Optimizing Fair Allocation in Food Rescue

Mason duBoef & Paula Navarrete Diaz

Rachel’s Table (RT)

- Volunteer-ran food rescue
- Take from ~100 food donors
  - E.g. grocery stores, restaurants, farms
- Deliver to 66 receiving agencies
  - E.g. food pantries
- 50k meals per month in Western MA

Rachel's TABLE

!

WHOLE FOODS MARKET

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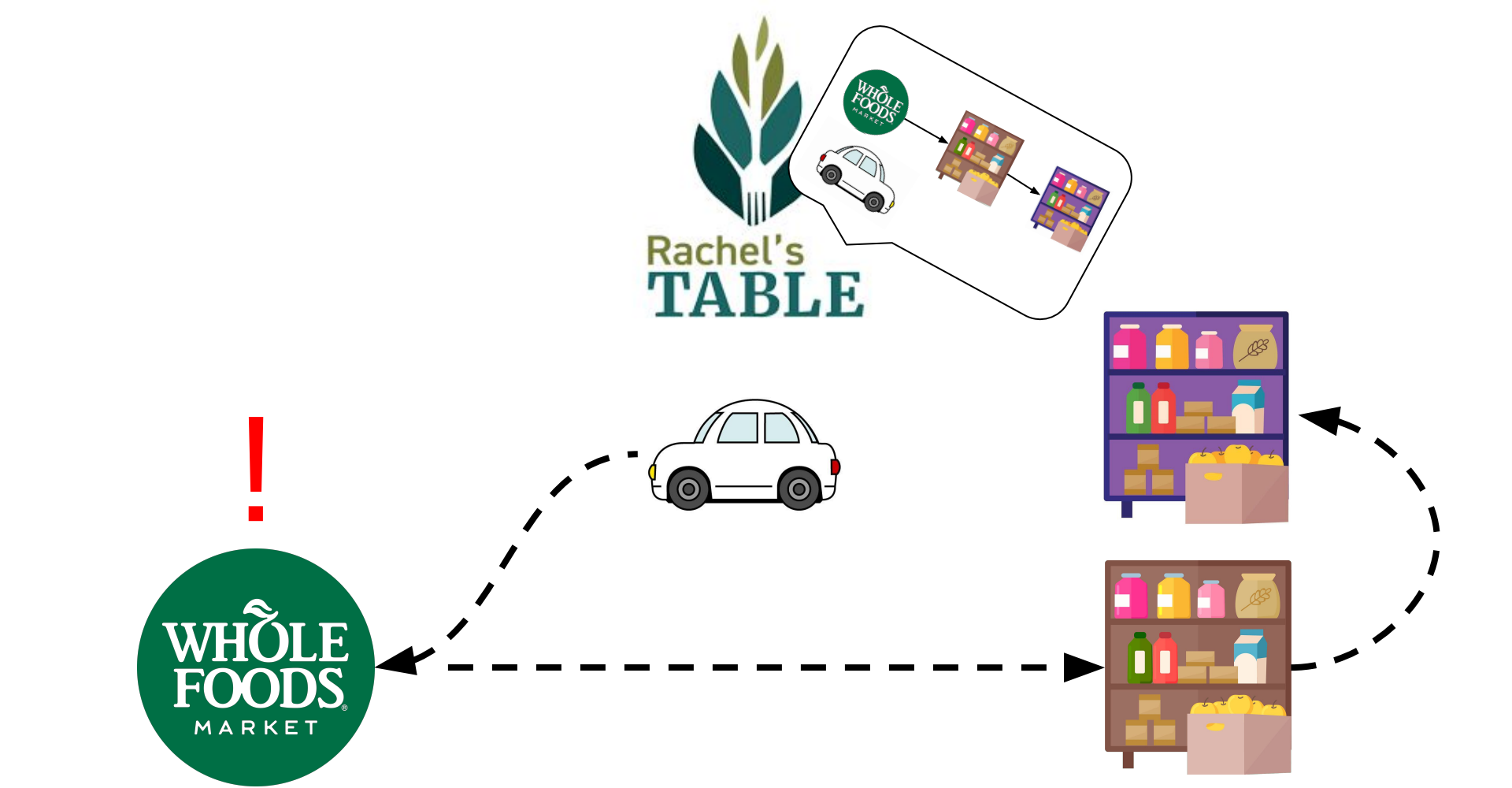
Rachel's
TABLE
!
WHOLE FOODS MARKET

(FBWM)

Donors

Receiving Agencies

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WHOLE FOODS MARKET

FBWM

How well-served are agencies?

? patrons/wk

? patrons/wk

How well-served are agencies?

? patrons/wk

10 meals served/wk

? patrons/wk

50 meals served/wk

How well-served are agencies?

MD_i : Avg number of meals allocated to agency i by RT per week
MS_i : Avg number of meals served by i per week

$$\mathrm{MDMS}_i = \frac{\mathrm{MD}_i}{\mathrm{MS}_i}$$

? patrons/wk

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50 meals served/wk

Problem Statement

- Lots of planning and work for RT Dispatch

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- “Unfairness” in outcomes
  - MDMS varies dramatically between agencies

MDMS: 1

MDMS: 0.0016

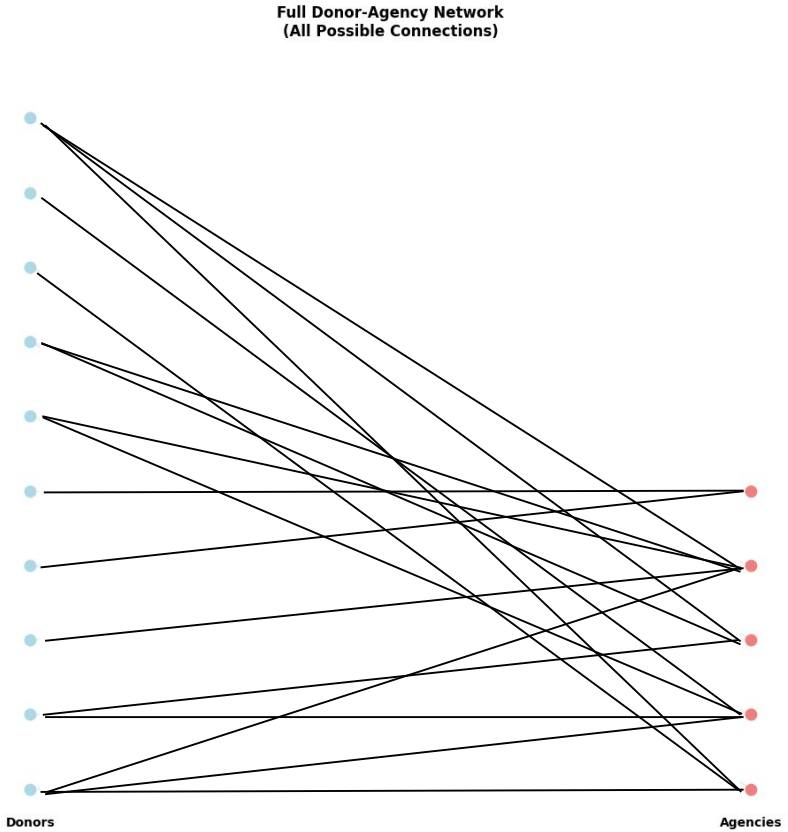
Deliverable

- RT inputs scheduled donations and one-offs

- Program gives a weekly shift schedule for RT drivers
  - Each shift is a route with drop off instructions
  - Produces fair outcomes for agencies

Modeling

- Adjacency matrix indicates what trips are feasible
  - Encodes distance constraints and FBWM constraints



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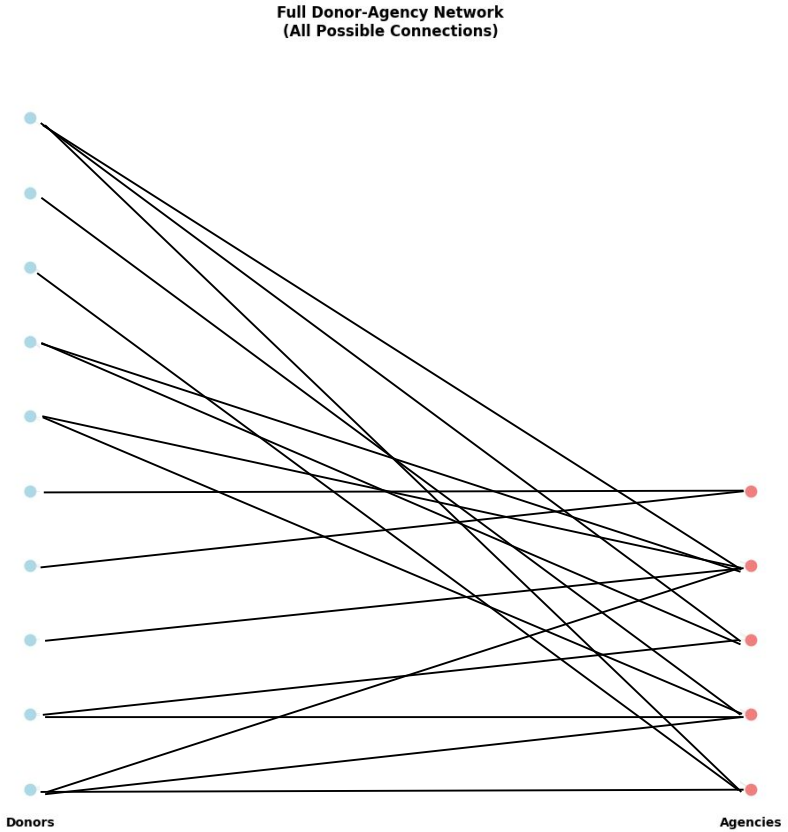
- Simulate donation of items over multiple timesteps



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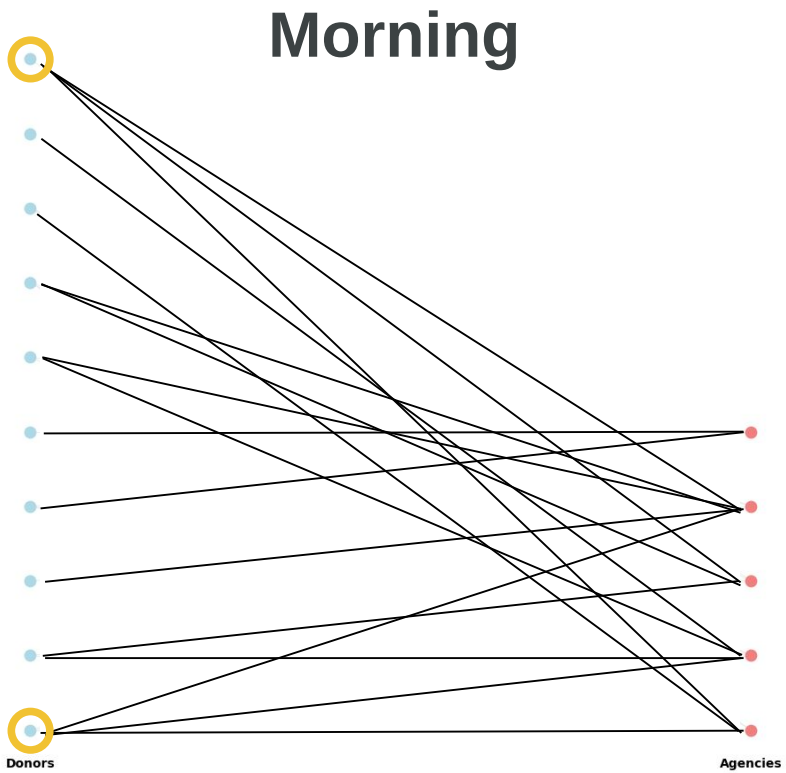

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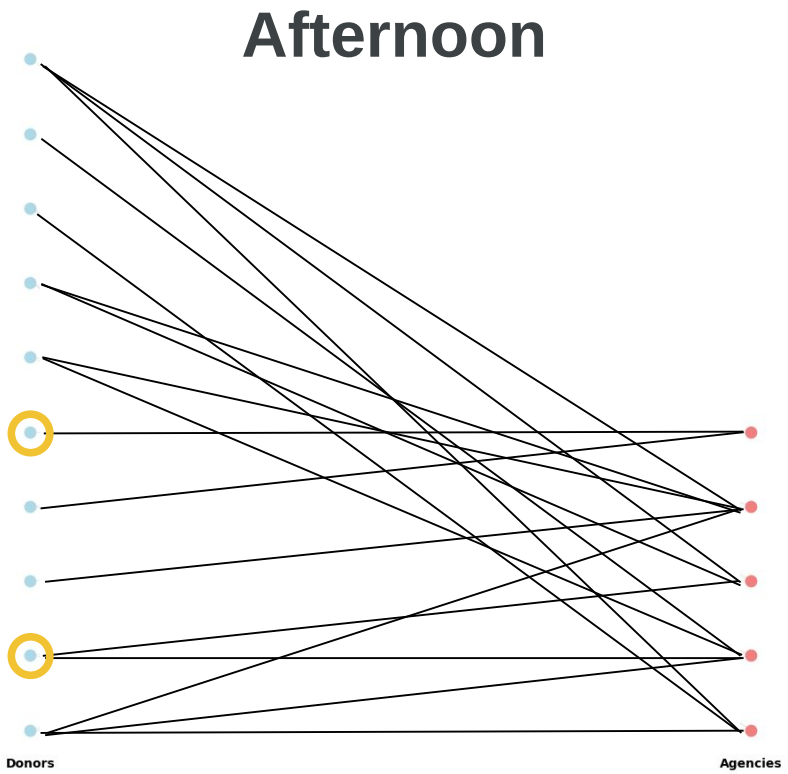

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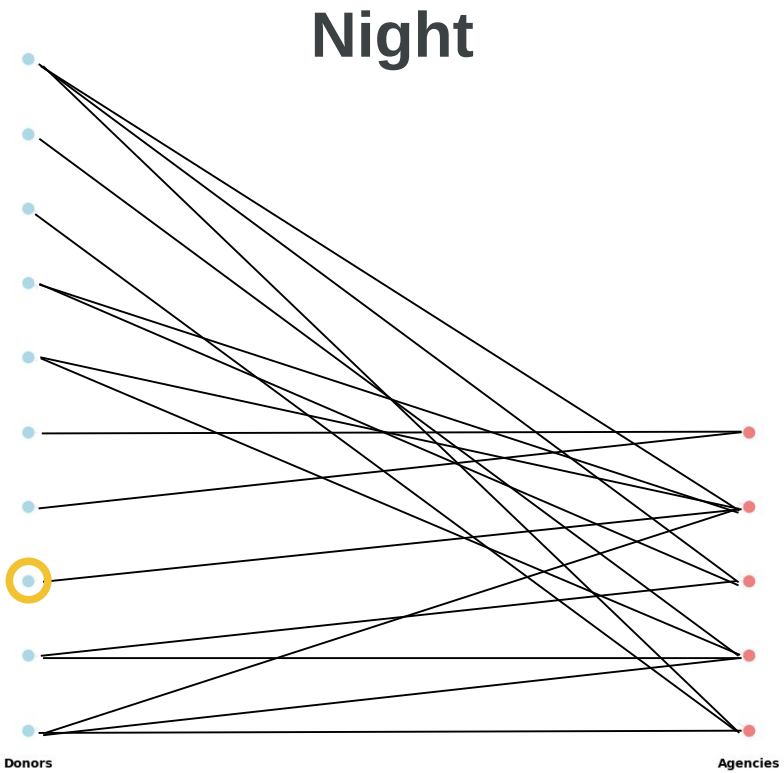

Modeling

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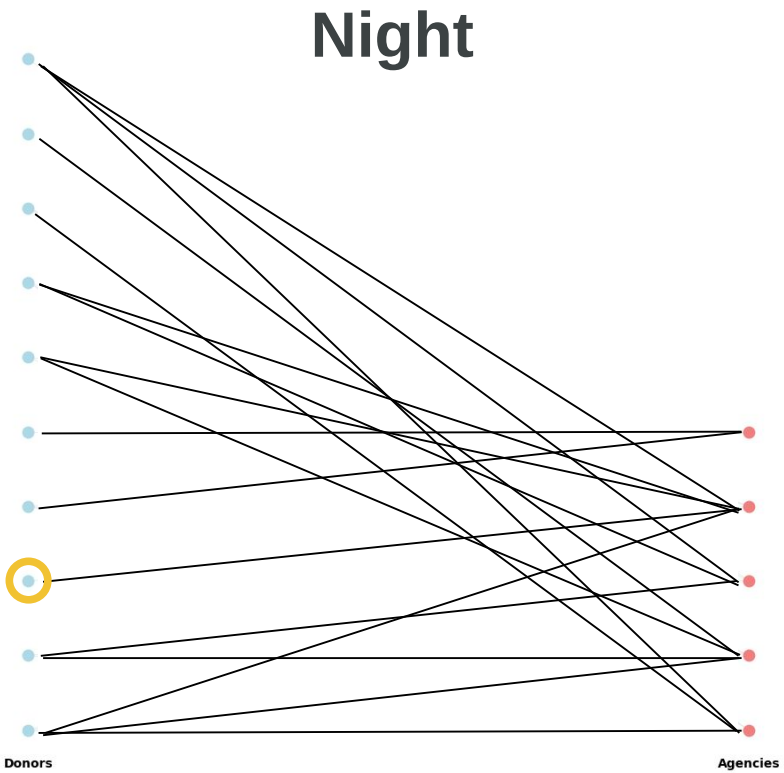
  - Items have corresponding food types
- Non-trivial requiring we go through lots of messy data



Fairness Goals

- We want to allocate goods to each agency based on their size
  - People going to a small food pantry aren’t more deserving
- We want to give agencies a mixture of food types

Options for Fairness

- Envy-based
  - Minimize envy between receiving agencies
  - Bad fit
    - Agencies don’t care/don’t see what other agencies get
    - Not very useful with identical valuation functions
- Egalitarian (ESW)
  - Determined by the welfare of the worst-off agency
- Utilitarian (USW)
  - Deliver as much food as possible

Problem Solving Stages

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Plan division of donated food among agencies

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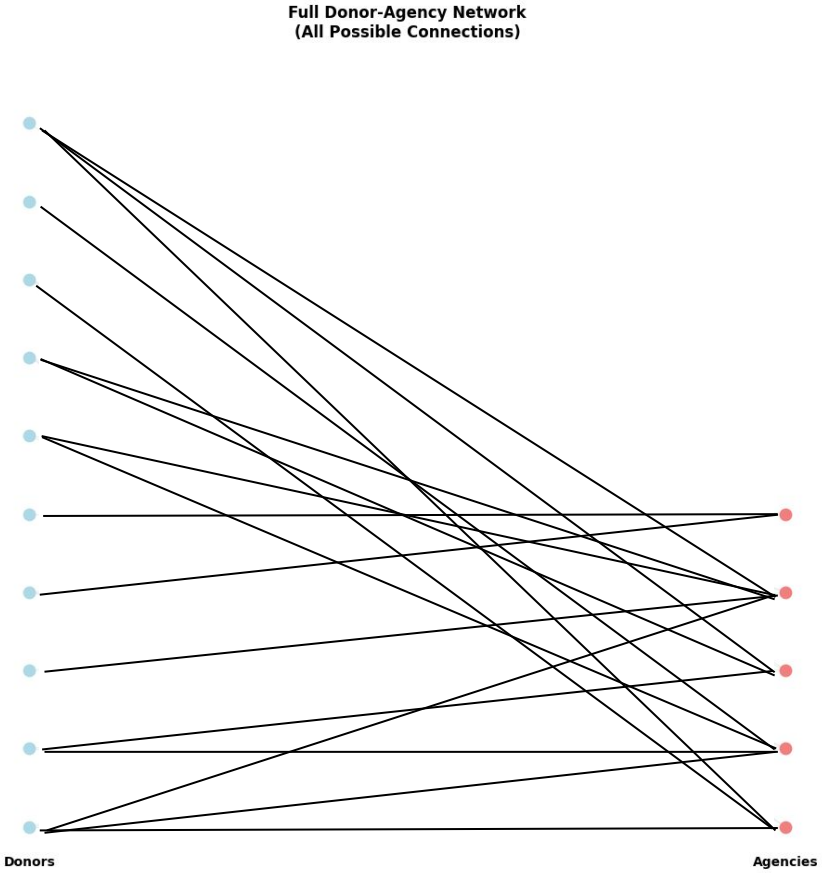
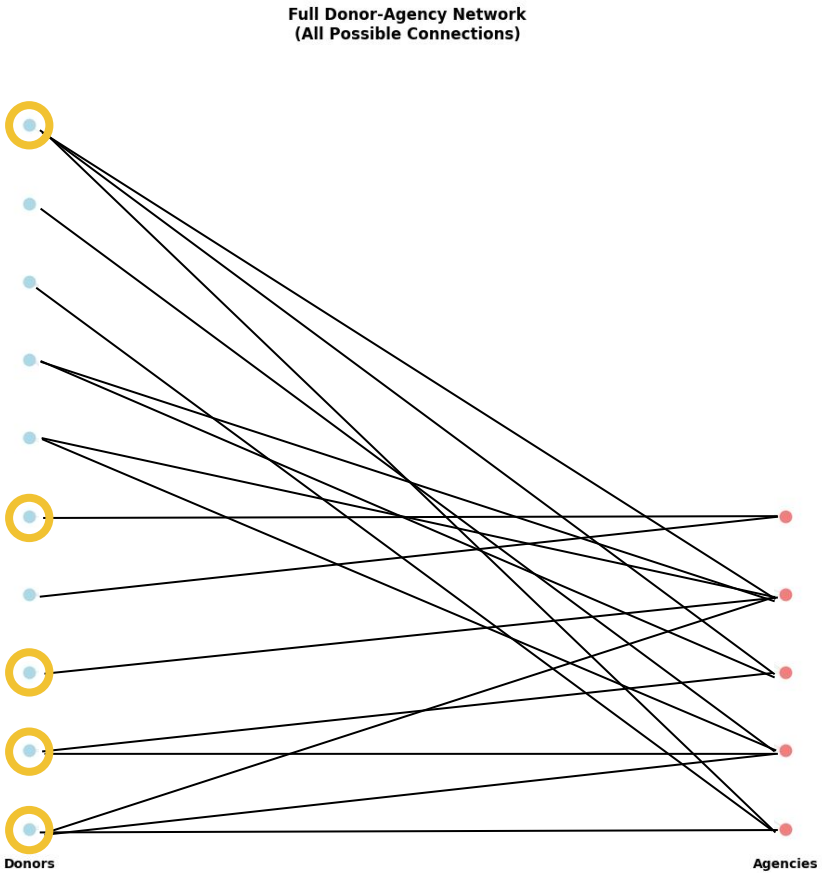

Full Donor-Agency Network
(All Possible Connections)
Donors
Agencies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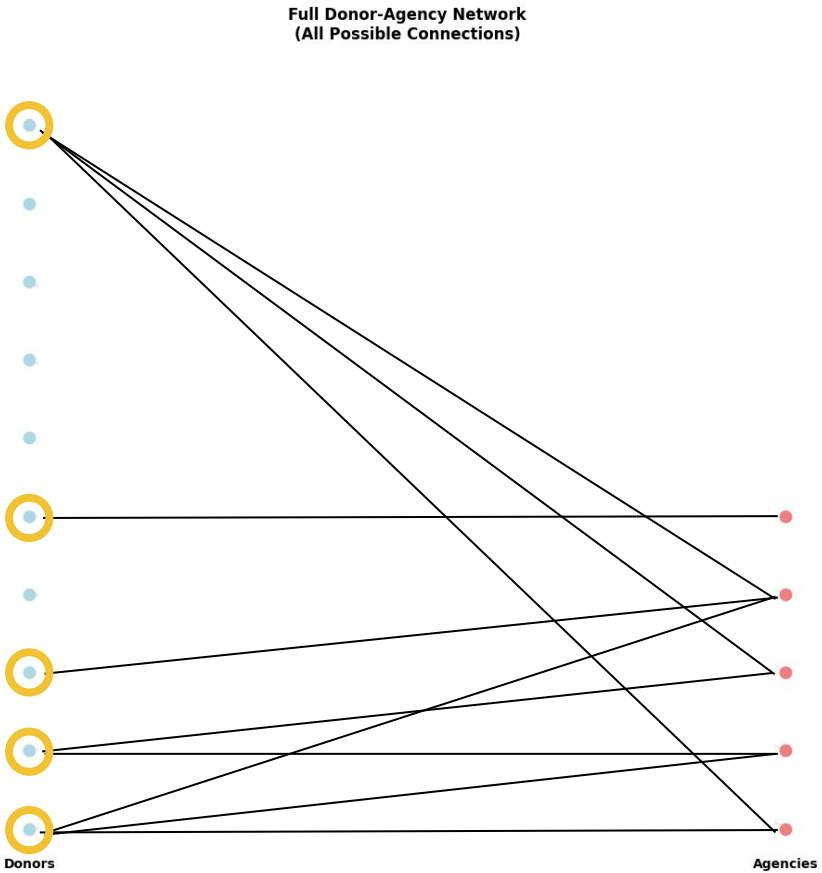
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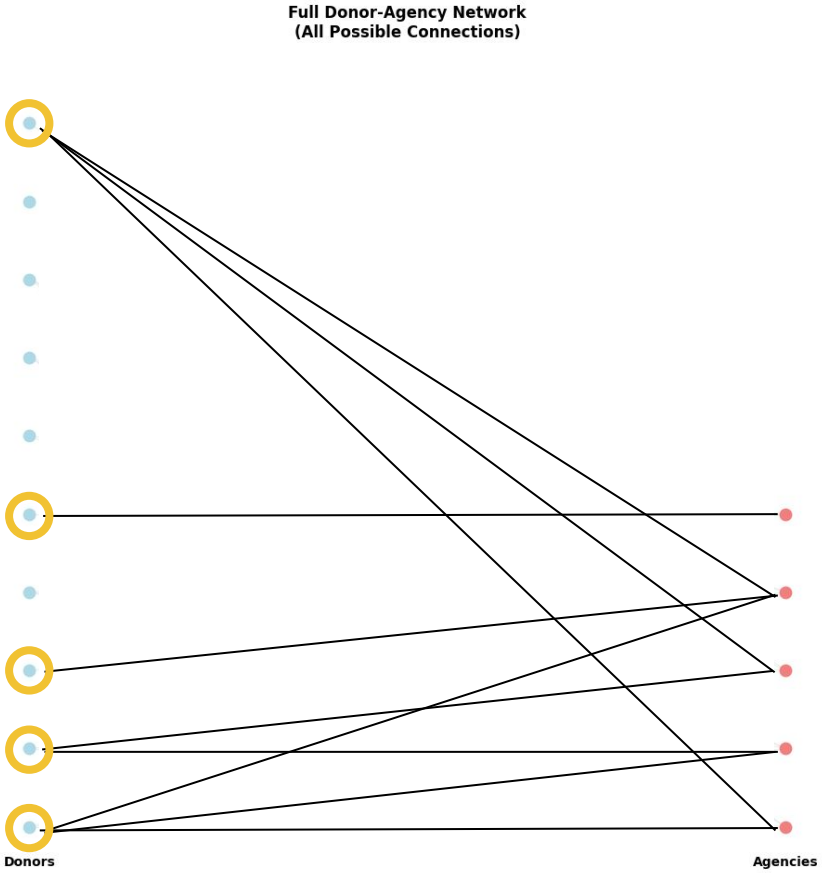
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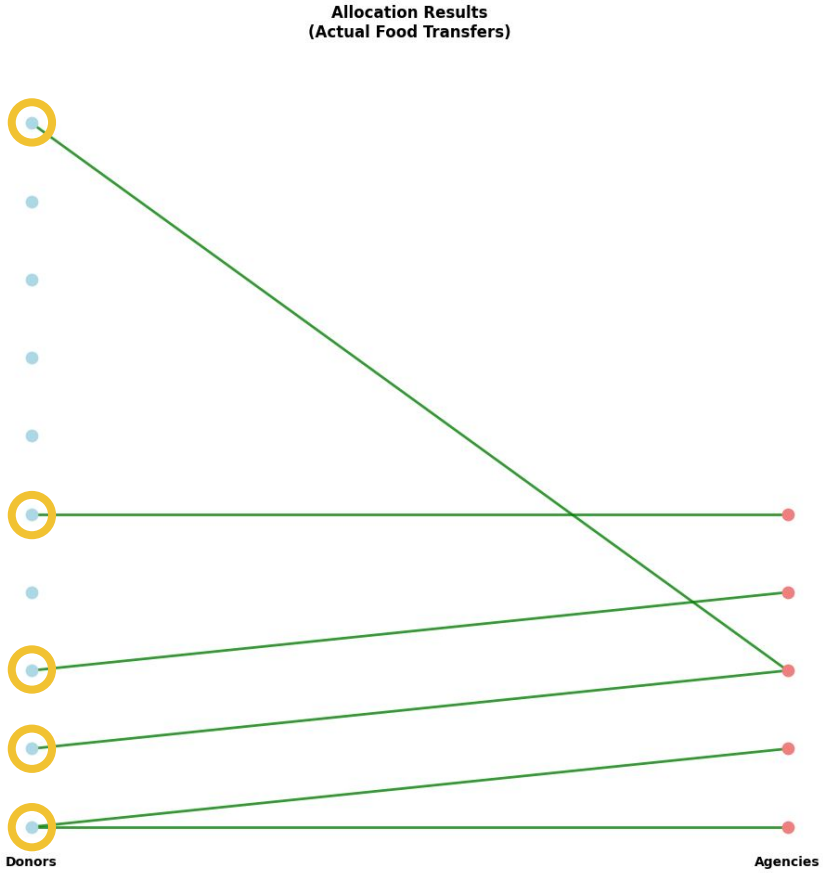
Allocation Results
(Actual Food Transfers)
Donors
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ILP Objective

maximize $\alpha \cdot r + \sum_{f \in F} \alpha_f \cdot r_f$

Maximize weighted combination of ESW and ESW over food groups

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Maximize weighted combination of ESW and ESW over food groups

$$\sum_{g \in G} \sum_{f \in F} \frac{x_{i,g} \cdot q_{g,f}}{W_i} \geq r \qquad \text{for all } i \in N$$

Def. of egalitarian welfare (ESW)

$$\sum_{g \in G} \frac{x_{i,g} \cdot q_{g,f}}{W_i} \geq r_f \qquad \text{for all } i \in N, f \in F$$

Def. of egalitarian welfare across food groups

ILP Constraints

$$\sum_{g \in G} \sum_{i \in N} \sum_{f \in F} x_{i,g} \cdot q_{g,f} \geq \beta \cdot OPT$$

Allocation must achieve a certain percent of USW

$$\sum_{i \in N} x_{i,g} \leq 1 \qquad \text{for all } g \in G$$

Each item can only be given once

$$y^t_{i,d} \leq m^t_{i,d} \qquad \text{for all } i \in N, t \in T$$

Every trip (donor -> agency) must be feasible

$$x_{i,g} \leq y^{z(g)}_{i,h(g)} \qquad \text{for all } i \in N, g \in G$$

An agency can't get items from donor without a trip being made

Binary decision variables

$$y^t_{i,d} \in \{0,1\} \qquad \text{for all } i \in N, d \in D, t \in T$$

Are we going to make someone go from donor d to agency i?

$$x_{i,g} \in \{0,1\} \qquad \text{for all } i \in N, g \in G$$

Is a given item assigned to a given agency?

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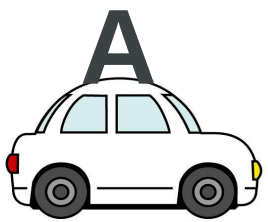
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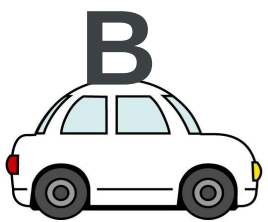
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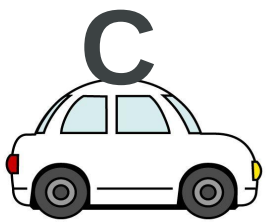
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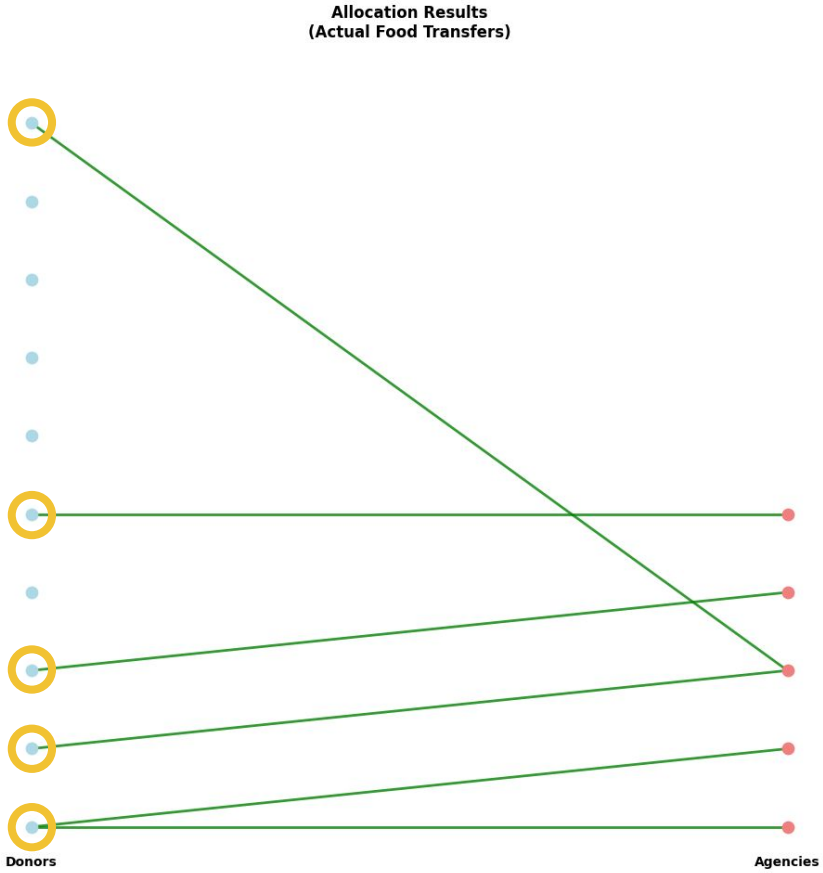
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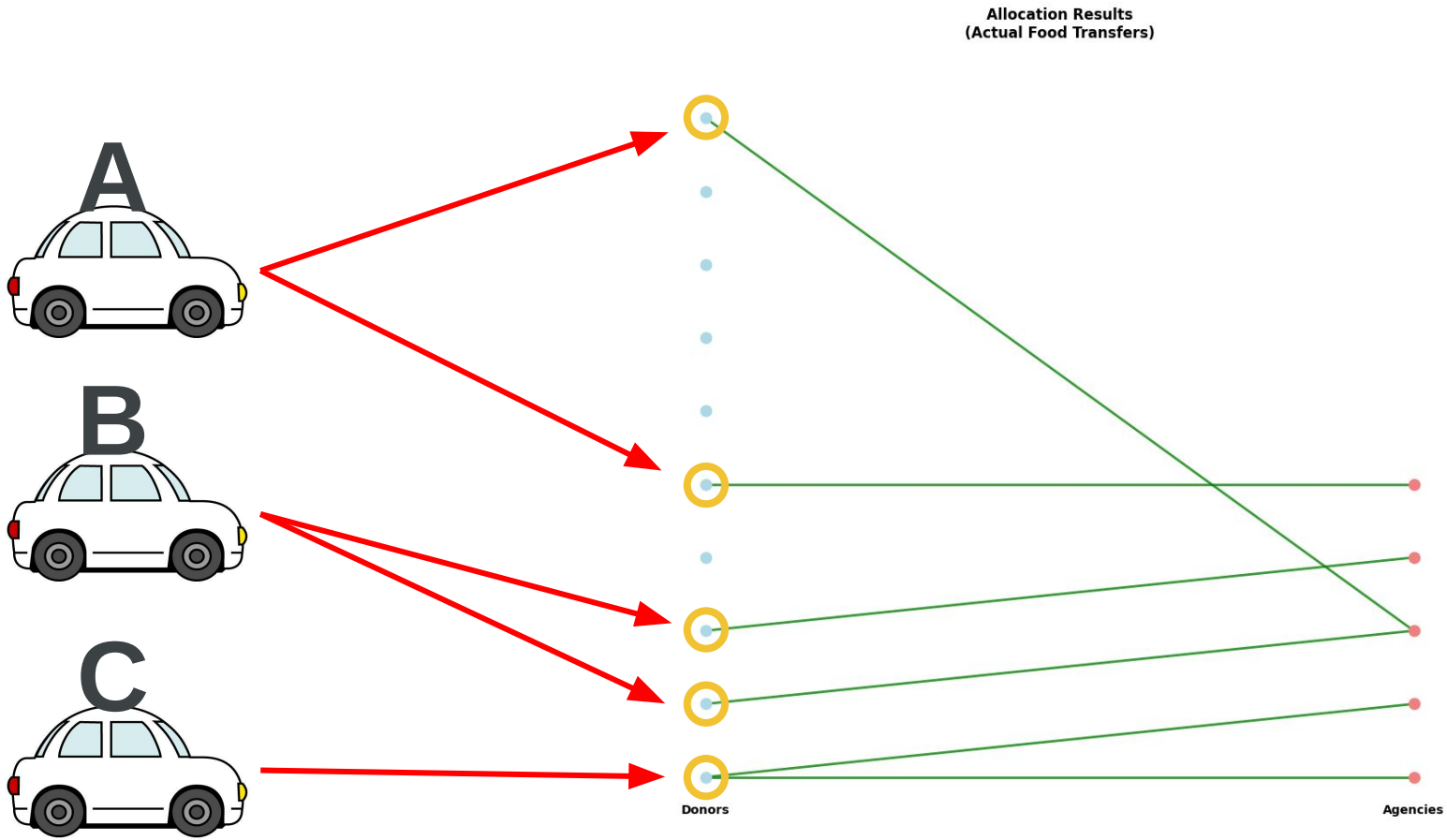
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End

Thank You!