



Optimization adjustment of human resources based on dynamic heterogeneous network

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HIGHLIGHTS

- The adjustment of human resource is abstracted as a dynamic heterogeneous network.
- The heterogeneous network includes personal network, job network and matching network.
- Monte Carlo method is used to simulate the change of intimacy and loyalty.
- The optimization process contains transformation, churn simulation and assignment.

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ABSTRACT

The human resources network, involves enterprise social networks and job networks, can be abstracted as heterogeneous networks or multi-layers networks. Adjusting the position assignments to maximize employee productivity and minimize the company's cost is the goal of organization optimization. Taking the churn and interaction among the staff into account, this paper puts forward a dynamic optimization model for human resource adjustment, which is based on heterogeneous network, to describe the influence among individuals who are in personal relationship or professional relationship. More specifically, intimacy and loyalty are constructed to form the basis of churn rate, which indicate the influence of the personal and professional relationship respectively. With the operation of the organization, the change of intimacy and loyalty leads to the churn process, which are simulated with Monte Carlo method in a dynamic process among the heterogeneous network. After churning, an optimal strategy of recruitment and position adjustment is obtained using the Genetic Algorithm. In general, the human resource optimization process consists three periodic parts: loyalty and intimacy transformation, staff churn simulation and position assignment. Finally, a case study of an organization with 370 employee positions is carried out to demonstrate the whole process.

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1. Introduction

In recent years, human resource management plays a crucial role in every company's operation. It can not only increase the employees work efficiency and job satisfaction, but also decrease the management cost. As a result, companies from all over the world have been urged to adopt a variety of performance-enhancing or progressive human resource (HR) management practices to improve their competitiveness in the global market [1,2].

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In order to pursue a higher salary and satisfy their career development, many people will leave for other jobs and the resulting turbulence is collectively termed organizational “churn”. Managing the fluid network of human resource within an organization and understanding organizational churn plays a crucial role in business [3]. J Welch said that the lack of emotional bond between employees and their boss is the main reason for resignation [4]. G Gregory found that the simplest reason of an employee’s resignation is that the company failed to keep him [5]. More specifically, employees leave because of low salary and conflict with coworkers. R Martin concluded the reasons, including the lack of enthusiasm for their work and opportunities for development within the company [6]. To sum up, the reason for their resignation can be attributed to their own reasons and the influence of others.

With the rapid development of social networks, the relationships among employees become closer and some employees leave the company just following their friends. In other words, the dynamic and instability of the employment are growing, which brings trouble to the normal operation of the enterprise. Therefore, in order to ensure the normal operation of the company, recruitment of staff and the training for new employees (including the newly recruited staff and the old staff adjusted to a new position) significantly increase the operation cost of the company. Management, an important content in an enterprise, can be used to decrease the operation cost and increase the company’s earnings [7]. So, the aim of the article is to obtain the optimal recruitment and adjustment scheme of the human resource management with minimal cost in the company’s reasonable operation.

Human resource management is a complex process that involves many subjective and unpredictable, non-quantifiable factors. Assuming that each employee has an initial loyalty to the company, and there is a certain emotional basis among colleagues. With the leaving of staff, how to recruit new employees and how to adjust the positions of old staff can minimize the cost and also ensure the normal operation of the company is the content of our research. Generally, our research topic is the employee-position adjustment problem. The employee-position adjustment problem is a complex management problem that is concerned with recruiting new employees and adjusting the original employees positions based on using minimal cost. In any company, with the increasing competition of superior talents, many experienced employees churn and the original organizational structure is interrupted. Thus, a large amount of money will be used in recruiting new persons and training new or old employees to fit their new positions. In addition, the churn of employees brings loss in productivity, which is transferred to indirect cost and considered in the optimizing process.

In this work, we first abstract employees and the relationship among them to construct a personal network and then establish a professional network using the organizational structure. When introducing the bipartite network of employees and positions, we put forward an integrated network based on the heterogeneous networks to illustrate the inner and interactive information of employees. The main contribution of this work is considering the changes of employees’ loyalty to a company and using a simulation method to display the whole process as time goes by. Furthermore, a GA is used to solve the optimization of employee-position adjustment problem. Finally, through optimizing the adjustment of the employees and positions, the loyalty of all employees will update and drive the staff churn simulation. Obviously, the adjustment of human resource is a dynamic cyclical process and once given a terminal time, an optimal adjustment scheme will be obtained.

The structure of this paper is organized as follows. Section 2 describes the human resource network model, which is the premise for churn and recruitment simulation. Section 3 elaborates the churn simulation in the human resource process and proposes a genetic algorithm to optimize the assignment of human resource. Section 4 provides a case to illustrate the application of our model. Conclusions are drawn in Section 5.

2. Human resource dynamic optimal model based on heterogeneous network

The system of human resource contains many factors, such as people, position, the matching between people and position, the relationship among people, the relationship among position, factors influencing their relationship and so on. Traditional, the network model was used to describe the human resource system because it takes the interaction of individuals into account. However, the homogeneous network model cannot distinguish the different characteristic of nodes and edges. For example, employees and job positions are two kinds of nodes in the network but they are treated as the same kind of node. Hence, to better illustrate the human resource system, the heterogeneous network [8], which contains more than two kinds of nodes and edges, are introduced. The definition of heterogeneous network is given in Definition 1.

Definition 1 (Heterogeneous Network). A heterogeneous network can be represented as $G = (V, E)$, where V denotes the set of nodes and E represents the set of links between the nodes in V . A node type mapping function is defined as $\phi : V \rightarrow V_{type}$ and a link type mapping function is defined as $\phi : E \rightarrow E_{type}$. If a network contains more than one node types $|V_{type}| > 1$ or link $|E_{type}| > 1$, this kind of network is called a heterogeneous network.

By analyzing the elements in human resource system, the heterogeneous network is made up of three sub networks: the personal network, the profession network and the bipartite network.

2.1. The personal network among employees

In the human resource system, the relationship between people can be friendship, leadership or others. In the personal network, we just consider the friendship among people, or private friendship, which does not relate to the business. Therefore, there is only one kind of nodes and edges, which is employee and the friend relationship in the personal network.

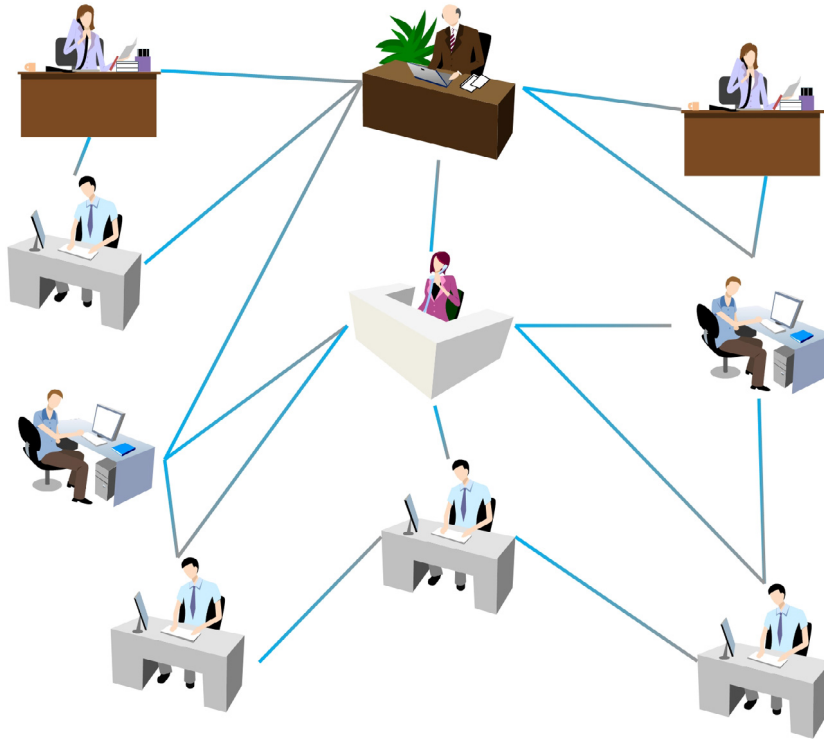


Fig. 1. The personal network among people.

The personal network can be described as a graph $G = (V, E)$ where V is the set of nodes and E is the set of edges that connect pairs of nodes [9,10]. In Fig. 1, the nodes mean people working in one company and the edges mean the friendship between two employees.

For a stable-operating organization, the manager hopes to keep the good, talented, well-trained people. However, the company’s personnel will change for a variety of reasons. When position change caused by the employees’ job-hopping or retirement, the resulting turbulence is collectively termed organizational “churn”. In order to manage the fluid network of human capital within an organization, the human resource specialists need to analyze the reasons for the employees’ churn.

There are two situations that people may churn: (1) Employees churn because their own reasons. Assuming that people with low loyalty tend to churn. (2) Employees churn because the people they were connected to have churned before. If the tie between A and B is strong and A churned in the last month, B is more likely to churn in this month. The assumption in this paper is that the influence of churned people will work in the next month.

To describe this process, two indexes, loyalty (α) and intimacy (β) are constructed. Loyalty, referring to people’s inner character, means the probability of retaining in the organization. More specifically, the loyalty of an employee is α , and the probability for he or she to churn is $1 - \alpha$. In fact, many factors will influence the value of α , such as the ratio of working time and mean time of moving up into the higher position, the culture of organization, the employee’s expectation and so on [11,12]. Since many inner characters will not change, the initial loyalty is defined as:

$$\alpha^{(0)} = F(c, e) \tag{1}$$

where c means the factor relating to organization culture, e means the expectation discrepancy factor.

Intimacy refers to the influence among people, which is an exterior character determined by the strength of their relationship. The intimacy between people may be influenced by many factors, such as the know of time, the distance of working departments, the discrepancy of position levels, the similarity of interest and so on [13]. In this paper, the initial intimacy is defined as:

$$\beta^{(0)} = F(t_{ij}, s_{ij}) \tag{2}$$

where t_{ij} represents the time of know between person i and person j , s_{ij} represents the similarity between person i and person j .

Of course, the loyalty and intimacy will change and it will be discussed in Section 3.1.

After giving the definition of loyalty and intimacy, the personal network is abstracted in Fig. 2. Intuitively, loyalty α is the inner value of the node, and intimacy β represents the value of the edge. The value on the edge indicates the degree of

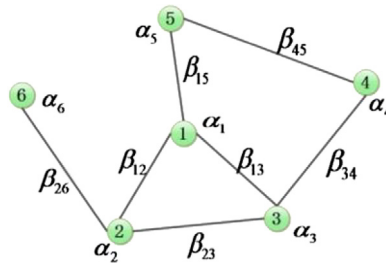


Fig. 2. The network of loyalty and intimacy.

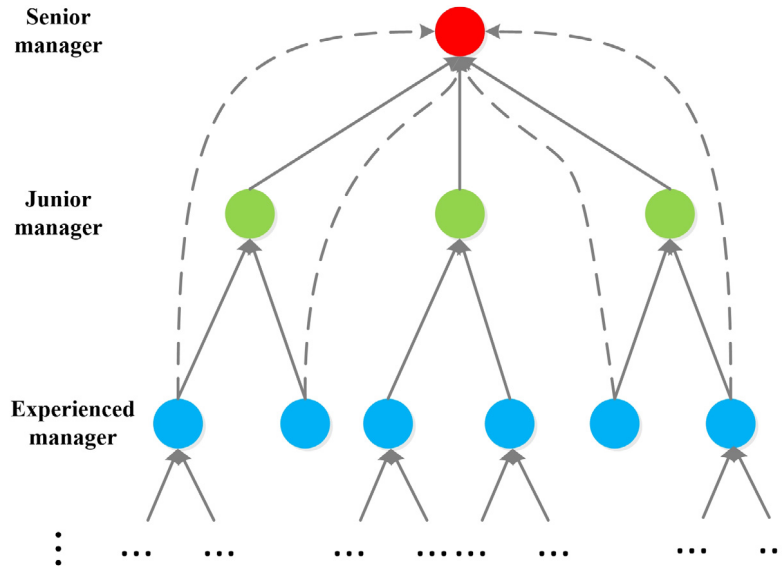


Fig. 3. The professional network of positions.

mutual influence between two people, and the value of the node can reflect the employee’s loyalty to the company, which can be used to calculate the probability that the employee leaves the company.

2.2. The professional network among job position

In an organization, the job positions have an obvious hierarchy. Thus, a tree network is put forward to describe the professional connection. In general, there are six levels of positions in organization. The highest level is senior manager and the lowest level is administrative clerk and inexperienced employee. The profession network is shown in Fig. 3, where the nodes represent positions and the edges represent affiliation relationship. Additionally, the solid line with arrow represents the belonging relation and the dash line means the probable adjustment of position.

In fact, changes in the position will lead to changes in remuneration and rights, and therefore change the loyalty of employees. Generally, if an employee gets the promotion opportunity, the loyalty will increase. Hence, the position network is put forward to analyze the influence on loyalty with the change of position. The dynamic analysis will be discussed in Section 3.1.

2.3. The bipartite graph between people and positions

The informal ties and formal ties among employees are presented in the personal network and professional network respectively. It is time to take a look at the graph between staff and positions. Theoretically, everyone can be assigned to any position. Of course, the cost of each person being assigned to any location will correspond to the cost and benefits. So, how to complete the optimal allocation and then bring higher efficiency for the company is the problem that the HR manager needs to consider. To perform the optimal analysis, the problem of position assignment is abstracted as a bipartite graph [14,15].

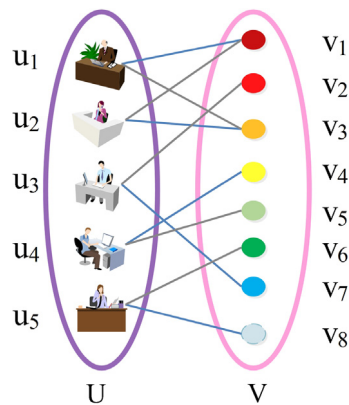


Fig. 4. The bipartite network between employees and positions.

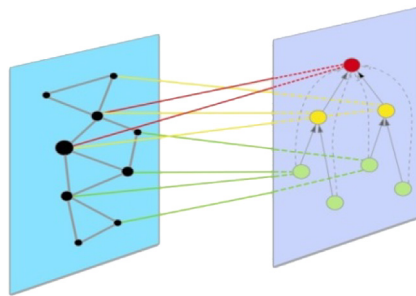


Fig. 5. A static human resource network.

In the bipartite graph, the nodes in two domains represent staff and positions. The edge matching an employee and a position means this person is assigned to this position by HR manager. In addition, each edge has a value which indicates the cost or benefit if this person takes this job. The bipartite network is shown in Fig. 4.

Where U is the set of employees and V is the set of positions. The gray edge means the existing assignment and the blue one means the possible assignment.

It is worth mentioning the characters of this bipartite graph. Firstly, there may not exist a perfect matching because not all people may have assigned to a certain position and not all job positions are taken by people. Secondly, the nodes in position set represent levels of position, so more than one staff can connect to the same node in V .

2.4. The dynamic human resource network

In Sections 2.1–2.3, three networks are established respectively. In fact, the personal network, the professional network and the bipartite network are combined to form a heterogeneous network [16,17], which is shown in the Fig. 5.

It is clear that the human resource network contains two kinds of nodes and three kinds of edges, which is a typical heterogeneous network. To get the optimal adjustment of human resources, the dynamic process needs to be taken into consideration. The time stamp is added to the static human resource network and a dynamic network is shown in Fig. 6.

As shown in the graph, every layer indicates a human resource network at a specific time. It contains the set of people, the set of positions, the informal and formal tie among employees, the matching relation between individuals and positions. As time goes by, the network in each layer changes and a dynamic human resource network generates. More specifically, there are three kinds of change in the network [18].

(1) No people churns and no new recruited people. Namely, the nodes are unchanged. The HR manager can adjust the matching between people and positions to influence the whole network.

(2) Some people churn. Namely, the nodes and edges decrease. The HR should recruit new employees to fill with the vacant positions or adjust the retaining people positions to minimize the cost and maximum the output.

(3) Some people join in the organization. Namely, the nodes and edges increase. The HR manager assigns them to the vacant positions.

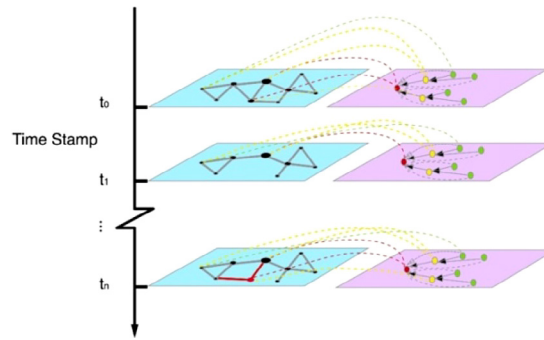


Fig. 6. A dynamic human resource network.

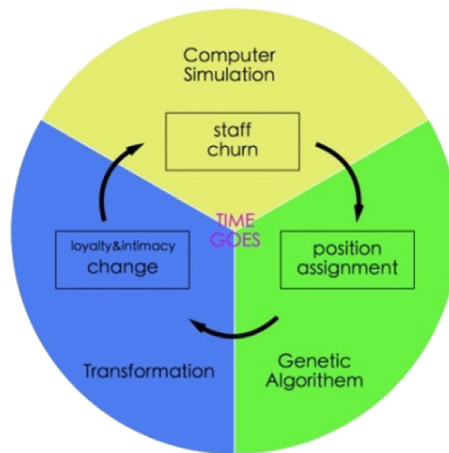


Fig. 7. The cyclic process of human resource management.

3. Human resource optimization based on churn simulation and genetic algorithm

Human resource management process is a dynamic process and contains three main parts:

- (1) The change of staff's loyalty and intimacy.
- (2) The churn and recruitment of individuals.
- (3) The position assignment of HR manager.

In the dynamic process, the staff's loyalty and intimacy will change, which leads to the staff churn. Since the company's personnel configuration has changed, HR manager should take measures to adjust the position assignment. Under the influence of position assignment and working time, the staffs loyalty and intimacy will change again. Hence, the dynamic process of human resource management is a mutual influence process in a circle.

In the first part, the loyalty and intimacy can be calculated as the models in Sections 2.1 and 2.2. For the second part, which is dependent on computer simulation, Monte Carlo method [19,20] is used to simulate the organizational churn and recruitment. The third part is the only one that can be intervened. The Genetic Algorithm [21,22] is used to get the optimal assignment, which is helpful for HR manager to do some adjustment. In conclusion, the optimization model of human resource management can be described in Fig. 7.

3.1. The change of loyalty and intimacy in the dynamic process

In the dynamic process, the years retaining in the same position level and the change of position levels may influence the value of the loyalty.

- (1) Retaining in the same position level

$$\alpha = \alpha^0 \times d^{\frac{t}{12} - \mu} \quad (3)$$

where d means the change proportion of loyalty as years goes on, t means the number of months that the employee stays in the same position, μ means the mean years to promotion at a specific position.

Table 1
The levels of positions.

Position	Level
Administrative clerk	1
Inexperienced employee	2
Experienced employee	3
Inexperienced supervisor	4
Experienced supervisor	5
Junior manager	6
Senior manager	6

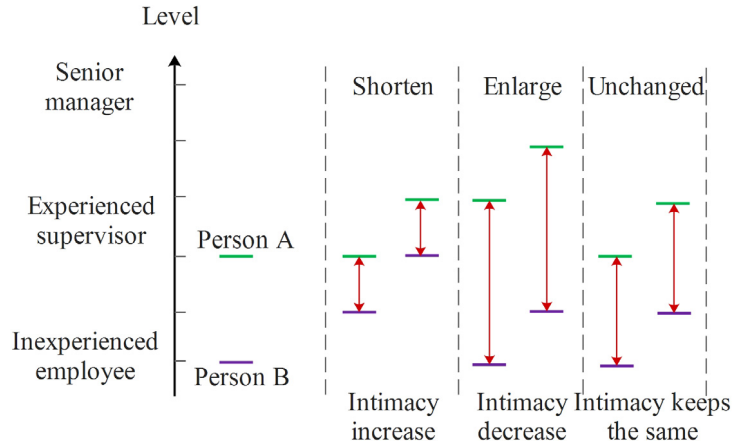


Fig. 8. The intimacy changes in different situations.

The loyalty of an employee will decrease if his or her working time in one position is more than the mean promotion years. On the contrary, the loyalty of an employee will increase if his working time in one position is less than the mean promotion years.

(2) Position adjustment

In order to reflect the influence of personnel transfer, a transformation matrix is constructed.

$$L = \begin{bmatrix} l_{11} & l_{12} & \cdots & l_{1m} \\ l_{21} & l_{22} & \cdots & l_{2m} \\ \vdots & \vdots & & \vdots \\ l_{m1} & l_{m1} & \cdots & l_{mm} \end{bmatrix} \tag{4}$$

where l_{ij} means the change of loyalty if an individual is adjusted from level i position to level j position, and m means the quantity of position level.

For all employees, they keep an initial loyalty α_0 at a certain position. Once an employee is adjusted from position i to j in the next month, his or her loyalty will change.

$$\alpha = \alpha_0 \times l_{ij} \tag{5}$$

Similarly, the intimacy will change with the change of the gap between people's position level. The levels of position can be given in Table 1.

The position level gap between individual i and j is:

$$\Delta l = |l_i - l_j| \tag{6}$$

To sum up, there are three kinds of situations that may change the intimacy, which are shown in Fig. 8.

(1) The position gap enlarges

If a person is promoted and the other one stays in the same position, their intimacy will decrease because they have fewer common topics.

(2) The position gap shortens

If the employee with a lower position is promoted to the same position level as the other one with a higher position, their intimacy will increase because they have more chance to contact each other.

(3) The position gap stays the same

If two persons all stay in the old position or they are promoted with a same grade, their intimacy will not change.

So the gap between people's position levels is used to calculate the change of intimacy. The intimacy between employee i and j is defined as:

$$\beta_{ij} = \beta_{ij}^0 \times \frac{\Delta l_{old} + 1}{\Delta l_{new} + 1} \quad (7)$$

where $\Delta l_{old(new)}$ represents the old(new) gap in position level between employee i and j .

3.2. Organizational churn simulation in dynamic process

It is assumed that the influence of churned people will work in the next month. In every month, every employee's loyalty may refresh because of the adjustment of position or the churn of connected people. Obviously, the higher the loyalty of the staff is, the lower the probability of their churn will be. According to the loyalty, the organizational churn can be simulated using Monte Carlo simulation method.

There are two situations may lead to people's churn.

(1) People want to churn for their own reasons, which are not influenced by connecting people. In this situation, the probability of churn is:

$$P_i^{inner} = 1 - \alpha_i \quad (8)$$

(2) People want to churn because of connecting people's influence. In this situation, the probability of churn is:

$$P_i^{outer} = \sum_j (1 - \alpha_i) \beta_{ij} \quad (9)$$

where j is the person who connected to i and churned in the last month.

In the first month, people's churn may be reduced by their initial loyalty, which leads to the change of human resource network. Then in the following month, two kinds of probability should be calculated for each employee. The first one is the churn probability influenced by connected people who have churned in the last month. And the second one is only caused by the loyalty. As time goes by, the dynamic process of the human resource network is formed and the process of simulation is described in Fig. 9.

At the beginning, some staffs leave the company with the probability of P_i^{inner} . Due to the impact of churn, the remainder leave the company following their connector with probability of P_i^{outer} starting from the second month. If the employees are not influenced by their connectors, they may leave because of personal reasons with the probability of P_i^{inner} . After the churn, the HR manager can adjust the remainders' position according to the total cost in this month. Then the loyalty and intimacy of the adjusted organization are changing. As time goes by, the churn process performs again and again. And the task of HR manager is to maximize the profit of the company.

Through the analysis, it is found that there are two different measures to reduce the rate of churn and improve the stability of the company. First, to improve the staff's loyalty through the transfer of the company's position; The second is to reduce the intimate relationship between the staff, or to reduce the personal friendship as much as possible.

3.3. Optimal management of human resource with genetic algorithm

In the previous parts, the human resources management model based on heterogeneous network has been constructed. To get the optimal result, the goal and the algorithm of optimization are introduced in the following sections.

3.3.1. The human resource cost in organizations

In this paper, the human resource optimal assignment problem is analyzed to help the HR manager to make the decisions. Generally, the object of human management is to maximize the output and minimize the cost. When the company's organizational structure is reasonable, then the company's output is stable. Therefore, the indirect costs caused by unreasonable organizational structure and the direct cost which consists of staff salaries, recruitment and training costs are considered in the analysis of human resources management. In detail, the cost of human resource consists of two parts:

(1) Indirect cost: the cost caused by unbalanced organizational structure

(2) Direct cost: the cost of salary, training and recruitment.

Namely, the total cost is represented as:

$$C = C_1 + C_2 \quad (10)$$

where C_1 means the indirect cost and C_2 means the direct cost.

There is a planned number of people in each position, and if the actual number is different from the original plan, the organizational structure is in an unbalanced state. Therefore, the indirect cost can be defined as:

$$C_1 = \sum_{i=1}^l \sigma_i \times S_i \times |n_i - \bar{n}_i| \quad (11)$$

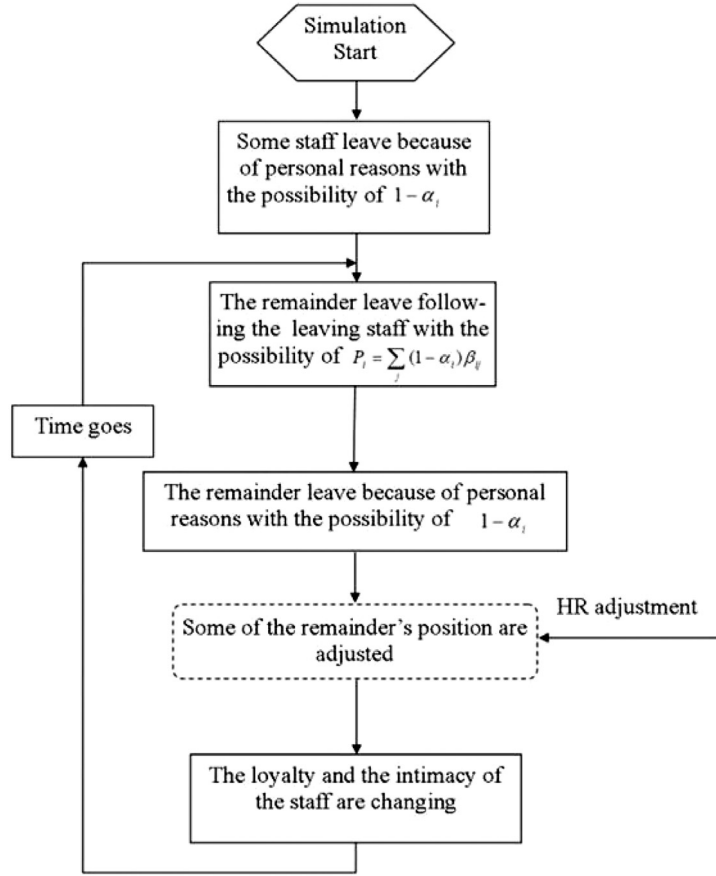


Fig. 9. The dynamic process of human resource management.

where: σ_i is a parameter, S_i is the salary of employees in the position level i , $\sigma_i \times S_i$ means the loss of output if the number of on-the-job staff is larger or smaller than the planned number. n_i means the number of staffs who are now on-the-job in i position level and \bar{n}_i means the planned number of staffs who are on-the-job in i position level.

Assuming that employees need be trained every year and the direct cost can be defined as:

$$C_2 = \sum_{i=1}^l S_i \times n_i + \sum_{i=1}^l r_i \times n_i^{new} + \sum_{i=1}^l k_i \times n_i^{old} \quad (12)$$

where: r_i means the average recruitment cost in position level i , k_i means the average training cost in position level i , $n_i^{(new(old))}$ means the number of the new(old) staff in position level i .

3.3.2. Optimal management of human resource with genetic algorithm

In Section 2.3, a bipartite network has been built to indicate the matching of people and positions. According to Section 3.3.1, the cost of every matching has been calculated. In order to minimize the total cost and get the optimal human resource structure, the Genetic Algorithm is used to assign positions. For the proposed model, the concrete explanation of chromosome and the optimal process of Genetic Algorithm are introduced in detail.

(1) The representation of chromosome

The represent of chromosome is the basic of Genetic Algorithm. In biology, the chromosomes are the units that indicate people's character. In this model, a valid chromosome is an effective assignment of positions. More specifically, the meanings of indexes are shown in Table 2.

In fact, the chromosome consists of a series of numbers. The i th bit stands for that the level of position is assigned to the i th person. In Fig. 10, the index N means this person leaved the organization more than one month and the index D means the person just departed from the organization.

Table 2
The meanings of indexes.

Index	Meaning
0	People are new recruited and still under training
1–6	People in six position levels relation to their salary, higher is better
N	The people are not in the organization now
D	The people departed from the organization

Table 3
The cost of time and money of employees in different positions.

Level of position	Median time to recruit (months)	Median cost to recruitment (months)	Number of employees at this level	Average annual salary rate for this level	Average annual training cost
Senior manager or Executive	7	1.2 σ	10	8 σ	0.5 σ
Junior manager or Executive	6	0.7 σ	20	4 σ	0.6 σ
Experienced supervisor	5	0.6 σ	25	2 σ	0.2 σ
Inexperienced supervisor	4	0.6 σ	25	1.5 σ	0.3 σ
Experienced employee	3	0.3 σ	110	σ	0.1 σ
Inexperienced employee	1	0.1 σ	150	0.9 σ	0.3 σ
Administrative clerk	2	0.3 σ	30	0.9 σ	0.05 σ

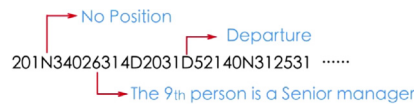


Fig. 10. The chromosome of position assignment.

(2) The optimal process of Genetic Algorithm

The Genetic Algorithm (GA) contains four steps: Initialization, Selection, Genetic operators and Termination. It is an iterative process and each process represents a generation. With the finite numbers of iteration, the algorithm can produce an approximate optimal solution. In this model, the fitness function is the total cost.

• Initialization

At this stage, the number of population, mutation rate, crossover rate and fitness function are illustrated. Then, the initial individuals will be produced.

• Selection

The first *N* individuals which are better to fit the environment are selected according to the fitness function. It is worth mentioning that a chromosome will be eliminated immediately if the structure is unreasonable. For example, there are only 25 positions in level 3. However, the number of level 3 is more than 25 in the chromosome. As a result, this chromosome is eliminated immediately.

• Genetic operators

There are two main operations, mutation and crossover, which are the methods to produce new individuals. A gene in the chromosome which has a possibility to change to any other gene called mutation. In this model, changing a gene represents the promotion of a person. So the number should increase when the gene is under mutation.

Two chromosomes exchange their genes with each other at the same position in their chromosomes called crossover. In this model, the exchange can only happen when the person who has the lower position get exchanged with the same position where the person has a higher position level.

In Fig. 11, the left two chromosomes mean two individuals. In the middle, chromosome A has a mutation on one gene, which means that the person was promoted from level 3 to level 4, so does the chromosome B. For the right couple, chromosome B get the same gene with A at the red point, which means that the person was promoted from level 3 to level 5.

• Termination

With the finite times of iteration, the algorithm will come to termination. Finally, the individual with the highest fitness is an approximate optimal solution.

4. Case study

4.1. Data

For the case study, the data that comes from 2015 COMAP's ICM are used to describe the optimal process. There are 370 positions in the organization. In addition, the number and level of employees, average salary, the average costs and time of external recruitment for various levels of personnel, and annual training costs are shown in Table 3. The median income of the company is defined as σ .

chromosomes		mutation		crossover	
.
.
.
0	0	0	0	0	0
3	1	4	1	3	1
5	3	5	3	5	5
N	N	N	N	N	N
6	4	6	4	6	4
1	2	1	3	1	2
2	5	2	5	2	5
4	6	4	6	4	6
D	D	D	D	D	D
.
.
.
A	B	A	B	A	B

Fig. 11. Genetic operators in GA.

In Table 3, it gives the hierarchical structure and number of employees at each level. For the cost, it gives median time to recruit, median cost of recruitment, average annual salary rate and average annual training cost for each level. Usually, the organization has only 85% on-the-job rate of its 370 positions and the hiring rate is about 8%–10%.

4.2. Model application to display the dynamic process in two years

Apply the proposed model to analyze the number of churned people and new recruited people within next two year at any time.

Step1: Initialization

The initial rate of on-the-job is 85%. The hiring rate is 10%. The churn rate is 18%. And 500 people are considered in the next two years. As for the initial connected relation, a random graph is used to simulate. Since the key point of this paper is to get the optimal assignment, people’s initial loyalty and intimacy is given by random values. Then a parameter is introduced to multiply the loyalty and adjust the parameter to reach a churn rate of 18%.

Step2: Simulation

After setting the initial value, the computer simulation is performed to indicate the process of “churn” and “recruit”. In this process, the change of loyalty and intimacy is calculated by the proposed model. In the simulation of this dynamic process, the number of churned people and new recruited people can be obtained.

Step3: Assignment

The genetic algorithm is used to get the optimal method to assign people and positions. In the genetic algorithm, the number of genes in one chromosome is set as 500. In addition, the number of population, the iteration times, the mutation rate and crossover rate are defined as 200, 2000, 0.4 and 0.1 respectively.

After ten times simulations, the result is shown Table 4.

According to the table, the annual churn rate is approximate to 19% and the recruitment rate is 12% in two years, which are close to the initial value 18% and 10%. Therefore, the simulation process is suitable. In addition, the total cost of recruitment is 38.2 and the total cost of training is 127.1 in two years after optimization. Once employees churn, there will be some vacant positions and the routine work may cannot be done. In order to sustain a reasonable organizational structure, the human resources manager will recruit more employees and also adjust the positions of the old staffs. Thus, the cost of recruitment and training will increase. In order to minimizing the cost in human resource, the company can regularly raise the position of the old employees to increase their loyalty. In addition, more attention should be paid to reducing the private exchange between employees as much as possible, so as to reduce the phenomenon of cascading churn.

4.3. The influence of churn rate on full status rate for positions

Usually, an organization wants to sustain its 80% full status for positions under the change of annual churn rate. Obviously, when the churn rate increases, the recruitment rate should be increased and the cost of the company will change. More people’s churn means more needs of recruitment, and that will result in higher cost. Similarly, if more people in higher position levels churn, the cost will be higher than that of the lower levels. The simulation is performed as the churn rate changes and the corresponding cost is shown in Fig. 12.

According to Fig. 12, the total cost first increases and then decreases as the increase of churn rate. It is rational because as the churn rate increases, more people will under recruitment. As a result, the salary cost will decrease, which is the biggest component of the total cost.

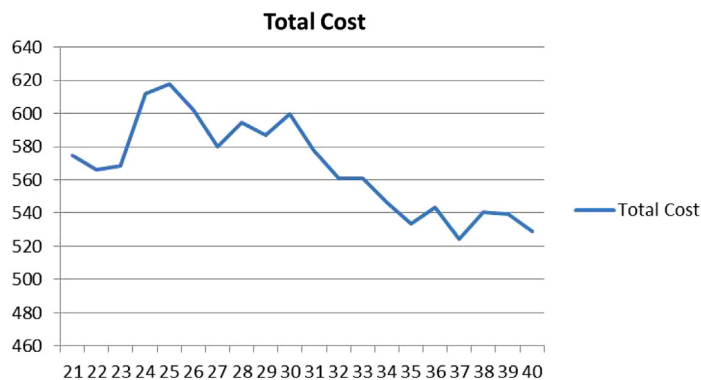
A healthy company structure is to sustain 80% full status for positions and also keep a better structure of organization. As the change of churn rate and recruitment rate, the rate of full status for positions will change. Then the situations where churn rate and recruitment rate changes from 0% to 40% are analyzed.

In Fig. 13, the circle means the rate of full status can be 80% and the structure is good under the recruitment rate and churn rate. The square means the rate of full status can be 80% but the structure is not good. The cross means the rate of full status cannot be 80%. Then, the available region is obtained.

Table 4

The result of churn simulation.

Month	Churn follows others	Churn for own reasons	The number of recruitment	The accumulative cost of recruitment	The accumulative cost of training
1	0	11	1	0.1 σ	5.9 σ
2	3	6	4	0.6 σ	11.6 σ
3	1	6	1	0.9 σ	17.2 σ
4	0	4	1	1.5 σ	22.8 σ
5	0	5	3	3.3 σ	28.3 σ
6	0	4	2	4.7 σ	33.8 σ
7	0	5	3	8.3 σ	39.3 σ
8	1	1	1	8.4 σ	44.9 σ
9	1	8	3	9.7 σ	50.3 σ
10	0	10	5	11.3 σ	55.6 σ
11	1	4	3	12.6 σ	60.8 σ
12	1	6	4	15.3 σ	65.9 σ
13	0	2	1	15.9 σ	71.2 σ
14	0	7	3	17.2 σ	76.4 σ
15	0	6	4	18.4 σ	81.6 σ
16	1	4	2	19.6 σ	86.6 σ
17	1	2	1	20.2 σ	91.6 σ
18	1	3	2	21.6 σ	96.6 σ
19	0	2	3	24.6 σ	101.7 σ
20	0	3	9	26.9 σ	106.7 σ
21	1	3	6	29.7 σ	111.9 σ
22	0	9	6	33.5 σ	117.0 σ
23	1	5	2	34.7 σ	122.1 σ
24	1	4	5	38.2 σ	127.1 σ
Total	14	120	75		

**Fig. 12.** The change of cost with different churn rate.

5. Conclusions

In this paper, we constructed a human resource network model to describe the relationship among persons, the structure of organization positions and the matching between employees and positions. It is worth mentioning that the heterogeneous network is used to construct the model of the human resource adjustment problem. When considering the time and the change of individuals' intimacy and loyalty, a dynamic human resource management network is established. Then, a churn and recruitment simulation was done based on staff's possibility to churn. After that, a genetic algorithm was designed to assign individuals to new positions in minimum cost. That is, the mapping problem between employees and positions is solved by the genetic algorithm and a reasonable adjusting scheme of human resources with as less as possible cost is obtained. Finally, we carried out a case study to analyze an organization's human resource structure development in two years. According to the finding, increasing employees' loyalty and minimizing private communication between employees can reduce the probability of leaving a job [23–25], thereby reducing the company's spending on staff recruitment and training.

Obviously, this article does not take the matching degree of the job and its required skills into account. The proposed method is suitable for those jobs that require low professional skills and employees can do the job after a period of training. In the future work, the matching problem should be considered. In addition, the structure of department in an organization has a significant impact on the analysis of managing human capital. For example, the individuals working in one department

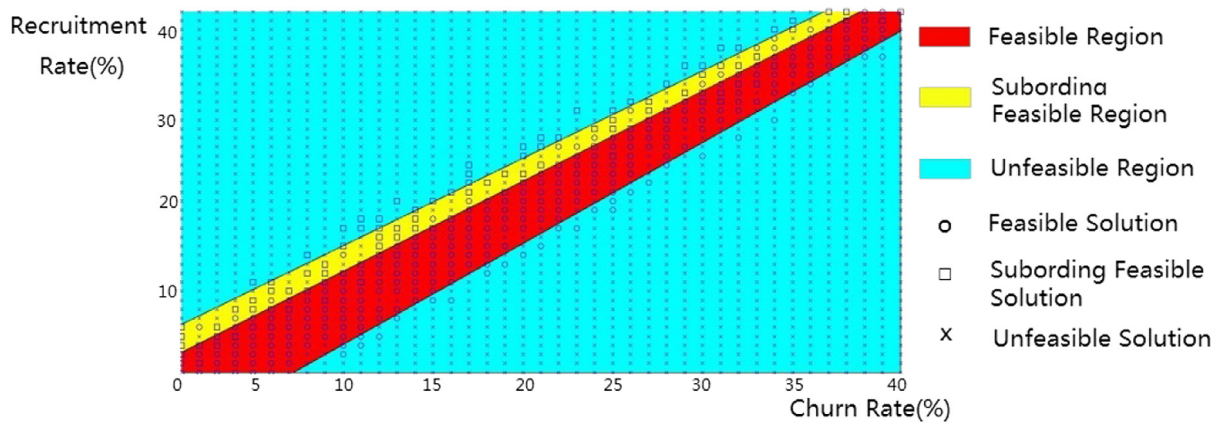


Fig. 13. Situations of different churn and recruitment rates.

have more complex relationship, including both positive and negative relation. In the future work, we will take the structure of the department into account to improve the simulation process and optimal process.

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