Resource Allocation in Project Scheduling application of GA

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Abstract - This paper presents the Genetic algorithm as a potential method for estimating the weightages of the activities for the multiple resources. Project network is taken as an example to explain. A linear equation formulation is used to find the weightages of the activities by GA involved in the project network. Using the weightages of the activities of the network rank the activities, scheduling the activities and obtaining the project duration for the network.

Keywords: Genetic algorithm; Project Network, linear equation, weightages

1 INTRODUCTION

Scheduling problems take place, in many fields, of human activity. Some of them are fundamentally easy and as a matter of fact, many scheduling problems are inherently very hard. These concerned scheduling problems are usually NP-hard, that is, it is probably impossible to secure optimal solutions using fast algorithms Parker [7]. It may be possible to formulate these problems as integer or disjunctive programs, but solving them to optimality may require an enormous amount of computer time.

Four main difficulties need to be addressed. First, production scheduling problems belong to a class of NP-hard problems; second, they are significantly constrained problems that change from shop to shop. Third, production scheduling decisions depend upon other decisions which are not inaccessible from other functions. Thus, it is subjected to dynamic and random events and finally production scheduling problems generally tend to embrace multiple schedule objectives to be optimized. These difficulties motivate the need to develop more robust and effective approaches to production scheduling problems.

For solving NP-hard problems, an approximation schema is constructed for the whole problem. It uses polynomial algorithms for its sub-problems, and establishes specified dominance properties in order to reduce the solution set. More recent approaches investigate the use of 'controlled random search', which have termed 'compu-search-techniques' because of their reliance on the computer, to achieve 'good', although not necessarily optimal, solution.

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2 Genetic algorithm

Genetic algorithm (GA) is a stochastic heuristic search method whose mechanisms are based upon the principal of biological evolution processes discover by Charles Drawn in 1859.

A **genetic algorithm (GA)** is a search heuristic that mimics the process of natural selection. This heuristic (also sometimes called a metaheuristic) is routinely used to generate useful solutions to optimization and search problems Mitchell [6].

The resource constrained project scheduling problems (RCPSP) is one of the most demanding and grate particle applications in product development, product planning, construction planning and scheduling etc. For over the decades, RCPSP has received attention of researchers for solving these problems with a choice of exact methods i.e. mathematical programming, dynamic programming, zero-one programming and branch and bound method using mathematical models but the disadvantage is that it could not solve the bigger and more complicated problems in practice.

Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover. In genetic algorithms the neighborhood perception is not based on a single solution, but rather on a set of solutions. A latest solution can be constructed by combining parents of solution. This process is often referred to as crossover.

Holland [1] invented the GA to mimic some of the processes of natural evaluation and selection. GAs are applied whose a population set of individuals as solutions is considered. Each individual is characterized by its fitness. The fitness of an individual is calculated by associated value of the objective function. The procedure works iteratively, and each iteration is generation. The population of one generation consists of individuals existing from the

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previous generation plus the new solutions or children from the preceding generation. The population size usually relics constant from one generation to the next. The children are generated through reproduction and mutation of individuals that were part of the preceding generation.

Li et al. [5] proposed a GA approach to earliness and tardiness production scheduling and planning problem. Khouja et al. [4] proposed a GA for solving economic lot size scheduling problem. Kimms [3] proposed a genetic algorithm approach for multi- level, multi-machine lot sizing and scheduling. Wang et al. [9] proposed a GA for scheduling grouped jobs on single machine to minimize the total flow time. Ip et al. [2] proposed a GA for planning and scheduling multi-product problems.

Genetic algorithms find application in bioinformatics, phylogenetics, computational science, engineering, economics, chemistry, manufacturing, mathematics, physics, pharmacometrics and other fields.

It is better than conventional methods, it is more robust. Unlike older optimization systems, they do not break easily even if the inputs changed slightly, or in the presence of reasonable noise. Also, in searching a large state-space, multi-modal state-space, or n-dimensional surface, a genetic algorithm may offer significant benefits over more typical search of optimization techniques. (Linear programming, heuristic, depth-first, breath-first, and praxis.)

Genetic algorithms have three main operators

1) Selection 2) Crossover 3) Mutation

Genetic algorithm is performed in the following steps:

Step 1: Population initialization

Step 2: Calculate the fitness value of each individual

Step 3: Selection

Step 4: Crossover

Step 5: Mutation

Step 6: Analyze the stop condition, if meet stop condition, go to step 7, else go to step 2

Step 7: Output the individual with best fitness value.

3 Model Formulation

Linear programming formulation for the GA. A network problem can be thought of as the contrary of the shortest-route problem, in the intellect that we are interested in finding the longest route from start to finish. We can apply the shortest-route LP formulation to network problem in the following manner. We assume that a unit flow enters the network at the start node and leaves at the finish node.

x_{ij} = amount of flow in activity (i, j) for all defined i and j

D_{ij} =Duration of activity (i, j) for all defined i and j

Thus the objective function of the linear programme for finding the weightages of the activities becomes

Maximize $Z=\sum D_{ij}x_{ij}$

all defined activities (i, j)

There is one constraint that represents the conservation of flow at each node that is, for all node j,

Total input flow = Total output flow

Naturally all the variables, x_{ij}, are nonnegative. Assume that one of the constraints is redundant. Illustrative example: Table 1

Activity	Duration (days)	Predecessors	Resource Requirements per day					
			R_1	R_2	R_3	R_4	R_5	R_6
A	6	-	5	2	2	2	7	4
B	3	-	3	5	2	3	9	6
C	4	A	2	4	4	2	3	1
D	6	-	5	4	3	5	5	4
E	7	A,B	3	5	2	3	8	0
F	5	C	4	1	4	9	2	5
G	2	D	4	1	4	3	9	8
H	2	A,B	5	5	4	0	9	1
I	2	G,H	3	2	4	3	4	2
J	6	F	1	5	4	6	7	3
K	1	C,E	3	3	2	4	5	1
L	2	E,G,H	3	2	2	8	3	4
M	4	I,K	2	2	2	2	4	8
N	2	F,L	1	4	4	3	4	1
O	3	L	5	5	4	6	2	3
P	5	J,M,N	3	2	3	4	7	8
Q	8	O	4	5	4	2	3	4
R	2	D,O	5	3	3	3	7	8
S	6	P,R	2	4	6	2	3	4
T	2	Q	1	6	2	7	5	2
Daily Resource Limit			7	10	10	16	18	13

Here Table 1 shows the example taken for illustration [8]. Table 1 gives the information about the activities, their duration, precedence relationship of each activity and the resources required for each activity.

Table 2: The LP formulation of the project example as illustrated in Table 1.

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19	X20	Sol
Maximize	6	3	4	6	7	5	2	2	2	6	1	2	4	2	3	5	8	2	6	2	
Node1	-1	-1		-1																	-1
Node2		1			-1			-1													0
Node3	1		-1		-1			-1													0
Node4	1					-1					-1										0
Node5	1	1									-1	-1									0
Node6			1							-1				-1							0
Node7				1			-1											-1			0
Node8				1					-1			-1									0
Node9	1	1							-1			-1									0
Node10							1	1					-1								0
Node11						1										-1					0
Node12			1		1								-1								0
Node13					1		1	1						-1	-1						0
Node14									1		1					-1					0
Node15						1						1				-1					0
Node16												1					-1	-1			0
Node17										1			1	1					-1		0
Node18															1					-1	0
Node19				1											1				-1		0
Node20																1	1	1			1

Objective function:

Maximize Z =

$$6x_1+3x_2+4x_3+6x_4+7x_5+5x_6+2x_7+2x_8+2x_9+6x_{10}+x_{11}+2x_{12}+4x_{13}+2x_{14}+3x_{15}+5x_{16}+8x_{17}+2x_{18}+6x_{19}+2x_{20}$$

S/to $-x_1-x_2-x_4=-1$

$x_2-x_5-x_8=0$

$x_1-x_3-x_5-x_8=0$

$x_1-x_6-x_{11}=0$

$x_1+x_2-x_{11}-x_{12}=0$

$x_3-x_{10}-x_{14}=0$

$x_4-x_7-x_{18}=0$

$x_4-x_9-x_{12}=0$

$x_1+x_2-x_9-x_{12}=0$

$x_7+x_8-x_{13}=0$

$x_6-x_{16}=0$

$x_3+x_5-x_{13}=0$

$x_5+x_7+x_8-x_{14}-x_{15}=0$

$x_9+x_{11}-x_{16}=0$

$x_{12}-x_{17}-x_{18}=0$

$x_{10}+x_{13}+x_{14}-x_{19}=0$

$x_{16}+x_{18}+x_{17}=1$

$x_{15}-x_{20}=0$

$x_4+x_{15}-x_{19}=0$

$x_6+x_{12}-x_{16}=0$

Solving the corresponding objective function and the constraint equations by using the GA tool in MAT lab for the population size of 20 and for the number of generation as 50. The following results are obtained for the weightages of the activities.

Table 3: This table will give the information regarding the weightages of the activities and then ranking the activities as per the weightages of the activities.

Activity	Duration (days)	Predecessors	Resource Requirements per day						Weighted sum W_i	Rank
			R_1	R_2	R_3	R_4	R_5	R6		
A	6	-	5	2	2	2	7	4	0.509	6
B	3	-	3	5	2	3	9	6	0.03	18
C	4	A	2	4	4	2	3	1	0.443	9
D	6	-	5	4	3	5	5	4	0.516	4
E	7	A,B	3	5	2	3	8	0	0.083	17
F	5	C	4	1	4	9	2	5	0.335	11
G	2	D	4	1	4	3	9	8	0.543	2
H	2	A,B	5	5	4	0	9	1	0	19
I	2	G,H	3	2	4	3	4	2	0.252	14
J	6	F	1	5	4	6	7	3	0.273	13
K	1	C,E	3	3	2	4	5	1	0.228	15
L	2	E,G,H	3	2	2	8	3	4	0.292	12
M	4	I,K	2	2	2	2	4	8	0.541	3
N	2	F,L	1	4	4	3	4	1	0.172	16
O	3	L	5	5	4	6	2	3	0.479	8
P	5	J,M,N	3	2	3	4	7	8	0.511	5
Q	8	O	4	5	4	2	3	4	0.392	10
R	2	D,O	5	3	3	3	7	8	0	20
S	6	P,R	2	4	6	2	3	4	0.994	1
T	2	Q	1	6	2	7	5	2	0.483	7
Daily Resource Limit			7	10	10	16	18	13		

Table 4: Arranging the activities as per their rank in the ascending order and scheduling the activities as per their precedence relation relationship taking into consideration of their rank.

Rank	Activity	Predecessor	Duration (days)	R_1	R_2	R_3	R_4	R_5	R_6
1	S	P,R	6	2	4	6	2	3	4
2	G	D	2	4	1	4	3	9	8
3	M	I,K	4	2	2	2	2	4	8
4	D	-	6	5	4	3	5	5	4
5	P	J,M,N	5	3	2	3	4	7	8
6	A	-	6	5	2	2	2	7	4
7	T	Q	2	1	6	2	7	5	2
8	O	L	3	5	5	4	6	2	3
9	C	A	4	2	4	4	2	3	1
10	Q	O	8	4	5	4	2	3	4
11	F	C	5	4	1	4	9	2	5
12	L	E,G,H	2	3	2	2	8	3	4
13	J	F	6	1	5	4	6	7	3
14	I	G,H	2	3	2	4	3	4	2
15	K	C,E	1	3	3	2	4	5	1
16	N	F,L	2	1	4	4	3	4	1
17	E	A,B	7	3	5	2	3	8	0
18	B	-	3	3	5	2	3	9	6
19	H	A,B	2	5	5	4	0	9	1
20	R	D,O	2	5	3	3	3	7	8

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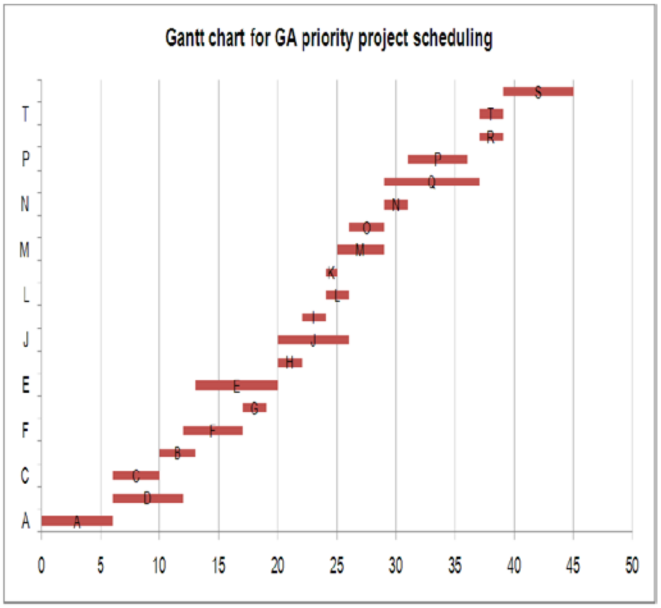

The critical path is A-C-B-E-J-O-Q-R-S OR A-C-B-E-J-O-Q-T-S and the project duration is 45days

4 Conclusions

The discriminating ability and methods to formulate sound decisions are involved in the intricate decision making situation in the project management. The project scheduling with the help of Genetic algorithm in developing the weightages for the activities are done in this paper and the corresponding project schedule is publicized in this paper. This paper provides the basis for applications of GA weightages in the project scheduling. The final project scheduling and the project duration are obtained from the Gantt chart.

References

[1] Holland, J., Adoption in Natural and Artificial Systems, (xxxxx), 1975.

[2] W.H., Li, Y., Man, K.F., Tang, K.S., Multi-product planning and scheduling using genetic algorithm approach, Computers and Industrial Engineering, 38(2), 283-296, 2000.

[3] Kimms, A., A genetic algorithm for multi-level, multi-machine lot sizing and scheduling. computers and Operations Research, 26(8), 829-848, 1999.

[4] Khouja, M., Michalewicz, Z., Wilmot, M., The use of genetic algorithms to solve the economic lot size scheduling problem. European Journal of Operational Research, 110(3), 509-524, 1998.

[5] Li, Y., Ip, W.H., Wang, D.W., Genetic algorithm approach to earliness and tardiness production scheduling and planning problem", International Journal of Production Economics, 54(1), 65-76, 1998.

[6] Mitchell 1996, p. 2

[7] Parker, R.G., Deterministic Scheduling Theory, (Chapman and Hall, U.K.), 1955.

[8] Tarek Hegazy, "optimization of resource allocation and leveling using Genetic algorithms"

[9] Journal of construction engineering and management, Vol. 125, ASCE, pp. 167-175, May/June 1999.

[10] Wang, D., Gen, M., Cheng, R., Scheduling grouped jobs on single machine with genetic algorithm, Computers and Industrial Engineering. 36(2), 309-324, 1999.