Mobility Patterns to Optimize Communication for Distributed Capture Processing Onboard Autonomous UAVs

Sam Jijina, Jun Chen, Zhen Jiang, Ashutosh Dhekne, Hyesoon Kim

Georgia Institute of Technology

Motivation
- Commercial UAV industry is valued at ~$30B in sales in 2021, with a CAGR of 15.5%.
- Increasing use cases of UAVs from mapping for agriculture, to emergency services and national security.
- Communication between multiple UAV agents is becoming a bottleneck.
- Optimizing communication directly affects overall flight range and mission time.
- Different urban environments have different communication challenges.

mmWave
- Millimeter Wave (mmWave) spectrum between 30 GHz and 300 GHz.
- Can be used for both Wi-Fi and 5G.
- High bandwidth
- Limited by short range
- Due to oxygen absorption
- Bandwidth vs. Data Rate
- Channel Capacity (C) is increased as higher bandwidth (B) keeping signal-to-noise ratio constant.

Utilizing mmWave for UAVs
- Two utility configurations
  - Communication
  - Camera
- Two modes of operation
  - Wi-Fi
  - mmWave
- Wi-Fi for long range low throughput
- mmWave for short range high throughput
- Dynamically switch between the two modes on-the-fly
- But when should it switch?

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Envisioned Setting
- Large scale forest fire
- Objectives in to quickly detect and map areas with immediate threat to human life & properties
- 3D map to be used for UAV
- High GPS abatement, current GPS base station
- Area of interest has large flares from single UAV
- Limited bandwidth limits
- Can be extended to any situation where broadband and cloud links are not feasible
- Global rescue, oil spill mapping, missions in mountain range etc.

Experiment Setup
- Distributed CV Processing
  - Single node, TensorFlow inside WiFi, TensorFlow node removed
  - Computer onboard from Raspberry Pi 4 (I) and parameters configured
  - Parameters and logs imported into virtual/real UAVs
  - Openairflow (I)
  - Vbias configured to match each run to simulate different mission characteristics
  - Network monitoring using Wireshark (I) and perf(III)

Virtual-Machine Based Mission Simulation
- Physical Parameters (energy usage, data-rate)
- Optimization Algorithm
- Location Schedule
- Experiment Run Time (s)
- Relative Time (w.r.t. Capture)

Key Contributions & Future Directions
- The key contributions of our work as summarized
  - A novel approach for distributed generation of autonomous agents where control of proximity improves efficiency.
  - A novel approach for distributed autonomous agents that incorporates goals of compute, communicate, and capture of data.
  - Example use cases that demonstrate the proposed algorithm's benefits to various distributed application scenarios.

- Future Directions
  - OCM to end system implementation
  - Variations in Compute Times
  - Real-time Decision making
  - Availability analysis