Algorithms and Heuristics for Remote Food Delivery under Social Distancing Constraints

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Project Focus

The COVID19 Pandemic created unique food insecurity problems

- School closings deprived children of meals they depend on
- Food pantries face similar challenges reaching seniors that have been isolated

Objectives:

- Formulate and solve the meal delivery problems created by these unique circumstances
- Work with local partners to transition solutions into practice
- Provide benchmark problems and results to research community

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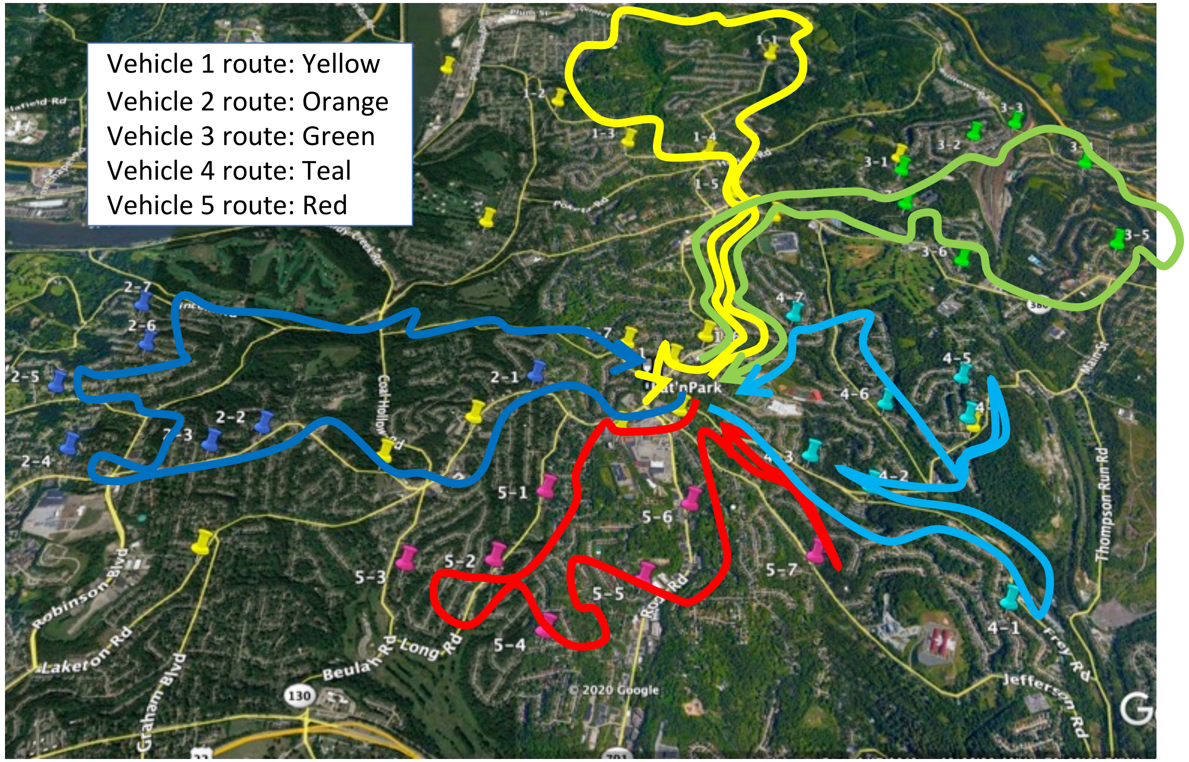
Initial Pilot Study:
Penn Hills Summer Meal Delivery

Goal: A set of vehicle routes that maximize the number of student meals delivered.



Data Sources:

- Anonymized home locations
- Set of current school bus stops

Constraints:

- Maximum walking distance to stop
- % students within walking distance expected to pickup meals
- Minimum/Maximum constraints on number of students per stop
- Fixed delivery window and vehicle fleet

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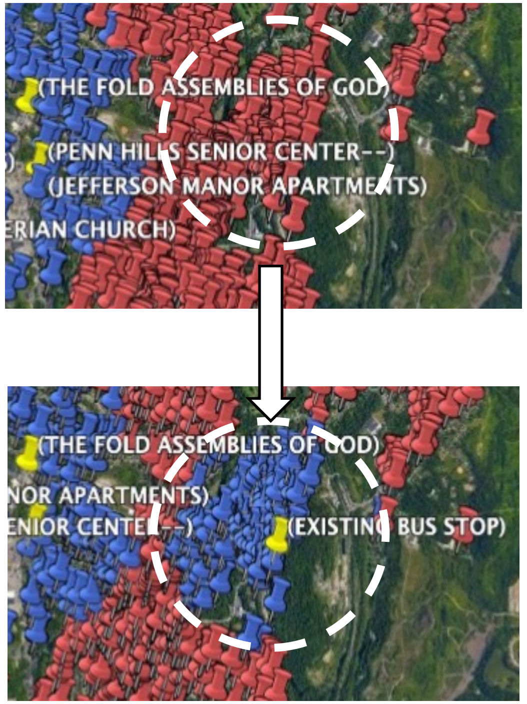
Solution Approach

1. Determine set of delivery stops

Blue pins: "served students"; **Red pins:** "unserved"
Yellow pins: Stops



2. Generate vehicle routes

Variable	Definition
S	the set of delivery stops to be covered; $\|S\| = s$
V	the set of delivery vehicles; $\|V\| = v$
$Meals_k, k = 1, ..., s$	the number of meals required at delivery stop k
$TDur_{a,b},\ a, b \in S$	travel time from delivery stop a to delivery stop b
$SDur$	the fixed duration of any delivery stop
$VehicleCap_i, i = 1, ..., v$	the maximum number of meals that vehicle i can carry
est	the earliest time that delivery can start at a given stop
lft	the latest time that delivery can finish at a given stop
$Assigned_{i,k}, i = 1, ..., s; k = 1, ..., v$	1 if vehicle i has stop k in its itinerary; Otherwise 0
$Succ_k, k = 1, ..., s$	the next stop after k in the route k has been assigned to
$Start_k, k = 1, ..., s$	the (earliest) start time of stop k in its route
$End_k, k = 1, ..., s$	the (latest) end time of stop k in its route

$$\max_{i,k} \left(\sum_{i=1}^{v}\sum_{k=1}^{s} Assigned_{i,k} \times Meals_k\right)$$

Subject to:

$$\forall i \in V \left(\sum_{k=1}^{s} Assigned_{i,k} \times Meals_k \leq VehicleCap_i\right) \quad (1)$$

$$\forall k \in S \left(\sum_{i=1}^{v} Assigned_{i,k} \leq 1\right) \quad (2)$$

$$\forall i \in V \left(\sum_{j=1}^{s-1}\sum_{k=j}^{s} Assigned_{i,j} \times Assigned_{i,k} \Rightarrow (End_j < Start_k \vee End_k < Start_j\right) \quad (3)$$

$$\forall i \in V \left(\sum_{k=1}^{s} Assigned_{i,k} \times (SDur + \sum_{k=1}^{s} Assigned_{i,Succ_k} \times TDur_{k,Succ_k})\right) \leq (lft - est + 1) \quad (4)$$

$$\forall k \in S \left(\sum_{i=1}^{v} Assigned_{i,k} = 1\right) \Rightarrow (Start_k \geq est) \quad (5)$$

$$\forall k \in S \left(\sum_{i=1}^{v} Assigned_{i,k} = 1\right) \Rightarrow (End_k \leq lft) \quad (6)$$

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Implementation

- Community partners
  - *Allies for Children* – school data collection, marketing and project management
  - *ACCESS Transportation* – delivery vehicles (funded by United Way)
  - *Eat 'n Park* – preparation of meals
- Some iteration on routes to enhance safety and respond to observed trends

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Project Impact

July 1, 2020 start Penn Hills

Nearly 6,000 meals are delivered monthly

October 28, 2020 start McKeesport

Over 1,000 meals are delivered monthly

December 1, 2020 start Sto-Rox

Nearly 1,600 meals are delivered monthly

Over 50,000 meals delivered

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