University of Illinois Facilities and Services
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Crowd Management for Quad Day

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Project topic

Event: Quad Day

Planning phase: Spring 2020

Event date: September 2020

Topic: Traffic measurement, estimation, planning, and control for special events

Summary and Recap

- **Information about Quad-Day last year and this year:**
  - This year, no carnival games (may be replaced by other activities/booths)
  - Lat year, there are a total of 660 spaces

- **Data acquisition:**
  - Number of students:
    - Each year, approximately 8000 new students.
    - Difficult to estimate/predict the popularity of various groups
    - No historical data of traffic directly available
  - Estimation using the app for this year
    - Can acquire students' locations
    - Need to make sure most attending students will use the app before Quad-Day
    - Can identify where to vote, get food, or do other activities
    - Can potentially work with the developers to make the app interactive

- **Practical situation:**
  - Will NOT extend Quad Day to two days

Summary and Recap

- **Potential solutions:**
  - Relocating the booths
  - Adding guiding facilities or barriers
  - Distribute guides/maps for the students before Quad-Day
  - Use apps to guide students going to various destinations; suggest routes based on origins and destinations.

Research Plan

- **Benchmarking – Status quo of current Quad Day (on-going)**
  - **Demand estimation**
  - **Route generation**

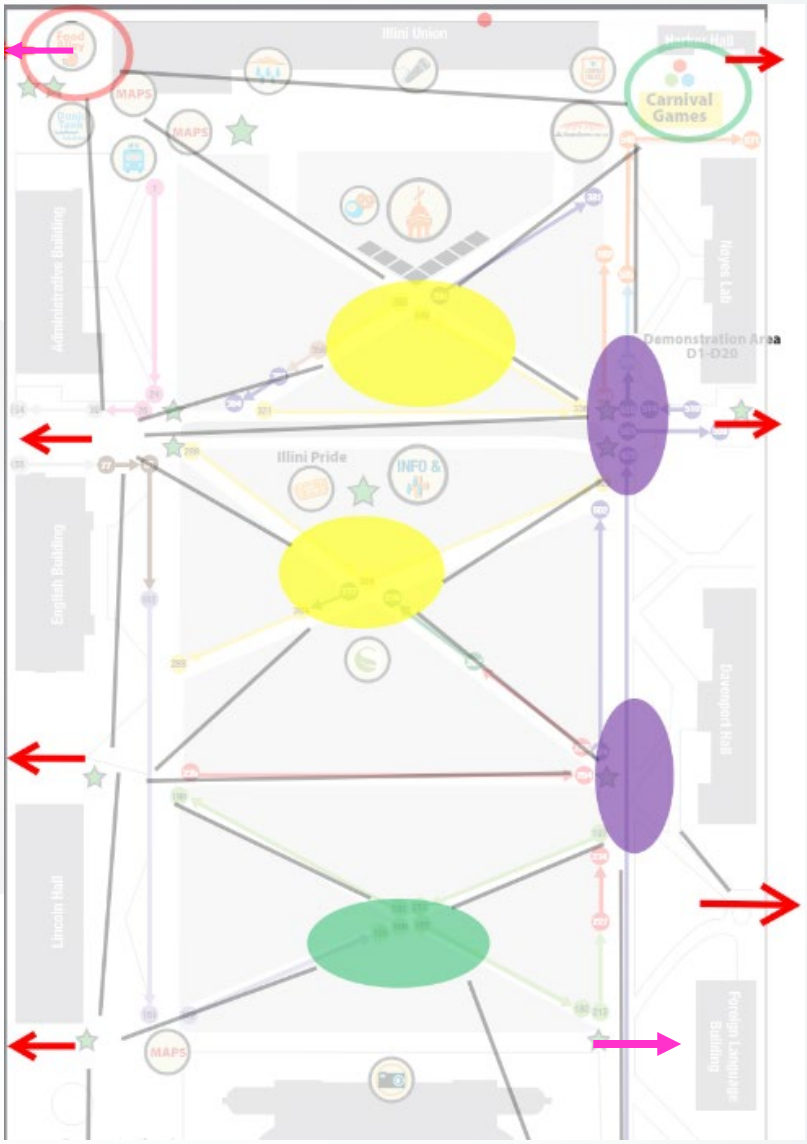
- **Improve traffic on Quad Day (next step)**
  - **Explore possible approaches**
    - Relocation of booths
    - Adding barriers
  - **Methodology**
    - Finite element method & topology optimization

- **Implementation (next step)**
  - Utilize the *Illinois* App for data collection and route suggestion

Benchmarking

Assumptions

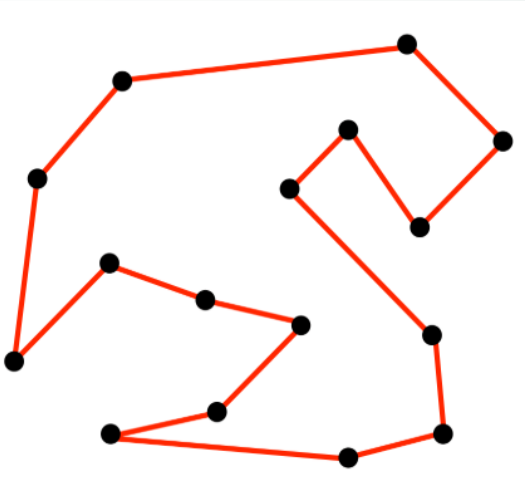
- Abstract graph from popular clusters
- Total duration: 11 AM – 4 PM
- Peak hour: **12 PM – 2 PM**
- Assume **20,000 people** visited throughout the duration, and peak-hour flow takes **30%** of total flow.
- Where do congestions form and how does the composition of visitors affect the pattern?
  - Background traffic: **2400 people/hour** uniformly distributed.
  - Categorized flow: **4000 people/hour** on specific routes.



Benchmarking

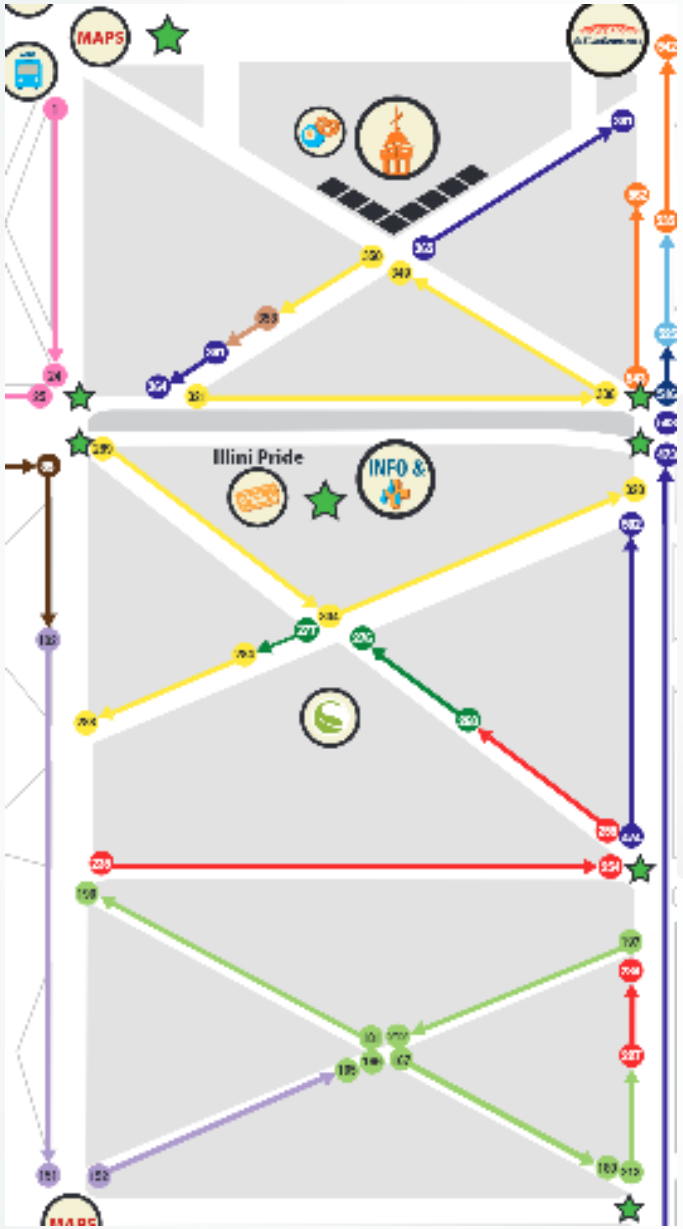
Methodology

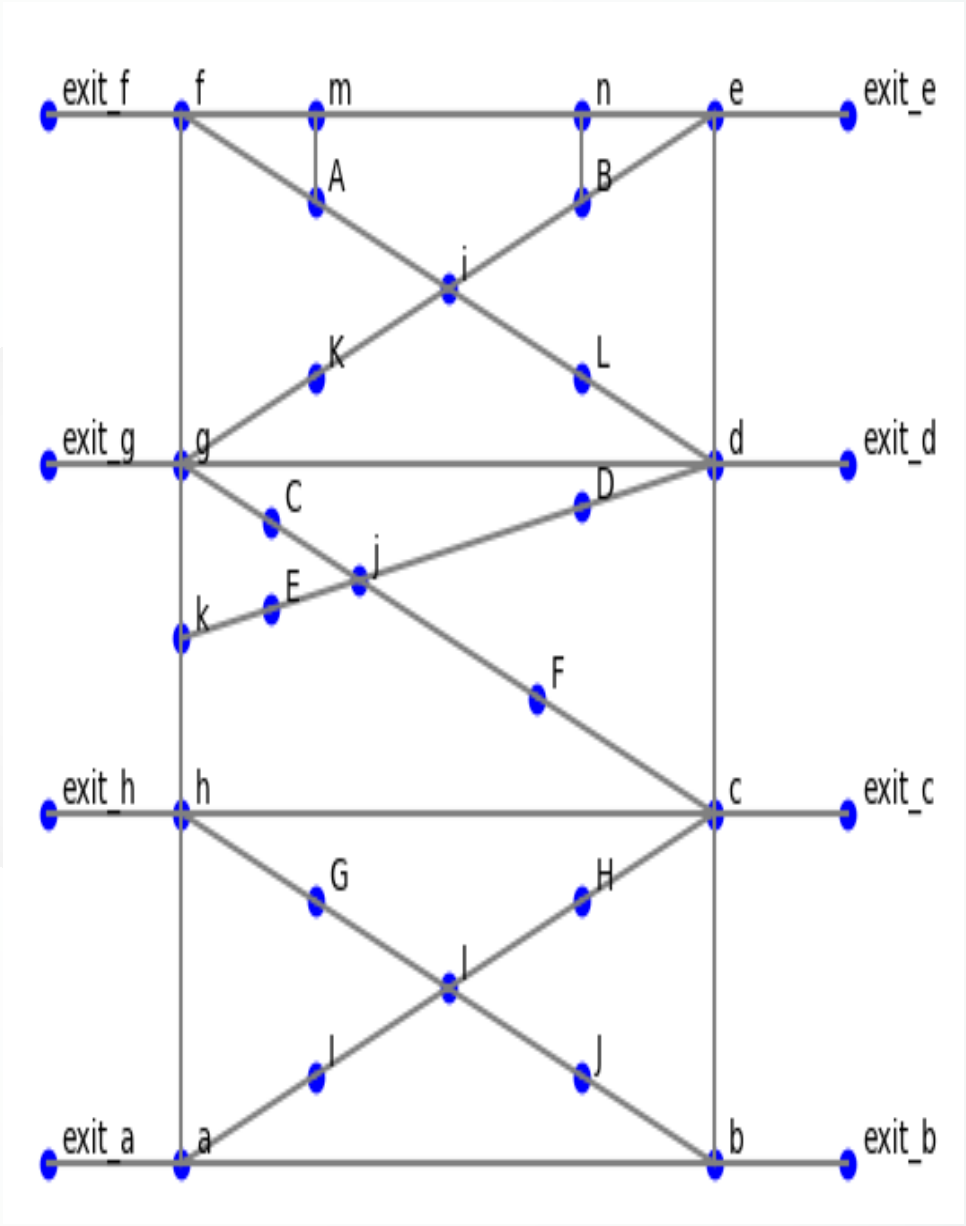
- Route Generation
  - Suppose we can categorize several representative groups of pedestrians, such that each of them has a set of booths to visit, while their route choice depends on the crowdedness of the Quad.
  - Solve a Travelling Salesman Problem to obtain travel plan for each pedestrian group.
    - Nearest Insertion Algorithm
    - Dijkstra's Algorithm



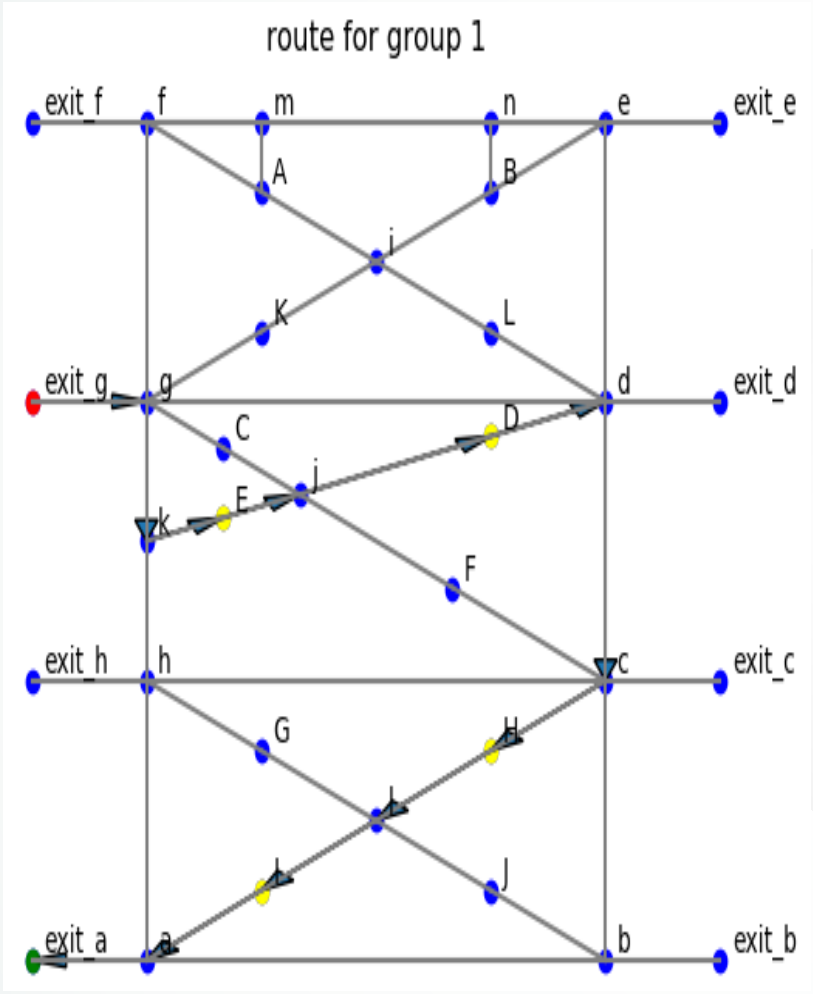
- Demand matching
  - Suppose we can have a confident estimate of the visit/flow rates at some of the booths.
  - We know the total amount of visitors (e.g., 4000 people/hr during peak hour)
  - Find the percentage of people in each group, such that the generated routes best reproduce the estimated booth visits
    - Least square estimation

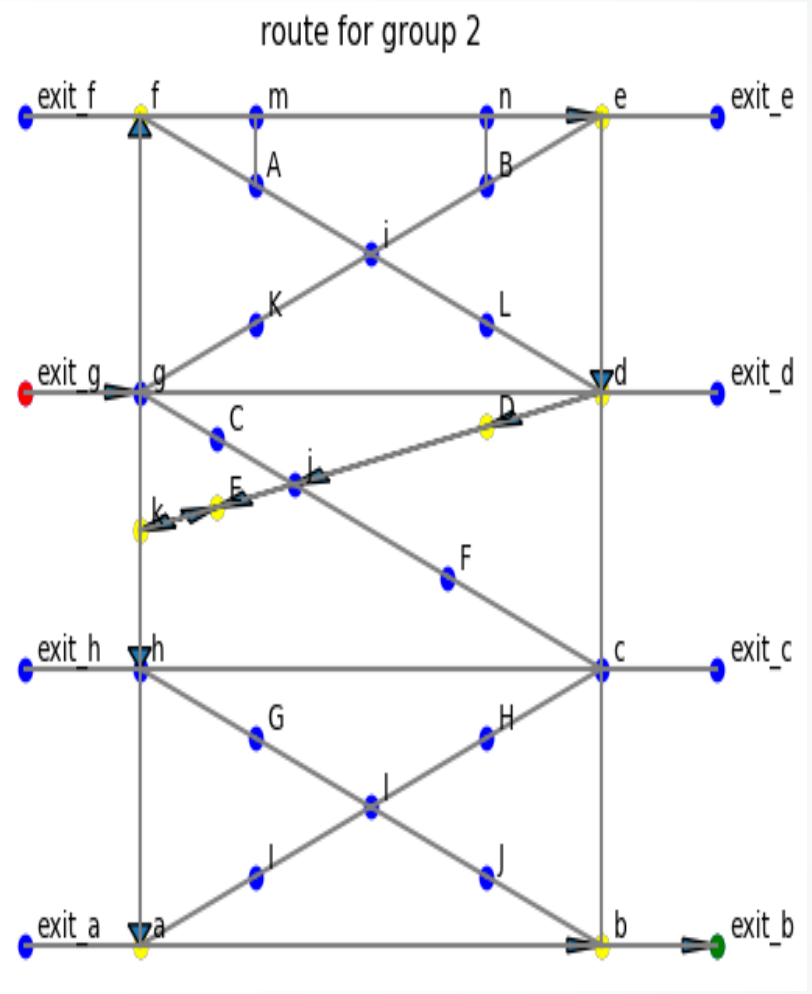
Benchmarking – Network Abstraction





Benchmarking – Generated tours





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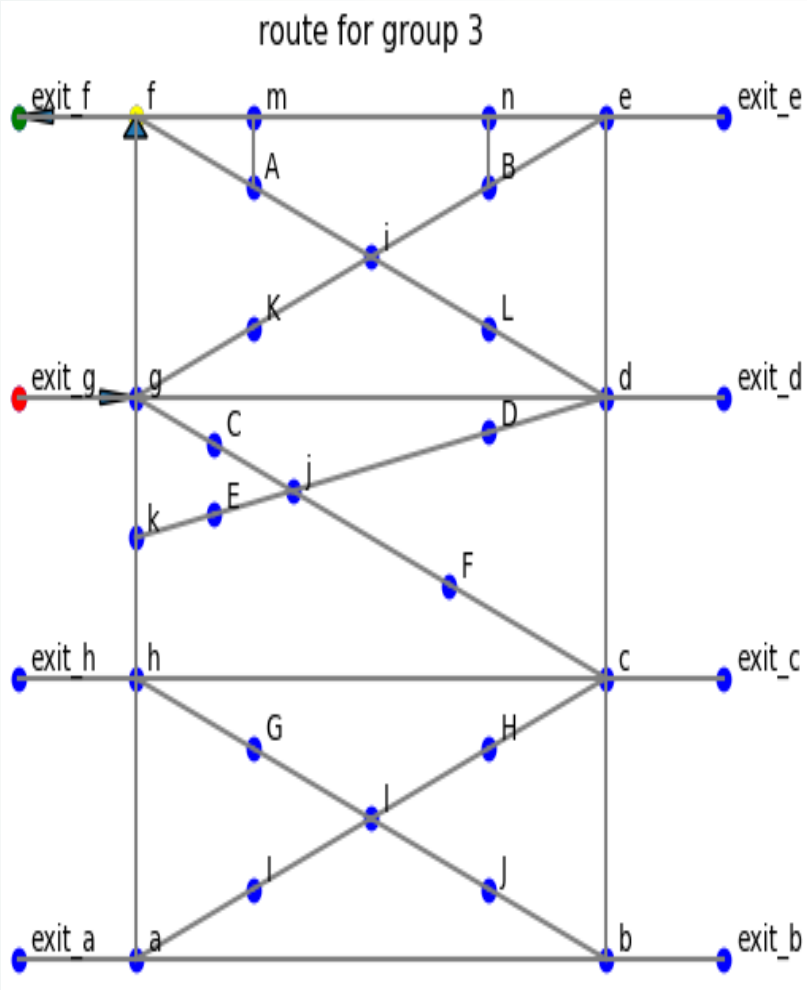
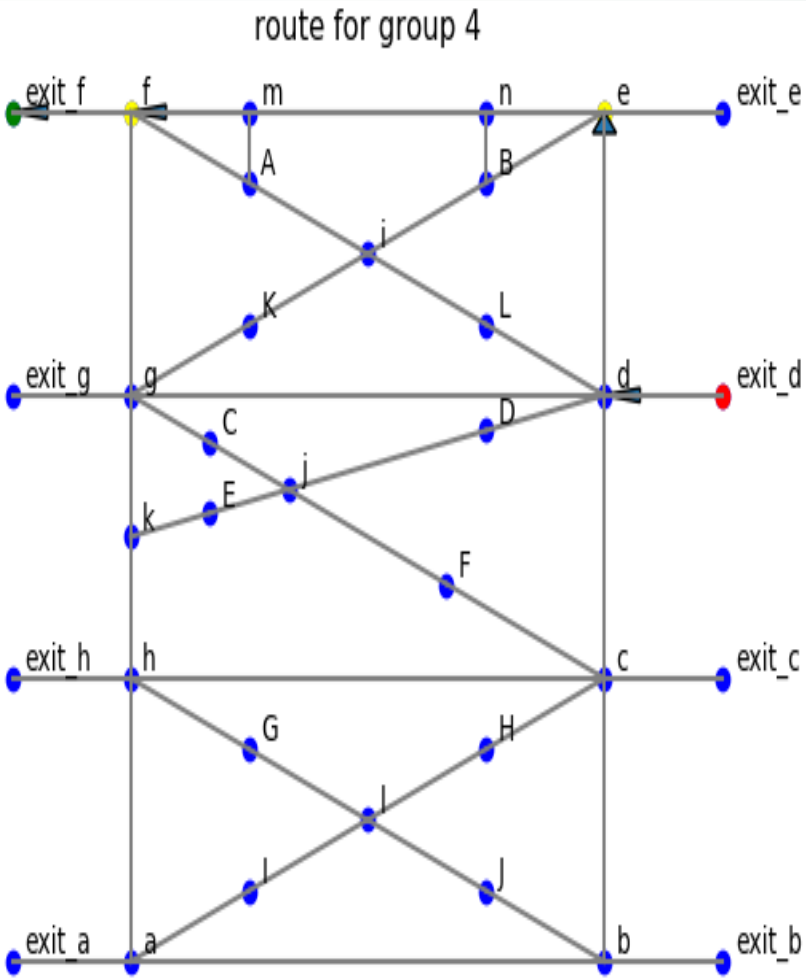
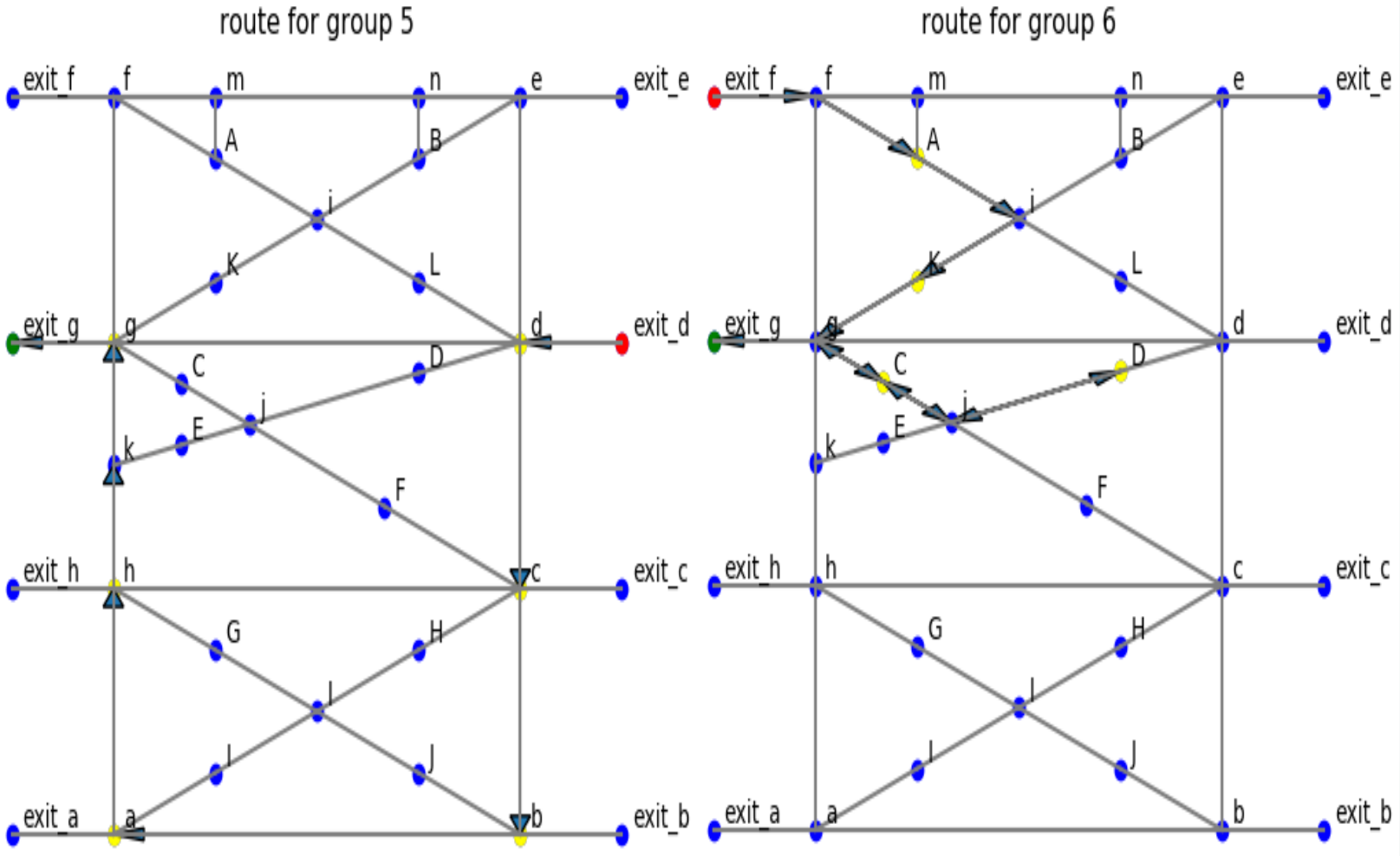


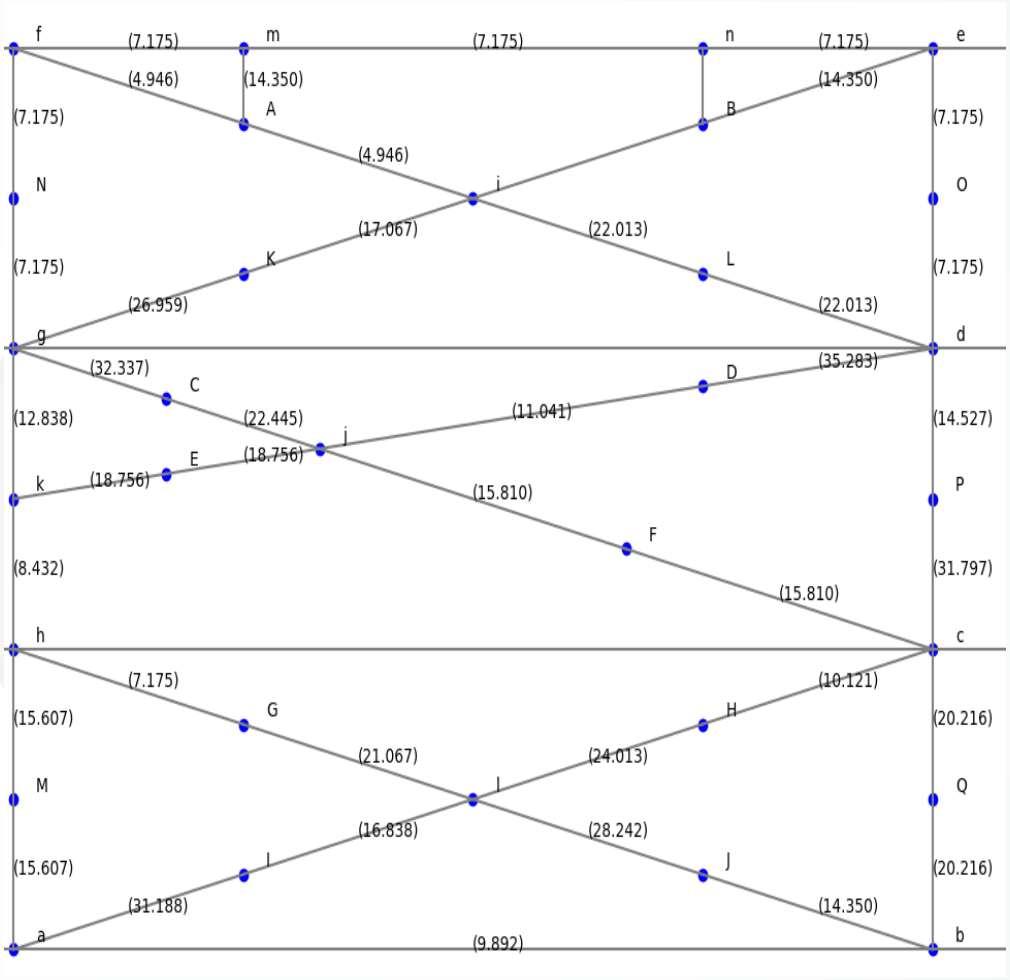


Benchmarking – Generated tours



Benchmarking – Generated Flows

Node	Flow
K	25
C	25
D	20
E	15
H	20
P	15
Q	20



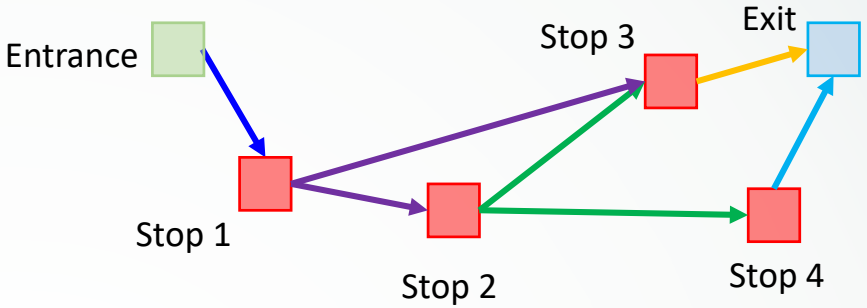
Benchmarking – Generated tours

	K	C	D	E	H	P	Q	Rel Error
Estimated (Input)	25	25	20	15	20	15	20	
Initial guess	16	24	16	20	8	24	16	100%
Matched result	23.732	22.165	21.842	17.381	20.211	17.976	20.216	27.6%

- **We developed a framework to reproduce the traffic during Quad day, so we can understand the likely traffic pattern and optimize accordingly.**
- **The framework proposes a combination of routes with associated flows that best match the estimated demand at booths.**
- **Therefore, we need a reasonable estimate of demand at booths as input.**

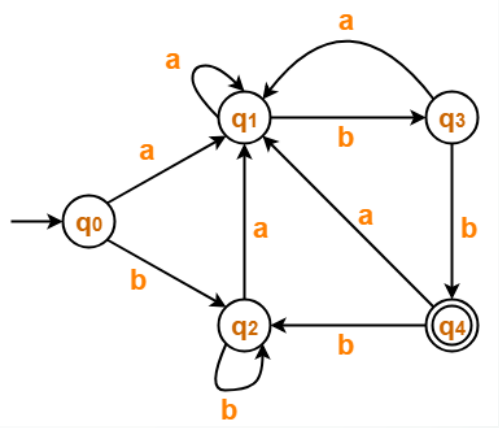
Ongoing and future steps

1. **Modeling of multiple traffic flows/stops (on-going)**



2. **Reproducing congestions patterns of last year (on-going)**

3. **Optimization (booth locations, guiding facilities, etc.) (next step)**

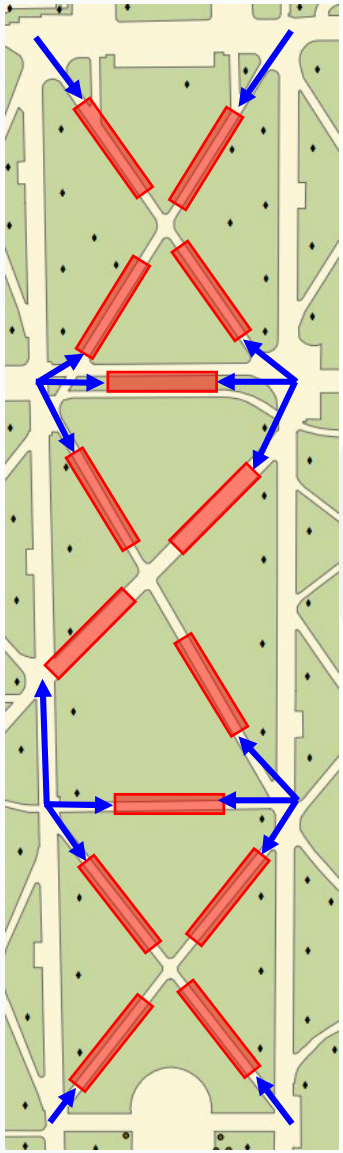


Advanced modeling: from single flow to multiple flows

Booth

Single flow group

Single flow

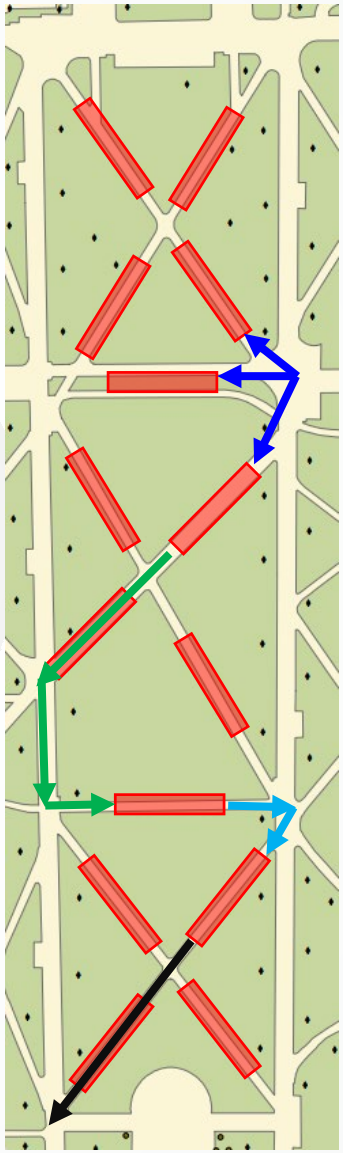


On-going work

More realistic modeling

Needed for optimization

Multiple flows



Booth

Flow group 1

Flow group 2

Flow group 3

Flow group 4

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Summary, questions, and suggestions

- **Summary of current progress**
  - Developed a framework that estimates travel pattern and congestions, given an estimate of flow at certain locations.
  - Reproduce the congestions patterns last year (on-going)
  - Develop FE model with multi-commodity flow (on-going)

- **Next steps**
  - Optimization framework exploring:
    - Re-allocation of booths
    - Adding barriers/guiding facilities
  - Work with the *Illinois* app developer to enable suggesting real-time routes to event goers.

- **Data needs/questions**
  - Quantified origin-destination demand
    - e.g. Do 10/20/30% of students enter the Quad from Wight & Daniel?
  - Popularity estimation at booths
    - e.g. Were there 100/500/1000/5000/10000 students stopping by at the most popular booths (e.g. athletic/recreational/professional development booths)?