Lecture Notes for CSCI 311: Algorithms

Set 1-Intro

Professor Talmage
Based on *Introduction to Algorithms* by Cormen, Leiserson, Rivest, Stein

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1 Motivating Exercise

Exercise:

In the last few years, global production capacity for integrated circuits has been strained, as demand exceeded capacity. This was aggravated by a few factors, such as the COVID-19 pandemic and droughts in Taiwan (where much, if not most, of the world's chip production capacity is). Suppose you are managing a new integrated circuit fabrication plant (a "fab"). Demand for your services is high, and you need to choose which contracts you will accept. Suppose you have capacity for 10 million units per year, and you have the following bids to choose from:

1. Grampa's Radio Parts: [10 million units, $3.5million]
2. Gogo Motor Company: [2 million units, $4million]
3. Yottahertz Motherboards [4, $3]
4. Thingamajig Home Automation [7,$10]
5. Hedgehog Audio Systems [.5, $7]
6. Blinkin' Flashlights [2, $4.7]
7. Krusnemghaha Flight Systems [0.7, $1.6]
8. Fresh Lawn Equipment [4, $7]
9. Bill's Trinkets [1, $5.7]
10. Alice's Messaging [3, $3.3]
11. Eve's Microphones [8, $7]
12. Overloud Toy Company [4, $7.8]
13. Water is Wet Pool Supply [10, $9.5]
14. Diggem Mining Co. [8, $.3]
15. Big Games [1, $4.8]
16. Yoinkin' Yo-Yos [10, $6.2]

Exercise, continued

(1.) Choose a set of contracts which will yield the highest revenue.

- Some possible solutions:

Items	Chips	Value
$[5, 9, 15, 6, 7, 2, 12]$	11.2	X
$[5, 9, 15, 6, 7, 2]$	7.2	27.8
$[5, 9, 15, 6, 7, 12]$	9.2	31.6
$[12, 8, 2]$	10	18.8

(2.) The board doesn't like that you are idling the fab X% of the time. Find a different schedule that doesn't idle the fab, or convince the board that your plan is better–you make more money by not working.

(a) How long does it take you to convince the board? (How many possible sets of contracts are there?)

(b) Suppose that idling the plant causes machines to break down. How much cost for repairs can you sustain before you need to adapt the schedule? How do you know?

(3.) You took too long to decide and the following bids have been withdrawn, going to your competitor. Come up with a new set of contracts to maximize profit and minimize idle time.

5. $[.5, \$7]$
7. $[.7, \$1.6]$
12. $[4, \$7.8]$
15. $[1, \$4.8]$

(a) How can you do this faster?

(b) How can you still convince the board that your selection is optimal? Recall that they have their own biases and preferred customers, so you need an ironclad justification for your selection.

(4.) What are some external ways you could solve the problem?

- Splitting contracts (accepting fractions of the work customers need done)
- Actively recruiting new customers
- What other ideas do you have?

(5.) What are some factors we're not considering in this analysis? How might you adapt your solution to account for those factors?

- Different products may have different materials costs. (Can hide by subtracting from the bid price.)
- Different products may take more/less time to fab. (Can hide by listing more expensive parts as multiple units each.)
- Other ideas?

A large part (sometimes the largest part) of solving algorithmic problems is *framing*–how you set up the problem, reduce it to a precise definition, and which aspects you set aside.

- How do you represent what you need to do in a way that you can treat formally? That is, how do you get from the idea of a problem to a representation to which you can apply algorithms?
- What if it is slightly different than the algorithmic techniques you know? Should you tweak the algorithm or the representation?
- Having called out its importance, we will not spend a huge amount of time this semester talking about framing. This course's primary intent is to teach you the algorithmic techniques you need to know to solve interesting problems. If you do not know any algorithmic techniques, you cannot frame a problem in relation to those techniques. If you are ever unsure why we are learning a particular technique, ask yourself (and me) what type of problem could use this knowledge.

The exercise we just went through is an example of an *optimization problem* which we will address more fully in a few weeks. These problems show up in our daily lives all the time. We "solve" small versions in our heads easily, but formally and verifiably finding optimal solutions to large versions is actually quite complex and will run us into some of the boundaries of what is computationally feasible.

2 Administrivia

Some notes on the syllabus and the expectations in this course:

- Office Hours. Listed in the syllabus, check there for changes. Should also be publicly visible on my google calendar. Reach out (email me) if you need to meet at another time.
- Communication:
  - Email is primary. Check yours! If sending me a class-related message, make sure to include "CSCI 311" in the subject line so that it is properly sorted. Otherwise, I am more likely to forget to respond when it gets buried.
  - I'm happy to answer small questions over Discord, though larger questions are better in person or over email.
  - I will generally respond fairly promptly during working hours, though sometimes I am in class, a meeting, office hours, etc. and will get to it when that is over. Do not expect a response in the evening or over the weekend. If I am working during those times, I may respond, but I will most likely leave it until the next working day.
- Accommodations: OAR, religious, athletic, etc. please inform me ASAP of needs or conflicts.
- Attendance: I expect you to be in every class, and to interact both with me and with each other. Your engagement is a significant portion of your grade. The exception is that you should not come to class if you are sick. Rest up, get well, and reach out to me to catch up on any missed material.
- Assignments:
  - Homework: Weekly, due Wednesday night at 11:59PM.
    - This is where you cement knowledge, by working hard to use it.
    - You can work alone or in a group. If you work in a group, submit only one copy, and be sure that everyone's name is both on the assignment and is added to the gradescope submission. If you work in a group on only some problems, credit the entire group on that problem in your writeup.
    - 10%/day late penalty, max two days.
    - Typeset your solutions with LaTeX. Recitation this week will get you up and running. Also, ask me and others in the class for help.

    - Grading: I will choose one problem per week on which I will provide full feedback. The other problems will be graded on a 0/1/2+ completion/completeness basis.
- Quizzes: Weekly, posted Friday afternoon, due Monday night at 11:59PM. 30 minutes on gradescope.
    - High-level checks that you are keeping up with material from class that week.
    - Must be entirely solo!
    - Each question is one point, no partial credit. For each question you get wrong, do the same-number problem on the retake available during the next week.
    - No late submissions.
- Projects: 2 Programming projects, assigned groups, announced later. These allow you to apply some of the course's main topics in a real-world problem.
- Four exams. Planned for approximately Feb. 14, Mar. 28, Apr. 18, though these dates are likely to change. Our final is Friday, May 9 (8-11AM).
- Recitations: Interactive, group-based problem solving sessions. You will not submit anything, your grade is based on participation. Show up ready to work, as time is limited.