EMORY GOIZUETA BUSINESS SCHOOL | Master of Science in Business Analytics MSBA

E Route Simulation & Analysis

Seal Team 6
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We are Seal Team 6

- Yaping Zhang
- Allegra Noto
- Carl Xi
- Mayur Kumar

Agenda

Analysis
- Stress Test
- Validation
- Verification

Interpretation
- Implications
- Next Steps

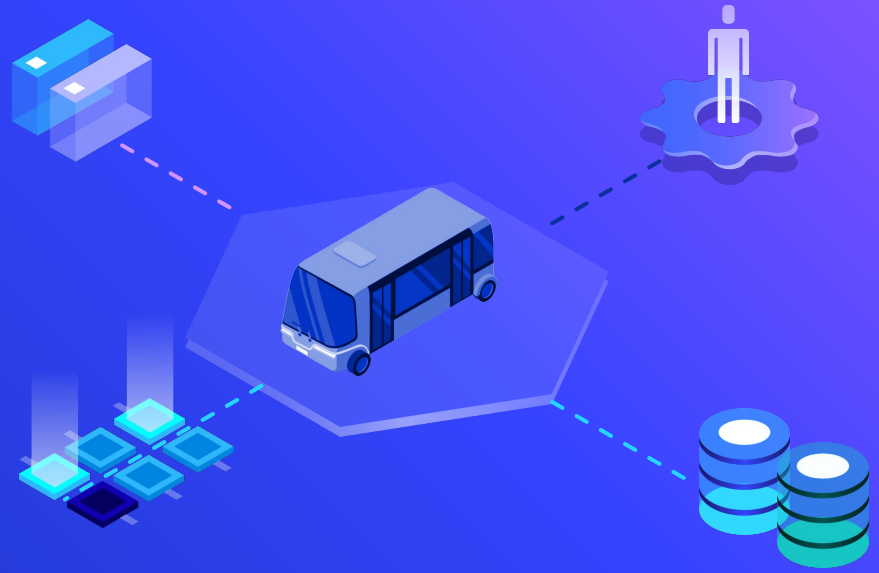
Foundation
- Data Cleaning
- Model Creation

Goal

- Examine current operations of the E Route Emory Shuttle using Simio Simulation
- Stress test said operation to find weaknesses and opportunities for improvement

Our Process

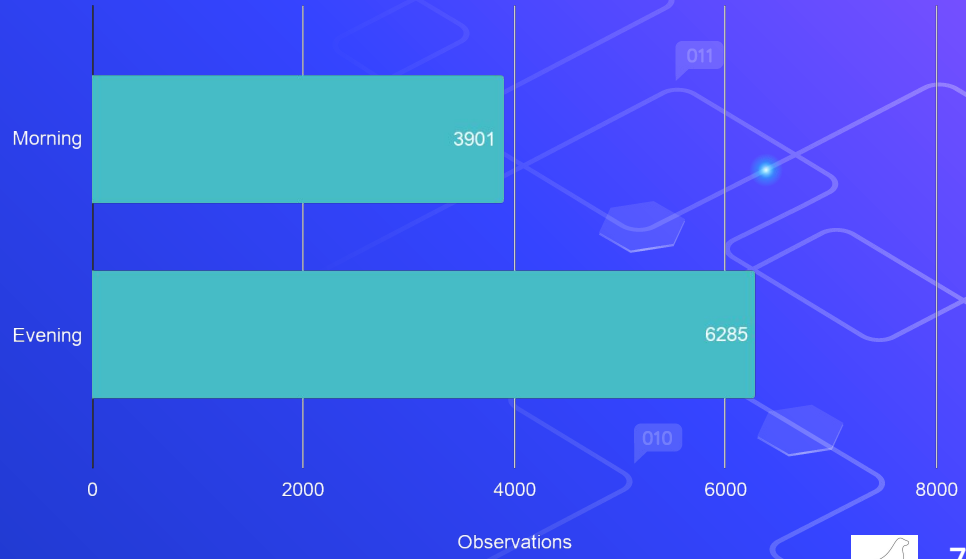
1. Data Cleaning
2. Information Extraction
3. Simulation Creation
4. Verification & Validation
5. Implications & Next Steps



1.
Data Cleaning

Data Cleaning

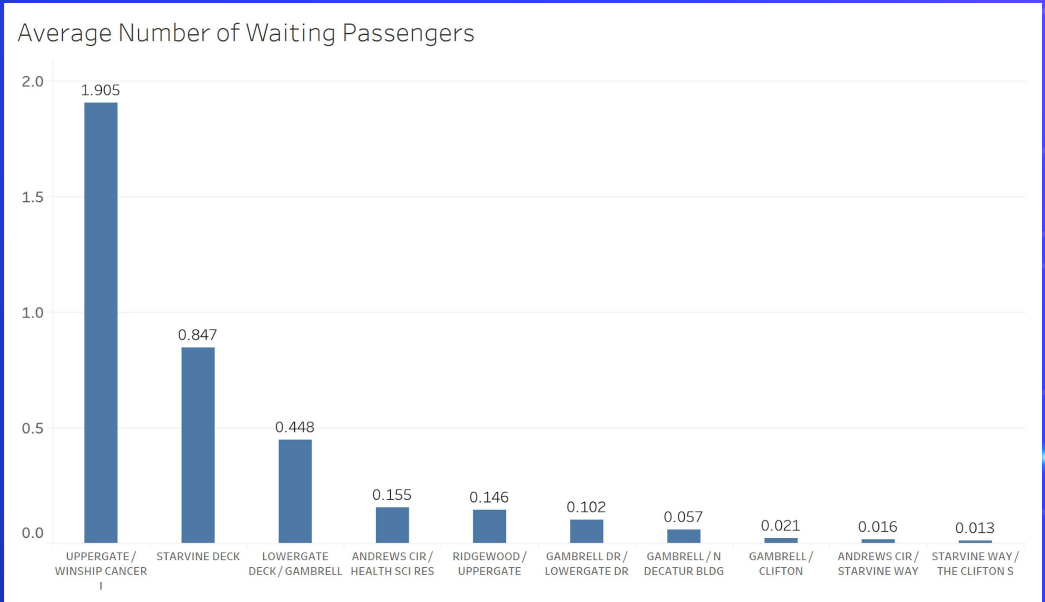
- Remove duplicates
- Removed negative travel time entries (about 700 entries)
- Use only data from M-T
- Create time buckets
  - Morning
  - Midday
  - Other



2. Information Extraction

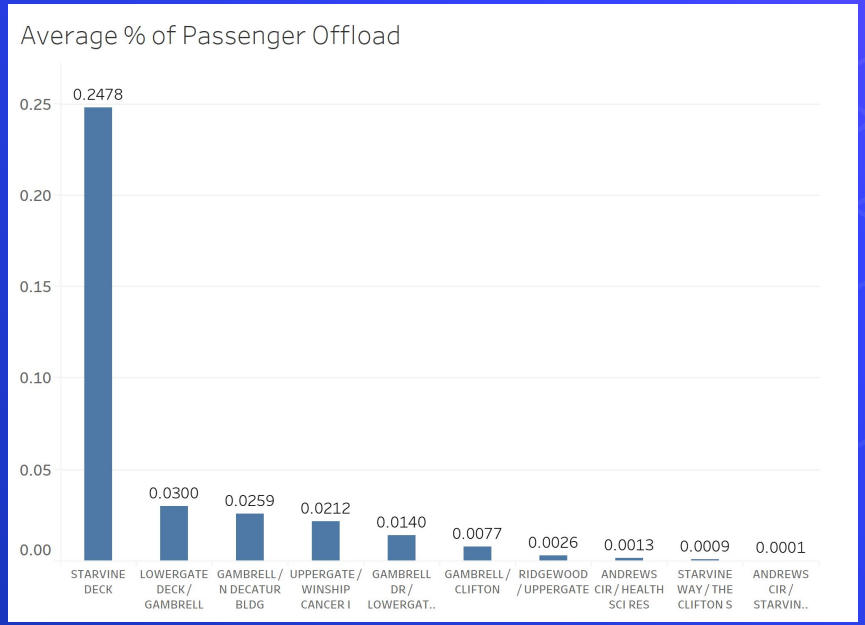
Information Extraction

- Average number of passengers waiting

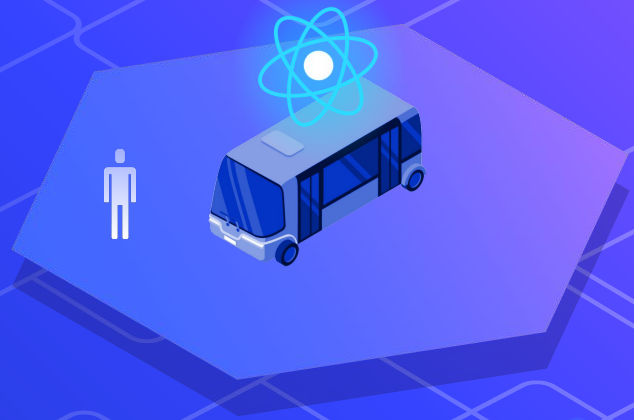


Information Extraction

- Average % of passengers getting off at each stop

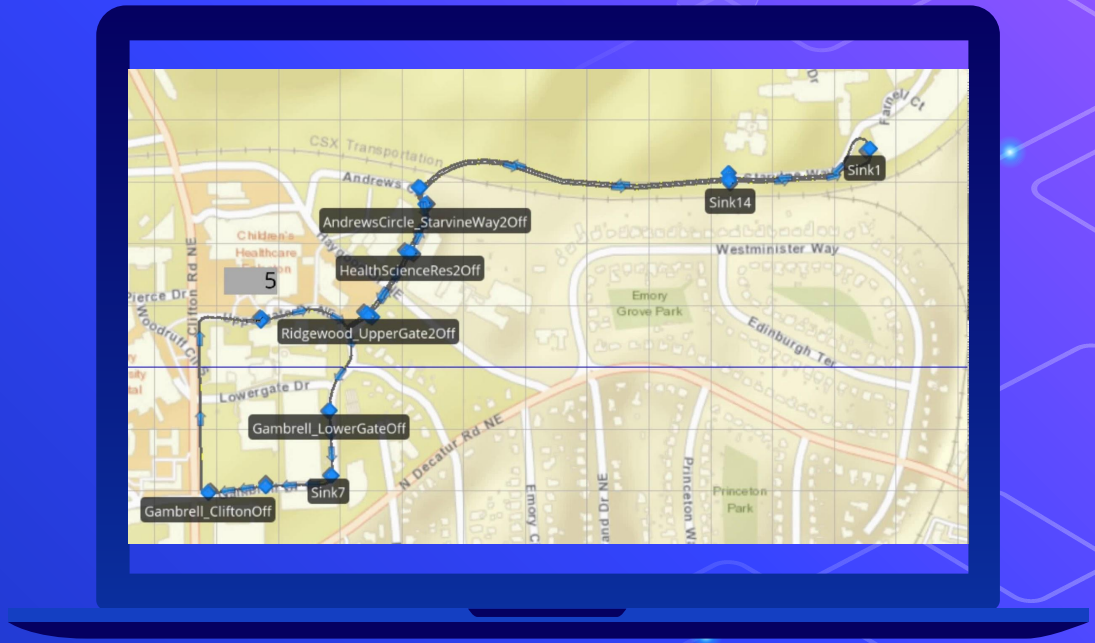


3.
Simulation Creation



Simulation

- 2D representation of Route Evening at 100x Speed



On vs Off, Everyone Off

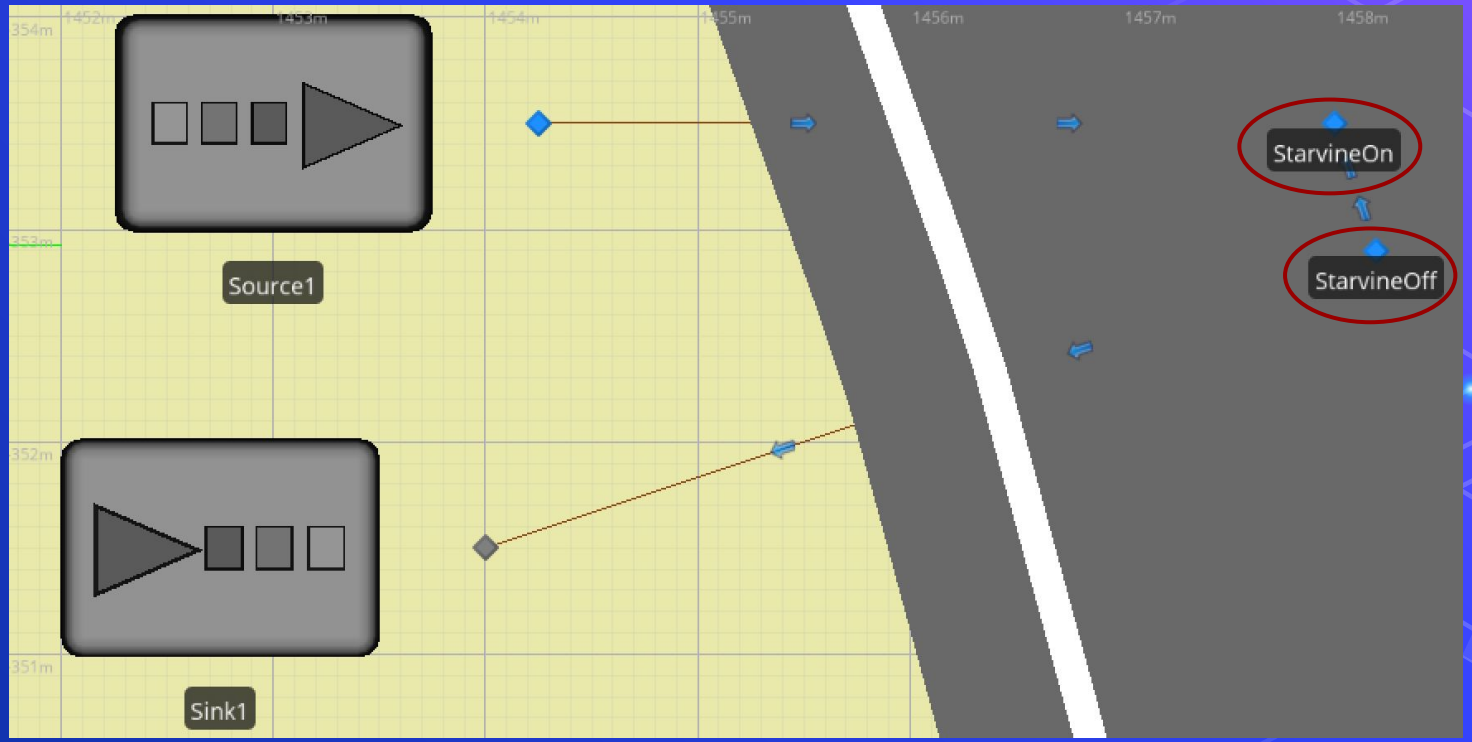
Problem:

- On & Off cannot be 1 node
- All passengers will get off at each sink

Solution:

- 2 nodes for each of the 14 stops for on & off
- Split off-passenger by weight and re-boarding % of passengers that got off

Typical Stop



North vs Southbound

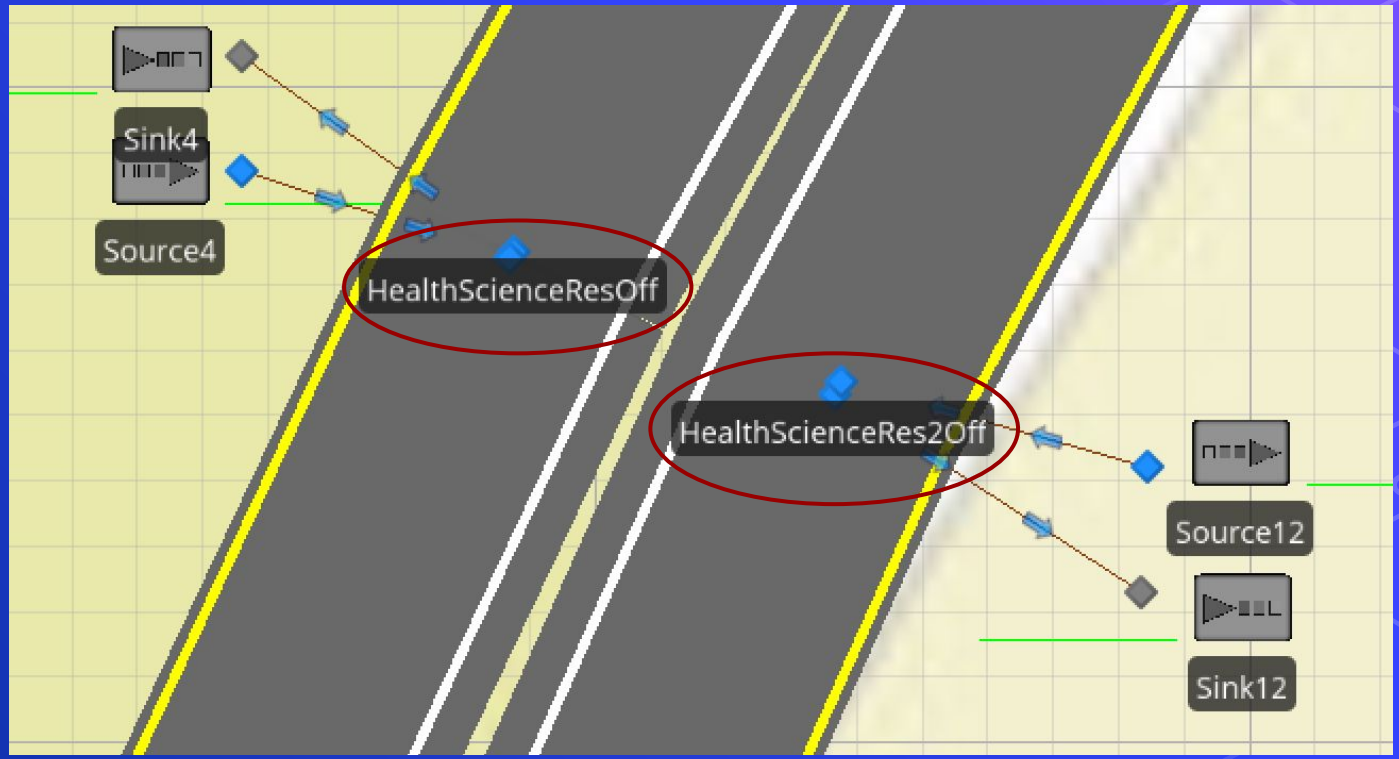
Problem:

- Some stop names represent 2 stops (both sides of the road)

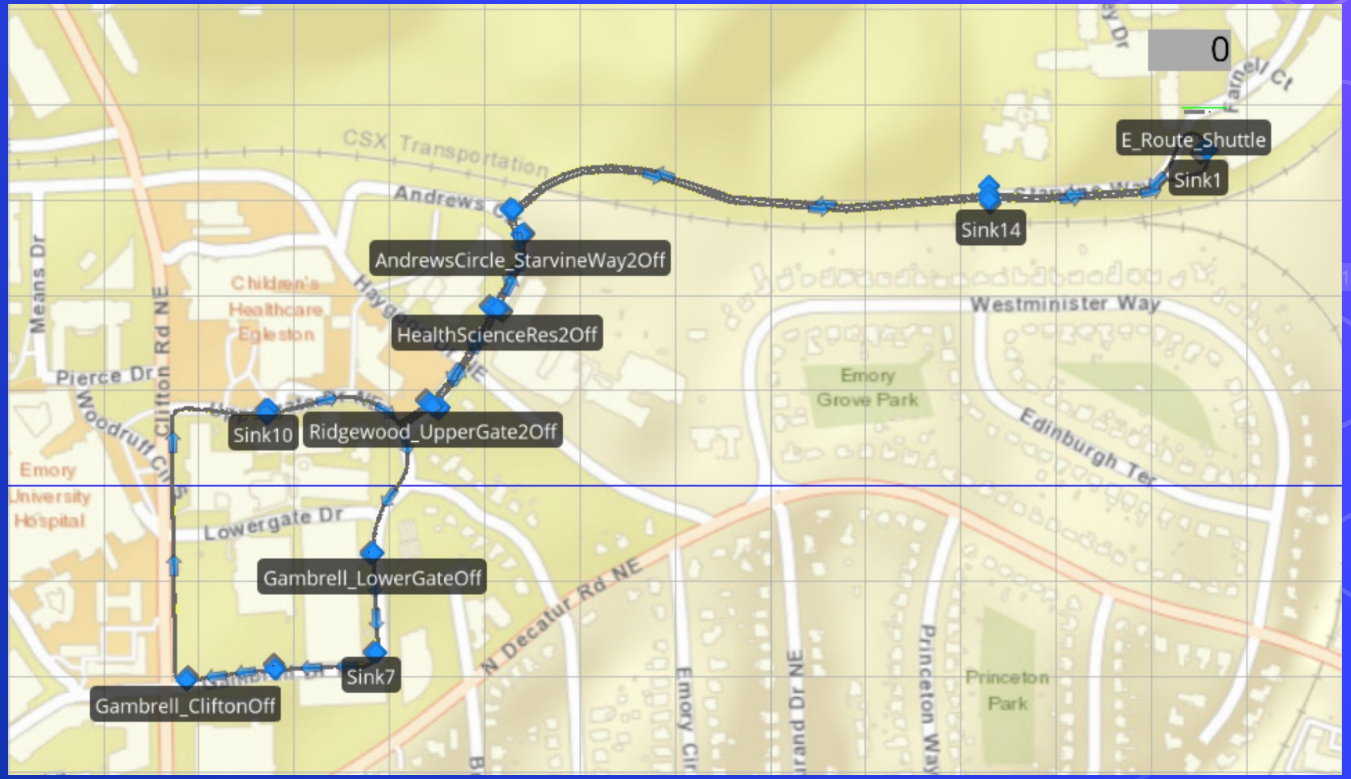
Solution:

- Look at the stop prior to each stop to distinguish northbound vs southbound

Typical Bi-Directional Stop



Completed Route



Simulation Creation Assumptions

- Arrival at each stop represented as a Poisson distribution as displayed earlier
  - Values within the 2 time buckets constant
  - Only 1 bus in operation at a time
  - Assume Monday-Thursday are equivalent
  - Created 14 Poisson distribution paths for time
  - Assume operation hours only 5-9am and 3-8pm

Rider Assumptions

- Rider Arrival Rate at each stop Poisson
  - Aggregate total onboards in each time bucket for each stop
  - Divide total list by 25 (# of days in sample) then by 4 or 5 (hours in morning or evening time bucket respectively) -> arrivals/hour for each stop for each time bucket
  - 1/result gives us hours/arrival for each stop for each time bucket
  - Insert resulting average into Random.Exponential(Avg) formula for arrival time distribution / passenger

Offloading Assumptions

- Percent of total riders get off at each stop
  - Aggregate total deboards in each time bucket for each stop
  - Divide total list by total offboards in sample to get % that get off at each stop
  - Transform result by Result/(1-Result) to get # of deboards/person that stay on the bus
  - Set weight of path to sink to this result and keep weight of path to onboard at 1

Travel Rate Assumptions

- Bus Arrival Rate Poisson
  - Get average inter-stop duration for each stop-to-stop path for each time bucket
  - Insert the resulting average into Random.Exponential(average)

Simulation

- 3D representation of Route Morning at 20x Speed

4.
Validation & Verification

Model Functionality Evaluation

- We changed runtime to 4 or 5 * 25 days = 125 or 100 hours

	Throughput (Morning)	Throughput (Evening)
Model	625	2139
Data Sample	589	2166
Difference	+36	-27

Model Functionality Evaluation

- We changed runtime to 4 or 5 * 25 days = 125 or 100 hours

	Flowtime (Starvine - Clifton School) Morning	Flowtime (Starvine - Clifton School) Evening
Model	**3.762 mins**	**1.842 mins**
Data Sample	**1.602 mins**	**1.602 mins**
Difference	**+2.160 mins**	**0.240 mins**

Stress Test

- Observe system behavior when demand is 1x, 2x and 5x
- Compare & contrast key metrics like throughput, distance traveled (bus) and avg number of passengers in system

Morning Stress Test

	Throughput (Delivered)	Avg # of Riders Waiting @ Each Station	Distance Travelled
1x Demand	154	2.8	29.4 Km
2x Demand	281	18.0	27.2 Km
5x Demand	276	18.7	25.7 Km

Evening Stress Test

	Throughput (Delivered)	Avg # of Riders Waiting @ Each Station	Distance Travelled
1x Demand	74	11.1	11.5 Km
2x Demand	43	18.5	5.4 Km
5x Demand	35	18.8	5.2 Km

Model Vs Data Difference

Percent of Passengers Off

- We calculated percentage of riders on a bus getting off at each stop, but this number resulted in an average of only 18% of passengers getting off

Solution

- We used a probability table where the total probability of getting off at all stops equal 1. This ensures that no passenger rides more than one full circle around the route.

5.
Deployment and Implications

Limiting Aspects

- Distribution assumptions
- Model is a simplified version of the E route
- Relies on limited data, collected over less than a semester.
- Passengers are assumed to arrive equivalently over the time buckets
- Intended destination of customers, which could help the model, is unknown, weather, traffic breakdown, Holidays ,weekends

Potential Modifications

Oversimplification

- Model is overly simple as we assume demand is constant throughout each time bucket and every day of Monday-Thursday
- Other factors like failure, cost, time-of-year etc. not taken into consideration

Solution

- Further reduce time bucket size and create separate models for each day of the week
- Consider costs and potential accidents (vehicle failure, weather, traffic, etc.)

More Potential Modifications

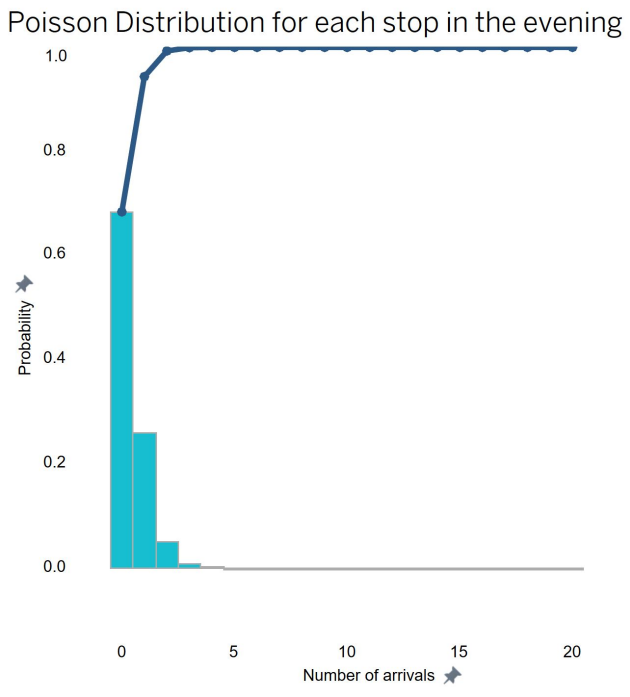
- Additional observation data
  - More Observations and several varied variables
  - Helps in distribution estimates
  - Improves the accuracy and applicability of the simulation

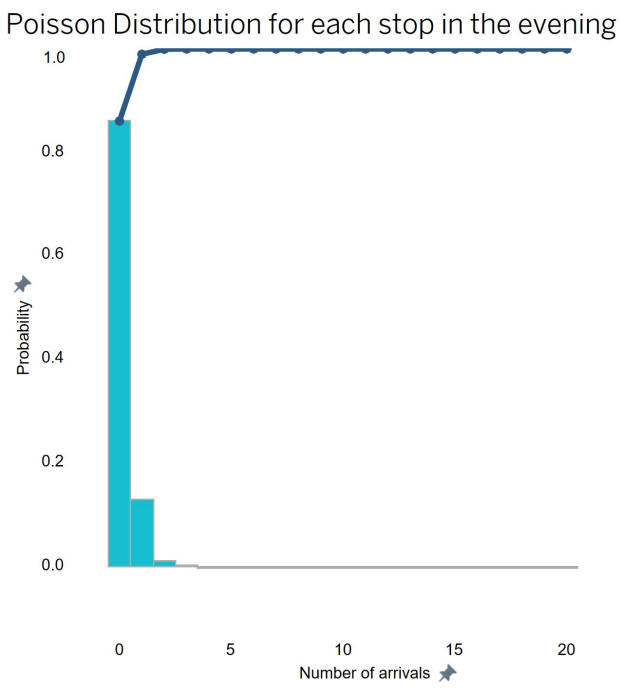
- More complex model
  - Helps capture additional nuances in operations

What can we do?

- Save Cost?
- Satisfy demands?
- Optimize resources?

Is Route E Necessary?





Considerations:

- 100% Utilisation, but only 1 bus per shift and low load
- Works for specific times which are convenient for students and workers living at Clairmont
- Can the demand currently being covered by route E be covered by any other routes?
- What is the potential effect of altering the current E Route (shorten, remove, etc.)

Thank you for staying awake!

Q&A