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Fuzzy Task Assignment Model of Web Services Supplier in Collaborative Development Environment

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Abstract

In view of collaborative development environment web services supplier in ability, cost, time supplier relations and component relevance information under uncertainty problems. The fuzzy multi-objective task assignment model of web services are built in a collaborative development environment. Using α *cut sets and extension principle to simplify the fuzzy multi-objective assignment mode, we get the solution of simplified assignment model via the Genetic and simulated-annealing algorithm. In view of the model solution sets are fuzzy and uncertain membership function, a new centroid defuzzification method is used for the model solution. Thus the optimization allocation of component supplier's fuzzy task is realized in collaborative development environment. Finally, the simulation results verify the feasibility of the proposed method, which can ensure the suppliers' tasking in successive software project in collaborative development environment.*

Keywords: *collaborative development, fuzzy task assignment, centroid defuzzification*

1. Introduction

In the process of collaborative software development based on web services, software designers and management personnel will consider the collaborative development of web services providers. By giving full play to the providers' capability and advantage of design and development, they will ensure the services quality, reduce the overall cost of development and even shorten the development cycle. In spite of those advantages, there are some problems such as how to assign tasks for the suppliers in the collaborative development and how to select supplier scientifically with uncertain information. Therefore, it is necessary to put forward a scientific and reasonable method and establish a fuzzy task assignment model for web services under the collaborative development environment.

Since suppliers' involvement is an important link in the process of development and innovation in collaborative product development, R&D enterprises are paying more attention to collaboration of more suppliers. Even the suppliers' collaborative development has been a subject among many research institutions and literatures which are dedicated to researching and exploring the theory from several aspects. The literature

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[1] not only defines for suppliers' involvement in new product development and assesses its theory foundation, but also makes a proposal that we should invite suppliers at the early stage of new product development, and take advantage of the suppliers' designing potential in order to boost the success rate of new product development. The literature [2] introduces an example of early supplier involvement in the product development of an international electronic company and further proves the vital significance of a responsible and capable supplier's collaboration in the process of new product development. The literature [3] assesses participants in collaborative development environment and establishes evaluation model, conducting in-depth analysis for the development process of a large project, and declares the assessment model has a valuable reference in terms of collaborative development projects. The above literatures mainly focus on exploring the necessity and function of suppliers' involvement in collaborative product development, and its principles and necessity also can be used in the collaborative product development based on web services. Despite these achievements, there remains a lack of corresponding theoretical basis and practical application in the supplier involvement in product design and task allocation.

In the process of suppliers' collaborative development based on web services, the assessment of supplier's development capacity, cost and delivery time will play a key role in the success of software project. Due to the uncertainty of development cost, the literature [4] uses sensitivity analysis method to solve assignment problem under fuzzy environment. Moreover, it also compares the three kinds of sensitivity analysis method and gives corresponding solutions in respective environment. The literature [5] introduces preference factor of decision makers in choosing a supplier and set up a fuzzy multi-task model dealing with suppliers' lowest cost, highest stability and shortest delivery time, then convert it into a convex fuzzy single objective model. By doing that we can fully present many influential factors between decision markers and suppliers. The literature [6] proposes a general model of collaborative design that contains the method framework, conceptual framework and technology framework. The user will finish the overall collaborative task design, task assignment and overall assessment. But the model is just a theoretical framework, rather a mathematical model corresponding to collaborative task assignment. The literature [7] puts forward the distributed collaborative software development model that describes the relationship between the development team and the task of formal concept, and introduces SMP (Stable Marriage Problem) method for task assignment. The literature [8] utilizes the particle swarm optimization algorithm to solve the problem of multi-supplier involvement in collaborative product task assignment, and constructs the total time model. The literatures [4, 5] are based on fuzzy multi-objective model with fuzzy information of suppliers and no account of suppliers' task assignment in collaborative environment. Even though the literatures [7, 8] solve the task assignment problem in collaborative environment by a multi- objective optimization model, they do not present how to assign tasks on the condition of fuzzy supplier information. Through the research literatures above, we find that most literatures concerning suppliers' involvements in product development mainly focus on the sequent interests brought by suppliers and assessments of suppliers' information, with little information of task assignment in collaborative development environment, especially in the field of software project development. The collaborative software development process, based on web services, can reduce the complexity of the software project and development risks. But there are still two problems to be solved in the process of software project development. On one hand, when suppliers are involved in the development, how to guarantee the coordination of the development process, and make the development time short. On the other hand, we need to take account of the suppliers' uncertain information and establish a scientific and rational model when the suppliers' development ability, collaborative development time and cost information are fuzzy.

In view of the above problems, the following work has been done in this paper. In the model construction process, we fully considered the ability of web services supplier, cooperative development time and cost information in the collaborative development environment. The fuzzy multi-objective task assignment model of web services supplier is proposed in collaborative development environment, which meet the suppliers' need of high reliability, low cost and short time in the process of software project development and provide the task optimization assignment for software development enterprises, which can guarantee the collaborative development environment software suppliers involved in the successful completion of the project. In the process of implementation in the model, we simplify the complex fuzzy multi-objective problem by the α sets and the extension principles and set up single objective optimization model decomposed with genetic and simulated-annealing algorithm. The model solution sets are fuzzy, the introduction of a new method of center of gravity defuzzification of fuzzy sets are operated. Finally, we prove the effectiveness of the method proposed in this paper by examples.

2. Model Construction

Assuming that the software maker has a large software projects demanding high reliability, low cost, the shortest time to market. The marker will decompose the project into several web services and choose some web services suppliers to participate in the project development, in order to make full use of their technology and resources. Assuming that the project decomposition has been completed, the number of web service is m, the number of web services supplier involved in the software development is n. There is a time sequence in the web services development process, so time process development is w.

i: the i the web services development tasks, $i = 1..m$;

j: the j the web services suppliers, $j = 1..n$;

x_{ij}: 0-1 variables, the i web services is assigned to the j supplier;

p_{ij}: the ability of j supplier development of i web services, as a fuzzy number range is [0,1];

t_{oij}: in the o development sequence, the j web services suppliers development the i WEB services of the time, as a fuzzy number range is [0,1];

t_i: the longest development time of the i web services;

q_{oi}: in the o development sequence, the start time of the i web services, $o = 1..w$;

c_{ij}: the costs of j supplier development of i web services, as a fuzzy number range is [0,1];

e_{ik}: degree of information dependence between the i web services and the k web services, as a fuzzy number range is [0,1];

$d_{j,f(k)}$: the coordination degree between the j supplier and bear the k web services supplier $f(k)$, as a fuzzy number range is [0,1];

During the web services supplier collaborative software development process, it is essential to determine the collaborative working time of each WEB services supplier. Each WEB services completion time depends on the three parts: web services started collaborative time, each supplier to the WEB services and WEB services between development time. By using the methods mentioned in the literature [9], there are dependencies among the web services, so the collaborative time supplier j required in the development of the web servcies i can be expressed as:

$$T_{com}(j)=\sum_{f(i)=j}\sum_{k=1}^{m}\frac{e_{ik}}{d_{j,f(k)}} \tag{1}$$

e_{ik} indicates the degree of information dependence between the i web services and the k web services, but the web services information dependence is difficult to represent specific quantitative data, so there are expressed by fuzzy numbers. $d_{j,f(k)}$ represents the coordination degree between the i supplier and the j supplier. Related to interoperability between suppliers, the exchange of information between the degree of supplier, the collaboration degree varies among different supplier. Since the specific quantitative criteria are complex, we use the fuzzy number as the evaluation data. When $f(k)=j$, the coordination degree of up to 1. Each supplier to the web services development time is expressed as $t_{oij}\times t_i$. According to the component of development time and each supplier to the component, the j supplier to develop collaborative development time of all web services can be expressed as :

$$T_{total}(j)=\sum_{f(i)=j}(\sum_{o=1}^{w}(q_{oi}+t_{oij}\times t_i)+\sum_{k=1}^{m}(\frac{e_{ik}}{d_{j,f(k)}})) \tag{2}$$

Because of the existence of information dependence between different web services in the process of web services development, there is a procedure problem when the web services assign tasks for suppliers. The overall time of software project development needs the completion of each web services, so it inevitably depends on the total time of suppliers who take the most development time in concurrent development process. Therefore, software project development time shortest is seeking a minimal model. The total time that each supplier to complete the assignment of web services required, all their suppliers to the maximum time of consumption is minimized, expressed as:

$$\min\max(T_{total}(j)) \qquad j=1..n \tag{3}$$

The fuzzy multi-objective task assignment model of web services is built in a collaborative development environment, which should consider web services performance optimization, collaborative development with the shortest time and lowest cost. Fuzzy task assignment problem of web services supplier in collaborative development environment can be described as a fuzzy multi-objective assignment problem as follows:

$$G_1=\max(\sum_{i=1}^{n}\sum_{j=1}^{m}p_{ij}x_{ij}) \tag{4}$$

$$G_2=\min(\sum_{i=1}^{n}\sum_{j=1}^{m}c_{ij}x_{ij}) \tag{5}$$

$$G_3=\min\max_{j=1,..,n}(\sum_{f(i)=j}(\sum_{o=1}^{w}(q_{oi}+t_{oij}\times t_i)+\sum_{k=1}^{m}(\frac{e_{ik}}{d_{j,f(k)}})x_{ij}) \tag{6}$$

$$s.t.\sum_{i=1}^{n}x_{ij}=1,\ j=1,..,m;$$

$$q_{oi}+t_{oij}\times t_i\le q_{o,i+1},o=1,..,w;i=1,..,m;\ j=1,..,n;$$

$$x_{ij}=0 \text{ or } 1, i=1,..,m;\ j=1,..,n$$

3. Model Solution

Fuzzy task assignment model of web services supplier in collaborative development environment is a multi-objective problem with fuzzy system, so it is difficult to get an accurate solution. According to the α sets and the extension principle, comprehensive analysis of the literature [9-11]. Let $G_p^{\min}$ and $G_p^{\max}$ as the target (4) of the upper and lower bounds, $G_c^{\min}$ and $G_c^{\max}$ as the target (5) of the upper and lower bounds, $G_t^{\min}$ and $G_t^{\max}$ as the target (56) of the upper and lower bounds, the multi-objective fuzzy assignment model is decomposed into two linear goal programming model(FMOAP_1 and FMOAP_2):

MODEL FMOAP_1:

$$Z_\alpha^L = \max(\beta \times \mu_p(x) + \delta \times \mu_c(x) + \gamma \times \mu_t(x))$$

$$s.t.$$

$$\mu_p(x) = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(p_{ij})_\alpha^L x_{ij} - G_p^{\min}}{G_p^{\max} - G_p^{\min}},$$

$$\mu_c(x) = \frac{G_c^{\max} - \sum_{i=1}^{m}\sum_{j=1}^{n}(c_{ij})_\alpha^U x_{ij}}{G_c^{\max} - G_c^{\min}}$$

$$\mu_t(x) = \frac{G_t^{\max} - \left\{ \max_{j=1,..,n}\left(\sum_{f(i)=j}^{m} \left(\sum_{o=1}^{w}(q_{oi} + (t_{oij})_\alpha^U \times t_i) + \sum_{k=1}^{m}\left(\frac{(e_{ik})_\alpha^U}{(d_{j,f(k)})_\alpha^L}\right)\right) x_{ij} \right) \right\}}{G_t^{\max} - G_t^{\min}} \tag{7a}$$

$$\sum_{j=1}^{n} x_{ij} = 1, j = 1,..,m;$$

$$q_{oi} + (t_{oij})_\alpha^U \times t_i \le q_{o,i+1}, o = 1,..,w; i = 1,..,m; j = 1,..,n;$$

$$x_{ij} = 0 \text{ or } 1, i = 1,..,m; j = 1,..,n;$$

$$\beta + \delta + \lambda = 1$$

MODEL FMOAP_2:

$$Z_\alpha^U = \max(\beta \times \mu_p(x) + \delta \times \mu_c(x) + \gamma \times \mu_t(x))$$

$$s.t.$$

$$\mu_p(x) = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(p_{ij})_\alpha^U x_{ij} - G_p^{\min}}{G_p^{\max} - G_p^{\min}},$$

$$\mu_c(x) = \frac{G_c^{\max} - \sum_{i=1}^{m}\sum_{j=1}^{n}(c_{ij})_\alpha^L x_{ij}}{G_c^{\max} - G_c^{\min}}$$

$$\mu_t(x) = \frac{G_t^{\max} - \left\{ \max_{j=1,..,n}\left(\sum_{f(i)=j}^{m} \left(\sum_{o=1}^{w}(q_{oi} + (t_{oij})_\alpha^L \times t_i) + \sum_{k=1}^{m}\left(\frac{(e_{ik})_\alpha^L}{(d_{j,f(k)})_\alpha^U}\right)\right) x_{ij} \right) \right\}}{G_t^{\max} - G_t^{\min}} \tag{7b}$$

$$\sum_{j=1}^{n} x_{ij} = 1, j = 1,..,m;$$

$$q_{oi} + (t_{oij})_\alpha^L \times t_i \le q_{o,i+1}, o = 1,..,w; i = 1,..,m; j = 1,..,n;$$

$x_{ij} = 0$ or $1, i = 1,.., m; j = 1,.., n;$

$\beta + \delta + \lambda = 1$

To solve the model FMOAP_1 and FMOAP_2, upper and lower bounds of each objective function value must be determined. We can solve each objective function(not considering the objective function) corresponding to the set $\alpha = 0$ of the maximum and minimum values. β, δ, λ respectively represent preference of the supplier ability, cost, development time, and the experts in charge give the value of preference according to the actual situation. It's value is in the range of [0, 1], and meet $\beta + \delta + \lambda = 1$. Because the coefficients of objective function are given fuzzy number, and the values are obtained by α cut sets is fuzzy. Therefore the different values, which obtained according to the specific requirements of decision makers or using the defuzzification method to confirm results.

4. Algorithm Design

According α cut sets and extension principle, we have decomposed the fuzzy multi-objective task assignment model into a linear goal programming model.

The assignments of web services supplier in the collaborative development are interactive, therefore it is necessary to select suitable heuristic algorithm. By using the genetic and simulated-annealing algorithm to solve the task assignment model, the basic process of solving algorithm are as follows:

(1) Describe the algorithm parameters

m : the number of web services;

n : the number of supplier;

T :initial temperature;

W :mutation rate;

Gen :the number of generation cycle;

(2) Algorithm description

1) Code

Using binary code (0 represent the supplier is not assigned, 1 represent the supplier is assigned), the length of the string is the number of web services;

2) The initial population

Randomly generating the required number of population, the length of each population for the web services number is m. The population of nodes are represented by binary, each individual in the population represents whether the supplier should be assigned to complete the corresponding web services;

3) Select operation

Generating the offspring group from the parent group, then randomly select individual of i and j both from the parent and offspring group, the i and j is competitive into the next generation of probability for：

$$\exp(\frac{f(i) - f(j)}{T})$$

4) Crossover operation

The random part structure of two parent individual is replaced and reorganized and then generates new individual by using the multi-point crossover operator.

5) Mutation operation

The random number 0-1 and the comparison between the ways of mutation, if the random number is less than W, the selected parent population by random mutation to generate new population.

5. Simulation Analysis

Assume that the software developer plans to design a set of software system which is decomposed into 12 web services. There are 8 candidate web services suppliers. Although each web services supplier has different information (development ability, the development cost, development cycle), we need to select the most proper supplier in collaborative development environment. The condition is: the shortest development cycle, the highest reliability and minimum cost. For the sake of clarity, we assume the same development time of different suppliers dealing with the same web services at different stages

Because the supplier basic information is fuzzy, we use the trapezoidal fuzzy numbers to represent the different degree of fuzzy information, as shown table 1.

Table 1. Trapezoidal Fuzzy Number Relationship

	ability	cost	time	web services relationship	Supplier relationship	fuzzy number
A	weakest	Lowest	shortest	weakest	weakest	0,0,0.1,0.2
B	weak	Low	Short	weak	weak	0.1,0.2,0.2,0.3
C	weaker	lower	Shorter	weaker	weaker	0.2,0.3,0.4,0.5
D	moderate	moderate	moderate	moderate	moderate	0.4,0.5,0.5,0.6
E	stronger	Higher	Longer	stronger	stronger	0.5,0.6,0.7,0.8
F	strong	High	Long	strong	strong	0.7,0.8,0.8,0.9
G	strongest	highest	longest	strongest	strongest	0.8,0.9,1.0,1.0

The following three Tables 2-4 respectively represent the supplier (S1-S8) fuzzy evaluation value of design web services (C1-C12) capacity, cost and development time.

Table 2. Supplier Development Ability

ability	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
S1	F	B	B	B	F	E	D	B	F	B	F	F
S2	E	G	F	B	F	F	G	D	B	B	B	C
S3	D	F	E	D	B	F	F	F	B	C	C	B
S4	B	D	F	A	F	E	B	G	F	F	F	F
S5	B	D	B	G	E	G	B	B	C	F	E	E
S6	D	B	G	F	C	B	B	C	C	F	B	F
S7	D	B	F	B	B	B	F	C	E	D	C	G
S8	F	D	E	C	F	D	F	F	F	G	E	B

Table 3. Suppler Development Cost

cost	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
S1	D	B	A	E	D	D	C	D	D	F	D	C
S2	D	F	D	C	C	D	D	C	D	C	D	F
S3	E	F	F	C	D	F	E	E	C	C	F	E
S4	C	E	D	B	E	B	F	C	C	B	F	C
S5	B	D	B	F	E	E	C	D	B	C	B	B

S6	C	F	D	E	D	G	E	D	B	D	B	C
S7	C	F	D	B	D	F	D	F	E	E	B	D
S8	F	C	E	F	B	D	E	F	F	D	E	D

Table 4. Suppler Development Time

time	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
S1	A	E	F	C	F	D	B	E	B	F	A	B
S2	C	A	B	F	A	D	A	F	F	E	G	F
S3	E	C	C	E	F	B	D	B	D	D	F	F
S4	G	B	D	G	B	F	D	A	A	B	B	E
S5	F	B	D	A	B	C	F	D	E	C	B	C
S6	D	D	A	B	D	F	D	F	D	D	F	B
S7	D	E	B	F	G	E	C	C	F	D	D	A
S8	C	F	B	F	F	D	B	C	B	A	D	B

After the decomposition of project, the information dependence degrees of each web services are given in Table 5. The information dependency matrix is symmetric, the same web services and the no dependence information degree of web services is 0.

Table 5. Information Dependence of Web Services

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
C1	0	F	G	C	B	B	C	0	0	0	0	0
C2		0	0	E	F	F	0	B	0	0	0	0
C3			0	0	0	0	F	0	C	C	0	0
C4				0	0	0	0	F	0	C	C	0
C5					0	0	0	F	0	C	B	0
C6						0	0	B	F	C	C	0
C7							0	0	F	F	C	0
C8								0	0	F	F	D
C9									0	F	D	B
C10										0	F	E
C11											0	F
C12												0

+

The coordination degrees of different suppliers are showed the Table 6, which the highest degree of coordination between suppliers is one. At the same time the higher degree of coordination, the coordination spend less time.

Table 6. Degree of Coordination Between Suppliers

	S1	S2	S3	S4	S5	S6	S7	S8
S1	1	F	B	F	B	E	D	B
S2		1	B	D	B	D	E	B
S3			1	B	B	D	B	C
S4				1	B	F	F	B
S5					1	B	D	B

S6	1	F	D
S7		1	F
S8			1

The web services for the longest time t_i: Time= [21 30 18 14 20 17 15 15 19 15 17 20],the web services process o is following Table 7:

Table 7. Web Services Process

o	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	1	2	2	2	3	4	5	6	7	7	8	8	9	10	11
	2	3	4	5	6	7	8	8	9	9	10	10	11	10	11	12

According to the SGSA algorithm in the MATLAB programming, input parameter T =1000,
W =0.35, Gen =1000. Supplier capacity, cost, development time is respectively 0.2,0.3,0.5. Using α cuts（α =0,0.1,0.2,..,1）can be calculated for each set of solutions of G_1, G_2, G_3, Z . The solution sets in Table 8, the corresponding membership function distribution is shown in Figure 1.

Table 8. G_1 **,** G_2 **,** G_3 **,** Z **Fuzzy Sets**

α	$(P)_\alpha^L$	$(P)_\alpha^U$	$(C)_\alpha^L$	$(C)_\alpha^U$	$(T)_\alpha^L$	$(T)_\alpha^U$	$(Z)_\alpha^L$	$(Z)_\alpha^U$
0	0.569	0.885	0.673	0.868	0.560	0.959	0.585	0.918
0.1	0.593	0.875	0.684	0.856	0.579	0.945	0.604	0.906
0.2	0.610	0.860	0.690	0.849	0.591	0.931	0.616	0.892
0.3	0.620	0.856	0.697	0.841	0.603	0.918	0.626	0.884
0.4	0.629	0.850	0.703	0.830	0.646	0.896	0.652	0.869
0.5	0.638	0.840	0.709	0.822	0.670	0.869	0.668	0.850
0.6	0.640	0.830	0.715	0.810	0.676	0.859	0.673	0.840
0.7	0.664	0.810	0.719	0.794	0.701	0.847	0.693	0.825
0.8	0.670	0.791	0.727	0.782	0.725	0.830	0.708	0.808
0.9	0.683	0.776	0.730	0.776	0.739	0.826	0.720	0.801
1	0.692	0.747	0.739	0.760	0.750	0.810	0.730	0.781

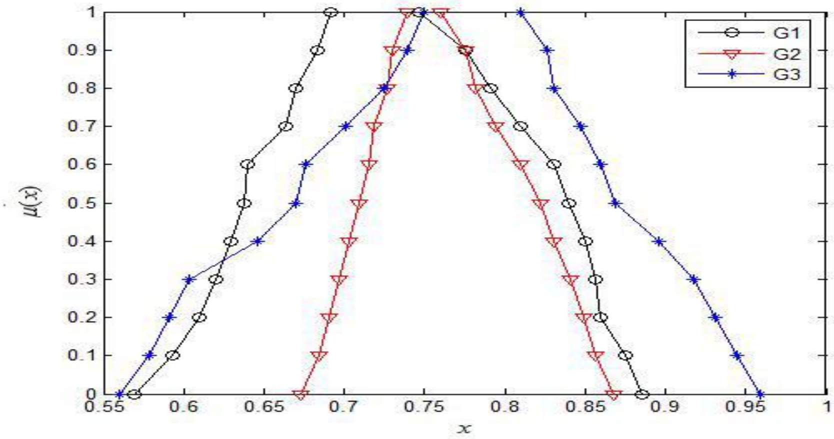

Figure 1. G_1, G_2, G_3 **Membership Function Distribution**

It can be seen from Figure 1 after calculating supplier ability, cost and time as a fuzzy number. The calculation results are different for different α cut sets, and the calculated results for the Z range are different (i.e. as a fuzzy number). It will need Z to be defuzzified into a real number, which provide an accurate assignment scheme for decision makers.

6. The Centroid Defuzzification Method

Several defuzzification methods have been developed in the fuzzy control area, such as the centroid, the center of maxima method, and the mean of maxima method [13]. Among them, the centroid defuzzification method is often used, and this method is defined as follows:

$$x_0(A) = \frac{\int_a^d x\mu_A(x)dx}{\int_a^d \mu_A(x)dx} \tag{8}$$

The model (FMOAP_1 和 FMOAP_2) can be defuzzified into a real number by Formula (8), that the fuzzy membership function must be known. But it is difficult to confirm the fuzzy membership function of the model (FMOAP_1 和 FMOAP_2). In this paper, using the method mentioned in the literature [12], we compute Z under the left and right boundary value by α set. By using α set defuzzification, we get Table 9. Using the data of Table 9 into formula (9) getting $Z(A) = 0.738$, finally get the task assignment scheme are given in Table 10 and development process following Figure 2.

$$Z(A) = \frac{1}{3} \times \frac{((z)_{\alpha_0}^{2U} - (z)_{\alpha_0}^{2L}) + 2\sum_{i=1}^{n-1}((z)_{\alpha_i}^{2U} - (z)_{\alpha_i}^{2L}) + \sum_{i=0}^{n-1}((z)_{\alpha_i}^{U} \times (z)_{\alpha_{i+1}}^{U} - (z)_{\alpha_i}^{L} \times (z)_{\alpha_{i+1}}^{L})}{((z)_{\alpha_0}^{L} - (z)_{\alpha_0}^{L}) + 2\sum_{i=1}^{n-1}((z)_{\alpha_i}^{U} - (z)_{\alpha_i}^{L})} \tag{9}$$

Table 9. The Solution of Centroid Defuzzification Method

α	$(z)_{\alpha_i}^U - (z)_{\alpha_i}^L$	$(z)_{\alpha_i}^{2U} - (z)_{\alpha_i}^{2L}$	$(z)_{\alpha_i}^L \times (z)_{\alpha_{i+1}}^L$	$(z)_{\alpha_i}^U \times (z)_{\alpha_{i+1}}^U$
0	0.333	0.500	0.353	0.831
0.1	0.302	0.456	0.372	0.808
0.2	0.276	0.416	0.385	0.788
0.3	0.258	0.390	0.408	0.768

0.4	0.217	0.330	0.435	0.738
0.5	0.182	0.276	0.449	0.714
0.6	0.167	0.253	0.466	0.693
0.7	0.132	0.200	0.490	0.666
0.8	0.100	0.151	0.509	0.647
0.9	1.081	0.123	0.525	0.625
1	0.051	0.077		

Table 10. Task Assignment Scheme

web services	1	2	3	4	5	6	7	8	9	10	11	12
supplier	1	2	6	6	2	3	7	4	4	4	1	7

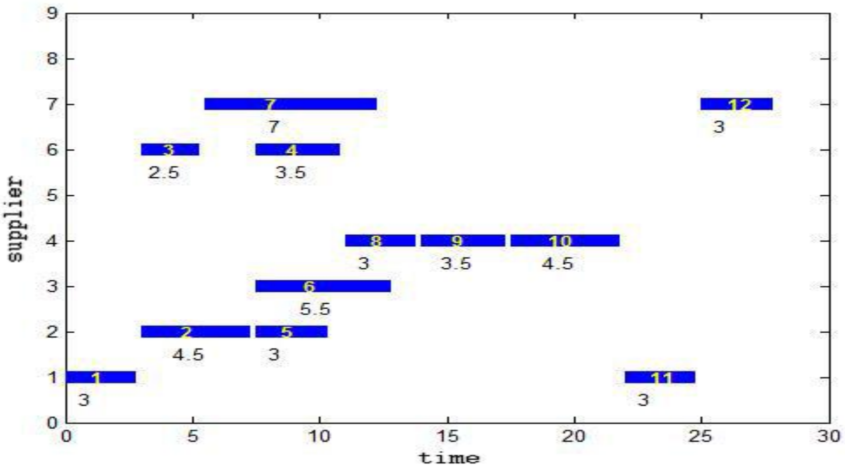

Figure 2. The Development of Task Process

7. Conclusions

Because there is no certain relevant information of component suppliers' ability, cost, time, supplier relations and web services in collaborative development environment, we put forward the fuzzy multi-objective task assignment model of web services in this paper. In this way, we not only realize the demand of high reliability, low cost and short time of web services in the process of software development projects, but also provide a task optimization assignment for software Development Company. In the process of solving the model optimal solution, we simplify the complex fuzzy multi-objective problem into a single objective optimization problem using α set and extension of the principle, get the simplified single objective optimization model with the Genetic and simulated-annealing algorithm, and finally verify its good convergence by simulation. Besides, in response to the final model solution sets are fuzzy and uncertain membership function, we introduce a new centroid method on fuzzy sets to be defuzzified and get the final solution, which can reasonably and effectively assign the corresponding suppliers the decomposed web services and arrange further procedures. Therefore, this paper can support task assignment for different suppliers involved in software development in collaborative development environment both in theory and in practice.

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