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Neural Based QoS aware Mobile Cloud Service and Its Application to Preeminent Service Selection using Back Propagation

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Abstract

The mobile cloud services can be accessed over an internet by portable devices. The rapid growth of mobile services and cloud computing, the Mobile Cloud Computing becomes so popular. Mobile Cloud Computing (MCC) incorporates the cloud computing technology with mobile environment. The service associated with quality of service parameters which make it preeminent service to a user. This paper proposed a Preeminet Service Ranking (PSR) method using backward propagation neural network (BPNN) to find the best services. The method consists of two phases which are the Training phase and the Ranking phase. In the Training phase, the network is trained and obtain the deviation. It means that error of the current network from the ideal network. In the Ranking phase, determine the best services are at any given time using the deviation obtained from the training phase. The mobile cloud services are measured by using Quality of Service (QoS) parameters. This paper proved that a proposed method performs better over conventional methods like TOPSIS, AHP, and ANP.

Keywords: Mobile Cloud Computing; Backpropagation; Mobile Service; QoS; Service Selection.

1. Introduction

Mobile Cloud Computing (MCC) means cloud computing services access in mobile ecosystem defined by Preston cox in 2010 in a blog entry in the open garden blog. The growth of mobile users need mobile computing technology for business application. Mobile technology depend to the cloud computing for limited storage and less computing power. So the mobile cloud computing support in storing and processing data outside mobile devices which helps reduce the loss of data, improve the availability and reliability. The MCC keeps the data and services are available when the user moving one location to another location. The MCC supports to scale a service to meet when the user demands more which can be done easily to offer the services.

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The evolution of mobile cloud computing, the qualities of service parameters are leading the service function. The service functions are available in the cloud for example business, education, health care, Game application and so on. This service functions are satisfying to the users request and the users not give any importance of cost factors [20, 21].The user needs to identify the best service to perform a complicate process [31]. The best service selected based on QoS [35] which are required for to take a decision making.

Mobile cloud services play an important role in Bioinformatics, these services are common and used into Bioinformatics research and development. Currently, more than 1200 Bioinformatics services are available in online which are helping to analyze the data by using computational methods [2]. The analyzed data are essential of biological studies [28, 8]. The bioinformatics web services permit easy access and integrate with other services which support Bioinformatics analyses. However, it has the limitation of being recognized by the community to identify best services. It is still difficult unless the user know how to identify the best services [24].The service selection method provides a facility for users to use to identify the best services for complex analysis of biological data.

Recently, a many mechanism has been proposed for finding the best services in different areas [10]. Particularly BioMoby Central and the DAS Registry, offer biological service which is used to monitor and identify behavior of its function [33, 34]. A biological group wants to apply this service selection process in bioinformatics domain. Currently they are doing data analysis through online web services for research and development of bioinformatics [5, 22]. They want to identify the best services to complete data analysis. The main idea of cloud service is to offer a service when needed by the user. The proposed system adapts easily in any domain to deliver best service based on QoS. For example, in medical application the system provides a good service without consideration of the user environment. The requirement of service selection process is to provide easy access to databases. Mostly the user finds the suitable service in a difficult manner. The proposed system assisted to find the best services based on user criteria such as response time, availability, throughput, successability and so on. The selected best service done the user requirement automatically without user interference [36, 37]. The QoS metric values needed to complete service requirement.The service metric values are determinate to what service to be offered [18]. The service selection process appears when available set of services which can fulfill the user requirements and select the best service to the user [14]. This process is very essential to the user who needed high quality of service whereas the other parameter such as cost may involve very less [13].

This paper used a Back Propagation Neural Network (BPNN) method for service selection which helps to user to find the best service. This PSR algorithm used QoS parameters which is given by a user based on their requirements. The traditional back propagation neural network affects low learning convergence rate value and instability in the training phase process [25].

2. Related Work

In the contemporary environment, the usages of mobile cloud computing services are getting popular. Many researchers survey the performance of mobile services in different application. For example: Mobile commerce, Mobile learning, Mobile healthcare, Mobile gaming and so on. There are many methods proposed to find the best services based on QoS parameters which are preferred by the user [19]. The proposed system implements PSR method by using QoS attributes value which is preferred by the user. The PSR method finds the error deviation from the current network and find the best services at a given time.

The QoS factors involved in mobile cloud service selection. This factor defines the non-functional characteristics of cloud services such as response time, reliability, availability, throughput and so on [6]. The popular existing system used multi criteria decision methods to find the best cloud services. The existing and proposed system rank the services which depend on the user preference QoS value.In the Bioinformatics web service, users need computational analysis in online. For completing this analysis, they need to identify the best cloud services.Hence, the research in Bioinformatics has become a most wanted topic in recent years and mobile commerce, mobile learning, mobile gaming are also applied in this area [36, 23]. Thus, it is essential to find the best cloud services by using QoS value [4].

2.1. Multiple-criteria decision-making (MCDM) Model

There is few research works have been carried out on QoS based service selection issue, but most of the problem is still open. In economy view, the cloud services are more important in a business firm. The main reasons are the service providers, discharge from service ownership rather than its individual. This entrepreneurial theory will help increase the firm efficiency and limitations [15].The firm can find their business boundaries and new opportunity in a current marketplace [11]. However, the firm needs more services to complete their requirements because single service cannot complete the entire requirement. Among the available of more services, the firms need to identify the best services to complete the task. In order to identify the best services, Multi-Criteria Decision Making (MCDM) model is needed. This model is very popular for selecting the best services based on QoS parameters.

The problem of complex decision making can be solved by the Analytic Hierarchy Process (AHP) method. This method developed by Prof.Thomas L.Saaty [3, 26]. It is a structured technique based on operation research. This problem can be applied healthcare, business, education and so on [16]. The AHP consists three levels of solving any complex problem. The purpose of Level 0 has defined the goal. The Level 1 explicitly defined multi criteria of decision making which belongs to the goal. The Level 2 show the alternatives based on Level 1 [17]. The AHP is more flexible and it takes the decision fairly. AHP allows small inconsistency in making decision. In addition to measuring the time complexity of cloud service ranking consist multiple phase. In the first phase, to build a hierarchy structure of cloud services based on quality of service parameters. The second phase, calculate the weights of each parameter. The Third phase is aggregate the ranking all cloud services. Thus, the worst case time complexity of the AHP method for ranking is $O(n^3)$ [9]. Hence, the AHP method used to find the best services based on multi criteria in the cloud. In this regard the proposed method PSR serves as a significant advantage.

L.Saaty proposed the analytic network process(ANP) method [26]. The AHP method uses the hierarchy structure, whereas ANP method used a network structure. This method has been applied in complex decision making problem in which can not be shown in a hierarchical model [26]. Both methods used pairwise comparison for calculating the weights of the factors. The ANP model entails three elements. (1) Identify the goal of best alternative. (2) Find criteria and sub criteria for the model. (3) Finally, rank the alternatives [27]. This method works well in a static environment and has produced the best result, but not in a dynamic environment. While applying a dynamic environment, it takes more time and may become outdated in some cases. The ANP method takes $O(n^3)$ time in the worst case .Therefore, the ANP method can be applied in nonhierarchical complex problem for finding the best alternatives based on multi criteria in the cloud. In this scenario the proposed PSR method serves better in a cloud service model.

Hwang et al proposed the multi-criteria decision analysis method called Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) [7]. TOPSIS is a systematic method. This is one of the best methods to rank the services based on service factors [7]. This method selects the best services from the alternatives. Each alternative is assessed against multi-criteria. This method takes the best decision making and find the closest ideal solution and too far from the non-ideal solution [32]. This ideal and non-ideal solution taken from the alternatives. The ideal solution gives the maximum benefit and minimum cost, whereas non-ideal solution gives minimum benefit and maximum cost [12, 32]. This method can be applied in the mobile cloud service selection and find the ideal and non-ideal solution. The ideal solution gives maximum performance and minimum cost of service where as non-ideal solution gives minimum performance and maximum cost of service. This solution make as benchmark, and find, the better solution continuously if necessary. When the criteria increase or decrease monotonically, finding the ideal or non-ideal solutions are easy [29, 30]. The disadvantages include the assumption of a monotonic criteria in a dynamic situation and complex calculations related to geometric distance which are also time consuming as compared to PSR. TOPSIS method takes $O(n^2)$ time in the worst case while solving any complex problem.In this environment the proposed PSR method gives better performance in a cloud service model.

3. Methodology

The purpose of this paper is to make the cloud services available in the mobile environment. For this it needs to check the requirements like response time, availability, throughput, successability and reliability. The network attributes are dynamically captured on the mobile host and send back to the cloud service along with the request. The entities involved are:

1. Cloudlet: a trusted, resource-rich computer or cluster of computers that is well-connected to the Internet and is available for use by nearby mobile devices.
2. QoS Parameters (Z): These are the attributes of network status i.e. QoS parameter involves in determining the service to be provided for the pool of service.
   Assuming P= response, throughput, reliability, successability, availability is the set having attributes the collect by the network host.
3. Input services (X): These are the input neurons, which are presented to the hidden layer.
4. Hidden parameter (z): Calculates the values of the web parameters.
5. Target Neuron (Y): This is used to evaluate the deviation from the ideal network.

3.1. Proposed Model and Components

The Cloud service framework is presented in Mobile cloud service selection architecture Fig.1. The model utilizes back propagation neural network in choosing the best service from the pool of service. The framework has 4 components:

1. Hidden layer weight calculator: It is used for calculating the weights of all services against the cloud parameters.
2. Sorter: Main purpose is to evaluate the minimum or maximum weights to be assigned to the hidden layer weights edges. Also calculate the sum of the deviation of the weights.
3. Error Calculator: Error calculator helps in calculating the net deviation that is generated at the output phase.
4. Ranker: This assigns the ranks to the web services based on the minimum deviation. The least deviated service gets the highest rank

3.2. Back Propagation Neural Network

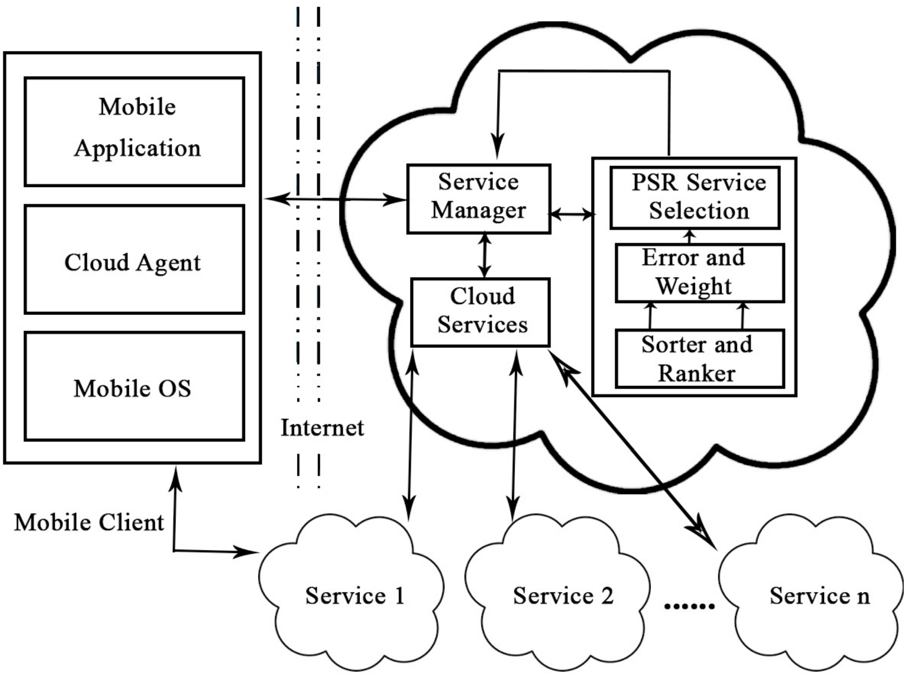

Fig. 1. Framework of Preeminent Service Ranking Mobile Cloud Service Selection

Back propagation Neural Network (BPNN), an acronym of "backward propagation of errors", is a common method of training artificial neural networks used in conjunction with an optimization method such as gradient descent. The method calculates the gradient of a loss function with respect to all the weights in the network, so that the gradient is fed to the optimization method which in turn uses it to update the weights, in an attempt to minimize the loss function. So using BPNN calculate the deviation in weights and use it to find the threshold value which filters the neurons (i.e. the services) in the next phase.

3.3. Preeminent Service Ranking Algorithm

The algorithm consists of two phases. In the first phase, training the network with the inputs. After getting input from the neurons, each input set is trained to the BPNN using this algorithm. In the next phase, test BPNN network with the updated weights. The train data are represented in a matrix form. The matrix represented in the following way.

$$M = \begin{vmatrix} w_{11} & w_{12} & w_{13} & \dots & w_{1m} \\ w_{21} & w_{22} & w_{23} & \dots & w_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ w_{n1} & w_{n2} & w_{n3} & \dots & w_{nm} \end{vmatrix}$$

Algorithm Proposed_PSR ( )
{ TrainPhase ( ); //Algorithm to train the BPNN. Phase 1
RankingPhase ( ); // Algorithm to find Appropriate Service. Phase 2 }

Algorithm TrainPhase ( )
{
Inputs: Weights (W_{ij}) of the input neurons;
n - number of input neurons. //number of web services.
m - number of hidden neurons //number of parameters.
d - demand of the parameter like response is minimum and throughput is maximum.
Output: A trained Network. //deviation from ideal network ($\Delta(k)$)
Variables Definitions: i - denotes loop variable for no of web services
j - denotes loop variable for number of parameters
sum - denotes sum of weights of input neurons, initialized to 0
z_j - denotes calculated sum of each hidden neuron
Z_j - denotes normalized hidden neuron value
W_{z_j} - denotes weights for next layer from hidden to target neuron
$f(z_j)$ - Activation Function - $(N - z_j)/N$ and N is the nearest hundred to the maximum value
$Y(o/p)$ - total of hidden neuron values, initialized to 0
Y_k - denotes target normalized value
$f(Yo/p)$ - Activation Function - $(N - Yo/p)/N$ and N is the nearest hundred to the maximum
$\Delta(k)$ - the deviation of the current network from ideal network

1. Calculate the sum of weights for input neurons across all parameters
   $for \quad j = 1 \quad to \quad m$
   $for \quad i = 1 \quad to \quad n$
   $sum+ = W_{ij}$
   $z_j = sum$
2. Calculate normalized weights
   $for \quad j = 1 \quad to \quad m$
   $Z_j = f(z_j)$
3. Find Edge weights to next layer
   $for \quad j = 1 \quad to \quad m$
   $Wzj = MergeSort(X_{ij})$
   $for \quad i = 1 \quad to \quad n$

$if(d == "asc")$
$Z_j = W_{0j}$
$else$
$Z_j = W_{nj}$

4. calculate output layer value
   $for \quad j = 1 \quad to \quad m$
   $Y(o/p) + = Z_j$
   $Y_k = f(Yo/p)$
5. Calculate the deviation
   $where\ w_{11}, w_{12}, \cdots, w_{nm}\ are\ parameters\ services.$

$$\Delta(k) = (1 - Yk) \times f(Yk)$$

}

Algorithm RankingPhase ( )
{
Inputs: α learning rate of the network, initialized to 0.25.
$\Delta(k)$ - the deviation obtained from TrainPhase.
Z_j - denotes weights of hidden layer neurons.
n - denotes number of input neurons.
m - denotes number of hidden neurons.
W_{z_j} - denotes the weights of hidden to target layer.
Weights (W_{ij}) of the input neurons.
Output: Ranked Web Services, the lowest deviation service gets highest rank.
Variable Definitions: i - denotes loop variable for no of input neurons.
j - denotes loop variable for no of hidden neurons.
W_{z_j} (new) - new hidden neuron value.
X_i - denotes sum of deviation for the input neuron i, initialized to 0.

1. Calculate updated weights for hidden layer.
   $for \quad j = 1 \quad to \quad m$
   $W_{z_j}(new) = W_{z_j} + \alpha * \Delta(k) * z_j$
2. Calculate the sum of deviation.
   $for \quad j = 1 \quad to \quad n$
   $for \quad j = 1 \quad to \quad m$
   $X_i + = mod(W_{z_j}(new)W_{ij}))$
3. Evaluate Ranking of services.
   $for \quad j = 1 \quad to \quad n$
   MergeSort(X_i)

}

The Fig.2. process starts by getting the weights of input neurons, that is the measured values of web services against the web parameters. After this, calculate the sum of weights of the input neurons at the hidden layers. This step is followed by normalizing the values of the hidden neurons by choosing the suitable activation function. After this step, assign next layer edges and find the sum of hidden neurons in the output layers. Finally, calculate the deviation in the current network from the ideal network at the target layer. This marks the end of Phase1 of the Training Phase. In the next step, determine the updated hidden neuron weights after which determine the sum of weights of deviation of the input neurons from the threshold values. Atlast use a Mergesort algorithm to determine the best services, it means that the web services with the minimum deviation. Since this is a continuous if BPNN network has not reached the ideal. Iterate again from the beginning until specified ideal network criteria has been reached.

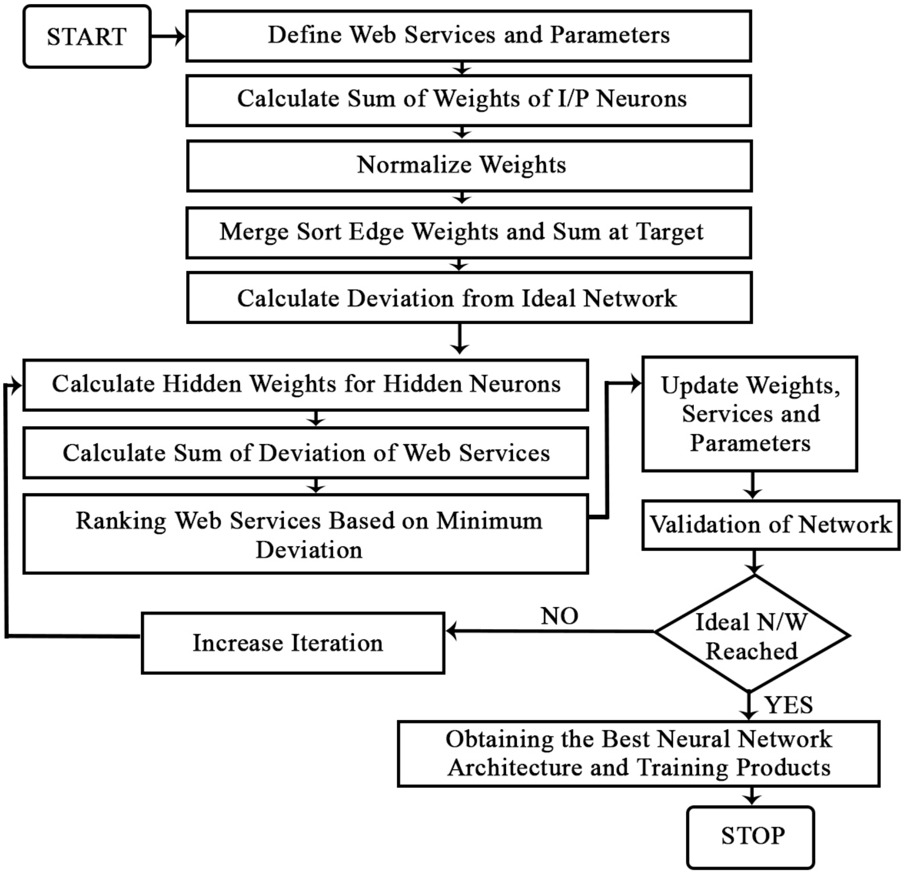

Fig. 2. Flow Chart of Preeminent Service Ranking process

4. Experimentation

Extract the data from the QWS dataset Table 1 and convert into a tabular form with each column representing an attribute and each row representing a service [1].

The data set needs to be converted into a BPNN network. For converting into a BPNN network, consider the services as an input neuron and parameters (like response time, throughput, availability and so on.) as the hidden layer neurons. These hidden layer neurons are then passed to the output layers. The weights of the neurons are the corresponding values of 2D matrix as depicts in Table 2. The weights of the next stage are determined based on the first stage like for response time hidden layer neuron, select the minimum of the weights and throughput is select the maximum of the neuron weight.

Ranking of services are as follows:

$X_2 > X_1 > X_4 > X_{12} > X_5 > X_{13} > X_8 > X_3 > X_{10} > X_7 > X_9 > X_{14} > X_{11} > X_{15} > X_6$

4.1. Time Complexity Analysis

Total Complexity of the network

1. Phase1: Train Phase
   Step 1: Calculation at the hidden layers = O (n*m)

Table 1. A 2D matrix of web services (X) against web parameters (Z) obtained from QWS data

Service Name	Service Notation	Rt	Av	Th	Su	Rel
DictionaryService	X_1	45	83	27.2	50	97.4
MyService	X_2	71.75	100	14.6	88	85.5
Aba	X_3	117	100	23.4	83	88
AlexaWebSearch	X_4	70	100	5.4	83	79.3
ErrorMailer	X_5	105.2	100	18.2	80	92.2
getJoke	X_6	224	100	24.6	83	80
States_x0020_Provinces	X_7	99.2	100	13.7	80	76.3
XigniteRetirement	X_8	108.2	100	16.8	80	90.7
DOTSEmailValidate	X_9	125.2	100	16.4	80	89.2
XigniteNews	X_{10}	110.3	100	13.9	87	87.5
DOTSFastTax	X_{11}	125.2	100	15.9	80	88.3
XigniteCompensation	X_{12}	105.4	100	16.5	80	89.4
ConvertCSharp2VBService	X_{13}	129	100	29.5	83	95.5
DOTSPackageTracking	X_{14}	124.92	100	11.9	89	84.1
Ssn	X_{15}	114	100	27.5	50	92.5

Table 2. A table showing the demand of parameters

WEB PARAMETERS	NOTATION	DEMAND (d)
Response Time (Rt)	Z_1	Ascending
Availability(Av)	Z_2	Descending
Throughput(Av)	Z_3	Descending
Successibility(Su)	Z_4	Descending
Reliability(Rel)	Z_5	Descending

Step 2: Normalizing the hidden neurons = O (m)
Step 3: Assignment of weight edges to next layer = O (m log n * m)
Step 4: Weight Calculation at target layer = O (m)
Step 5: Calculation of deviation = O (1)
Overall complexity of PHASE 1: O (n*m + m + m*m * log n + m + 1)
Dominant term O (n * m)

2. Phase 2: Ranking Phase
   Step 1: Weight Calculation at the hidden layer = O (m)
   Step 2: Calculation of sum of deviation = O (n)
   Step 3: Ranking of Web Services = O (n log n)
   Overall complexity of PHASE 2: O (n log n + m + n)
   Dominant term O (n log n)

Where n is the number of web services, m the number of parameters
Overall Complexity of the network O (nm + n log n)
Dominant term: O (m n)

Table 3. Time complexity comparison

Algorithm	AHP	ANP	TOPSIS	PSR
Time Complexity	O(n^3)	O(n^3)	O(n^2)	O(m.n)

The proposed PSR method is better than existing methods. Such as AHP, ANP, and TOPSIS. The Fig.3. has been plotted as X axis represents the number of input neurons (or cloud services) and y- axis as the execution time to complete the process.

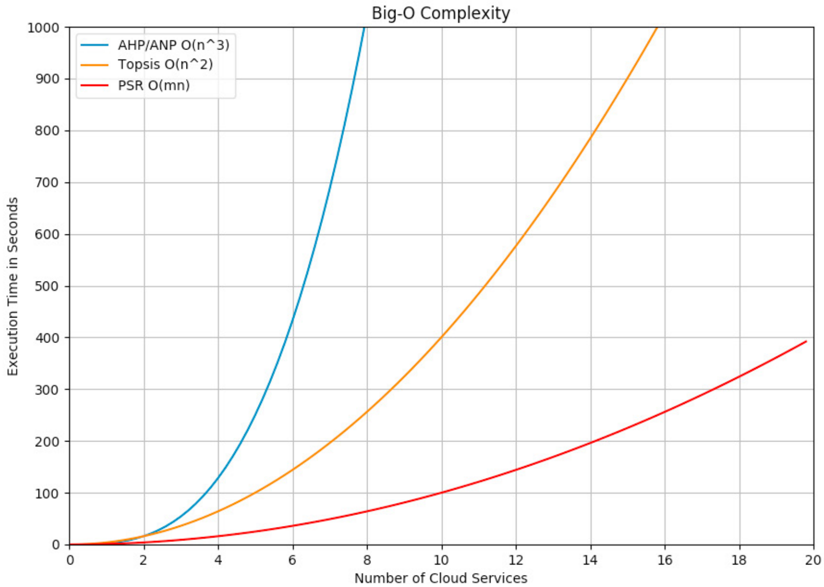

Fig. 3. Preeminent Service Ranking (PSR) Performance Graph

5. Conclusion

MCC is one of the widely followed activities of cloud computing. Business save maney with mobile computing. The user can access more features on their mobile phones. The application developers gets a markets through mobile cloud. So service selection in mobile cloud computing is of utmost importance. The customers wants the best services to be allocated to them within the best possible time and resources. User ability to reach any cloud services from anywhere is dependent on the fact how well the cloud service selection algorithm works. Users geographical location should not be a problem to his unrestricted access to mobile cloud services. So a proper cloud service selection is utmost necessary. The PSR method 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 users needs. Thus it has been seen that this method can be one of the best methods for cloud service selection algorithms.

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