MATH 190: MATHEMATICS OF SUSTAINABILITY
Emory University
Spring 2026
Prof. Scott

Project # 3

Markov Chains in Public Transportation

Markov Chains are all around us. In class, we looked at many environmental networks, complex graphs, physical states, etc. as Markov chains. However, for this assignment, we will merge environmentally friendly travel with Markov chains.

Each consulting group is hired by Metropolitan Atlanta Rapid Transit Authority (MARTA) to analyze their current train system and see if they can increase business by building an extension line to the MARTA system. Each consulting group will provide the below Markov Chain analysis using real world MARTA data, and present their findings in a 3-5 page perspective and 15 minute pitch to the MARTA Board of Trustees (your classmates in Math 190).

Name	Station	Name	Station
A	Airport	**S**	Ashby
L	Lakewood- Ft. McPherson	**H**	Hamilton E. Holmes
F	Five Points	**B**	Bankhead
G	Lindbergh	**R**	Inman Park - Reynoldstown
N	North Springs	**V**	Avondale
D	Doraville	**I**	Indian Creek
C	Chamblee	**M**	Stone Mountain
T	Bolton	**P**	Panthersville
W	Windward Pkwy		

Assignment

1. **Analyze the current MARTA train lines to figure out yearly revenue**

   (a) Turn the ridership data in Table 3 into a stochastic matrix. Then using MATLAB's `dtmc` command to visualize the Markov Chain.

   (b) Determine the stationary distribution for the data by using the MATLAB Live Script notes, if it is possible, and explain what condition it violates if it's not possible.

   (c) What is the stationary distribution of trains showing up on time based on the data in Table 2?

   (d) When the train is late, riders, many of whom have somewhere to get to, tend to leave the station, not paying for the ride. Below is the data:

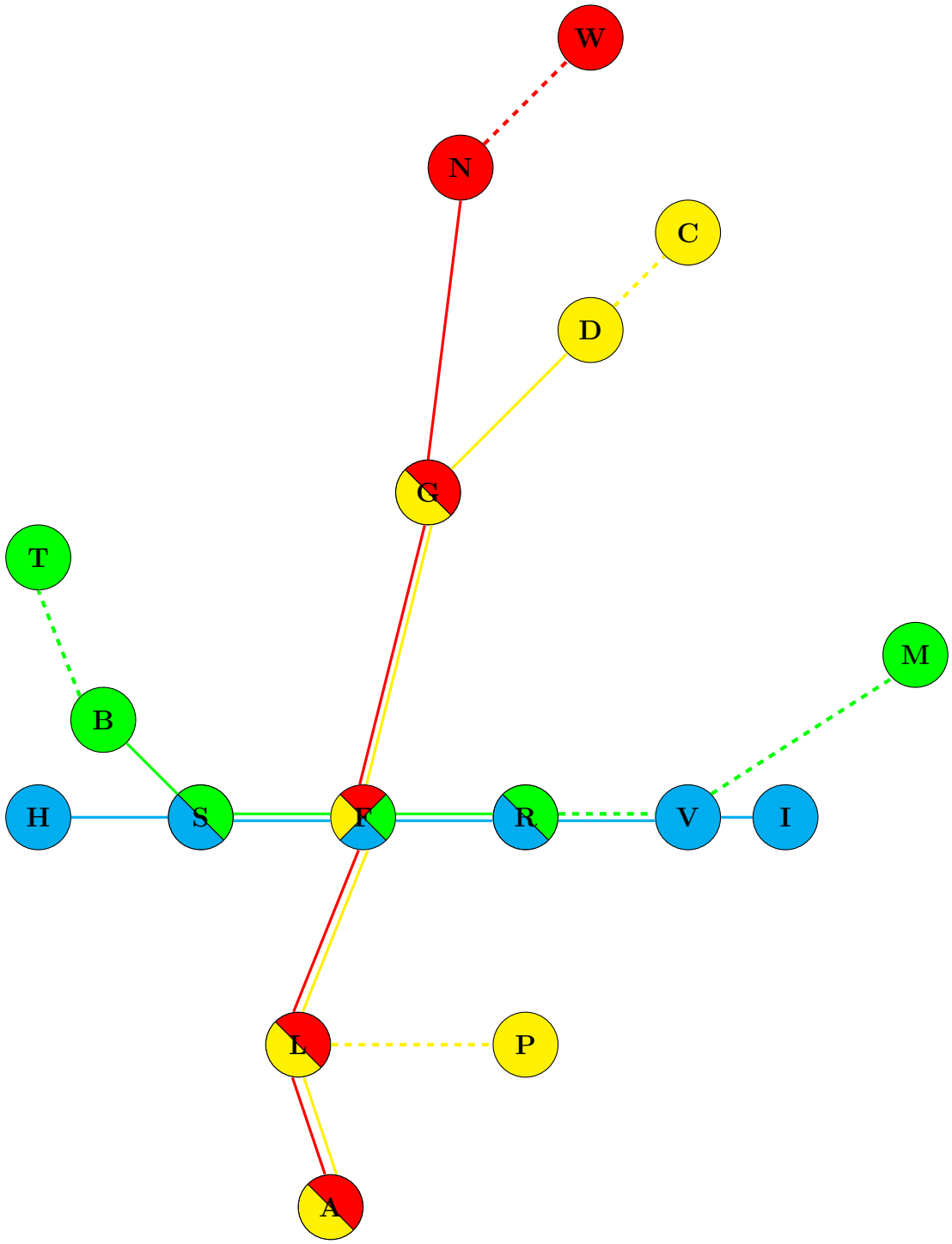

Figure 1: Depiction of the simplified MARTA system we will use as our project.

Train Timing	% of passengers leaving
On-time	0
3-5 min late	0.5%
5-10 min late	2%
10+ min late	5%

Table 1: Later trains tend to lead people to leave the station and find another way to where they are going.

Using your answer in part 1c, how much money is lost due to the trains being late? (Assume that everyone traveling pays the MARTA fare of $2.50 for a one-way trip.)

2. **Analyze the proposed extension of MARTA train lines for your group to figure out projected yearly revenue**

   (a) Based on the new extension data, make a modified stochastic matrix, and create a visualization of your Markov Chain.

   (b) Does the new MARTA system change the structure of the Markov Chain, i.e. is it periodic, connected, transient, etc?

   (c) Determine the stationary distribution for the data, if possible, and explain what condition it violates if it's not possible. How many people will use the new station.

   (d) Does this extension bring more people into the MARTA system, or will it just eat into its own profits? Use discussion from previous questions.

   (e) Using the data above, does this extension make fiscal sense? What about when we add in environmental sense?

3. **Write a 3-5 page prospectus on your project with your detailed work included.**

4. **Give a 20 minute presentation on your data. Treat it like a business meeting where your group has been asked to determine if the extension should happen. Does it generate profit, will it be work the hastle, etc?**

Data

Train Timeliness	On-time	2-5 minutes	5-10 minutes	10+ minutes
On-time	0.7	0.24	0.06	0
2-5 minutes	0.09	0.72	0.12	0.01
5-10 minutes	0.005	0.24	0.65	0.105
10+ minutes	0	0	0.15	0.85

Table 2: Data for on-time MARTA trains from 9-27-2024.

Acknowledgements

The data presented in this project is based on 2024 real ridership data provided by MARTA. Special thanks to Ryan VanSickle who provided the ridership and station data, and Paul Lopes, who provided the on-time train data.

Rubric

The rubric is a direct reflection of the learning objective for this course:

- Breaking down problems into smaller, tractable steps
- Interpreting and analyzing real world data
- Communicating technical details to a general audience
- Working on a project with people in an equitable and responsible fashion.

The last learning objective will be measured by your peers on how the work was split, performed, and communicated.
Below is the rubric that the professor will use to evaluate.

Presentation	**Points**
Delivery (13 points)	
Topical Knowledge (10 points)	
Time Limit (3 points)	
Content (12 points)	
Titles/ Headings (2 points)	
Informative (7 points)	
Cohesive Story (3 points)	
Total Presentation Points	
Report	**Points**
Content (50 points)	
Stochastic Matrix (4 points)	
Stationary Distribution - Passengers (4 points)	
Stationary Distribution - Trains (4 points)	
Revenue Computation (10 points)	
Extension Stochastic Matrix (6 points)	
Extension Stationary Distribution - Passengers (4 points)	
Revenue Computation (18 points)	
Clarity (10 points)	
Technical Communication (5 points)	
Supporting Data (5 points)	
Formatting (5 points)	
Font (1 point)	
Executive Summary (1 point)	
Page Number (2 points)	
Correct Margins (1 point)	
Total Report Points	
Presentation (25 points) **Report** (65 points) **Peer Review** (10 points) ***TOTAL PROJECT POINTS***	

Start \ Stop	**A**	**L**	**F**	**G**	**N**	**D**	**S**	**H**	**B**	**R**	**V**	**I**
A		1581918										
L	66810		179432									
F		311814		469009			113054			214147		
G			836490		121884	109804						
N				606238								
D				688018								
S			75613					11097	2607			
H							553278					
B							90242					
R			247961								59526	
V										280633		43390
I											431706	

Table 3: 2024 MARTA ridership data

Category	0: Improving	1: Good	2: Excellent	Total
Communication	Communicating with this student was difficult. It was hard to get ahold of them, and when talking to them, it was sparse and disconnected.	Communicating with this student was overall good. They were somewhat repsonsive to messaging about meeting. They were receptive to chatting.	This student was great about communicating where they were, what they needed to do, and helped make the project succeed.	
Content	This student doesn't have mastery of the content, and it slowed the project down	This student has a good grasp on the content and made accurate and correct contributions to the project	This student has mastery of the material. They clearly know what is going on, and everything they added to the project was correct and beneficial	
Workload	This student contributed very little to the content of this project. They did not pull their fair share.	This student overall did their fair share, but it did require check-ins and reminders.	This student did their fair share or more. They were willing to add more content and go above and beyond.	
Presentation	This student did a poor job presenting the material, either from reading off the slides, not knowing the material, etc.	This student presented well. They knew what they were talking about and were engaging.	This student showed mastery in presenting. They laid out a wonderful narrative arc and were very engaging.	
Attitude	This student had a poor attitude about the project. It made working with them uncomfortable.	This student had a positive attitude and made this project fun.	This student had a wonderful attitude. They were really excited, interested, and motivated to help.	
Peer Review Points				