Implementation Of Adaptive Resource Allocation in OFDMA using various Optimization Techniques

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Abstract-OFDMA adds multiple accesses to OFDM by allowing a number of users to share an OFDM symbol. OFDMA technique is used for resource allocation in wireless systems for achieving high data rate and high downlink capacity. The total capacity of OFDMA can be maximized by adaptively assigning sub channels to the user with the best gain by various optimization techniques. The sum Capacity increases with the no of users for the optimization techniques called PSO, NSGA-II and Hybrid PSO-GA. And also the performance of various optimization techniques is compared.

Keywords: Orthogonal frequency division multiple access (OFDM),Particle swarm optimization(PSO),Genetic Algorithm, Resource allocation, Sum capacity, Computational complexity

I. INTRODUCTION

The resources such as bandwidth and power are limited, hence allocation of these resources to the users with the best gain are crucial. Exploitation of existing technologies and discovery of new technologies that supports high data rates are being carried out all over the world to meet the customer demands. High data rate communication over wideband channels is limited by inter-Symbol Interference (ISI),which can be reduced by using the multicarrier modulation technique called OFDM.

OFDM divides a broadband channel into N narrow subcarriers of equal width such that the channel frequency response on a particular subcarrier is approximately flat. The main reason to use OFDM is to increase the robustness against frequency selective fading or narrowband interference.
In OFDM systems, only a single user can transmit on all the subcarriers, time or frequency division multiple access is employed to support multiple users. OFDMA is optimized for multiple users. In OFDMA entire bandwidth is divided into number of sub channels for parallel transmission of symbols from different users.(10,20)

Chapter 2 deals with the OFDMA system model, and optimization problem is considered. Resource allocation i.e. subcarrier and power allocation algorithm are discussed in chapter 3.Particle Swarm Optimization is described in chapter 4. Proposed system is described in Chapter 5.Chapter 6 shows simulation results and chapter 7 deals with the conclusion and future enhancement of the project.

II. SYSTEM MODEL

The block diagram of downlink OFDMA system model is shown in figure 2.1.In the base station(BS) all channel state information(CSI) of each couple of transmit and receive antennas is sent to the subcarrier and power algorithm block through the feedback channels from all mobile users. The resource allocation scheme is forwarded to the OFDMA transmitter. The transmitter then loads each user data onto its allocated subcarriers. The resource allocation scheme is updated as soon as the channel information is collected and the subcarrier and bit allocation information is sent to each user for revealing, through a separate channel.

Consider a multiuser OFDMA system where K users are allocated to N subcarriers and each subcarrier is assigned with the power $\mathbf{P_{k,n}}$. In OFDMA system serial data from all the users were fed into the resource allocation block at transmitter, then it will allocate bits from different users to different subchannels. Based on the channel information, the transmitter will apply the sub channel, bit and power allocation algorithm to assign different sub channels to different users and the number of bits/OFDM symbol to be transmitted on each sub channel. Depending on the no of bits assigned to a sub channel, the adaptive modulator would use corresponding modulation scheme, and the transmit power level would be adjusted according to the sub channel, bit

2.1. Assumptions in the System Model

- BS has the perfect knowledge of instantaneous channel information for all users.
- The assumption was that each sub channel would be uniquely assigned to a single user and two or more users would never share the same sub channel.
- Each sub-carrier can only be occupied by one user.
- No free sub-carrier left.

2.2. Optimization Problem

Mathematically, the optimization problem considered in this paper is formulated as follows

$$\max_{\rho_{k,n}P_{k,n}} \sum_{k=1}^{k} \sum_{n=1}^{N} \frac{\rho_{k,n}}{N} \log_2 \left[1 \frac{P_{k,n} h^2{}_{k,n}}{N_0 \frac{B}{N}} \right] \qquad \textbf{………………. (1)}$$

Subject to the constraints,

$$c_1: \sum_{k=1}^{k} \sum_{n=1}^{N} \rho_{k,n} \leq P_{total}$$

$$c_2: P_{k,n} \geq 0 \qquad \forall k, n$$

$$c_3: \rho_{k,n} \in \{0,1\} \forall k, n$$

$$c_4: \sum_{k=1}^{k} \rho_{k,n=1} \forall n$$

$$C_5 = R_1 : R_2 \ldots R_k = \gamma_1 : \gamma_2 \ldots \gamma_k, \ \forall i,j \in \{1,\ldots,K\};\ I \neq j$$

Where,N_0-Power spectral density of additive white Gaussian noise,**B**-Total available bandwidth,$h_{k,n}$-Channel gain for user k in sub-channel n**,**In C_1 **,**$\mathbf{P_{total}}$-Total available power,$P_{k,n}$-Power allocated for user k in the sub-channel n,In C_3 , $\rho_{k,n}$- Can only be either 1 or 0, indicating whether sub-channel n is allocated the user k or not, C_4- It restricts allocation of one sub-channel to one user only,C_5- Proportional rate constraint

The capacity for user k, denoted as R_k**,** is defined as

$$R_k = \sum_{n=1}^{N} \frac{\rho_{k,n}}{N} \log_2 \left[1 + \frac{P_{k,n} h^2{}_{k,n}}{N_0 \frac{B}{N}} \right] \quad \text{.................... (2)}$$

,

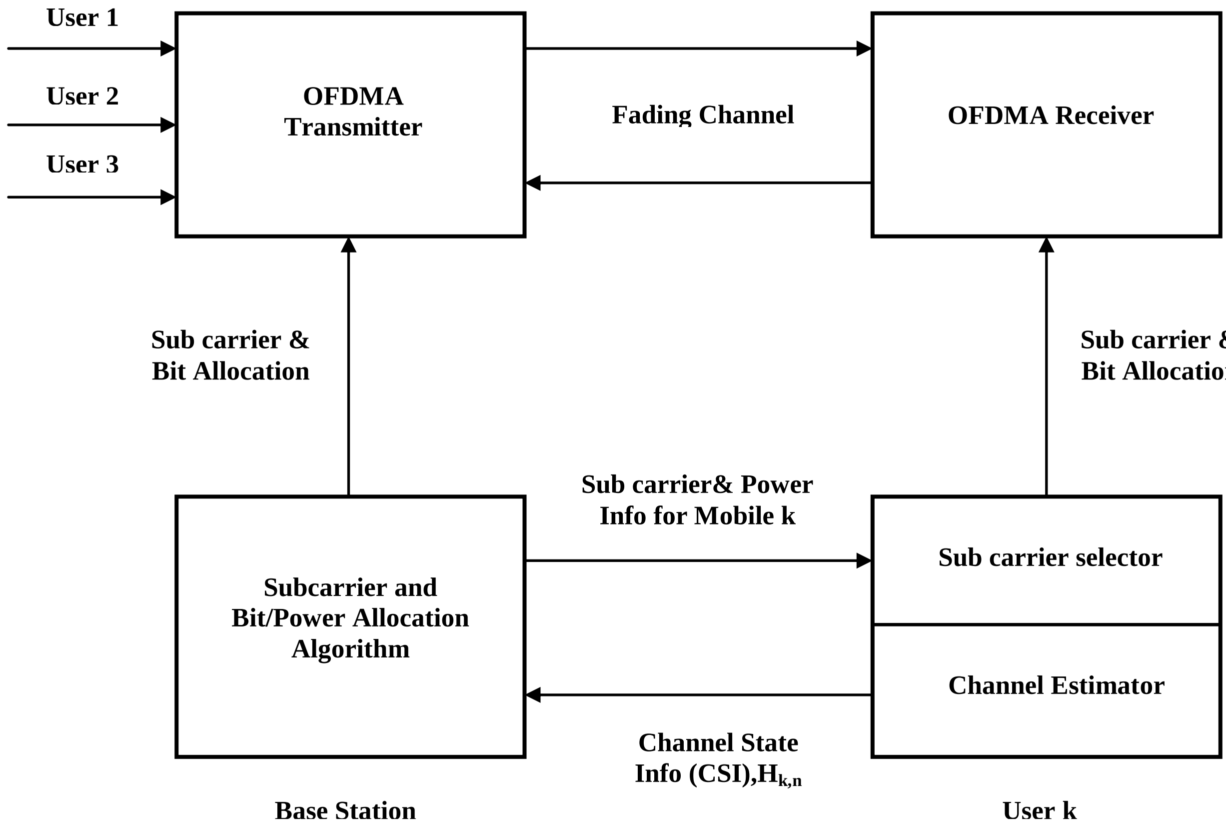


Fig. 2.1 OFDMA System Model

III. RESOURCE ALLOCATION

Resource allocation in OFDMA includes sub channel allocation, power allocation, and bit loading. This project includes subcarrier allocation, Particle Swarm Optimization (PSO) technique which is a bio-inspired evolutionary algorithm is proposed for sub-channel allocation.

Two classes of resource allocation:

1. Fixed Resource Allocation (FRA)
2. Dynamic Resource Allocation (DRA).

Assignment in FRA schemes is non-optimal, since scheme is fixed regardless of channel conditions. On the other hand, DRA schemes are based on users channel gains and make full use of multiuser diversity to achieve higher performance. Adaptive/Dynamic Resource Allocation is advantageous over Fixed Resource Allocation.

VI. OPTIMIZATION TECHNIQUES

4.1. PSO

Particle swarm optimization (PSO) is a population-based stochastic approach for solving continuous and discrete optimization problems. In PSO particles move in the search space of an optimization problem. Each particle searches for better positions in the search space by changing its velocity according to rules originally inspired by behavioural models of bird flocking. Particle swarm optimization belongs to the class of swarm intelligence techniques used to solve optimization problems.

Pbest

Each particle keeps track of its coordinates in the solution space which are associated with the best solution (fitness) that has achieved so far by that particle. This value is called personal best,**pbest**.

Gbest

Another best value that is tracked by the PSO is the best value obtained so far by any particle in the neighbourhood of that particle. This value is called global best,**gbest**

4.2 GA

This algorithm begins with random set of solutions called population. In each step (generation) new population is made from the old one. New individuals are made by crossing old ones (parents). The probability that the individual become the parent depends on its fitness function. The mutation is introduced to prevent falling in local optimum.

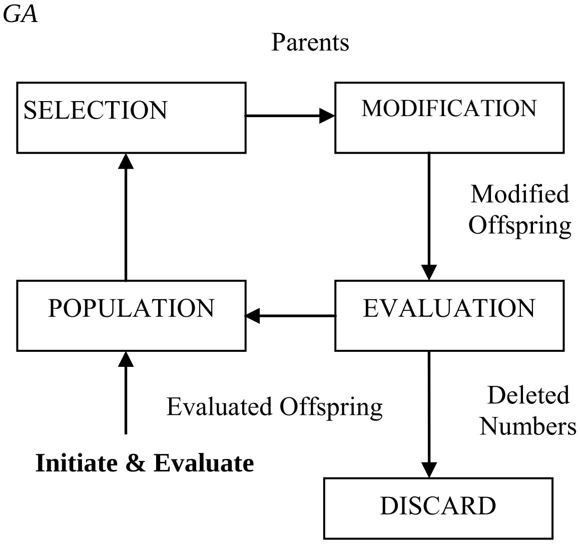
The simplest form of GA involves three types of operators

Selection: This operator selects chromosomes in the population for reproduction. The fitter the chromosome, the more times it is likely to be selected to reproduce.

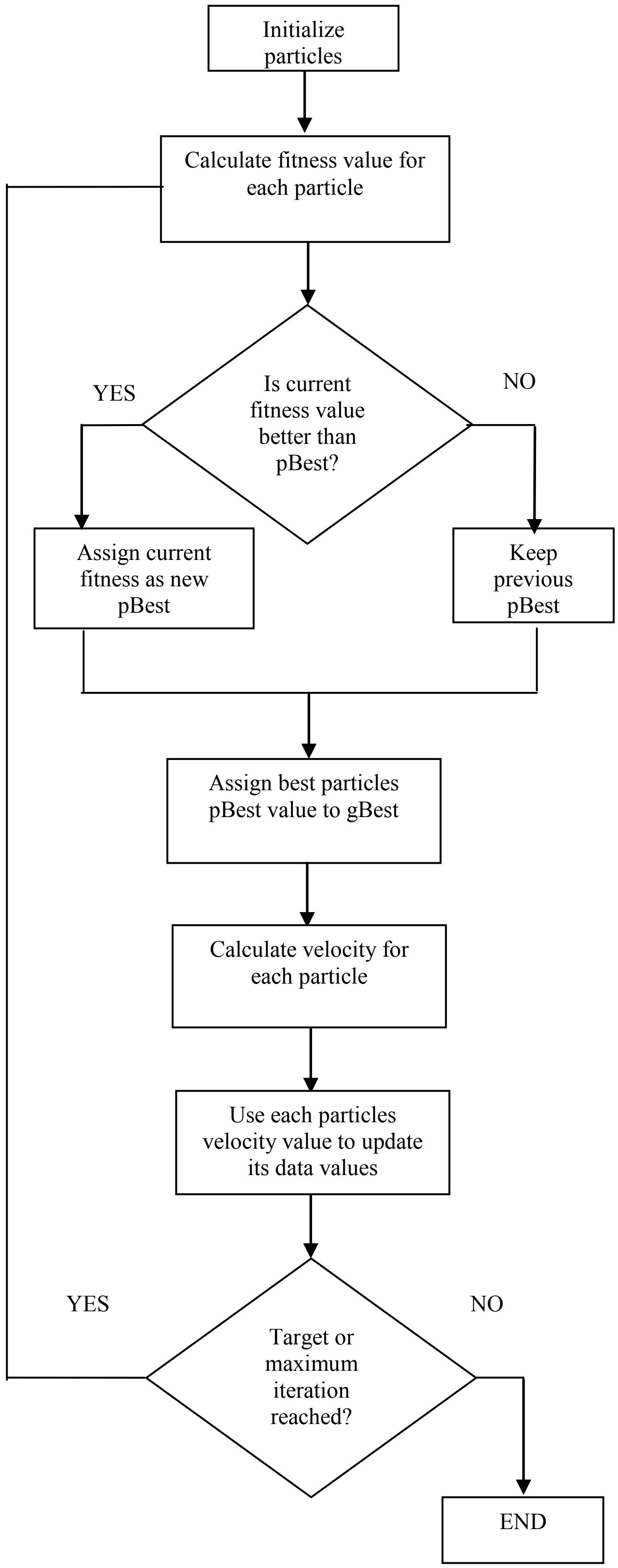
Crossover: This operator exchanges subsequence's of two chromosomes to create two offspring.

Mutation: This operator randomly flips some bits in a chromosome. For example, the string 00000100 might be mutated in its second position to yield 01000100.

FLOW CHART FOR GA



FLOWCHART FOR PSO



4.3 NSGA-II

Non-dominated Sorting Genetic Algorithm is to use to progress the adaptive fit of a population of candidate solutions to a Pareto front which is inhibited by a set of objective functions [9]. The algorithm uses an evolutionary process with for evolutionary operators that include selection, genetic crossover, and genetic mutation. The population is sorted into a hierarchy of sub-populations based on the ordering of Pareto dominance.

Similarity between members of each sub-group is evaluated on the Pareto front, and the resulting groups and similarity measures are used to endorse a various front of non-dominated solutions.

NSGA-II algorithm includes the following steps to be employed:

1. Population initialization
2. Evaluate the objective functions
3. Non-dominated sorting
4. Crowding distance calculation
5. Crossover and Mutation
6. Generation of New population

4.4 HYBRID PSO-GA

PSO and GA are population based heuristic search technique which can be used to solve the optimization problems modelled on the concept of Evolutionary Approach. The hybrid mechanism combines different approaches to be benefited from the advantages of each approach. To overcome the limitations of PSO, hybrid algorithms with GA are proposed. The basis behind this is that such a hybrid approach is expected to have merits of PSO with those of GA.

V. SIMULATION RESULTS

Assumptions and constants taken:

PARAMETER	VALUE
N(Sub carriers)	64
N_o (Noise density)	1.1565 × W/Hz
B(Bandwidth)	5 MHz
P_{total}	1W
PSO parameters	$C_p=C_g= 2$, $w = 0.2$

5.1. Results of PSO

From the fig 5.1 it is shown that the use of PSO for sub channel allocation for OFDMA systems has consistently higher sum capacity than the method in [15].The CPU time is calculated for the performance of each user. (Fig 5.2)

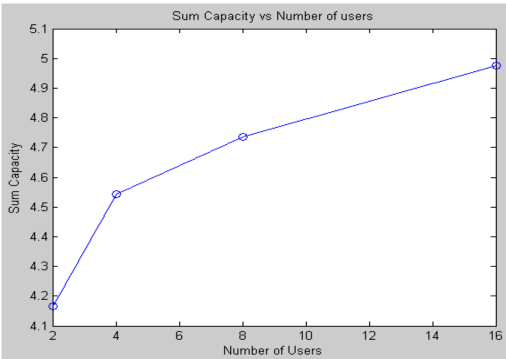


Fig 5.1: Sum Capacity Vs. no of users

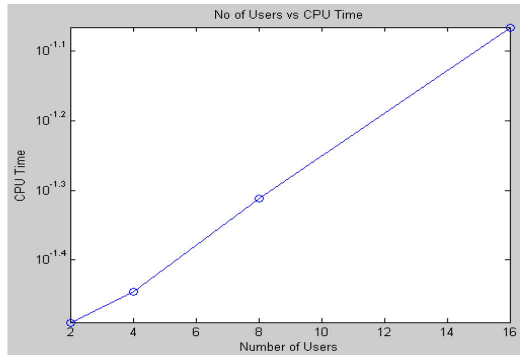


Fig 5.2: CPU Time VS no of users

It is shown from Fig. 5.3 the sum capacity initially increased with the number of iterations and then gradually saturated for the higher values. It is shown from Fig. 5.4 the sum capacity initially increased with the number of bees and then rapidly saturated to near optimum value.

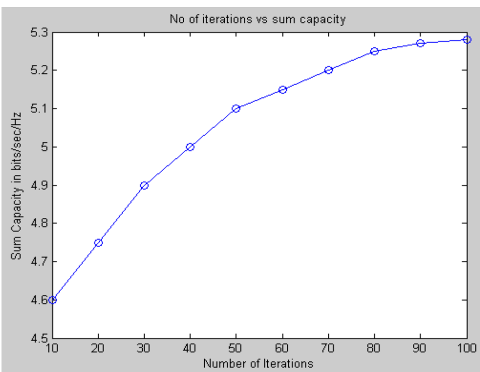


Fig 5.3: Sum capacity vs. no of Iterations

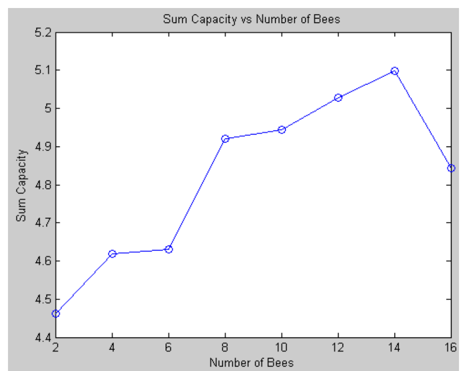


Fig 5.4: Sum capacity vs. no of Bees

5.2. Results of NSGA II

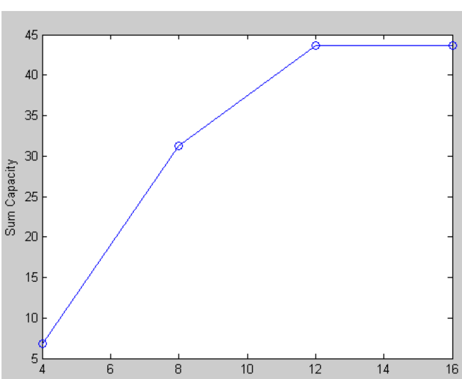


Fig 5.5: Sum rate (b/s hz) vs Number of users for Snr=24.6db

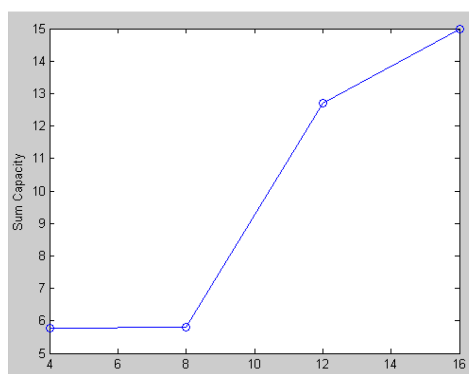


Fig 5.6: Sum rate (b/s hz) vs Number of users for Snr=4.6db

The Simulation results indicate the optimized Sum rates(b/s/Hz)for fixed number of sub-carriers(N=64)versus number of users(K=4,8,16) for SNR=24.6Db (Dmax=16 bits) (Fig 5.5) and for SNR=4.6db (D_{max}=8bits) (Fig 5.6).

VI. COMPARISION RESULTS

PERFORMANCE COMPARISON OF PSO and PSO-GA

Table 6.1 shows the performance comparison of PSO and PSO-GA. While increasing the no of users the PSO-GA technique will attain more capacity than PSO.

No of users	**Sum capacity(bits/sec/Hz)**	
	PSO	**PSO GA**
2	6.6306	7.1744
4	6.8301	7.2189
8	7.1882	7.4907
16	7.4910	7.5792

Similarly it is inferred from Table 6.2 while increasing the no of Iterations also PSO-GA method will attain more capacity than PSO.

Iterations	**Sum capacity(bits/sec/Hz)**	
	PSO	**PSO GA**
10	6.8888	6.8317
20	7.0589	7.1228
30	7.1830	7.1878
40	7.2159	7.2709
50	7.2159	7.3512
60	7.2159	7.3767
70	7.2159	7.3901
80	7.2159	7.3937
90	7.2159	7.4338
100	7.2159	7.4434

From the Fig 6.1 it is shown that the use of PSO-GA for subchannel allocation for OFDMA systems has consistently higher sum capacity than the PSO method. The CPU time is calculated for the performance of each user in both the techniques and compared.

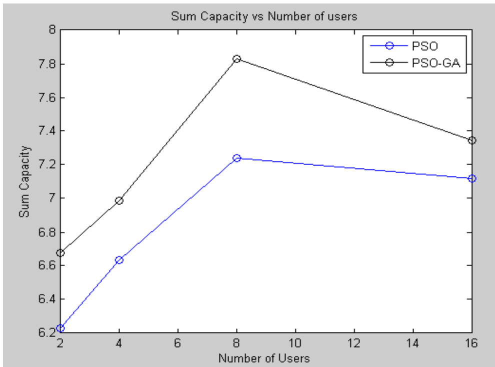


Fig 6.1 Sum capacity Vs no of users

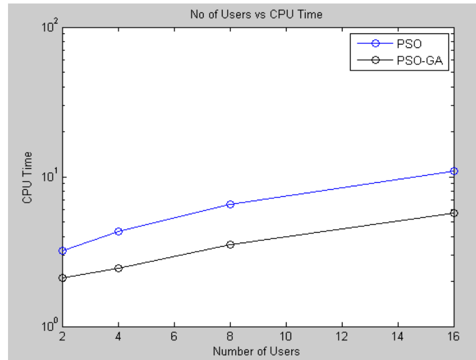


Fig 6.2 No of users Vs CPU time

It is shown from Fig.6.3 for both the technique the sum capacity initially increased with the number of iterations and then gradually saturated for the higher values. This showed that, initially the particles were consistently moving to new positions giving higher values of fitness function and then slowly converged to a near optimal point.

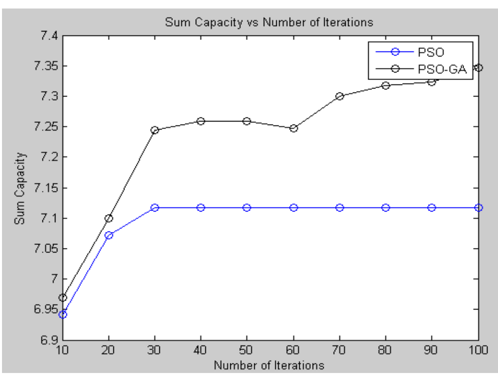


Fig 6.3 No of Iterations Vs sum capacity

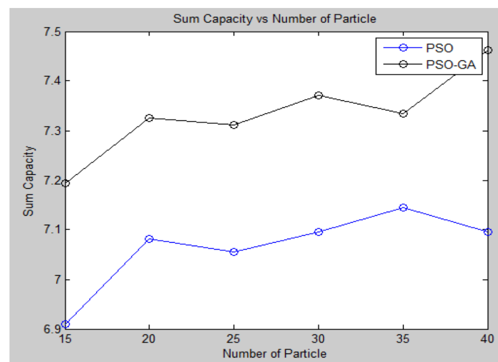


Fig 6.4 No of Population Vs Sum capacity

It is shown from Fig. 6.4 the sum capacity initially increased with the number of bees and then rapidly saturated to near optimum value. It is also illustrated that PSO-GA has more capacity than PSO for each particle.

VII. CONCLUSION

The results obtained by the simulations shows that the sum capacity increases with the increase in number of users.This result suggests that PSO based sub channel allocation can provide significant gain in capacity even with very small population size and number of iterations. PSO-GA is used for sub channel allocation in downlinkof OFDMA systems.The results obtained by the simulations shows that the sum capacity increases with the increase in number of users. This result suggests that PSO-GA based subchannel allocation can provide more gain in capacity thanthe PSO technique even with the population size and number of iterations.

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