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SWIFT-SAT: Efficient and On-Demand Spectrum Coexistence for Satellite-Terrestrial Systems

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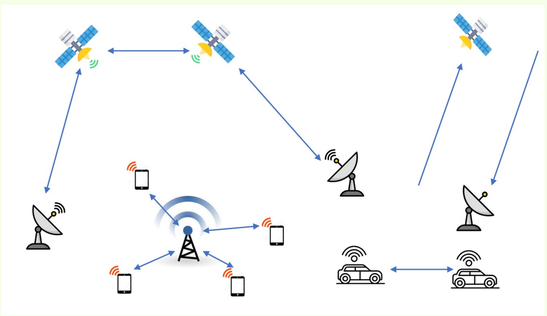
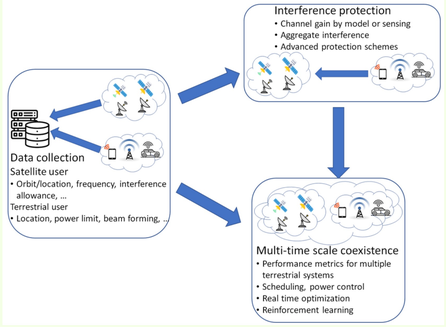
Project Summary

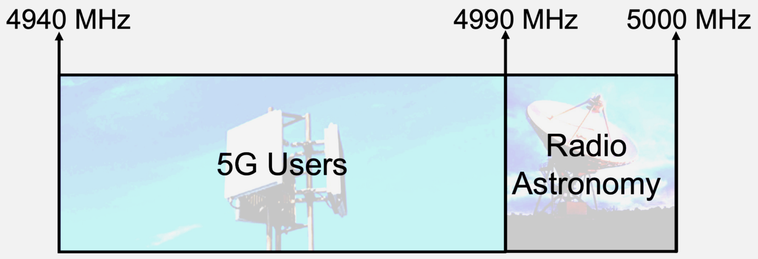


- **Objective**: Design efficient spectrum coexistence schemes for satellite and terrestrial systems.
  - Challenge: **Passive users** in satellite systems are extremely sensitive to interference.
- **Research Thrusts**:
  - Develop a system architecture for data collection, interference protection, and spectrum coexistence.
  - Ensure interference protection for satellite systems.
  - Design a multi-time scale coexistence scheme to support different satellite services.



Introduction

- 4990-5000 MHz band: Used for radio astronomy
  - Very sensitive instruments to detect and analyze the faint radio waves from celestial objects.



- Recently FCC unveiled 4.9 GHz band (4940 – 4990 MHz) for sharing with commercial users
- 4.9 GHz band:
  - For public safety, currently underutilized
  - Band Manager:
    - Frequency coordination between public safety users and 5G users.
    - Protect public safety users from interference.

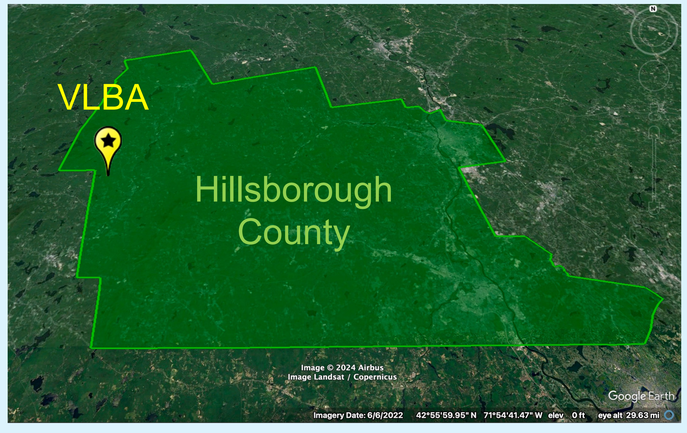
- **Problem**: Commercial 5G users in the public safety band produce **out-of-band interference** to radio astronomy band.

- **Objective:** Manage the out-of-band interference from commercial 5G users in the public safety band to the radio astronomy band.

Approach

- Exploit **power control** to limit out-of-band interference to radio astronomy
- For each active 5G BS, its operating power is within $[P_{min}, P_{max}]$.
- Employ lexicographic order to achieve fairness in power maximization

Case Study:



- 8,547 base stations in Hillsborough County, NH. $P_{min} = 24$ dBm and $P_{max} = 55$ dBm.
- Interference threshold for a Very Large Baseline Array (VLBA): -200 $dB(W/m^2 \cdot Hz)$.
- The size of active BS set is 7,044 and their transmit power is 29 dBm (> P_{min}).
- 82% BS can remain active (vs. completely turn off)

Intellectual Merit

- Determined interference protection requirement and an out-of-band interference model, developed corresponding constraint for the 4.9 GHz band.
- Exploited power control (including turn off completely) at 5G BS to meet the interference protection constraint.
- Developed an optimization problem based on the lexicographic minimization objective and an optimal solution.

Broad Impacts

- Two GRAs involved in this project receive advanced training and gain valuable skills in wireless communications, optimization, machine learning, and spectrum policy.
- Developing teaching materials for ECE courses at Virginia Tech based on research findings.

On-going Tasks/Future Directions

- Enhance system architecture for improved satellite-terrestrial coexistence across diverse scenarios.
- Develop advanced interference mitigation techniques for broader satellite system protection.
- Design more spectrum coexistence schemes for other satellite-terrestrial coexistence scenarios.