Low-Complexity Beamforming Designs of Sum Secrecy Rate Maximization for the Gaussian MISO Multi-Receiver Wiretap Channel

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Abstract

Motivated by the thinking of ZF and SLNR, we propose three low-complexity beamforming algorithms for finding a local SSR optimum in the MISO-MRWC. The simulation results show that the SLNR-based beamforming algorithm outperforms the other two algorithms with ZF preprocessing.

System model

- **Gaussian MISO-MRWC model**
- **one N_t-antenna transmitter (Alice)**
- **K single-antenna legitimate receivers (Bobs)**
- **passive eavesdropper (Eve) with N_e antennas**
- **Confidential messages from Alice to Bobs are kept secret from Eve**
- **Perfect CSI at Alice**

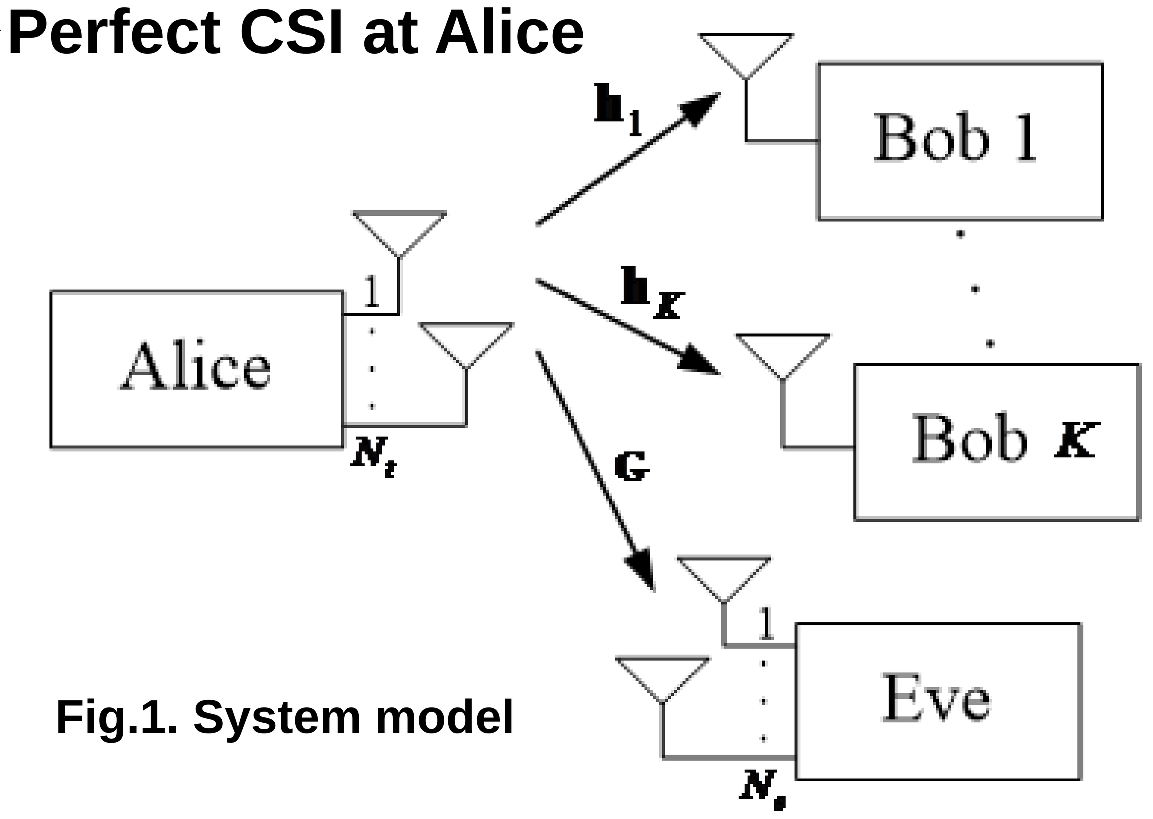

Fig.1. System model

Problem formulation

◆Goal: maximizing the sum secrecy rate (SSR) subject to the total power constraint

$$\max_{\mathrm{Tr}(\mathbf{F}\mathbf{F}^H)\le P_t} \sum_{k=1}^{K} \log_2\left(1+\mathrm{SINR}_k\right)-\log_2\left(1+\mathrm{SINR}_{e,k}\right)$$

◆ SINR_k and SINR_{e,k} are the SINR at Bobs and Eve.

SLNR-Based Beamforming

- **the SSR maximization problem is transformed into the SLNR maximization problem**

$$\max_{\mathrm{Tr}(\mathbf{t}_k\mathbf{t}_k^H)\le 1} \frac{\mathbf{t}_k^H \mathbf{h}_k^H \mathbf{h}_k \mathbf{t}_k}{\mathbf{t}_k^H\left(\mathbf{I}/p_k+\mathbf{H}_{\tilde{k}}^H\mathbf{H}_{\tilde{k}}+\mathbf{G}^H\mathbf{G}\right)\mathbf{t}_k}$$

- **joint optimization and alternating iterative optimization of t_k and p_k are hard to resolve;**
- **we only consider equal power allocation, p_k = P_t/K;**

$$\mathbf{t}_k \propto \max.\mathrm{eigenvector}\left(\left(\mathbf{I}/p_k+\mathbf{H}_{\tilde{k}}^H\mathbf{H}_{\tilde{k}}+\mathbf{G}^H\mathbf{G}\right)^{-1}\mathbf{h}_k^H\mathbf{h}_k\right)$$

ZF-Based Beamforming

- **the SSR maximization problem**

$$\max_{\mathbf{G}\mathbf{F}=\mathbf{0},\ \mathrm{Tr}(\mathbf{F}\mathbf{F}^H)\le P_t} \sum_{k=1}^{K}\log_2\left(1+\mathrm{SINR}_k\right)$$

- **Algorithm 1**

Modified ZF-based Beamforming

- **the SSR maximization problem**

$$\max_{\sum_{k=1}^{K} p_k\le P_t} \sum_{k=1}^{K}\log_2\left(1+p_k\mathbf{t}_k^H\mathbf{h}_k^H\mathbf{h}_k\mathbf{t}_k\right)$$

$$\mathrm{s.t.}\quad \mathbf{H}_{\tilde{k}}\mathbf{t}_k=\mathbf{0},\ \mathbf{G}\mathbf{t}_k=\mathbf{0},\ \forall k.$$

- **water filling algorithm**

Simulation results

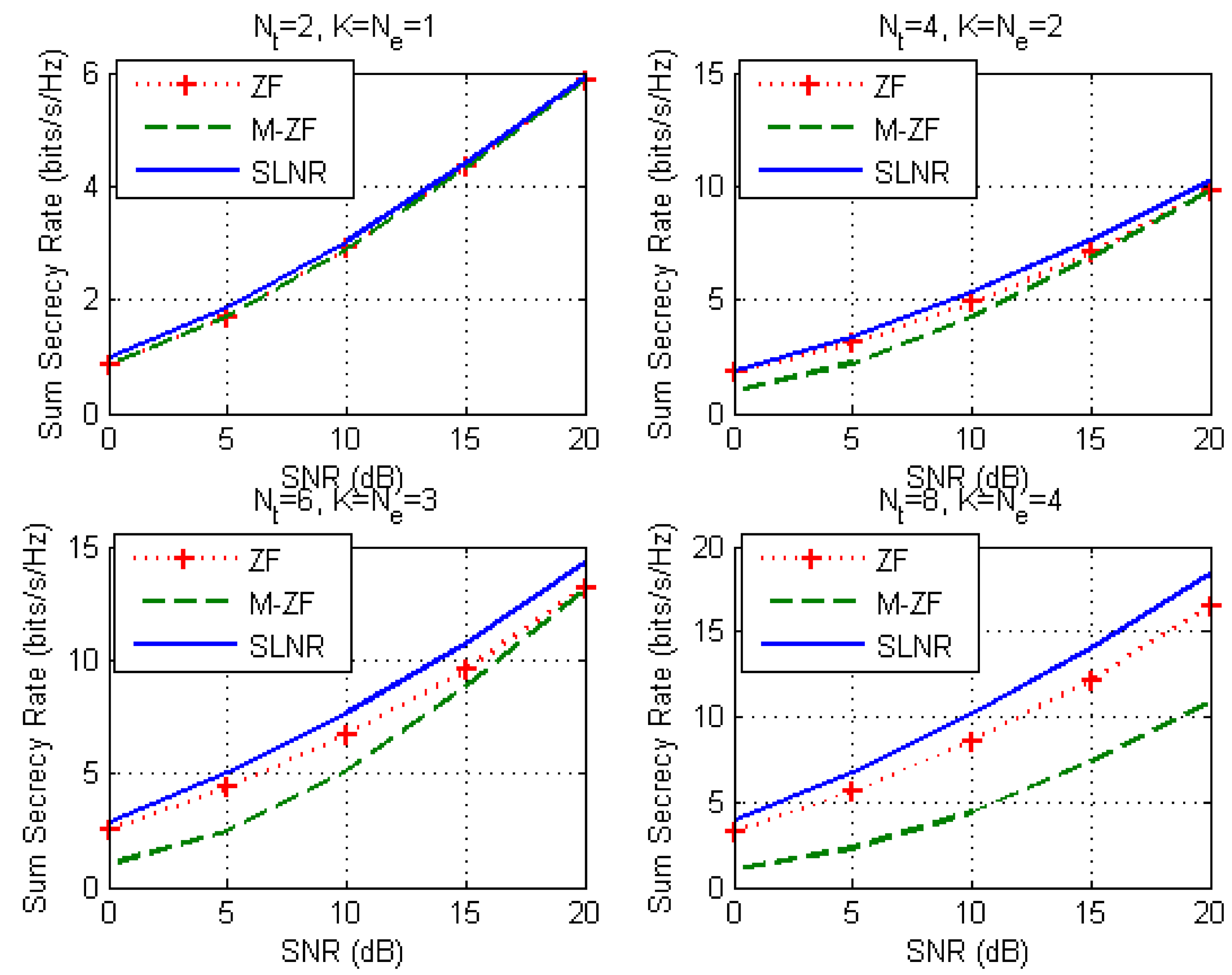

Fig.2. Achievable SSRs of the proposed beamforming algorithms.

- **"SLNR" has the best SSR performance, "ZF" is the second, while "M-ZF" is the worst;**
- **the SSR performance gaps of these three algorithms increase with K.**

Conclusions

Based on the thinking of ZF and SLNR, we proposed three beamforming algorithms for the Gaussian MISO-MRWC to maximize the SSR. The results show that the SLNR-based beamforming algorithm outperforms the other two algorithms with ZF preprocessing.

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