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# The Algorithms Research of Personnel Configuration in Product Data Management

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**Abstract.** This paper analyzes the problem of personnel configuration in product data management system and sets up integral programming math model. Based on other algorithms, it brings forward genetic algorithms as a new method to resolve the problem of personnel configuration with describing the encoding method, fitness function and mutation process.

**Keywords:** Product Data Management; Personnel Configuration; Genetic Algorithms

## 1. Introduction

Product data management is a technique that manages all the information and processes related to a product, in which the product project management plays an important part. Generally, a product management uses a series of knowledge, skill, implement and technology to meet or exceed the requirement of the related client. Four elements are crucial for a successful project management—scope, time, cost and quality—among which time, cost and quality are called TQC. In addition, person is another important element although often neglected. It is the person that defines the target of a project and promotes its process, as well as makes creation of value with the project achievement. Due to this neglectfulness, the product project management lays particular stress on the management of information and document. As a result, personnel configuration, which is completely defined by the staff, always ends up with inefficiency. Therefore, it is necessary to do some research into the personnel configuration of the product data management. This paper brings forward genetic algorithms as a new solution.

## 2. Problem Analysis

Product data management system is aimed at the management of series of large and complicated product, such as locomotives, planes and cars. These products are composed of thousands of components and each component's design is a single task. The product data management system is mainly a designing task, whose principal work is intellect-based brainwork, with manpower as the most principle resource. On the premise of ensuring the quality, time is the greatest touchstone of a project.

Take product A as an example. Product A is made up of six parts—labeled from1 to 6, and each part is given to an individual design office. Designers in these offices will be appointed to be in charge of these designs. For example, if the number of the designated designers of part 1 to 6 is 6, 5, 7, 4,8and 10, there are $6\times5\times7\times4\times8\times10=67200$ plans for us to select. Supposing: (1) the design of each part is mutually exclusive, that is to say each design task cannot be parallel; (2) if the plan department gives 52 days to complete designing product A, the personnel configuration module ought to select the best personnel configuration plan that satisfies the requirement of the given time through the 67200 plans mentioned above in product management. Additionally, it is necessary to acknowledge that the "zero inventories" concept caused by modern products is also applicable to the product designing. This requests project completion exactly on the due date and not in advanced.

## 3. Model Set Up

From the designing time of product A, we can get the objective function:

min(z)=|(total time)－52|.

For personal configuration, this function only shows whether the designated designer will be taken into the designing project of product A. Take the variable $x_{ij}$ into consideration. If $x_{ij}=1$, this shows the designated designer j is in charge of part i, but if $x_{ij}=0$, it shows that designer j takes no responsibility for part i. This way, $x_{ij}$ can only be 0 or 1.

According to the definition of personnel configuration, the design of each part can choose only one designer in charge, from which we can get a mathematical formula:

$$\sum_{j=1}^{n} x_{ij}=1, \quad i=1,2,...m \tag{1}$$

$$x_{ij}=0 \text{ or } 1 \tag{2}$$

Total time$=\sum_{i}\sum_{j} c_{ij}x_{ij}$

The objective function is:

$$\min z=\left|\sum_{i}\sum_{j} c_{ij}x_{ij}-52\right| \tag{3}$$

In this formula, $c_{ij}$ is called the time coefficient, indicating the time needed for part i. Following table shows it in detail.

| Orders | Parts | Designer 1 | Designer 2 | Designer 3 | Designer 4 | Designer 5 | Designer 6 | Designer 7 | Designer 8 | Designer 9 | Designer 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Part 1 | $C_{12}$ | $C_{13}$ | $C_{14}$ | $C_{15}$ | $C_{16}$ | $C_{17}$ | | | | |
| 2 | Part 2 | $C_{21}$ | $C_{22}$ | $C_{23}$ | $C_{24}$ | $C_{25}$ | | | | | |
| 3 | Part 3 | $C_{31}$ | $C_{32}$ | $C_{33}$ | $C_{34}$ | $C_{35}$ | $C_{36}$ | $C_{37}$ | | | |
| 4 | Part 4 | $C_{41}$ | $C_{42}$ | $C_{43}$ | $C_{44}$ | | | | | | |
| 5 | Part 5 | $C_{51}$ | $C_{52}$ | $C_{53}$ | $C_{54}$ | $C_{55}$ | $C_{56}$ | $C_{57}$ | $C_{58}$ | | |
| 6 | Part 6 | $C_{61}$ | $C_{62}$ | $C_{63}$ | $C_{64}$ | $C_{65}$ | $C_{66}$ | $C_{67}$ | $C_{68}$ | $C_{69}$ | $C_{610}$ |

Fig. 1: Timetable for designers in charge of each component

Obviously, as it shown above, the variable of this model can be only 0 or 1. It's a typical 0-1 integer model project.

Among the algorithm of the 0-1 integer model project, exhaust algorithm is taken into consideration most often. In this example, the number of the variable is 6+5+7+4+8+10＝40. However, this is infeasible since there are as many as $2^{40}$＝1099511627776 possible values of these 40 variable to be checked.. Due to the large amount variables, the branch and bound algorithm of implicit enumeration method is also unsuitable. To solve this problem, genetic algorithm is put forward after much study and analysis.

# 4. Genetic Algorithm Solution

Genetic algorithm[2,3], a stochastic search method evolved from the genetic mechanism of survival of the fittest in organic sphere, is an optimization algorithm formed by the interpenetration of natural inheritance and computer science[4].

## 4.1. Encoding scheme

### 4.1.1. Standard binary encoding scheme

With the adoption of binary symbol set {0, 1}, the standard binary encoding is the main encoding method in the genetic algorithm. The individual gene it forms is a binary symbol bunch, the length of which has something to do with the demanded analysis accuracy of the problem. The standard binary encoding scheme of this model is:

$x_{11}x_{12}x_{13}x_{14}x_{15}x_{16}x_{21}x_{22}$ ..... $x_{25}x_{31}$ ..... $x_{37}x_{41}$ ..... $x_{44}x_{51}$ ..... $x_{58}x_{61}$ ..... $x_{68}x_{69}x_{610}$ .

It is a 40-bit encoding. If adopting this standard binary encoding scheme, the chromosome will be too long to be controlled in the selecting process. Besides, it is hard to guarantee the feasibility of the chromosome, not to mention the big memory it will take and a dissatisfactory result it can only provide.

#### 4.1.2. Sequential encoding scheme

Based on the analysis above, to solve the limitation of the binary encoding, a sequential encoding of personnel configuration must be put forward, which uses the encoding scheme of the position changed expression (also called sequential expression) of traveling salesman problem as a source of reference.

Suppose part 1, 2, 3, 4, 5 and 6 respectively chooses NO.3, 5, 2, 4, 6 and 9 designated designer, then the encoding scheme can be expressed simply as [3, 5, 2, 4 6, 9], which is called sequential expression. Each number shows who will take charge of a certain component. More efficient in size and calculation, this expression is simpler and clearer than standard binary encoding.

We can get the objective function from the analysis of the model:

min(z)=|(total time)－52|.

For the genotype above, each number represents the designated designer in charge of each part.According to the sequence, number 3 means the NO. 3 designated designer takes charge of part 3, and the design time is $c_{13}$. Number 5 means the NO. 5 designated designer is in charge of part 5, and his design time is $c_{25}$, etc. Consequently, the genotype and phenotype above are:

Genotype: [3, 5, 2, 4, 6, 9]

Phenotype:

$c_{13}+c_{25}+c_{32}+c_{44}+c_{56}+c_{69}=C$, and the corresponding total design time is C.

The objective function is:

min (z)= | C-52 |

### 4.2. Fitness function

The goal of personnel configuration is to make the design time correspond with the planned time given by project division. The required design time lasts nearly 52 days in the example above, then the absolute value of |total time－52| is minimum. It can be seen that the maximum value problem and extreme minimum value problem must be dealt with differently according to the difference of the goal. In other words, different fitness function is needed in the realization of programming algorithm.

The maximum value problem adopts the objective function as its algorithmic fitness function, that is eval(x) =f(x). While the reciprocal of the extreme minimum value problem is the fitness function of the objective function, that is eval(x) =1/f(x). This example adopts the reciprocal of the objective function as its fitness function.

### 4.3. Variation algorithm

For the variation of the personnel configuration genotype, we adopt the following algorithm:

Supposing the second gene of chromosome $V_1$ is selected to be a variation and this gene is 5, there are 5 plans to choose at this place. Then take a base number $b_2$＝(5＋1)=6, and change it into ($b_2$-5)=1. In this way, the variant chromosome is $V_1$'. The specific express is:

$V_1$=[3,5,2,4,6,9]

$V_1$'=[3,1,2,4,6,9]

The other variation ways are just the same.

## 5. Conclusion

Based on the theory of natural selection and genetic mechanism, the genetic algorithm is a stochastic search algorithm[4], an effective way of solving the optimization problem. It could jump out the bound of the locally optimal solution with a polydirectional search by means of keeping a species group of latent solution. To solve the personal configuration problem of complicated product designing, this paper has adopted the

genetic algorithm, which is beneficial to popularize product data management system, as well as a new attempt to perform the functions of personal configuration management and product project management efficiently. This algorithm has been proved practicable through pilot calculation.

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