BIO INSPIRED OPTIMIZATION MECHANISM FOR QOS-BASED WEBSERVICE COMPOSITION

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Abstract: In Service era, there is a significant use of Web Services by the internet users that necessitates seamless web service composition. As multiple services that provides the same functionality are available in enormous number over the net, reliable service selection is needed for service composition for the determination of the composite Quality of Service (QoS). From the literature, it can be seen that dynamic web service composition has been carried out using transactional or QoS constraints of workflow. In this paper, in continuation of Improved Variant Ant Colony Optimization for reliable Web Service Composition (IACO) and Improved Grenade Explosion Model based Artificial Bee Colony Optimization Algorithm (GMABCA), an integrated algorithm (IACO-GMABCA) for reliable web service composition is propounded as metaheuristic algorithms can be used for finding the solution of combinatorial optimization problem. IACO-GMABCA uses the multistage graph for depicting the workflow model of service composition for determining optimal path that yields the best solution in terms of convergence rate in comparison with individual performance of IACO and IABC. The experiment was conducted with two real time data sets QWS and WS-ANON. IACO-GMABCA confirms its effective performance by means of two metrics namely optimality measure and success rate and it can be seen that the integrated algorithm has extended its scope in the dynamic, reliable web service composition.

Keywords: Ant Colony Optimization, Quality of Service, Dynamic service composition, transactional attributes, web services, Grenade Explosion Model, Artificial Bee Colony Optimization

1. Introduction

Service Oriented Computing (SOC) is an exploring paradigm which provides end user to utilize the benefits of each of the services that are present in the service composition. The web services are software modules that are easily available over the internet representing business functionalities. These encapsulated, interoperable services can be used for development of web applications and can be used via a standard publishing process, identification, composition, and deployment process [1]. In [2] the two distinctive advantages of service composition are given as: i) highly efficient and cost-effective during the development of web-based applications by the maximum reutilization of the existing services and ii) improved operations which satisfy the personalised QoS requirements specified by the service consumer that may not be fulfilled by the simple standalone process/service [3]. As internet is getting exploded with millions of services every day, the end user has a wide option of selecting the service for the accomplishment of particular task [4]. The QoS parameters like response time, availability and cost place a vital role in the selection as well as in the optimized composition of services as per the personal requirements of the user which is termed as QoS aware web service composition [5]. The population based algorithms are advantageous [6] because of their anytime behaviour [7], which is suitable in practical applications where we need a best-so-far solution as per the service consumer’s ‘at any time of request’ for improving the solution over time. The quality of the service rendered is evaluated based on QoS which is related with domain independent and domain specific attributes that are exhibited when the integration of services takes place at run time [8-9]. In addition to QoS parameters, the transactional features of services have to be satisfied for supporting the process of web service composition [10]. Hence, in our earlier work [11] QoS and transactional properties were considered as the perspective parameters that are to be fulfilled to provide a reliable web service composition using ACO. From the literature point of view, a significant contributions have been made by the researchers in determining optimal workflow during web service
composition using a graph modeled workflow structure through meta-heuristic algorithms [12-13]. The meta-heuristic algorithms like ACO and ABC based on population have some drawbacks in terms of stagnation and delayed convergence during the local and global optimization of web service composition [13]. In this paper, the work in [11] has been analyzed further by the integration of Improved Ant Colony Optimization Algorithms with Improved Grenade explosion Model [14] based Artificial Bee Colony Optimization Algorithm (IACOA-GMABCA) for the reliable web service composition with due consideration for the transactional and QoS constraints [10,11,14]. IACOA-GMABCA is an algorithm for providing an optimal search solution vector for the WSC problem depicted as a multi stage graph. The local optimum problem and delay in convergence are reduced in IACOA-GMABCA, by experimenting by introducing novel technique for the exploration and exploitation mechanisms used resulting in improving the efficiency of the algorithm. By the joint venture of ants and bees an attempt has been made to yield optimum and near optimum solutions for the QoS aware web service composition problem. The performance of IACOA-GMABCA is verified using two real time data sets and for the quantification of results produced in the determination of optimal path identification of workflow model, two quantifying parameters, namely success rate and optimality measure are used.

2. Related Work

In [10], Wu, Q et. al., modelled the web service composition problem in terms of a constrained directed acyclic graph and implemented the ant colony optimization algorithm for finding a near-to-optimal solution by taking into consideration the universally available dataset QWS for exhibiting the efficiency. In our earlier work [11], we have formulated an improved ant colony algorithm for reliable web service composition. This algorithm has been devised to provide near optimal solution for the QoS aware web service composition problem by eliminating the drawbacks identified in the work [10] by introducing novel exploration and exploitation mechanisms while finding optimal solution using ACO. We have considered the QoS parameters as potential input for the identification of optimal path and as an experimental measure evaluated the overall QoS score by taking into account 4 main QoS parameters namely time, cost, reliability, availability for illustration purpose and context aware transactional value as given in [10]. In [14], Jian-Guo Zheng et. al. have proposed an enhanced Artificial Bee Colony algorithm by combining Grenade Explosion method (GEM) and Cauchy operator to find optimal solutions and experimented with bench mark functions and proved that their algorithm provides a global optimum solution over the traditional ABC. In [15], Lijuan et. al. have proposed an exploring review on Web service concretization based on three bio-inspired algorithms. In their review they have taken into account the ant colony optimization algorithms and the most researched genetic algorithms, and yet another population based particle swarm optimization algorithms and discussed pros and cons of each algorithm in terms of fitness function used and selection operator and identified the applications of bio-inspired algorithms in the scope of data-intensive service concretization problems. In [16] Lijuan Wang et. al. have proposed a new multi-phase, multi-party negotiation protocol which is an ant colony based mechanism used for data-intensive service provision for the best or near-optimal. They have experimented the performance of their algorithm in the modification of pheromone for the dynamic Ant Colony System and implemented negotiation approach for finding the pareto optimal solution. In [17], Shuiguang et. al. have proposed a new mechanism for optimal service selection known as the correlation-aware service pruning (CASP) method which incorporates the correlation between the QoS of web services for the integration of web services to find the optimal composite service set of web services and to carry out the pruning operation of non-optimal services. In [18], Jones Granatyr et. al. have identified the significant relations that exist between different trust dimensions and exhibited the different interaction types namely coalition between communicating agents, argumentation and negotiation between agents, recommendations provided by one to the other and provided a wider scope of knowledge in trust models among multi agents. In [19], Ahmed Moustafa et. al. have propounded a trustworthy mechanism to eradicate the limitations of existing traditional QoS-based service composition problems by introducing trust metric as an important criteria for the optimal service selection. They have improved the performance by the use of local search operators with adaptation mechanism. In [20], Shumugapriya P. et. al. introduced an hybrid search intelligence algorithm by considering the key elements of ACO and ABC, provided a reduced size of the features subset, improving the classification of features in terms of increased accuracy, reduced computational cost, complexity and quick convergence. Our work is different from [20] in that we have proposed an hybrid version of
improved ACO and ABC for reliable web service composition. In [21] Incheon Paik & Wuhui Chen have propounded a framework for ASC involving the life cycle of web service composition namely planning an execution workflow, discovering process of identifying services from a registry, selection process of best candidate services, and execution flow of the selected services. Li et al. [22] proposed a web service composition scheme called WSVO-QoS for enabling service discovery based on three levels of QoS, Input-output-precondition and basic description. This QoS-based model is optimal in service composition as they derive maximum number of input, outputs and the workflow constructs for identifying optimal workflow. This model reduces the complexity in estimating the optimal workflow from a number of feasible workflows derived based on graph workflow modeling. Further, Wu et al. [23] have proposed a reliable QoS forecasting-based web service composition which implements exception handling mechanism that increases composition speed. The metrics used for the validation of this exception scheme are success rate and optimality as optimal workflow structure is required for speeding up composition. In [24], Rostami et al. have introduced an ant colony optimization mechanism in order to find optimal service composition plan by fulfilling the workflow constraints. This mechanism finds all possible candidate solutions that meet the workflow constraints which results in reliable composition of web services. The stagnation factor and convergence delay in ABC have not been eliminated. Sheng et al. [25] have provided a novel solution using ant colony optimization mechanism and provided an optimized solution for web service composition problem. A selection technique is used which employs a pseudorandom partition based mechanism with the metric reliability for finding the best solutions for web service composition. This algorithm uses a well defined five-tuple based solution vector in addition to quality vector. The quantified value then may be used for exploring new optimal solutions in the subsequent web service composition steps. The above mentioned articles were analyzed and the drawbacks were identified. These articles cultivated and provided a base for the formulation of IACO-GMABCA. In [26] Lijuan Wang et al. had conducted a systematic review on the current research of Web service composition mechanisms on three bio-inspired algorithms, namely, ant colony optimization algorithms, genetic algorithms, and particle swarm optimization algorithms and provided a hierarchical taxonomy. They have pointed out that the performance of the bio-inspired algorithms with respect to the parameters that influence the efficiency of the algorithms are yet to be well explored. In [27], Xianzhi Wang et al. propounded a discrete version of ABC for the web Service Selection Problem (SSP) and achieved an approximation of the optimal continuity property of continuous optimization by leveraging unique characteristic of SSP with improved neighbourhood search.

3. QOS and Transaction Properties-Based Reliable Service Composition Using IACO-GMABCA

This article is based on our previous work [11]. In IACO-GMABCA, web service composition problem is depicted as multi stage graph, the conventions used for the evaluation of utility score of web services with the perspective of the QoS parameters and the transactional properties and other necessary constructs used are similar to the service composition scheme defined in IACOA [10-11].

A. Problem Statement

IACO-GMABCA is devised as a reliable service composition scheme based on our earlier work [11] that uses QoS and transactional properties of web services for achieving its objective as we follow the same convention as given in [10] and in our work [11] represented through five tuples

\[ PP_{QoS\rightarrow Trans} = \{UTFR, QoS_{WF}, DC_{IS\rightarrow OS}, QT_c, CP_{QoS} \} \]

Where, i) 'UTFR' specifies the total number of requirements as per the functional requirements that make up the complete set of tasks as per the work flow of service composition which is accomplished by a set of sequential activities that are related through different service constructs (sequential, loop or parallel) of web service composition.

ii) 'QoS_{WF}' defines the user personal QoS-based user specified weights related to each of the specific QoS factors \{QoS_{WF(1)}, QoS_{WF(2)}, \ldots, QoS_{WF(k)}\} which is ranging between 0 and 1 and hence the user weights pertaining to each QoS factor 'i' is realized using \[ \sum_{i=1}^{n} QoS_{WF(i)} = 1 \],

iii) 'DC_{IS\rightarrow OS}' refers to the quantified value imposed on each of the user global personal requirements specified QoS factor set \{DC_{IS\rightarrow OS(1)}, DC_{IS\rightarrow OS(2)}, \ldots, DC_{IS\rightarrow OS(k)}\} in which each particular 'DC_{IS\rightarrow OS(i)}' corresponds to the 'QoS' attribute in relation with each service used for service
composition. $DC_{CS-QoS}$ is categorized into positive(maximum) or negative(minimum) value depending on the type of QoS attribute used with its upper and lower thresholds. In this context, $DC_{CS-QoS\leq 0}$ specifies that no constraint is imposed on each of the specific QoS attribute considered for web service composition.

iv) ‘$QTC$’ corresponds to the transactional characteristics used for user requirement based service composition.

v) $CP_{QoS}$ pertains to the contextual priority of QoS represented through the set \{(CP_{QoS(1)},CP_{QoS(2)},\ldots,CP_{QoS(1)})\} whose value also ranges between the value of 0 and 1 as analogous to $QoS_{UW}$.

In this reliable web service composition approach, user can provide the specifications for the functional requirements at run time and QoS -UDDI-based service registry is explored by the service composition engine that works on the principle of orchestration.

B. Improved Ant Colony and Grenade Model based Artificial Bee Colony Optimization Algorithm for reliable web service composition

From the literature, it has been known that QoS-based service composition problem is a combinational problem and has the NP-hard complexity. When the personalized user requirements specified in terms of global and local constraints, the problem becomes more crucial and the solution by means of Brute force searching process is of exponential computational complexity. Hence, searching algorithms like Brute force are unsuitable for real time dynamic web service composition but they behave as the ideal among the service composition techniques. Heuristic optimization algorithms based service composition is effective for ensuring local QoS optimizations but they are not successful in generating candidate solutions that satisfy global QoS constraints of web service composition. The Meta-heuristic optimization algorithms such as Ant Colony Optimization (ACO) and Artificial Bee Colony (ABC) algorithms are confirmed to be exceptional in the identification and generation of optimal paths or sub-optimal paths from the graph that are modeled for representing workflows of web service composition using global functional requirements. The effective performance and applicability of ACO and ABC algorithms in diversified problems made the integration of these two algorithms for finding complete and reliable solution vector for web service composition modeled as directed acyclic graph. But, the traditional ACO scheme suffers stagnation during the process of intensification and ABC algorithm involves delayed convergence due to the maximum degree of intensification enabled by its onlooker bee phase [20]. We have devised an Improved Ant Colony Optimization Algorithm in our previous work [11] and used Grenade Explosion Method based Artificial Bee Colony Algorithm(GMABCA). In this paper, an integrated Ant Colony and Artificial Bee Colony Optimization Algorithm based solution is formulated for web service composition based on QoS and Transactional factors. The known drawbacks of ACO and ABC algorithms are resolved because of the integration of new improved algorithms of ACO and ABC in terms of exploration and exploitation. In [11], we have taken measures to overcome the stagnation problem and identified the areas where improvement can be made in traditional ACO. Also time delay caused by the initial random search of Employed bees and onlooker bees of ABC algorithm can be improved by the introduction of grenade explosion model ultimately results in improvisation of the process of intensification. This proposed IACO-GMABCA method is an effective mechanism for the reliable web service composition as it covers the merits of ACO and ABC optimization schemes. The agents in IACO-GMABCA, on behalf of service consumer share the responsibility of finding the search solution vector of the problem space. Initial solution set provided by ants of IACO are utilized by employed bees of GMABC which perform the initial level of exploitation rather than generating the new random solution set. This phase being followed by the Onlooker bees for the greedy exploitation at the second level and for detection of worst solutions from the problem space. This process of workload sharing between ants and bees continued until convergence takes place and the abandoned solution vectors can be further explored by scout bees on set which is to be again investigated by ACO. ACO in IACO-GMABCA
considers only the optimal solutions returned by ABC and enable the global searching process for estimating missing solutions of the web service composition-based optimization problem.

In this IACO-GMABCA oriented reliable service composition, the workflow of the web service composition activity is modeled as directed acyclic graph. The vertices and edges of this modeled directed acyclic graph \((V_{CS}, E_{CS})\) corresponds to candidate solution set that includes initial and end vertex of the graph and the collection of directed edges that relates two workflow activities of service composition from \(k\) activities derived based on functional requirements. The candidate solutions refereed in this context relates to the significant capability of possible solutions that satisfy the functional requirements of the workflow based on the imposition of QoS and transitional properties of service composition. The possibility of determining optimal paths from the graph is initiated immediately after the process of modeling the task of web service composition into a directed acyclic graph. The optimal paths from the starting vertex to the sink vertex of the directed acyclic graph are estimated when they satisfy the global QoS constraints that need to be ensured by activities of the workflow. In IACO-GMABCA, the directed edges of the modeled graph are assigned with weights for representing the intensity of pheromone in its embedded ACO and its corresponding upper and lower thresholds of pheromone are also assigned for preventing it from stagnation. Similarly, the primitive parameters that facilitate the exploitation and exploration process of ABC are also assigned for facilitating the process of implementing IACO-GMABCA for reliable dynamic service composition.

In the subsequent section, the steps of IACO-GMABCA applied for web service composition is discussed.

C. Algorithm IACO-GMABCA

Zeng et al. [5] first formalize the Service Selection Problem (SSP) as a combinatorial optimization problem and solve it via a Mixed Integer Programming (MIP) model. We have followed that model.

\begin{align*}
\text{Maximize:} & \sum_{i=1}^{D} w_i \left( \sum_{j=1}^{N} p_{ij} \right) s_j, (s = 1, 2, ..., M) \\
\text{subject to:} & \sum_{i=1}^{D} p_{ij} = 1, p_{ij} \geq 0, \lambda_i
\end{align*}

\[\sum_{i=1}^{D} w_i = 1, p_{ij} \in (0, 1)\]

\[\sum_{i=1}^{D} p_{ij} = 1, i = 1, 2, ..., D, j = 1, 2, ..., N (u) - - - - - - - (1)\]

* We denote each composite solution by an \(M\) - tuple, i.e.,
* SC = \((s_1, s_2, ..., s_M)\) where each element stands for a service selected for the corresponding task, i.e., \(s_u = s_{uY}\) for each \(u = 1, 2, ..., M\).

* For a candidate solution be optimal, it should not only satisfy QoS constraint but also achieve the maximal objective value of Eq.(1).

Repeat

1. \(\text{Iteration} = 1\)
2. Initialize ACO

Set the number of ants equal to the number of service consumers (\(M\))

For \(i\) from 1 to \(M\), assign the pheromone values of each of the edges is set to initial value 0 or fixed value, and utility of the candidate service(\(\eta\))

\[\eta(j+1, y) = Q\text{Score}[s(j+1, y)] \times T\text{Score}[s(j+1, y)]. \quad (2)\]

is assigned as specified in (3)

\[Q\text{Score}(s_j) = \sum_{q_i}^q (q_i - q_i, \text{max} - q_i(s_j))/(q_i, \text{max} - q_i, \text{min}) \quad \text{wi} + \sum_{q_i}^q (q_i(s_j) - q_i, \text{min})/(q_i, \text{max} - q_i, \text{min}) \quad \text{wi} \quad (3)\]

Transaction score (TScore) is assigned as per the transaction property [10, 11]

3. Initialize ABC

Set the population of EmpBees and OutBees(BN)equal to the number of ants (\(N\))

Each solution vector \(PN\) is a D-dimensional solution vector where D represents the number of tasks to be included in WSC and \(PN_i = (PN_{i1}, PN_{i2}, ..., PN_{iD})\) represents the \(i^{th}\) solution of the global search problem.

4. Ant phase

Repeat

// D – number of tasks

For \(i\) from 1 to \(D\), for each task \(i\),

Calculate the probability of selecting the service(node) \(i\) by the ant

Update the pheromone value deposited on the edge of the selected node

End For
Until all the ants have finished
Repeat

5. Employed Bee phase:
Assign the subsets of nodes ie path selected by each ant (Ant phase) to each of the employed bee as food source positions

Each node chooses the optimal search path only when it satisfies the fitness function defined through

\[\text{fitness}(PN_i) = \frac{1}{1 + f(PN_i)}, f(PN_i) \geq 0 \quad \text{----(4)}\]

\[\text{fitness}(PN_i) = 1 + \text{abs.} f(PN_i), f(PN_i) < 0 \quad \text{-----(5)}\]

Where \(f(PN_i)\) is the objective function value of solution \(PN_i\).
Calculate the objective function( ) and the fitness value ( )
Produce solutions subset of nodes for onlookers phase
Calculate the probability ( ) to determine the number of onlookers to be assigned to exploit the subsets of nodes

The probability of selecting a node by the onlooker bee is presented by

\[P_{PN(i)} = \frac{\text{fitness}(PN_i)}{\sum_{i=1}^{T} \text{fitness}(PN_n)} \quad \text{----(6)}\]

6. Onlooker Bee phase: using Grenade Explosion Mechanism

Use the greedy selection mechanism to choose the optimum set of services(nodes)
// a number of grenades (\(g_n\)) are generated that are initialized at random locations with \(SR(g_n) \in [-1,1]^n\)
n pieces of shrapnel are thrown in all the dimensions (i.e., only one shrapnel is assigned for one task) to gather nectar information around the current grenade (already visited node);
Generate a position area \(PX_k^i\) for identifying optimal search solutions around the \(k^{th}\) grenade through

\[PX_k^i = \{PX_k + \text{sign}(UD_{rand}))(UD_{rand}) \}^{L_{ge}} \quad \text{(7)}\]

Where \(UD_{rand}\) and \(L_{ge}\) refers to the uniformly distributed random number and length of influence of each grenade \(k=1, 2, \ldots, g_n\) with a constant

\[f=\max\{ln(n(\frac{R_g}{R_{e}}))\}, \quad \text{-----(8)}\]

Evaluate the distance between \(PX_k^i\) and radius of exploration \(R_e\) and if \(X_i^k\) is found at least \(R_e\) distance apart from the position of grenades, then \(X_i^k\) is selected. Pass the optimum set of services to the ant colony until required number of cycles or convergence

7. Ant Phase:
Update the pheromone value globally by considering set of nodes selected by the onlooker
8. Iterations = Iterations + 1
9. Traverse new set of nodes as pheromone trail has been updated in the previous run
10. If solution vector to be abandoned then call Scout bees:
EmpBees of neglected nodes becomes scout Cauchy operator is employed in the scout bee phase of GMABC using \(PON_{ij} = PON_{ij}\text{Cauchy}(0,1)\) \quad \text{----(9)}

Where \(PON_{ij}\) is the abandoned food source, Cauchy (0, 1) refers to the standard Cauchy distribution with center ‘0’ and scaling parameter 1 as defined through

\[\text{Cauchy}(0,1) = \frac{1}{\pi(1 + PON_{ij}^2)} \quad \text{------(10)}\]

Assign the newly generated subsets of nodes to the scout
11. Save optimum set of nodes obtained.

Until Maximum number of iterations done

4. Improved ant colony optimization with grenade method based artificial bee colony optimization algorithm for finding optimal solution of wsc.

In IACO-GMABCA, the assumption is made that there are ‘m’ different service providers, providing services of same functionality but with different QoS parameters. For the WSC problem ‘n’ different tasks are to be completed. To accomplish a particular task, the assumption is made that the service consumer can choose a service from ‘m’ different services provided by ‘m’ different service providers. During Ant Phase, by appointing ‘m’ ant agents for each of the service
providers, at the end of one iteration ‘m’ different feasible solution vectors represented by paths from source node to sink node of the directed acyclic graph are obtained. For Employed Bee phase, instead of selecting a random set of food sources/services and checking for the feasibility, the output of ant phase is used as the starting point, and further exploitation is carried out by the greedy mechanism followed by the on looker bees. Since there are ‘m’ service providers providing same service/activity for each task, the bees have the option of selecting any one service out of ‘m’.

In our algorithm, we use Grenade explosion Model [14], by means of which the node which has maximum damage caused by the shrapnel of the grenade is used as the selection criteria for including a service in the feasible set of services. The node with higher damage is selected. At the end of first iteration, so far obtained best solution is compared with the newly generated solution vector. If the new solution is better than the previous one, the previous solution set is abandoned. Otherwise, the previous one is retained. If the solution vector is to be abandoned, the scout bee phase is used for further exploring the solution space. It has been proven in [14], that Cauchy distribution provides a way for widening the search space thereby improving exploration. In the next iteration of ant phase the solution set provided by ABC helps the ants to exploit and explore. This process is continued for the fixed number of iterations or stopped when the convergence occurs. The Mathematical background related details of this paper can be referred in [14] and in our earlier work [11].

The proposed IACO-GMABCA is advantageous because of the following reasons

1. In IACOA [11], the new state transition rule is used which provides pareto optimal solution by avoiding stagnation. The feasible solution vector provided by the ants are used by the employed bee as the initial search space instead of starting from random search space.

2. Out looker bee phase of GMABCA dynamically exploits the solution vector provided by employed bee using grenade explosive method [14] updates the service subset determined by ants of ACO rather than generating its own service subset.

3. In the case of abandoned solution vector, Scout bees similar to employed bees utilize the solution vector provided by ants instead of starting from random search space.

4. The implementation of IACO-GMABCA is verified for two real time data sets based on two metrics optimality score and success rate.

5. The convergence rate of this integrated IACO-GMABCA is improved in comparison with the other two individual performance of algorithms namely IACO and ABCOA.

5. Experimental Results And Inferences

The performance evaluation of IACO-GMABCA is carried out with Windows XP and JAVA 2 Version 6.0. installed on PC with 2 GB RAM. The experiments were conducted by varying the number of tasks to be completed and by varying the number of similar activities in each task. As per the orchestration workflow model, tasks are considered to be ‘n’ in number where each task can be performed by ‘m’ number of abstract services. The experimental set up for QoS parameters and transactional properties that are used here are similar to the one defined in [10,11]. The simulation experiments of IACOA-GMABCA are conducted using two real world service dataset referred as QWS dataset [28] and WS-ANON [29] for the determination of utility score of web services which determines the ranking of web services. Classification of web services into low, medium and high level reliable services which is required for flexible pheromone updating thereby providing dynamism in WSC. According to the Simple Additive Weighting(SAW) rule the intensity of QoS Intensity constraints (I) is determined for simulation. Further clarification regarding the calculation of (I) can be found in [10,11]. In IACO-GMABCA, the number of times iteration to be performed, upper and lower threshold are assigned to 100, 0.2 and 1 respectively with the workflow count of 15 and set of services that fulfill the fitness function is set to 30% in the total workflow using WS-ANON data set for QoS.

The experiment is done using metrics success rate and optimality to prove the efficacy of IACO-GMABCA over IACOA, GMABCA. The Brute force technique is used as a bench mark model as it explores all possible combinations for analyzing the performance of this algorithm in achieving reliable web service composition. Figures 3 and 4 reveal the performance of IACO-GMABCA conducted based on success rate and optimality metrics for 300 user requests taken from WS-ANON data set. Figure 3 proves that the success
rate of IACO-GMABCA can be seen to improve with increase in the QoS strength compared to IACOA, GMABCA in two different data set environment at the same time found to be closer to the success rate of currently considered Brute force method as it explores all possible combinations. Figure 5 shows the efficiency of IACO-GMABCA by means of improved success rate is possible as a result of the integration of IACO and GMABC optimization schemes that excludes local optimum and time delay, hence the average success rate of IACOA-GMABCA is exceptional to about 19% better to IACOA and GMABCA algorithms under two data sets considered for reliable web service composition. Similarly, Figure 4 shows that the optimality measure of IACO-GMABCA is closer to 1 which is the success rate at the maximum value for the Brute force technique and thus optimality measure of IACO-GMABCA is found to be superior by 14% and 11% compared to IACOA and GMABCOA algorithms implemented for providing reliable web service composition for WS-ANON data set.

![Fig. 3. Performance result of IACO-GMABCA using Success Rate for WS-ANON data set](image1)

![Fig. 4. Performance result of IACOA IACO-GMABCA using Optimal Measure for WS-ANON data set](image2)

![Fig. 5. Performance result of IACOA IACO-GMABCA using average Success rate for QWS and WS-ANON data set](image3)
In addition to the above examination, the performance of IACO-GMABCA is studied using Mean Computational Time (MCT) by varying the number of tasks and the activities constituting the service with reference to the QoS constraint intensity(I) assigned to 0.4 and 0.6 respectively for WS-ANON data set. Figures 7 and 8 shows the actual performance of IACO-GMABCA compared to ACOA, GMABCA and Brute Force mechanism in terms of MCT examined for WS-ANON data set. The results reveal that IACO-GMABCA is special in average to about 23% and 14% better to ACOA, ABCOA and it is found to be...
converging to the maximum of 15% to the performance of Brute force technique used in realizing MCT evaluated under different QoS constraint intensity of 0.2, 0.4 and 0.6 respectively.

Further, the implication of IACO-GMABCA in reliable web service composition is examined using Mean Computational Time (MCT) by varying the number of task with QoS constraint intensity of 0.4 and 0.6 respectively for WS-ANON data set. Figures 9 and 10 aids in realizing the exceptional performance of IACO-GMABCA compared to ACOA, ABCOA and Brute Force scheme in terms of MCT analyzed varying the number of activities for each task of WS-ANON data set. The results proves that IACO-GMABCA is remarkable in about 25% and 14% better to ACOA, ABCOA and it is also seem to exhibit a performance which is very close to about 10% in the performance of Brute force scheme investigated using MACT with QoS constraint intensity of 0.4 and 0.6 respectively.

6. Conclusion

An Integrated improved Ant Colony Optimization and Grenade explosion Model based Artificial Bee Colony Optimization Algorithm (IACO-GMABCA) for reliable web service composition scheme has been proposed in this paper for improving the performance in the case of web service composition to overcome the problems of local optimum and time delay in convergence at a much effective rate and experimented with the data sets QWS and WS-ANON. The two data sets used, provide experimental results of IACO-GMABCA in two different scenario and confirms that mean exceptional better performance in terms of success rate and optimality measure under comparison with IACOA and GMABCA web service composition algorithms. The evaluation results under two different data sets for the execution of IACO-GMABCA by changing the number of tasks and number of activities in each task for orchestration based workflow model indicates a mean computation time better than IACOA and GMABCA search mechanisms. The search for optimum solution for workflow problem can be enhanced by modeling workflow as a directed acyclic graph in order to satisfy the global and local constraints to a much significant level than the traditional optimization schemes and has been experimented for reliable service composition by the average success rate and optimality measure of two data sets. In future we like to experiment our algorithm for varied number of tasks ranging from 100 to 1000.

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