

Mutual Reputation Based Service Mapping in Cloud Environment

Neeraj Yadav, Major Singh Goraya, Damanpreet Singh

Abstract—Due to increase in the number of cloud users (CUs), the number of cloud service providers (CSPs) have also been increased. Among the number of available CSPs, the selection of a suitable CSP for a CU has become a complicated issue. In literature, the reputation of CSPs is used to evaluate their suitability. Since, cloud has a strong business perspective, suitability of CU for a CSP is equally important. The mutual suitability of CSPs and CUs can give new dimensions to service orchestration in cloud. Therefore, this paper proposes a mutual reputation-based service mapping framework for the cloud environment. The mutual reputation of both the CSPs and CUs is used during the service mapping. The reputation of CSPs and CUs is evaluated based on their quality of service (QoS) attributes and for evaluating the reputation of CUs the parameters are defined. Analytical Hierarchy Process (AHP) is used to evaluate the reputation of CSPs and CUs. The mutual reputation-based mapping is depicted through a case study in the paper. Results prove the enhanced performance of the proposed framework in terms of system overhead in comparison to an existing framework.

Keywords—service mapping, quality of service, reputation, ranking, cloud computing

I. Introduction

Cloud computing (CC), is considered as the fifth utility service [1] (four utility services are water, electricity, gas, and telephony) in the modern world. Nowadays the computing needs of the end users (individuals as well as organizations) are changing rapidly. CC gives a viable computing infrastructure where the end users are riden off from the high investments in owning and managing the computing resources locally to fulfill their rapidly changing computing needs. CC also provides various other benefits such as ubiquitous availability, large scalability, and reliability etc.

Because of the enormous benefits of CC, there is a drastic increase in the number of cloud users (CUs) over the years and so is the increase in the number of CSPs. In the competitive open cloud environment similar services are made available by many CSPs. Therefore, CUs has the choice of obtaining cloud-based services (CBSs) amongst many CSPs based on their suitability. Many times, confusion arises in the selection of a suitable CSP for a CU. Therefore, this issue has got a fair deal of consideration in literature. The ranking of CSPs has been recommended in the literature by

many researchers for the selection of a suitable CSP for a CU [2,3,4].

Cloud is a business model where the relationship between CC and CU is set up [5,6]. In business, the identification and retention of the high value and potential customers are important for the competitive industry [7]. In this context, Sohrabi and Khalnari [8] stressed the importance of determining the profitability of customers before deploying resources to them in accordance with their customer value. A TRCSM framework is also proposed in paper [9], two-way ranking based service mapping framework (TRCSM) is proposed which ranks both the participating entities (CSPs and service customers) during service mapping based on their owned and required quality of service (QoS) attributes value. The present research work gives simultaneous consideration to evaluate the suitability of customer along with service provider in cloud environment. Since many CUs may compete for a service from a CSP at an instance, the selection of a suitable CU for a CSP is also important. The mutual suitability of both the participating entities (i.e. CSP and CU) in a service transaction (service delivery and consumption by a CSP and a CU respectively) will give new dimensions to service orchestration in the cloud environment.

Rest of the paper is organized as follows. Next section presents the background on which this work is based and also introduces the attributes of CUs reputation evaluation. Service mapping framework and its components are discussed in section III. Section IV explains the process of reputation based mutual service mapping using a case study. In section V experimental results are discussed. Section VI concludes the research work along with specifying some future directions.

II. Background and attributes of CUs reputation evaluation

In this section, QoS attributes and monitoring tools, MCDM based service selection, and reputation in cloud environment are defined. CU's reputation evaluation parameters are introduced at the end of this section.

A. QoS attributes of CSPs

The QoS in the cloud is the set of standards and mechanisms which ensures the high-quality performance of the typical applications. QoS based service selection has been highly recommended in the cloud environment [11,12]. At present, various performance evaluation tools for the cloud-based services are also available such as CloudCmp [13], CloudHarmony [14], Cloud Monitoring Tool [15], and Cloud-Stone [16]. Besides, the online QoS monitoring of

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CSPs is also available through many websites such as www.dynatrace.com, www.logicmonitor.com, www.site24x7.com, and www.solarwinds.com are also available for evaluating the QoS. The consolidated reputation value of CSPs is evaluated by averaging their ranking score for each CU. In this paper, the standard QoS attributes agility, assurance, financial, performance, and security defined by Cloud Service Measurement Initiative Consortium (CSMIC) [17] are used for ranking the CSPs.

B. Decision Making and Multi-Criteria Based Resource/User Selection

Decision making is the way of selecting alternatives based on single and multiple attributes. While choosing a suitable service provider among many service providers, single QoS attribute has been used in most of the earlier research works. Since, different tasks may have different requirements in terms of QoS parameters. For example, ‘distance’ is an important factor for the time-critical task and ‘efficiency’ should be the high priority for large size tasks. Distance cannot be same for all the tasks because the server may or may not be at the same location [18]. Therefore, this is difficult to combine all the QoS attributes. This is a MCDM problem. Several MCDM methods such as SVD [19], REMBRANDT [20], AHP [21] etc. are used in cloud environment for evaluating the CSPs. AHP method is used for evaluating the reputation of CSPs and CUs.

C. Reputation in the Cloud Environment

In the cloud environment, the reputation of CSPs is intuitively different than others because of the versatility of the CU’s service requirements and the cloud dynamism. The reputation of an entity shows the belief and opinion about that entity. The reputation of a service provider is assumed to be associated with its demand in the cloud environment. A highly demanded service provider has more reputation value. Reputation value is achieved by evaluating the average of the credible value of the service provider that is assigned by different clients [3]. The reputation is defined as:

$$Reputation = \frac{\sum_{i=0}^n R_i}{n} \quad (1)$$

where n number of counterparts (CSPs or CUs) and R_i is the reputation value based on the requirement of their counterpart.

D. CUs Attributes for reputation evaluation

In the cloud environment, no global method is available for comparing the CUs in order to ascertain their suitability (profitable CUs) for a CSP. The suitability of CUs can be represented through their reputation value which is evaluated in the context of desired QoS values of CSPs. For the reputation evaluation of CUs, we introduce flexibility, regularity and financial as their behavior attributes in the present research work. The CUs behavioral attributes are referred as their QoS attributes in the paper to create the

homogeneity with CSPs QoS attributes. The QoS attribute value for each CU is evaluated from their past transactions. The QoS attributes of the CUs are briefly defined as:

- **Flexibility:** Flexibility of a CU shows its adjustability with the QoS of the CSP. The CU who does not get the expected QoS value from a CSP and still does not quit is said to be flexible with the service provider. For example, if CU_1 is demanding 99% of availability but he is getting 97% of availability and still continue the service then the CU’s flexibility is 2% ($\frac{99-97}{100}$). If another CU_2 is demanding 98% of availability and getting 97% of availability and still continue the service, then its flexibility is 1% ($\frac{98-97}{100}$).
- **Regularity:** Regularity depends on the number of service transactions of a CU in a limited time. Large number of service transactions in small time is better for CUs. For example, if CU_1 has 10 transactions in one month and CU_2 has 20 transactions in 3 months then the regularity of CU_1 is higher than CU_2 .
- **Financial:** The amount spent by a CU during each service transaction greatly affects the profit of CSP. Total financial value of a CU is obtained by adding the amount of all transactions.

III. The proposed service mapping framework

Fig. 1. represents the proposed framework. Primary

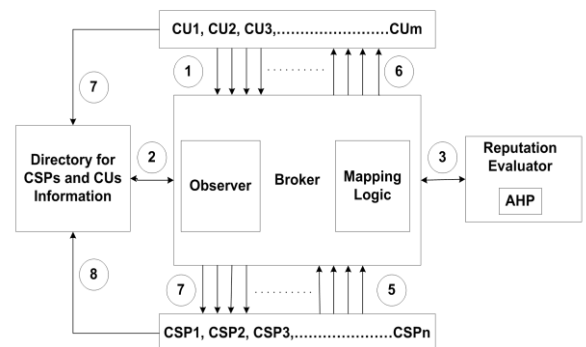


Figure 1. Service mapping framework. Primary components of the framework are:

- **CUs:** CUs requests the cloud-based services. CUs submit the service requests in terms of resource requirements and QoS attributes. The service requests are passed to the broker for mapping and scheduling in cloud environment.
- **Broker:** broker component works as an interface between CSPs and CUs. Broker takes the CU’s service request as input and produces a suitable CSP as output after taking a mapping decision. Broker include observer and mapping logic.
- **Observer:** Observer checks from CSP directory that how many CSPs can fulfill the service requirements. It sends the list of CSPs and CUs to the reputation evaluator. If a CSP violates the SLA, the broker can stop the service.

Mapping Logic: After getting the reputation score of CSPs and CUs from the reputation evaluator the mapping logic performs the mapping between a suitable CSP and CUs.

- CSPs and CUs directory: The directory is a repository to store the information about CSPs and CUs including their reputation value. Broker, CSPs, and CUs are directly connected to the directory for getting and updating the values of CUs and CSPs.
- Reputation Evaluator: Reputation evaluator takes the QoS attributes value of CSPs, behavioral attributes of CUs and the QoS expectations from their counterparts. It evaluates the reputation of each CU and CSP using their ranking score which is evaluated using AHP. After each service transaction, the QoS attributes value and reputation value of both the CSPs and CUs is updated in the directory.
- Cloud Service Provider (CSP): CSP is an organization which provide the cloud-based services to the CUs based on their requirement.

iv. Reputation-based service mapping (RBSM) algorithm

This section presents RBSM algorithm in the cloud environment.

Algorithm: Reputation-based service mapping (RBSM) algorithm

Input: The offered and required QoS attributes of CSPs and CUs.

Output: Reputation based efficient mapping of CSPs and CUs.

Begin

1. initialize variables count, i, j, k ← 0, reputation ← 0;
2. for each SRC(i) do
3. set ranking score of all CSPs for each SRC(i) ← AHP (Offered QoS of CSPs, required QoS values SRC i);
4. end for
5. for each CSP(j) do
6. set ranking score of all CU for each CSP(j) ← AHP (Offered QoS of CUs, required QoS values of CSP j);
7. end for
8. for each CSP(j) do
9. for each CU(i) do
 reputation ← reputation + ranking score of CSP(j) based on the requirement of CU (i);
11. end for
12. reputation of CSP(i) ← reputation;
13. reputation ← 0;
14. end for
15. for each CU(i) do
16. for each CSP(j) do
 reputation ← reputation + ranking score of CSP(j) based on the requirement of CSP(i);
18. end for
19. set reputation of CSP(i) ← reputation;
20. reputation=0;
21. end for
22. bind the first highest reputed CSP to the first highest

reputed CU, second highest reputed CSP to the second highest reputed CU and so on.

End

The CUs are mapped to the CSPs using a single pass of the RBSM algorithm. List of CSPs (who can fulfil the service requests) and CUs (who demands the services) is given as input to the algorithm. If many CUs are requesting the service which can be fulfilled by many CSPs. The CSPs are ranked for each CU based on the offered QoS attributes value of CSPs and required QoS attributes value of each CU (see line 2-4). CUs are also ranked for each CSP based on their offered QoS attributes value and the required QoS attribute value of the CSP (see line 5-7). Aggregated reputation value of CSPs is obtained in line 8-14 of the algorithm by averaging their ranking score evaluated for each CUs. Aggregated reputation value of CUs is obtained by averaging their ranking score for all the CSPs (see line 15-21). The algorithm maps the first (highest) reputed CSP to the first reputed CU, second reputed CSP to the second reputed CU and so on (see line 22).

v. Case Study

Case study depicts the process of proposed mutual reputation-based service mapping framework in the cloud environment. The delivered cloud service is an IaaS service. Three CSPs i.e. CSP₁, CSP₂, CSP₃ and three CUs i.e. CU₁, CU₂, CU₃ are taken in the case study. Table A contains the QoS attribute values of CSPs that is measured by the third party or claimed by the CSPs. In Table B, the requested QoS values of CUs are presented. To get the reputation of each CU, Table C contains the QoS attributes of the CUs based on their past transaction history and Table D contains the required QoS attributes of CSPs. The data values are assigned randomly. The attributes value is normalized in the scale (1 to 9) using Equation 2.

$$new\ score = \frac{nub - nlb}{oup - olb} (old\ score - olb) + nlb \quad (2)$$

TABLE A. QoS attributes offered by CSP

Top level weights	1 st level weights	2 nd level weights	CSP ₁	CSP ₂	CSP ₃
Agility	Elasticity (1)	Time (0.7)	0.5	0.1	0.6
		Cost (0.3)	0.3	0.4	0.2
Assurance	Reliability (0.4)	0.4	97 %	96 %	98 %
	Availability (0.6)	0.6	98 %	97 %	99 %
Finance	Cost (1)	1	1.5 \$/hr	0.3 \$/hr	0.6 \$/hr
Performance	Response Time (1)	1	0.7	0.3	0.2
Security (0-10 scale)	-	-	6	7	8

TABLE B. QoS attributes requested by CUs

Top level weights	First level weights	CSP ₁	CSP ₂	CSP ₃
Agility	Elasticity (1)	0.4	0.3	0.35
Assurance	Reliability (0.4)	95%	94%	96%
	Availability (0.6)	98%	97%	95%

Finance	Cost (1)	0.8 \$/hr	1 \$/hr	1.6 \$/hr
Performance	Response time (1)	0.8	0.9	0.8
Security (0-10 scale)	-	3	6	4

TABLE C. QoS attributes offered by CUs

Top level weights	CU ₁	CU ₂	CU ₃
Financial	0.5	0.7	0.8
Regularity	0.6	0.5	0.4
Capacity	0.7	0.8	0.8

TABLE D. QoS attributes requested by CSPs

Top level weights	CU ₁	CU ₂	CU ₃
Financial	6	3	5
Regularity	3	5	2
Capacity	20%	80%	60%

where, *nub* denotes new upper bound, *nlb* denotes the new lower bound, *oub* denotes the old upper bound, and *olb* denotes the old lower bound.

The normalized QoS attributes value (Table A) of CSPs are:

$$\begin{pmatrix} 4 & 8 & 7 & 7 & 7 \\ 5 & 8 & 2 & 3 & 8 \\ 4 & 8 & 3 & 2 & 9 \end{pmatrix}$$

The normalized QoS attributes value requested by CUs (Table B) are:

$$\begin{pmatrix} 4 & 8 & 4 & 7 & 3 \\ 3 & 8 & 5 & 8 & 5 \\ 3 & 8 & 7 & 7 & 4 \end{pmatrix}$$

The Relative Value Service Matrix (RVSM) of CSPs for agility is given by:

$$RVSM_{Agility} = \begin{matrix} & CSP_1 & CSP_2 & CSP_3 \\ CSP_1 & 1 & 4/5 & 4/4 \\ CSP_2 & 5/4 & 1 & 5/4 \\ CSP_3 & 4/4 & 4/5 & 1 \end{matrix}$$

The Relative Value Service Vector (RVSV) of CSPs for agility is given by:

$$RVSV_{Agility} = 0.3076 \quad 0.3846 \quad 0.3076$$

Similarly, the RVSV for assurance, financial, performance, and security are given by:

$$RVSV_{Assurance} = 0.3333 \quad 0.3333 \quad 0.3333$$

$$RVSV_{Financial} = 0.5833 \quad 0.1666 \quad 0.2500$$

$$RVSV_{Performance} = 0.5833 \quad 0.2500 \quad 0.1666$$

$$RVSV_{Security} = 0.2916 \quad 0.3333 \quad 0.3750$$

By arranging RVSV of CSPs for each attribute into column matrix we get the Overall Performance Matrix (OPM) matrix as given by:

$$\begin{pmatrix} 0.3076 & 0.3333 & 0.5833 & 0.5833 & 0.2916 \\ 0.3846 & 0.3333 & 0.1666 & 0.2500 & 0.3333 \\ 0.3076 & 0.3333 & 0.2500 & 0.1666 & 0.3750 \end{pmatrix}$$

For getting the relative weightage of each attribute required by CU₁, the QoS attributes value are compared and we get the RVSV for CU₁:

$$RVSV_{CU_1} = 0.1538 \quad 0.3076 \quad 0.1538 \quad 0.2692 \quad 0.1153$$

Similarly, relative value vector matrix for CU₂ and CU₃:

$$RVSV_{CU_2} = 0.1035 \quad 0.2760 \quad 0.1725 \quad 0.2760 \quad 0.1725$$

$$RVSV_{CU_3} = 0.1035 \quad 0.2760 \quad 0.2415 \quad 0.2415 \quad 0.1380$$

To get the final ranking score also called Value for Money Matrix (VFM) of each CSP for each CU is obtained by multiplication of OPM and RVSV of each CU.

$$VFM_{CU_1} = \begin{pmatrix} 0.3076 & 0.3333 & 0.5833 & 0.5833 & 0.2916 \\ 0.3846 & 0.3333 & 0.1666 & 0.2500 & 0.3333 \\ 0.3076 & 0.3333 & 0.2500 & 0.1666 & 0.3750 \end{pmatrix} \times \begin{pmatrix} 0.1538 \\ 0.3076 \\ 0.1538 \\ 0.2692 \\ 0.1153 \end{pmatrix}$$

$$VFM_{CU_1} = [0.4301 \quad 0.2930 \quad 0.1265]$$

Similarly, VFM for CU₂ and CU₃ is given by:

$$VFM_{CU_2} = [0.4357 \quad 0.2870 \quad 0.2776]$$

$$VFM_{CU_3} = [0.4458 \quad 0.2784 \quad 0.2761]$$

Using Eq. 1, the reputation of CSPs is evaluated which is given below.

$$\text{Reputation of } CSP_1 = \frac{0.4301+0.4357+0.4458}{3} = 0.4372$$

$$\text{Reputation of } CSP_2 = \frac{0.2930+0.2870+0.2784}{3} = 0.2861$$

$$\text{Reputation of } CSP_3 = \frac{0.1265+0.2776+0.2761}{3} = 0.2267$$

Similarly, the reputation of CUs is evaluated by considering the required QoS attributes value of CSPs and offered QoS attributes value of CUs we have

$$VFM_{CSP_1} = [0.3382 \quad 0.3440 \quad 0.3174]$$

$$VFM_{CSP_2} = [0.2365 \quad 0.1964 \quad 0.3169]$$

$$VFM_{CSP_3} = [0.2686 \ 0.3900 \ 0.3411]$$

$$\text{Reputation of } CU_1 = \frac{0.3382+0.2365+0.2686}{3} = 0.2811$$

$$\text{Reputation of } CU_2 = \frac{0.3440+0.1964+0.3900}{3} = 0.3101$$

$$\text{Reputation of } CU_3 = \frac{0.3174+0.3169+0.4458}{3} = 0.3251$$

CSPs and CUs are sorted based on their reputation value and the CSPs are mapped to the CUs in the order of their reputation values. CSP₁ is mapped to CU₃, CSP₂ is mapped to CU₂ and CSP₃ is mapped to CU₁ in the presented case study.

VI. Experimental Results and Discussion

Simulation experiments are performed to obtain the execution time of the RBSM algorithm. CloudSim 3.0 toolkit with Intel Core i7 2.60GHz and 8 GB system configuration is used in the experimentation. The maximum number of CSPs and CUs is set to 4000 in the simulation. The input data for each attribute and weights are populated using uniform distribution. It is assumed that for an application, the SMI attributes will be bounded by a constant, then the time complexity of the proposed algorithm depends on the number of CSPs and CUs. Results (execution time) are presented in Table E. Results shows that up to 4000 number of CSPs and CUs the proposed mapping algorithm takes less than 10 second. As shown in the table, the performance of the RBSM algorithm is compared with the existing TRSM algorithm proposed in paper [9]. Compared results are presented in Table E. The results clearly show that RBSM algorithm outperforms the existing TRSM algorithm in terms of system overhead. The generated system overhead for a comparative larger input size (number of CSPs and CUs) proves its applicability in the online cloud-based service selection.

Table E. COMPARATIVE ANALYSIS OF EXECUTION TIME

CSPs, CUs	TRSM Algorithm (Execution time in seconds)	RBSM Algorithm (Execution time in seconds)
100, 100	4.153	0.266
500, 500	4.992	0.735
1000, 1000	23.698	1.475
1500, 1500	75.698	2.14
2000, 2000	172.757	3.321
2500, 2500	217.173	4.385
3000, 3000	400.806	5.959
3500, 3500	551.862	7.86
4000, 4000	718.586	9.842

VII. Conclusion

In this paper, a novel mutual reputation-based service mapping framework for cloud environment is presented. Framework presents a brokerage-based selection of CSPs for CUs considering their reputation value. The reputation value of the CSPs and CUs are updated based on the QoS attribute

values and behavior over the service transactions respectively. Thus, the proposed framework motivates the CSPs and CUs to maintain a high reputation in cloud in order to be associated with a reputed counterpart. The efficiency and applicability of the framework in cloud is proved by achieving the reasonable system overhead in terms of execution time of the algorithm used in the framework. In terms of system overhead the presently proposed framework outperforms an existing service mapping framework proposed for the cloud environment in literature. In future, the service satisfaction through service mapping by the proposed framework will be evaluated.

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