# Physical-Layer Security via Distributed Beamforming in the Presence of Adversaries with Unknown Locations

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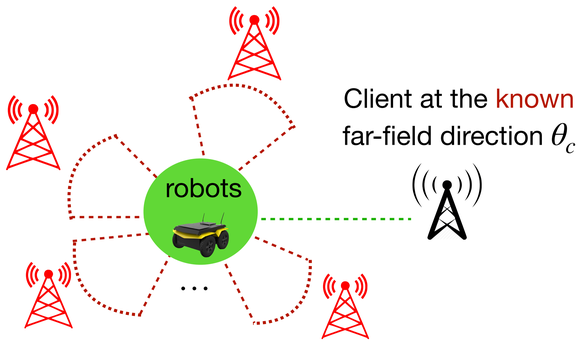
## Motivation

How can a group of robots securely communicate with a client in the presence of multiple adversaries that eavesdrop on the transmission?




Adversary $a_i$ at the unknown far-field direction
Possible directions: $I_i \subseteq [-\pi, \pi)$

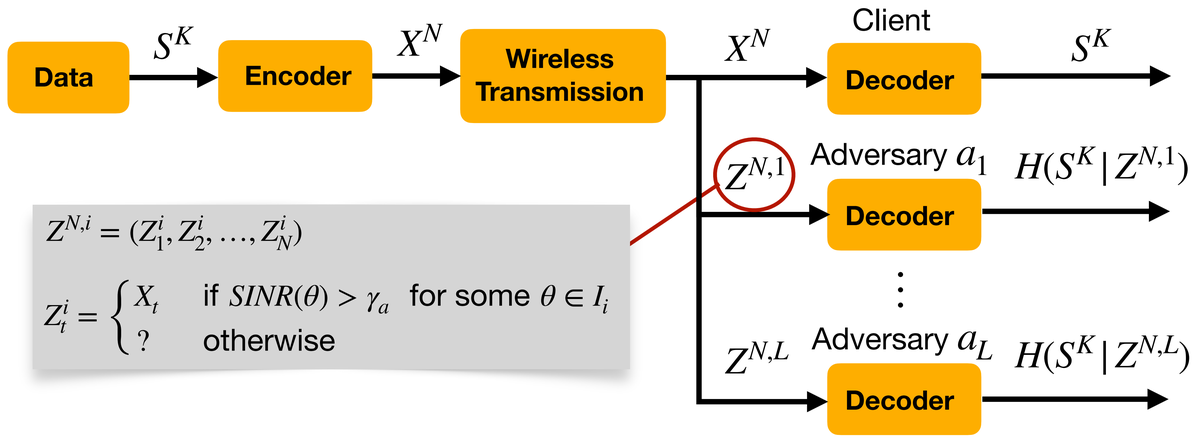
### Key challenges:

- Unknown adversary locations
- Limited individual transmission power

### Assumptions:

- Free space propagation
- $L$ adversaries in the environment
- Communication to far-field region
- Possible adversary directions are expressed by direction intervals

## Problem Statement




$$Z^{N,i} = (Z_1^i, Z_2^i, \ldots, Z_N^i)$$

$$Z_t^i = \begin{cases} X_t & \text{if } SINR(\theta) > \gamma_a \text{ for some } \theta \in I_i \\ ? & \text{otherwise} \end{cases}$$

**Design a transmission strategy such that the client receives the transmitted symbols while we have $H(S^K \mid Z^{N,i}) = K$ for all adversaries**

## Proposed Approach

- Design a periodic transmission strategy such that the client receives all transmitted symbols while each adversary receives at most $K$ symbols
- Linear MDS codes ensure security, i.e., $H(S^K \mid Z^{N,i}) = K$ [Ozarow '84]

Transmit each symbol $X_k$ using the pair $(\mathbf{w}_k, \mathbf{\Sigma}_k)$:

$$\min_{\mathbf{w}_k \in \mathbb{C}^m, \mathbf{\Sigma}_k \succcurlyeq 0} \quad Tr(\mathbf{\Sigma}_k) + \|\mathbf{w}_k\|_2^2$$

$$\text{subject to:} \quad SINR_k(\theta_c) \geq \gamma_c$$

$$\forall \theta \in I_{k \mod L}, \quad SINR_k(\theta) \leq \gamma_a$$

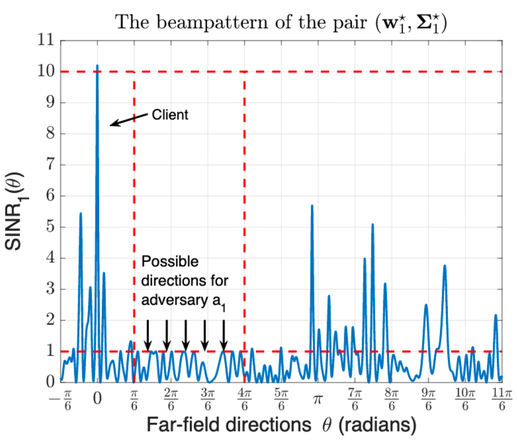
$$\forall i \in [m], \quad \mathbf{w}_k(i) + \mathbf{\Sigma}_k(i,i) \leq P$$

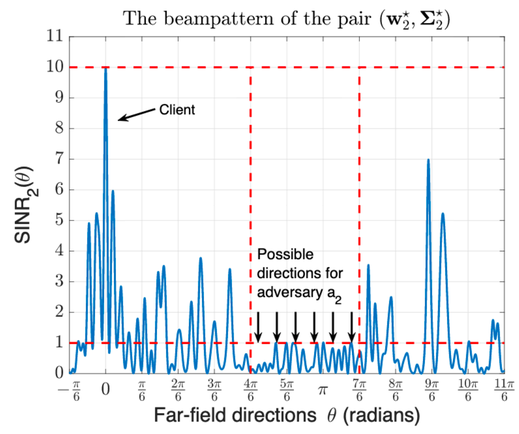
**Semi-infinite non-convex** program!

We present a **finite convex** program whose solution coincides with this program **with probabilistic guarantees**

## Main Contribution

**We ensure security in scenarios in which all existing strategies fail**

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