CS 240: Algorithm Design and Analysis

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ShanghaiTech University
Fall 2017

Administrative Stuff

Classes

- Tue/Thu 10:15-11:55am @教学中心303
- 12 weeks (Sept 19 – mid Dec)

Instructor: 屠可伟

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- Office: SIST 1A-304B
- Office hours: TBA

TA: 周扬、梅俊、邹彦良、王丰

- Office hours: check your email and take a survey

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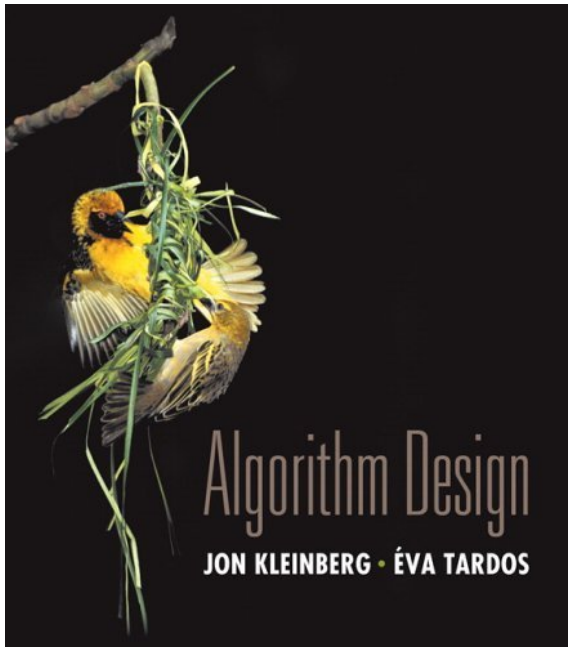
Textbook

- 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
- Algorithms (undergraduate)

Survey

- https://www.wenjuan.in/s/rYNBFvb/

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Blackboard

- Announcements, homework assignments, slides, etc.
- Forum for discussion and QA
- Roster will be updated at the end of the 2nd week
- Students from 高研院: please check your email

Grading (percentages are tentative)

- Homework (20%): 5-6 homework assignments, due in one week
- Midterm (30%): in late Oct or early Nov
- Final (30%): in late Dec or early Jan
- Participation (10%): class, forum
- Project (10%): to be determined

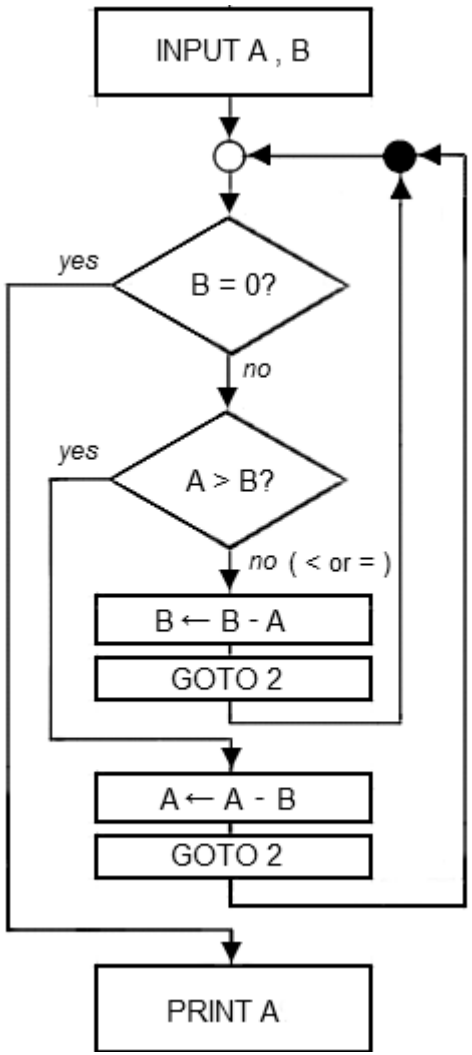
Course Overview

Algorithms

Algorithm.

- [Wikipedia] In mathematics and computer science, an algorithm is an unambiguous specification of how to solve a class of problems.

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



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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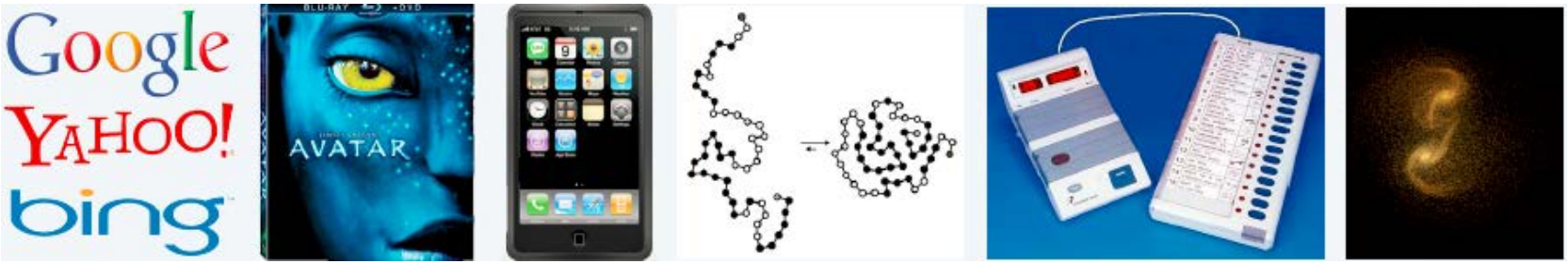


Typical Undergraduate Algorithm Course

Understanding and implementing classic algorithms

- Sorting
- Searching
- String algorithms
- Graph algorithms

Critical thinking, problem-solving, coding

This Course

Design and analysis of computer algorithms

- Graph algorithms
- Greed
- 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*

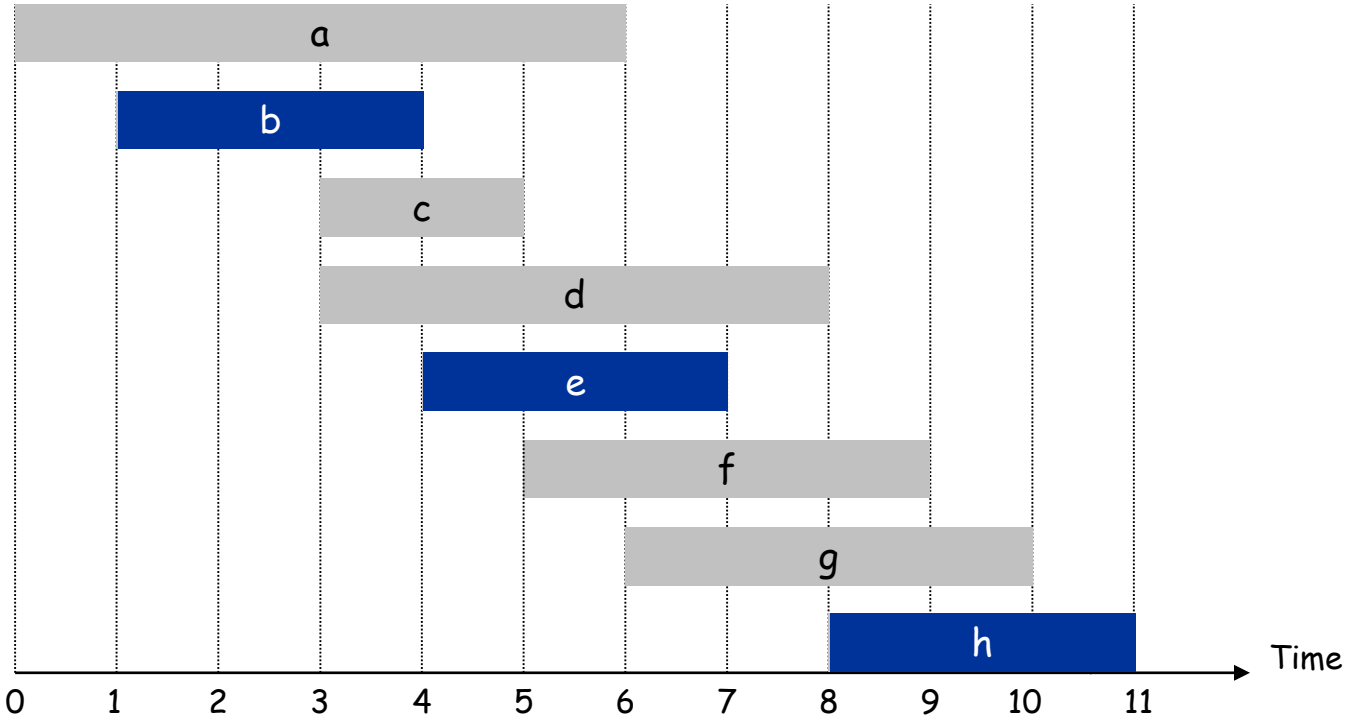
Five Representative Problems

Interval Scheduling

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

Goal. Find maximum cardinality subset of mutually compatible jobs.

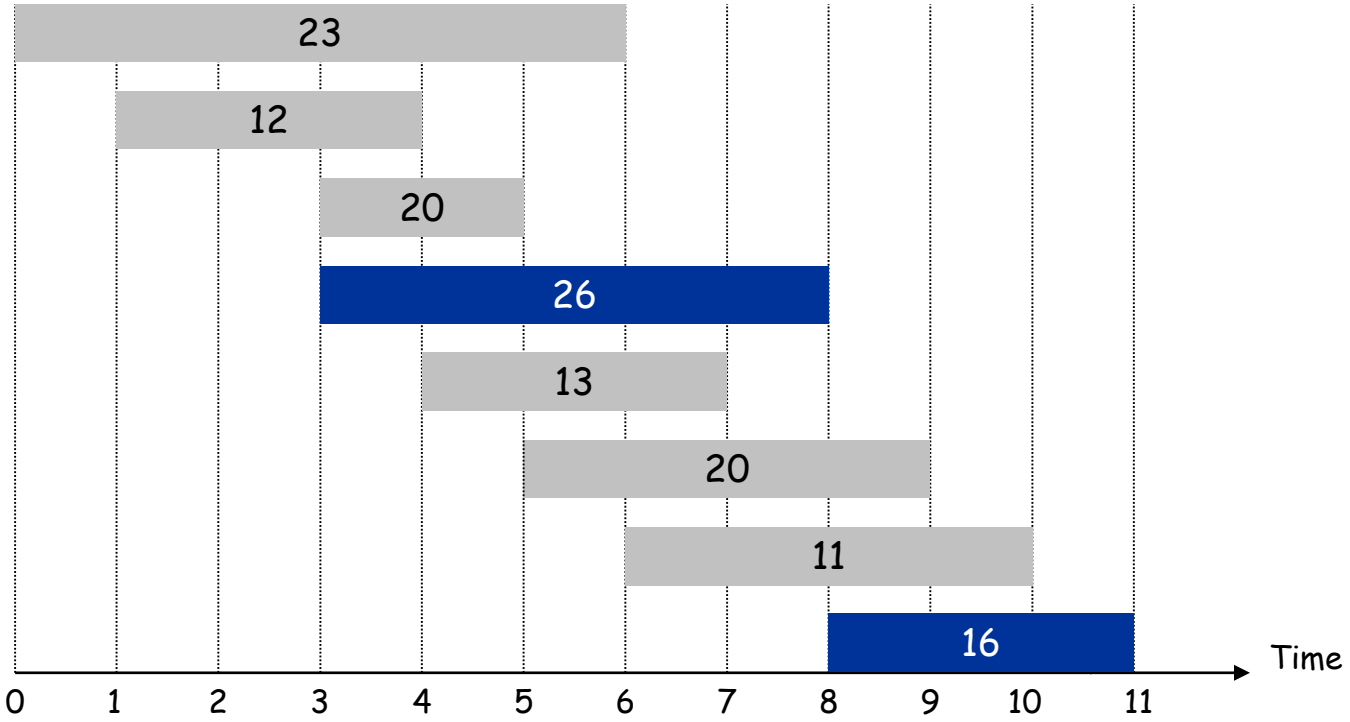
jobs don't overlap



Weighted Interval Scheduling

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

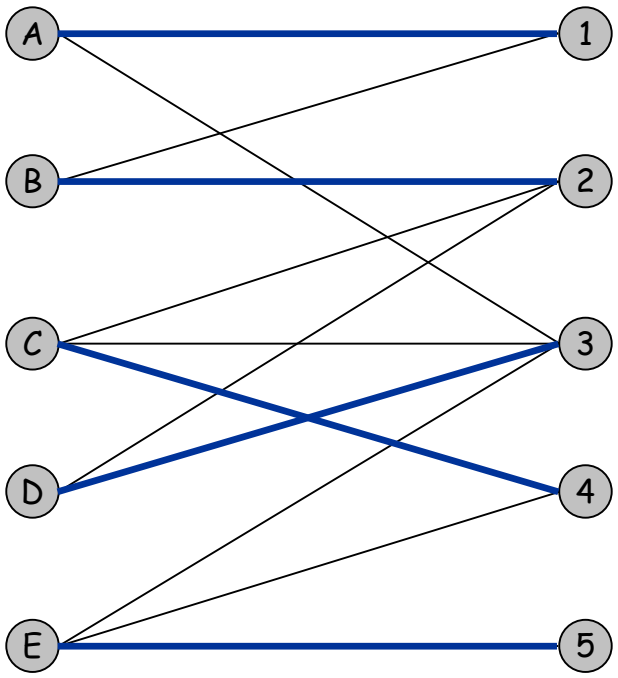
Goal. Find maximum weight subset of mutually compatible jobs.



Bipartite Matching

Input. Bipartite graph.

Goal. Find maximum cardinality matching.

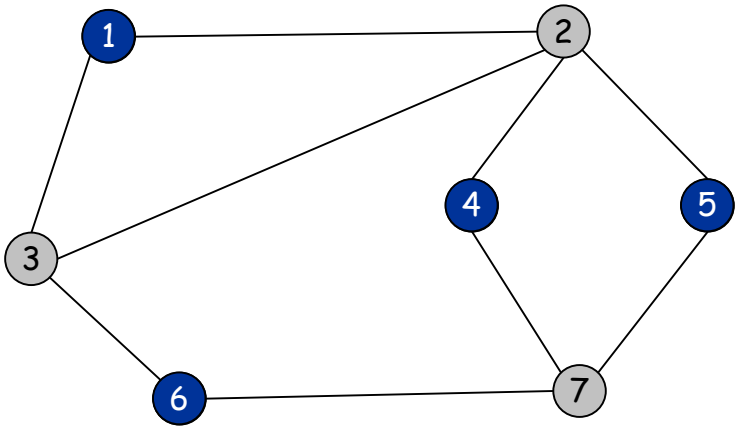


Independent Set

Input. Graph.

Goal. Find maximum cardinality independent set.

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



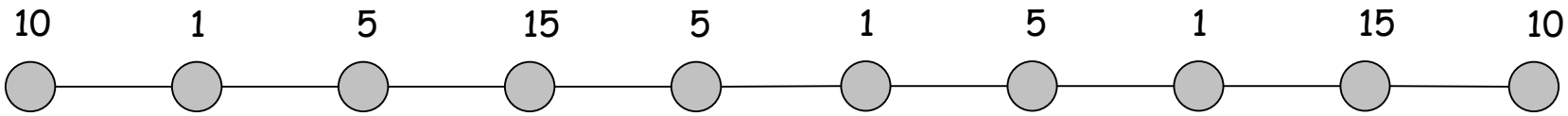
Extension: Weighted independent set.

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.

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.