Base Station Localization and Optimized Placement using Cuckoo Search (CSA) Algorithm

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Abstract
The employment of BTSs is a tiresome work for network designers. The problem considered in the research is to decide the best localities of BTSs to meet traffic demands. Optimal coverage of BTSs is essentially a resource allocation/optimization problem. The path loss, received power, and attenuation are main parameters of considerations during the optimization. Okumara - Hata model is considered for parameters calculations. Cuckoo Search Algorithm is investigated in the research to find optimal locations against PSO technique for same scenarios. Results were analyzed considering fixed population of mobile stations but with varying number of movable stations. Power received from all the BS locations searched by CSA is greater than the power received from BS location searched by PSO. Also the signal which travels from location searched by CSA suffers lesser path loss and attenuation than the location searched by PSO. So CSA outperforms PSO in every respect. The results show that the CSA approach is effective and robust for efficient coverage problem of BTS location and is considered to give almost the optimal solution in implementation of a wireless communication efficient network.

Keywords
Base Station Localization, CSA (Cuckoo Search Algorithm), Cellular Mobile Communication

I. Introduction
In finding out the solutions for optimization , a set of nature inspired algorithms are widely and effectively used nowdays., Collectively, these are called swarm intelligence Algorithms or systems. The focuses on the behavior of certain insects and has developed some of the meta - heuristics which are capable of cloning insect's ability of finding solution to the problem. A new Cuckoo Search Algorithm (CSA), is a similar type of algorithm which is used for getting numerical optimization that is well inspired from the breed behavior of certain cuckoo species intensively and the algorithm is implemented and investigated, in this research, for the localization of BTSs so that maximum number of users or subscribers could be covered under placed BTSs.
When the cellular concept was first proposed, BTS locations were usually selected according to a regular reuse pattern. With the growth of cellular technology, it is becoming increasingly important for any cellular operator to have a network which is not only better in terms ofquality of service than its competitors but also is more profitable than the others. It is worth noting that cost, required to be spent and invested for providing best QoS Network with a strong backbone depend intensively on number of BTSs installed in that network, more BTS, more is the cost but better coverage at more infrastructural cost.
One of the reason for the difficulty in implementation of network, being the frequency channels becomes increasingly congested and propagation environments become more complex.The problem considered in the research focuses in determining the best and optimal locations of BTSs in a network to meet traffic demands. Optimal coverage of BTSs is essentially a resource allocation/optimization problem. The research focuses in parameters for optimization and theses are confined to received power, path loss and attenuation.

The paper trails as: Analysis of earlier work is specified in Section. II. Section III focuses on the Planning Model. Section V elaborates the proposed research. Section VI here says anumber of tentative results to display the performance of the new algorithm. In the end, conclusions are drawn in Section VII.

II. Literature Survey
In [Singh and Kaur, 2013] authors reflected how to optimally define positions of Base Transceiver Station (BTS), such that least count of BTS can be connected to insure higher quantity of subscriber at smaller infrastructural cost. Inhabitants based Evolutionary Algorithms (EAs) are established by demonstrating the actions of diverse groups of insects and animals e.g., bees, termites, ants, fishes, birds. These EAs can be utilized to get best results for NP-Hard arbitrary optimization difficulties. Artificial Bee Colony (ABC) procedure is a meta - heuristic exploration process and is examined, in this investigation, to confine BTSs so as to shield maximum count of subscribers. The consequences were then matched with K-Mean clustering technique.
In [Awasthi and Arora, 2014] authors designated that Radio Coverage universally gets affected by Antenna activities, Position of BTS and also the Presentation of Base Station. Their research measured as how to detect the best position of Base Station Transceiver (BTS), so that with smallest count of BTS, largest count of users can be connected at less infrastructural price. The idea of Using Evolutionary process is fairly operative and competent as the processes are established by demonstrating the conduct of various groups of faunas like bees, ants, and birds. These processes can be used to define the best position of BTS. In this investigation, ABC algorithm was utilized to find the position of BTS so as to provide coverage to large count of user. The consequences were then also matched with GA algorithm.
In [Pereira et. al., 2014] authors showed the there is a major improvement of using PSO for multiple Base Station (BS) placement over a wide area. They evaluated the algorithm's performance using a combination of Shannon's capacity formula and Jain's index of fairness for two sets of traffic demand points, corresponding to an estimation of average and peak traffic, respectively. They showed results performed by using 8, 32, 128 and 256particles to place sets of new BSs versus number of iterations. They also exhibited potential optimal points for placement found by PSO. The improvement seen using optimization in the average capacity is 17% and also with an increase on the number of BSs smaller than 10%.

III. Planning Models
Broadcast in terrestrial movable facility at frequencies from 300 to 1800MHz is exaggerated in variable grades by morphography, topography, ground constants and atmospheric conditions. A very communal method of broadcast damage performance is the

practice of so named broadcast bends. The most usually castoff path loss representations are:

A. Okumura Model

Okumura developed an empirical model that is derived from extensive radio propagation studies in Tokyo. It is represented by means of curves with which is applicable for urban areas. For other terrain, Okumura has provided correction factors for three types of terrain:

1. Open Area: this covers rural, desert type of terrain.
2. Quasi Open area: this covers rural, countryside kind of terrain.
3. Suburban area.

B. Hata Model

The model is an empirical formulation of the graphical path loss data provided by Okumura. This model says that the urban area propagation loss can be easily presented as a standard formula and hence defines correction equations for other types of areas [Hata, 1980].

The general Path loss equation is given by (Okumara - Hata urban propagation model)

$$L_p = Q_1+Q_2 \log (f)-13.82 \log (H_{bts})- a(h_m) +\{44.9-6.55\log(h_{bts})\} \log (d)+Qo \quad (1)$$

And is determined based on the parameters

L_p=path loss in dB

f =Frequency in MHz

d =distance between BTS and the mobile (1-20 Kms)

H_{bts}=base station height in meters (30 to 100m)

a (h_m)= Correction required if mobile height is more than 1.5 meters and is given by:

$a (h_m) =\{1.1 \log (f)-0.7\}h_m –\{1.56 \log (f)-0.8\}$ for urban areas and

$= 3.2\{\log (11.75h_m)^2-4.97$for Dense urban areas

h_m = mobile antenna height (1-10m)

Q_1 = 69.55 for frequencies from 150 to 1000MHz

=46.3 for frequencies from 1500 to 2000MHz

Q_2 = 26.16 for 150 to1000 MHz

= 33.9 for 1500 to 2000 MHz

Q_o = 0 dB for urban

= 3 dB for Dense urban

IV. Fitness Function and Parameters

The optimum location is finding out in the proposed research considering the three main parameters (a) Path loss, Lp (b) Attenuation, A(c) Power received, using (1), (2) and (3).

$$A = 42.6 + 20 \log_{10} f + 26 \log_{10}d \quad (2)$$

$$Pr = 10 \log_{10}(P_t) - abs(L_p) \quad (3)$$

Where P_t = Transmit power

f =Frequency

d = distance between MS and BTS

L_p = Path loss determined by equation (1)

The problem of finding the optimal location of any BTS within its coverage area can be articulated as a fitness function described by equation (4) to achieve large received power by Mobile Station, Less Attenuation and less path loss. So the objective function is maximized to achieve these objectives.

Maximum fitness, F, is achieved given by equation (4).

$$F = \frac{abs\ (Pr)}{LpXA} \quad (4)$$

V. Proposed Algorithm

In the proposed work location of Base Transceiver Station (BTS) is optimized using Cuckoo Search Algorithm. Three main parameters; Path Loss, Attenuation, and Power Received by Mobile Station (MS) are considered for this problem of finding the optimized location. And optimal solution is find so that power received is maximum, path loss and attenuation is minimum. The algorithmic flow of work is shown in figure 1. An area of 100 X 100 is considered for deployment of network.

In this area a population of mobile stations (MSs) is created. Then the desired number of Base Stations to cover the whole population is initially deployed on randomly selected locations. Then each MS is assigned under the least distant BS and hence coverage cluster of every BS is built on the basis of Euclidean distance. Then Cuckoo search algorithm as in figure 2 is applied to find the optimal location of each BS in its cluster with respect to the locations of MSs covered under it so that maximum fitness is achieved for the objective function represented by equation (4).

VI. Result and Discussion

To confine the performance analysis of the projected CSA algorithm in the BTS localization problem and to study its performance against PSO algorithm, experiments are performed using both algorithms for same scenarios. Results were analyzed considering fixed population of mobile stations but with varying number of mobile stations from 2 to 4. And here the results for the case of 3 BSs are discussed and compared. Figures 3 to 11are qualify the performances of CSA over PSO. Figure 3 shows the random locations of population of 20 mobile stations and initial random locations of 3 base stations before optimization. And figure 4 and 5 describes the results after optimization. Fig. 4 shows the optimized locations of BSs searched by PSO and fig. 5 the optimized BS locations searched by CSA.

Figures 6 and 7 describes the statistical analyses of all the parameters Power received, path loss, and attenuation for all three BS locations searched by PSO and CSA respectively.

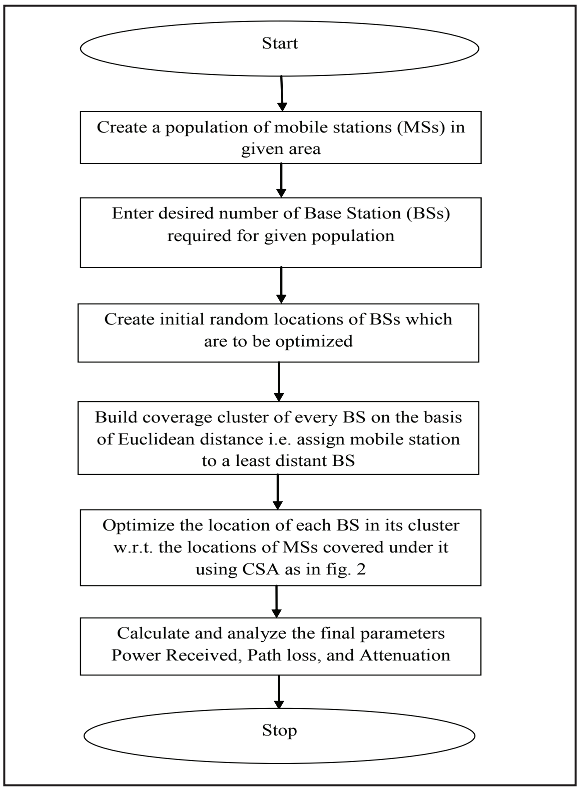

Fig. 1: Algorithmic Flow of Proposed Work

ISSN : 2230-7109 (Online) | ISSN : 2230-9543 (Print)

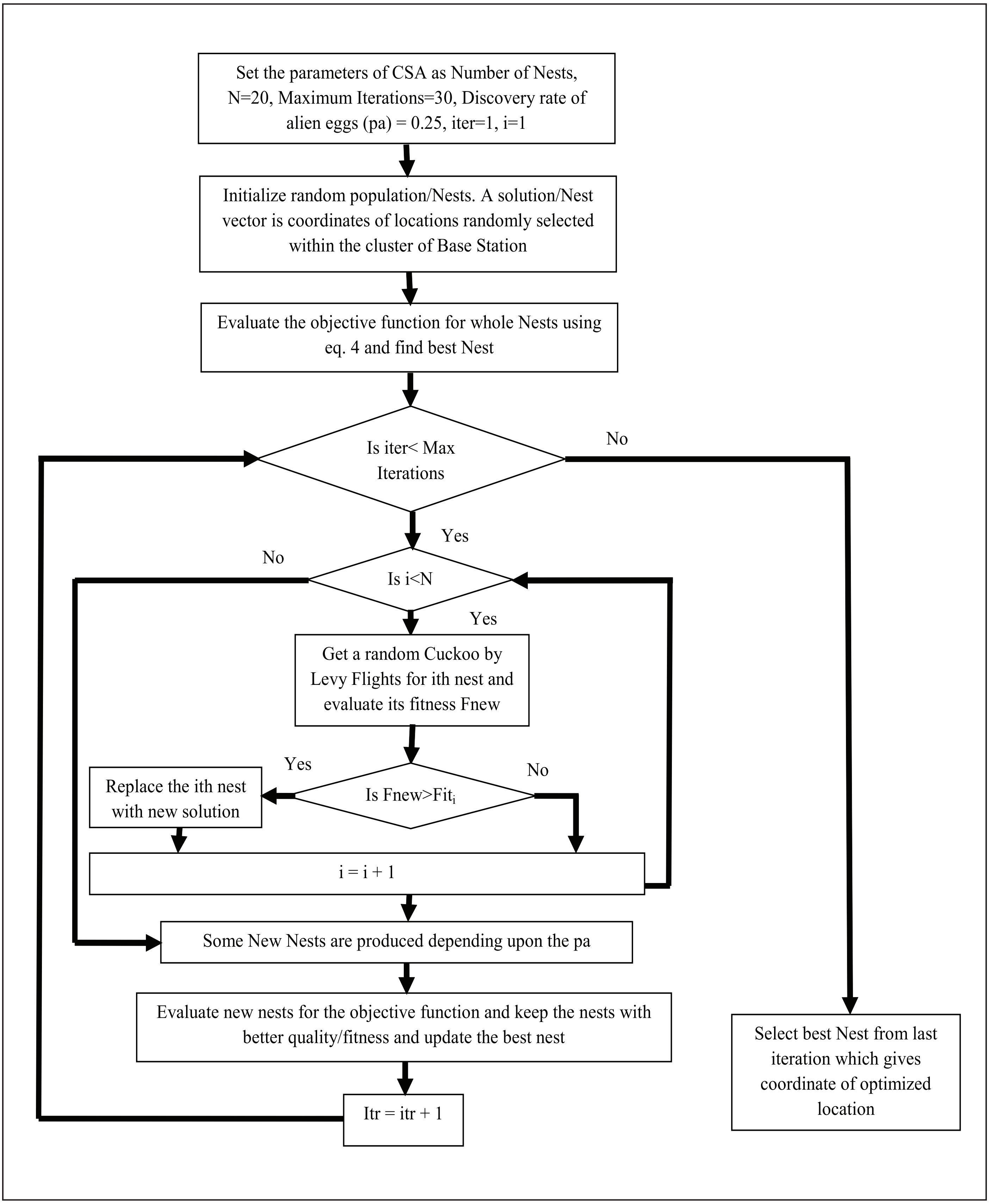

Fig. 2: Flow chart of Location Optimization using CSA in Projected Research

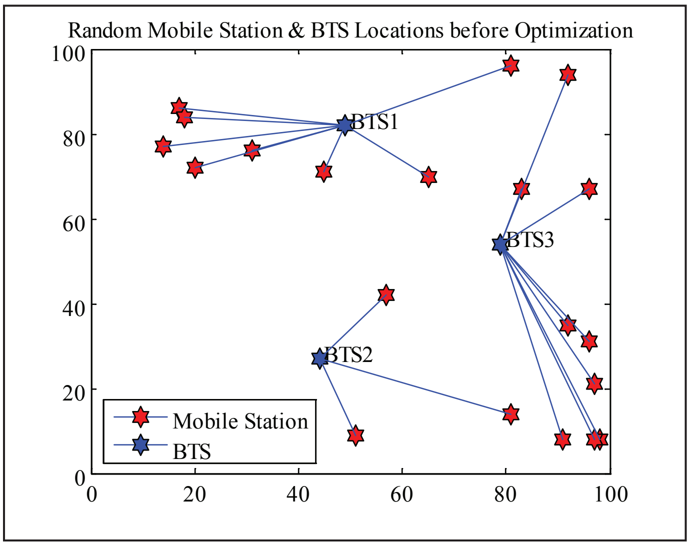

Fig. 3: Initial Random Base Station Locations and Cluster Formation (3 BS and 20 MS)

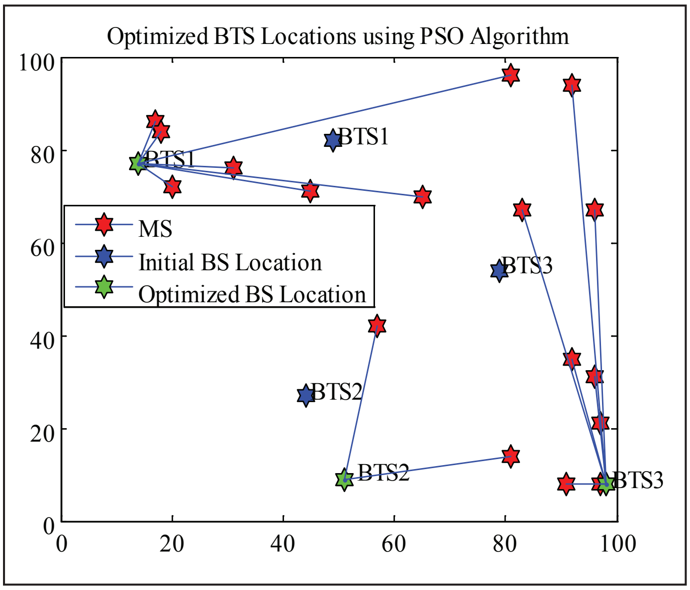

Fig. 4: Optimized Locations of all three Base Stations Searched by PSO

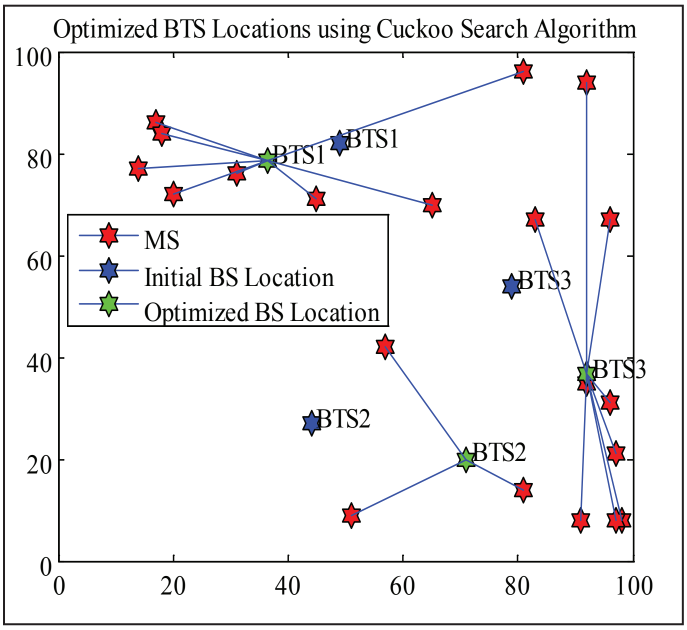

Fig. 5: Optimized Locations of all three Base Stations Searched by CSA

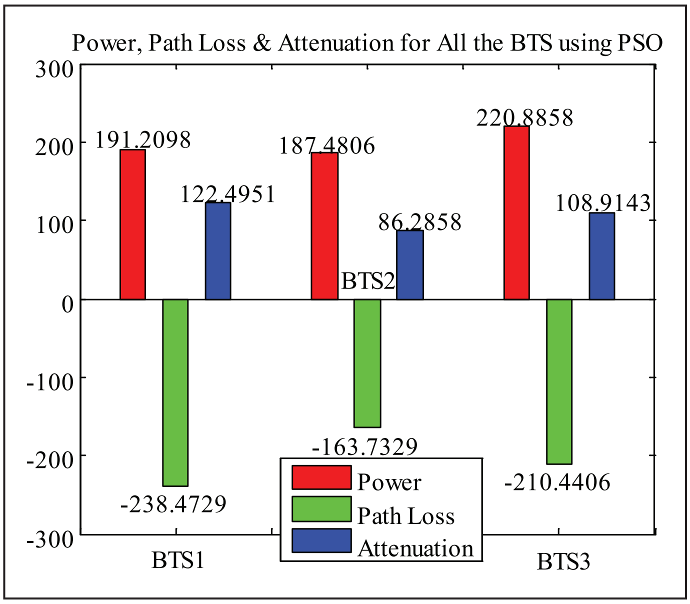

Fig. 6: Power Received, Path loss, and Attenuation for all three BS locations searched by PSO

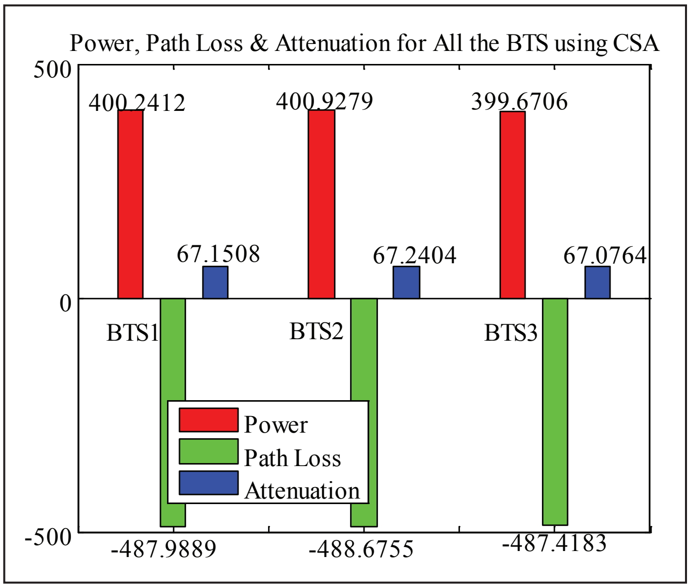

Fig. 7: Power Received, Path loss, and Attenuation for all three BS locations searched by CSA

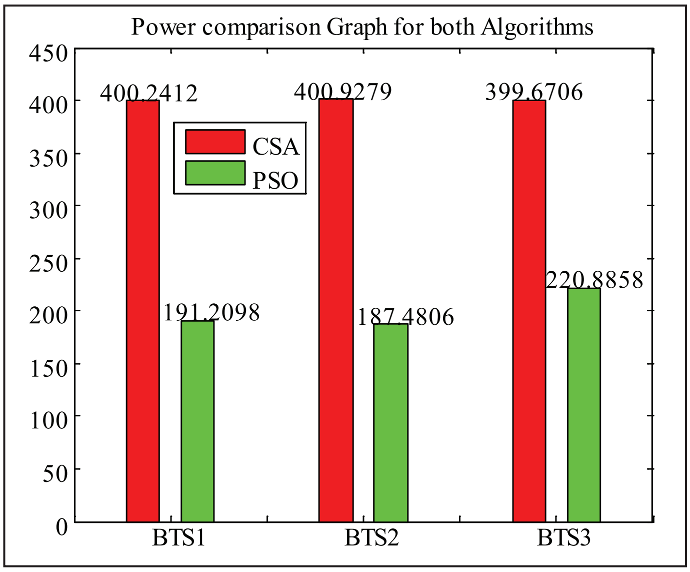

Fig. 8: Power comparison for all three BS locations searched by CSA and PSO

ISSN : 2230-7109 (Online) | ISSN : 2230-9543 (Print)

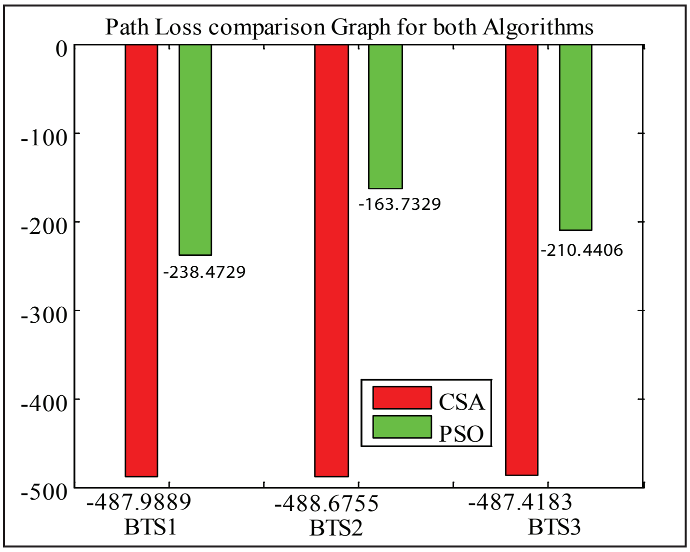

Fig. 9: Path Loss comparison for all three BS Locations Searched by CSA and PSO

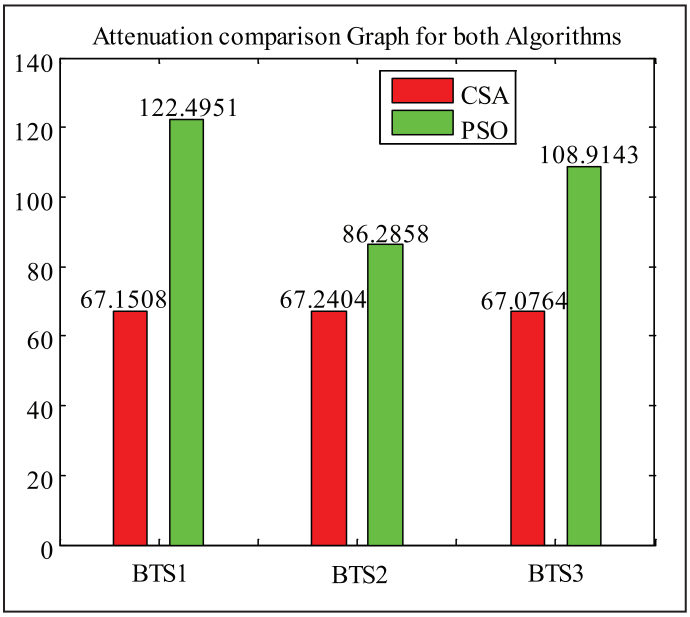

Fig. 10: Attenuation Comparison for all three BS Locations Searched by CSA and PSO

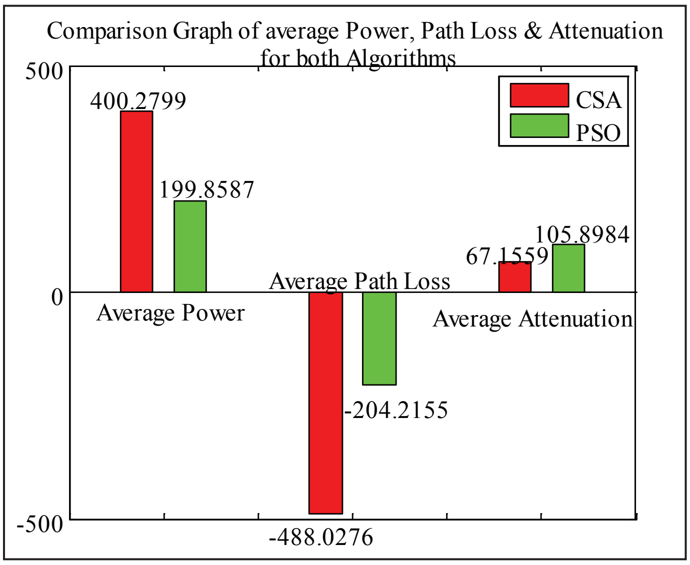

Fig. 11: Comparison of Average Power, Average Path Loss, and Average Attenuation of all three BS locations searched by CSA and PSO

Table 1: Comparison of all Parameters of BS Locations Searched by CSA and PSO

Parameter	BTS	Proposed Algorithm (CSA)	Literature Algorithm (PSO)
Power Received	BTS 1	400.2412	191.2098
	BTS 2	400.9279	187.4806
	BTS 3	399.6706	220.8858
	Average	400.2799	199.8587
Path Loss	BTS 1	-487.9889	-238.4729
	BTS2	-488.6755	-163.7329
	BTS 3	-487.4183	-210.4406
	Average	-488.0276	-204.2155
Attenuation	BTS 1	67.1508	122.4951
	BTS 2	67.2404	86.2858
	BTS 3	67.0764	108.9143
	Average	67.1559	105.8984

From figures 8 to 11 and table 1 it is very clear that the power received from all the BS locations searched by CSA are greater than the power received from BS location searched by PSO. Also the signal which travels from location searched by CSA suffers lesser path loss and attenuation than the location searched by PSO. So CSA outperforms PSO in every respect.

VII. Conclusion

In this work a relatively new system of optimization of swarm intelligence family that is defined as "cuckoo search algorithm" is explained in detail. The previous work on Base Station optimization algorithms is tried to be reviewed. Most of the work in the literature is carried out in recent years and researchers mainly concentrated on continuous optimization problems. Previous work has presented that cuckoo search algorithm have a very promising potential for modeling and solving complex optimization problems. In this thesis work CSA is applied to determine the optimal location of BTS. The proposed work has ability to achieve optimal solution of coverage problem with desired number of BTS in cellular networks. This approach cultivates an innovative idea employing the CSA with enhanced fidelity. The results show that the CSA approach is effective and robust for efficient coverage problem of BTS location and is considered to give almost the optimal solution in wireless communication network.

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