CS 240: Algorithm Design and Analysis

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ShanghaiTech University
Spring 2020

Administrative Stuff

Classes

- 12 weeks (Mar. 2 – late May)

Instructors:

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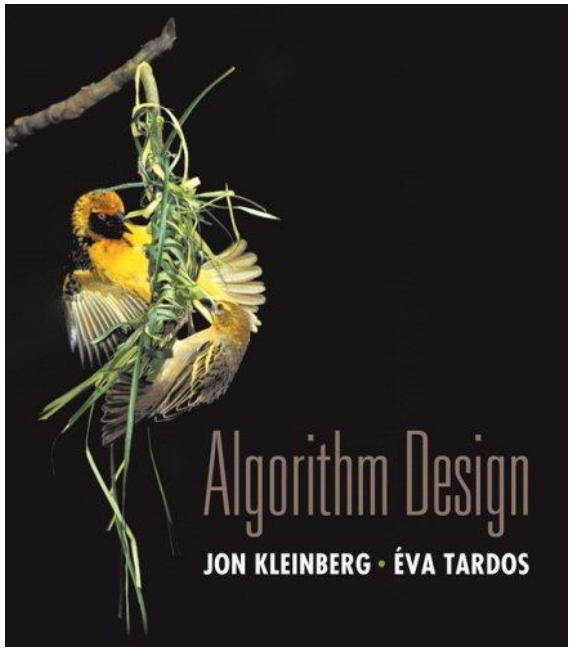
Textbook

- Algorithm Design, Jon Kleinberg and Éva Tardos
- Reference
  - Introduction to Algorithms, C. E. Leiserson, C. Stein, T. H. Cormen, and R. Rivest, (third edition)



Prereq

- Computer Programming
- Data Structures and Algorithms (undergraduate level)

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Grading (percentages are tentative)

- Homework (20%): ~5 homework assignments, due in one week
- Midterm (35%): in mid April
  - May be canceled if campus is still closed by then
- Final (35%): in late May or early June
- Project (10%): to be determined

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Blackboard (https://elearning.shanghaitech.edu.cn:8443)

- Lecture videos, slides
- Announcements
- Homework assignments

Piazza
(https://piazza.com/shanghaitech.edu.cn/spring2020/cs240/home)

- QA and discussions

Gradescope

- Homework submission and grading

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Online Lectures

- Each lecture video and slide will be uploaded to Blackboard at least one day before the lecture time
- Students watch the video & slide, ideally before or during lecture time
- You can ask questions on Piazza at any time and we will answer them within 24 hours
- Voice chat during lecture time
  - You can request voice chat with us in your Piazza question or reply
  - We will schedule a chat with you during lecture time (1-2:40pm, Mon&Wed)
  - Software: Tencent meeting

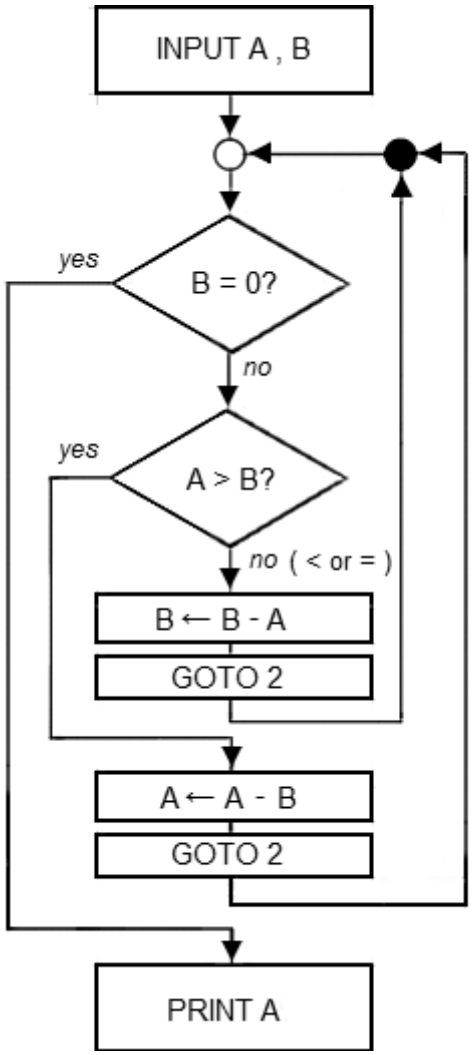
Course Overview

Algorithms

Algorithm.

[Knuth, TAOCP] An algorithm is a finite, definite, effective procedure, with some input and some output.

[Wikipedia] An algorithm is a finite sequence of well-defined, computer-implementable instructions, typically to solve a class of problems or to perform a computation.



Why study algorithms?

Wide range of applications.

- Internet. Web search, packet routing, distributed file sharing, ...
- Biology. Human genome project, protein folding, ...
- Computers. Circuit layout, databases, caching, networking, compilers, ...
- Computer graphics. Movies, video games, virtual reality, ...
- Security. Cell phones, e-commerce, voting machines, ...
- Multimedia. MP3, JPG, DivX, HDTV, face recognition, ...
- Social networks. Recommendations, news feeds, advertisements, ...
- Physics. N-body simulation, particle collision simulation, ...
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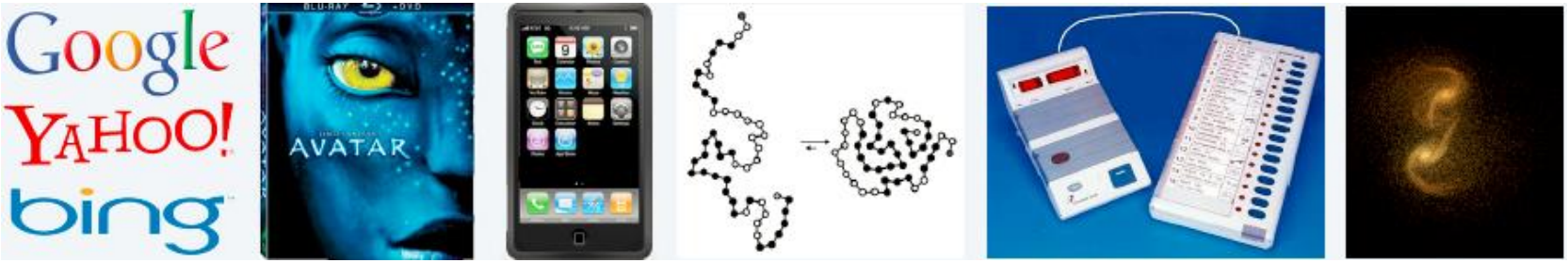


Typical Undergraduate Algorithm Course

Understanding and implementing classic algorithms

- Sorting
- Searching
- String algorithms
- Graph algorithms

Critical thinking, problem-solving, coding

This Course

Design and analysis of computer algorithms

- Greedy algorithms
- Divide-and-conquer
- Dynamic programming
- Network flow
- Intractability (complexity classes)
- Coping with intractability
- Approximate algorithms
- Randomized algorithms
- Local search

Critical thinking, problem-solving, *rigorous analysis*

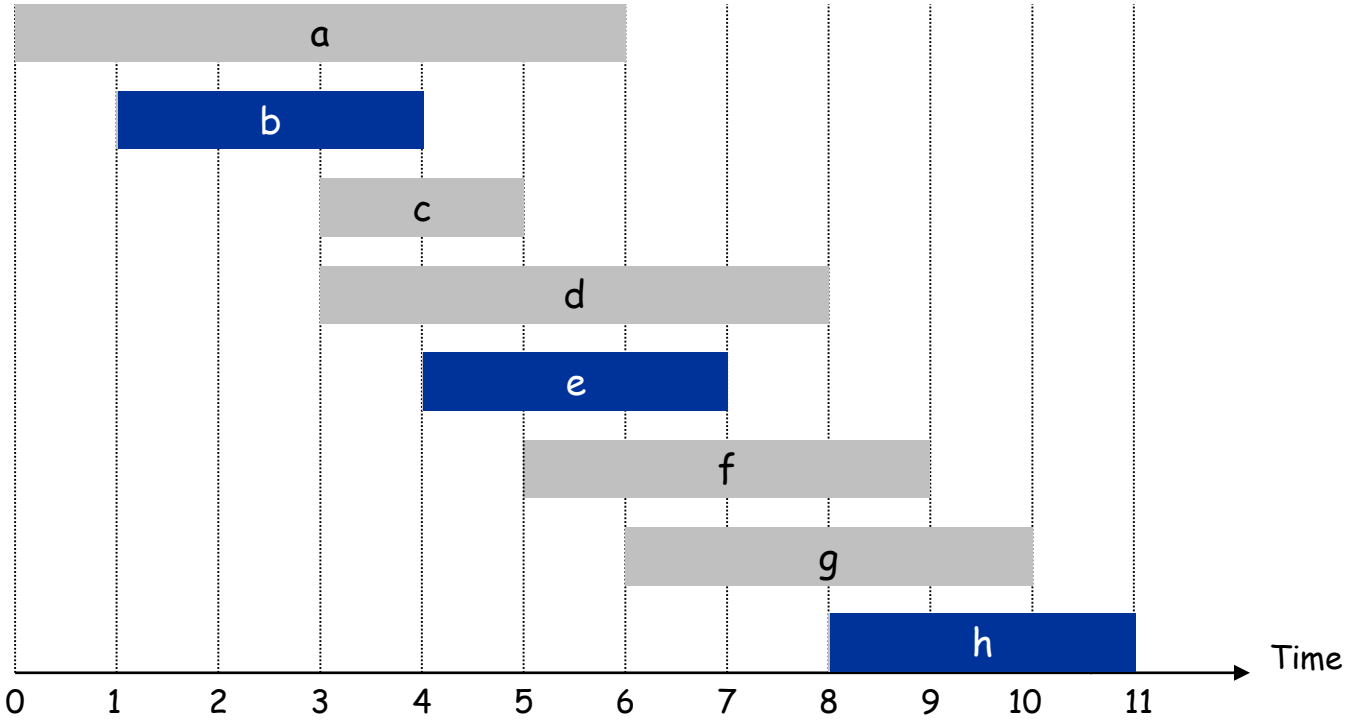
Five Representative Problems

Interval Scheduling

Input. Set of jobs with start times and finish times.

Goal. Find maximum cardinality subset of mutually compatible jobs.

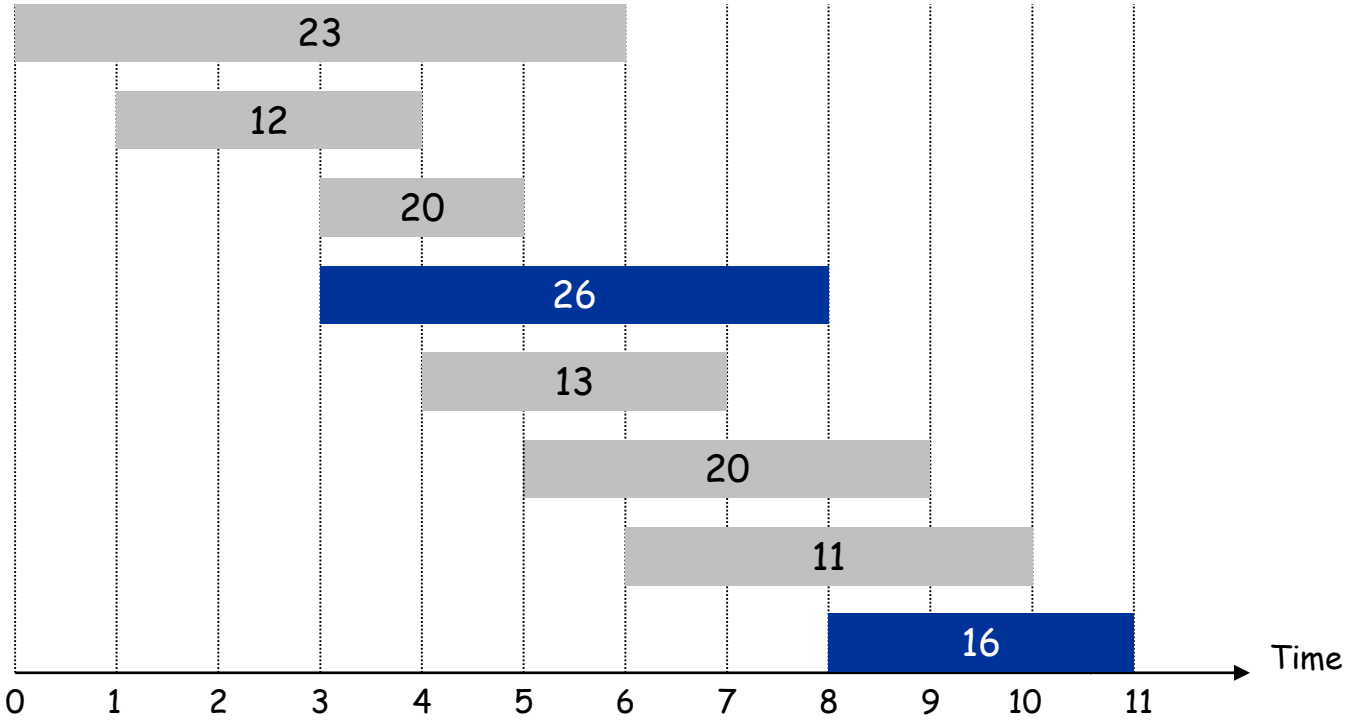
jobs don't overlap



Weighted Interval Scheduling

Input. Set of jobs with start times, finish times, and weights.

Goal. Find maximum weight subset of mutually compatible jobs.

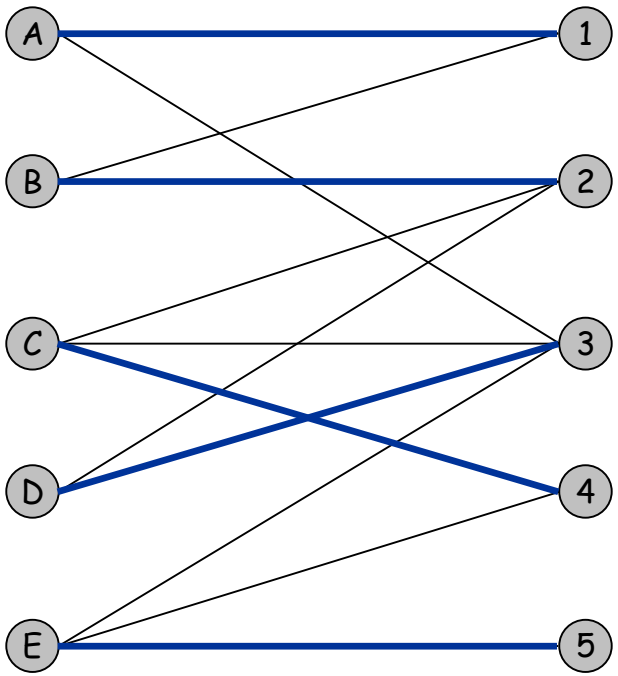


Bipartite Matching

Input. Bipartite graph.

Goal. Find maximum cardinality matching.

找到一个子集使得各个边不共享节点



Independent Set

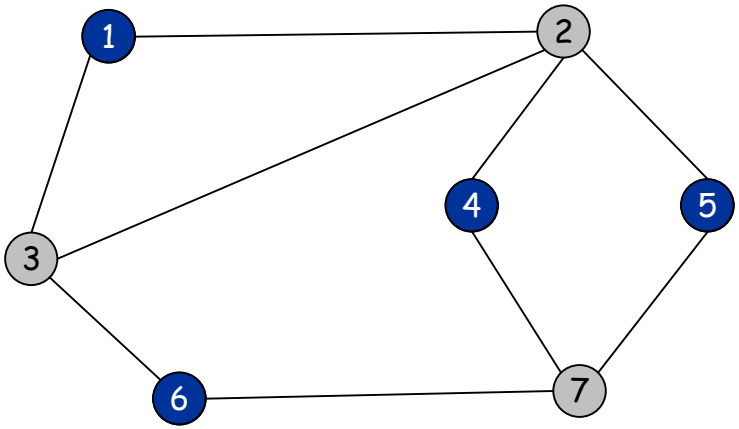
Input. Graph.

Goal. Find maximum cardinality independent set.

↑ subset of nodes such that no two joined by an edge

找到节点的子集使得节点之间没有边

可以通过将边与点转换，来讲independent set 转化为 bipartite matching



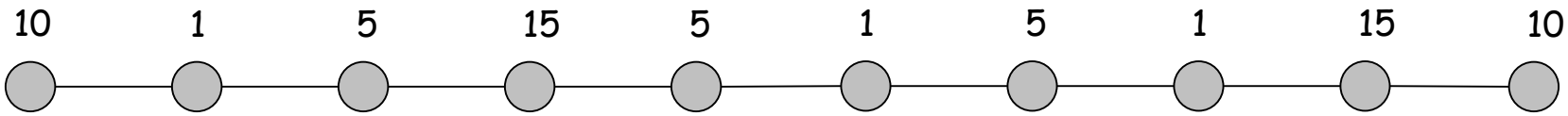
Extension: Weighted independent set.

Competitive Facility Location

Input. Graph with weight on each node.

Game. Two competing players alternate in selecting nodes. Not allowed to select a node if any of its neighbors have been selected.

Goal. Select a maximum weight subset of nodes.



Second player can guarantee 20, but not 25.

难证明

Five Representative Problems

Variations on a theme: independent set.

Interval scheduling: n log n greedy algorithm.
Weighted interval scheduling: n log n dynamic programming algorithm.
Bipartite matching: n^2 max-flow based algorithm.
Independent set: NP-complete.
Competitive facility location: PSPACE-complete.