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# Beamforming algorithm for physical layer security of multi user large scale antenna network

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**Abstract.** The traditional network security uses encryption and decryption operations in the application layer. However, this will not only increase the computational overhead of network, and there is no way to avoid user eavesdropping and attack from the physical layer, aiming at this problem, this paper proposes multi user large scale antenna network physical layer security beamforming algorithm, according to the optimization criterion the dual criterion beamforming design method. The simulation results show that the proposed method can effectively improve the network security capacity.

**Keywords:** Large Scale Antenna, Physical Layer Security, Beamforming, Secrecy Capacity

## 1 Introduction

Recently, the third generation and fourth generation cellular networks have made significant progress in performance, such as high speed downlink packet access, high speed uplink packet access, multi user multiple input multiple output, channel adaptive scheduling, cooperative multi point transmission, relay protection technology can improve spectral efficiency. This confirms the effective integration of these services on the physical layer, making the characteristics of the radio broadcast fully utilized [1-4].In this case, the concept of physical layer security is becoming increasingly attractive because it uses only physical properties to create secure for wireless channels. In order to pave the way for the practical implementation, it is necessary to strengthen the integration of the physical layer services from the perspective of signal processing. If there is enough power to transmit, then a large-scale MIMO system can significantly expand the scope of operation, even though the loss of power consumption of the RF front end, the conclusion is that Massive MIMO is a means to improve energy efficiency in the future network.

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## 2 Related works

Privacy is a relative concept, involving the difference in the rate of Eve and Bob. The secrecy capacity is implemented by a random encoding, where each message is associated with a plurality of code words to confuse the listener. Along with the rate of information $C_S$ and confusion $I(X;Z)$, both the secure message and the chaotic message can be decoded by Bob, because his channel can decompose the combined message when the rate is up to $I(X;Y)$. The channel prefix of equation (1) shows another aspect of the security relativity [5-6]. For the Gauss channel, the non-fading wireless communication channel model, the input of a Gauss channel maximizes mutual information, and computes the difference between the mutual information, so the secrecy capacity is equal to the channel capacity difference between the legal link $C_B$ and the eavesdropping link $C_E$. Let us suppose $C_B \geq C_E$, then

$$C_S = C_B - C_E = \frac{1}{2}\log\left(1+\frac{P}{\sigma_B^2}\right) - \frac{1}{2}\log\left(1+\frac{P}{\sigma_E^2}\right) \quad (1)$$

We note thatthe secrecy capacity of the equation (1) is not proportional to the transmitted power $P$ of the legitimate transmitter. That is, when $P$ is infinite, $C_S$ converges to a constant.The cost of providing information theory is often measured by the degree of freedom (s.d.o.f.), defined $P$ as the ratio of a secure communication rate.

Research on signal processing in large scale MIMO is mainly pre encoding and signal detection. In the MIMO system with a single cell, using linear precoding can be obtained as well as rate performance of the optimal dirty paper encoding approach. The use of high dimension matrix inverse properties can be simplified,linear precoding can also achieve low complexity method[7]. On the other hand, signal detection has also been research on personnel's attention. Large scale MIMO system shows good performance in large scale system by using the large scale MIMO joint channel estimation and data detection algorithm, it constrained packet detection algorithm and reduced complexity [7-9].

## 3 Proposed scheme

In this paper, we consider the downlink MIMO Massive system, the single cell BS is a transmitter, the BS is equipped with $M$ antennas, and BS serves $K$ users. Each $k-th$ user is equipped with multiple antennas, and the number of receiving antennas is $N_k$ ($k=1,2,3,\ldots,K$). $K$ users uniform in a radius of $R$ in a cell, the information received by $K$ users is in the same time - frequency resource block[10-13].The channel from $K$ users to the BS can be expressed as $G = HD^{1/2}$ , where, $D = diag\{\beta_1, \beta_2, \ldots, \beta_K\}$ is the large scale fading system matrix of the channel,mainly consider path loss and shadowing fading, $\beta_k = \phi d_k^{-\alpha}\zeta$ , where $\phi$ is the fading constant, $d_k$ is the distant of user $k$ to the BS, $\alpha$ path loss fading index , $\zeta$ is the shadow fading coefficient. The signals received by the user $k$ can be expressed as

$$y_k = \sqrt{p_k} G_k T_k \mathbf{s}_k + \sum_{i=1, i \neq k}^{K} \sqrt{p_k} G_i T_k \mathbf{s}_k + \mathbf{n}_k \tag{2}$$

In the optimization system, the two variables need to be determined, $\eta_1$ and $\eta_2$ respectively, which are constant in this paper [14-15].Its iterative algorithm is:

1) Initialization $T_m$ , $\mu_1$, $\eta_1$ and $\eta_2$ ,2)Repeated iteration with initialization values $T_m$ , $\mu_1$, $\eta_1$ and $\eta_2$, solving the problem 3) Setting reasonable threshold, so that the algorithm will convergence, which can save the computation and time,4) Finally, getting the precoding $T_m$ .5),eventually get the optimal value values $T_m$ , $\mu_1$, $\eta_1$ and $\eta_2$ .

## 4 Simulation results and analysis

Tab.1 is the parameters setting.

**Table 1.** Downlink Massive MIMO system parameters

| Parameter | Value |
|---|---|
| Factor $\phi$ | 1 |
| Path loss exponent $\alpha$ | 3.7 |
| shadow fading standard deviation $\sigma_{sh}$ | 8 |
| Noise power $\sigma^2$ | -104 $\left(dBm gHz^{-1}\right)$ |
| Power amplifier efficiency $\eta$ | 0.5 |
| Users consume power $P_E$ | 0.01 $mW$ |

| | |
|---|---|
| Each antenna circuit consume power $P_C$ | $0.1\times10^{-3}\,mW$ |
| Basic power consumption of BS $P_0$ | $0.2\,mW$ |

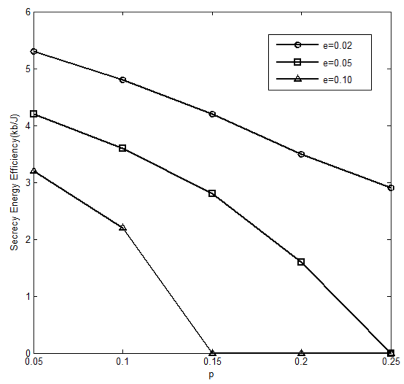


**Fig. 1.** Secrecy energy efficiency

Fig.1 from the point of view of the secrecy energy efficiency, which can be seen, when $\eta_1$ is smaller, the secrecy energy efficiency is higher, and is bigger, the secrecy energy efficiency is lower, and with the increase of $\eta_2$, the secrecy energy efficiencydecreases. It can be seen that the energy efficiency of the secrecy capacity is at the expense of the total transmission efficiency, as follow-up work to be discussedfor this problem.

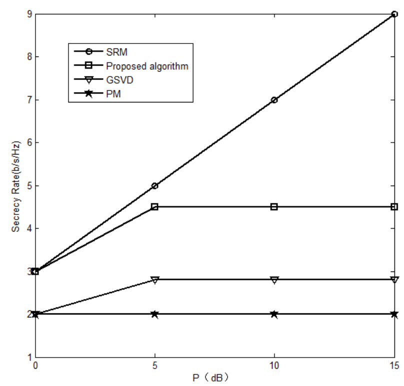


**Fig. 2.** Maximum mutual information with the transmission power conversion

From Fig.2, we can see that the proposed scheme has higher efficiency in the existing scheme, and it has the high secrecy capacity efficiency, which is the possibility that the numerical solution can be more close to the optimal solution, the price is the high computational complexity,in the other three schemes, the optimal solution is closed, but its secrecy capacity will not increase with transmission power.

# 5 Conclusion

In this paper, according to the topological structure of the fifth generation mobile communication, that is the simplest multi-user structure, with the large antenna deployment,considering the secrecy transmission energy utilization rate and the maximum secrecy capacity of the system, and the optimized solution of the system is obtained by iteration,according to the optimized solution, from the figure we can see that the proposed scheme has a great advantage in the secrecy capacity than other schemes.

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