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Optimal Transmit Antenna Selection using Hybrid Algorithm for Massive MIMO Technology

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Abstract: “Massive Multiple Input Multiple Output (M-MIMO) systems specifically refers to a practical technique for sending and receiving more than one data signal simultaneously over the same radio channel by exploiting multipath propagation”. It depends on several antennas for transferring varied data streams simultaneously. With the increase in count of antennas, the energy or power utilization also gets increased. Thus, it becomes necessary to select optimal transmit antennas that exist as the great challenge in M-MIMO systems. This work introduces a new “Hybrid Sea Lion-Whale Algorithm (HS-WA)” for selecting the optimal transmit antenna by considering the multi-objectives, which increases both capacity and efficiency. The adopted scheme is the combination of both “Whale Optimization Algorithm (WOA) and Sea Lion Optimization Algorithm (SLnO)” that optimizes the antenna’s count and moreover, it finds out “which antenna to be selected”. At last, the supremacy of presented model is confirmed over existing models in terms EE and capacity analysis.

Keywords: MIMO; Antenna Selection, Energy Efficiency; SLnO Algorithm; HS-WA Algorithm

Nomenclature

Abbreviation	Description
AS	Antenna Selection
ASC	Average Secrecy Capacity
BER	Bit-Error-Rate
BS	Base Station
BPSO	Binary Particle Swarm Optimization
CNN	Convolutional Neural Network
CDF	Cumulative Distribution Function
CSI	Channel State Information
DF	Decode-And-Forward
EE	Energy Efficiency
HS-WA	Hybrid Sea Lion-Whale Algorithm
IVM	Import Vector Machine
LUs	Legitimate Users
MF	Match Filtering
M-MIMO	Massive Multiple Input Multiple Output
NB	Naive-Bayes
OP	Outage Probability
RF	Radio Frequency
SNR	Signal To Noise Ratio
SLnO	Sea Lion Optimization
SVM	Support Vector Machine
SE	Spectral Efficiency
SM-MIMO-FDR	Spatial Modulation MIMO Full-Duplex Relaying
SER	Symbol Error Rate
SIC	Successive Interference Cancellation
TAS	Transmit Antennas Selection
WOA	Whale Optimization Algorithm
ZF	Zero Forcing

1.Introduction

M-MIMO [9] [10], known as larger-scale MIMO depends on varied antennas for transferring various data streams in the network. Thus, it significantly raises the resolution and EE by exploiting several antennas at BS. By deploying numerous antennas at the receiver and/or transmitter, MIMO systems can [11] [12] accomplish enhanced spatial diversity. This

improves the reliability during transmission and obtains high multiplexing gains that enhance system capacity and data rate. Accordingly, several RF chains are essential, which rapidly raises the hardware complexity and system cost. Therefore, to compute the cost and power consumption of RF chain, TAS is necessary [13] [14] [15] at both transmitting and receiving ends.

TAS in conventional systems are a foremost research problem for the past few decades. It reveals the improvements of the system with respect to EE, and moreover it depicts the process of deploying the antenna subset in communication. Along with SE, EE may also get improved that remains a challenging crisis for the upcoming networks [19] [20]. A promising method that reduces the aforesaid issue is optimal antenna selection. Optimal TAS adopts reasonable count of antennas at receiver or transmitter, and reduces the count of RF chains.

The measure of TAS could be the reduction of BER, maximization of SNR [21] or channel capacity at the receiver side and so on [8]. Choosing the optimal count of active RF chains and portraying the antenna formation improves the EE [22] [23]. In addition, more energy could be saved while RF chains of inactive antennas are turned off. Several TAS approaches like, Exhaustive search and norm-based TAS schemes were developed for improving EE in MIMO [4]. However, these approaches fail to attain a stable EE with respect to the count of transmission antennas [26]. The main contribution of the work is as follows:

- Introduces “Hybrid Sea Lion-Whale Algorithm”, which is the hybridized edition of WOA as well as SLnO models.

The paper is arranged as follows: Section II shows the review on existing models. Section III explains the system model for optimal TAS. Section IV depicts the hybrid sea lion-whale algorithm for TAS in M-MIMO. Section V analyses outcomes and section VI concludes the work.

2.Literature Survey

2.1 Related Works

In 2020, Cao *et al.* [1] presented an effectual approach for TAS in “SM-MIMO-FDR systems”, in which the relay exploits DF protocol. In addition, the accurate SER as well as OP were derived for indicating the performance of adopted system. The experimentations have revealed that the proposed method significantly enhanced the efficiency over the compared schemes.

In 2020, Khalid *et al.* [2] have designed a joint TAS mechanism along with pre-coding mechanism. Accordingly, heuristic approaches with minimal complexity were deployed to carry out the antenna selection for limiting the count of active antennas. Therefore, lessening the power utilization consequently enlarges the EE. Moreover, SIC oriented technique was exploited for pre-coding the chosen transmit antennas. Furthermore, the outcomes demonstrated that the designed model was really effective with minimal complexity and high EE.

In 2019, Moualeu *et al.* [3] have presented an enhanced framework for analysing the MIMO systems at $\alpha - \mu$ fading conditions. Subsequently, 2 scenarios were considered here; the transmitter has awareness regarding the CSI and (b) the transmitter has no awareness regarding CSI of wiretap connection. In addition, two new techniques were suggested for deriving a systematic analysis of the ASC. Further, the superiority of proposed technique was proved in terms of high SNR.

In 2018, Eskandari *et al.* [4] developed a new solution for solving power allocation issues and for maximizing EE in point-to-point MIMO systems. Subsequently, an optimum solution was derived that revealed the association among the optimal EE and system constraints like channel states and circuit power conditions. Moreover, an upper bound was derived and

based on that bound, a novel TAS model was proposed to attain optimal solution. Further, the performance of the developed technique was analyzed in terms of complexity.

In 2018, Asaad *et al.* [5] have analysed the impact of TAS on confidentiality performance of M-MIMO schemes. In addition, a wiretap setting was considered, where a predetermined count of antennas were chosen and the secret data were passed to a legitimate receiver. Moreover, a precise estimation of the instantaneous secrecy rate was derived, by which the secrecy could be enhanced. Finally, the simulated outcomes have demonstrated the enhancement of presented technique with high accuracy.

In 2020, Tran *et al.* [6] have established 2 TAS solutions, “Solutions I and II” for modelling a secure TAS communication model. Particularly, these solutions focused on increasing the receiver signal power among nearer user and source and among distant user and source. Consequently, asymptotic and accurate expression was derived for the confidential OP of overall system and LUs. At last, the attained outcomes illustrated the superiority of solution II over solution I in terms of overall secrecy.

In 2018, He *et al.* [7] have focused on the scenario, in which the source adopted TAS as the transmission approach. Here, it was assumed that the CSI of authenticated receiver was known to source, whereas, the CSI of eavesdrop could be unknown or known to source. Moreover, by considering TAS as a classification issue, two approaches namely, NB and SVM have been proposed. Experimentation was done with the proposed work, and its performance was compared over the traditional model in terms of overhead.

In 2020, Yang and Zhao [8] have presented a novel multi-class IVM oriented framework for maximizing the average received SNR. In fact, TAS was known to be a capable approach for reducing the cost and it also increases the gain of the MIMO system. Furthermore, the analysis has demonstrated the superiority of introduced model, which has acquired minimal complexity with high SNR over other compared models.

TABLE I. Review on existing M-MIMO Antenna Selection techniques

Author	Methods	Features	Challenges
Nguyen <i>et al.</i> [1]	SM-MIMO-FDR	<ul style="list-style-type: none"> ❖ Better throughput ❖ Reduced error rate 	<ul style="list-style-type: none"> ❖ Hardware impairment may occur. ❖ Self interference is not eliminated completely.
Khalid <i>et al.</i> [2]	BPSO	<ul style="list-style-type: none"> ❖ Better SE ❖ Offers high spatial gain 	<ul style="list-style-type: none"> ❖ No consideration on RF chain selection.
Moualeu <i>et al.</i> [3]	CDF	<ul style="list-style-type: none"> ❖ High SNR ❖ Reduced fading 	<ul style="list-style-type: none"> ❖ No consideration on varied fading scenarios. ❖ Need more focus on capacity loss
Eskandari <i>et al.</i> [4]	Water-filling algorithm	<ul style="list-style-type: none"> ❖ High EE ❖ Reduced complexity 	<ul style="list-style-type: none"> ❖ EE decreases with increase in distance.
Asaad <i>et al.</i> [5]	Gaussian based model	<ul style="list-style-type: none"> ❖ Minimal complexity ❖ Improved secrecy performance 	<ul style="list-style-type: none"> ❖ Noise generation should be combined with TAS for more confidentiality.
Tran <i>et al.</i> [6]	CDF function	<ul style="list-style-type: none"> ❖ Reduced interference ❖ Enhanced secrecy performance 	<ul style="list-style-type: none"> ❖ Difficult to accomplish on realistic scenarios.
He <i>et al.</i> [7]	SVM classifier	<ul style="list-style-type: none"> ❖ Minimal overhead ❖ Reduced complexity 	<ul style="list-style-type: none"> ❖ Performance gets degraded if only partial CSI is available.
Yang and Zhao [8]	IVM	<ul style="list-style-type: none"> ❖ Minimal complexity ❖ High SNR 	<ul style="list-style-type: none"> ❖ No consideration on error factors.

2.2 Review

Table 1 demonstrate the review on TAS in MIMO systems. Initially, SM-MIMO-FDR model was presented in [1] that offers accurate throughput and it reduced the error rate. Nevertheless, hardware impairment may occur. BPSO was developed in [2] that offers high spatial gain with better SE, but it have to consider more on RF chain selection. In addition, CDF was used in [3], which provides minimal fading and it presents high SNR; nevertheless, it should focus on capacity loss. Also, Water-filling algorithm was employed in [4] that provide high EE with reduced complexity. However, EE decreases with increase in distance. Likewise, Gaussian based model was presented in [5] that offer enhanced secrecy performance with minimal complexity. However, noise generation should be combined with

TAS for more confidentiality. In addition, CDF function was deployed in [6] that ensure reduced interference and it offers enhanced secrecy performance. Nevertheless, it is difficult to accomplish on realistic scenarios. SVM classifier was deployed in [7] that provide minimal overhead and reduced complexity, however, performance gets degraded if only partial CSI is available. IVM was presented in [8] that offer reduced complexity with high SNR; but, there is no consideration on error factors.

3. Optimal TAS for MIMO Technology

3.1 System Model

Assume an isolated cell with one BS and A terminals. The TX antennas in O_t counts are integrated in BS and all A includes separate RX antennas. The received signal vectors at A is indicated in Eq. (1), where E refers to $A \times O_t$ small scale Rayleigh fading channel matrix, s refers to $A \times 1$ received vector for all A , P_{tx} refers to all TX power at forward link, ς refers to TX power normalization factor, which is evaluated as in $\varsigma \approx \sqrt{\frac{O_t}{A}}$. sv refers to $A \times 1$ signal vector, nv refers to $A \times 1$ AWGN noise vector and V refers to $O_t \times A$ pre-coding matrix to reduce IUI. Accordingly, 2 pre-coding matrices are formulated for LS-MIMO, namely, MF $(MF : V = O_t^{-1} B^B)$, and ZF $(ZF : V = B^B (B B^B)^{-1})$.

$$s_m = \sqrt{P_{tx}} B \varsigma V s v + n v \quad (1)$$

Suppose, if transmitter has idyllist CSI, then the system is termed as LS-MIMO. For computing the EE of LS-MIMO BS, there should be a proper design for power consumption. Eq. (2) defines the sum power, P_{sum} as a tractable power utilization technique, here P_{PA} and P_{BA} refers to power utilization of Power Amplifier (PA) and baseband (BB), and the RF front-end power consumption is pointed out as $P_{RF_{front}}$.

$$P_{sum} = P_{PA} + P_{BA} + E_t P_{RF_{front}} \quad (2)$$

In addition, power utilization P_{cp} is evaluated, which increase with increase in O_t as shown in Eq. (3). Consequently, Eq. (3) is redefined as in Eq. (4).

$$P_{cp} = (P_{BA} / O_t + P_{RF_{front}}) \quad (3)$$

$$P_{sum} = P_{PA} + O_t P_{cp} \quad (4)$$

Accordingly, consider OFDM system (10MHz) having “Class-B efficiency (78.5%) with subcarriers (1024), and IBO as 11dB”. Based on these parameters, the PA efficiency is assumed as 22%. The association among P_{PA} and P_{tx} is given in Eq. (5).

$$P_{tx} = \eta P_{PA} \quad (5)$$

As P_{BA} , the LSMIMO BB evaluation design, $sv(U \text{ flops})P_{BA}$ is addressed in [11].

$$z = O_t S \cdot \left[\left(\frac{C_{gi}}{C_{sd}} \right) \log_2(C_{gi} S) + \left(\frac{C_{gi}}{C_{sd}} \right) \left(1 - \frac{C_{pt}}{C_{st}} \right) A + \left(\frac{C_{gi}}{C_{sd}} \right) \right] \quad (6)$$

$$\left[\left(\frac{C_{pt}}{C_{st}} \right) \log_2 \left(\frac{C_{gi} C_{pt}}{C_{sd} C_{dl}} \right) + \left(\frac{C_{dl}}{C_{st}} \right) A^2 \right]$$

All constraints in Eq. (6) are explained below.

- Parameter S refers to bandwidth with 10MHz power utilization.
- Parameter C_{st} refers to slot length with 0.5ms power utilization.
- Parameter C_{pt} refers to pilot length in a single slot with 0.214ms power utilization.
- Parameter C_{sd} refers to symbol duration with 0.214ms power utilization.
- Parameter C_{co} refers to GI with 4.7μs power utilization.
- Parameter C_{gi} refers to GI having 66.7μs power utilization.
- Parameter C_{dl} refers to delay spread of GI with 4.7μs power utilization.

The correlation among P_{BA} and $sv(U \text{ flops})$ is shown in Eq. (7), where VLSI efficiency is referred as ϖ , and $\varpi = 5U \text{ flop} / R$ and $50U \text{ flop} / R$ was chosen.

$$P_{BA} = \frac{sv(U \text{ flops})}{\varpi(U \text{ flops} / R)} \quad (7)$$

3.2 Optimal Selection of Transmit Antenna

The received signal by m^{th} user is shown in Eq. (8), wherein, the $1 \times E_t$ channel vector of m^{th} user is signified as $g_{k,:}$ and pre-coding vector for m^{th} user is signified as $p_{:,k}$. The last term in Eq. (8) is called IUI.

$$q_k = \sqrt{\frac{P_{tx} E_t}{B}} g_{k,:} p_{:,k} z_k + e_k + \sqrt{\frac{P_{tx} E_t}{B}} \sum_{l \neq k} g_{k,:} p_{:,l} z_l \quad (8)$$

The capability of one isolated cell is revealed in Eq. (9), here α refers to scaling factor, $O_0 S$ refers to noise power at bandwidth S .

$$M = \alpha S \cdot \sum_{k=1}^K D \left[\log_2 \left(1 + \frac{\frac{P_{tx} O_t}{A} |g_{k,:} p_{:,k}|^2}{\frac{P_{tx} O_t}{A} \left| \sum_{l \neq k} g_{k,:} p_{:,l} \right|^2 + O_0 S} \right) \right] \quad (9)$$

Eq. (9) is formulated when the system moves to LS MIMO area, (i.e. $O_t > 10 A$). In Eq. (10), X refers to IUI. EE is modelled as per Eq. (11). Further, the optimal TX antenna count O_t^{opt} must satisfy Eq. (12).

$$S_{approx}^{LS-MIMO} \approx \alpha S A \left[\log_2 \left(1 + \frac{P_{tx} O_t}{(X + O_0 S) A} \right) \right] \quad (10)$$

$$EE = M / P_{sum} \quad (11)$$

$$\begin{aligned}
\frac{\partial}{\partial E_t} EE &= \frac{\partial}{\partial E_t} \left(\frac{M_{approx}}{\frac{1}{\eta} P_{tx} + O_t P_{cp}} \right) \\
&= \frac{SAP_{tx}}{(X + O_0 S) A \left(1 + \frac{P_{tx} O_t}{(L + O_0 S) A} \right) P_{sum} \log_2 p} - \\
&\quad \frac{SAP_{cp} \cdot \log_e \left(1 + \frac{P_{tx} O_t}{(X + O_0 S) A} \right)}{P_{sum}^2 \log_2 p} \\
&= 0
\end{aligned} \tag{12}$$

Thereby, O_t^{opt} is computed as in Eq. (13), where $\Gamma = \frac{P_{tx}^2 - AO_0SP_{cp} - AXP_{cp}}{A(X + O_0S)P_{cp} \exp(1)}$ and R represents

the lambert function and is expressed as $\Gamma = R(\Gamma) \exp(R(\Gamma))$.

$$O_t^{opt} \approx \frac{(X + O_0 S) A}{P_{tx}} (-1 + \exp(1 + R(\Gamma))) \tag{13}$$

Using Eq. (13), O_t^{opt} could be attained, however, the challenge is “how to select the O_t^{opt} antennas from total number of antenna O_t^{total} ”. The channel capacity of O_t^{opt} when choosing columns of B are $\{b_1, b_2, \dots, b_{O_t^{opt}}\}$, $M_{\{b_1, b_2, \dots, b_{O_t^{opt}}\}}$ is given in Eq. (14), where, $1 \times O_t^{opt}$ channel vector for k^{th} user is referred as $g_{k, \{b_1, b_2, \dots, b_{O_t^{opt}}\}}$, $O_t^{opt} \times 1$ pre-coding vector referred as $p_{\{b_1, b_2, \dots, b_{O_t^{opt}}\}, k}$ when $\{b_1, b_2, \dots, b_{O_t^{opt}}\}$ is chosen.

$$M_{\{b_1, b_2, \dots, b_{O_t^{opt}}\}} = \alpha S.D \left[\log_2 \left(1 + \frac{\frac{P_{tx} O_t}{A} \left| d_{k, \{b_1, b_2, \dots, b_{O_t^{opt}}\}} p_{\{b_1, b_2, \dots, b_{O_t^{opt}}\}, k} \right|^2}{\frac{P_{tx} O_t}{A} \left| \sum_{l \neq k} g_{l, \{b_1, b_2, \dots, b_{O_t^{opt}}\}} p_{\{b_1, b_2, \dots, b_{O_t^{opt}}\}, l} \right|^2 + O_0 S} \right) \right] \tag{14}$$

On considering green BS, EE should be maximized instead of increasing the capacity. In Eq. (11), the optimal AS for EE and channel capacity are same, as O_t^{opt} was already chosen from Eq. (13). Thus, P_{sum} turns out to be independent of AS. For optimally selecting the

antennas, O_t^{opt} columns with higher EE is chosen as per Eq. (15), where, all feasible combinations of O_t^{opt} antennas is referred as L .

$$\{b_1, b_2, \dots, b_{O_t^{opt}}\} = \arg \max_{\{b_1, b_2, \dots, b_{O_t^{opt}}\}} \frac{M_{\{b_1, b_2, \dots, b_{O_t^{opt}}\}}}{P_{sum}} \quad (15)$$

4. Hybrid Sea Lion-Whale Algorithm for TAS in M-MIMO

4.1 Solution Encoding

The proposed work concerns on electing the optimal count of antennas and it finds out “which antenna should be selected”. This optimization problem is solved by a new hybrid algorithm and the input solution to the algorithm is illustrated in Fig 1. The antennas b are provided as solutions and chromosome length depends on antenna count E_t . In Fig 1, “0” indicates unselected antennas and “1” depicts the selected antennas. Thus, the optimal count and the appropriate antenna to be selected is determined.

Fig. 1. Solution Encoding

4.2 Proposed WTU Algorithm

For enhancing the traditional WOA [25] [29] [30], it is intended to hybridize the concept of SLnO [24] with WOA. In fact, the hybrid optimizations are reported to be capable for solving search issues [26] [31]. The arithmetical model of adopted HS-WA algorithm is described here.

(i) Encircling Prey: As per the presented HS-WA model, the update occurs depending on random number ϕ . If ϕ is lesser than 0.5 ($\phi < 0.5$), and if $(|I| < 1)$ and if random integer, ra is less than 0.5 (i.e. $ra < 0.5$), the update takes place as per encircling phase of WOA, i.e. as

shown in Eq. (17). In Eq. (16) and Eq. (17), $\vec{I}$ and $\vec{H}$ refer to the coefficient vectors and present iteration is signified by t .

$$\vec{G} = \left| \vec{H} \cdot \vec{Q}_p(t) - \vec{Q}(t) \right| \quad (16)$$

$$\vec{Q}(t+1) = \vec{Q}_p(t) - \vec{I} \cdot \vec{G} \quad (17)$$

Also, $\vec{Q}$ denote position vector and $\vec{Q}_p$ signifies best position. Furthermore, $\vec{I}$ and $\vec{H}$ are evaluated by Eq. (18) and Eq. (19). In Eq. (18), the component $\vec{a}$ is diminished from 2 to 0 for further iterations. The arbitrary vectors ra_1 and ra_2 lies among $[0, 1]$.

$$\vec{I} = 2\vec{a} \cdot ra_1 - \vec{a} \quad (18)$$

$$\vec{H} = 2ra_2 \quad (19)$$

On the other hand, if $ra > 0.5$, the update occurs as per detecting phase of SLnO as given in Eq. (20), in which D denotes the distance among sea lion and target prey, $\vec{H}$ refers to random integer, $\vec{M}(t)$ refers to the position of target prey.

$$\vec{Q}(t+1) = \vec{M}(t) - D \cdot \vec{H} \quad (20)$$

If $(|I| > 1)$, and if $ra < 0.5$, the update occurs as per exploration phase of WOA, i.e. as shown in Eq. (22), where the arbitrary position vector elected from the present population is indicated by $X_{(rand)}$.

$$\vec{G} = \left| \vec{H} \cdot \vec{Q}_{(rand)} - \vec{Q} \right| \quad (21)$$

$$\vec{Q}(t+1) = \vec{Q}_{(rand)} - \vec{I} \cdot \vec{G} \quad (22)$$

On the other hand, if $ra > 0.5$, the update takes place based on exploration phase of SLnO as shown in Eq. (23), where $\vec{Q}_{rnd}(t)$ refers to the arbitrary sea lion chosen from present population.

$$\vec{Q}(t+1) = \vec{Q}_{rnd}(t) - D \vec{H} \quad (23)$$

Likewise, if $\phi > 0.5$, and if $ra < 0.5$, the update occurs as per exploitation phase of WOA, i.e. as given in Eq. (24). Here, $\vec{G}$ refers to distance of i^{th} whale to prey and is given in Eq. (25), b denotes “logarithmic spiral shape” and l is an arbitrary variable between $[-1,1]$.

$$Q(t+1) = \vec{G}' e^{bl} . \cos(2\pi l) + \vec{Q}_p(t) \quad (24)$$

$$G' = |\vec{Q}_p(t) - \vec{Q}(t)| \quad (25)$$

Conversely, if $ra > 0.5$, the update occurs as per exploitation phase of SLnO as given in Eq. (26), here the distance amongst target prey and sea lion is denoted by $\vec{M}(t) - \vec{Q}(t)$, the absolute value is denoted by $||$ and the random number among to 1 is referred by l .

$$\vec{Q}(t+1) = |\vec{M}(t) - \vec{Q}(t) . \cos(2\pi l)| + \vec{M}(t) \quad (26)$$

Algorithm 1: Proposed HS-WA model
Assign the population of whales $Q_i (i = 1, 2, \dots, n)$ Measure the fitness of all exploring agents Q^* is the best agent for exploring While t is less than the number of iterations For every search agents Update a, I, H, ϕ and l if $1 - \phi < 0.5$ if $(I < 1)$ if $ra < 0.5$ Update position as in Eq. (17) else Update position as in Eq. (20), i.e. based on detecting phase of SLnO end if else if If $ra < 0.5$ Update position as in Eq. (22) else Update position as in Eq. (23), i.e. based on exploration phase of SLnO end if end if else if $ra < 0.5$ Update position as in Eq. (24) else Update position as in Eq. (26), i.e. based on exploitation phase of SLnO end if end for

```

Measure the fitness of exploring agent as per Eq. (15)
if better solution is attained, update  $Q^*$ 
 $t = t + 1$ 
end while
return  $Q^*$ 

```

5. Results and Discussions

5.1 Simulation Setup

The proposed optimal TAS model was implemented in “MATLAB” and the outcomes were noticed. Accordingly, the supremacy of the presented HS-WA model was evaluated over existing models namely, MV-GSA [27], I-SL_{NO} [28], SL_{NO} [24] and WOA [25]. Here, analysis was done using 2 setups. The first setup was “ $P_{tx} = 40W$, $sv(U \text{ flop} / R) = 5U \text{ flop} / R$, $P_{RF_{front}} = 975mW$ and the 2nd setup was “ $P_{tx} = 10W$, $P_{sum1}sv(U \text{ flop} / R) = 50U \text{ flop} / R$, $P_{RF_{front}} = 97.5mW$ ”. Moreover, the analysis was carried out for MF coding and ZF coding with respect to relative efficiency and capacity.

5.2 Analysis on Capacity

The capacity analysis of adopted HS-WA scheme over existing schemes like MV-GSA, I-SL_{NO}, SL_{NO} and WOA is given in Fig. 2. The analysis is done for MF and ZF under two set ups by varying the count of users from 1 to 8. From the analysis, the presented model has revealed higher capacity value over other compared models. Initially, the capacity is lower for lesser count of users; however, as the count of users increases, the capacity has reached a higher level. Particularly, for ZF under set up 2 (from Fig. 2(d)), the HS-WA scheme has obtained a higher capacity, whereas, for other experimentations, the proposed work has exhibited a comparatively lower capacity values. More specifically, the implemented model for MF under set up 1 is 48.89%, 15.56%, 15.56% and 2.22% improved than traditional MV-GSA, I-SL_{NO}, SL_{NO} and WOA when user count is 7. Likewise, the capacity analysis of the

developed HS-WA model over conventional schemes for ZF under 2nd set up is illustrated in Fig. 2 (d), where the proposed HS-WA scheme has accomplished a higher capacity of 7.3. That is, the performance of adopted model is 65.75%, 1.37%, 17.81% and 1.37% improved than traditional MV-GSA, I-SL_nO, SL_nO and WOA when user count is 8. Altogether, from the analysis, the presented scheme has found to be effective with higher capacity.

Fig. 2. Capacity analysis of adopted model over existing models for (a) MF (b) ZF for setup 1 and (c) MF (d) ZF for setup 2

5.3 Energy efficiency Analysis

The analysis on relative efficiency attained by the developed HS-WA model over existing models is analysed in this section. The analysis is carried out for ZF and MF for varied number of users' ranges from 5, 10, 15, 20, 25, 30, 35 and 40. On observing Fig. 3, the adopted work has attained a higher efficiency than the compared models for both the set ups.

In particular, the adopted HS-WA model has achieved a higher efficiency of 0.979; while, the compared approaches has revealed a comparatively lower efficiency. From Fig. 3(c), the adopted model for MF under set up 2 is 0.92%, 0.102%, 0.102% and 0.102% superior to other existing models like MV-GSA, I-SL_nO, SL_nO and WOA, when the number of users is 40. Moreover, from Fig. 3(d), the implemented scheme for ZF under set up 2 has achieved a higher efficiency value of 0.979, whereas the compared models have achieved a relatively lower efficiency of 0.97. That is, the developed model is 0.92%, 0.102%, 0.102% and 0.102% superior to other existing models like MV-GSA, I-SL_nO, SL_nO and WOA, when the number of users is 40. Therefore, the improved efficiency accomplished by the developed HS-WA model has been proved effectively.

Fig. 3. Analysis on relative efficiency by adopted model over existing models for (a) MF (b) ZF for setup 1 and (c) MF (d) ZF for setup 2

5.4 Analysis on Optimal Transmit Antenna Count

Table II and Table III reveals the optimal count of transmitted antennas attained by the presented approach and conventional approaches for varied number of users that ranges from 5, 10, 15, 20, 25, 30, 35 and 40. Table II portrays the optimal count of antennas obtained by developed HS-WA and existing models for ZF and MF under set up 1. In addition, Table III exhibits the optimal count of antennas attained by the presented and existing models for ZF and MF under set up 2. From the results, it was observed that the optimal antenna count varies for ZF and MF depending on the count of users.

TABLE II. Optimal count of transmit antenna by implemented model over existing models for setup 1

Match Filtering					
No of User	MV-GSA [27]	I-SL _n O [28]	SL _n O	WOA	HS-WA
5	4448	5066	7579	3459	3796
10	4453	7500	5038	5335	5115
15	4331	7516	7435	6612	6534
20	4382	7563	7580	7433	7752
25	4357	7509	7509	7385	7832
30	4352	7649	7530	7364	7597
35	4293	7522	7492	7527	7988
40	4296	7553	7553	7550	7337
Zero Forcing					
No of User	MV-GSA [27]	I-SL _n O [28]	SL _n O	WOA	HS-WA
5	4431	7514	5005	3335	3464
10	4281	7600	4125	5426	5253
15	4321	7445	7490	6679	6474
20	4319	7487	7487	7173	7548
25	4371	7589	7589	7194	7632
30	4376	7513	7555	7215	7865
35	4342	7544	7580	7739	6934
40	4290	7533	8576	7602	7737

TABLE III. Optimal count of transmit antenna by implemented model over existing models for setup 2

Match Filtering

No of User	MV-GSA [27]	I-SL _n O [28]	SL _n O	WOA	HS-WA
5	9156	4919	4919	9121	9142
10	9088	4981	8084	9071	9076
15	9065	4906	4976	9052	9053
20	9052	7523	4982	9042	9042
25	9044	9035	7507	9035	9035
30	9038	9030	7707	9030	9030
35	9034	9026	4987	9026	9026
40	9030	8726	7462	9023	9024
Zero Forcing					
No of User	MV-GSA [27]	I-SL _n O [28]	SL _n O	WOA	HS-WA
5	9159	8256	9750	9121	9145
10	9090	4184	9072	9072	9077
15	9065	7403	8838	9053	9054
20	9052	7487	9042	9042	9042
25	9044	9035	4991	9035	9035
30	9038	6436	9030	9030	9030
35	9034	8357	9026	9026	9027
40	9030	6968	9024	9024	9024

6. Conclusion

This paper has developed a novel algorithm for choosing the optimal transmit antenna, by which the capacity and relative efficiency was increased. In order to carry out optimal TAS, a novel algorithm namely HS-WA was introduced, which optimally selected the antenna count and it also determined “which antenna to be chosen”. At last, the superiority of presented scheme was proved over the existing models in terms of efficiency and capacity. On observing the analysis outcomes, the adopted model for MF under set up 2 was 0.92%, 0.102%, 0.102% and 0.102% superior to other existing models like MV-GSA, I-SL_nO, SL_nO and WOA, when the number of users was 40. Moreover, the implemented scheme for ZF under set up 2 has achieved a higher efficiency value of 0.979, whereas the compared models have achieved a relatively lower efficiency of 0.97. i.e. the developed model was 0.92%, 0.102%, 0.102% and 0.102% superior to other existing models like MV-GSA, I-SL_nO, SL_nO and WOA, when the number of users was 40. Thereby, the enhancement of the developed model has been proved over the conventional works.

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