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Mobile Phone Selection Problem Solved by an Unbalanced Assignment Model by using ROA-Method with Ghadle & Muley Rule in Mat Lab

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ABSTRACT

Assignment problem is one of the most important in the theory of optimization in operation research, in which a group of workers has to perform a set of task. The problem is to assign each worker to a distinct task so as to minimize the total cost. In this paper we discussed about an application of an unbalanced assignment problem by using revised ones assignment method with Ghadle and Muley rule in Matlab coding. Mobile phones are assigning one – to –one assignment for the required users at minimum cost.

KEYWORDS: *Assignment problem, revised one's assignment (ROA) method with Ghadle and Muley rule, Linear integer programing, Matlab coding*

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1. INTRODUCTION

We can't imagine our lives without a mobile phone now. We are addicted to them. Now a day's mobile phones are needed to everyone in our day to day life. And it gives us the freedom to communicate with anyone in anywhere and at any time. In this competitive technological world, a different verity of techniques and features are attracting peoples much more. The latest mobile phones are incorporated with features like MP3 players, high resolution camera, high sound quality, high GB memory space, and 3G/4G technology and the list goes on.

If an individual person wants to purchase a mobile phone, in market different verities of products and companies are available so anyone can be confused. And also each person needed different features. Consider that an individual person wants to purchase a mobile phone; the seller gives the latest model which cost approximately between Rs.1, 700 to Rs. 75,000. So the problem arises here because each person's requirements are different about their purpose of uses. To solve this problem here we considered three categories of users and recommended which mobile phone is suitable for their requirements.

By using an Assignment model to solve this mobile phone selection problem. An assignment problem is a complete degenerate form of transportation problem and it is a special type of linear programming problem (LPP). And also it is known as maximum bipartite matching problem, in which the objectives is to minimize the total cost of the mobile phone and also maximize the total features of the mobile phone. Mobile phone selection problem is in unbalanced form, where three types of users have to choose three mobile phones from 12 described mobile phones (see Table2).To solve this problem used by ROA method with Ghadle and Muley rule to find the optimal solution and verify the result by Matlab program.

2. Mathematical Construction for an assignment problem:

Let C_{ij} be the cost of assigning the i-th resource to the j-th task.

We define the cost matrix to be n x n matrix

C_{ij} =

	Job 1	Job 2	Job 3 …	Job j …	Job n
Worker 1	C_{11}	C_{12}	C_{13} …	C_{1j} …	C_{1n}
Worker 2	C_{21}	C_{22}	C_{23} …	C_{2j} …	C_{2n}
…					
Worker i	C_{i1}	C_{i2}	C_{i3} …	C_{ij} …	C_{in}
…					
Worker N	C_{n1}	C_{n2}	C_{n3} …	C_{nj} …	C_{nn}

An assignment is a set of 'n' entry positions in the cost matrix, no two of which lie in the same row or column. The sum of the n entries of an assignment is its cost. An assignment with the smallest possible cost is called an optimal assignment. The assignment problem can be written mathematically as:

MinimizeZ= $\sum_{j=1}^{n}\sum_{j=i}^{n} C_{IJ}x_{ij}$

Subject to $\sum_{i=1}^{n} x_{ij} = 1$

$$\sum_{j=1}^{n} x_{ij} = 1\,, \qquad x_{ij} \in [0,1]$$

$$x_{ij} = \begin{cases} 1; \textit{if the ith worker is assigned the jth job} \\ 0; \textit{otherwise} \end{cases}$$

Preliminaries:
Balance Assignment problem: The tasks are equal to the resources.
Unbalance Assignment problem: The tasks are does not equal to the resources.

3. Revised Ones Assignment Method (ROA) for Assignment Problem [2 3]

In ROA method, by dividing minimum element from each row and column to corresponding rows and columns we get at least one value in each rows and columns. Then find complete assignment in terms of ones. Now, in assignment matrix C_{IJ} is the cost or effectiveness of assigning i-th machine.

$$\begin{array}{c} \\ 1 \\ 2 \\ \vdots \\ n \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & \dots & n \end{array} \\ \begin{pmatrix} C_{11} & C_{12} & \cdots & C_{1n} \\ C_{21} & C_{22} & \cdots & C_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ C_{n1} & C_{n2} & \dots & C_{nn} \end{pmatrix} \end{array}$$

The new algorithm is as follows.

Let us consider an assignment problem in which the objective function can be minimized or maximized.

Step 1
In a minimization case, find the minimum element of each row (say a_i) and write it on the right hand side of the matrix.

$$\begin{array}{c} \begin{array}{cccc} 1 & 2 & \dots & n \end{array} \\ \begin{pmatrix} C_{11} & C_{12} & \cdots & C_{1n} \\ C_{21} & C_{22} & \cdots & C_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ C_{n1} & C_{n2} & \dots & C_{nn} \end{pmatrix} \end{array} \begin{array}{c} a_1 \\ a_2 \\ \vdots \\ a_n \end{array}$$

After dividing each element of i-th row of the matrix by a_i. We get at least one ones in each rows.

In term of one for each row and one for each column, do assignment. Otherwise go to step 2.

Step 2
Find the minimum element of each column (say b_j), and write it below jth column, by dividing each element of jth column of the matrix by b_j. We get at least one ones in each columns. This gives assignment matrix in terms of ones. If no feasible assignment can be achieved from step (1) and (2) then go to step 3.

$$\begin{array}{c} \\ 1 \\ 2 \\ \vdots \\ n \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & \dots & n \end{array} \\ \begin{pmatrix} C_{11}/a_1 & C_{12}/a_1 & \cdots & C_{1n}/a_1 \\ C_{21}/a_2 & C_{22}/a_2 & \cdots & C_{2n}/a_2 \\ \vdots & \vdots & \ddots & \vdots \\ C_{n1/a_n} & C_{n2/a_n} & \cdots & C_{nn/a_n} \end{pmatrix} \\ \begin{array}{cccc} b_1 & b_2 & \dots & b_n \end{array} \end{array}$$

Note: In a maximization case, the end of step 2 we have a fuzzy matrix. Which all elements are belong to [0, 1], and the greatest is one.

Step 3

To find optimality test draw the minimum number of lines which cover all the ones in the Assignment matrix. If the numbers of drawn lines are less than 'n', then optimality condition fails i.e. complete assignment is not possible. While optimality condition satisfied, if the number of lines is exactly equal to 'n', then the complete assignment is possible.

Step 4

If optimality condition fails in step 3, then select the smallest element (say d_{ij}) out of those which do not lie on any of the lines in the above matrix. By dividing the smallest element d_{ij} to each element of the uncovered rows or columns. This gives some new ones to this row or column.

If still optimality condition fails in this new matrix, then use step 4 and 3 iteratively. By repeating the same procedure the optimal assignment will be obtained.

Step 5 (Ghadle and Muley Rule)

For minimization problem select max value from calculated matrix and write it on right hand side as well as bottom side.

- To assign one, start from min value of columns (mentioned at bottom side) and select ones.
- If there are more than one ones in any column then ignore temporarily, and give last priority to that column.
- If still there are identical ones in column then give the priority to max value of rows (mentioned at right hand side).

Or Vice – Versa.

Remarks: In Unbalanced Assignment Problem, if there are more than one ones in any row then give priority to first element**.**

Priority rule

To solve Unbalanced Assignment Problem (nonsquare matrix), we convert it into Balanced Assignment Matrix form by adding artificial row or column, which having all elements one.

Hence we can solve the problem using ROA method. After performing the steps reduces to a matrix which has ones in each rows and columns. So, the optimal assignment has been reached.

4. APPLICAIONS:

Today uses of mobile phone can be compared with computer. Modern mobile phone has all the facilities that a computer had. Mobile phone usage is taking a lead to a computer that it is small in size, light in weight, and can operate within minimum power. It is handy in dialing, talking, making video film, e- mailing, sending pictures etc. so mobile phones to admitted people as per their requirements and features. In Currently our market sector had a lot of mobile phones are available with various brands and prices. So we need to choose which brand has maximum features with minimum cost. Let consider as per the requirement of features of mobile phone users we divide into three categories, like Basic mobile phone users, Smart phone users, iPhone users.

Users Requirements:

As per the user's requirements, the results are as follows.

1. Basic mobile phone users:

School students and senior citizens have used their mobile phones for their basic requirements such as dialing and taking calls, texting messages.

2. Smart phone users:

A smart phone is to do more then make to call and text messages. Smart phones are loaded with features and capabilities that make them more than a phone. Smart phones are used to browse internet, taking photos, making videos, and also playing games in offline and online mode and so on. Now a day's many smart phones are rising due to its advanced technical development in science. Most smart phone users are college students and educationalist.

3. iPhone users:

iPhone is a smart phone that can do many things over the smart phone. iPhone users are professionals and business peoples. Because their needs of requirements are as per the smart phone users with most advanced level. And also I phone have the following extra features except smart phones, they have very high resolution camera, i-cloud and Face time and.

To handle this situation there are several credit points under consideration, firstly consider the competencies necessary to develop the users. Obviously some competencies only need the basic features like dialing and texting. But some group of competencies need high sound quality, high storage space, latest technologies, high resolution camera, and also a fantastic look and list go on. Moreover, usually the users are not independent; therefore a relationship among them could appear. Finally, all particular with credit points are shown in table 1 as per their necessary requirements.

Particulars	Credit points
Essential	5
Fairly high	4
High	3
Moderate	2
Low	1
Fairly low	0

Table 1

	Users / Particulars	Basic mobile phone users	Smart phone Users	iPhone users
Dialing	Yes	5	5	5
Text messaging	Yes	5	5	5
Radio	Yes	5	5	5
RAM / ROM(Internal)	8 MB	4	0	0
	6 GB/128GB	0	4	0
	4 GB/128GB	0	0	0
	4 GB/64 GB	0	3	0
	2 GB/16 GB	0	0	0
	3 GB/32 GB	0	0	0
	6 GB/64 GB	0	5	0
	2 GB/32 GB	0	0	4
	256 GB	0	0	5
Storage (External)	32 GB	4	0	0
	512 GB	0	4	0
	128 GB	0	3	0
	256 GB	0	0	5
	250 GB	0	0	0
	2 TB	0	5	0
OS	Series 30	5	0	0
	Android 9.0	0	4	0
	Android 8.0	0	3	0
	Android 7.1	0	2	0
	iOs10	0	0	5
	iOs12	0	0	5
Processor	Octa core	0	4	0
	Snapdragon	0	5	0
	Deca core	0	0	0
	Media tek	0	0	0
	Cortex A53	0	0	0
	A10	0	0	5
	A12	0	0	5
Sound	Vibration, MP3, Ring	0	5	0
	Vibration, Ring	4	4	5
USB	Yes	5	5	5
Battery(mAh)	3200	0	3	0
	3400	0	2	0
	4020	0	0	0
	1960	0	0	4
	2942	0	0	5
	4000	0	4	0
	3000	0	5	0
	1020	5	0	0

Camera rear/front	No	5	0	0
	12+5mp/16mp	0	4	0
	12+5mp/25mp	0	3	0
	48+5mp/16mp	0	5	0
	12mp/7mp	0	0	5
	13+5mp/13mp	0	0	0
	8mp/15mp	0	0	0
	13mp/8mp	0	0	0
Video	1920x1080@30sps	0	5	4
	3840x2160@30sps	0	4	5
	1080@30sps	0	3	4
	1280x720@30sps	0	4	5
Sensors	Yes	5	5	5
Sim card	Dual	5	4	4
	Dual Nano	0	5	5
	Nano	0	3	5
Network	GSM	5	0	0
	2G/3G/4G	0	5	5
Games	Yes	5	5	5

Once the users involved in the selection procedure have been determined, the mobile phones must next to considered. Let it be imagined that there are 12 mobile phones (see table 2) that might be able to select for different users.

Mobile phone	**Name**
Mobile phone1	M1
Mobile phone2	M2
Mobile phone3	M3
…	…
Mobile phone12	M12

Table 2: [1]

Brands Features	Nokia 130	Samsung Galaxy A70	Huawei Y9 prime	Lenovo K8 Note
Dialing	Yes	Yes	Yes	Yes
Text messaging	Yes	Yes	Yes	Yes
Radio	Yes	Yes	Yes	Yes
RAM (Internal)/ ROM	8MB/-	6 GB/ 128GB	4GB/ 128GB	4GB/64B
Storage (External)	32 GB	512 GB	512 GB	128GB
OS	Series 30	Android 9.0	Android 9.0	Android 7.1
Processor	-	Snap dragon	Octa core	Deca-core
Sound	Vibration	Vibration,MP3,ring	Vibration,MP3, ring	Vibration,MP3, ring
USB	Yes	Yes	Yes	Yes
Battery(mAh)	1020	4500	4000	4000
Camera rear/front	No	32+8 mp/32mp	16+6mp/16mp	13+5mp/13mp
Video	No	3840x 2160 @30 FP	1080p@ 30fps	1920x1080@30fps
Sensors	No	Yes	Yes	Yes
Sim card	Dual	Dual nano	Dual nano	Dual nano
Network	Gsm	2G/3G/ 4G	2G/3G/4G	2G/3G/4G
Games	Yes	Yes	Yes	Yes
Rs	**1699**	**28990**	**15900**	**9999**
Code No	M1	M2	M3	M4

Brands Features	Lava Z61	Xiaomi Redmi 7A	LG Q7	Motorola G 6 plus
Dialing	Yes	Yes	Yes	Yes
Text messaging	Yes	Yes	Yes	Yes
Radio	Yes	Yes	Yes	Yes
RAM /ROM (Internal)	2GB/ 16GB	2GB/ 16GB	3GB/ 32GB	6GB / 64GB
Storage (External)	32GB	256GB	2TB	256GB
OS	Androidv 8.1	Android 9.0	Androidv 8.0	Android 9.0
Processor	Cortex A53	Octa core	Media tek	Octa core
Sound	Vibration, MP3, ring	Vibration,MP3, ring	Vibration,MP3, ring	Vibration,MP3,ring
USB	Yes	Yes	Yes	Yes
Battery(mAh)	3000	4000	3000	3200
Camera rear/front	8mp/ 15mp	12mp/5mp	13mp/8mp	12+5mp/16mp
Video	1080p@ 30fps	1920x1080@30fps, 1280x720@30fps	1080p@ 30fps	1920x 1080 @ 30fps
Sensors	Yes	Yes	Yes	Yes
Sim card	Dual , nano	Dual nano	Dual nano	Dual nano
Network	2G/3G/4G	2G/3G/4G	2G/3G/4G	2G/3G/4G
Games	Yes	Yes	Yes	Yes
Rs	**5099**	**6399**	**12990**	**11999**
Code No	M5	M6	M7	M8

Brands Features	Vivo/Model V11 pro	Oppo F11	Apple I phone 7	Apple I phone XR
Dialing	Yes	Yes	Yes	Yes
Text messaging	Yes	Yes	Yes	Yes
Radio	Yes	Yes	Yes	Yes
RAM /ROM (Internal)	6GB/ 64GB	4GB/ 128GB	2GB/ 32GB	256GB
Storage (External)	256GB	250GB	No	No
OS	Android 8.1	Android 9.0	iOS 10	iOS 12
Processor	Snapdrgon660	Octa core	A10	A12
Sound	Vibration,MP3,ring	Vibration,MP3,ring	Vibration, ring	Vibration, ring
USB	Yes	Yes	Yes	Yes
Battery(mAh)	3400	4020	1960	2942
Camera rear/front	12+5mp/ 25mp	48+5mp/ 16mp	12mp/7mp	12mp/7mp
Video	2160p@ 30fps, 1080p@ 30fps	1920x 1080@30fps	4k@30fps, 1080p@30fps or 60fps	3840x2160@60fps, 1920x1080@240fps, 1280x720@30fps
Sensors	Yes	Yes	Yes	Yes
Sim card	Dual nano	Dual nano	Nano	Dual nano
Network	2G/3G/4G/Volte	2G/3G/4G	2G/3G/4G	2G/3G/4G
Games	Yes	Yes	Yes	Yes
Rs	**23990**	**16990**	**36490**	**74890**
Code No	M9	M10	MP11	MP12

For each one it is necessary to find out by some appropriate, means the levels in each of the particular required for the users. Finally as there are links between the users and mobile phones (using table 1 credit pints in table 3) must be looked at in order to find out the relationships that there would be among them, as shown in table 2.

Table 2:

Code No / Users	MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9	MP10	MP11	MP12
Basic mobile phone users	28	19	24	24	19	24	19	24	19	19	15	20
Smart phone users	60	69	63	64	61	60	67	59	63	67	68	63
iPhone users	58	64	48	53	55	62	52	47	49	59	78	83

Matlab program:

```
clc
tic;
x= [28 19 24 24 19 24 19 24 19 19 15 20
 60 69 63 64 61 60 67 59 63 67 68 63
 58 64 48 53 55 62 52 47 49 59 78 83]
% matrix x is copied in xnv and x1 variable
xnv=x;
x1=x;
% calculating each row minimum no.
maxr= nnmaxr(x)
% find row and column no
[r c]=size(x)
% dividing each element of row
for i=1:r
for j=1:c
x(i,j)=x(i,j)/maxr(i);
end
end
x
y=x;
for i=1:r
for j=1:c
if x(i,j)<1
x(i,j)=0;
end
end
end
x
l=1;
for i=1:r
for j=1:c
[xr xc]= find(x==l,'1');
k1=length(xr);
for m=1:k1
x(xr(m),xc(m))=1;
if x(xr(m),j)~= x(xr(m),xc(m))
x(xr(m),j)=0;
end
end
end
end
x;
z=xnv.*x
toc;
```

An Unbalance assignment problem is solved by using ROA method with Ghadle and Muley rule and Matlab programming. This gives optimal solution as:

Users	**Mobile phone**
Basic Mobile phone users	M1
Smartphone users	M2
iPhone users	M12

5. CONCLUSIONS:

This research article proposes an application of an unbalanced assignment problem. To select the appropriate mobile phone as per the users requirements. The given problem converted into assignment method and solved by using ROA method with Ghadle and Muley rule in Matlab coding. And it which gives the optimal solution.

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