Fuzzy Task Assignment Model of Web Services Supplier

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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 $\alpha$ 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. 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; extension principle.

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[1],[2]. 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.1

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In view of the above problems, 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 $\alpha$ sets and the extension principles and set up single objective optimization model decomposed with genetic and simulated-annealing algorithm [6].

## 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 components is $m$, the number of the 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 $w$.

$t$: the $i$ 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]; $t_{ij}$: 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]; $t_{ij}$: the longest development time of the $i$ web services; $d_{io}$: 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]; $d_{i..f(k)}$: 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[3], there are
dependencies among the web services, so the collaborative time supplier \( j \) required in the development of the web services \( i \) can be expressed as:

\[
T_{\text{coll}}(j) = \sum_{f(i) \neq j} \sum_{k \neq j} \frac{e_{ik}}{d_{j,f(k)}}.
\]  

(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. \( d_{j,f(i)} \) represents the coordination degree between the \( i \) supplier and the \( j \) supplier. When \( f(k) = j \), the coordination degree of up to 1. Each supplier to the web services development time is expressed as \( t_{\omega j} \times t_i \). According to the web services of development time and each supplier to the web services, the \( j \) supplier to develop collaborative development time of all web services can be expressed as :

\[
T_{\text{coll}}(j) = \sum_{f(i) \neq j} \left( \sum_{o=1}^{n} (q_{\omega o} + t_{\omega o} \times t_i) + \sum_{k \neq j} \left( \frac{e_{ik}}{d_{j,f(k)}} \right) \right).
\]  

(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[4],[5]. Therefore, software project development time shortest is seeking a minimal model, expressed as:

\[
\min \max(T_{\text{coll}}(j))(j = 1..n).
\]  

(3)

Fuzzy task assignment problem of web services supplier in collaborative development environment can be described as a fuzzy multi-objective assignment problem as follows:

\[
G_1 = \max \left( \sum_{i=1}^{n} \sum_{j=1}^{m} p_{ij} x_{ij} \right).
\]  

(4)

\[
G_2 = \min \left( \sum_{j=1}^{m} c_{j} x_{ij} \right).
\]  

(5)

\[
G_3 = \min \max \left( \sum_{j=1}^{m} \sum_{o=1}^{n} (q_{\omega o} + t_{\omega o} \times t_i) + \sum_{k \neq j} \left( \frac{e_{ik}}{d_{j,f(k)}} \right) x_{ij} \right)
\]  

s.t. \( \sum_{j=1}^{m} x_{ij} = 1, \ j = 1,..,m; \ \ q_{\omega o} + t_{\omega o} \times t_i \leq q_{\omega, i+1, o} = 1,..,n \wedge i = 1,..,m; \ j = 1,..,n; \)

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

(6)
3 Algorithm Design

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

MODEL FMOAP_1:

\[ Z^u = \max \left( \beta \times \mu_p (x) + \delta \times \mu_c (x) + \gamma \times \mu_i (x) \right) \]

s.t.

\[ \mu_p (x) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} (p_{ij})^L x_{ij} - G_p^{\min}}{G_p^{\max} - G_p^{\min}}, \quad \mu_c (x) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} (c_{ij})^U x_{ij}}{G_c^{\max} - G_c^{\min}}, \quad \mu_i (x) = \frac{G_i^{\max} - \left( \max \left( \sum_{i=1}^{m} \sum_{j=1}^{n} \left( q_{ai} + (t_{ai})^U \times t_i \right) + \sum_{k=1}^{u} \left( d_{i,k} \right)^U \right) x_{ij} \right)}{G_i^{\max} - G_i^{\min}} \]

\[ \sum_{j=1}^{n} x_{ij} = 1, \quad j = 1, \ldots, m; \quad q_{ai} + (t_{ai})^U \times t_i \leq q_{a,j+1}, \quad a = 1, \ldots, w; \quad i = 1, \ldots, m; \quad j = 1, \ldots, n; \]

\[ x_{ij} = 0 \quad \text{or} \quad 1, \quad i = 1, \ldots, m; \quad j = 1, \ldots, n; \quad \beta + \delta + \gamma = 1 \]. \quad (7a)

MODEL FMOAP_2:

\[ Z^u = \max \left( \beta \times \mu_p (x) + \delta \times \mu_c (x) + \gamma \times \mu_i (x) \right) \]

s.t.

\[ \mu_p (x) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} (p_{ij})^L x_{ij} - G_p^{\min}}{G_p^{\max} - G_p^{\min}}, \quad \mu_c (x) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} (c_{ij})^L x_{ij}}{G_c^{\max} - G_c^{\min}}, \quad \mu_i (x) = \frac{G_i^{\max} - \left( \max \left( \sum_{i=1}^{m} \sum_{j=1}^{n} \left( q_{ai} + (t_{ai})^L \times t_i \right) + \sum_{k=1}^{u} \left( d_{i,k} \right)^L \right) x_{ij} \right)}{G_i^{\max} - G_i^{\min}} \]

\[ \sum_{j=1}^{n} x_{ij} = 1, \quad j = 1, \ldots, m; \quad q_{ai} + (t_{ai})^L \times t_i \leq q_{a,j+1}, \quad a = 1, \ldots, w; \quad i = 1, \ldots, m; \quad j = 1, \ldots, n; \]

\[ x_{ij} = 0 \quad \text{or} \quad 1, \quad i = 1, \ldots, m; \quad j = 1, \ldots, n; \quad \beta + \delta + \gamma = 1 \]. \quad (7b)

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: $\exp\left(\frac{f(i) - f(j)}{T}\right)$.

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.

4 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 $\alpha$ set and extension of the principle. Finally, we get the simplified single objective optimization model with the Genetic and simulated-annealing algorithm.

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