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IMPROVED PSO FOR MU-MIMO USER SELECTION IN 802.11AX- BASED WI-FI NETWORKS

[1]T ESWARI NAGASRI, [2]Dr. A M PRASAD
[1]M Tech Student, [2]Professor, Department of ECE
[1]Department of ECE,
[1]University college of Engineering, JNTUK, Kakinada, Andhra Pradesh, [2]University College of Engineering, JNTUK, Kakinada, Andhra Pradesh

Abstract: Particle Swarm Optimization (PSO) is an optimization technique that is used to solve many problems in different applications. However, most implementations are sequential. Innovative multi- user communication mechanisms, MU-MIMO (multi-input multi-output) and OFDMA (orthogonal frequency division multiple access) have recently attracted much attention as key technologies to boost the capabilities of 802.11 wi-fi systems. 802.11ax – based wi-Fi systems the methods used for uplink OFDMA transmission and downlink MU-MIMO transmission bear great deal of resemblance to each other. By exploiting uplink OFDMA for MU-MIMO user selection, MUSE obtains system throughput. To realize PSO, a new resource allocation algorithm and frame structure are developed. PSO is better user among many users to find out IMPSO is implementing. Compared to MUSE multiusers it will work better in PSO. Extensive MATLAB simulation results shows that PSO significantly improves the network throughput, even in dense network scenarios, and works effectively in co-existence with legacy nodes.

Index Terms – **PSO, 802.11ax, OFDMA, MU-MIMO, User Selection, wi-fi.**

I. INTRODUCTION

Over the past few years, the number of Wi-Fi users and devices has been steadily rising due to high data rates, simple installation, and free Internet access. By 2021, there will be over 500 million Wi-Fi hotspots, and more than half of all Internet traffic will be transmitted by Wi-Fi, according to industry research estimates. Multi-user (MU) transmission has drawn a lot of interest as a basic answer to these problems in Wi-Fi systems. MU-MIMO and OFDMA performance can be significantly influenced by the users involved in the MU transmission, but using the suggested user selection strategies or creating an appropriate user group is currently impracticable due to the present MU transmission protocols. The benefit of these strategies, however, may only be minimal in practise, particularly if there is high channel contention from several users, which makes it difficult for the AP to acquire access to the channel. This research suggests enhanced PSO (Particle Swarm Optimization) based User Selection for networks to overcome the aforementioned problems. In addition, a number of technological obstacles are overcome in order to deploy PSO. For MU-MIMO user selection, MUSE was able to significantly outperform traditional methods by utilising uplink OFDMA. In wireless networks, we suggest using PSO-based user selection. Wi-Fi networks are constructed, and a new PSO is created to implement the suggested notion.

II. RELATED WORK

This remainder of this paper describes existing results on improved PSO based user selection technologies in wi-fi.

A. MU-MIMO

MU-MIMO stands for multi-user, multiple input, multiple output, and represents a significant advance over single-user MIMO (SU-MIMO), which is generally referred to as MIMO. MIMO technology was created to help increase the number of simultaneous users a single access point can support. This was initially achieved by increasing the number of antennas on a wireless router. With 802.11ax (Wi-Fi 6), basic MU-MIMO was updated to include uplink MU-MIMO, which means that an access point transmitting concurrently to multiple receivers can now also simultaneously receive from multiple transmitters (that also include uplink MU-MIMO).

MUSE and a number of other contemporary methods were built in the MATLAB simulator to assess its performance. In-depth MATLAB simulations show that MUSE achieves system throughputs that are, respectively, 3.9, 3.7, and 1.4 times higher than those of 802.11ac, OPUS [10] (a MU-MIMO user selection technique), and 802.11ax. Additionally, it is confirmed that MUSE functions effectively when coexisting with legacy nodes; in fact, because of MUSE's great MAC efficiency, legacy nodes' throughput actually increases rather than degrading. The following are the paper's contributions:

- For MU-MIMO user selection in 802.11ax-based Wi-Fi networks, we had already developed the usage of OFDMA. A new OFDMA frame structure with MCS is created, as well as the idea of integrated uplink/downlink MU transmission.
- Additionally, the algorithm for the improved PSO (particle swarm optimization) approach is based on the high-performance evaluation of the PSO's current methodology. In terms of the performance of both the uplink OFDMA and the downlink MU-MIMO, OFDMA resource allocation is presented as a utility maximization problem, and extensive performance assessments using MATLAB simulator are carried out.
- The findings point to a potential throughput imbalance issue in diverse 802.11ax networks and demonstrate that the Wi-Fi standard's EDCA could be a useful remedy. And based on the current EDCA technique, PSO is now a viable option to tackle this.

B. OFDMA

Wi-Fi 6 (802.11ax) has a feature called orthogonal frequency-division multiple access (OFDMA) that enables access points to serve numerous clients concurrently. Data transfer between many terminals through a transmission medium is governed by a set of rules called OFDMA (such as a wireless network). The frequency-division multiplexing (FDM) technique is an improved version used to partition data packets into distinct bands that are carried by distinct signals.

It is specifically expected that OFDMA users can only send data over the TF of the AP and do not take advantage of channel conflict to do so. Each node's transmission queue receives a data frame in a Poisson manner with rate data when there isn't a lot of traffic, allowing the AP and users to both operate normally. Along with the data frame, a TF additionally arrives in the AP's transmission queue every 1 ms. Regardless of whether it is MUSE-capable or not, a node can transmit data for the maximum TxOP duration (prefixed as T) when it accesses a channel. K potential RUs, or sub-channels, are available for OFDMA. the RUs for an 802.11ax channel at 20 MHz. This specifies that for a 20MHz, each RU may be composed of 26, 52, 106, or 242 tones, and that only one RU, regardless of size, may be given to a single user at a time.

RU type	20 MHz BW	40 MHz BW	80 MHz BW	80+80/160 MHz BW
26-tone RU	9	18	37	74
52-tone RU	4	8	16	32
106-tone RU	2	4	8	16
242-tone RU	1	2	4	8
484-tone RU	N/A	1	2	4
996-tone RU	N/A	N/A	1	2
2x996-tone RU	N/A	N/A	N/A	1

Figure 1. Plot among tones, Bandwidth and number of users.

C. PSO

Particle Swarm Optimization (PSO) is an evolutionary algorithm which requires the generation of random numbers. The performance of PSO algorithm is affected by the quantity and the quality of the numbers generated. The initial iteration is performed over the entire search space. The basic PSO is influenced by a number of control parameters, namely the dimension of the problem, number of particles, acceleration coefficients, inertia weight, neighbour- hood size, number of iterations, and the random values that scale the contribution of the cognitive and social components. The statement “PSO is more efficient than GA at solving the same problems” is proven to be true with a confidence of 99% given the author's testing setup.

D. 802.11AX

802.11ax is an IEEE draft amendment that defines modifications to the 802.11physical layer (PHY) and the medium access control (MAC) sublayer for high-efficiency operation in frequency bands between 1 GHz and 6 GHz. The technical term for an 802.11ax is High Efficiency (HE).

III. OVERVIEW OF PSO

PSO is a stochastic optimization technique based on the movement and intelligence of swarms. In PSO, the concept of social interaction is used for solving a problem. It uses a number of particles (agents) that constitute a swarm moving around in the search space, looking for the best solution.

PARTICLE SWARM OPTIMISATION ALGORITHM

Let us assume a few parameters first. You will find some new parameters, which I will describe later. f: Objective function, Vi: Velocity of the particle or agent, A: Population of agents, W: Inertia weight, C1: cognitive constant, U1, U2: random numbers, C2: social constant, Xi: Position of the particle or agent, P_b Personal Best, gb global Best. The actual algorithm goes as below:

1. Create a 'population' of agents (particles) which is uniformly distributed over X.

2. Evaluate each particle's position considering the objective function (say the below function).

$$Z = f(x, y) = \sin x^2 + \sin y^2 + \sin x \sin y$$

3. If a particle's present position is better than its previous best position, update it.

4. Find the best particle (according to the particle's last best places).

5. Update particles' velocities.

$$V_i^{t+1} = W.\ V_i^t + c_1 U_1^t (P_{b1}^t - P_i^t) + c_2 U_2^t (g_b^t - P_i^t)$$

6. Move particles to their new positions.

$$P_i^{t+1} = P_i^t + v_i^{t+1}$$

7. Go to step 2 until the stopping criteria are satisfied.

The proposed method Particle Swarm Optimization (PSO) works on finding the maximum or minimum of the solution among any solutions. The PSO suits better than any of the existing methods for finding an optimized solution. For small scale there is no significant difference between the two methods. Differences are seen in medium and large scale where genetic algorithms can only produce feasible solutions that are near optimal. PSO algorithm has ease of implementation and also has high calculation accuracy.

- If a particle's current position is better than its previous best position, update it.
- Determine the best particle (according to the particle's previous best positions).

The PSO is applied at the stage where there exists a number of users among one is a prioritized one or may be primary one, to find the best among many users are extracted using particle swarm optimization. In addition, there are few parameters to adjust in PSO. That's why PSO is an ideal optimization problem solver in optimization problems.

PERFORMANCE EVALUATION

UPLINK OR DOWNLINK TRANSMISSION

MUSE improves performance by performing user selection for MU-MIMO during uplink transmission opportunities. Even if no users require uplink transmission during this phase, some of them can be asked to submit frames for CSI estimation. The benefits of PSO and 802.11ax, which use uplink MU transmission techniques, may be negligible if the network's uplink traffic is minimal. However, as was already said, numerous interactive applications and services constantly raise the demand for uplink traffic. PSO will result in improved performance.

In data transmission, network throughput is the amount of data moved successfully from one place to another in a given time period, and measured in bits per second(bps), as in Mbps mega bits per second. To carry out an overall performance evaluation, the throughput of PSO is compared to those of other schemes as the number of users (i.e., *S*) varies. Fig 2 shows the results, and the purpose of comparison, the saturation throughput results of MUSE and PSO are also illustrated.

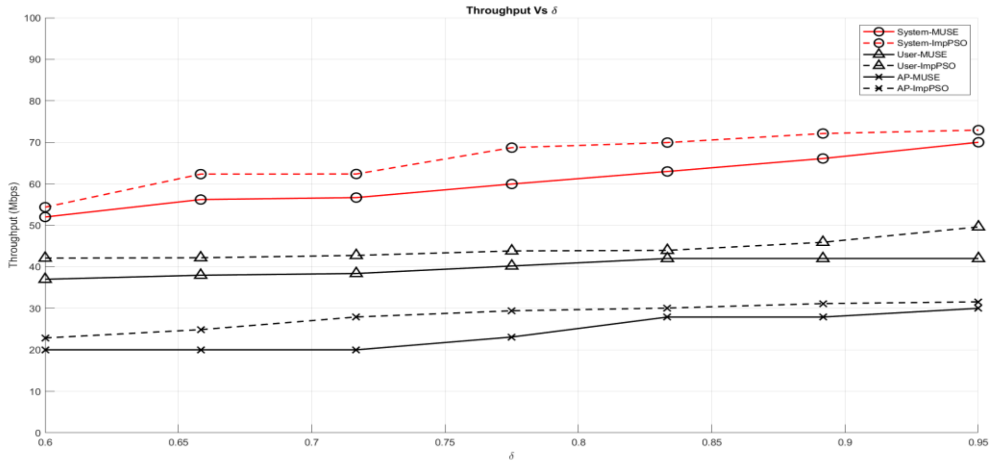


Figure 2 Throughput vs δ. The value of δ strongly affects the performance of the AP-MUSE and AP-ImpPSO, and thus the system performance.

In 802.11ax-based networks, it is necessary to use the appropriate λtf in consideration of the traffic needs of users in order to optimize system performance. MUSE delivers significantly more throughput, but the ImpPSO is much higher than MUSE and delivers more throughput to the AP and users than any other scheme by utilizing MU-MIMO user selection and uplink OFDMA.

SYSTEM DOWNLINK CHANNEL THROUGHPUT AND NUMBER OF ITERATIONS

The downlink is mainly characterized by OFDMA as multiple access scheme and MU-MIMO technology. The benefit of deploying OFDMA technology on downlink is the ability of allocating capacity on both time and frequency, allowing multiple users to be scheduled at a time.

System performance and individual end user experience depend on the propagation conditions, the mobile device feedback, which is based on measurements, and the scheduling algorithm. The channel conditions are provided by the UE through the channel state feedback reports. The scheduler considers the channel variations in its resource allocation, as shown in below fig (3). There are different ways in which improvement can be measured. For example, if the average change in particle positions is small, the swarm can be considered to have converged.

- if the average particle velocity over a number of iterations is approximately zero, only small position updates are made, and the search can be terminated.
- The search can also be terminated if there is no significant improvement over a number of iterations.

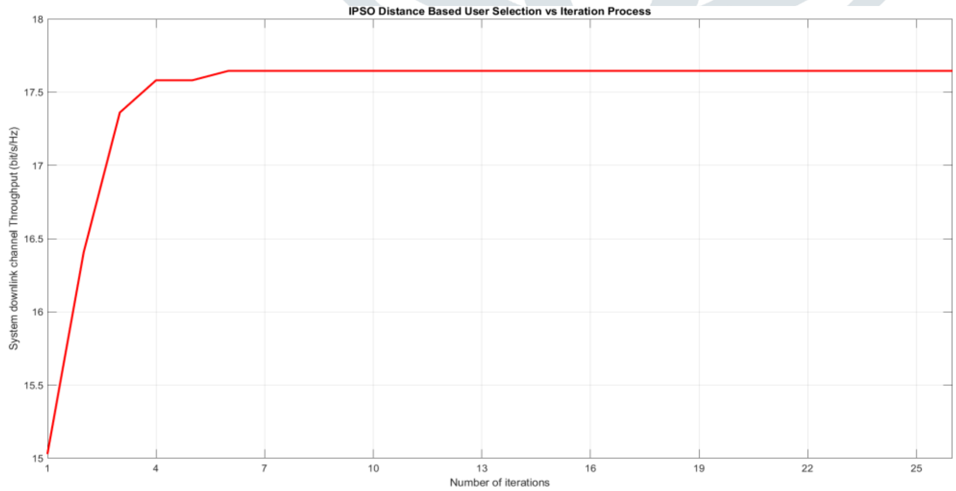


Figure 3 PSO distance-based user selection vs iteration process.

PERFORMANCE FOR DIFFERENT TRAFFIC TYPES

PSO inherits the random-access characteristics of the existing 802.11 protocol because it is developed on top of it. Although the poisson model, one of the most basic traffic models, is employed in this research to evaluate performance, there may still be other types of traffic.

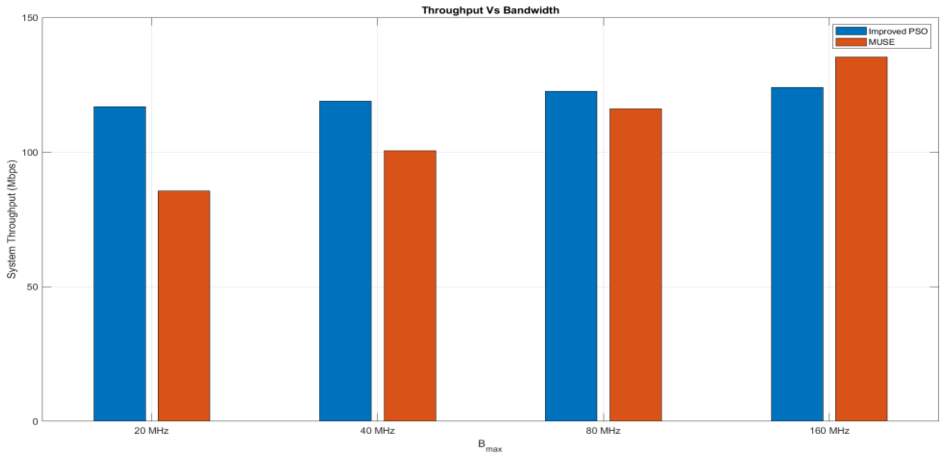
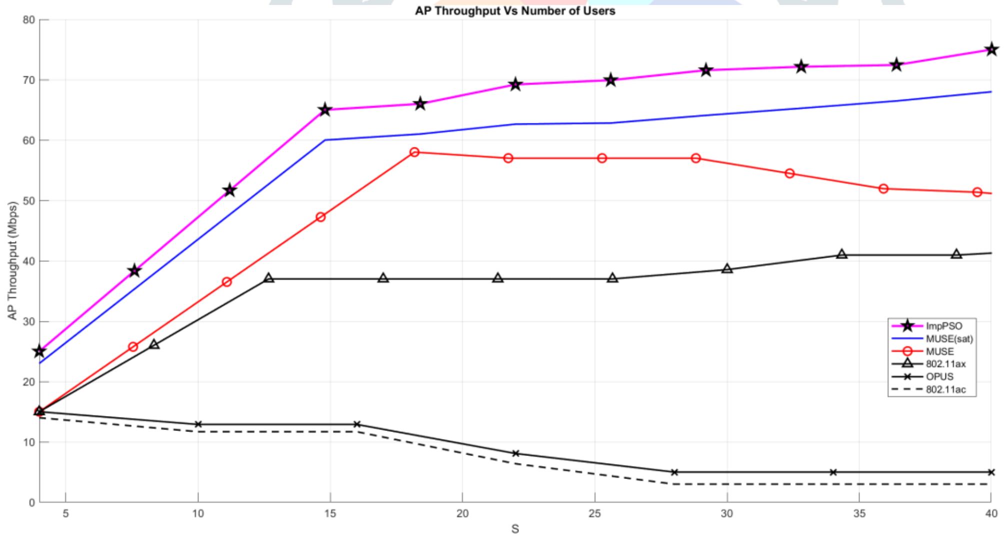


Figure 4 system throughput vs bandwidth configurations of nodes.

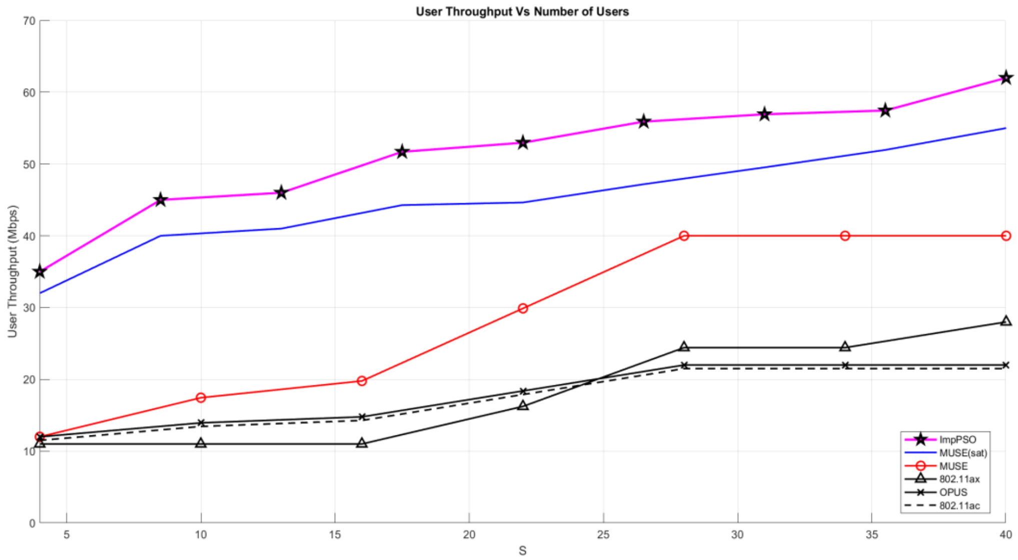
Low-rate nodes can't monopolize the medium for an unreasonably long period thanks to TxOP. By utilizing them effectively, PSO can handle a variety of traffic types because these features complement it. From the results, we can see that both the total available bandwidth (i.e., B^{max}) and the configuration strongly affect the system throughput. This gain can be further increased when there are more users that are capable of a wider bandwidth in the network. As shown in fig (4) for a bandwidth of 160 MHz, the system throughput is 20% higher.

PERFORMANCE EVALUATION

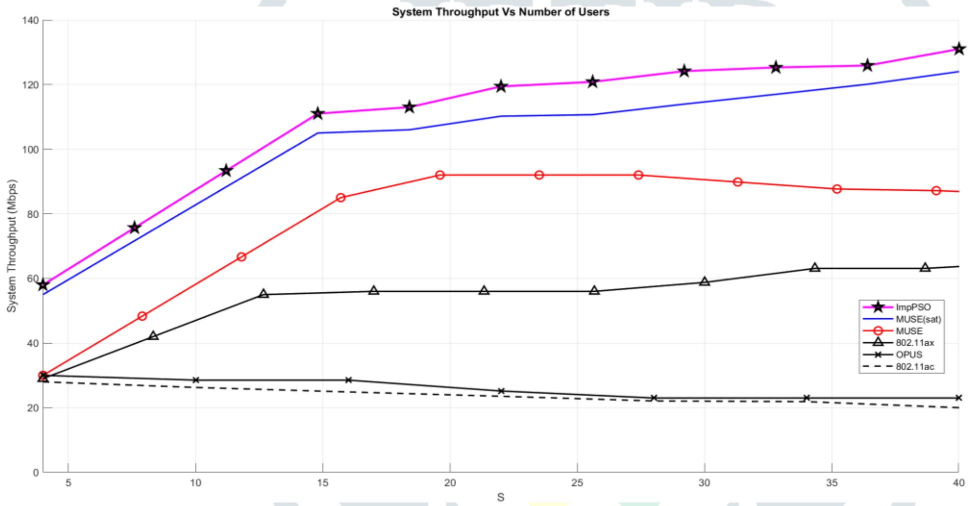
In this section, the performance of MUSE is evaluated and analyzed via MATLAB simulations. In addition to PSO, the following schemes are implemented. The simulation parameters are set to the default values. Each simulation is run for 10 minutes and is repeated 100 times. In the results, user throughput means the total throughput of users, and system throughput is the sum of the AP throughput and the user throughput. A maximum available bandwidth of 20 MHz is applied to both the users and the AP, unless otherwise stated.



5(a) AP throughput



5(b) User throughput



5(c) System throughput

We first examine the user throughput results. We can see that compared to 802.11ac and 802.11ax, OPUS, MUSE both suffer from a high throughput imbalance between user types: legacy users obtain most of the user throughput, while the others have a little, even though they are equipped with new processes. As-expected the throughput of PSO,802.11ax and MUSE users increases to the level of legacy users in 802.11ac, showing that both can work well legacy users.

CONCLUSION

For 802.11ax networks, this study suggests a novel MU-MIMO user selection method called PSO. PSO significantly outperforms traditional systems in terms of throughput by utilizing uplink OFMDA for MU-MIMO user selection. According to the results of a MATLAB simulation, PSO achieves system throughput that is, respectively, 3.9x, 3.7x, and 1.4x higher than that of 802.11ac, OPUS, and 802.11ax. It also successfully coexists with legacy nodes. This paper also suggests that the potential throughput imbalance issue in 802.11ax-based heterogeneous networks might be effectively solved by using existing EDCA.

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