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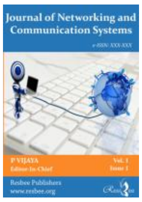

Optimal Rescheduling Based Congestion Management using HBOABC Algorithm

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Abstract: Under a deregulated environment, the rescheduling-based CM approaches are well-known solutions for safe and consistent power flow. The role of heuristic approaches has become important because the rescheduling methods show multimodal behavior by nature. In the literature, various heuristic search approaches are presented to address the issue. Hence, this paper exploited Hybrid Butterfly Optimization and Artificial Bee Colony (HBOABC) method which is a famous optimization method. The proposed HBOABC method tries to resolve the rescheduling issue in a hybrid electricity market. Hence, the congestion is intended to reduce at the optimal cost of rescheduling. An investigational study is performed in IEEE14 bus system in a multipoint and single point congestion cases. The simulation outcomes revealed that the proposed technique is better than Butterfly Optimization Algorithm (BOA) and Artificial Bee Colony (ABC) with respect to the cost-effective congestion mitigation.

***Keywords*-**Congestion Management; Rescheduling; Power system; optimization method; IEEE bus system

Nomenclature

Abbreviations	***Descriptions***
CM	Congestion Management
SVM	Support Vector Machines
SR	Spinning Reserve
FACTS	Flexible AC Transmission Systems
PSO	Particle Swarm Optimization
HEMS	Home Energy Management System
CDI	Congestion Detection Index
HIFs	High Impedance Faults
DG	Distributed Generators
LBFL	Learning-Based Fault Locator
ANN	Artificial Neural Network
RTCM	Real-Time Congestion Management
DT	Distribution Network
GLCM	Generation and Load shedding Cost Minimization
MM	Mathematical Morphology
DPT	Daily Power-Based Network Tariffs
ITCC	Index of Total Congestion Cost
SWM	Social Welfare Maximization
DSO	Distribution System Operator
TCSC	Thyristor Controlled Series Compensator
WG	Wind Generator
DS	Distribution System
DT	Dynamic Tariffs
MOPSO	Multi-Objective Particle Swarm Optimization
DRPs	Demand Response Programs
TLBO	Teaching-Learning-Based Optimization

1.Introduction

The power system encounters deviations in operating circumstances incessantly. Contingency circumstances can happen because of the enforced outage of a transmission line, the abrupt rise of electrical load, or else any flaw in the equipment of the system [14] [15]. Best generation load shedding and rescheduling at the contingency situation is considered as the vital problems in scheduling the protected operation of power systems [16]. To attain a new equilibrium state, the load shedding is represented as the set of controls that outcomes in the load demand reduction in the power system. Moreover, the load shedding approaches encompass more significant in deregulated power systems, whereas there is the absence of sufficient SR or a lack of tie-line power ability to formulate up for the lost generation. The load shedding approaches are essential to stop the occurrence namely line overload, voltage collapse, and so forth that can tend to flow outages as well as after that blackout. In order to evade the system-wide blackouts, the load shedding is represented as a powerful tool [17].

Generally, the congestion is the circumstance while a transmission network creates operating further than convinced allowable limits namely stability, voltage, as well as the physical limit of a line [18] [19]. Generally, in the deregulated market congestion happens as buying as well as selling of energy, which can be resolved without taking into consideration of the restraints of the power system. Insufficient reactive power support, outage offline, stoppage of equipment, the diversity is considered as the major reasons for congestion source real risk to power system security as well as an outcome in electricity cost ramble. To alleviate the congestion of transmission networks, CM takes measures or manages actions. Generally, the approaches selected for CM such as load shedding, generation rescheduling, market splitting, line switching, zonal pricing and so forth.

The evaluation and alleviation of congestion are necessary for the vigorous power market operations. Moreover, under the deregulated market, it is complicated to preserve the constancy as well as the competence of system in terms of the market transaction actions such as bilateral, pool, as well as multilateral transactions. Here, in the deregulated power market non-cost and cost-free approaches are exploited with the ISO to alleviate the congestion [22] [23]. The cost-free approach uses operation of existing compensation devices such as out aging of the transmission lines, phase-shifters, and transformer taps operation and FACTS devices. These approaches could not engross in any generation and distribution companies while load curtailment, as well as generation rescheduling, are included in the non-cost- free technique [20] [21].

In an open-access electricity market, an efficient optimization method like Firefly method [26] was presented for the CM issues [11]. Moreover, a novel technique [27] [28] [29] [30] is recommended for approximate transmission congestion cost on the basis of power flow tracing using PSO method [12] [24] [25]. Information gap decision theory was used to undertake the CM issue exploiting the flexible abilities of DG as well as demand response [13].

This paper presents a hybridization of Butterfly optimization and Artificial Bee colony optimization algorithm. Moreover, this method has the capability to resolve the rescheduling based CM issue. The rest of the paper is organized as follows: Section 2 describes the literature review of the paper. Section 3 defines the problem formulation of congestion management. Section 4 describes the rescheduling based congestion management using HBOABC Algorithm. Section 5 defines the results and discussions. Section 6 summarizes the conclusion of the paper.

2. Literature Review

In 2017, S. Surender Reddy [1] presented a novel congestion management approach exploiting the load shedding and generation rescheduling, by means of the practical voltage-dependent load model. Here, voltage-dependent load models were exploited it evidently states that the unsuitability of traditional single objectives for CM, namely SWM/GLCM because of the minimization of the number of loads served. Consequently, multi-objective optimization was needed and the objectives were wisely combined according to the loading circumstance.

In 2018, Fariborz Zaeim-Kohan et al [2] proposed the MOPSO approach was exploited for transmission CM in view of generation rescheduling and DRPs. The main objective of this issue was the cost of DR, production and raising the loading of transmission lines. By exploiting DRPs enhances the operator power of option regarding the contribution of small customers in minimizing the demand. In addition, the proposed approach experimented on IEEE 118 and 30-bus test systems. Finally, outcomes of the assessment something diverse cases demonstrate that DRPs decrease the power system transmission lines congestion, permitting employ of the transmission lines by fewer loading capacity.

In 2017, Sumit Verma et al [3] presented a TLBO method for CM in a pool on the basis of the electricity market. Congestion was a major issue that a sovereign system operator features in post deregulated period. The main objective of exploiting TLBO method was to efficiently alleviate congestion in the line with least divergence in the first generation. When dealing with this problem several safety restraints namely line loading and load bus voltage was considered. Motivated by the teaching-learning procedure of the classroom, this method was a new population-based approach that does not need any method definite control parameters, not like other methods. It only needs general control parameters such as a number of generations and population size.

In 2018, Mohammad Ali Fotouhi Ghazviniet al [4] presented a market-based method to improve DN congestions during centralized coordinated HEMS. Here, the DSO implements DT and DPT were exploited. As DPT and DT price signals aim the aggregated nodal demand, the individual uncoordinated HEMS approaches operating in these price signals were not capable to efficiently ease the congestion.

In 2019, Prashant Kumar Tiwari et al [5] presented an easy, proficient and consistent two-step optimization approach to resolve the congestion issue beside with minimization of system generation cost, congestion cost, maximization of system profit, and emission using optimal position and numbers of TCSC with WG in a deregulated power market. Two new indices such as CDI and ITCC were also presented towards more rapid recognition and decrease of system congestion efficiently. For this study, the pool and bilateral deregulated market approach were considered. After the best position of WG and TCSC(s) in the system, the maximum system profit was significantly attained.

In 2017, Mohammad Mahmoudian Esfahaniet al [6] presented an adaptive RTCM approach that optimally uses adaptive thermal ratings for transmission lines. It was exploited to deal with real-time congestions with the assistance of all power system abilities. Moreover, this method was represented as a necessary subsidiary service in a power market, whereas customers and all generation companies can be involved. Here, a demand response program was modeled in addition to solve the RTCM issue, a real-time hybrid optimization technique was modeled, which was aimed at identifying the best solution in a short time span. Moreover, they presented an integrated adaptive ANN along with a modified PSO method as a real-time hybrid optimization technique.

In 2018, Sekar Kavaskar and Nalin Kant Mohanty [7] presented a novel detection approach for HIFs in power DN on the basis of MM. Here, from the distribution feeder, the current signals were noticed to identify HIFs. The MM was exploited with a time domain to extract the features, as well as a simple rule-based method, was used to categorize HIFs from other power system disturbances.

In 2019, E. Correa-Tapasco [8] presented the adjusting and the validation approach, which was exploited to model a fault locator, as well as its performance, was analyzed in the account of different distorted measurements as inputs. Moreover, the LBFL was developed especially for DS, whose central part was the Support SVM. In an unbalanced 34.5 kV distribution feeder, the LBFL was tested taking into consideration of diverse operating circumstances and fault cases that comprise various locations, general disturbances on the voltage, as well as current input signals and fault resistance.

3. Problem Formulation of CM

The problem on the basis of the hybrid electricity market is formulated. Here, both the pool market features and bilateral contract are presumed to be accessible. By rescheduling the generators, the congestion issue is planned to overcome. Hence, the congestion has to be reduced with minimum rescheduling cost. Moreover, the main aim of CM is to reduce the congestion cost when fulfilling the network constraints. The CM issue is resolved by rescheduling (minimizing or maximizing) the generators real power output. But the change in real power output is related to a cost that in order to depend on the price bids presented by GENCOs. Therefore, the complete issue can be developed as a constrained minimization function, which is represented in eq. (1).

$$G^* = \underset{\Delta P_n \forall n}{\arg\min} \sum_{n=1}^{N_g} f(\Delta P_n) \tag{1}$$

Consider $\Delta P_n : 0 \le n \le N_g$ (MW) be the change of power for n^{th} generation unit, which needs to be rescheduled for a cost of $f(\Delta P_n)$ in $.

(a) Generation capacity constraint:

$$P_n^{min} \le P_n \le P_n^{max} \tag{2}$$

$$P_n = \Omega P_n + \Delta P_n \tag{3}$$

In eq. (2) P_n represents the generation quantity in MW. If ΩP_n is the previous power quantity being generated it can also be stated as eq. (3).

(b) Real power balance constraint:

In Eq. (4), P_D indicates the total power demand in MW and P_L indicates transmission losses that can be indicated as eq. (5), where, B_{mn}, B_{0n} and B_{00} are the loss coefficients.

$$\sum_{n=1}^{N_g} P_n - (P_D + P_L) = 0 \tag{4}$$

$$P_L = \sum_{m=1}^{N_g} \sum_{n=1}^{N_g} (P_m B_{mn} P_n) + \sum_{n=1}^{N_g} (B_{0n} P_n) + B_{00} \tag{5}$$

(c) Stability Limits:

To characterize the congestion and to assure congestion mitigation the stability limits are the main criterion. They are represented in eq. (6), (7) and (8). In eq. (6), (V_i^{min}, V_i^{max}) represents the voltage limits, and in eq. (7), $(\partial_i^{min}, \partial_i^{max})$ represents the angle limits that indicate voltage stability from the generators to load buses. Eq. (8) assures the transmission lines are not overloaded in that S_{ij}^{max} indicate maximum power flow limit in MVA.

$$V_i^{min} \le V_i \le V_i^{max} \quad 6)$$

$$\partial_i^{min} \le \partial_i \le \partial_i^{max} \tag{7}$$

$$P_{ij}^2 + Q_{ij}^2 \le (S_{ij}^{max})^2 \tag{8}$$

(d) Ramp up limits:

The up and down rescheduling quantity limits are indicated by ramp-up limits. In view of the fact that equal up and down rescheduling costs is considered, and the eq. (9) states the ramp limits

$$\Delta P_n^{min} \le \Delta P_n \le \Delta P_n^{max} \tag{9}$$

From Eq. (1), G^* is attained that is the best rescheduling approach by that congestion is decreased with minimum rescheduling cost. This paper makes an effort to solve eq. (1) by means of conventional BOA and ABC as well as proposed HBOABC and then examines the attained rescheduling approach.

4. Rescheduling Based Congestion Management using HBOABC Algorithm

4.1 Conventional BO Algorithm

In recent times developed a population-based nature-inspired optimization algorithm termed as Butterfly Optimization Algorithm (BOA) [24]. It discovers its basis of motivation in the butterflies food foraging behavior. In nature, the butterflies are capable to discover their food and the similar food searching technique is exploited in the method.

In BOA, to carry out optimization the butterflies are exploited as search agents. Nature has provided the butterflies with intellect receptors that let them to intellect the smell of food and as a result, they move to a particular direction. It is supposed that each butterfly is capable to produce smell with some intensity in BOA. Further, this fragrance is linked with the fitness of the butterfly. It represents while a butterfly moves from one place to other meticulous place in the search space, thus its fitness will differ. In addition, the smell that is being produced by the butterflies is broadcasted against distance to all the other butterflies in that area. By the other butterflies, the broadcasted smell is sensed and a cooperative social knowledge network is created. In the area, while a butterfly is capable to sense smell from the optimal butterfly, it moves to the optimal butterfly and this stage is known as the global search stage of BOA. Next, in the search space, while a butterfly is not capable of intellect smell of any other butterfly, it will move arbitrarily in the area and this stage is known as local search stage in BOA

The fundamental power of BOA reclines in the method of adapting the smell in the complete searching procedure. At first, it must be examines that how any sense such as sound, heat, smell, light and so forth is processed by a stimulus of a living organism to know the modulation of fragrance. The fundamental idea of sense is dependent on three crucial parameters. m indicates the sensory modality, i indicates the stimulus intensity, e indicates power exponent.

Sensory modality describes the scheme by that the form of energy is measured and developed with the stimulus. Various modalities/senses have the ability to light, sound, smell, pressure or temperature and so on and in BOA, it is smell. The physical stimulus magnitude is represented as i in BOA; it is linked with the fitness of the butterfly solution i.e. in the search space a butterfly with high fitness value attracts other butterflies. The parameter e permits reply compression specifically as the stimulus obtains robust; insects become more and more minimum sensitive to the stimulus changes.

Let us consider the truth of biological butterflies; the searching fact is on the basis of two important problems: (1) difference of i, (2) formulation of f. For ease, i of a butterfly is linked with the encoded objective formulation in BOA. On the other hand, f is relative specifically it must be sensed in the search space by other butterflies. For that reason, bearing in mind these ideas of biological butterflies, the fragrance is represented as a physical intensity function of stimulus in BOA is shown in eq. (10).

$$f_i = mi^e \tag{10}$$

In the global search stage, the butterfly gets a step to the fittest solution that is denoted in eq. (11). Here, z_i^{t+1} represents the solution vector for i^{th} butterfly in the iteration t. The optimal solution establishes among all the solutions in the current generation is represented as h. The step size is indicated as $levy(\lambda)$. Eq. (12) indicates the local search stage.

$$z_i^{t+1} = z_i^t + \left(levy(\lambda) \times h - z_i^t\right) \times f_i \tag{11}$$

$$z_i^{t+1} = z_i^t + \left(levy(\lambda) \times z_k^t - z_j^t\right) \times f_i \tag{12}$$

where z_k^t and z_j^t are j^{th} and k^{th} butterflies selected arbitrarily from the solution space. If z_k^t and z_j^t goes to the similar swarm and $levy(\lambda)$ is the step size, subsequently eq. 12 becomes a local arbitrary walk. At the local and global level, the food searching procedure can happen, thus considering a switch probability p is exploited to control the general intensive and global-local search in BOA.

4.2 Conventional ABC algorithm

The ABC approach illustrates its inspiration from the intelligent behavior of real honey bees. Here, the honey bees are characterized into three types such as onlooker bees, employed bees, and scout bees. Moreover, the colony is characterized into two divisions such as first division comprises of employed bees while the second division comprises of onlookers bees.

In the search space, each solution comprises of a set of optimization parameters that indicate a food source population. The number of food sources is equivalent to the number of employed bees; specifically, one employed bee is there for every food source. Moreover, employed bees contribute to the information concerning food sources with onlooker bees that stay in the hive. On the basis of the contributed information, a food source is chosen to be used. Some employed bees whose food source is tired are interpreted to scout bees. Following the initialization of population, the entire iterative procedure of ABC is classified into three stages such as onlooker bee selection phase, employed bee search phase, and scout bee phase. In the first stage, a candidate food position is formed utilizing the old one. It is attained by the eq. (13).

$$u_i^j = z_i^j + \gamma_i^j\left(z_i^j - z_k^j\right) \tag{13}$$

where z_i^j and z_k^j are the indexes, selected arbitrarily while k is determined arbitrarily, diverse from i. γ_i^j indicates an arbitrary number in the range [-1, 1]. A food source u_i^j within the neighborhood of each food source place indicated by z_i, which is computed by adapting one parameter of z_i. Subsequent to the u_i is computed, it will be assessed and compared to z_i. To choose the better one among z_i and u_i a greedy chosen approach is utilized that depends on fitness values demonstrating the nectar amount of the food sources at z_i and u_i correspondingly. If the fitness of u_i is equal to or better than that of z_i, then u_i will replace z_i, and turn out to be a new member of the populations, else z_i is engaged. In the second stage, one food source is chosen by each onlooker bee based on the fitness value attained from the employed bees. At present, any fitness on the basis of the probability chosen scheme is utilized such as rank-based, roulette wheel, the tournament was chosen, etc. In general ABC, roulette wheel chosen scheme is exploited, and it is stated in eq. (14).

$$P_i = \frac{f(z_i)}{\sum_{m=1}^{n} f(z_m)} \tag{14}$$

$f(z_i)$ represented as the fitness of the solution i. Evidently, higher fitness value represents more probability of chosen attainment. Subsequent to the chosen food source, onlooker bees will move to the chosen food source and a new aspirant location is created in the neighborhood of the chosen food source utilizing eq. (13).

In the final stage, after the achievement of searches by an onlooker and employed bees, the technique ensures whether the source that is tired requires to be neglected. It represents that if a better location cannot be obtained an encoded number of likelihood specifically cycles, after that the particular food source is supposed as neglected and a new food source is computed exploiting eq. (15).

$$z_i = z_{min} + r(z_{max} - z_{min}) \quad (15)$$

In eq. (15), r indicates an arbitrary number in the range [0, 1] whereas z_{min} and z_{max} indicates the individual lower and upper bounds of a variable z_i. The final stage aids the method to evade suboptimal solutions.

4.3 Proposed HBOABC Algorithm

In this paper, the two algorithms are combined and a hybrid BOABC algorithm is proposed for fault diagnosis problems. By exploiting the benefits of both the techniques, the proposed method has the ability to update the poor solutions that accelerate its convergence speed. Moreover, HBOABC algorithm is effectual in exploring the search space and exploiting the solutions. Hence, the proposed method has the ability to solve the rescheduling based congestion problem.

Algorithm: Pseudocode of Proposed BOABC

Initialize the objective function $f(z)$, $z_i(i = 1,2,.....n)$
Produce an initial population of individuals
In the initial population find the optimal solution
Describe switch probability P
while stopping criteria not attain perform
for each butterfly in population perform
Use r_1 and r_2 from a uniform distribution
if $r_1 < 0.5$
Exploiting eq. (10) compute fragrance of the butterfly
if $r_2 < p$ then
Exploiting eq. (11) perform global search
else
Using eq. (11) perform local search
end if
Calculate new solutions
Update Better Solutions
end if
else
for each employed bee do
Using eq. (13) generate a new solution u_i
Compute its fitness value $f(z_i)$
Apply the greedy selection process
Using eq. (14) Calculate P_i for the solution z_i
end for
for each onlooker bee do
Choose a solution z_i depending on P_i
Generate a new solution V_j
Compute its fitness value $f(V_j)$
Apply the greedy selection process
end for
Using eq. (15) if there is an abandoned solution for the scout, then substitute it with a new solution
Memorize better solutions
end else
end while
Output the best solution found

5. Results and Discussions

5.1 Simulation setup

In this paper, an HBOABC method is exploited for experimental investigation on IEEE 14 bus system. Here, in a generator bus system, three GENCOs are connected. Fig. 1 exhibits the pictorial illustration of a single line diagram for the IEEE 14 bus system. Moreover, the system consists of 5 synchronous machines with type-1 exciters, three of that are synchronous compensators used for reactive power support. Here, 11 loads and 14 busses in the system comprised of 259 MW and 81.3 Mvar.

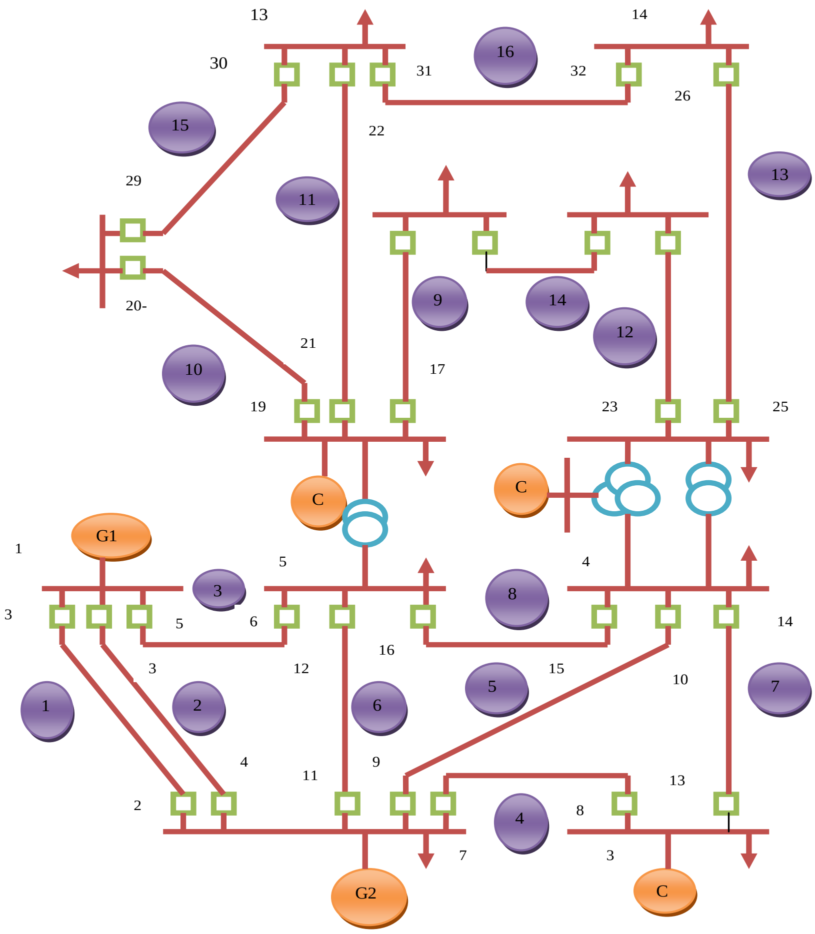

Fig. 1. *Diagrammatic representation of the single line for the IEEE 14 bus system*

5.2 Statistical Report of Single Point Congestion

In this section, the statistical analysis of single point congestion is described. Congestion is introduced in individual load buses under this experimental scenario. Since load buses, 5, 11 as well as 14 are extremely important; hence by doubling the load congest these load buses. The techniques are summoned to alleviate the congestion, and the performance is experiential for each load bus getting congested. Because of the stochastic nature of the techniques, 100 invokes completes to achieve statistical values and therefore Tables 1, 2 and 3 are summarized.

In Table 1, the statistical analysis for single point congestion scenario on minimizing rescheduling cost. Here, the proposed HBOABC method is superior to conventional BOA and ABC methods on attaining minimum rescheduling cost. Moreover, the average performance stated in Table 1 summarizes that the rescheduling cost acquired by the proposed method is smaller than the cost incurred by conventional methods. Here, the congestion cost is not specified because both proposed and conventional methods have shown equal performance in managing congestion cases. Nevertheless, they differ to achieve them as a minimum rescheduling cost.

Since the rescheduling cost differs, congestion cost, as well as the total cost, differs and this is shown in Table 2. Furthermore, the most significant metrics to examine is computational complexity i.e., execution time, which is shown in Table 3. Here, the proposed method consumes lesser time than conventional BOA and ABC methods to attain the rescheduling scheme.

Table 1. *Statistical Analysis For Single Point Congestion Scenario On Minimizing Rescheduling Cost*

Congested Points	**Best**			**Worst**			**Mean**			**Median**			**Std Dev**		
	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC
1	72.2	75.3	71.23	54.2	53.3	53.1	61.2	63.2	60.2	54.2	53.34	52.34	6.23	5.3	4.23
2	60.23	61.22	60.00	45.23	43.3	42.89	54.23	54.24	54.33	49.23	49.21	9.00	8.23	8.22	7.97
3	54.23	54.22	54.02	51.22	50.21	49.23	46.23	46.21	45.21	43.21	42.28	41.22	2.23	1.22	0.22

Table 2.*Statistical analyzing for single point congestion scenario on minimizing the total cost*

Congested Points	**Best**			**Worst**			**Mean**			**Median**			**Std Dev**		
	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC
1	52.21	51.22	50.21	42.32	41.23	41.02	62.21	61.21	60.11	54.22	53.22	52.12	2.22	1.22	1.09
2	49.21	49.11	48.90	42.21	41.22	40.98	42.98	43.32	42.01	52.21	51.22	51.12	2.21	1.12	0.21
3	43.21	42.11	41.21	39.21	39.11	38.21	42.32	43.23	39.21	42.21	41.31	40.21	2.51	3.12	1.11

Table 3: *Statistical analysis of single point congestion scenario on computational complexity*

Congested Points	**Best**			**Worst**			**Mean**			**Median**			**Std Dev**		
	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC
1	80.22	81.21	80.00	78.23	76.22	75.34	77.34	76.33	74.23	66.67	65.23	64.35	4.32	4.22	3.23
2	77.22	76.23	75.23	67.22	66.23	65.21	70.21	70.11	69.22	67.21	67.20	66.21	4.21	3.28	2.12
3	66.32	67.22	65.23	54.23	55.22	54.11	62.32	61.22	60.11	59.21	59.11	58.91	2.11	1.21	0.11

5.3 Statistical Analysis of Multi Point Congestion

All the buses apart from the slack bus i.e., Bus no. 1 as well as the generator bus i.e., Bus no. 2 are done congested using doubling their load in this congestion case. As same as single point congestion, the simulation outcomes are attained and summarized in Table 4. In Table 4, the proposed method has limited the total cost, rescheduling cost, and computational complexity than conventional BOA and ABC.

Table 4: *Statistical analysis of Multi point congestion scenario of proposed and conventional methods*

Congested Points	**Best**			**Worst**			**Mean**			**Median**			**Std Dev**		
	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC	BOA	ABC	HBOABC
Rescheduling cost	56.2	51.5	53.7	42.5	45.8	31.1	42.1	61.2	60.1	44.2	52.2	52.0	2.0	1.3	1.2
Congestion cost	48.2	49.1	48.9	42.7	41.9	50.7	42.8	43.3	42.0	82.2	71.2	61.1	2.1	1.8	0.5
Total cost	23.2	41.4	44.2	39.8	39.9	38.3	42.7	43.2	39.2	92.2	81.3	80.3	0.5	0.2	0.1
Computational Complexity	11.2	22.5	32.6	89.5	43.1	67.1	57.3	42.3	61.8	91.3	21.3	76.1	6.1	1.1	3.3

6. Conclusion

This paper presented a hybrid version of BOA and ABC methods, which is referred to as HBOABC to solve rescheduling-based CM issue. The effectiveness of the proposed HBOABC method was exhibited by adopting single point congestion on three buses, such as 5, 11 as well as 14 of the IEEE14 bus system. It was followed by adopting multipoint congestion on 3–14 buses of the similar system. The possible of the proposed method on imposing cost competent rescheduling schemes to alleviate congestion was experiential and compared with conventional BOA and ABC methods. The simulation outcomes revealed proposed method has reduced the cost acquired for CM against the cost suggested by traditional approaches.

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