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Ergodic secrecy capacity of MRC/SC in single-input multiple-output wiretap systems with imperfect channel state information

Key words: Ergodic secrecy capacity (ESC); Maximal ratio combining (MRC); Weighting errors; Physical layer security; Selection combining (SC); Single-input multiple-output (SIMO)

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Motivation

- Channel state information (CSI) cannot be obtained perfectly because of the complexity of electromagnetic wave spreading and transmitting delay. Thus, CSI has estimation errors at the receiver.
- Due to the broadcast nature of wireless links, it is difficult to prevent eavesdroppers from overhearing wireless communications.
- Due to the fact that the diversity weighting factors are proportional to the complex conjugate of the channel fading vector in time, when the pilot frequency range and channel bandwidth are similar, it is easy to cause a Gaussian channel estimation error.

Motivation

- Because of the rapid increase in the demand for wireless communications services, the capacity of fading channels is increasingly becoming a main concern in the design of wireless communication systems.
- In fading channels, such as Rayleigh fading channels, the SNR of receivers varies with time. This offers an explanation why the capacity of fading channels has to be calculated in an average sense
- Due to the transmitting delay, the CSI obtained from the pilot at the receiver may be outdated, leading to an imperfect SC and the degradation of the combined SNR.

Method

1. We first derive the integral general form for the closed-form expression for ESC. Then, we substitute the PDF and CDF of the SNR at the receiver, derived from the previous works, namely Gans (1971) and Tomiuk *et al* (1999), into the general form. Finally, using the integral equation given in Appendix B in Alouini and Goldsmith (1999), we can derive the closed-form expression for ESC.
2. As for asymptotic analysis, when $\bar{\gamma}_D \to \infty$, we have $\ln(1+\bar{\gamma}_D) \approx \ln\bar{\gamma}_D$

$1 - F_{\gamma_D}(x) \approx 1$, and after some mathematical manipulations, we can derive the asymptotic closed-form expression for ESC

Major results

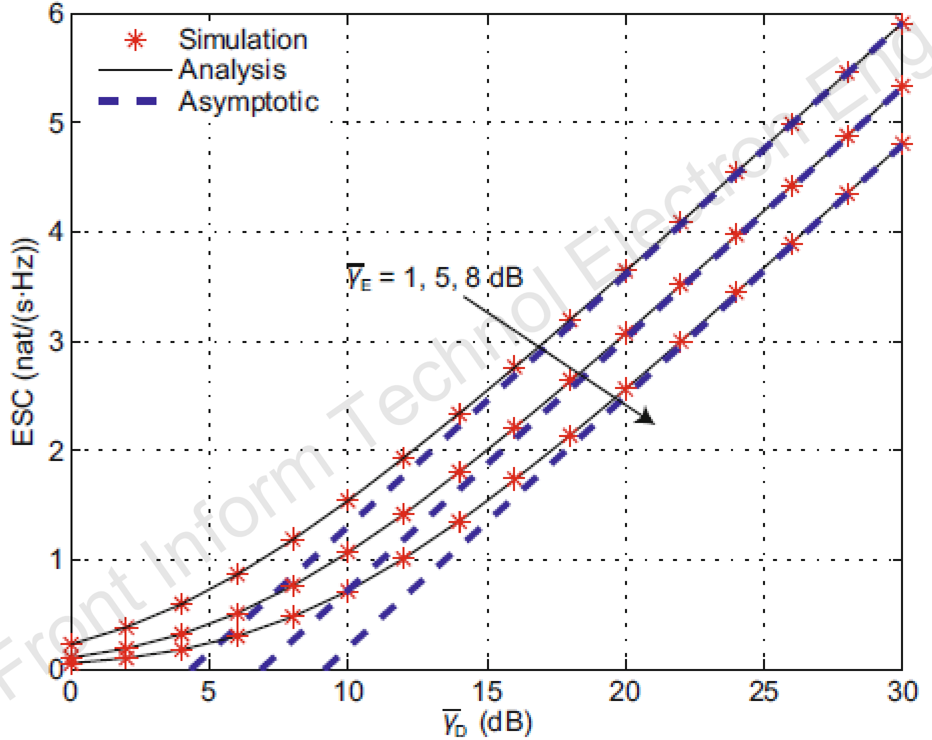

Fig. 1 ESC vs. $\overline{\gamma}_D$ of MRC with weighting errors for $M = N = 2$, and $\rho_D = \rho_E = 0.5$

Major results

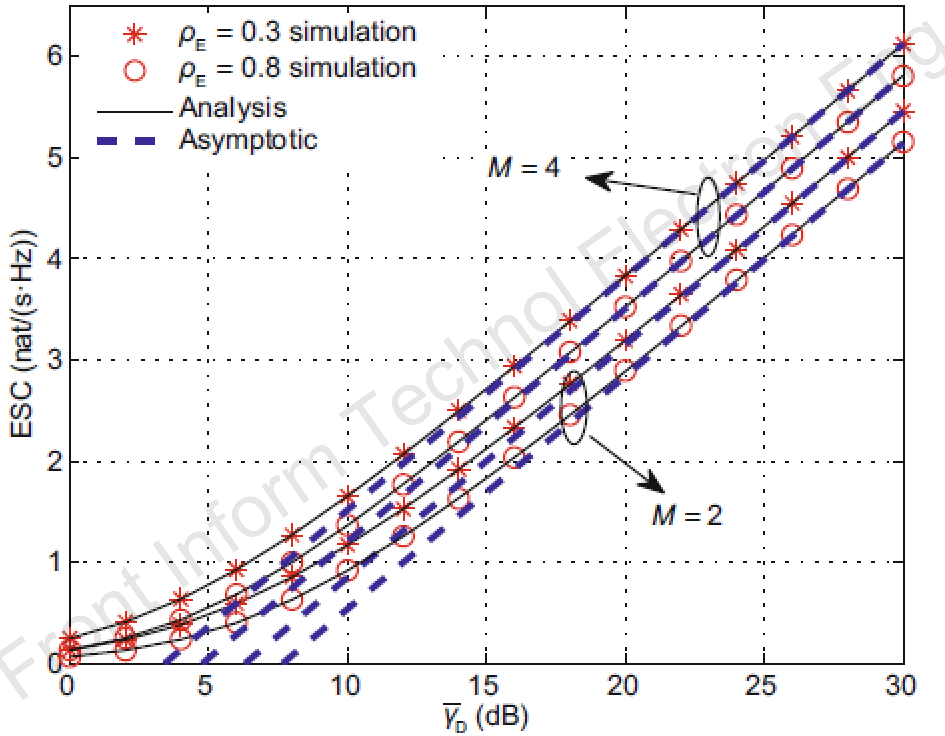

Fig. 2 ESC vs. $\overline{\gamma}_D$ of MRC with weighting errors for $N = 2, \rho_D = 0.5$, and $\overline{\gamma}_E = 5$ dB

Major results

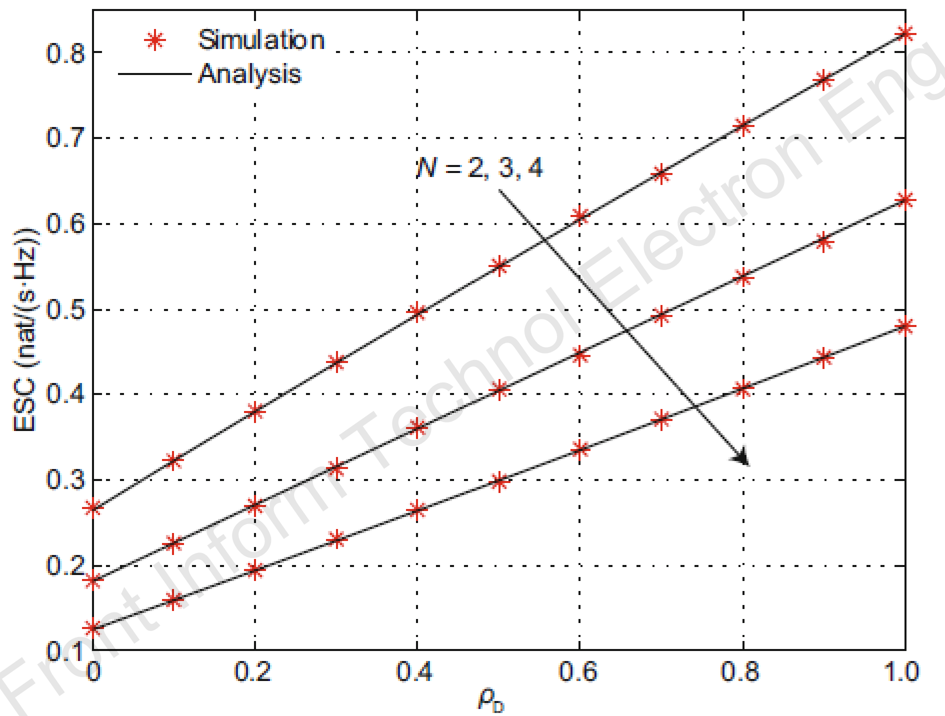

Fig. 3 **ESC vs.** ρ_{D} **of MRC with weighting errors for** $M = 3, \rho_{\mathrm{E}} = 0.5$, **and** $\overline{\gamma}_{\mathrm{D}} = \overline{\gamma}_{\mathrm{E}} = 5$ **dB**

Major results

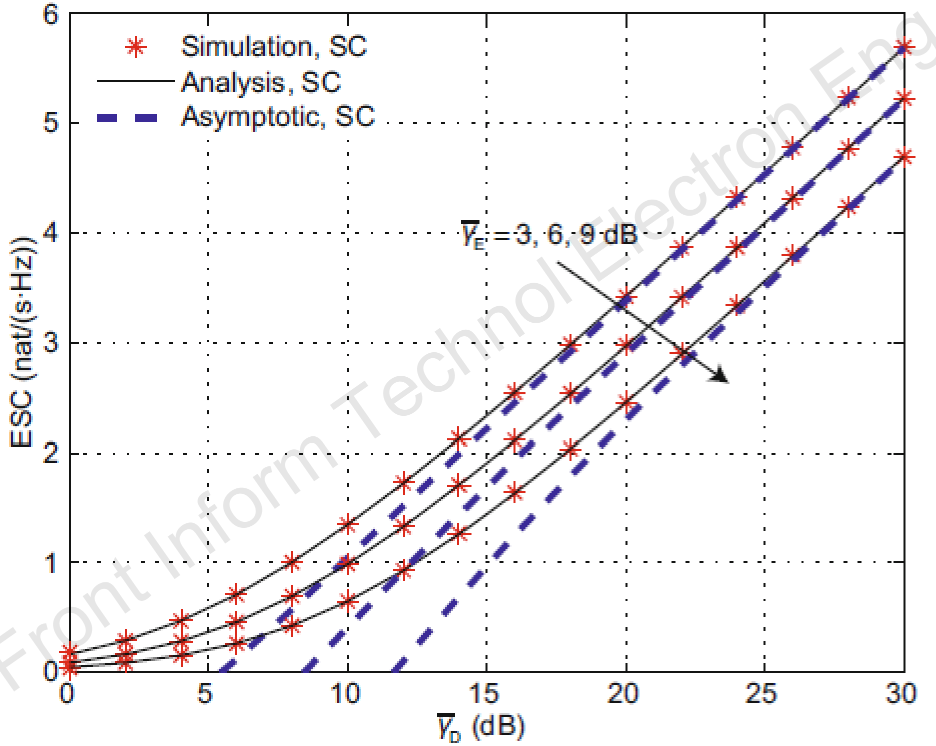

Fig. 4 ESC vs. $\overline{\gamma}_{\mathrm{D}}$ of SC with outdated CSI for $M = 3, N = 2, \rho_{\mathrm{D}} = 0.5, \rho_{\mathrm{E}} = 0.6, N_0 = 1$, and $P_{\mathrm{S}} = 3$ dB

Major results

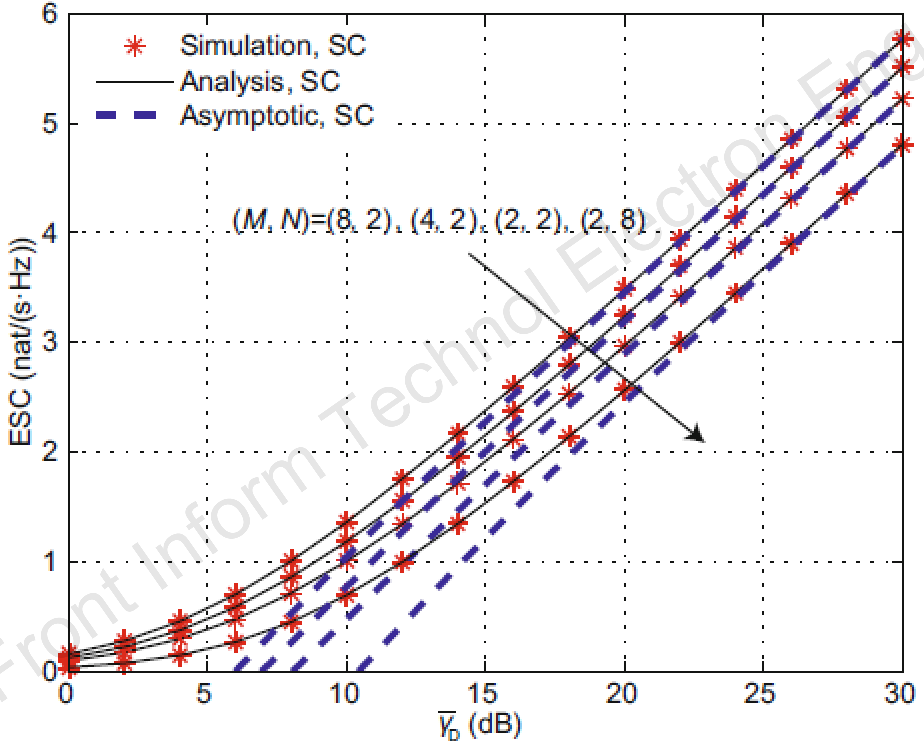

Fig. 5 ESC vs. $\overline{\gamma}_D$ of SC with outdated CSI for $\overline{\gamma}_E = 5$ dB, $\rho_D = 0.5$, $\rho_E = 0.6$, $N_0 = 1$, and $P_S = 3$ dB

Major results

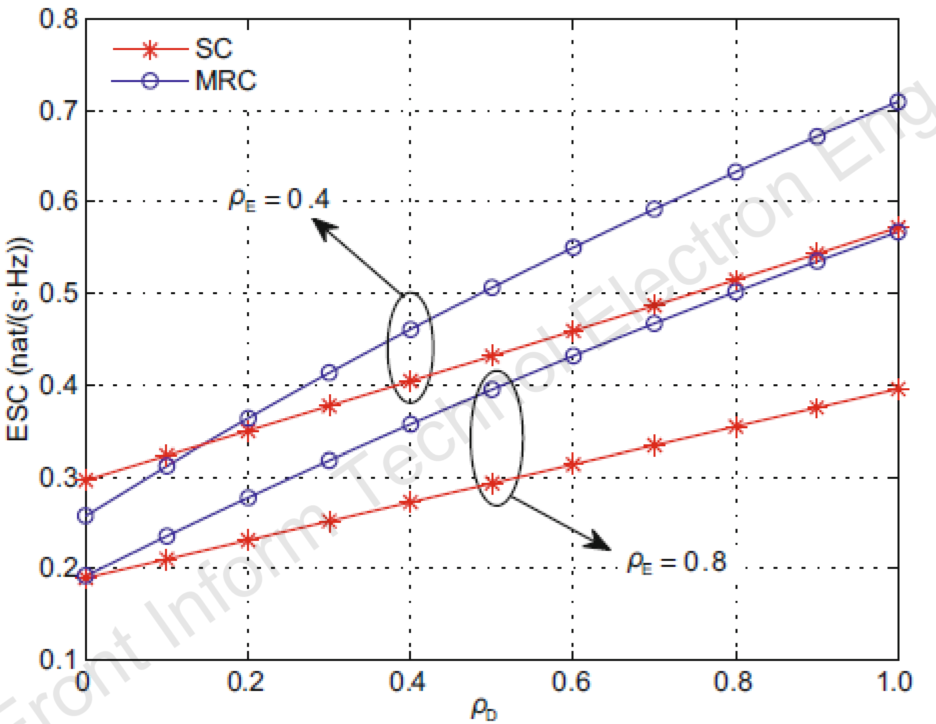

Fig. 6 ESC vs. ρ_D of MRC with weighting errors/SC with outdated CSI for $M = N = 3, \overline{\gamma}_D = \overline{\gamma}_E = 5$ dB, $N_0 = 1$, and $P_S = 1$ dB

Conclusions

- ESC rises with the increase of the number of antennas and the received SNR at the destination, and fades with the increase of those at the eavesdropper. When a flow request comes, the controller simply looks up in its cache for the corresponding rules, without the interaction of applications.
- High SNR slope is constant, which means that high SNR slope is independent of the number of antennas and the received SNR at the destination and the eavesdropper. In contrast, high SNR power offset is correlated with the number of antennas at the destination and the eavesdropper.