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QoS Ranking Prediction Approach for Cloud Services Using Spearman Rank Correlation Based Nature Inspired Firefly Optimization

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***Abstract*—**QoS (Quality of Services) is a very important research topic in cloud computing. When we select an optimal cloud service from functionally equivalent service we use QoS value for a good decision making. QoS ranking provides priceless information in selecting the best cloud service in cloud computing. In order to avoid time consumption and to select the best service for the cloud customer a good QoS ranking prediction framework is required. It should be a much user as friendly and less time consuming. In this paper Spearman Rank Correlation Based Nature Inspired Firefly Optimization (SRC-NIFO) method is analyzed for ranking prediction. It will give higher accuracy and be less time consuming. When the proposed framework is compared with the previous works on the basics of response in time, throughput, and latency the proposed work is proved to be much better than the previous works.

***Keywords*—**Cloud computing, quality of service (QoS), Cloud Service Provider, Ranking Prediction, Rank Correlation, Selection.

I. INTRODUCTION

Cloud computing is a developing technology that are exponentially increasing the interest among users to use the cloud applications. Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to shared pool of configurable computing resources that are rapidly provisioned and released with minimal management effort. Cloud services are broad category that encompasses many IT resources provided over internet. In addition, it also describes the professional services that support selection, deployment and ongoing management of many cloud-based resources. Fig1 shows the common architecture of cloud services. Cloud services are introduced to present easy, scalable access to applications, resources and services that are fully managed by cloud service providers. Quality-of-Service (QoS) is an essential idea for service selection and user satisfaction in cloud computing. QoS rankings present valuable information for optimal cloud service selection from set of functionally equivalent service candidates. QoS ranking prediction is the process of predicting the top ranked cloud services. But, the existing ranking prediction techniques failed to increase the prediction accuracy and to reduce the prediction time.

QoS is measured in the client side or server side. The client side QoS properties provide us a very realistic measurement by user experience [3]. The QoS properties commonly used include throughput, response time, Latency etc. In this paper we focus mainly on client side QoS properties. In our proposed work client side QoS properties are used for experimental analysis.

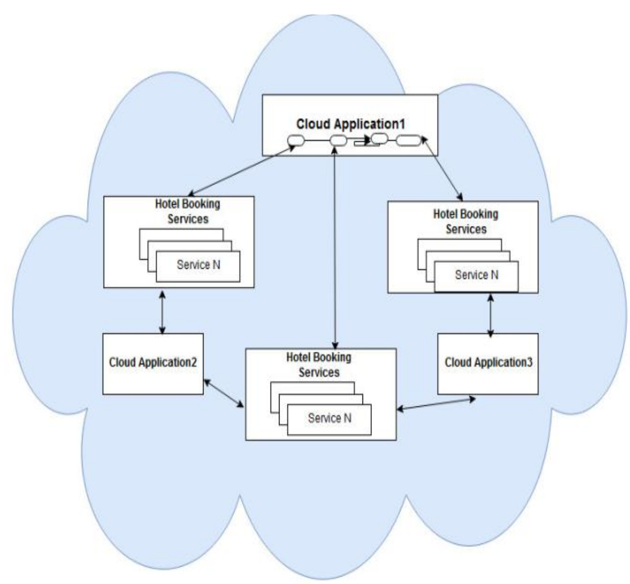

Figure 1 Architecture of cloud services

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The remainder of this paper is organized as follows: Section II describes the literature review. Section III presents the proposed methodology in detail. Section IV introduces the experimental results. Section V concludes the paper.

II. RELATED WORK

An adaptive matrix factorization (AMF) approach was presented in [4] to execute online QoS prediction for candidate services. AMF was considered from many collaborative filtering techniques in recommender systems and increased conventional matrix factorization model with data transformation methods, online learning, and adaptive weight techniques. But, the stochastic gradient descent algorithm failed to increase the performance of prediction.

A correlated QoS ranking algorithm was introduced in [5] with data smoothing technique and joined with QoS to forecast the personalized ranking for the service selection by active user. However, Time-Aware was correlated with QoS ranking techniques for cloud services by data collected from service. Location aware ranking prediction technique was not discussed in correlated QoS ranking algorithm.

A Time-Aware Approach was introduced in [6] to forecast the trustworthiness in ranking of cloud services with performance-cost and risks in various periods. The Interval Neutrosophic Set (INS) theory was employed to explain the performance-costs and risks of cloud services. The original assessment data regarding the cloud services were preprocessed into Interval Neutrosophic Numbers (INNs). A new INS operator was introduced to compute the possibility degree and ranking values of trustworthiness INNs for neighboring users' detection was depended on Kendall rank correlation coefficient (KRCC). However, the assessment modes of history trustworthiness data and execution performance require deep-going studies.

A new two-way ranking based cloud service mapping framework (TRCSM) was introduced in [7]. Ranking participating entities was evaluated for service mapping with the QoS attributes value. Analytic Hierarchy process (AHP) was employed to compute the ranking score of CSPs and SRCs in TRCSM. The service mapping process was employed in TRCSM. Sensitivity analysis was carried out to authenticate the stability of entities in mapping process. However, TRCSM failed to consider trust problems in QoS history and short-term advertisements.

A cloud service composition framework was introduced in [8] for selecting the optimal composition depending on end user long-term Quality of Service (QoS) needs. In distinctive cloud environment, the solutions were not appropriate when service providers do not confer QoS provision advertisements. The designed framework employed multivariate QoS analysis for forecasting the long-term QoS provisions from service providers with QoS data and short-term advertisements by Time Series. The quality of QoS prediction was enhanced through QoS attributes correlations into multivariate analysis. However, cloud service composition framework failed to control agenda for intelligent engineering in cloud computing.

III. PROPOSED METHODOLOGY

A. *Spearman Correlation Coefficient*

The Spearman correlation coefficient is a nonparametric (distribution free) rank statistic for measuring the strength of association between two variables and the direction of the relationship [2]. Spearman's correlation method returns a value from -1 to 1, where +1 means: is a positive correlation between ranks, -1 means: is a negative correlation between ranks and 0 means: is no correlation between ranks. Spearman correlation coefficient is based on the ranks of the data, it can well represent the similarity of the trend of the time series. Spearman correlation ranking method ranks each variable separately from lowest to highest and record the difference between ranks of each data pair. The sum of the square of the difference between ranks signifies the strength of the correlation between different variables. If the data is strong correlated, then the sum will be small, vice versa. Besides, the magnitude of the sum is related to the significance of the correlation. The Spearman ranks correlation coefficient method is calculated by using the following equations.

$$\rho\,(a,u) = 1 - \frac{6\sum d^2}{n\left(n^2 - 1\right)}$$

Where a is the active user, u is the user, d is the difference between ranks for each data sets and n is the number of datasets.

B. Firefly Algorithm

The firefly algorithm was developed by Xin-She Yang in late 2007 and 2008 in the Cambridge University in 2007 and 2008. This algorithm is based on the flashing patterns and behavior of the firefly [1]. The following three are the characteristics of the firefly algorithm. Fig 2 shows the flow chart of firefly algorithm.

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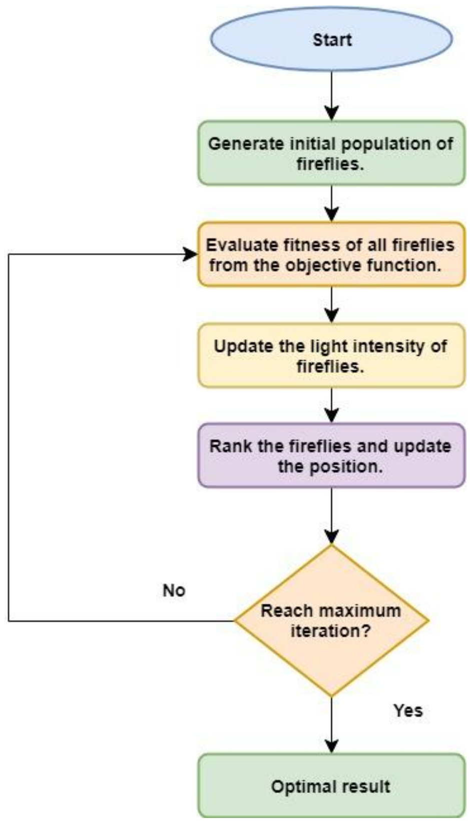

Figure 2 Flow chart of firefly algorithm

- Fireflies are unisex so that one firefly will be attracted to other fireflies regardless of their sex.
- The attractiveness is proportional to the brightness, and they both decrease as theirdistance increases. Thus for any two flashing fireflies, the less brighter one will movetowards the brighter one. If there is no brighter one than a particular firefly, it willmove randomly.
- The brightness of a firefly is determined by the landscape of the objective function.

C. Proposed Work

In this paper Spearman Rank Correlation based Nature Inspired Multi-Criterion Firefly Optimization (SRC-NIMCFO) Method is proposed for ranking prediction with higher accuracy and lesser time. Spearman rank correlation and nonparametric measure of rank correlation are used to evaluate the relationship between two variables using monotonic function. In SRC- NIFO method, Spearman rank correlation is used to identify the degree of association between the historical cloud user service to separate the user service as similar or dissimilar. The spearman correlation of similar cloud user service produces the result '+1' and dissimilar cloud user service produces the result '-1'. Then, similar cloud user services are taken as initial population for firefly optimization technique. For each cloud user services are calculated based on the QoS properties. When the cloud service satisfies, it is taken as an optimal cloud service. Based on the satisfaction level, the light intensity of the firefly gets changed. The lesser brighter firefly gets attracted by brighter one. Based on the light intensity value, the ranking process is carried out for finding the optimal one. By this way, the ranking prediction for cloud services is carried out in effective manner. Experimental evaluation is carried out on factors such as prediction accuracy, prediction time and error rate with respect to number of historical cloud user service. Fig3 shows process flow of the firefly optimization.

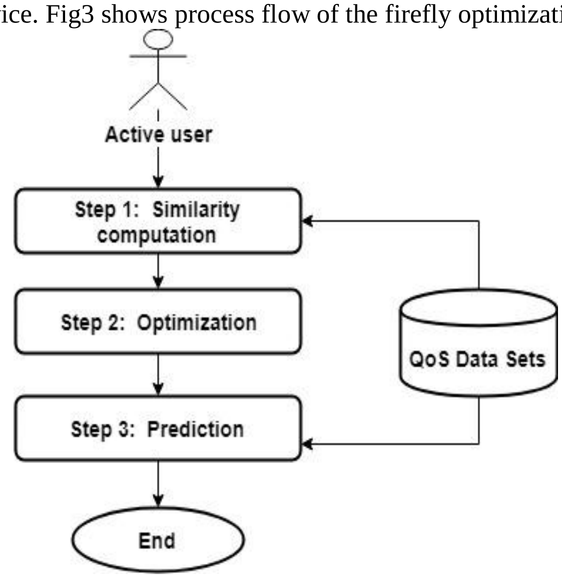

Figure 3 process flow of the proposed work.

Algorithm 1 Firefly Optimization method

1: Objective Function f(x) x=x1, x2, x2,.....xn
2: Input: List of similar cloud user services
3: Initialize:Fireflies,generations,intensity
*4: **whiledo** objective Function*
5: Calculate rank
*6: **for** i=1 to generations **do***
7: Calculate optimal rank
8: Pbest= intensity.best with lowest t
*9: **if** intenity =best fit() **then** assign as optimum*
*10: **else** Evaluate new solution*
*11: **end if***
*12: **end for***
13: Rank all Solution Find Best one
*14: **end while***
15: Return best

IV. EXPERIMENTAL ANALYSIS

To evaluate the performance of SRC- NIFO, results were simulated in Window 10 (64-bit), i5 Processor, 370 M Processor, 2.40 GHz of speed with memory of 4 GB. Java is used for develop our proposed work and the cloudSim framework is used for modeling and simulating the prediction model [9]. It provides data centers, virtual machines (VMs) and resource provisioning policies. The client side QoS properties are used for experimental analysis: throughput, response time and Latency.

Response time: The time taken by the cloud serviceprovider to give response to the loud user. It is measured in millisecond.

Throughput: Throughput is a measure of how many units of data can process in a particular time. It is measured in mbps.

Latency:The time interval between submitting a packet and arrival at its destination.It is measured in millisecond.

Table1 performance comparison by response time

Number of tasks	Firefly Optimization Method	[5]Adaptive Matrix Factorization	[6]Correlated QoS Ranking Prediction	[7]Time-Aware Trustworthiness Ranking Prediction
1	420	622	670	701
2	443	660	690	724
3	449	673	696	722
4	471	686	702	728
5	475	693	709	729
6	482	696	711	738

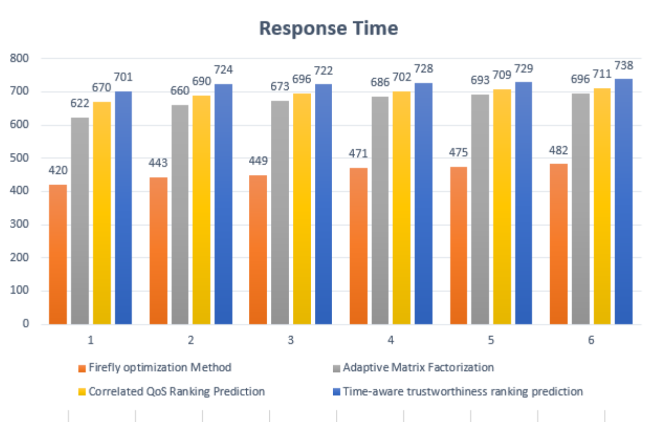

Figure 4 Response time chart

Table1 shows the average response time of various methods. Fig1 shows the response time chart. It shows that proposed Firefly Optimization method for QoS ranking prediction methods response quicker than the existing methods.

Table2 performance comparison by Throughput

Number of tasks	Firefly Optimization Method	[5]Adaptive Matrix Factorization	[6]Correlated QoS Ranking Prediction	[7]Time-Aware Trustworthiness Ranking Prediction
1	490	340	390	320
2	482	332	380	317
3	481	336	377	313
4	475	331	362	309
5	471	331	355	305
6	462	328	350	301

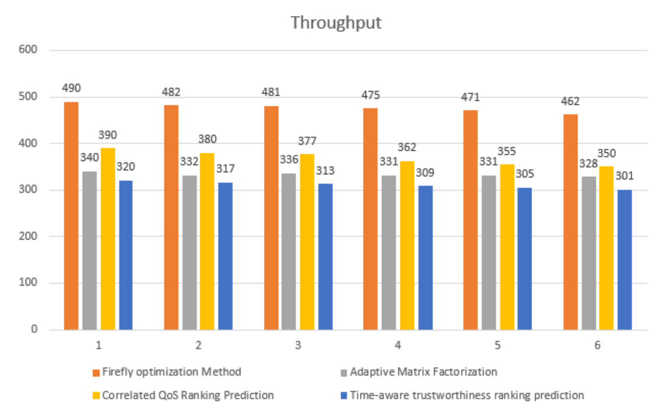

Figure 5 Throughput chart

Table 2 and fig 5 shows the result of QoS Throughput for QoS Ranking Prediction and Firefly Optimization Method for QoS Prediction. It shows that proposed Firefly Optimization Ranking method for QoS Prediction method achieves higher throughput result than existing QoS Ranking Prediction methods for services.

Table3 performance comparison by latency

Number of tasks	Firefly Optimization Method	[5]Adaptive Matrix Factorization	[6]Correlated QoS Ranking Prediction	[7]Time-Aware Trustworthiness Ranking Prediction
1	109	148	152	170
2	119	149	157	173
3	121	152	162	178
4	129	158	164	184
5	133	159	167	185
6	138	161	172	190

Table 3 and fig 6 shows the result of average latency for QoS Ranking Prediction and Firefly Optimization Method for QoS Prediction and Optimization. It shows that Firefly Optimization method reduces the average latency rate.

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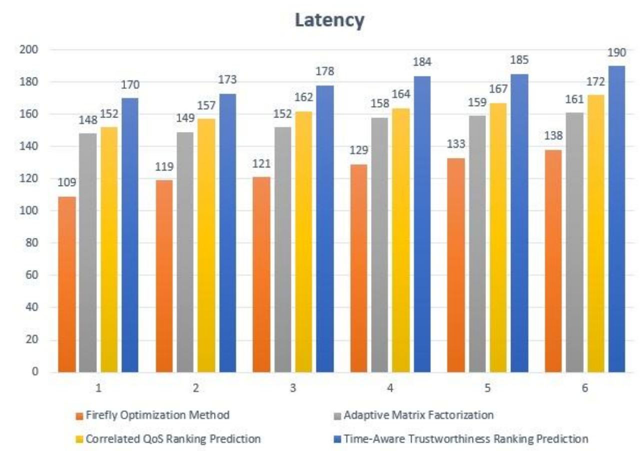

Figure 6 Latency chart

V. CONCLUSION

Nowadays cloud service is gaining popularity. Cloud is providing shared pools of configurable computer resources over the Internet. The QOS is a very important topic in cloud service. It is already seen through the literature survey there are still several drawbacks in the cloud service ranking prediction. Two main methods are used in the proposed work. First, the spearman ranking correlation method is used to select the similar cloudservices. Secondly,the Firefly Optimization Technique is used to select the optimal rank, improve the accuracy, prediction speed and decrease the error rate. Our experimental results are based on response time throughput and bandwidth. The system we proposed provides less error rate and more optimal ranking prediction.

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