CSE 400

HANDOVER PROBABILITY ANALYSIS IN DRONE CELLULAR NETWORKS

Representing connection transitions in a dynamically changing wireless communication environment with stochastic geometry.

Group: s1_g14_net

PROJECT OBJECTIVE AND SCOPE

Examination of the risk of connection switching across a given temporal window and connection mobility model.

Exact Objective: Analytically characterize the handover probability within a specific time window.

Estimation Goal: Calculate probability that the first handover occurs at or before time t (PH(t)).

Same Speed Model (SSM): Scenario where all drones move at the same speed.

Different Speed Model (DSM): Drones move at different speeds based on a random distribution.

PROJECT SYSTEM OVERVIEW

An end-to-end mathematical framework from spatial distribution to handover calculation

1

DBS Plane Distribution

Spatial distribution of drones deployed at a constant height h.

2

Ground Plane User

User Equipment (UE) located at the origin for connectivity assessment.

3

Association Policy

Nearest-neighbour policy where UE connects to the closest available drone.

4

Mobility Displacement

Applying time t displacement to initial drone locations based on velocity vectors.

5

Handover Event

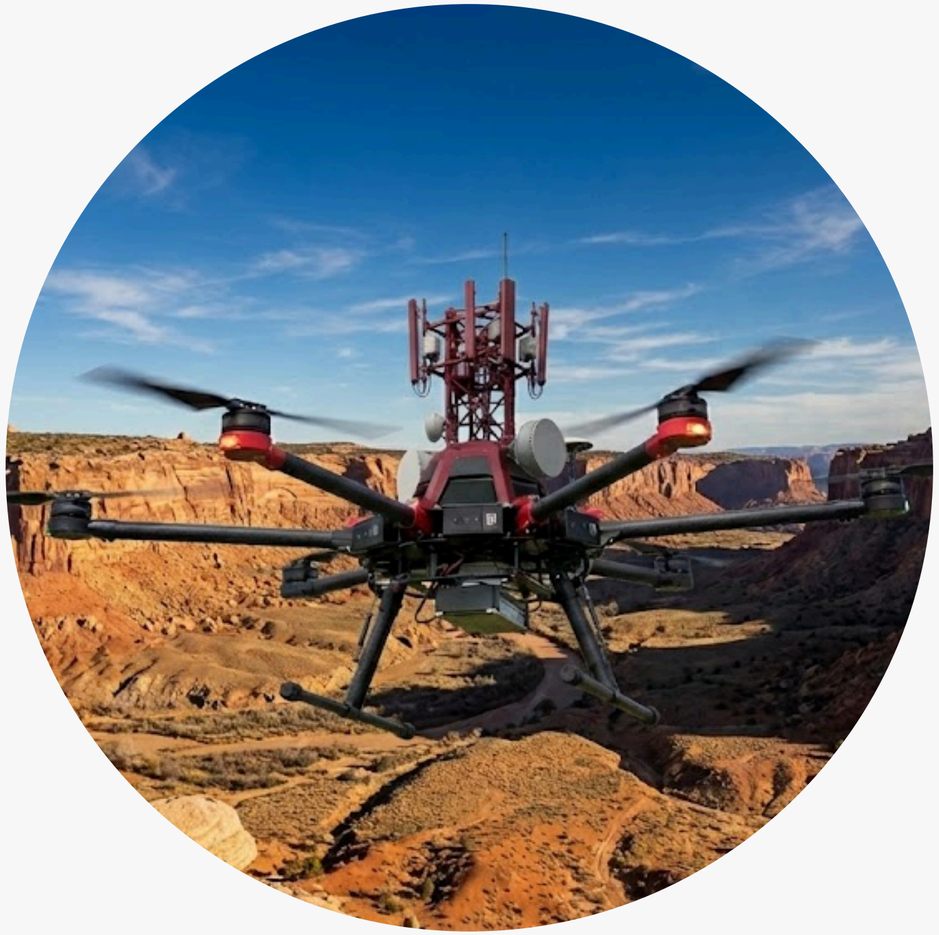
Distance check calculation to determine if the serving station transition occurs.

SOURCES OF UNCERTAINTY IN THE PROJECT

01 Spatial Uncertainty: Positions of initial DBS are randomly distributed as a homogeneous Poisson Point Process (PPP).

02 Direction Uncertainty: Each drone moves in a uniformly random direction independent of others.

03 Speed Uncertainty (DSM): Speed is a random variable, such as Rayleigh or Uniform distributed.



KEY RANDOM VARIABLES AND THEIR ROLES

Variable	Definition And Functional Role
$\Phi_D(0)$	Set of locations of all drones at time t (Point Process)
V (or v)	Speed random variable in the Different Speed Model (DSM)
θ	Random variable Theta representing movement angle
$x^*(t)$	Speed random variable in the Different Speed Model (DSM)

PROBABILISTIC MODELS AND ASSUMPTIONS

01 Deployment: Initial DBS setup uses a Homogeneous Poisson Point Process (PPP) with density lambda λ.

02 Mobility: Drones move along straight lines, standard in 3GPP studies for drone networks.

03 Independence: Direction and speed of each drone are independent of other drones.

Standardizing the analytical approach using 3GPP-inspired drone network benchmarks

PROBABILISTIC MODELS AND ASSUMPTIONS

Exploring the duality between mobile swarms and static network equivalents

1 **SSM Reasoning Pathway**

Mobile drone swarms with identical speeds are statistically equivalent to a static network seen by a mobile user.

2 **DSM Reasoning Pathway**

Variable speeds create an inhomogeneous process, requiring 'void probability' calculations for lower bounds.

3 **Propagation of Uncertainty**

The Displacement Theorem ensures the network remains a PPP at any instant t despite independent movement.

OPERATIONALIZING PROBABILISTIC REASONING IN THE PROJECT

Validating theoretical formulas with Monte Carlo simulation datasets

01 Initial DBS Density

1 Simulation set to 1 DBS per square kilometer (DBS/km^2)

02 Movement Speed

45 Drone base stations traveling at 45 kilometres per hour (km/h)

03 Primary Metric

PH(t) Handover Probability versus Time evaluated against derived integrals

CURRENT LIMITATIONS AND GAPS

Identifying constraints in mobility modeling and signal variation assumptions

01 **Mobility Simplicity:** Current model does not account for drones turning, hovering, or looping.

02 **Metric Limitation**: Characteristics currently focus on probability rather than handover frequency (rate).

03 **Assumption Sensitivity:** Analysis ignores signal strength variations due to **fading or shadowing.**

PLANNED REFINEMENTS

Model Extension: Support sophisticated patterns like Random Waypoint or Cyclical Mobility.

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Support sophisticated patterns like Random Waypoint or Cyclical Mobility

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02 **Analytical Goals:**

Deriving the exact handover rate for the Different Speed Model (DSM).

03 **Role Coordination:**

Reviewing code to ensure exclusion zones match theoretical void arguments.

SUMMARY OF GROUP-LEVEL UNDERSTANDING

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Establishing equivalence for uniform speed networks and identifying DSM trends. Introducing variable speeds breaks equivalence and lowers handover probability as the network evolves.