A Survey of Drone Scheduling Research
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Outline

- Coverage and small cells
- Path planning
- Protocols
- Data collection
- Disaster management applications
- Everything else!

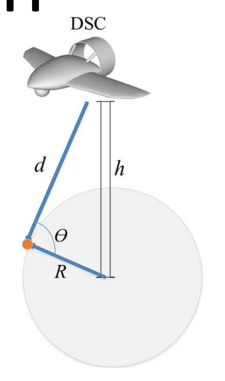
COVERAGE AND SMALL CELLS

The Coverage Problem in UAV Network: A Survey

- Yueyue Chen, Haidong Zhang, Ming Xu, ICCCNT 2014
- Key question: How well can a set of UAVs monitor a given area?
  - Coverage ability
  - Lifetime: limited flight-time of UAVs
  - Connectivity
  - Obstacles
- Coverage: UAVs are mobile
  - Coverage needs to be found in conjunction with a time duration
    - Typical approach: Area decomposition followed by path planning
  - In hover mode: same as sensor network coverage problem
- Deployment: autonomous/user-controlled
- Heterogeneous UAVs with different capabilities

Drone Small Cells: Design, Deployment and Performance Analysis

- Mozaffari, Saad, Bennis, Debbah, 2015
- DSC: aerial wireless BSs mounted on UAVs
- Goal: maximize ground coverage, minimize transmit power
  - Multi-drone setup – interference between DSCs
- Design optimal height and min. separation
  - Greater height: higher LOS probability
    - Lower pathloss with LOS compared to NLOS



$$d = \sqrt{R^2 + h^2}$$

$$\theta = \tan^{-1}(h/R)$$

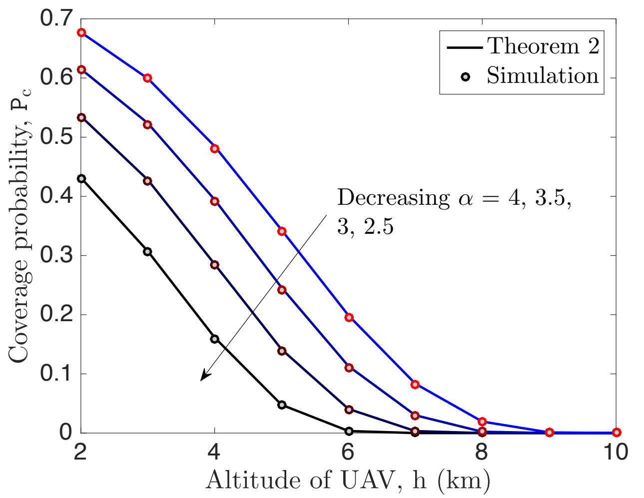
$$L_{\mathrm{LoS}}(dB) = 20\log(\frac{4\pi f_c d}{c}) + \xi_{\mathrm{LoS}},$$

$$L_{\mathrm{NLoS}}(dB) = 20\log(\frac{4\pi f_c d}{c}) + \xi_{\mathrm{NLoS}},$$

$$\mathrm{P(LOS)} = \frac{1}{1 + \alpha\exp(-\beta\left[\frac{180}{\pi}\theta - \alpha\right])},$$

Downlink Coverage Probability in a Finite Network of UAV BSs

- V. V. C. Ravi and H. S. Dhillon, 2016
- Finite network of UAV BSs modeled as a uniform binomial point process
- Derive exact expression for the coverage probability of a target
  - Receiver connects to the nearest UAV
  - Dominant interference from next nearest UAV
  - Derive Laplace transform of the interference and use it to derive the coverage probability
- Take away: Coverage prob. deteriorates with increasing height of UAVs when the area over which the UAVs are distributed is kept constant



Network Connectivity and Area Coverage for UAV Fleet Mobility Model with Energy Constraints

- M-A. Messous,S-M. Senouci,H. Sedjelmaci, WCNC 2016
- Distributed mobility model for autonomous interconnected UAVs for area exploration
  - Goal: Explore area while maintaining connectivity
- Online approach: UAVs exchange their current energy levels and decide on the next move
- More of a protocol-type study
- Metrics: Global coverage (% area covered in a given amount of time), Coverage evolution (how the % coverage evolves over time), Coverage fairness, Number of UAVs connected to the BS directly

The New Frontier in RAN Heterogeneity: Multi-Tier Drone-Cells

- I. Bor-Yaliniz and H. Yanikomergolu, Comm Mag. Nov. 2016
- Multiple tiers similar to terrestrial hetnets but with the advantage of mobility of drones
  - Addresses sporadic nature of “hotspots”
  - Rethinking required: in conventional cellular networks, BS locs are fixed, but drone BSs are mobile
- Propose a drone cell management framework
  - Reduce the cost of utilizing drone-cells
  - 3D placement of drone BSs

PATH PLANNING

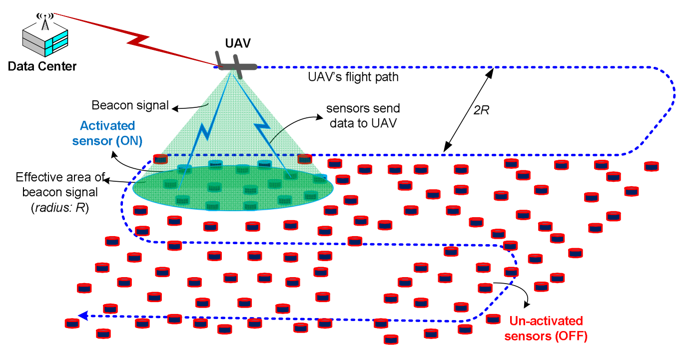
Path Planning Papers

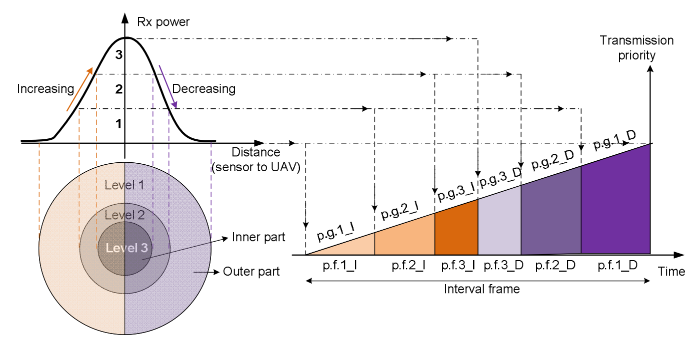
- C. Xiao-Dong, Z. De-Yun, Z. Ruo-Nan, “New Method for UAV Online Path Planning,” 2013
  - Across 3D terrain with obstacles
  - Proposed: List expanding algorithm
- N. Wen, X. Su, P. Ma, L. Zhao, “Online Creating an Improved UAV Path in Complex and Hostile Environments,” ICIMCCC, 2015
- H. Chen, H. Wang, L. Jiang, ”Path Planning of UAV Based on Cultural Algorithm in Dynamic Environments,” 2016
- Y. Zeng, R. Zhang, “Energy-Efficient UAV Communication with Trajectory Optimization,” TWC Jun. 2017
  - UAV flies horizontally at a fixed altitude
  - Optimize UAV’s trajectory w.r.t. throughput and energy consumption
  - Solution uses linear state-space approximation and sequential convex optimization techniques

PROTOCOLS

Papers on Protocols for Drones

- Power and Performance Tradeoff of MAC Protocol for Wireless Sensor Network Employing UAV





- Multiple-UAV Coordination and Communications in Tactical Edge Networks

More on Protocols

- MAC Performance Improvement in UAV Ad-Hoc Networks with Full-Duplex Radios and Multi-Packet Reception Capability
- A Green Strategic Activity Scheduling for UAV Networks: A Sub-Modular Game Perspective
- Optimal Resource Allocation for Packet Delay Minimization in Multi-Layer UAV Networks
- Cyclical Multiple Access in UAV-Aided Communications: A Throughput-Delay Tradeoff
- Throughput Maximization for UAV-Enabled Mobile Relaying Systems
- Enabling UAV Cellular with Millimeter-Wave Communication: Potentials and Approaches

Data Collection Papers

- Effective Data Gathering and Energy Efficient Communication Protocol in Wireless Sensor Networks employing UAV (WCNC 2014)
- Evaluation of Compressive Sensing encoding on AR Drone (AISPA 2015)

Disaster Management Papers

- UAV-Assisted Disaster Management: Applications and Open Issues (2016)
- Emergency Ad-Hoc Networks by Using Drone Mounted Base Stations for a Disaster Scenario (2016)

Other Papers

- Emergency Ad-Hoc Networks by Using Drone Mounted Base Stations for a Disaster Scenario (JSAC 2017)
- Effects of Heterogeneous Mobility on D2D- and Drone-Assisted Mission-Critical MTC in 5G (Comm. Mag. 2017)
- UAV-Based IoT Platform: A Crowd Surveillance Use Case (Comm. Mag. 2017)
- Energy Management in Cellular HetNets Assisted by Solar Powered Drone Small Cells (2017)
- Mobile cloud computing with a UAV-mounted cloudlet: optimal bit allocation for communication and computation (IET 2017)

Problem Statements

- Golf course: ball retrieval
- Pizza delivery problem
- First responder assistance