Welcome to CVL851: Special Topics in Transportation Engineering-Transportation Network Optimization

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IIT Delhi

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First of all

Happy New Year!

Outline

Course information

- Meeting time: M and Th Slot A 8-9:30 A.M (Try to be on-time!)
- My office: 322, Block-IV
- Office hours: M 2:30-3:30 or appointment by email
- Email: pkk@iitd.ac.in. Include "CVL851" in the subject line

What is this course about?

Introduction to network optimization techniques, which includes

- Basics of network modeling
- Linear Programming
- Dynamic Programming
- Network flow algorithms
- Integer Programming
- Non-linear Programming

Applications from transportation and other fields will be taught.

Outline

Routing in highway networks

Which path is the shortest path from IIT Delhi to Nizamuddin Railway Station?

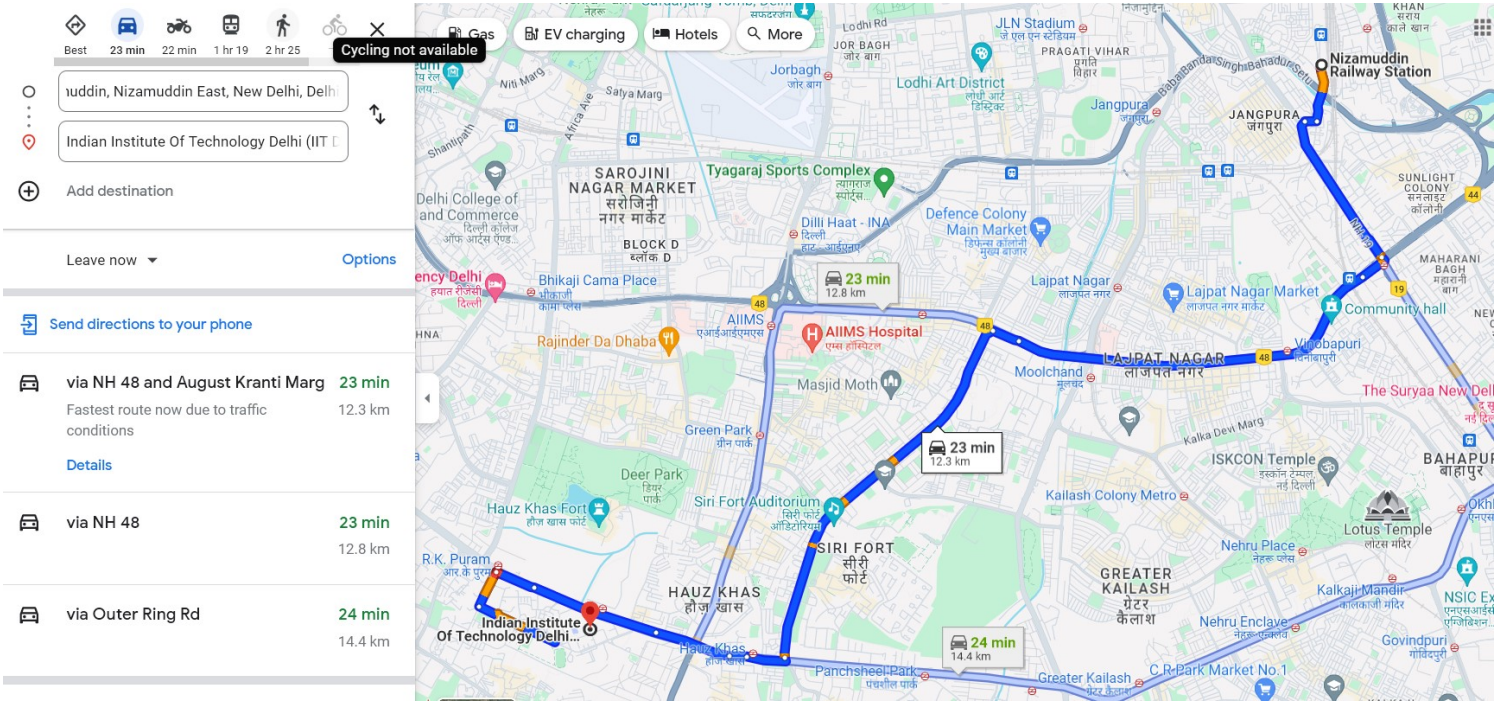

Figure: Shortest path from IIT Delhi to Nizzamuddin Railway Station (Source: Google Maps)

Shortest path algorithms can help.

Traffic assignment

How would you assign travelers going between different geographic locations to the highway network so that you know traveler flow and travel time on each link?

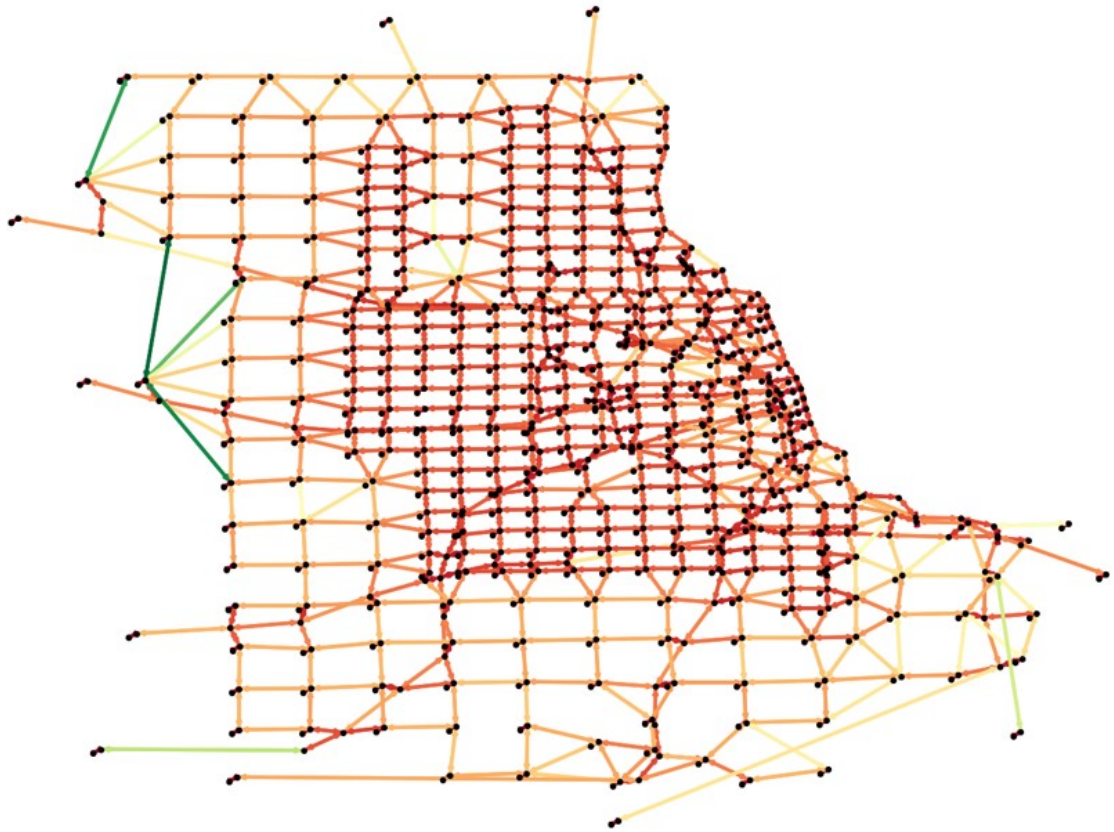

Figure: Travel time on Chicago sketch network

Non-linear programming can help.

Transit assignment

How would you assign passengers going between different geographic locations to the network of buses and trains so that you know passenger loads on routes and passenger waiting times?

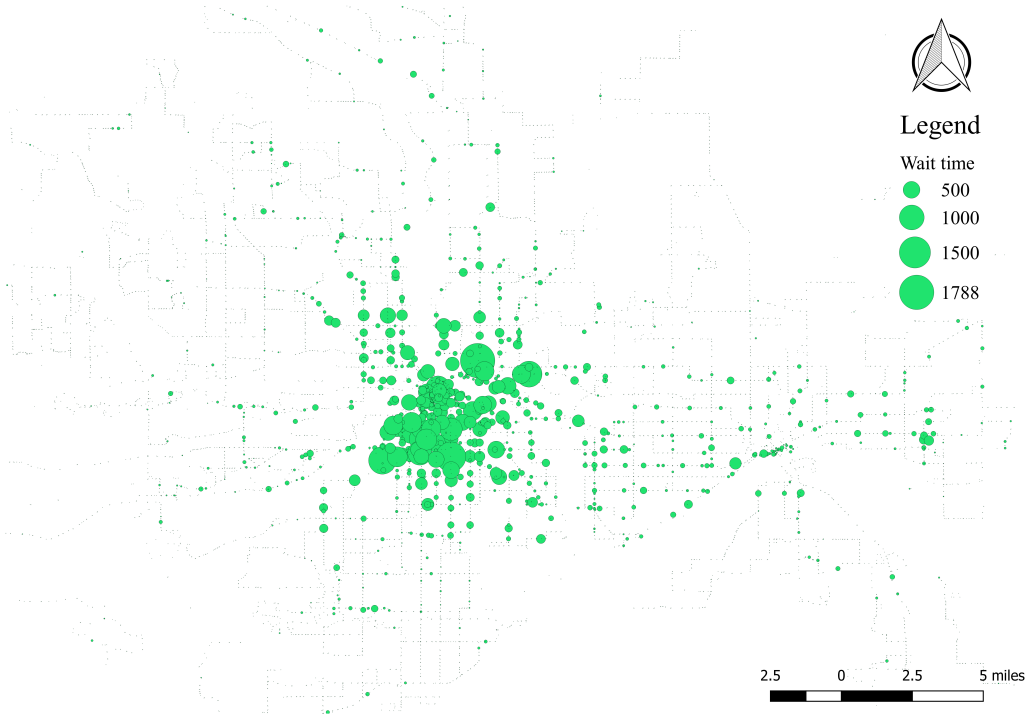

Figure: Peak hour passenger wait time (pass-min) in Twin Cities transit network

Linear programming can help.

Ridesharing

How would you match drivers and riders for ridesharing?

Figure: Rider and driver (Source:Forbes)

Matching algorithms can help.

Vehicle Routing Problem (VRP)

What is the optimal set of routes for a fleet of vehicles to traverse in order to deliver to a given set of customers?

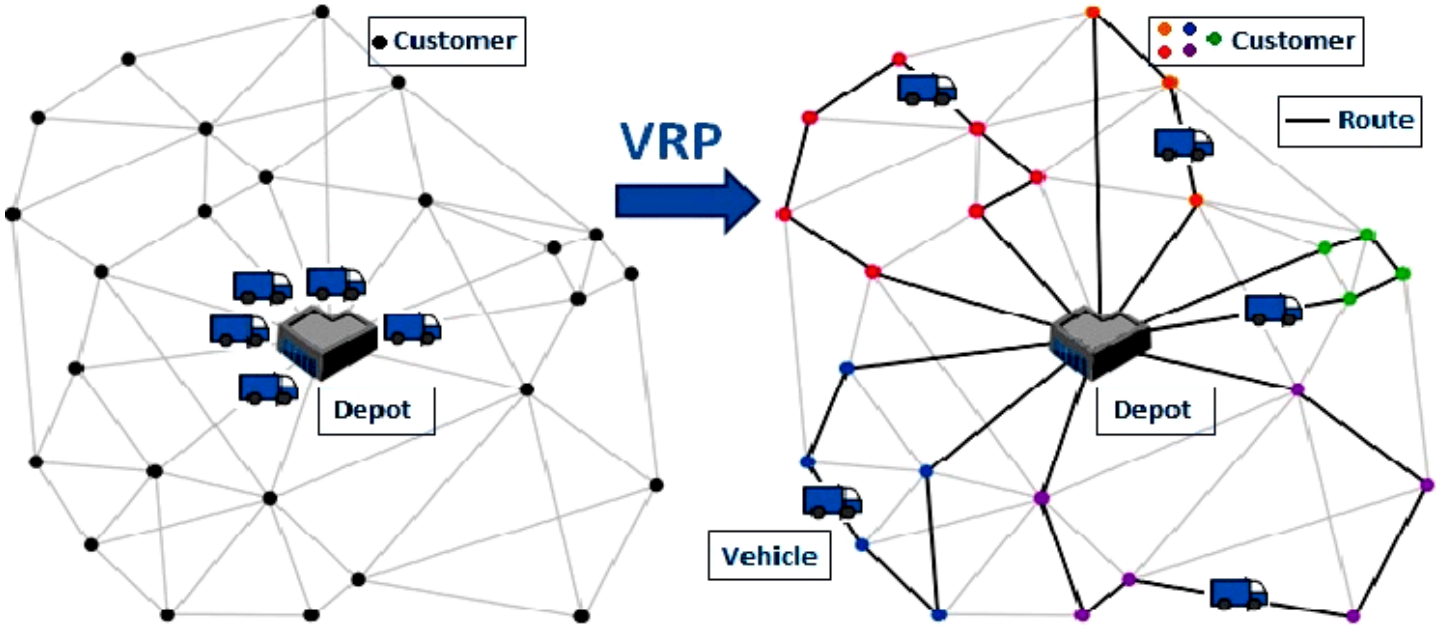

Figure: Deopt, Customers, and Vehicle routes (Gupta et al.)

Integer/Dynamic Programming can help.

Maximum flow problem

What is the maximum number of bogeys manufactured in Detroit that can be shipped to a warehouse in San Francisco if there is a limit on how many compartments can be shipped across each link of the train network?

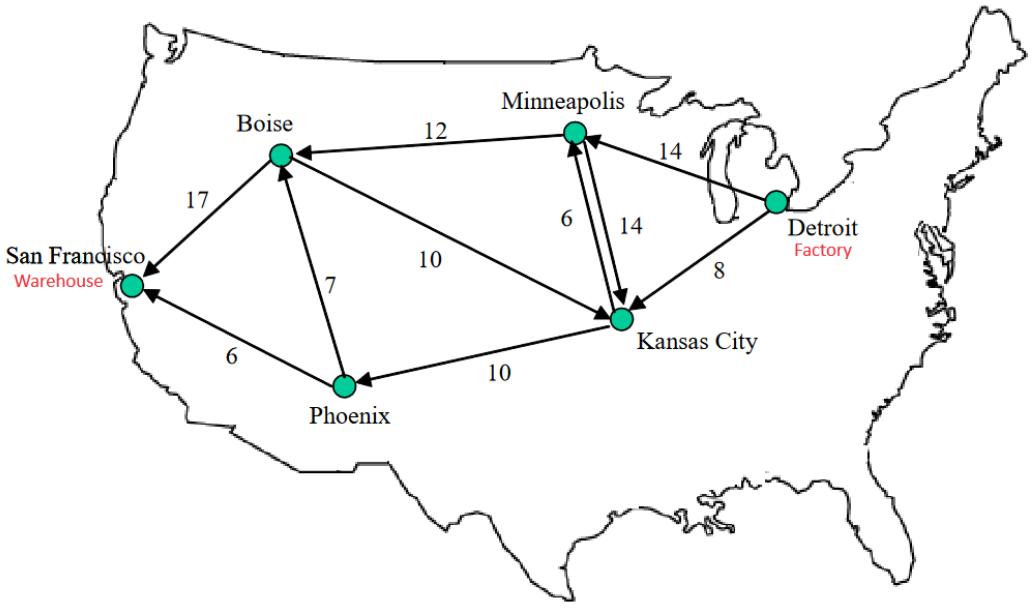

Figure: Golf cart shipping
(Source: https://ieda.ust.hk/dfaculty/ajay/courses/ieem101/lecs/graphs/graph-maxflow.pdf)

Max flow algorithm can help.

Supply chain management

Figure: Supply chain (Source:TeamViewer)

Integer programming can help.

Outline

Student learning expectations

- Modeling transportation network flow problems
- Solving standard network flow problems
- Formulating and solving linear programs and applying duality theory
- Formulating integer programming problems
- Formulating nonlinear programming problems
- Using computer programming packages available for optimization

Outline

Prerequisites

- Linear algebra
- Calculus
- Compute Programming

Outline

Grading

1. In-class exercises (10%)
2. Homework assignments (20%)
3. Minor exam (15%)
4. Major exam[1] (25%)
5. Class Project (30%)

[1] Major exam will be cumulative

In-class exercises

- I'll ask you to work on some in-class exercises.
- You are encouraged to discuss these with your peers.
- Please submit your exercise sheet right after the class ends.

Homework assignments

- Submit them through Moodle.
- Late submission of assignment will be allowed up to two days after the deadline. For each day, there will be a penalty of 25% deduction in points.
- You may discuss it with your peers but you should submit your solutions individually.
- I take copying and plagiarism very seriously. So please don't do it! Please refer to the syllabus and honor code available in Courses of Study for more details.

Course Project

More details to follow.

Auditing the course

To get an NP grade

- You need to attend at least 75% of classes
- You need to earn at least 30%(aggregated) of total marks.

Outline

Reference books

1. [VR] Vanderbei, Robert J., Linear Pogramming: Foundations and Extensions, Springer Fifth Edition, 2020. [Link]
2. [AMO] Ahuja, R., Magnanti, T., and Orlin, J., Network Flows: Theory, Algorithms, and Applications, Pearson, 2014. [Free PDF copy].
3. [BV] Boyd, Stephen P., and Lieven Vandenberghe. Convex optimization, Cambridge university press, 2004. [Free PDF copy]
4. [CLRS] Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, Introduction to algorithms, MIT press, 2022. [Link]

Thank you!