Semester project: Optimizing drone delivery with bus network

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Introduction

Drones can be used to deliver packages in an urban environment. To overcome the coverage limitation imposed by their battery life, drones may ride on buses for a segment of their journey to conserve energy. The objective of this project is to develop an optimization framework where drones ride on buses with predefined stops and schedules in order to minimize the total flying distance, and compare the service level with a scenario where drones do not ride on buses.

Experience with Python is necessary. Knowledge on classical Vehicle Routing Problems and related problems is an asset, but not mandatory. The student(s) will get a chance to learn about Pick-Up and Delivery Problems and related optimization tools in Python.

Task

Given a fleet of drones, a list of pick-up and drop-off locations, and a list of bus stops with regular bus service, plan the order of drone operations so that all orders are delivered with the shortest total drone flight path possible.

Problem description

Map

The problem takes place on a 2-D network with nodes and arcs. The drones can fly over all areas within the network, while buses operate along arcs in the network.

Nodes

Static situation: all pick-up and drop-off node pairs known beforehand.

Depot: predefined depot location for drone initial and final location, plus battery replacement.

Drones

Each drone initially starts at the depot. A drone has a capacity of 1 package. Its flight range is limited by its battery life, so the drone must return to the depot for battery replacement. The drone uses the shortest path to fly from one cell to another. Given that drones can fly at different altitudes, we assume that they never collide.

Buses

Buses run along predefined arcs with fixed stops at regular headways. Drones can only board at bus stops. They can leave the bus at any time. Only one drone can be aboard a bus at any time.

Commands

You can give the drones the following commands:

- fly to a pick-up node
- fly to a drop-off node
- fly to a depot
- fly to a bus stop
- ride on a bus until a specific location along bus arc
- wait at a specific location

Results

The objective is to minimize the total length of flight paths for all the drones, satisfying operational constraints.

Benchmark: Vehicle Routing Problem with drones, without bus network, for the same set of pick-up and delivery nodes.