MIT Supply Chain MANAGEMENT
MIT MEGACITY LOGISTICS LAB
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Drones for Last-Mile Delivery

MIT GLOBAL SCALE NETWORK
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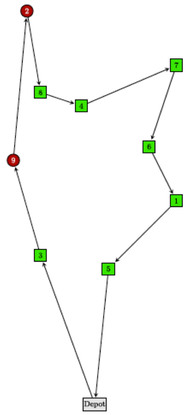
Motivation / Background

Background:

- Global parcel delivery market valued at $82 bn and expected to double in next decade (McKinsey, 2016).
- Last mile makes up greater than 50 percent of market costs.

Immediate benefits with drones:

1. Significantly cut variable costs by cutting fuel and labor.
2. Faster delivery of products due to higher travel speeds.



(a) An optimal truck delivery sequence, without the aid of a UAV.

Key Question / Hypothesis

Under what conditions will the integration of drones into last-mile delivery make sense?

Relevant Literature

2015 – Murray and Chu, The flying sidekick traveling salesman problem: Optimization of drone-assisted parcel delivery. *Transportation Research Part C: Emerging Technologies*, 54:86-109.

2016 – McKinsey & Company, Parcel Delivery: The Future of Last Mile.

The Problem

Physical Limitations	Operational Strategy	Government Regulation
Drones have a max payload of 5 lbs and limited range of 10 mi.	A complete solution defining drone delivery execution has not been fully developed.	Current laws in US require line of sight and 400 ft ceiling.

Methodology

- Vehicle Routing Problem
- Mixed Integer Linear Programming
- Approximate Solutions with Heuristics

Initial Results

Objective Function:

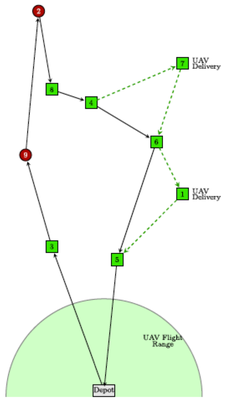
Min Cost =

$$\underbrace{\sum_{i}^{N}\sum_{j}^{N} x_{ij} t_{ij}\, c_t}_{\text{Truck}} + \underbrace{\sum_{i}^{N}\sum_{j}^{N}\sum_{k}^{N}\sum_{n}^{D} y_{ijkn}\, c_d \left(t_{ij}^{d} + t_{jk}^{d}\right)}_{\text{Drone}} + \underbrace{\sum_{n}^{D} C_n z_n}_{\text{Drone Deploy}}$$

Variables:

x_{ij}, y_{ijkn}, z_n = Binary Decision Variables
$t_{ij}, t_{ij}^{d}, t_{jk}^{d}$ = Travel Time
c_t, c_d = Variable Cost
C_n = Fixed Cost per Drone Dispatch

Expected Contribution



(b) The UAV is launched from a delivery truck, delivering parcels to two eligible customers.

Develop algorithms to:

1. Model and optimize drone operations as a function of cost.
2. Model multi-drone deployment.
3. Solve problems more efficiently with heuristic.

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