The Decision Model for the Optimal Configuration Management of Knowledge Employees in Enterprises

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With the development of knowledge economy, the role of knowledge employees in enterprises is becoming more and more important, and employees with rich knowledge represent the tower of strength in the development of enterprises. Knowledge employees with strong autonomy and creativity have stronger self-awareness in daily work. Thus, how to dispatch knowledge employees and assign them to proper positions, is of utter importance. To solve the problem of employee dispatch, bacterial foraging algorithm was proposed to optimize the configuration management of knowledge employees in enterprises in this study, a mathematical model based on the optimal configuration of knowledge employees was established, and a simulation experiment was carried out on the model. It was found that the algorithm could effectively optimize the configuration of knowledge employees. It is a feasible method for employee dispatch in enterprises.

Povzetek: Predstavljena je metoda za organiziranje zaposlenih v družbi znanja.

1 Introduction

Since the 21st century, information age has started, and knowledge economy has gained a rapid development. Producing products using cheap labour force has not been able to ensure the survival and development of enterprises; therefore, enterprises should improve its competitiveness by taking advantages of knowledge employees. Knowledge employees are the most active cells in enterprises, and the task assignment and scheduling for them directly determines the coordination between user demand, employee personality and enterprises benefits, the utilization of knowledge resources and the competitiveness and values of enterprises. Bogdanowicz et al. [13] considered that managing knowledge could bring challenges to the field of human resource development, especially when employees concerned more about their employment ability, and that an enterprise should pay attention to knowledge employees if placing great importance on knowledge. But knowledge employees are of high risks to leave enterprises because of their autonomy and creativity. How to optimize the configuration of knowledge employees is an urgent problem. A project may not be completed in time if decisions are made only considering the task assignment and scheduling of employees involved in that project regardless of the integrity of multiple projects. Through discussing the concept, connotation and composition of knowledge cooperative capability, Cao [1] concluded the influence factors and established an evaluation indicator system for the flood carrying capacity of knowledge employees in enterprises based on collaboration through introducing the concept of cooperation process, in order to improve the cooperative ability of knowledge employees and ensure the effective development of enterprises. Liu [2] introduced the loyalty of knowledge employees in state-owned coal enterprises, analysed the main reason for the decrease of loyalty in details, and finally concluded the strategies for improving loyalty, which was beneficial to the correct configuration of human resources and the improvement of enterprises. Based on the study of optimal configuration of knowledge employees, this study put forward working arrangement and dispatch for knowledge employees based on bacterial foraging algorithm to highlight their advantages and satisfy the demands of clients efficiently. Bacterial foraging algorithm was used to establish a mathematical model for the optimal configuration of knowledge employees, and then the feasibility of the algorithm was verified by a simulation experiment.

2 Configuration of knowledge employees in enterprises

2.1 Knowledge employee

The term "knowledge employee" refers to a person that works by applying symbols and concepts and using knowledge or information [3]. Knowledge employees as the carriers of knowledge play a vital role in the competition between enterprises, the innovation and utilization of knowledge and the reasonable configuration of resources [4]. Compared to non-knowledge employees, knowledge employees have the following characteristics.

(1) Employees have specialty in knowledge, good education background and high individual quality.

(2) They have strong wishes for realizing self-worth and high requirements and are interested in challenging works.

(3) With strong creativity and autonomy, they can independently fulfil most of creative tasks and produce new knowledge achievements based on their own knowledge [5].

(4) The working process is difficult to be monitored. The work form of knowledge employees with high randomness and subjectivity is different with that of employees in traditional workshops and offices.

(5) Their work results cannot be measured directly. The labour achievements created by knowledge employees exist in the form of inventions which cannot be directly measured by ordinary economic forms [6].

2.2 Configuration management of knowledge employees

The competition between enterprises and knowledge creation in enterprises are usually fulfilled by knowledge employees. The configuration management of knowledge employees refers to fulfil tasks using the shortest time.

3 The decision model for optimal configuration

3.1 Bacterial foraging algorithm

Bacterial foraging algorithm is a swarm intelligent optimization algorithm which achieves optimization through chemotaxis [7], reproduction and migration behaviours [8] according to the basic rules of the growth and evolution of bacteria [16]. Firstly, the individual evolutionary mechanism is formulated according to the reproduction rules of bacteria. Then the motion patterns of individuals in the algorithm are established according to the characteristics of bacterial foraging. Finally, the information share system was established according to the information exchange means of bacterial in colonies.

3.2 The flow of solving optimal configuration with bacterial foraging algorithm

X, Y and Z were set as the maximum execution counts of taxis, reproduction and migration operations respectively. x, y and z are the count values of the three operations. U stands for the maximum swimming distance, and w stands for the number of swimming steps.

(1) The parameters of the algorithm were initialized, and X, Y and Z were set to 1.

(2) Taxis operation was performed, $x \leftarrow x+1$. The bacteria were cycled. Before reaching the maximum times, the bacteria were turned over and swam.

(3) After taxis operation, reproduction operation was performed if the reproduction number did not reach the maximum value Y. Then the second procedure was repeated. The next step was done if the value reached Y.

(4) Then the bacteria were processed by migration operation, and the number of bacteria was initialized randomly.

(5) If the maximum migration number did not reach Z after migration operation, then it returned to the second procedure; if it did, then the algorithm ended and the result was output.

The flow of the optimal configuration based on bacterial foraging method is shown in Figure 1.

3.3 Modelling

Figure 2 shows the flow of mathematical modelling.

3.3.1 Embodiment of abstract problems

Based on the consideration on actual situation, this study found that staff dispatch and allocation should satisfy three conditions, i.e., the maximum customer satisfaction, uniform workload of knowledge employees and minimum enterprises cost [9]. Therefore, the optimal configuration of knowledge employees was implemented based on the three conditions. The details of the three conditions are as follows.

(1) Customer satisfaction maximization refers to maximizing satisfaction of customers on the services provided by enterprises, which is beneficial to the long-term development of enterprises benefits. Client satisfaction can be expressed by the time spent on tasks. Maximum client satisfaction also means the shortest time spent on tasks.

(2) Uniform working load of knowledge employees refers to uniform allocation of working load according to the working ability and conditions of employees. To realize the uniform allocation of workload, the work time and average time difference of employees should be the minimum.

(3) Enterprise cost minimization refers to minimize resource cost in the process of production and services. The main purpose of enterprises is profits. Minimizing enterprise cost can efficiently gain profits.

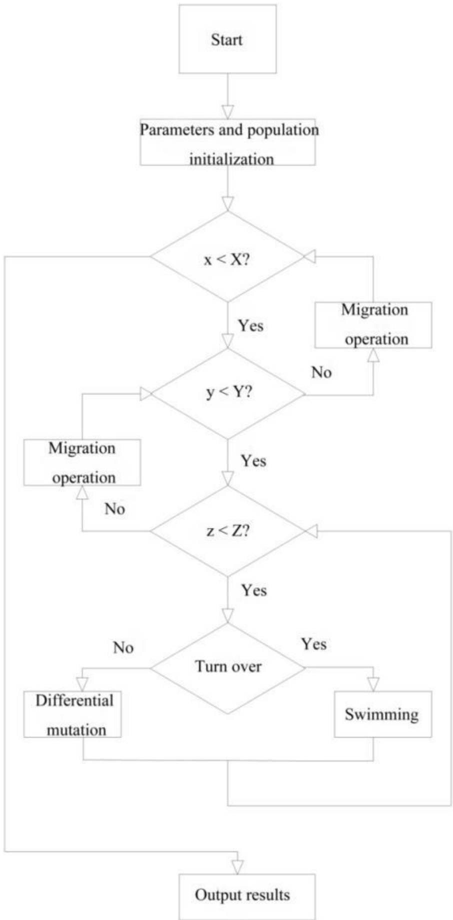

Figure 1: The flow of optimal configuration based on bacterial foraging algorithm.

3.3.2 Assumption

To effectively study resource optimization, the working scheduling of knowledge employees was assumed firstly. The starting time point of tasks was set to 0. Each employee could only do one task simultaneously. Each task could only be fulfilled by one employee. When tasks have been going on, the other tasks should have been waiting. The completion time of each task was associated to the capacity of the employee. Next task could start after last task was completed. Only broad setting was given, thus hypothesis needs to be formulated according to the actual condition of enterprises in practical application.

3.3.3 Setting variables

To simplify modelling, variables were designed after assumption.

(1) M: a set of m projects, $M=\{M_1,M_2,M_3\cdots,M_i,\cdots M_m\}$

(2) N: a set of n knowledge staffs, $N=\{N_1,N_2,N_3\cdots,N_k,\cdots N_n\}$ ($k=1,2,3,\cdots,n$)

(3) P_i : a sequenced set of j tasks of project i, $P_i=\{P_{i1},P_{i2},P_{i3}\cdots P_{ij}\cdots P_{iu}\}$ ($j=1,2,3\cdots,u$)

(4) g_{ijk} : whether knowledge employee N_k could be competent for task P_{ij}. If he could, then $g_{ijk}=1$; otherwise, $g_{ijk}=o$.

(5) t_{ijk} : time for employee N_k completing task P_{ij}

(6) a_{ij} : the starting time of task P_{ij}

(7) b_{ij} : the end time of task P_{ij}

(8) c_{ijk} : cost for employee N_k completing task P_{ij}

For individual employee, IN_k was the set of tasks which needed to be fulfilled:

$IN_k=\{IN_1,IN_2,\cdots,IN_{kr},\cdots,IN_{kk(0)}\}$ ($r=1,2,3,\cdots,k(0)$)

d_{ijkr} stands for whether task P_{ij} could be allocated to employee N_k; $d_{ijkr}=0$ means the task could not be allocated to employee N_k; $d_{ijkr}=1$ means the task could be allocated to employee N_k.

H_{kr} refers to the time when employee N_k started the r-th task; L_{kr} refers to the time when employee N_k completed the r-th task.

3.3.4 Establishment of mathematical model

Mathematical expression models were proposed against the three conditions which should be satisfied in dispatching and allocation.

Customer satisfaction could be expressed as:

$$f_1(x)=\min_{1\le i\le m}\left(\max_{1\le j\le u}(b_{iu})\right) \tag{1}$$

The workload of knowledge employees can be expressed as:

$$f_2(x)=\min\sum_{k=1}^{n}\left(t_{ijk}\cdot d_{ijkr}-\sum_{k=1}^{n}t_{ijk}\cdot d_{ijkr}/n\right)^2/n \tag{2}$$

Enterprise cost minimization can be expressed as:

$$f_3(x)=\min\sum_{k=1}^{n}\sum_{r=1}^{k(0)}c_{ijk}\cdot d_{ijkr} \tag{3}$$

The configuration management of enterprises knowledge employees was optimized by three mathematical formulas. The formula of the decision model was:

$$\min\left(f_1(x),f_2(x),f_3(x)\right) \tag{4}$$

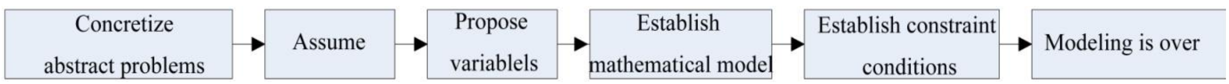

Figure 2: The flow of mathematical modelling.

Then equation (4) was processed by normalization using $q_i = \log_{10}(f_i(x))$. The three targets were set as θ_1, θ_2 and θ_3. Then the objective function of the model was:

$$F(x) = \min \sum_{i=1}^{3} \theta_i q_i(x) \quad (5)$$

3.3.5 Establishment of constraint condition

A constraint condition was needed before every time of decision making. When the decision-making objective was formulated, there was also a constraint condition. The constraint condition was:

$$\sum_{i=1}^{m} \sum_{j=1}^{u} \sum_{k=1}^{n} \sum_{r=1}^{k(0)} d_{ijkr} = 1 \quad . \quad (6)$$

Formula (6) means every task was independent and could only be completed by one knowledge employee. The formulas of the starting time points when taking tasks and knowledge employees as subjects respectively are:

$$a_{ij} = \max\left(b_{ij-1}, \sum_{k=1}^{n} \sum_{r=1}^{k(0)} L_{kr-1} \cdot d_{ijkr} \right) , \quad (7)$$

$$H_{kr} = \max\left(L_{kr-1}, \sum_{i=1}^{m} \sum_{j=1}^{u} b_{ij-1} \cdot d_{ijkr} \right) . \quad (8)$$

The formulas of the completion time points when taking tasks and knowledge employees as subjects respectively are:

$$b_{ij} = aij + \sum_{k=1}^{n} \sum_{r=1}^{k(0)} t_{ijk} \cdot d_{ijkr} , \quad (9)$$

$$L_{kr} = H_{kr} + \sum_{i=1}^{m} \sum_{j=1}^{u} t_{ijk} \cdot d_{ijkr} . \quad (10)$$

Formula (11) was used to ensure allocating a task to a knowledge employee when he was able to complete the task. Formula (12) was used to ensure that the set variable was non-negative.

$$d_{ijkr} \le g_{ijk} \quad (11)$$

$$b_{ij}, a_{ij}, t_{ijk}, d_{ijkr}, g_{ijk}, L_{kr}, H_{kr} \ge 0 \quad (12)$$

4 Simulation experiment and analysis of the results

Task assignment and scheduling of employees are most widely used in transportation system [14]. In the field of transportation, they have the same characteristics. They are limited by time and space; each task must take into account the start time and location and ending time and location. It has the most extensive application in the scheduling of airline crew, followed by the scheduling of drivers in the automotive industry. In the field of health care, it is necessary to take into account whether the nurses have appropriate qualifications and whether they are long-term in-service nurses or short-term in-service nurses to ensure the fairness of nurses' shifts at night and on weekends, and the vacation and housing problems of them. To ensure the even distribution of workload, the bacterial foraging method can be used to optimize the configuration management during the task assignment and scheduling. It considers whether it is possible to insert a task into the existing time slot. If it is, then the time can be shortened, and the feasible solution can be optimized. Finally, the management of scheduling can be achieved with the least time and cost.

A project team was set up to solve the performance management related projects of an enterprise. The members of the project team should satisfy the following conditions.

They should know the core knowledge of enterprises operation and development, have strong bearing capacity to shoulder tasks with different difficulties which were allocated by enterprises and be responsible for management works.

According to the characteristics of the team, the members in the team were processed by optimal configuration management. A simulation experiment was performed to verify the role of decision model in optimal configuration of resources.

4.1 Basic data

In the process of experiment, an issue of optimal configuration of knowledge employees was proposed. The issue included two projects, each project contained six tasks, and each task was completed by one employee. The experimental data are shown in Table 1.

M_i		M_1						M_2					
P_{ij}		P_{11}	P_{12}	P_{13}	P_{14}	P_{15}	P_{16}	P_{21}	P_{22}	P_{23}	P_{24}	P_{25}	P_{26}
N_k	N_1	5/0.8	/	6/1.8	/	10/3	6/2.8	11/2.1	/	6/1.8	/	8/1.5	/
	N_2	6/3.8	9/4.8	4/0.8	/	4.1/1.8	11/5.8	10/3.3	5/1	9/3.2	/	10/2.6	7/2
	N_3	4/0.8	/	5/1.2	16/6	/	7/4.1	14/4.2	/	6/1.1	16/7.1	/	9/2.6
	N_4	/	8/3.8	/	13/5.5	5/1.6	/	/	8/2.5	/	18/6.9	13/3.3	/
	N_5	/	7/5.8	/	10/7	8/5.8	9/5.1	/	7/4.4	/	15/5.2	12/2.9	8/5.3
	N_6	6/6.8	8/4.3	7/7	12/5.2	/	/	14/8.1	8/3	10/3	16/5.6	/	10/3.2

Table 1: The time and cost spent on the tasks.
The symbol / means the task cannot be completed by the employee.

4.2 Results analysis

The algorithm was simulated by MATLAB software [10]. The parameters were set according to actual conditions. The maximum number of iteration was 200, the total number of bacteria was 50, there were 10 chemotaxis procedures, and the maximum number of steps was 4. After the forward direction was determined, the forward step length of bacterial individuals was 0.7, there were three copying procedures and three migration procedures, the number of cleavage cells was half of the total number of bacteria, and the probability of migration was 0.6. The simulation results are shown in Figure 3.

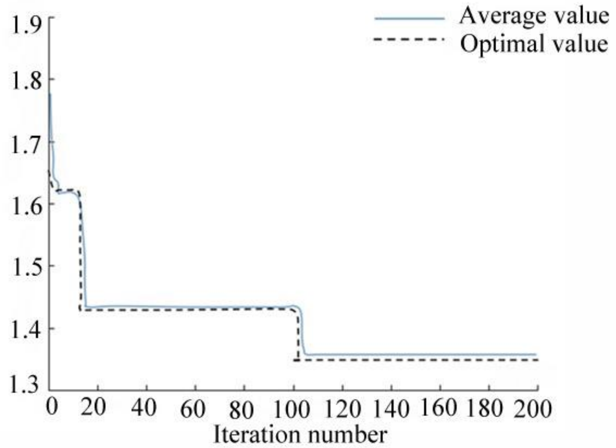

Figure 3: Simulation results.

Figure 3 demonstrates that the average value and optimal value of the model for the optimal configuration of knowledge employees based on bacterial foraging algorithm were basically the same, suggesting the algorithm had favourable convergence. When it was iterated to the 10th generation, the value began to close to the optimal value and maintained at 1.42 all the time. When it was iterated to the 100th generation, the local optimal solution, i.e., 1.32, was obtained. It indicated that the algorithm had strong global searching ability.

4.3 Performance test of bacterial foraging algorithm

To verify the effectiveness of bacterial foraging algorithm in practice, Sphere function, Quartic function and Rastrin function were selected as the benchmark functions, as shown in Table 2. Then the effectiveness of bacterial foraging algorithm and common particle swarm algorithm [15] in the three functions were compared.

To ensure the fairness of the results, the population number, operation times and maximum iteration times were set the same for the algorithms. Scale of population was set to 30, the maximum iteration times was set to 1,000, and operation times was 50. Chemotaxis times was set to 150, replication times was 8, and migration/dispel times was 5. After the setting, every example was independently operated for 25 times. The results are shown in Table 3.

Benchmark function	Results	Particle swarm algorithm	Bacterial foraging algorithm
$sphere(x)$	Average value	3.247±30.351	0.716±0.198
	Optimal value	3.247	0.416
	Standard deviation	3.268e-4	1.045e-5
$quartic(x)$	Average value	4.1e-2±0.051	1.621e-5±2.18e-5
	Optimal value	4.137e-3	3.529e-5
	Standard deviation	0.902	5.842e-5
$rastrigin(x)$	Average value	1.216e2±20.152	1.548e2±20.421
	Optimal value	1.133e2	1.213e-2
	Standard deviation	0.028	4.489e-2

Table 3: The experimental results of the examples.

When the times of iteration was the same, the optimal value obtained by bacterial foraging algorithm was smaller than that obtained by particle swarm algorithm.

5 Conclusion

Today knowledge employees have been an indispensable part in knowledge-based enterprises. How to optimize the configuration of knowledge employees has been a research task of many experts. Wang and Zheng [11] performed optimal configuration on knowledge employees using particle swarm optimization and found that the algorithm was scientific and effective in the dispatch of knowledge employees. Lin et al. [12] optimized the configuration of knowledge employees in modern enterprises with sliding mode control strategy and

Benchmark function	Index range	Optimal solution	Peak value
$sphere(x)=\sum_{i=1}^{n} x_i^2$	[-100,100]	0	Unimodal
$quartic(x)=\sum_{i=1}^{n} ix_i^4 + random[0,1]$	[-1.28,1.28]	0	Unimodal
$rastrigin(x)=\sum_{i=1}^{n}\left[x_i^2 - 10\cos(2\pi x_i)+10\right]$	[-5.12,5.12]	0	Unimodal

Table 2: Benchmark functions.

found the robustness of knowledge employee system through offline rectangle inequality. This study realized the optimal configuration of knowledge employees in enterprises using bacterial foraging algorithm, investigated the issue of employee dispatch, and established mathematical decision models. A simulation experiment was carried out to prove the effectiveness of the algorithm in optimizing the configuration of knowledge employees. The convergence performance of bacterial foraging algorithm and particle swarm algorithm was compared using three example functions, and the results demonstrated that the optimal value obtained by bacterial foraging algorithm was smaller than that obtained by particle swarm algorithm. This work can provide a reference for the dispatch of knowledge employees in the future.

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