CS 577 - Introduction to Algorithms

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University of Wisconsin – Madison

Summer 2023

TopHat Section 001 Join Code: 275653

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

CS 577 - Introduction to Algorithms: Summer 2023

Analysis of Algorithms

Problem

- Mathematical model of the problem area.
- Rules of the game.

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- Ex: I have kitchen with a stocked pantry and I want a cookie.

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- Ex: I have kitchen with a stocked pantry and I want a cookie.

Algorithm

- Step-by-step procedure for solving an *instance* of a given problem.

- Ex: Given a kitchen with a stove, etc... and a pantry with chocolate chips, etc...

Chocolate Chip Cookies

Ingredients:

- 227g (1 cup) butter, softened
- 200g (1 cup) sugar
- 105g (½ cup) brown sugar
- 2 eggs
- 2 tsp vanilla
- 250g (2 cups) all-purpose flour
- 1 tsp soda
- 1 pinch salt
- 1 ½ cups of chocolate chips

Instructions:

1. Beat butter, sugars, eggs and vanilla until light and fluffy.
2. Add flour, soda, and salt; blend well.
3. Add chips.
4. Drop from a teaspoon 2 inches apart.
5. Bake 190°C for 9 min.

Stable Marriage Problem (SMP) (1962)[1][2][3]

Problem Definition

Given a set of n men, M, and an opposite set of n women, W. Each person has a preference ranking of the opposite set. Compute a stable matching between M and W. A matching is stable if it is (i) perfect, and (ii) there are no pairs (m, w) and (m', w') in the matching where m prefers w' and w' prefers m.

[1] Algorithm Design, Ch 1.
[2] Algorithms, Ch 4.5
[3] `http://mathsite.math.berkeley.edu/smp/smp.html` (Uses Flash)

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- A.k.a Stable Matching Problem.
- There are more complicated variations of the model.
- Used in the real world (e.g. matching doctors to hospitals).
- Nobel Prize in Economics in 2012 (Shapley and Roth).

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Gale-Shapely Algorithm [4] for SMP (1962)

Initially all $m \in M$ and $w \in W$ are free
while *there is a man m who is free and hasn't proposed to every woman* **do**
    Choose such a man m
    Let w be the highest-ranked woman in m's preference list to whom m has not yet proposed
    if *w is free* **then**
        (m, w) become engaged
    else w is currently engaged to m'
        if *w prefers m′ to m* **then**
            m remains free
        else w prefers m to m'
            (m, w) become engaged
            m' becomes free
        end
    end
end
return *the set S of engaged pairs*

[4] Algorithm Design, p.6

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- Correct?

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Is it good?

- Complete?
- Correct?
- Efficient? With respect to what (time, space, ...)?

[4] Algorithm Design, p.6

About You

My current year in school is:

a. Freshman
b. Sophomore
c. Junior
d. Senior
e. Graduate Student
f. Other

About You

I took CS 200 with:

a. Marc Renault
b. Jim Williams
c. Summertime instructor
d. Skipped straight to 300 (AP, etc)
e. Other

About You

My primary reason for taking CS 577:

a. I am very interested in the subject.
b. I am curious to learn more about the subject.
c. It fulfils a requirement for my program, major or certificate.
d. It fits my schedule.
e. I've heard good things about the course.

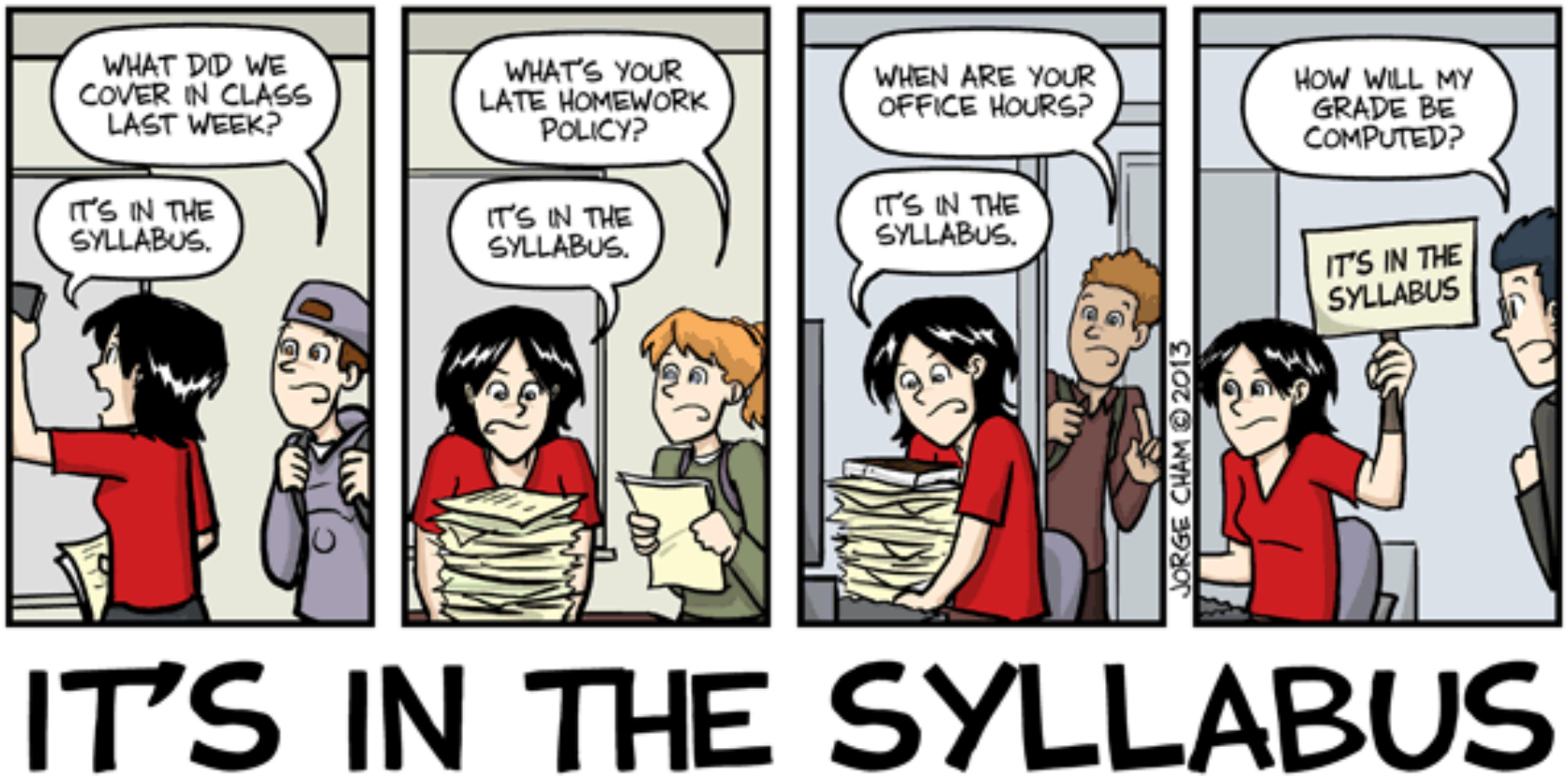
About You

My favourite Star Wars movie (from the trilogies) is:

a. I - The Phantom Menace
b. II - Attack of the Clones
c. III - Revenge of the Sith
d. IV - A New Hope
e. V - The Empire Strikes Back
f. VI - Return of the Jedi
g. VII - The Force Awakens
h. VIII - The Last Jedi
i. IX - The Rise of Skywalker
j. Never seen them

Syllabus (Course Logistics)

https://canvas.wisc.edu/courses/349716



Course Aim

https://canvas.wisc.edu/courses/349716

Overall

- Basic paradigms for the design and analysis of efficient algorithms:
  - greedy,
  - divide-and-conquer,
  - dynamic programming,
  - reductions, and
  - the use of randomness.
- Computational intractability including typical NP-complete problems and ways to deal with them.

Course Aim

https://canvas.wisc.edu/courses/349716

Specific Learning Outcomes

- Design and analyze efficient algorithms based on the paradigms of divide-and-conquer, dynamic programming, and greed.
- Formulate abstractions of computational problems, and design and analyze efficient reductions between computational problems.
- Know, understand, and apply paradigmatic algorithms and reductions dealing with numbers, strings, graphs, and networks.
- Recognize computational intractability, demonstrate NP-hardness, and understand its repercussions.

Getting Started

Getting Started Checklist

https://canvas.wisc.edu/courses/349716

Checklist

1. Review the Syllabus
2. Activate Piazza account
3. Register for Gradescope
4. TopHat Registration
5. Exam Conflicts
6. OPTIONAL: Sign up for the zyBook

2. Activate Piazza Account

`http://piazza.com/wisc/summer2023/cs577`

Access code: 001002

Online question resource

- One discussion area for all sections.
- Interaction of students, TAs and instructor.
- First stop for getting questions answered.

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Rules

- Be courteous.
- Don't post answers to homework!
- Search first, post second.

3. Register for Gradescope

How to Register

1. Go to:
   `https://www.gradescope.com/`
2. The entry code is V5YNB2.
3. Use your wisc.edu email address!

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Submission, Testing, and Grading Tool

1. For each assignment, you will upload a pdf of the assignment (and code if there is a coding portion).
2. Once uploaded, you will get some autograder feedback if there is a coding portion.
3. No submission limit or delay.
4. Human-grading will also happen via Gradescope.

4. TopHat Registration

TOP HAT

Section 001 Join Code: 275653

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In-class participation

- Facility classroom participation.
- Participation grade (5%) – Participation not correctness.

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- 80% rule.

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In-class participation

- Facility classroom participation.
- Participation grade (5%) – Participation not correctness.
- 80% rule.
- Will have 1 week to answer questions.

5. Exam Conflicts and Accommodations

Conflicts and Accommodations (by week 3)

- During class time: Wednesday, Jul 12, 2023 @ 9:30AM to 11:30AM
- via Canvas and Honorlock with active proctoring
- By week 5, enter your conflicts or accommodations into the following Google form:
  `https://forms.gle/B8KB2rK588p2xVv69`

6. OPTIONAL: Sign-up for the zyBook

zyBook Bonus

- 5% possible bonus points:
  - 2% bonus points for completing all particiption activities by Jul 11, 2023 @ 23:59.
  - 3% bonus points for completing designated exercises by Jul 11, 2023 @ 23:59. Submitted to Gradescope and graded based on participation like homework.
  - Will get credit for percentage completed.
- This is OPTIONAL - there are no extensions or 80%. This is not required to earn full marks.
- Go to `learn.zybooks.com` and use code WISCCOMPSCI577RenaultSummer2023.
- Cost is $58.

1. Review the Syllabus

Grading

- Participation (25%)
  - TopHat Questions (5%)

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Grading

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  - TopHat Questions (5%)
  - Discussion Participation (5%)

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Grading

- Participation (25%)
  - TopHat Questions (5%)
  - Discussion Participation (5%)
  - Assignments (15%)
    - 7 assignments in total (due Tuesday 23:59)
    - Graded on participation not correctness!
    - Participation credit requires a reasonable attempt to answer a question.

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Grading

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  - Discussion Participation (5%)
  - Assignments (15%)
  - All have the 80% rule

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Grading

- Participation (25%)
  - TopHat Questions (5%)
  - Discussion Participation (5%)
  - Assignments (15%)
  - All have the 80% rule
- Quizzes (30%) [See syllabus for dates.]
  - 30 minute Canvas quiz (honorlock); weeks 2 through 7 open from Wed 16:30 to Thur 16:30.
  - Let a be an array (0 based indexing) containing your 6 quiz scores, in order, from highest to lowest.

    $$\text{Quizzes score} = a[0]\cdot 15 + a[1]\cdot 8 + a[2]\cdot 4 + a[3]\cdot 2 + a[4]\cdot 1 + a[5]\cdot 0$$

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Grading

- Participation (25%)
  - TopHat Questions (5%)
  - Discussion Participation (5%)
  - Assignments (15%)
  - All have the 80% rule
- Quizzes (30%) [See syllabus for dates.]
  - 30 minute Canvas quiz (honorlock); weeks 2 through 7 open from Wed 16:30 to Thur 16:30.
- Exam(s) (45%)
  - Wednesday, July 12, 2023 @ 9:30AM to 9:45AM (45%)

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Flexibility Built-in for Everyone

- 80% rule for Participation.
- Generous quiz aggregation.

Course Expectations

Doing less than 80% of the assigned discussions, classes, and assignments risk: altering the knowledge and skills of the course, lowering the academic standards, and fundamental altering the nature of the course.

- We expect every student to attend lectures, discussions, submit all homework, and do all the quizzes.
- The flexibility is provide because life happens NOT because we expect students to only do 80% of the work or skip quizzes.

1. Review the Syllabus

Bonus Points

- Bonus calculations are as is. No extensions, flexibility, or exceptions.
- zyBook (5%):
  - 2% for participation activities.
  - 3% for designated exercises (see assignment on Canvas).

1. Review the Syllabus

Academic Integrity

- Academic dishonesty or misconduct is taken very seriously by the university (see UW–Madison Academic Integrity policy).
- It is academic misconduct to submit someone else's work as your own.
- It is academic misconduct to help another student commit academic misconduct.

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Peer Help on Assignments

- You may not email, post on Piazza, or otherwise make solutions (or part of) available for others.
- Process:
  - If you receive or give help on an assignment, be sure to cite them.

Textbooks (optional)

- **Kleinberg, and Tardos. *Algorithm Design*. Addison Wesley, 2006.** Main textbook for 577.

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- **Cormen, Leiserson, Rivest, and Stein. *Introduction to Algorithms, 3rd Edition.* MIT Press, 2009.** Now with C-style pseudocode! The classic (presumable because it was the textbook I used in my intro to algorithms course) introduction to algorithms textbook.

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- **Sedgewick, and Wayne. *Algorithms, 4th Edition* Pearson, 2011.** Another introduction to algorithms textbook with working Java code.

Getting Help

Getting Help

https://canvas.wisc.edu/courses/280151

Help!

- Piazza Online Discussion
- Weekly Discussions
- Weekly Study Groups on Specific Topics (Watch Piazza for sign-ups)
- TA Office Hours
- Instructor Office Hours

Appendix

References

Image Sources I

https://tophat.com/

https://piazza.com/

https://brand.wisc.edu/web/logos/

http://bigpicture.typepad.com/comments/images/2008/07/14/dont_panic.png

http://phdcomics.com/comics.php?f=1583

Image Sources II

https://www.linkedin.com/company/gradescope/