Journal of Engineering and Applied Sciences 12 (22): 6022-6028, 2017
ISSN: 1816-949X

An Approach on Efficient Priority Based Service Selection Model in Mobile Cloud Computing

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Abstract: Mobile Cloud Computing (MCC) has recently received tremendous attention from mobile commerce, mobile learning, mobile healthcare and mobile gaming. The mobile cloud services are available to the customers in a pay as you go manner and the customer can access the service anytime, anywhere. The services are dynamically scalable to the users through the internet. Therefore, service provisioning plays a key role in MCC. The challenge of selecting the best service offers becomes in more difficult for the user. This study proposed a priority based multiple criteria based decision making algorithm for the service selection and ranking process. The ranking process involved to take the Quality of Experience (QoE) and quality of service parameters of services such as response time, availability, throughput, reliability, etc. The Priority based Ranking algorithm (PRT) consider QoS parameters for the ranking service which would be differ based on number of QoS parameter considers. The PRT algorithm compared with existing popular service selection methods and proposed method takes O (m·n·logn) time for the ranking the service and identifying which services are better satisfied for the user requirements.

Key words: Mobile cloud computing, QoS, QoE, service selection, fuzzy expert system

INTRODUCTION

Mobile computing is now becoming into reality with the ubiquitous internet connectivity, the power of mobile devices and the vast amount of available cloud services. However, the characteristics of mobile environment such as mobility, unpredictability and variation of the signal-strength of mobile network bring great challenges for the selection of optimal services for orchestration (Huang and Deng, 2014). Also with multiple cloud services available for any given tasks, it becomes difficult to determine the best service which a mobile client should be provided with.

Since, Cloud Computing (CC) is the distributed computing model which provides computing facilities and resources to the users in an on-demand pay-as-you-go model. The aim of the cloud computing model is to increase the opportunities for cloud user by accessing leased infrastructure and software applications from anywhere anytime manner (Buyya *et al*., 2009). So, service, selection becomes a determining factor as there are multiple cloud computing services for the same tasks. As such the service, selection algorithms help in determining the rankings of cloud services. Here, for each service we determine the values of multiple parameters like response time, throughput time, etc. This parameters act as decision criteria for determining the ranking and as such a multi criteria decision analysis is done in service to select the best services for the task. Priority service selection models offer the best cloud services to the users. Traditional recommender systems in e-Commerce usually take similarity computation services on user-item metrics. The values in these matrices are subjective rating according to user preferences (Pan *et al*., 2015).

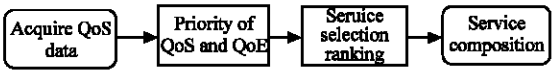

Fig. 1: Proposed Priority Ranking method

The existing methods of service selection do not handle the QoS and QoE constraint defined by the users. In this study, we develop a new priority based cloud service model which combines the QoS of cloud service and the QoE among the users to predict the best cloud services. As shown in Fig. 1, the proposed method contains three phases. The first phase is individual parameter ranking services. The second phase is QoS prioritization with QoE and a final ranking list of services in which find the best services in mobile cloud model. The

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experimental results are shown by using a PRT approach in effective ranking for selecting cloud services among QoS and QoE.

Literature review: There are four different analyses can be performed by using Multi-Criteria Decision Making (MCDM) approach with some criteria. To find the best alternatives To construct a rank ordering of the alternatives from good to bad. To categorize sort the alternatives and perform requirement by using their criteria. The outcome of the proposed method is choice of criteria, ranking and sorting of the services. In originating this outcome, both choice and ranking results are depending on considered of criteria. On the other hand, sorting/classification decision results are absolute judged (Zopounidis and Doumpos, 2002).

The MCDM method is necessary to find the best services from group of services. The quality of service attributes is used as a significant part in the process of decision making to evaluate in multiple criteria conditions. Kumar and Agarwal (2014) discussed a framework for cloud service selection by allowing the user to choose the most suitable cloud service provider. This framework uses Analytic Hierarchy Process (AHP) approach to improve the multi criteria QoS decision making. In this method, the service components and elements are decomposed into multiple levels. The QoS properties have been categorized into mandatory and optional attributes in a hierarchical structure (Tran *et al*., 2009). This algorithm results are sorted to obtain the service ranking to satisfy the QoS properties and it executed on $O(n^3)$ time. The user can find the best services based on their personalized needs.

The Analytical Network Process (ANP) is a one of the muticriteria decision making approaches which is generalized from AHP. This approach designed for pairwise comparisons for measuring the weights of the components to solve a dependence and feedback among the criteria, using unidirectional, bidirectional hierarchical relationships between decision levels. It could handle the complex decision problems where hierarchical model and allows for feedback connection and loops. In ANP criteria, sub criteria and alternatives are equally treated with ANP methods. The results are obtained in $O(n^3)$ time for finding the alternative services in a cloud model (Whaiduzzaman *et al*., 2014; Karim, 2011).

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a fast, reliable method in Multi-Criteria Decision Making (MCDM) approach. It is used to find the alternatives from the positive ideal solution and negative ideal solution. The positive ideal solution maximizes the benefit criteria and minimizes conflicting criteria, whereas the negative ideal solution maximizes the conflicting criteria and minimizes the benefit criteria (Mohammadshahi, 2013). This method obtained the result in $O(n^2)$ time for positive-negative ideal solution for a decision making problem.

The service selection process is very hard from the large availability of mobile cloud services. The process could not meet the user's needs. The service selection process is used to identify a best service that fulfills the QoS properties. On the other hand, the selection process refers to assessing and rank the services (Badr *et al*., 2008). Thus, we propose as a new methodology that consider several parameters to estimate the quality of experience. The QoE is often measured from the response time, availability and reliability (Lalanne *et al*., 2012). However, it is not adequate to evaluate the service quality (Bouch *et al*., 2000). If the users need to wait a longer time during the service session time, then it will be perceived negatively. So, select the service based on QoS and QoE. The proposed methodology selects the best services based on QoS-QoE correlation which is obtained through the fuzzy inference system.

MATERIALS AND METHODS

Priority Service Selection (PSS) framework: Figure 2 shows priority service selection architecture and it consists three major parts-mobile client, mobile cloud and cloud services. The mobile client tries to perform the tasks through the mobile application in the mobile unit. The application transfers the request to the Agent who forwards the request to mobile cloud through the internet. In the mobile cloud, the service manager identifies the tasks and determines the possible cloud services that could potentially solve the tasks.

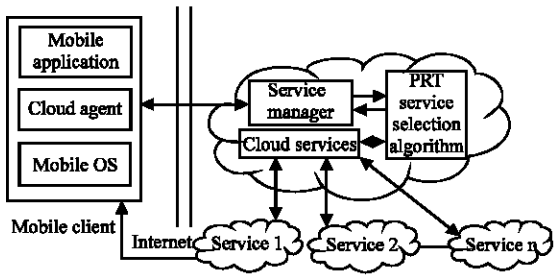

Fig. 2: Priority service slection framework

Table 1: Sample scoring chart

Position	Response time	Availability	Throughput	Successability	Reliability
1	24	22	20	18	16
2	22	20	18	16	14
3	20	18	16	14	12
4	18	16	14	12	10
5	16	14	12	10	8
6	14	12	10	8	6
7	12	10	8	6	4
8	10	8	6	4	2
9	8	6	4	2	0
10	6	4	2	0	0

Afterwards the service manager transfers the list of cloud services to PRT service selection algorithm which then determines the ranking of services. Based on these rankings the service manager selects the best cloud service and patches the selected service with mobile client.

Priority Ranking Technique (PRT): The Priority Ranking Technique is a simple and effective algorithm which is easy to implement and deploy. In PRT we apply a 3 phase scoring system as shown in Fig. 3. First, we will rank the positions of each service in their respective parameters. So, through this we will get the ranking of each service based on each parameter. Basically, we will make decisions for services based on single criteria decision making. So, we will get ranking for services for each decision criteria.

In the 2nd phase as certain decisions have more importance than others, the user decide a priority order of individual parameters. Table 1-3 define a fuzzy rule for determining QoE parameter value from other QoS parameters.

Now based on the parameters priority order we will prepare a scoring chart for points to be awarded for each position in each decision parameter. Table 6 preparing the scoring chart, we will first decide on the maximum score possible (say 24). Now prepare a table with rows as ranks (i.e., 1, 2, 3, 4, …) denoting the ranks a service can get and columns represent the parameters in an order of priority with 1st column having the highest priority. Now the value in cell (1, 1) will be the maximum score possible (i.e., 24).

Now horizontally, score the first cell of each parameter from with value the left cell value-10% of the maximum score. Thus the maximum possible score for any service is 100.

Now for each column travel vertically from the 2nd cell and score each cell with value the top cell value-10% of maximum score.

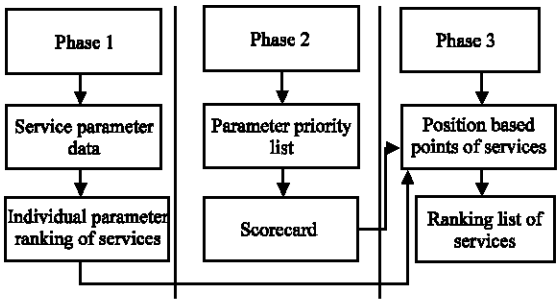

Fig. 3: Different phases of service ranking

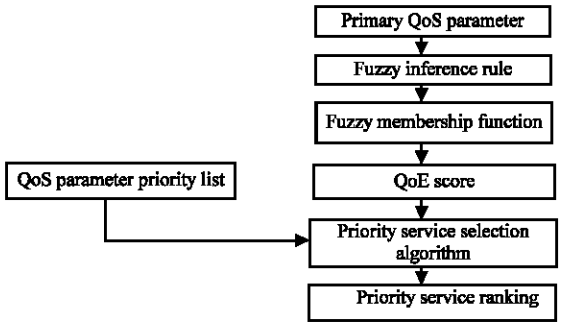

Fig. 4: Flow diagram of priority service ranking

In the 3rd phase, we will use the scoring chat to calculate the points each service will get for its ranking for each parameter and rank them on the based on the total score of each service. This process flow shown in Fig. 4.

Priority service selection algorithm ( ):

1 Get no. of services-n and no. of parameters-m from the client
2 Get the values of A_{ij} i.e., value of jth parameter for ith service
3 Get the priority order of parameters from the user
4 Determine the Fuzzy rule base and scorecard for QoE
5 Prepare a scoring chart where Bij is the score for ith ranked service in jth parameter
6 For each parameter j from 0 to m
Rank the services with the service i having maximum value for that parameter as
A [i, j] = 1, service k with 2nd maximum value as A [k, j] = 2 and so on
7 For each service i from 0 to n

$$A[i,j] = B[A[i,j],j]$$

8 For each service i from 0 to n

$$A[i,m] = \sum_{j=0}^{m-1} A[i,j]$$

9 Based on A [i, m] rank the services with the service i having maximum value as 1st, service with 2nd maximum value as 2nd and so on

Table 2: QWS sample dataset

Services	Response time (msec)	Availability (%)	Throughput (invokes/sec)	Successability (%)	Reliability (%)
DictionaryService	45	83	27.2	50	97.4
MyService	71.75	100	14.6	88	85.5
Aba	117	100	23.4	83	88
AlexaWebSearch	70	100	5.4	83	79.3
ErrorMailer	105.2	100	18.2	80	92.2
getJoke	224	100	24.6	83	80
States_x0020_Provinces	99.2	100	13.7	80	76.3
XigniteRetirement	108.2	100	16.8	80	90.7
DOTSEmail Validate	125.2	100	16.4	80	89.2
XigniteNews	110.3	100	13.9	87	87.5
DOTSFastTax	125.2	100	15.9	80	88.3
XigniteCompensation	105.4	100	16.5	80	89.4
ConvertCSharp2VBService	129	100	29.5	83	95.5
DOTSPackageTracking	124.92	100	11.9	89	84.1
Ssn	114	100	27.5	50	92.5

Table 3: QoE decision making table

Response time	Availability	Reliability	QoE
Low	Low	Low	Fair
Low	Low	Medium	Good
Low	Low	High	Good
Low	Medium	Low	Good
Low	Medium	Medium	Good
Low	Medium	High	Excellent
Low	High	Low	Good
Low	High	Medium	Excellent
Low	High	High	Excellent
Medium	Low	Low	Poor
Medium	Low	Medium	Fair
Medium	Low	High	Good
Medium	Medium	Low	Fair
Medium	Medium	Medium	Good
Medium	Medium	High	Good
Medium	High	Low	Good
Medium	High	Medium	Good
Medium	High	High	Excellent
High	Low	Low	Very poor
High	Low	Medium	Poor
High	Low	High	Fair
High	Medium	Low	Poor
High	Medium	Medium	Fair
High	Medium	High	Good
High	High	Low	Fair
High	High	Medium	Good
High	High	High	Good

RESULTS AND DISCUSSION

Test data has been taken from QWS dataset developed by Eyhab Al-Masri and Dr. Qusay H. Mahmoud (Table 2).

Phase 1: Single criteria decision making for each parameter, service parameters data from QWS dataset-extract the data from the QWS dataset and convert into a tabular form with each column representing an attribute and each row representing a service.

The QoE of webservice influences a priority based service selection method based on customer satisfaction. Thus, can be valuable in selecting the right web service. The proposed service selection quality assessment is based on QoS-QoE correlation which is attained through the subjective tests. The fuzzy expert system takes QoS to rate each web service. From Table 3 and 4, the QoE gets

Table 4: QoE score card

QoE value	Score
Excellent	30
Good	25
Fair	20
Poor	15
Very poor	10

a score based on QoS rating which is effectively represent the user satisfaction (excellent, good, fair, poor, very poor) (Pokhrel *et al*., 2014). It is used to improve the service selection by the web client. The fuzzy expert system (Negnevitsky, 2005) is very simple and easily predict a QoE score with imprecise information as shown in Fig. 5. This system used Gaussian membership function to represent a degree of QoS parameter value.

Ranking for services for each individual parameter. After the initial data preparation on each column, we apply a merge sorting algorithm to determine the ranking of services for that parameter as shown in Table 5. Than plot those ranking in a tabular form with each cell in the table representing the rank that the service got in that parameter.

Response time: Ascending order as lesser the value, better the service. Availability, throughput, successability, reliability-descending order as more the value, better the service.

Phase 2: Priority based scoring chart Parameter considered for decision making:

- Response time: time taken to send a request and receive a response
- Availability: number of successful invocations/total invocations
- Throughput: total number of invocations for a given period of time
- Successability: number of response/number of request messages

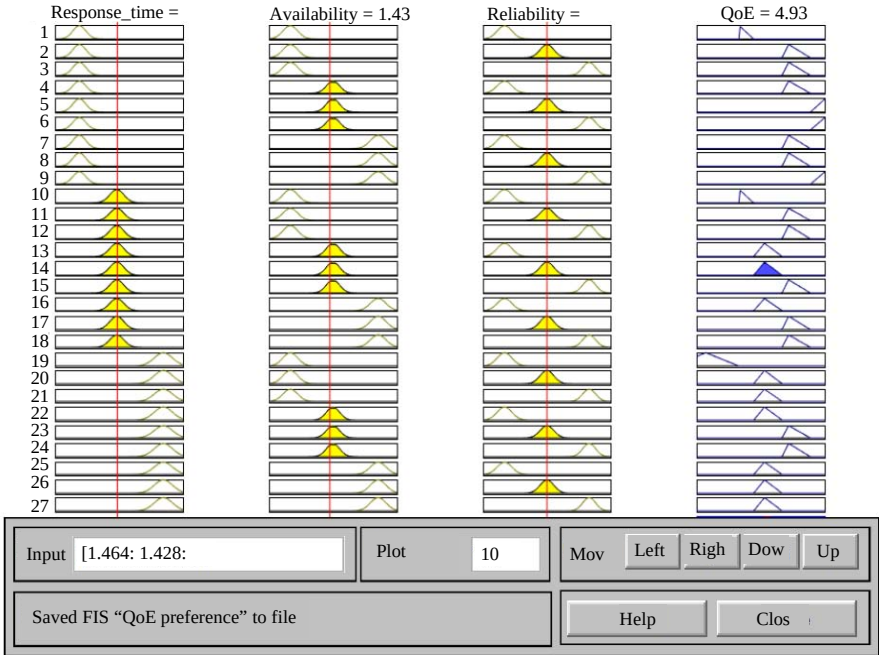

Fig. 5: QoE score using Fuzzy Expert System

Table 5: QoS-QoE service data set correlation

Service	Response time (msec)	Availability (%)	Throughput (invokes/sec)	Successability (%)	Reliability (%)	QoE
DictionaryService	1	15	3	14	1	Good
MyService	3	1	11	2	11	Fair
Aba	10	1	5	4	9	Poor
AlexaWebSearch	2	1	15	4	14	Fair
ErrorMailer	5	1	6	8	4	Excellent
getJoke	14	1	4	4	13	Fair
States_x0020_Provinces	4	1	13	8	15	Fair
XigniteRetirement	7	1	7	8	5	Good
DOTSEmailValidate	12	1	9	8	7	Poor
XigniteNews	8	1	12	3	10	Poor
DOTSFastTax	12	1	10	8	8	Fair
XigniteCompensation	6	1	8	8	6	Good
ConvertCSharp2VBService	15	1	1	4	2	Good
DOTSPackageTracking	11	1	14	1	12	Poor
Ssn	9	1	2	14	3	Poor

Table 6: QoS score chart

Position	Response time	Availability	Throughput	Successability	Reliability
1	24	22	20	18	16
2	22	20	18	16	14
3	20	18	16	14	12
4	18	16	14	12	10
5	16	14	12	10	8
6	14	12	10	8	6
7	12	10	8	6	4
8	10	8	6	4	2
9	8	6	4	2	0
10	6	4	2	0	0
11	4	2	0	0	0
12	2	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0

- Reliability: ratio of the number of error messages to total messages
- Parameter preference order: determine the priority order of parameters based on user's choice
- Response time>Availability>Throughput time> Successability> Reliability

Scoring chart; Prepare a scoring chart to score the services based on their ranks. Here each cell [i, j] represents a score that a service with rank i for parameter j would be awarded with.

Phase 3: Scoring of service based on ranking. Here, we utilize the points of scoring chart to score the services based on their ranks they get in each parameter (table in point b). Position based points of services based on the ranking table of services and scorecard, prepare a score (Table 6) with each cell representing the point the service is awarded for that parameter. After which

Table 7: Service ranking using Qos-QoE of service

Service	Response time (msec)	Availability (%)	Throughput (invokes/sec)	Successability (%)	Reliability (%)	QoE	Total score	Rank
DictionaryService	24	0	16	0	16	30	86	3
MyService	20	22	0	16	0	20	78	6
Aba	6	22	12	12	0	10	62	10
AlexaWebSearch	22	22	0	12	0	20	76	7
ErrorMailer	16	22	10	4	10	40	92	2
getJoke	0	22	14	12	0	20	68	8
States_x0020_Provinces	18	22	0	4	0	20	64	9
XigniteRetirement	12	22	8	4	8	30	84	4
XigniteNews	10	22	0	14	0	10	56	11
XigniteCompensation	14	22	6	4	6	30	82	5
ConvertCSharp2VBService	0	22	20	12	14	30	98	1

Table 8: Performance comparison

Algorithm	PRT	AHP	ANP	TOPSIS
Tim.Comp	O(n.m.logn)	$O(n^3)$	$O(n^3)$	$O(n^2)$

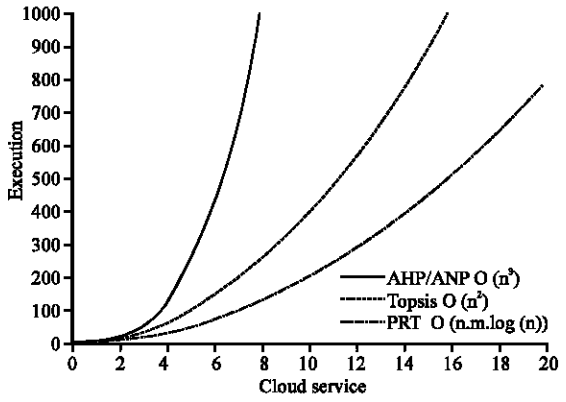

Fig. 6: Performance graph

the points are added to get a final score based on which the ranking list of services is prepared as shown in Table 7. The below servies are orderd by using PRT method.

ConvertCSharp2VBService>ErrorMailer>Dictionary Service>XigniteRetirement>XigniteCompensation> MyService>getJoke>States_x0020_Provinces>Aba> XigniteNews>DOTSPackageTacking>DOTSFastTax>Ssn >DOTSEmailValidate.

Performance analysis: In PRT, phase 1, we will apply merge sorting algorithm to sort and rank services for all the m parameters. So, for n services and m parameters the time complexity will be O(n.m.log n) as shown in Table 8. Phase 2, we will prepare a scoring chart by setting the score for all the elements in a table that has n services and m parameters. So it will have a time complexity will be O(n.m). Phase 3, we will score each service and parameter based on the corresponding value of rank in the scoring chart. So, it will have a time complexity will be O(n.m).

Time complexity = O(n.m.logn+n.m+n.m) = O(n.m.logn)

Figure 6 shows the performance of the PRT method. Here, x-axis represents the number of input elements or 'n' while y-axis represents the time taken to execute the code.

CONCLUSION

The proposed PRT service selection algorithm is easy to implement and efficiently. The PRT method ranks the services with keeping the priority of the users in the mind, thus providing results more relevant to the user compared to the other methods. In PRT service selection algorithm based on the user's priority of parameters the ranking of services changes making the results more customer centred. It is a simple design that has a lot of potential if incorporated in mobile services architecture for selecting services as it will help provide services that are suitable and desirable to user's needs.

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