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Research Article

MODELING HUMAN RESOURCE ALLOCATION TO MULTIPLE PROJECTS USING GOAL PROGRAMMING APPROACH

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ABSTRACT
Decision making about resource allocation is a problem that we face every day, resource allocation is a multi-criteria decision making problem and goal programming is a common technique for solving resource allocation problems with multiple objectives. This paper deals with the problem of human resource allocation to multiple software development projects in order to fill the voids in this area simultaneously, with two measures of cost minimization and response time. The methodology chosen for this programming is cascade and model human resources using goal programming so that minimum human resources requirements are met at every phase of the projects and sum of weighted deviations is minimized from goal values of wage costs and project completion time. GAMS software is used to solve the model and its results are analyzed and it suggests that human resource planning in several projects simultaneously is very effective in minimizing the costs of company both in terms of completion time and amount of wage, and modeling using goal programming allows programmer to prioritize completion time or wage cost of human resources if it is necessary.

Keywords: *Human Resource Allocation, Modeling, Multiple Projects, Goal Programming Cascade Methodology*

INTRODUCTION
One of the most frequently used operations research branches is allocation problem. Wherever there is need to allocate limited resources to a set of activities or teams so that different combinations lead to maximum efficiency, we can use operations research approach resource allocation issues (Taha, 1987). A variety of programming techniques, project scheduling under resource limitations are provided, implemented and evaluated during the last two decades (Diranlu, 2006). But the problem of single project scheduling is more addressed and problem of scheduling multiple projects is less focused (Kargar and Kheyrkhah, 2009). Multiple projects include a group of related projects which consist of several implementation phases and these phases can also be prerequisite and sometimes co requisite and resource allocation is done in proportion to phase implementation time, these projects are managed in coordinated way in order to obtain benefits and control that are not available in their individual management.
Since the advent of business computers in mid-twentieth century, advances in Information Systems has changed our world in a way that is totally dependent on information systems in many respects. Therefore, the success of any organization depends on the success of information systems projects that is an example of multiple projects, so better use of this knowledge is the main motivation of knowledge management in software engineering which requires deeper analysis (Curtis *et al.*, 1998). For this purpose, organizations must own information systems projects and success of these projects depends on effective involvement of people who are in charge of professional and business tasks of information systems in organizations. They participate in production of a successful software product of a team, regardless of its size and dimensions and the team can never be successful without having a common work culture that is the same production process. A successful team can consist of system analyst, Requirements Specifier, Requirements Reviewer, Software Architect, Integrator, Implementer, test manager, test analysts, test designer, tester, configuration manager, Change Control Manger, technical writer, Deployment Manager, Project Manager.
Software development process that is known as "software development lifecycle," is a structure that is applied on development and production of software products. With the enlargement of software projects

and development of software engineering, organized methods were developed for software development that each of them are applicable in a particular place depending on the project and its limitations. Software development methods include: cascade model, incremental approach, RAD method, prototyping method, spiral method, concurrent development method. There are other methods in addition to listed models. Each of them can be used in its place. However, these models are the most common methods that are used. For example, the cascade model is the first software engineering methods and sometimes is called the traditional method. Each engineering method usually involves six main processes including: requirements analysis (needs analysis - feasibility), software design, System Implementation, System Testing, System Integration, system maintenance. Six processes are expressed in the simplest form in cascade method, so that, each phase of overall process is done and then the next phase begins. This method is used in projects where first phase is analysis that is recognized by software engineer who is responsible for analysis and designer knows system requirements and will begin the design of system architecture in the next phase. Although, every step has the option to return to the previous step, but this return will cost much to software team, because any change in the previous step will results in project restart from the next phase (Prsmn, 2008).

The most common technique for resource allocation to multiple projects is goal programming. Goal programming is a multi-criteria decision-making model in the field of linear algebra; this model constitutes simultaneously multi objectives and is set based on the minimization of deviation from objectives (Khalili and Suri, 2002; Yadollahi, 2002). The main art of goal programming is to consider limitations and goals with regard to decision variables and also eliminate the weak human reasoning in planning and decision-making. This art will have special effects when we seek to improve simultaneously multi factors. The mathematical model must distinguish between two items of objective and goal, objective is presented in the form of a function that must be maximized or minimized but goal represents the ideal amount for value of a function. In goal programming, each goal will be provided using an ideal limitation and thus we can consider several different goals in a model. In goal programming, a numeric and determined amount is considered for any given goal limitation. The problem is modeled in such a way that sum of weight deviation from these values is minimized with respect to goal. The study tries to express innovation in order to respond the lack of human resource allocation model for software development projects.

Importance of Subject

In today's competitive world, the need for reducing the cost and project time is felt more, for this purpose, programming becomes important, sometimes the importance of both factors of cost and time is identical for programmer, and sometimes the make prioritization for minimization. Consequently, the need for review in this area is felt, especially, in multi-phase projects in software development methodology, this gap is obvious in the area of human resource planning, human resources are the most important sources of these projects and are valuable assets of their organizations. Considering the number of projects and their human resources sharing, it is important to allocate human resources to projects so that human resource needed for each phase is met in addition to prioritize cost or time minimization.

Research Literature on Human Resource Allocation

The issue of resource allocation to a project is proposed by many people and several innovative methods are proposed. However, allocation of human resources has been less considered less in literature and limited number of articles is provided in this field.

In 2004, Caballero et al offered a methodology as a guide mechanism for resources allocation and management of university financial resources with the aim of efficiency that specifically estimated staff policy planning model within university, in this model, two techniques of Data Envelopment Analysis and multi-criteria decision that both techniques have the possibility of transferring information from one to other (Caballero *et al.,* 2004).

At 2007, Saaty and colleagues reported that one of the amazing things is that people in organizations make complex decisions to allocate money to project and prioritize the allocation of public resources. Another factor in optimizing resource allocation is the efficiency of investment in employment. They

clarify the use of multiple prioritization criteria for allocation of resources and allocation of human resources especially. They emphasize on measurement of intangible criteria and their incorporation into Analytical Hierarchy Process and linear programming with the best combination to assign people to related jobs (Saaty *et al.,* 2007).
In 2009, Wang and Chen examined a business model of capacity planning and resource allocation that is composed of two profit-driven factories.

This research proposal is to solve a set of nonlinear mixed integer programming, Ant Colony Algorithm. The proposed method allows the resources capacity program to allocate cost to set of client tasks by two parties with private information regarding company objectives (Wang and Chen, 2009).

In 2011, Bi with his colleagues adopted an organization in which various production units had parallel production lines, resource allocation and target setting is a common problem in organization, the method that they intended to solve this problem was Data Envelopment Analysis non- parametric method (Bi *et al.,* 2011).

But in 2012, more people work in this field as follows:

Evelina *et al.,* stated that stakeholders and decision makers often suggests views and perspectives related to ideal as a response to complex social problems, and accordingly design activities.

Nevertheless, the performers (actors) sometimes have limited understanding whether their attitudes are practical and possible or not, what activity is required and what are the potential consequences.

They have presented a method in order to connect attitudes to resource allocation scenario which represents different options and strategies for implementation of views, and then they do multi criteria evaluation of results in order to find optimal, desirable and acceptable performance ways.

As a result, stakeholders and decision-makers acquire knowledge about attitudes and even they may re-think before decision making.

Therefore, this method accompanies impractical and hypothetical targets and samples to analytical data that provides a new approach using quantitative techniques in weak framework (Evelina *et al.,* 2012).

Ballesteros and colleagues point to new application of psychological key concepts in the field of Sociometry in order to select workers of organizations that implement a project.

The project manager can use a new method in order to determine who shall be selected from among those available and how they will be simultaneously distributed in one or more groups/ projects to obtain the highest possible performance in terms of group interaction (Ballesteros *et al.,* 2012).

History of Mathematical Models on Human Resource Planning

Modeling is a regular tool that can provide the necessary information for decisions in formulation and allocation of resources, in order to achieve aims.

Planners can examine systematically some relationships between variables using models. It is not simply possible the relationships that understanding them without model are possible.

We expect a model to provide our planning demands. Some of these demands include: the ability to predict flexibility, performance evaluation capability, optimal resource allocation, compatibility between applications and its application simplicity (Azar, 1996; Yadollahi, 2002).

A summary of what was reviewed in mathematical models of human resource planning is given in Table 1. The first column references, the second to fourth columns, inputs, outputs, and limitations, respectively.

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Table 1: Reviewed proceedings in the case of mathematical models application in human resource planning

Limitation	output / decisions variables	input / parameter	References
(i) No limitation (ii) unit limitations (iii) multiple limitations (iv) Both limitations	Allocation matrix dimensions M(d, p, h, v):	d - Number of working days in a month P - period h- Department of Health v- The number of vacancies in a period Si = {s1, s2, . . . , sn5}	CiceroFerreira Fernandes Costa Filho, Dayse Aparecida Rivera Rocha, MarlyGuimaraes FernandesCosta, Wagner Coelho de Albuquerque Pereira.(2012)
- Wage limitation - Limit in the number of people in each position	Xi : Applicants	B –beneficiary score C - cost	Thomas L. Saaty, Kirti Peniwati,JenS.Shang(2007)
- Limit in the number of sellers - Each vendor belongs only to a store	Xij: 1: If seller j belongs to regin i 0: Otherwise	n-total seller areas M - total sellers cij –cost of area i with seller pij - income of area i with seller j	Chi-Ming Lin, Mitsuo Gen. (2008)
- Every person for a work - Any work for a person	Xij: 1: Allocating Ai to do Bj work 0: Otherwise	Cij- Time of person i to do work j	MaXian-ying. (2012)
  - Every person for a work - All posts are filled by people	Xij: 1:Decision variable is binary If worker j is allocated to work i 0: otherwise	N- total number of jobs Mi- total number of workers that can be allocated to i Cij - Cost when workers i allocate to work j eij- productivity when worker j is allocated to work i	Yun-ChiaLiang, Chia-YinChuang.(2013)

The brief overview of mathematical models structure that is expressed in articles is presented in Table 2. The first column includes references; second to fifth columns include nature of objective function, single or multi-objective, having solution or not, the innovative or exact solution and limited or non- limited resources.

Table 2: A review of mathematical model structures in the case of using mathematical models in human resource planning

Limited or non- limited resources?	Exact or innovative solutions?	Solution or no solution?	Single- or multi-objective	Objective function nature	References
LR	HE	Yes	SO	C	CiceroFerreira Fernandes CostaFilho, Dayse Aparecida Rivera Rocha, MarlyGuimaraes FernandesCosta, WagnerCoelho de Albuquerque Pereira (2012)
LR	EX	Yes	SO	P	Thomas L. Saaty, Kirti Peniwati, Jen (2007)
LR	-	No	MO	P,C	Chi-Ming and Mitsuo (2008)
LR	-	No	SO	Z	MaXian-ying (2012)
LR	HE	Yes	MO	E_{ij},C_{ij}	Yun-ChiaLiang and Chia-YinChuang (2012)
LR	EX	Yes	SO	C	Our work

Abbreviations: In second column, C cost function, P profit function, Z least time of allocation, Eij productivity and Cij cost
In third column, SO single objective, MO multi objective
In fourth column, HE innovative solution, EX exact solution
In fifth column, LR limited resources

Research purposes

-Human resource planning in order to reduce wage costs
-Human resource planning in order to reduce the project time
-Human resource planning for multiple projects simultaneously in order to reduce the cost and time
- Modeling human resource allocation with priority of minimizing cost or time
-Modeling human resource allocation to several software development projects

Problem hypotheses

The main hypotheses are as follows:
- Projects are independent of each other.
- All groups are involved in all projects.
- The decision variables are integer.
- The development methodology of this company is cascade.
- The number of human resources in each group is limited.
- The minimum work time for each group is known in order to complete the entire project.
- The work time per person is known for each group of any phases of project.
- Human resource wage of each group is known per person of each project.
- The goal amount of human resource wage for project completion is known.

- The goal amount of project completion time is known.

MATERIALS AND METHODS

Method

This research is scientific - survey.

Statement of Problem

Human resource balancing for multiple projects (software development projects with cascade methodology) with goal programming approach is so that the minimum human resource requirements are met at every phase of project and sum of weight deviations is subtracted from human resource wage value and project completion time is minimized with respect to their goal values. If human resource costs are more than F (goal), for each unit of extra cost, M unit fine will be awarded, also it is similar for project completion, so that if project completion time is greater than L (goal), for each unit of extra time (hour, day, or ...) N unit fine will be awarded. The cascade methodology consists of six phases; each phase consists of several working groups. Table 3 shows phases and groups.

Table 3: Shows Bi, $C_{i,j}$,$T_{i,j}$, Pi values

Phase			**j**		**1**	**...**		**N**	**Min**
		i	**P_i**	**$T_{i,j}$**	**$C_{i,j}$**	**...**	**$T_{i,j}$**	**$C_{i,j}$**	**B_i**
Requirements analysis	Requirements analysis	1	P_1	$T_{1,1}$	$C_{1,1}$	...	$T_{1,n}$	$C_{1,n}$	B_1
	Descriptor of requirements	2	P_2	$T_{2,1}$	$C_{2,1}$	...	$T_{2,n}$	$C_{2,n}$	B_2
	Requirements Reviewer	3	P_3	$T_{3,1}$	$C_{3,1}$	...	$T_{3,n}$	$C_{3,n}$	B_3
	Project Manager	4	P_4	$T_{4,1}$	$C_{4,1}$	...	$T_{4,n}$	$C_{4,n}$	B_4
Software Design	Software Architect	5	P_5	$T_{5,1}$	$C_{5,1}$	...	$T_{5,n}$	$C_{5,n}$	B_5
	Designer	6	P_6	$T_{6,1}$	$C_{6,1}$	...	$T_{6,n}$	$C_{6,n}$	B_6
	Database designer	7	P_7	$T_{7,1}$	$C_{7,1}$	...	$T_{7,n}$	$C_{7,n}$	B_7
	Test Designer	8	P_8	$T_{8,1}$	$C_{8,1}$	...	$T_{8,n}$	$C_{8,n}$	B_8
	Project Manager	9	P_9	$T_{9,1}$	$C_{9,1}$	...	$T_{9,n}$	$C_{9,n}$	B_9
Implementation	Software Architect	10	P_{10}	$T_{10,1}$	$C_{10,1}$	...	$T_{10,n}$	$C_{10,n}$	B_{10}
	Implementer	11	P_{11}	$T_{11,1}$	$C_{11,1}$	...	$T_{11,n}$	$C_{11,n}$	B_{11}
	Technical browser	12	P_{12}	$T_{12,1}$	$C_{12,1}$	...	$T_{12,n}$	$C_{12,n}$	B_{12}
	Integrator	13	P_{13}	$T_{13,1}$	$C_{13,1}$	...	$T_{13,n}$	$C_{13,n}$	B_{13}
	Project Manager	14	P_{14}	$T_{14,1}$	$C_{14,1}$	...	$T_{14,n}$	$C_{14,n}$	B_{14}
System Testing	Test Manager	15	P_{15}	$T_{15,1}$	$C_{15,1}$	...	$T_{15,n}$	$C_{15,n}$	B_{15}
	Test Analyst	16	P_{16}	$T_{16,1}$	$C_{16,1}$	...	$T_{16,n}$	$C_{16,n}$	B_{16}
	Test Designer	17	P_{17}	$T_{17,1}$	$C_{17,1}$	...	$T_{17,n}$	$C_{17,n}$	B_{17}
	Tester	18	P_{18}	$T_{18,1}$	$C_{18,1}$	...	$T_{18,n}$	$C_{18,n}$	B_{18}
	Project Manager	19	P_{19}	$T_{19,1}$	$C_{19,1}$	...	$T_{19,n}$	$C_{19,n}$	B_{19}
System Integration	Deployment Manager	20	P_{20}	$T_{20,1}$	$C_{20,1}$	...	$T_{20,n}$	$C_{20,n}$	B_{20}
	Configuration Manager	21	P_{21}	$T_{21,1}$	$C_{21,1}$	...	$T_{21,n}$	$C_{21,n}$	B_{21}
	Technical Writer	22	P_{22}	$T_{22,1}$	$C_{22,1}$	...	$T_{22,n}$	$C_{22,n}$	B_{22}
	Implementer	23	P_{23}	$T_{23,1}$	$C_{23,1}$	...	$T_{23,n}$	$C_{23,n}$	B_{23}
	Project Manager	24	P_{24}	$T_{24,1}$	$C_{24,1}$	...	$T_{24,n}$	$C_{24,n}$	B_{24}
System Maintenance	Systems analyst	25	P_{25}	$T_{25,1}$	$C_{25,1}$	...	$T_{25,n}$	$C_{25,n}$	B_{25}
	Programmer	26	P_{26}	$T_{26,1}$	$C_{26,1}$	...	$T_{26,n}$	$C_{26,n}$	B_{26}
	Project Manager	27	P_{27}	$T_{27,1}$	$C_{27,1}$	...	$T_{27,n}$	$C_{27,n}$	B_{27}

Indices and parameters:
Number of Pi i
A positive integer n is the total number of projects
Ci, jj i amount paid per person in group projects
At the time i work group for the project n Bi
Zmankary value of i for each individual project Ti, j
Goal amount of wage labor costs F
Goal amount of time to finish projects L
The additional charge of Y1
The amount of extra time Y2
The amount of money per unit fined an additional charge of M
The amount of money per unit of excess N fines
The decision variables of the problem:
Number of human resources that are allocated from i to j Project Xi, j

i	1,2,…,27	Indexes of each group
j	1,2,…,n	Indexes of each project
k	1,2	The extra and deficiency indices
P_i		Members of group i
n		A positive number for total number of projects
$C_{i,j}$		Wage of group i per each member in project j
B_i		The minimum work time of group i for doing n projects
$T_{i,j}$		Work time of group i per each member in project j
F		Goal amount of labor wage
L		Goal amount of time to finish projects
Y_1		Extra cost value
Y_2		Extra time value
M		The amount of fines money per unit extra cost
N		The amount of fines money per unit extra time

The decision variables of problem:
Number of human resources that are allocated to project j from group i $X_{i,j}$
Model expression

$$\text{Min } Z = M * Y_1^{+} + N * Y_2^{+} \quad (1)$$

S.t.

$$X_{i,j} \leq P_i \quad \forall\ i=1,\dots,27 \quad , \quad j = 1,\dots,n \quad (2)$$

$$\sum_{j=1}^{n} T_{i,j} * X_{i,j} \geq B_i \quad \forall\ i=1,\dots,27 \quad (3)$$

$$X_{i,j} \geq 1 \quad \forall\ i=1,\dots,27 \quad , \quad j = 1,\dots,n \quad (4)$$

$$\sum_{j=1}^{n} C_{i,j} * X_{i,j} - (Y_1 -^{+} Y_1^{-}) = F \quad \forall\ i=1,\dots,27 \quad (5)$$

$$\sum_{j=1}^{n} T_{i,j} * X_{i,j} - (Y_2 -^{+} Y_2^{-}) = B \quad \forall\ i=1,\dots,27 \quad (6)$$

$$Y_k^{+} \geq 0 \quad k = 1,2 \quad (7)$$

$$Y_k^{-} \geq 0 \quad k = 1,2 \quad (8)$$

Equation (1) shows the final objective function; this function is related to minimization of fines amount and is resulted from difference between project completion time and wage of human resources and their goal amounts. Equation (2) is limitation on number of human resources in each group. Equation (3)

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shows limitations on the minimum completion time of project. At least one person from each group is involved in each project that is shown in Equation (4).

Equation (5) shows limitations of cost goal amount and Equation (6) shows limitations of time goal amount. Equations (7) and (8) state that difference between project completion time and human resources wages and their goal amounts must be positive or zero.

The Sample

A software development methodology company has accepted to carry out three projects. The number of members of each group in company is limited and according to the needs of each project, number of people is assigned to project. Software development methodology of company is cascade and company's structure is shown in Table 4.

This company has considered 3,700 hours to complete three projects and has estimated 120 million Tuman for wages of personnel in projects. If it cannot finish the project on time, it will be fined 50,000 Tuman per extra hour work and if the amount of human resource estimated wage is increased it will be fined per 1 Tuman extra.

In Table 4, i is group indexes, j is project index, Pi is number of group I members, Ti,j is the work time of group i per each member in project j, Ci,j is the wage of group i per each member in project j and Bi is the least work time of group i for implementing n project.

Table 4: Shows Pi, $T_{i,j}$, $C_{i,j}$, Bi values

Phase			j	1		2		3		Min
		i	P_i	$T_{i,1}$	$C_{i,1}$	$T_{i,2}$	$C_{i,2}$	$T_{i,3}$	$C_{i,3}$	B_i
Requirements analysis	Requirements analysis	1	10	20	600000	40	1200000	10	300000	130
	Descriptor of requirements	2	5	10	300000	20	600000	5	150000	50
	Requirements Reviewer	3	5	10	300000	20	600000	5	150000	70
	Project Manager	4	3	4	800000	8	1600000	2	400000	20
Software Design	Software Architect	5	10	40	800000	80	1600000	20	400000	250
	Designer	6	10	50	1000000	100	2000000	25	500000	400
	Database designer	7	7	20	400000	40	800000	10	200000	200
	Test Designer	8	5	10	300000	20	600000	5	150000	60
	Project Manager	9	3	5	1000000	10	2000000	3	500000	30
Implementation	Software Architect	10	8	40	800000	80	1600000	20	400000	250
	Implementer	11	10	50	1000000	100	2000000	25	500000	400
	Technical browser	12	5	10	300000	20	600000	5	150000	70
	Integrator	13	5	20	400000	40	800000	10	200000	180
	Project Manager	14	3	5	1000000	10	2000000	3	500000	30
System Testing	Test Manager	15	4	10	300000	20	600000	5	150000	80
	Test Analyst	16	5	10	400000	20	800000	5	200000	70
	Test Designer	17	5	10	400000	20	800000	5	200000	50
	Tester	18	5	10	500000	20	1000000	5	250000	50
	Project	19	3	2	500000	4	1000000	1	250000	10

System Integration	Manager Deployment Manager	20	8	40	800000	80	1600000	20	400000	300
	Configuration Manager	21	7	40	800000	80	1600000	20	400000	300
	Technical Writer	22	5	20	400000	40	800000	10	200000	100
	Implementer	23	10	80	2000000	160	4000000	40	1000000	500
	Project Manager	24	3	10	2000000	20	4000000	5	1000000	60
System Maintenance	Systems analyst	25	5	10	300000	20	600000	5	150000	90
	Programmer	26	5	10	300000	20	600000	5	150000	60
	Project Manager	27	3	2	500000	4	1000000	1	250000	8

Hypotheses
The main hypotheses of problem are listed hypotheses of model.
Model Expression
$\text{Min } Z = 5 * Y_1^+ + 50000 * Y_2^+$
S.t.
$X_{i,j} \leq P_i \qquad i=1,\dots,27 \quad , \quad j = 1,2,3$

$\sum_{j=1}^{n} T_{i,j} * X_{i,j} \geq B_i \qquad i=1,\dots,27$

$X_{i,j} \geq 1 \qquad i=1,\dots,27 \quad , \quad j = 1,2,3$

$\sum_{j=1}^{n} C_{i,j} * X_{i,j} - (Y_1^+ - Y_1^-) = 120000000 \qquad i=1,\dots,27$

$\sum_{j=1}^{n} T_{i,j} * X_{i,j} - (Y_2^+ - Y_1^-) = 3700 \qquad i=1,\dots,27$

$Y_k^+ \geq 0 \qquad k = 1,2$

$Y_k^- \geq 0 \qquad k = 1,2$

Solving Model
Operations research software of GAMS (The General Algebraic Modeling System) is used to solve the model. This software is very fast in solving large models. Thus, GAMS is the best software for solving large and complex optimization problems.
GAMS is used to solve linear programming, nonlinear programming (NLP), mixed integer linear programming (MINLP), mixed integer nonlinear programming (MINLP) and linear complementary problems (MCP). GAMS is a professional software in solving mathematical optimization problems.
Solving Model using GAMS Software

$\text{Min } Z = 5 * Y_1^+ + 50{,}000 * Y_2^+$
VAR y :
$Y_1^+ = 100{,}000$
$Y_2^+ = 164$
Objective function value that is actually the amount of fine is equal to:
VAR Z: 8.7000E + 6 = 8,700,000

Decision variables value
VAR X_{ij} :
Values calculated for decision variables are shown in Table 5.

Table 5: Shows Xij values

j / **i**	**1**	**2**	**3**
1	4	1	1
2	2	1	2
3	4	1	2
4	2	1	2
5	4	1	1
6	5	1	2
7	7	1	2
8	3	1	2
9	2	2	1
10	4	1	1
11	5	1	2
12	4	1	2
13	5	1	4
14	1	2	2
15	4	1	4
16	4	1	2
17	2	1	2
18	2	1	2
19	3	1	1
20	5	1	1
21	5	1	1
22	2	1	2
23	4	1	1
24	3	1	2
25	5	1	4
26	3	1	2
27	1	1	3

In solving model using GAMS software, the extra cost value is 100,000 Tuman, extra time compared estimated to amount is 164 hours; as a result, the minimum amount of fines calculated by objective function is 8,700,000.

Model Analysis

This study examines simultaneously Human resource planning for multi-phase projects and its aim is to minimize project duration and cost of labor wages. For this reason, a company has been studied as a sample.

The company has accepted to carry out simultaneously three projects and development methodology of three projects is cascade. The project examines the wage and completion time of three projects when they are implemented separately compared to wage and completion time of three projects when they are implemented simultaneously.

The project sizes are different. The second project size is two times the first project and the third project size is half the first project; for this purpose, the time of total projects completion, the total cost of wages and the least working time of each groups of three projects will be divided between them based on project size and each one will be assessed separately.

The first project:
This company has considered 3,700 hours to complete three projects and has estimated 120 million Tuman for wages of personnel in projects. As a result, the time proportion of first project is equal to 1057 hours and wage proportion is equal to 34,000,000 Tuman.
According to the amount of fine per extra work hour is 50,000 Tuman and per Tuman extra is 5 Tuman. The objective function value is calculated using GAMS software.
In Table 6, i is group index, Pi is number of group i members, Ti,1 is the work time of group i per member in first project, Ci,1 is the wage of group i per member in first project and Bi is the least work time of group i for implementing first project.

Table 6: Shows Pi, $T_{i,1}$, $C_{i,1}$, Bi values

Phase		**i**	**P_i**	**1 $T_{i,1}$**	**$C_{i,1}$**	**Min B_i**
Requirements analysis	Requirements analysis	1	10	20	600000	37
	Descriptor of requirements	2	5	10	300000	14
	Requirements Reviewer	3	5	10	300000	20
	Project Manager	4	3	4	800000	6
Software Design	Software Architect	5	10	40	800000	72
	Designer	6	10	50	1000000	114
	Database designer	7	7	20	400000	57
	Test Designer	8	5	10	300000	17
	Project Manager	9	3	5	1000000	9
Implementation	Software Architect	10	8	40	800000	72
	Implementer	11	10	50	1000000	114
	Technical browser	12	5	10	300000	20
	Integrator	13	5	20	400000	52
	Project Manager	14	3	5	1000000	9
System Testing	Test Manager	15	4	10	300000	23
	Test Analyst	16	5	10	400000	20
	Test Designer	17	5	10	400000	15
	Tester	18	5	10	500000	15
	Project Manager	19	3	2	500000	3
System Integration	Deployment Manager	20	8	40	800000	85
	Configuration Manager	21	7	40	800000	85
	Technical Writer	22	5	20	400000	29
	Implementer	23	10	80	2000000	143
	Project Manager	24	3	10	2000000	17
System Maintenance	Systems analyst	25	5	10	300000	26
	Programmer	26	5	10	300000	17
	Project Manager	27	3	2	500000	2

Solving model using GAMS software:
Min Z = 5 * Y_1^+ + 50,000 * Y_2^+
VAR y:
Extra cost value $Y_1^+ = 6{,}900{,}000$
Extra time value $Y_2^+ = 277$
Objective function value that is actually the amount of fine is equal to:
VAR Z : 48,350,000
The second project:

The second project size is two times the first project; as a result, the company sets the second project value equal to 2114 hours and wage costs has been estimated as 68,000,000 Tuman.
Given fines value, Objective Function in second project is calculated using GAMS software.
In Table 7, i is group indexes, Pi is number of group I members, Ti, 2 is the work time of group i per each member in second project, Ci, 2 is the wage of group i per each member in second project and Bi is the least work time of group i for implementing second project.

Table 7: Shows Pi, $T_{i,2}$, $C_{i,2}$, Bi values

Phase		**i**	**P_i**	**2 $T_{i,2}$**	**$C_{i,2}$**	**Min B_i**
Requirements analysis	Systems analyst	1	10	40	1200000	74
	Descriptor of requirements	2	5	20	600000	28
	Requirements Reviewer	3	5	20	600000	40
	Project Manager	4	3	8	1600000	12
Software Design	Software Architect	5	10	80	1600000	144
	Designer	6	10	100	2000000	228
	Database designer	7	7	40	800000	114
	Test Designer	8	5	20	600000	34
	Project Manager	9	3	10	2000000	18
Implementation	Software Architect	10	8	80	1600000	144
	Implementer	11	10	100	2000000	228
	Technical browser	12	5	20	600000	40
	Integrator	13	5	40	800000	104
	Project Manager	14	3	10	2000000	18
System Testing	Test Manager	15	4	20	600000	46
	Test Analyst	16	5	20	800000	40
	Test Designer	17	5	20	800000	30
	Tester	18	5	20	1000000	30
	Project Manager	19	3	4	1000000	6
System Integration	Deployment Manager	20	8	80	1600000	170
	Configuration Manager	21	7	80	1600000	170
	Technical Writer	22	5	40	800000	58
	Implementer	23	10	160	4000000	286
	Project Manager	24	3	20	4000000	34
System Maintenance	Systems analyst	25	5	20	600000	52
	Programmer	26	5	20	600000	34
	Project Manager	27	3	4	1000000	5

Solving model using GAMS software:
Min Z = 5 * Y_1^+ + 50,000 * Y_2^+
VAR y :
Extra cost value Y_1^+ = 14,800,000
Extra time value Y_2^+ = 558
Objective function value that is actually the amount of fine is equal to:
VAR Z : 101,900,000
The third project:
The third project size is half of the first project; as a result, the company sets the third project value equal to 529 hours and wage costs has been estimated as 18,000,000 Tuman.
Given fines value, Objective Function in third project is calculated using GAMS software.

In Table 8, i is group indexes, Pi is number of group I members, Ti, 3 is the work time of group i per each member in third project, Ci, 3 is the wage of group i per each member in third project and Bi is the least work time of group i for implementing third project.

Table 8: Shows Pi, $T_{i,3}$, $C_{i,3}$, Bi values

Phase		**i**	**P_i**	**3 $T_{i,3}$**	**$C_{i,3}$**	**Min B_i**
Requirements analysis	Systems analyst	1	10	10	300000	19
	Descriptor of requirements	2	5	5	150000	8
	Requirements Reviewer	3	5	5	150000	10
	Project Manager	4	3	2	400000	2
Software Design	Software Architect	5	10	20	400000	34
	Designer	6	10	25	500000	58
	Database designer	7	7	10	200000	29
	Test Designer	8	5	5	150000	9
	Project Manager	9	3	3	500000	3
Implementation	Software Architect	10	8	20	400000	34
	Implementer	11	10	25	500000	58
	Technical browser	12	5	5	150000	10
	Integrator	13	5	10	200000	24
	Project Manager	14	3	3	500000	3
System Testing	Test Manager	15	4	5	150000	11
	Test Analyst	16	5	5	200000	10
	Test Designer	17	5	5	200000	5
	Tester	18	5	5	250000	5
	Project Manager	19	3	1	250000	1
System Integration	Deployment Manager	20	8	20	400000	45
	Configuration Manager	21	7	20	400000	45
	Technical Writer	22	5	10	200000	13
	Implementer	23	10	40	1000000	71
	Project Manager	24	3	5	1000000	9
System Maintenance	Systems analyst	25	5	5	150000	12
	Programmer	26	5	5	150000	9
	Project Manager	27	3	1	250000	1

Solving model using GAMS software:
Min Z = 5 * Y_1^+ + 50,000 * Y_2^+

VAR y :
Extra cost value Y_1^+ = 350,000
Extra time value Y_2^+= 121
Objective function value that is actually the amount of fine is equal to:
VAR Z : 7,800,000
According to obtained values of Extra cost, Extra time and objective function in three separate projects compared to three projects simultaneously, impressive results are obtained, and thus, the results of three separate projects are collected together and are compared with results of three projects simultaneously.
Extra cost in implementing three projects separately:
6,900,000 + 14,800,000+350,000 = 22,050,000
Extra time in implementing three projects separately:
277 + 558 + 121 = 956
Fine value in implementing three projects separately:

48,350,000 + 101,900,000 + 7,800,000 = 158,050,000
As we mentioned previously, implementing three projects simultaneously will have following results:
Extra cost $Y_1^+ = 100,000$
Extra time $Y_2^+ = 164$
Fine value VAR Z: 8.7000E + 6 = 8,700,000

RESULTS AND DISCUSSION

Results

These studies indicate that in implementing 3 projects separately extra cost is 220 times, extra time is 6 times and total fine is equal to 18 times compared to implement simultaneously. These results provide evidences that Human resource planning in several projects simultaneously is very effective in minimizing the costs of company both in terms of completion time and amount of wage.
If we want to do further analysis on final objective function (Min $Z = 5 * Y_1^+ + 50,000 * Y_2^+$), the goal programming will provide the opportunity for company, this means that we can prioritize completion time or wage cost of human resources through subtract or add fine value, for example, it can be stated that if company has projects that their completion time is very important or they must be completed at least time, thus, it must consider more extra time fine or, conversely, if minimizing the cost of projects is important, it must consider more extra cost fine, in this case, it will reach the goal values.

Conclusion

The main problem in this research is modeling human resource allocation through software development projects (with cascade methodology) with goal programming approach so that the minimum human resource requirements are met at each phase of project and sum of weighted deviations is minimized from human resource cost values and project completion time with respect to their goal values. The necessity of this research is due to the fact that in present competitive world, the need for reducing costs and project time is felt more than ever, for this purpose programming is very important in software development projects simultaneously. Then, it reviews the literature in the field of human resource allocation to projects which states that the issue of resource allocation in a project is proposed by many people and several innovative and goal methods are proposed, however, human resource allocation sector has been considered less. Then it examines human resources programming in projects especially information system projects and states that human resources are the most important sources of organization assets, for this reason, given the multiplicity of projects and sharing of human resources, proper allocation of human resources to projects is important and knowing project management techniques and being familiar with various models of Human resource planning and allocation create good view for modeling based on organization appropriateness.
Then it states that software development process has different methodologies, including cascade model which consists of six phases and software manufacturers do these phases, respectively, and methodology used in this study is cascade. After stating the problem and hypotheses, it model the allocation of resources to several projects which consist of several phases by goal programming and explains a case sample, it exemplifies a company that has accepted 3 simultaneous software development projects and needs for Human resource planning in order to minimize time and cost of 3 projects and expresses mathematical model for human resource allocation to 3 projects and determines simultaneously an goal value for wages and time of 3 projects through goal programming planning of an goal, and considers the fine for its excess amount and solves model by GAMS software, then analyses model, for this purpose, it models projects separately and solves model using GAMS software and adds extra cost, time and fine for 3 projects and compares simultaneously with modeling of 3 projects and concludes that Human resource planning simultaneously in several projects is very effective both in terms of completion time and wages in order to minimize the company costs. In the second analysis it suggests that goal programming allows the company to subtract or add fine value, as a result, it can prioritize project completion time or human resource wages it could be also stated that if there are projects and their completion time is very important it must consider more extra time fine or, conversely, if minimizing the

cost of projects is important, it must consider more extra cost fine, in this case, it will reach the goal values.

There are various aspects to develop proposed model of this research including:

- Software Development Methodology is cascade in this research; this methodology can be changed to RUP or other methodologies.
- The study focused on human resource allocation to software development projects; this can also be extended to allocate required resources.
- The model presented in this study is the base model and various limitations can be added to the model such as waiting times.
- The objective function of this study is minimization type and it can be modified to maximization and profit functions or both maximum and minimum objective functions can be used simultaneously.

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