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Physical Layer Security for mmWave Drone Links with NOMA

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Abstract

Non-orthogonal multiple access (NOMA) and millimeter-wave (mmWave) transmission are two prominent technologies for 5G wireless networks where unmanned aerial vehicles (UAVs) act as base stations (e.g., temporary events and disasters).

Physical layer (PHY) security plays a key rule in maintaining the confidentiality of the information in 5G networks. In order to improve PHY security, we consider a *protected zone* around the *user region*, which is free from eavesdroppers.

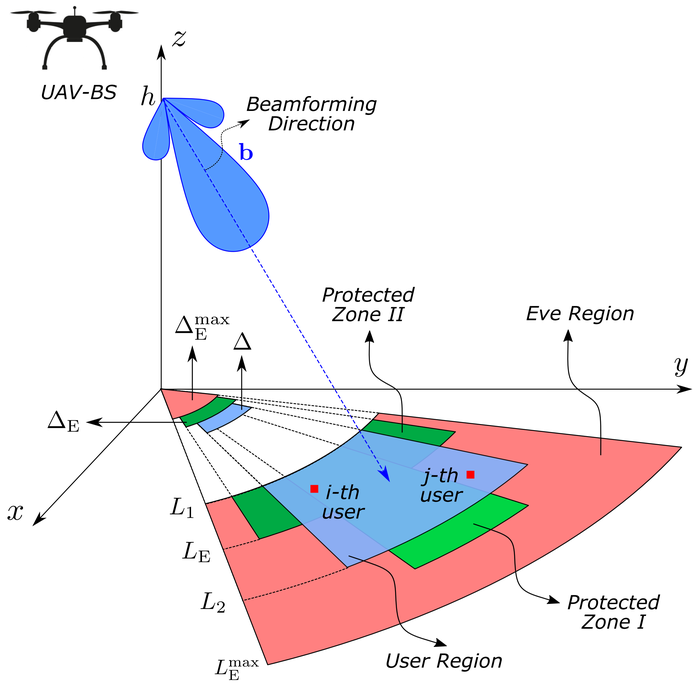

Figure 1: System scenario where NOMA transmission serves multiple users simultaneously in a single downlink beam.

Problem Formulation

Assuming that $\mathrm{R}_k^{\mathrm{NOMA}}$ is rate of the kth user being served by NOMA, and $\mathrm{R}_{k,\mathrm{E}}^{\mathrm{NOMA}}$ is the rate of the respective most detrimental eavesdropper, the secrecy rate is defined as

$$C_k^{\mathrm{NOMA}} = \left[\mathrm{R}_k^{\mathrm{NOMA}} - \mathrm{R}_{k,\mathrm{E}}^{\mathrm{NOMA}}\right]^+,$$

where $[x]^+ = \max\{x, 0\}$.

A secrecy outage event occurs with the probability $\mathrm{P}_k^{\mathrm{o}} = \mathrm{P}\{C_k^{\mathrm{NOMA}} < \overline{\mathrm{R}}_k\}$ with $\overline{\mathrm{R}}_k$ being the respective desired secrecy rate. The outage sum secrecy rate is given as

$$\mathrm{R}^{\mathrm{NOMA}} = \sum_{k=1}^{K} (1 - \mathrm{P}_k^o)\overline{\mathrm{R}}_k. \tag{1}$$

The optimal shape for the protected zone is

$$\Delta_{\mathrm{E}}^*,\ L_{\mathrm{E}}^* = \underset{\Delta_{\mathrm{E}},\, L_{\mathrm{E}}}{\operatorname{argmax}}\ \mathrm{R}^{\mathrm{NOMA}} \tag{2}$$

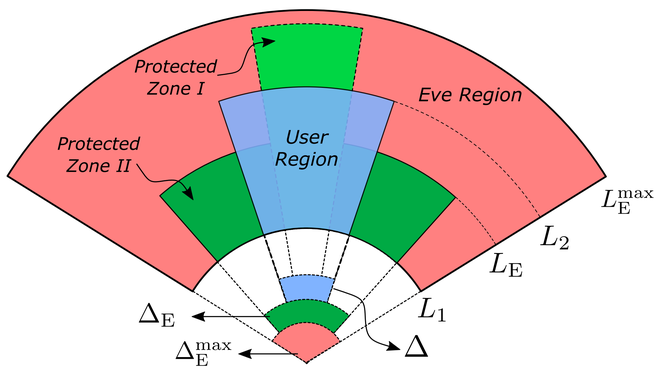

Figure 2: Footprint of *protected zone* represented by angle-distance pair $(\Delta_{\mathrm{E}},\ L_{\mathrm{E}})$, which is free from any eavesdroppers.

Numerical Results

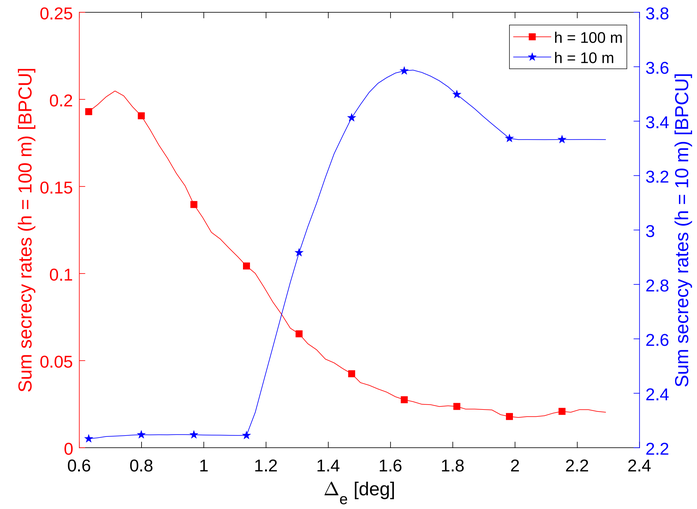

Figure 3: Sum secrecy rates of NOMA along with the protected zone angle (i.e., Δ_{E}) for $h = \{10, 100\}$ m, $q = 0.2$, and $\lambda_{\mathrm{E}} = 0.1$.

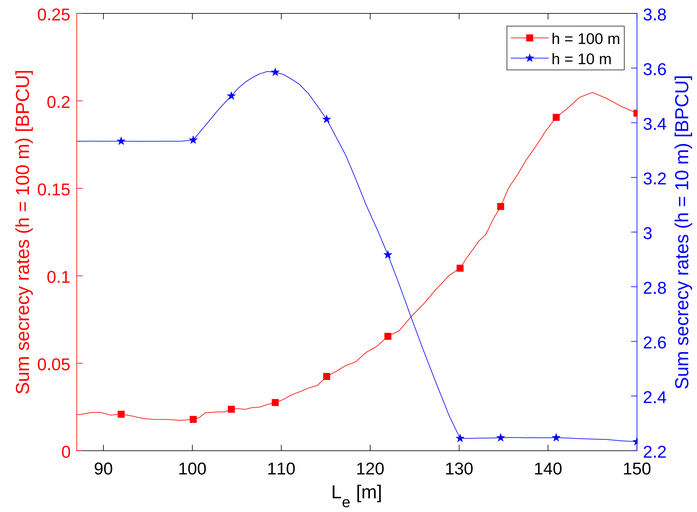

Figure 4: Sum secrecy rates of NOMA along with the protected zone distance (i.e., L_{E}) for $h = \{10, 100\}$ m, $q = 0.2$, and $\lambda_{\mathrm{E}} = 0.1$.