

CS 3100

Data Structures and Algorithms 2

Lecture 26: Finale

Co-instructors: Robbie Hott and Tom Horton
Fall 2023

Announcements

- Upcoming deadlines
 - PS5 (Max Flow, Reductions, ML), due tonight at 11:59pm
 - PA5 (Tiling Dino) due tonight at 11:59pm
- Interested in being a TA?
 - Fill out form sent out yesterday
- Quiz 5 (and Quiz 1-4 Retakes) on December 12, 2023 at 7pm
 - In our normal room
 - Final Exam conflict form – see announcement on Canvas
 - Only if you have an exam scheduled *at the same time* as our Quiz + Retakes
 - If you are an SDAC student, please schedule with them ASAP

Today's Agenda

- Review of Topics for Quiz 5
 - Can generative AI help us review one of our reductions?
- Quiz Re-takes
 - Info about format, the process, etc.
 - Review of some problems on previous Quizzes 1-4
- Q&A on grading issues
- Discussion of a scenario related to algorithms, ethics and professional responsibility
- A look back on what you've learned in CS3100

Research Consent Form



<https://bit.ly/Consent6064>

Quiz 5 Review

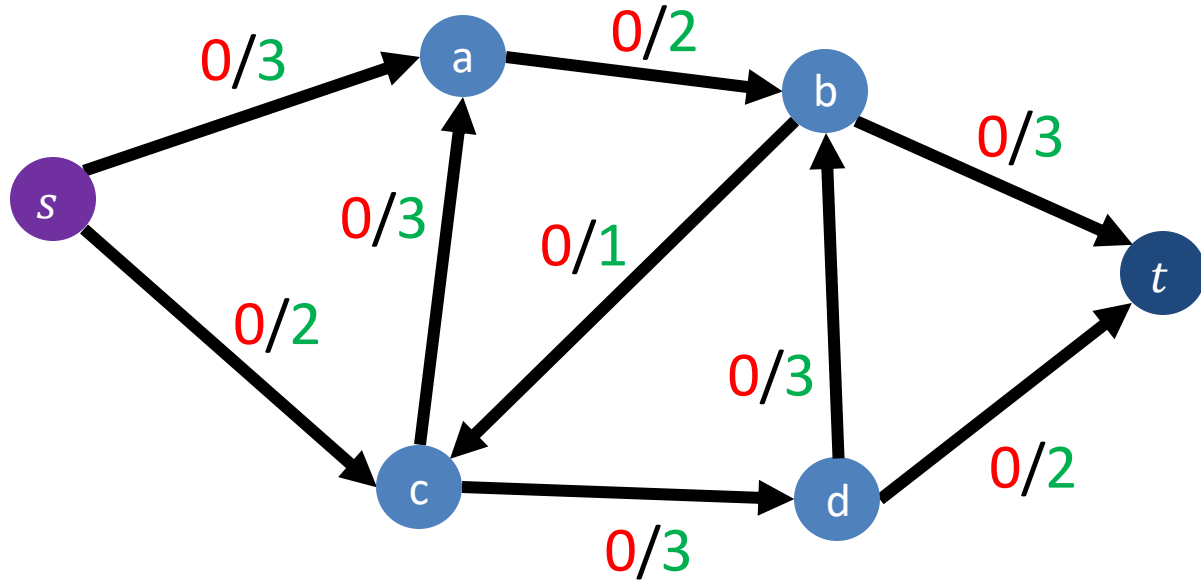
Quiz 5 Review

- Topics list posted on course website
- No quiz questions on last two problems on PS5
- Questions on ML lectures
 - We gave you an overview, so our questions will address high-level concepts
 - We may ask questions to see if you understand the **strategies** for k-means clustering and k-nearest neighbors (but not the **details**, and nothing on time-complexity of these)

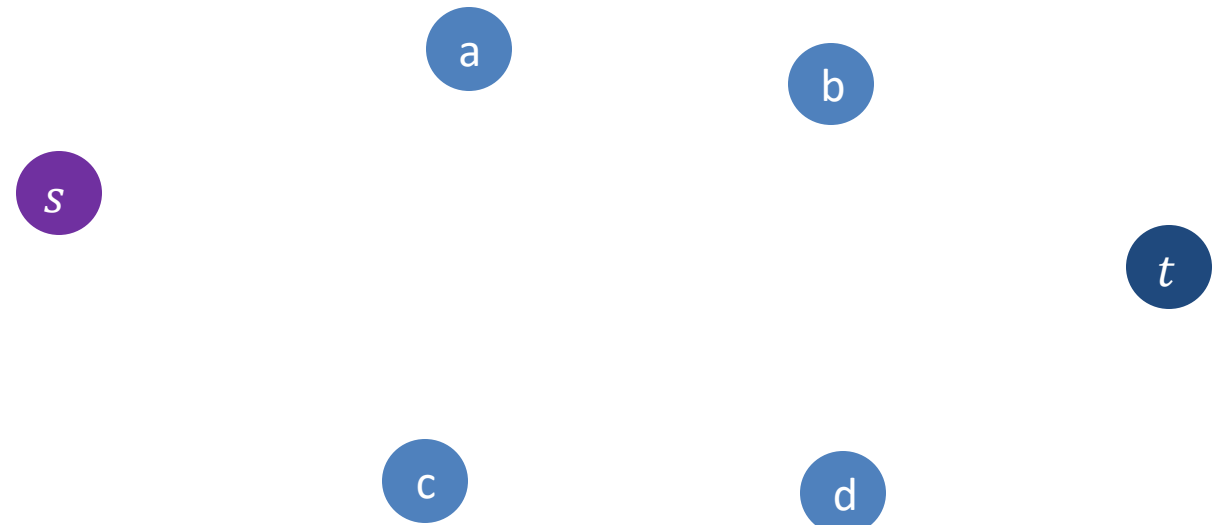
Quiz 5 Review: Network Flow

Do We Need to Work with an Example?

Flow graph G

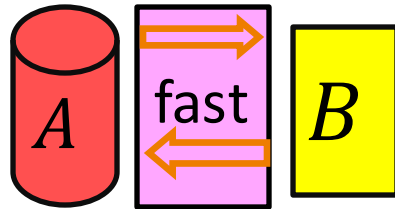


Residual graph G_f

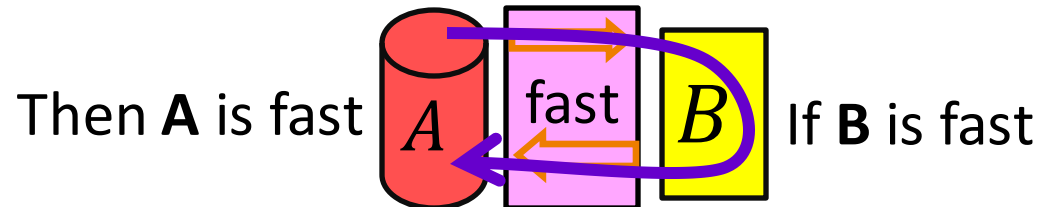


Reminders about Reductions

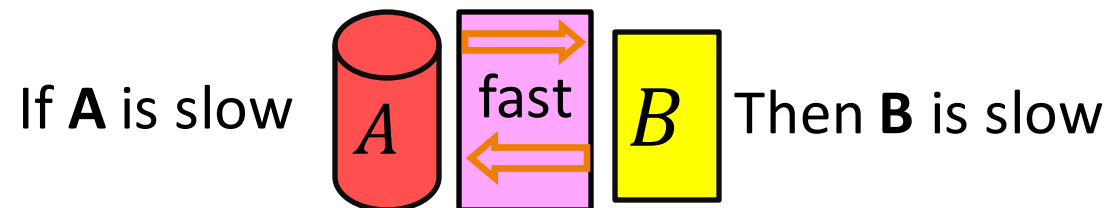
Suppose we have a “fast” reduction from **A** to **B**



1. A “fast” algorithm for **B** gives a fast algorithm for **A**

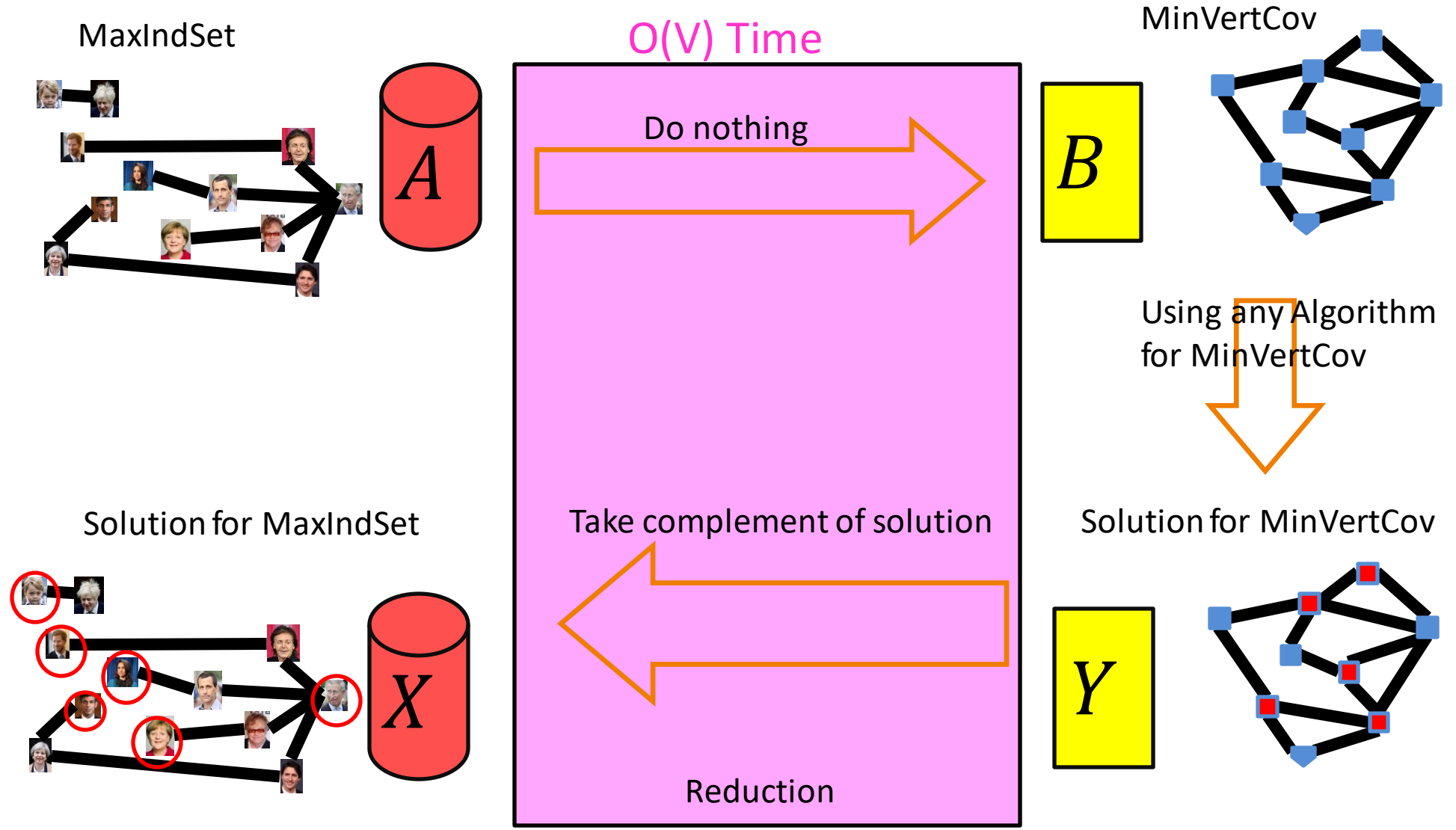


2. If we have a worst-case lower bound for **A**, we also have one for **B**



Quiz 5 Review: Reductions

Example/Reminder: MaxIndSet V -Time Reducible to MinVertCov



Generative AI and this Reduction

- **Prompt:** As a computer scientist, prove that the maximum independent set problem reduces to the minimum vertex cover problem
- Let's see responses by some AI tools here:
<https://bit.ly/cs3100-genai-1>
- Try this prompt yourself with an AI tool!



Quiz Re-takes

Final Exam Period

- Quiz 5 will have same format and length as previous quizzes
 - Designed to be completed in 35-40 minutes or less
- Each re-take for Quiz 1 through 4
 - Designed to be completed in 20-25 minutes or less
 - Roughly half the length of earlier quizzes
 - One sheet each
 - One “bigger” problem and one or a few shorter problems
- Total time needed: maybe 115-140 minutes, so we’ll give you 2.5 hours (150 minutes)

Info and Updates on Grading

Grading Progress and Updates

- Still to be done
 - Regrades on various PSs, etc
 - PS5 and PA5, of course
 - Goal: all done and posted by Tuesday morning, Dec. 12
- One adjustment to PA scoring
 - PA1's average was lower than others. Many of you adjusted well after!
 - A grading adjustment (on all PAs, including PA5)
 - To recognize time and effort that didn't work out
 - Those who submitted 2 or more times but had a 0 now will get a 30
 - Those who got a 30 will now get a 50

A Scenario for Discussion

Your company MegaRouting* makes popular mapping software RouteMe* that's used in cars and on phones. A proposed new version will

- Find best routes based on combination of fastest path while also avoiding dangerous neighborhoods or parts of town
- Scoring for “danger” will be based on
 - Initial ratings by people hired to evaluate neighborhoods
 - Later updated by crowd-sourcing: users can enter a rating for any location

* These names are intended to bear no relation to any company or app!

Any Issues? Red Flags?

- Can you see any unanticipated consequences that might develop over time?
 - Any suggestions for how to avoid or mitigate those?

- The RouteMe app also shows gas stations, restaurants, etc. along the routes
 - What's shown may be influenced by those who pay for ads
- Does this add any complications?

Looking What You've Achieved in CS3100

And some things we've learned too

Department's Student Learning Outcomes for CS3100

- Understand and implement more advanced data structures, including (but not limited to) graphs and sets (e.g., find-union). Students will be able to analyze the asymptotic complexity of the operations of these structures and use them to solve problems.
- Understand a variety of problem solving paradigms such as dynamic programming, divide-and-conquer, and greedy algorithms. Students will be able to implement a variety of algorithms, including Breadth-First (and Depth-First) Search, Dijkstra's algorithm, Ford-Fulkerson, and others.
- Analyze a new problem and select an appropriate problem-solving technique. Students will be able to construct an algorithm to solve the problem, prove the correctness of their algorithm, and analyze the asymptotic behavior of the algorithm.
- Analyze behavior of algorithms with recursive, and other more advanced properties. Solve recurrence relations for their closed form either manually or via the Master Theorem. Prove both upper and lower bounds on the behavior of such algorithms.

Dept's List of Topics to Be Covered in CS3100

- Graphs - Definition and Operations
- Selection of Graph Algorithms.
Instructor chosen, but might include:
 - Dijkstra's Algorithm / Proof
 - Flow Networks
 - Min-Cut and Flow-Value
 - Find-Union data structure, Kruskal's Algorithm
- Divide-and-Conquer
 - Recurrence Relations
- Greedy Algorithms
- Dynamic Programming
- Comparisons of Difficulties of Problems through Reductions
 - Can be between problems in P, or involve a discussion of NP
- Introduction to Machine Learning
 - Overview of ML (training vs. test data, ML process, etc.).
 - Overview of algorithms
 - Ethics of Machine Learning

Highlights from our Journey

- Graphs
 - You know an important data structure that models many problems
 - You've seen a rich set of algorithms and algorithm design approaches that apply to graph problems
- Reasoning about Algorithms
 - You know many time-complexity issues
 - Including exponential vs. polynomial complexity
 - You can analyze an individual algorithm and also recognize patterns (e.g. what you learned in the divide and conquer section with the master theorem)
 - Correctness: you're better at making informal arguments and formal proofs
- Reasoning about problems
 - You've started to learn how to make arguments about a problem's lower bounds
 - Prove something about any algorithm that could solve a given problem

Highlights from our Journey

- You've learned about algorithm design strategies
 - **Search** in graphs
 - **Divide and Conquer**
 - Optimization problems: **Greedy** and **Dynamic Programming**
 - **Network flow** and related problems
 - And one example of **iterative refinement**: k-means clustering
- You've had an overview of an important “new” area in computing: Machine Learning

You've Come a Long Way!

- All of this is a significant advance from what you knew at the end of CS2100
 - Yes, you learned more algorithms and data structures
 - But you have higher-level understanding and abilities
 - Analysis, both logical and mathematical
 - Types of problems (e.g. optimization problems)
 - Algorithm design strategies
 - Relations between different problems and how to solve them (e.g. using graph search in other algorithms like network flow; using network flow for other problems like bipartite matching; reduction in general)

We and the CS Department Learning, Too

- CS3100: successor to long established course CS4102
Algorithms in “old” curriculum
 - Differences: CS4102 students took course later in program, had more programming (have you heard of 2150?)
 - CS2100 was intended to give a deeper intro to data structures than the “old” CS2110
- New courses piloted pre-pandemic
- Fall 23 is 3rd offering of CS3100 (all with different instructors)
- CS department DSA committee has been evaluating things....

CS DSA Committee's Thoughts

- Time in the degree program matters more than we thought
 - Now we recommend CS3140 be done before CS3100
- More students enter CS3100 with varying pre-req experiences than the old CS4102 (due to place-out tests, transfer, etc)
- Too much of a step-up from UVA's CS2100 to CS3100
 - Seems CS2100 does a series of small programs, and perhaps needs some larger ones at the end with less “scaffolding”
 - Perhaps CS3100 needs to start with smaller programs/problems with some scaffolding
 - So adjustments at end of CS2100 and CS3100 may help improve things
- Your thoughts?

End-of-Course Survey!



https://virginia.az1.qualtrics.com/jfe/form/SV_6rRVNZfZLGeIG0u

Finale – Thank You!

- Thanks for your hard work this semester!
- Complete the SET and our survey and give us constructive feedback to make the course better in the future
 - **0.5% extra credit** overall for each: SET and our feedback form
 - **Must be filled out by 12/7/2023** to receive extra credit
- All the best with end of term and finals!
- Have a great winter break!