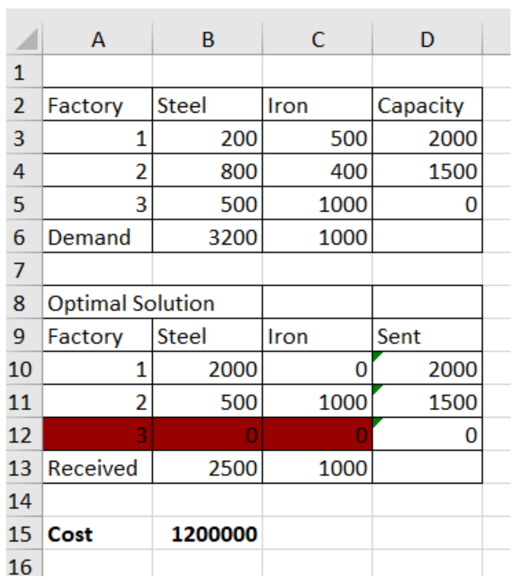


Figure 9 – Finding the optimal assignment using Solver



	A	B	C	D
1				
2	Factory	Steel	Iron	Capacity
3	1	200	500	2000
4	2	800	400	1500
5	3	500	1000	0
6	Demand	3200	1000	
7				
8	Optimal Solution			
9	Factory	Steel	Iron	Sent
10	1	2000	0	2000
11	2	500	1000	1500
12	3	0	0	0
13	Received	2500	1000	
14				
15	**Cost**	**1200000**		
16				

Figure 10 – Formulation of transportation matrix

After solving the matrix, there is still a shortage of steel (700 tons). This is because the total capacity of Factory 1 and Factory 2 is 3500 tons whereas the demand is 4200 tons. Since the Factory 1 has a cheaper price to ship steel compared to factory 2, the capacity of Factory 1 is increased by 700 tons as shown below:

	A	B	C	D
1				
2	Factory	Steel	Iron	Capacity
3	1	200	500	2000
4	2	800	400	1500
5	3	500	1000	0
6	Demand	3200	1000	
7				
8	Optimal Solution			
9	Factory	Steel	Iron	Sent
10	1	2700	0	2700
11	2	500	1000	1500
12	3	0	0	0
13	Received	3200	1000	
14				
15	**Cost**	**1340000**		
16				

Figure 11 - Solution

Hence, the total cost of shipping the demand is GBP 1340000.

c. With the given cost of raw materials for the factories, the new transportation matrix is as follows:

	A	B	C	D
1				
2	Factory	Steel	Iron	Capacity
3	1	250	600	2000
4	2	870	520	1500
5	3	545	1130	2500
6	Demand	3200	1000	
7				
8	Optimal Solution			
9	Factory	Steel	Iron	Sent
10	1			0
11	2			0
12	3			0
13	Received	0	0	
14				
15	**Cost**	**0**		
16				

Figure 12 – Formulation of transportation matrix

Using Solver to find the optimal assignment plan:

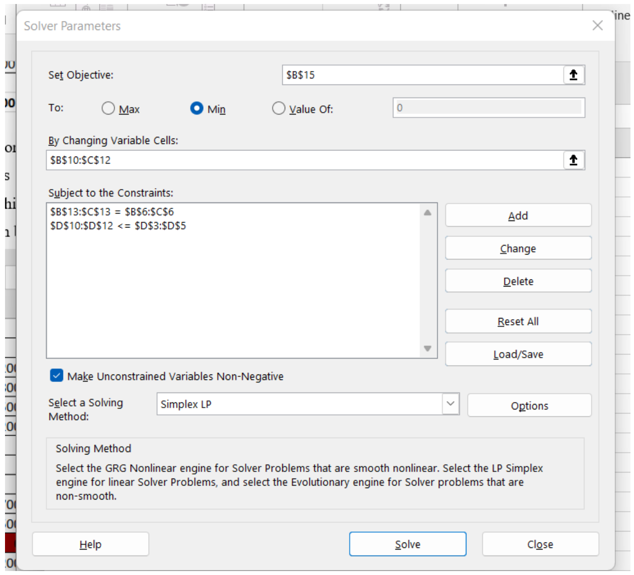


Figure 13 – Finding the optimal assignment using Solver

The new assignment plan is shown below and it is found to be similar to the previous assignment plan as in a. the base case, but with a slightly increased cost of GBP 1674000.

	A	B	C	D
1				
2	Factory	Steel	Iron	Capacity
3	1	250	600	2000
4	2	870	520	1500
5	3	545	1130	2500
6	Demand	3200	1000	
7				
8	Optimal Solution			
9	Factory	Steel	Iron	Sent
10	1	2000	0	2000
11	2	0	1000	1000
12	3	1200	0	1200
13	Received	3200	1000	
14				
15	**Cost**	**1674000**		
16				

Figure 14 - Solution

Project 3

a. To find the digital route for the client to reach maximum promotion, the shortest path algorithm needs to be applied using Excel Solver. All the nodes and their paths with the cost of investing is noted and the start and end node are marked (1 and 12).

Using the SUMIF function, the constraints are calculated as shown below:

Node	Constraints
1	=SUMIF($A$2:$A$30,F2,$D$2:$D$30)-SUMIF($B$2:$B$30,F2,$D$2:$D$30)
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	

The same formula is repeated for the remaining nodes.

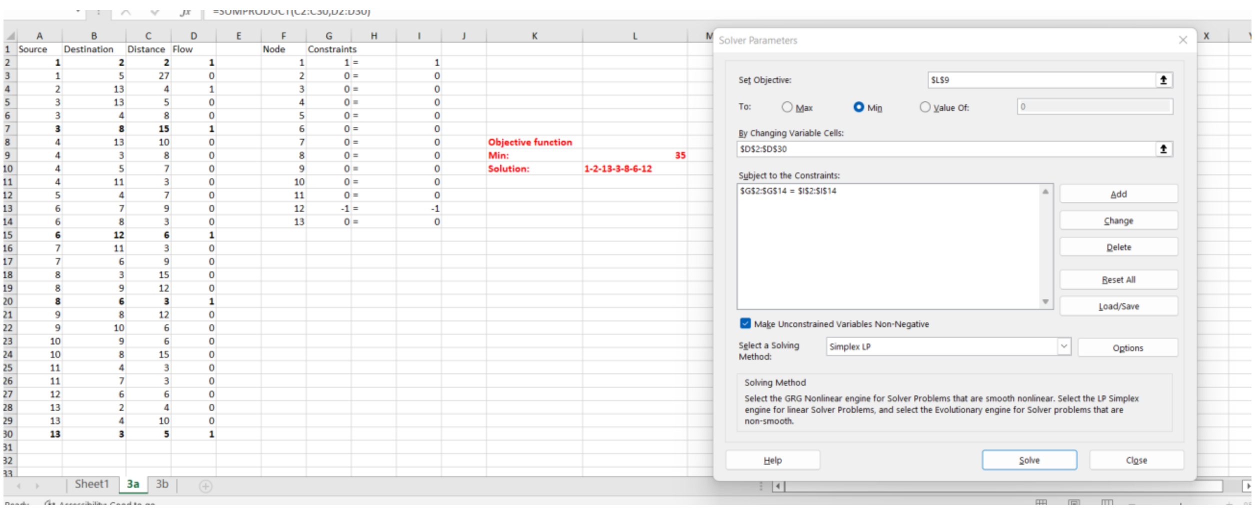
Node	Constraints		
1	1	=	1
2	0	=	0
3	0	=	0
4	0	=	0
5	0	=	0
6	0	=	0
7	0	=	0
8	0	=	0
9	0	=	0
10	0	=	0
11	0	=	0
12	-1	=	-1
13	0	=	0

Next to find out the route for the influencers, the path from node 1 to 12 needs to be in such a way that the sum of weights is minimum (so the cost is minimum as per the example). The objective function in this case is the sum of product of the distance and flow as shown below:

SUM =SUMPRODUCT(C2:C30,D2:D30)

	A	B	C	D	E	F	G	H	I	J	K	L
1	Source	Destination	Distance	Flow		Node	Constraints					
2	1	2	2			1	0	=	1			
3	1	5	27			2	0	=	0			
4	2	13	4			3	0	=	0			
5	3	13	5			4	0	=	0			
6	3	4	8			5	0	=	0			
7	3	8	15			6	0	=	0			
8	4	13	10			7	0	=	0		Objective function	
9	4	3	8			8	0	=	0		Min:	=SUMPRODUCT(C2:C30,D2:D30)
10	4	5	7			9	0	=	0			
11	4	11	3			10	0	=	0			
12	5	4	7			11	0	=	0			
13	6	7	9			12	0	=	-1			
14	6	8	3			13	0	=	0			
15	6	12	6									
16	7	11	3									
17	7	6	9									
18	8	3	15									
19	8	9	12									
20	8	6	3									
21	9	8	12									
22	9	10	6									
23	10	9	6									
24	10	8	15									
25	11	4	3									
26	11	7	3									
27	12	6	6									
28	13	2	4									
29	13	4	10									
30	13	3	5									
31												
32												

Using the excel solver the minimum possible weight with the Simplex LP method is identified as 35.



Hence the optimum path from influencer 1 to 12 with minimal cost is **1-2-13-3-8-6-12.**

b. To obtain the maximum profit for the same problem, the following assumptions are made:

1. Since there is no source, sink and the arrows, the initial node is assumed as 12.
2. It is desirable to do a project only once, that is each node can be visited only once.

Nodes	12	6	7	11	4	5	1	2	13	3	8	10	9	
Path	12-6(6)	6-7(9)	7-11(3)	11-4(3)	4-13(10)	5-1(27)	1-2(2)	2-13(4)	13-2(4)	3-13(5)	8-3(15)	10-9(6)	9-8(12)	
		6-8(3)	7-6(9)	11-7(3)	4-3(8)	5-4(7)	1-5(27)	2-1(2)	13-3(5)	3-4(8)	8-9(12)	10-8(15)	9-10(6)	
		6-12(6)			4-11(3)				13-4(10)	3-8(15)	8-10(15)			
					4-5(7)						8-6(3)			Total
PROFIT	6	9	3	3	7	27	2	4	5	15	15	6	12	**114**

Hence the optimum path to obtain the maximum results is 12-6-7-11-4-5-1-2-13-3-8-10-9 and it yields a total profit of 114 million.

c. Examples for shortest path algorithm:

1. Global Positioning Systems (Maps, Location Identifiers) – The shortest path algorithm has a major application in the field of location tracking and Mapping software such as Google Maps. To be precise, this algorithm is very useful for ambulances and fire fighting trucks to help them reach the location of fire or accident as quick as possible to save lives. Further, it can also be helpful to delivery services such as food delivery to ensure fast delivery and happy customers.
2. In aerospace applications, the shortest path algorithms can be used to set paths for satellite careers that are shortest to save fuel and hence reduce the payload.
3. Electrical transmission – In electrical transmission systems, the electricity is transmitted using wires through distribution grids. At pre calculated distance, there are transformers to step up or step down the voltages to help long distance transmission. However, there is significant transmission loss in this process and setting up of the transformers and their maintenance is a while different story. The shortest path algorithm can be applied here to ensure the shortest distance between electricity generation and reception. The grids or transformers can act as nodes and the distribution network can be designed in such a way to reduce the transmission losses as much as possible.

Examples for maximum flow algorithm:

1. Airline scheduling – Once an Airline starts its journey, it is vital to make sure that the journey is as long as possible with multiple stops from a business perspective. This is because from the airline point of view, the amount if financial resources invested is huge and having multiple stops will attract passengers from each of these stops. This help in time maintenance and ensures that the airplanes remain in the flight mode for maximum time as the money spent on a flying airplane and the one laying dormant in an airport has no big difference.
2. Sports – In games such as the Indian Premier League or other Football club league matched that involves many teams participating, it is important to ensure that each of the team gets an opportunity to play with every other team. In such cases, the maximum flow algorithm can be used to formulate the match table by considering each team as a node.

3. Goods delivery – The online delivery systems for e-commerce platforms such as Amazon or other parcel services have separate delivery team for every geographical location. The main aim of them is to ensure maximum delivery in a particular time. To achieve this, they could make use of the maximum flow algorithm to help them have a path that covers the maximum area.
4. Election Campaigns and other Public Movements – In public events such as strikes, election campaigns, the main aim of the organization would be to cover the maximum distance and visit every portion of the particular city or town considered. In such cases, they can use the maximum flow method to set up their journey in a such a way that they cover the maximum area.

References

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