AerSix: Stochastic Spectrum Coexistence for UAV Networks in 6 GHz Band

Jiangqi Hu, Sabarish Krishna Moorthy, Ankush Harindranath, Zhangyu Guan, and Nicholas Mastronarde
Department of Electrical Engineering, University at Buffalo
Jiangqih@buffalo.edu

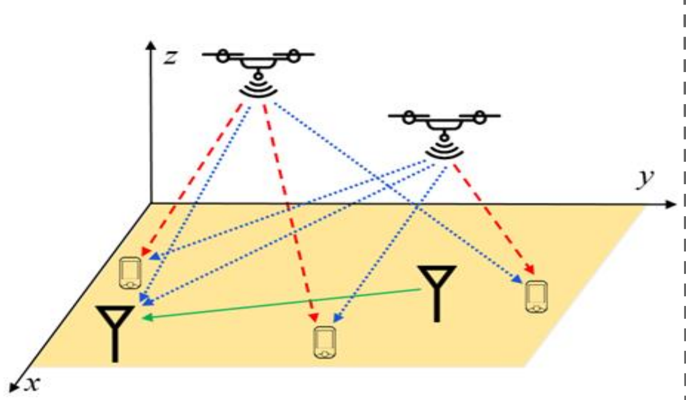
Motivation

- UAVs can enable a wide set of new applications, e.g., surveillance, packet delivery, environment monitoring, among others.
- The wide adoption of UAVs will impose significant burden to the capacity of the underlying wireless networks.
- We explore new approaches to extend UAV operations to 6 GHz band to harvest more spectrum resources.

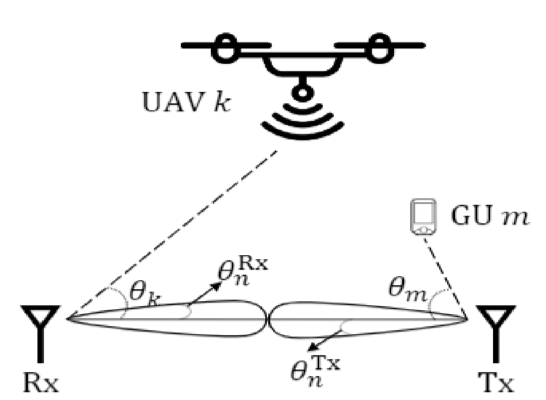
Challenge

- Incumbent systems in 6 GHz band share spectrum on a directionality basis, and carrier sensing can not be used directly because of their low detectability.
- It is hard to model the aggregate interference to the incumbent systems with altitude-dependent channels and high mobility of UAVs.
- It is challenging to track the UAV locations in real time, which are closely coupled with ground users' spectrum access and association strategies.

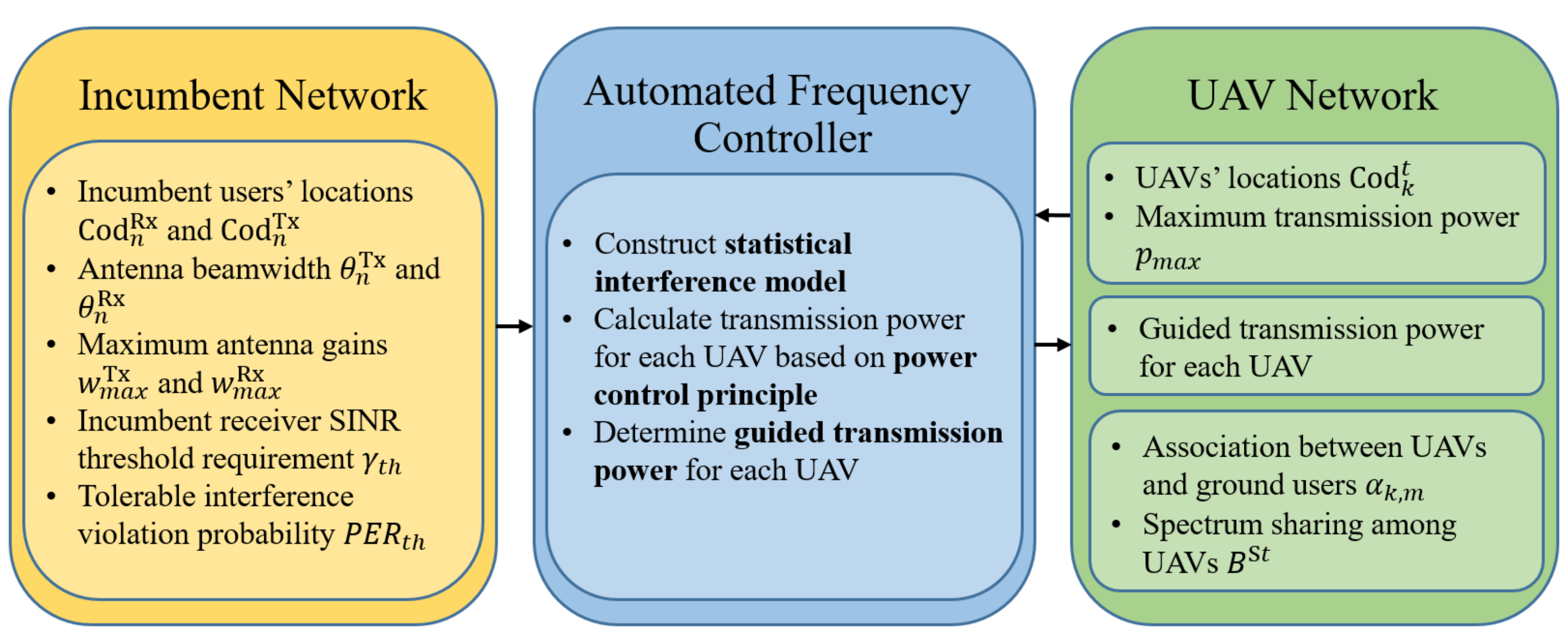
System Model and Coexistence Framework



System Model



Bi-sectorized Directional Antenna Model



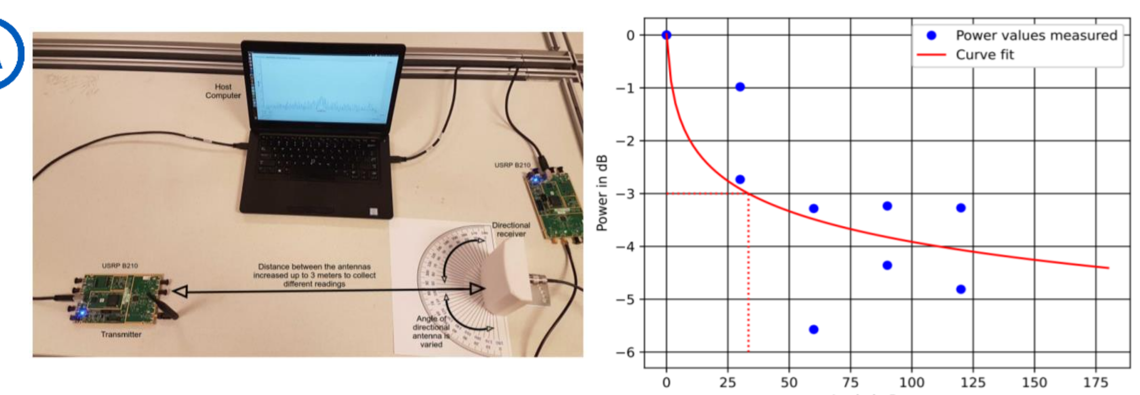
Spectrum Coexistence Framework

- **Statistical interference model:** Gamma distribution is adopted and calibrated by the target violation probability threshold.
- **Power control principle:** Lower transmission power with higher altitude, shorter distance to the incumbent receiver, and smaller angle to the incumbent receiver's boresight axis.
- **Guided transmission power**: Adjust the transmission power for each UAV based on the calibrated statistical interference model.
- **Objective:** Maximize UAV system's throughput by jointly optimizing UAVs' trajectory and their association to ground users, under the interference constraints of the incumbent system.

$$\mathcal{P}1: \max_{\mathbf{A},\mathbf{Q},\mathbf{P}} \quad C$$
$$\text{s.t.} \quad 0 \le p_k^t \le p_{\max}, \forall k \in \mathcal{K}, n \in \mathcal{N},$$
$$\sum_{k=1}^{K} \alpha_{km}^t \le 1, \forall k \in \mathcal{K}, t = 1, 2, \cdots, T,$$
$$\alpha_{km} \in \{0,1\}, \forall k \in \mathcal{K}, m \in \mathcal{M}, t = 1, 2, \cdots, T,$$
$$\Pr(\gamma_n^t \le \gamma_{th}) \le PER^{th}, \forall n \in \mathcal{N},$$

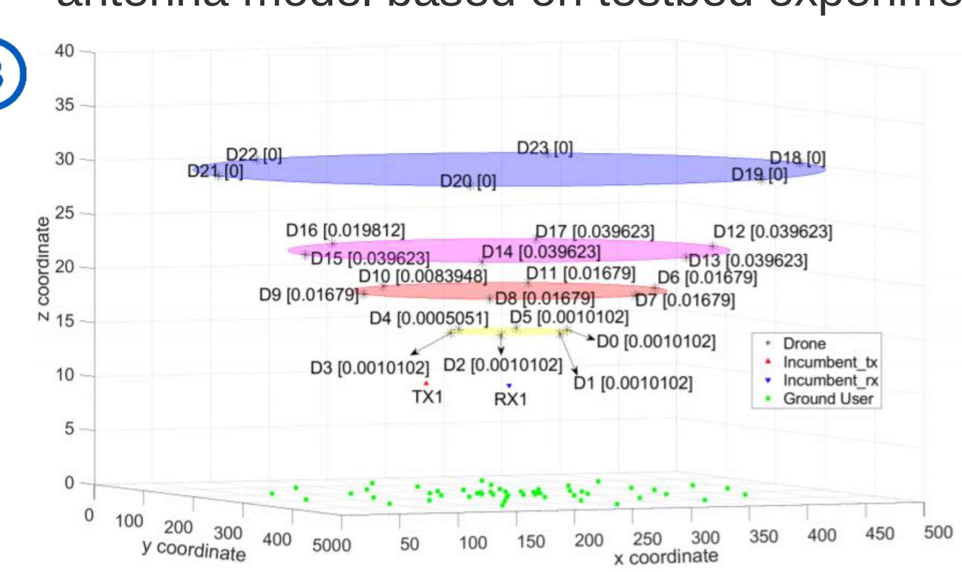
Results

A



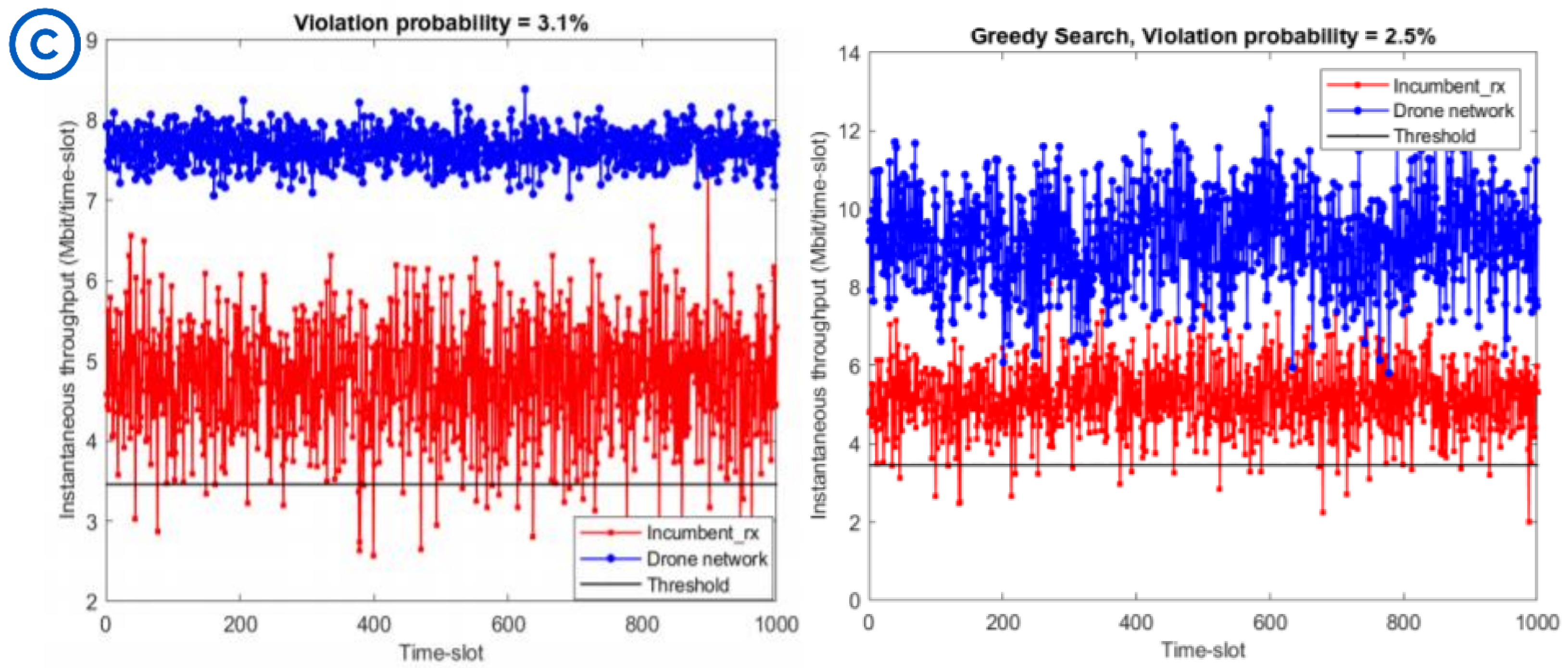
Determine the threshold angle for the directional antenna model based on testbed experiments

B



Validation of the power control principles

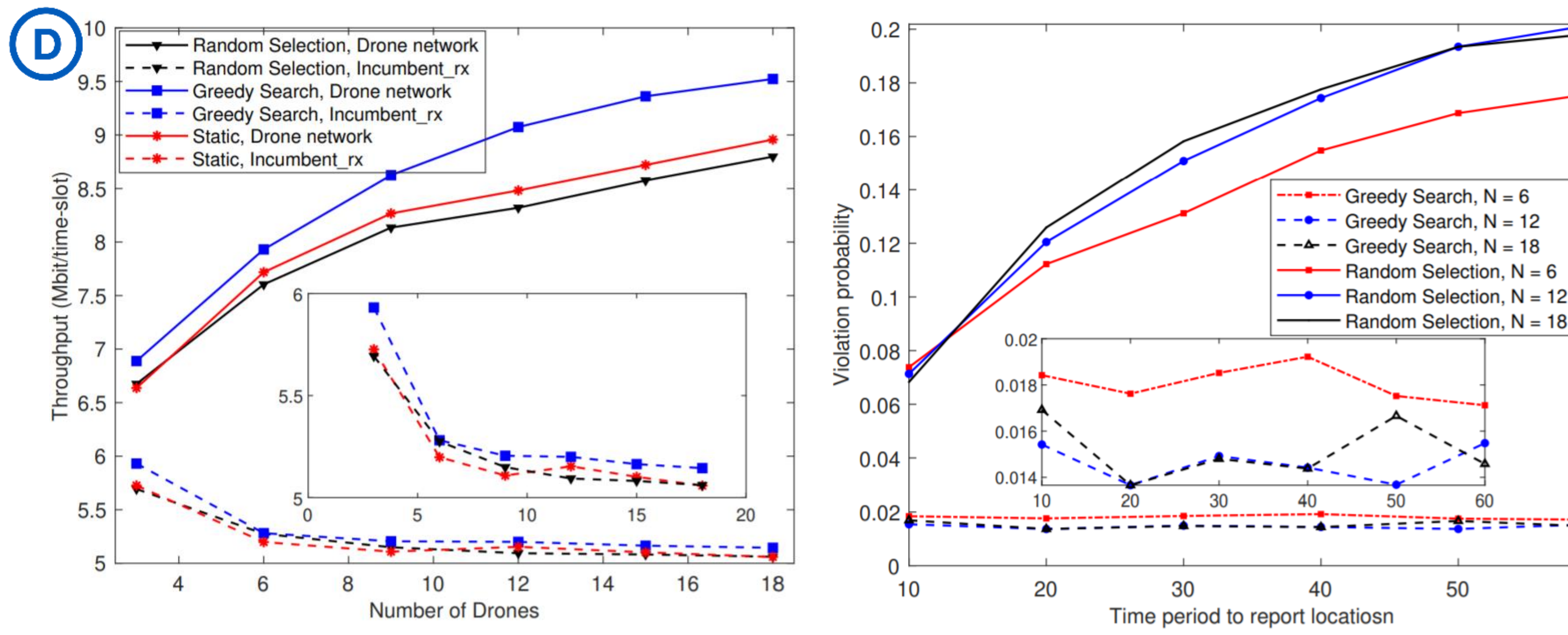
C



(a): Static (N = 6) (b): Dynamic (N = 12)

Case study of power control for coexisting UAV and incumbent systems in the 6 GHz band

D



Average throughput of coexisting UAV and incumbent systems

Average interference constraint violation probability

Conclusion

- Proposed a new framework called AerSix to enable UAV operations in the 6 GHz band
- Formulated the control problem of AerSix with the objective of maximizing UAV throughput under the cross-system interference constraints
- Characterized the aggregate interference based on Gamma distribution model and determine the power for UAVs by calibrating the model
- The effectiveness of AerSix has been validated based on simulations