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Service Combination Using Lagrange Optimization Method and Evolutionary Algorithm

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Abstract

Various methods on the combination of web services have been implemented in the past. Each one of these methods is aimed at achieving an optimal service combination among the numerous ones; however, each method suffered from some disadvantages, regardless of its advantages. The selection of a suitable approach is key to adopting an optimal web service combination. The present study tackles the investigation of the Lagrange optimization method, which is a systematic approach based on the minimum distance between the user's request and the Lagrange curve. The results obtained from using the Lagrange optimization method indicated that this method provides a yielding output compared to other methods of web service combination. Also, given the features of Lagrange functions, it can be concluded that the Lagrange method can be used for higher service quality modes and settle multi-objective problems, while this might be unrealized in other related methods. Finally, the evolutionary algorithm of Single_EA (Single Evolutionary Algorithm) was used to implement the plan.

Keywords: Evolutionary algorithm, Optimization of Lagrange, Web service combination, Web service.

1. Introduction

Service oriented architecture provides a calculation model of loose coupling, in which business performance and API access data are defined (Griffiths and Chao, 2010). Most companies and organizations nowadays place their business on the internet platform and seek to downsize their physical structure by outsourcing the projects of different parts of their organization. Also, as time passes, the requirements of customers in business environments increase rapidly, and this may result in serious challenges confronting the development of information systems (Zhang, 2011). A single service cannot mostly meet the intricate needs of customers; accordingly, the aforesaid needs are expected to be satisfied with a combination of several services. Now, how can users select their desirable and suitable service from among the similar ones? Is this service always available? Is it a cost-effective service? Is the service able to reach the answer early, before the expected time duration? Is the selected service well known and reputable? Such questions have always been proposed on service quality criteria in electronic business and exchanges between enterprises (Zhao et al., 2012). Therefore, this study is aimed at providing a new approach to a proper selection and combination of web services in large-scale organizations based on service quality criteria so that users can adopt, from among the available services, the best service at the earliest time, based on the quality criteria of each service (Wang et al., 2007). Here, a question arises as to "How is it possible to reach an optimal service with the least limitation?" When it comes to m multiple dimensions in discussing web service combination, multi-objective optimization model problems come up, since favourite linear functions can be used only in convex spots, and fail to reach a right answer at non convex points (Sashay et al., 2010). It goes without saying that given the limited web service combination at an agreed upon level, using a systematic method based on the available models and its combination with a number of certain available algorithms may particularly settle the multi-objective optimization model problems. The current study provides a Lagrange optimization method, which could resolve current problems related to web service combination. This method also enjoys a better and shorter response time duration in the adoption of an ideal combination among the current methods.

2. Lagrange optimization

Lagrange optimization is one of the most common scalarization methods in multi-objective optimization (Funaro, 2008). Its main advantage lies in the fact that each request of the user is obtained through the minimum distance, irrespective of it being a convex, non-convex or discrete problem.

The Lagrange optimization method has an evaluation function on the basis of which the Lagrange curve can be drawn. The Lagrange function can be defined for all solutions of the desired service class as below, in Eq. (1) (Lin et al., 2010):

$$\mathrm{p(X)} = \mathrm{L_0(X)f(X_0)} + \cdots + \mathrm{L_n(X)f(X_n)} \qquad (1)$$

Given Eq. (1), we have:

i. $\mathrm{L_{n:}}$ $\mathrm{L_n}$ values are defined as Eq. (2):

$$\mathrm{L_{n.k}(x)} = \frac{(\mathrm{x}-\mathrm{x_0})\ldots(\mathrm{x}-\mathrm{x_{k-1}})(\mathrm{x}-\mathrm{x_{k+1}})\ldots(\mathrm{x}-\mathrm{x_n})}{(\mathrm{x_k}-\mathrm{x_0})\ldots(\mathrm{x_k}-\mathrm{x_{k-1}})(\mathrm{x_k}-\mathrm{x_{k+1}})\ldots(\mathrm{x_k}-\mathrm{x_n})} \qquad (2)$$

In Eq. (2), values of (x_0, x_1, … ,x_k , x_{k+1},…, x_n) are identical to the values of x-axis ($\mathrm{q_i}$).

ii. $f(x_n)$: values of $f(x_n)$ are identical to the values of y-axis (q_j).

The following lines help shed light on the matter by presenting the steps of the procedure along with an example. In this connection and prior to getting down to the stages some notes should be considered first.

i. Dimensions of the quality used in the Lagrange optimization method have been examined at two dimensions of q_1 and q_2. It will be proved that the Lagrange optimization method is required to know the more relevant dimensions. The dimensions adopted may include response cost, response time, usage memory, etc.

ii. The example provided here focuses on how the method is applied. Thus, four service classes $\mathrm{CS_1}$, $\mathrm{CS_2}$, $\mathrm{CS_3}$ and $\mathrm{CS_4}$ are used in this connection.

Example 1: Four service classes with service quality values, as per Table 1, are assumed.

Table 1
The quality of service.

Class of Service	Q1	Q2
CS1	1	-6
CS2	2	4
CS3	3	2
CS4	4	6

Stages of obtaining the Lagrange optimization method include:

i. Obtaining the Lagrange values

In order to obtain the Lagrange values, the dimensions of $\mathrm{Q_1}$ and $\mathrm{Q_2}$, with values of X and Y respectively, were considered on the coordinates plane. In order to obtain $\mathrm{L_n}$ (Lagrange) values, the abovementioned Eq. (2) was used.

Given Eq. (2) and Table 1, the Lagrange value of $\mathrm{L_0}$ was achieved, as below:

$$\mathrm{L_0} = \frac{(\mathrm{X}-\mathrm{X_1})(\mathrm{X}-\mathrm{X_2})(\mathrm{X}-\mathrm{X_3})}{(\mathrm{X_0}-\mathrm{X_1})(\mathrm{X_0}-\mathrm{X_2})(\mathrm{X_0}-\mathrm{X_3})} = \frac{(\mathrm{X}-2)(\mathrm{X}-3)(\mathrm{X}-4)}{(1-2)(1-3)(1-4)} = \frac{\mathrm{X^3}-9\mathrm{X^2}+26\mathrm{X}-24}{-6}$$

Likewise, the other values of Lagrange were calculated as follows.

$$\mathrm{L_1} = \frac{\mathrm{X^3}-8\mathrm{X^2}+19\mathrm{X}-12}{2}$$

$$\mathrm{L_2}\frac{\mathrm{X^3}-7\mathrm{X^2}+14\mathrm{X}-8}{-2}$$

$$\mathrm{L_3}\frac{\mathrm{X^3}-6\mathrm{X^2}+11\mathrm{X}-6}{6}$$

ii. Obtaining the evaluation function

In order to obtain the evaluation function, Eq. (3) was used (Lin et al., 2010).

$$\mathrm{P(x)}= \mathrm{f(x_0)L_{n.0}(x)} + \cdots + \mathrm{f(x_n)L_{n.n}(x)} = \textstyle\sum_{\mathrm{L-n}}^{\mathrm{n}} \mathrm{f(x_k)L_{n.k}(x)} \qquad (3)$$

Given Eq. (3) and the Lagrange values achieved from the first stage, the evaluation function for the aforementioned example would be as:

$$\mathrm{P(x)}=\left(\frac{\mathrm{X^3}-9\mathrm{X^2}+26\mathrm{X}-24}{-6} * -6\right) + \left(\frac{\mathrm{X^3}-8\mathrm{X^2}+19\mathrm{X}-12}{2} * 4\right) + \left(\frac{\mathrm{X^3}-7\mathrm{X^2}+14\mathrm{X}-8}{-2} * 2\right) + \left(\frac{\mathrm{X^3}-6\mathrm{X^2}+11\mathrm{X}-6}{6} * 6\right) = 3\mathrm{X^3} - 24\mathrm{X^2} + 31\mathrm{X} - 46$$

3. Equations and graphs

At this stage, the polynomial equation obtained from the second stage should be solved so that the results obtained are used for calculations in the next stage. However, an important note here is the fact that when the equation is of high grade, it is difficult to solve; i.e. for *n* service classes, there would be *n-1* polynomial grades. Therefore, certain kinds of software are needed to solve the polynomial equations. A range, as stated earlier, is required in this respect, in order to cope with this problem.

Fig. 1 shows the Lagrange function *P(x)*, with two dimensions of q_1 and q_2.

1. Obtaining the distance between the request and the drawn curve.

At this stage, the best suitable service is selected, based on the user's request. The selection of the optimal service (s) is made, considering the distance of the quality value of the service requested by the user to the spots on the curve. Prior to getting down to the method of calculation of this distance, it is necessary to consider that after making the request, it may be subjected in two situations to the Lagrange curve, which has been drawn based on the quality value of the service classes.

a. The request is placed on the curve

This rare situation indicates that the request of the user has been excellent, and the distance between the request and the desired service class is zero. Therefore, the aforementioned class was selected. In this situation, the user's request is limited to only one optimal service class, because the best suitable situation of all has been adopted.

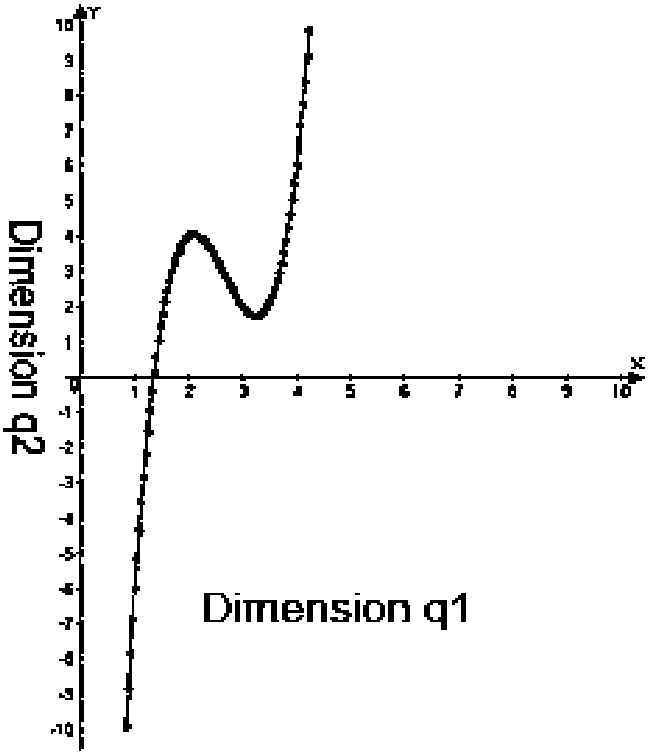

Fig. 1. Function Chart $P(x)= 3X$^$3-24X$^$2+31X-46$.

b. The request is not placed on the curve

In this situation, the distance of the user's request as a point with dimensions of q_1 and q_2 to all service classes the points with dimensions of q_1 and q_2 is calculated. In such circumstances, the minimum distance to the service classes is investigated and the minimum distance is selected. Now, it is possible, like the first situation, that only one service class or TOP K of the first situation is selected. Eq. (4) could be used to calculate the distance between the two points (Fletcher, 2013; Zeidler, 2013).

$$\sqrt{(q_{1.0}-q_{1.1})^2+(q_{2.0}-q_{2.1}\,)^2} \tag{4}$$

Example 2: The assumption is a request by the user based on the optimal web service combination with dimensions of 2×2. In order to obtain the minimum distance to the four classes presented in Table 1, we have:

Distance between request and the first service class $= \sqrt{(2-1)^2+(2+6)^2} = 8/06$.

Distance between request and the Second service class $= \sqrt{(2-2)^2+(2-4)^2} = 2$.

Distance between request and the Third service class $=\sqrt{(2-3)^2+(2-2)^2} = 1$.

Distance between request and the Fourth service class $=\sqrt{(2-4)^2+(2-6)^2} = 4/47$

Considering the results obtained from the example provided, it could be concluded that:

For the request made by the user with dimensions of 2×2, CS3 service class could be selected as the optimal combination of the available service classes (four assumptive classes). Likewise, the service classes of CS2, CS4 and CS1 are placed in the next ranks.

4. Single_EA evolutionary algorithm

It is a typical single objective evolutionary algorithm, which has been developed to determine an optimal or near-optimal solution for a service combination. In the present study, the abovementioned algorithm was used for the Lagrange optimization method (Zhao et al., 2015).

Single objectiveness means there is always only one optimal or near-optimal solution. Every implementation of Single_EA evolutionary algorithm makes the previous optimal solution substituted for a newly obtained one.

5. Simulation results

In order to implement and analyse the Lagrange method, two different situations on the current methods are examined, including:

Situation 1: Weighted Tchebycheff distance method, Lagrange method in two dimensions, and *k* service selection are examined. K service refers to the notion that the best suitable service is adopted amongst all services for combination with the user's request. In order to select the best service from among 10,000 available ones, the number space of available services is selected randomly. Tables 2 and 3 show the performance evaluation of the two above mentioned methods in optimal web service combination for this situation.

Situation 2: Weighted distance method, Lagrange method in two dimensions, and 10 service sample selections are examined.

Following the tests, it was observed that the results obtained from the Lagrange method were optimized. Two results were assessed, as below, in the output of the test with different records:

i. Response time given to the request of the user
ii. Size of the memory used

Table 1
Situation 1 with two dimensions and a single optimal service.

Search space	The number of service	The number of dimensions	Method Tchebycheff		Method Lagrange	
			Time	Space	Time	Space
20	1	2	0.46	0.72	0.32	0.12
150	1	2	0.31	0.93	0.55	0.23
315	1	2	0.64	1.13	0.81	0.28
615	1	2	1.25	1.78	0.94	0.44
1000	1	2	2.02	2.01	1.01	0.70
4000	1	2	8.03	3.14	1.83	2.67
5000	1	2	10.05	3.82	2.04	3.31
7030	1	2	14.1	4.70	2.49	4.58
8500	1	2	17.05	5.63	2.71	5.58
9500	1	2	19.04	6.33	2.93	6.16

Table 3
Situation 2 with two dimensions and 10 optimal service samples.

Search space	The number of service	The number of dimensions	Method Tchebycheff		Method Lagrange	
			Time	Space	Time	Space
20	10	2	0.11	0.64	0.03	0.39
150	10	2	0.31	0.97	0.13	0.66
315	10	2	0.64	1.92	0.23	0.82
615	10	2	1.25	2.32	0.43	1.12
1000	10	2	2.02	2.38	0.70	1.65
4000	10	2	8.03	3.93	2.66	2.23
5000	10	2	10.05	4.57	3.34	2.77
7030	10	2	14.1	5.91	4.72	4.05
8500	10	2	17.05	6.67	5.58	5.77
9500	10	2	19.05	8.32	6.18	6.55

In order to elucidate the results that have been obtained and to know whether the method offered is better than the weighted distance method, different evaluations are presented in the paragraphs to come together with the relevant charts and figures.

5.1 Evaluation of run time and the memory used, based on two dimensions of quality and single candidate service.

As Table 2 shows, different surveys on service storages demonstrated that the increase in the number of search space in the services entails a roughly linear rise in run time and the used memory in both methods (i.e. offered and weighted distance). However, in the Lagrange optimization method, given the nature and features of this method, the run time and the used memory are reduced compared to the weighted distance method. For instance, the run time and the used memory in a weighted distance method with 4,000 web services were 8.03 seconds and 3.14 mb respectively, while the aforesaid number of services in the offered method were 2.67 seconds and 1.83 mb respectively. The results of the run time and the used memory of the combination algorithm are shown respectively in Figs. 2 and 3. The horizontal coordinate indicates the number of storage services and the vertical coordinate marks the run time in seconds and the used memory in MB.

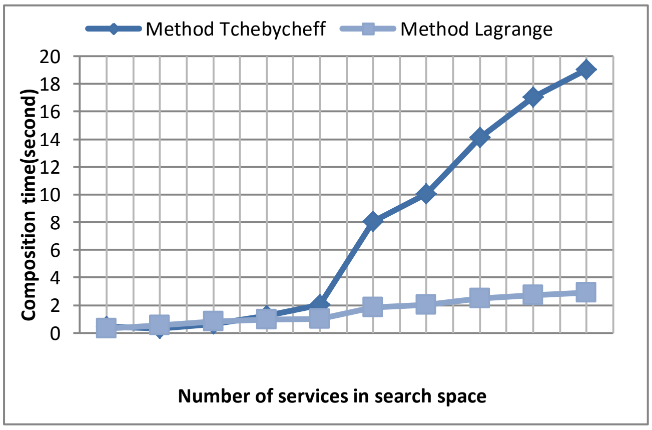

Fig. 2. Run time of combination based on two dimensions and single candidate service.

5.2 Evaluation of run time and used memory, based on two dimensions of quality and top 10 candidate services.

As Table 3 shows, different surveys on service storage demonstrated that the increase in the number of candidate services does not leave a significant impact on the run time in both methods, whilst the memory used in both the methods increases, given a rise in dimensions. Nonetheless, the Lagrange optimization method provides a better output compared to the weighted distance method. For example, the run time and used memory in the weighted distance method with 4,000 web services and 10 optimal candid services were 8.032 seconds and 3.93 mb respectively, and in the offered method, with the same number of services and 10 optimal combinations, were respectively 2.655 seconds and 2.23 mb. The results of the run time and used memory of the combination algorithm are demonstrated in Figs. 4 and 5.

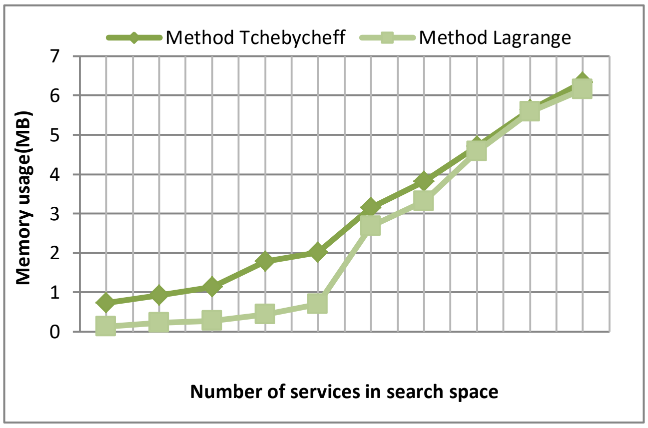

Fig. 3. Used memory of combination based on two dimensions and single candidate service.

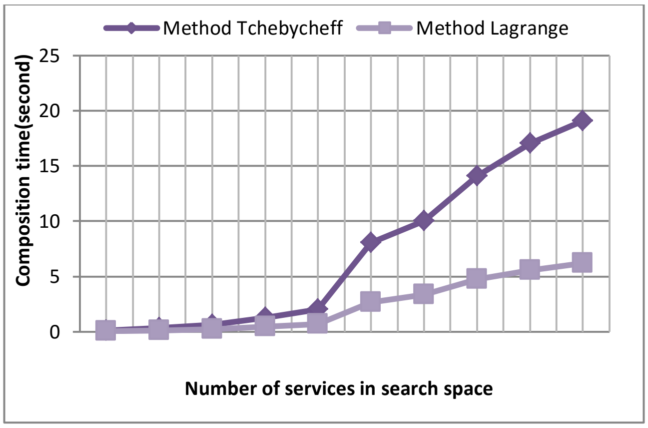

Fig. 4. Run time of combination based on two dimensions and top 10 candidate services.

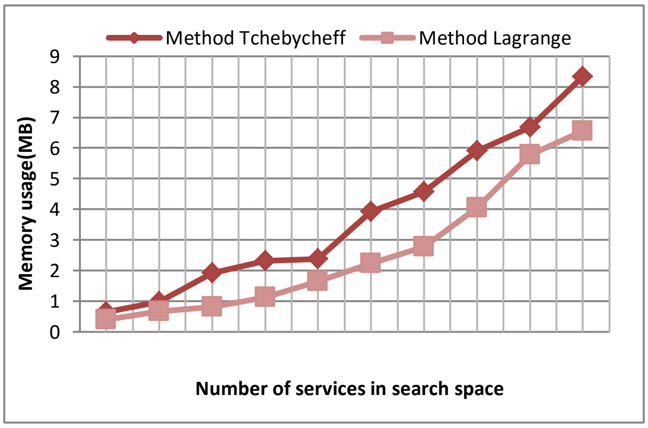

Fig. 5. Used memory of combination based on two dimensions and top 10 candidate services.

6. Conclusion

The present study investigated the evaluation and examination of the results following the implementation of two methods. The results of the output data of these methods demonstrated that the Lagrange optimization method is able to represent a better performance on run time and used memory compared to another method examined. The following findings help cast light on the matter and interpret the results better.

i. An increase in the search space entails a rise in all the algorithms of the web service combination in terms of run time and used memory. However, it is of high significance as to which approach or algorithm is preferred to reduce the run time or used memory.
ii. The results obtained revealed that with an increase in the dimensions of quality, the run time increases slightly, while the used memory rises considerably.
iii. It was witnessed that the weighted Tchebycheff distance method can be considered a more ideal method compared to other ones in the web service combination. Still, the Lagrange optimization method may be a suitable substitute for the aforementioned method, given the fact that based on the overall results, Lagrange provides a better output than the weighted distance method.
iv. Given the features of Lagrange functions, it can be concluded that the Lagrange method can also be used for cases with more dimensions to solve the multi-objective optimization problems while other methods may fail in conducting this.
v. Lagrange's method, generally speaking, is an ideal method in web service combination. The only difficulty which may arise is associated with solving equations that could be settled via the abovementioned offered method.

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