VE281

Data Structures and Algorithms

Introduction

Outline

- Course logistics
- Introduction

Time and Location

- Time: Wednesday 4:00-5:40 pm, Friday 4:00-5:40 pm, and Monday 4:00-5:40 pm (even weeks)

- Location: East Lower Hall 315

Instructor

- Weikang Qian
- Email: qianwk@sjtu.edu.cn
- Phone: 34206765-4301
- Office: Room 430, Long Bin Building

- Office hour
  - Monday 1:00 – 2:00 pm
  - Friday 1:00 – 2:00 pm
  - Or *by appointment*

Teaching Assistants

- Liu, Yihao
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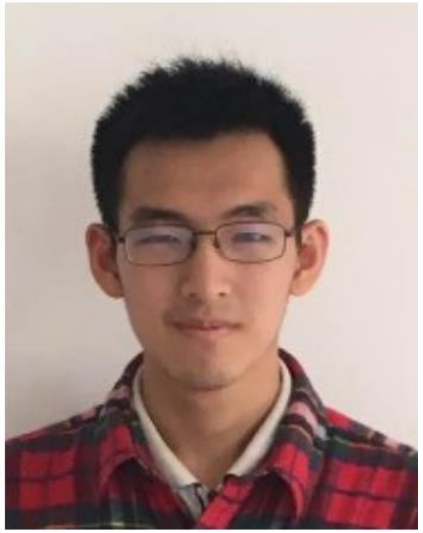

- Wu, Yifan
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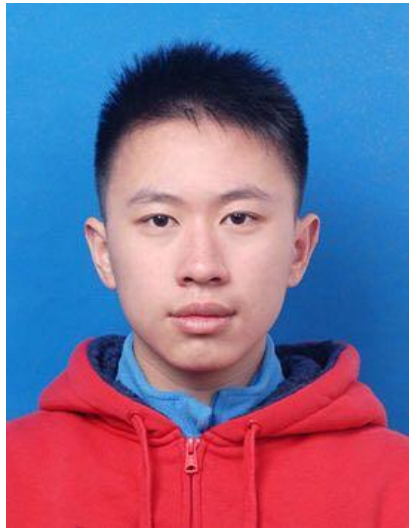

Teaching Assistants

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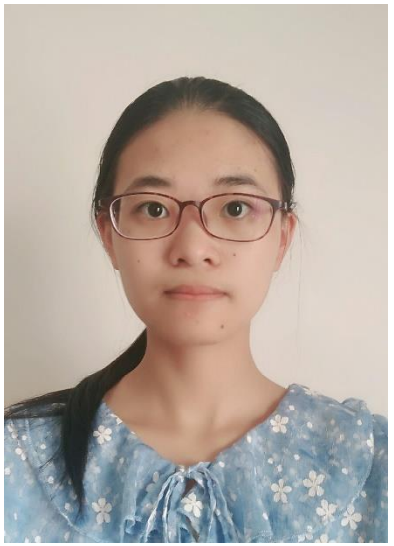

Textbooks for Reference (Not Required)

- "Data Structures and Algorithm Analysis," by Clifford Shaffer. Online available: http://people.cs.vt.edu/~shaffer/Book/C++3e20120605.pdf
- "Algorithms," by S. Dasgupta, C. Papadimitriou, and U. Vazirani.
- "Introduction to Algorithms, 3rd edition," by Thomas Cormen et al., MIT Press, 2009.
- "Data Structures and Algorithms with Object-Oriented Design Patterns in C++," by Bruno Preiss.

Grading

- Composition
  - In-class quiz: 5%;
    - No other conflicting event at the lecture time unless getting approval in advance
  - 6 written assignments: 20%
  - 5 programming assignments: 30%
  - Midterm exam (written): 20%
  - Final exam (written): 25%
- We will curve the final grades, if necessary.
- Questions about the grading?
  - Must be mentioned to the instructor or the TAs within one week after receiving the item.

Programming Assignments

- We require you to develop your programs using C++ on **Linux operating systems** with the compiler g++.
- C++11 standard is allowed.
  - Compile with the option –std=c++11
- We will grade your programs in the Linux environment: they must compile and run correctly on this operating system.
- Do experiments on algorithms, e.g., sorting algorithm

Assignment Deadline

- Each written assignment must be turned in before class on its due date.
- Each programming assignment (PA) must be turned in by 11:59 pm on the due date to be accepted for full credit.
  - However, we still allow you to submit your PA within 3 days after the due date, but there is a late penalty.

Hours Late	Scaling Factor
(0, 24]	80 %
(24, 48]	60 %
(48, 72]	40 %

  - No PA will be accepted if it is more than 3 days late!

Assignment Deadline

- In **very occasional** cases, we accept deadline extension request.
  - Contact me, not TAs!
  - **ONLY** be granted for **documented** medical/personal emergencies that could not have been anticipated.
  - **NOT** granted for reasons such as accidental erasure/loss of files and outside conflicting commitments.

Some Suggestions

- Taking notes in class is a good idea.
- Start doing the homework early!
  - Don't wait until the last minute. Numerous lessons before
- Back up your code frequently in case your computer crashes.
  - Consequence: "computer crash" is NOT a reason for late submission!

Exams

- Written exams.
  - Some short questions
  - Some algorithm design problems
- Closed book and closed notes.
- No electronic devices are allowed.
  - These include laptops and cell phones.

Collaboration and Cheating

- You may discuss in oral with your classmates.
- **But** you must do all the assignments yourself.
- Some behaviors that are considered as cheating:
  - Reading another student's answer/code, including keeping a copy of another student's answer/code.
  - Copying another student's answer/code, in whole or in part.
  - Having someone else write part of your assignment.
  - Using test cases of another student.
  - Testing your code with another one's account. (Testing chances are limited.)

"**Another student**" includes a student in the current semester or in the previous semester.

Collaboration and Cheating

- The previous lists of behaviors are **deliberate** cheating, but some **unintentional** actions could make you look like cheating. For example,
  - You use another's computer to upload your code (in some cases like network/computer problems), but upload another's copy.
- You should be extremely careful!
  - If due to network/computer problem, you need to use another's computer, double check the uploaded file.

Collaboration and Cheating

- In summary, you should be responsible for all answers/codes you submit. If you submit a copy of another student's work (or overwrite another student's work), it is considered cheating, **no matter of the reason**!

Collaboration and Cheating

- Any suspect of cheating will be reported to **the Honor Council at JI**.
- For programming assignments, we will run an automated test to check for unusually similar programs. Those that are highly similar - in whole or in part - will be reported to **the Honor Council at JI**.
- **Penalty** of honor code violation

1. Reduction of the grade for this assignment to 0, **plus**
2. Reduction of the final grade for the course by one grade point, e.g., B+ → C+, for **both students** involved

Canvas

- Log into Canvas: https://umjicanvas.com

- Check the class webpage on the Canvas regularly for
  - Announcements
  - Slides
  - Assignments

- Course slides will be uploaded onto Canvas before each lecture.

Getting Help

- If you have any technical questions, come to see TAs and instructor during the office hour!
  - Answering technical questions through email is inefficient.

Fun Quizzes!

- What?
  - Multiple-choice questions on slides with 
  - **Non-graded** and **Anonymous**
  - Feel free to answer even if you're not sure!
- How?
  - Scan a QR on your smartphone
  - Enter any name (possibly fake)
  - Answer
- Why?
  - Have fun!
  - Allow you to check your understanding
  - Allow the instructor to adapt his teaching
- Let's try one!

Do You Know Data Structures?

Choose one answer:

- **A**. I don't know any data structures.
- **B**. I only know some basic data structures like stacks and queues.
- **C**. I know some advanced data structures such as hash tables and binary search trees, but have never used them.
- **D**. I have used some advanced data structures before.

Prerequisite

- Ve280 Programming and Elementary Data Structures
  - Compiling and debugging on Linux operating systems
  - C++ programming, including pointers, arrays, structs, etc.
  - Recursion
  - I/O streams, including file I/O
  - Classes
  - Dynamical memory management
  - Template
  - Linked list, stack, and queue

Prerequisite

- Ve203 Discrete Mathematics
  - Computational complexity analysis
  - Some basic sorting algorithm, e.g., bubble sort, insertion sort, merge sort
  - Divide-and-conquer algorithm, master theorem
  - Graph, graph representation, depth first search, Dijkstra's algorithm (shortest path)

- Some important concepts will be reviewed

References and Copyright

- Slides used (modified when necessary)
  - Sugih Jamin, University of Michigan
  - Sartaj Sahni, University of Florida
  - Bert Huang, Columbia University
  - Tim Roughgarden, Stanford University
  - Clifford Shaffer, Virginia Tech

Outline

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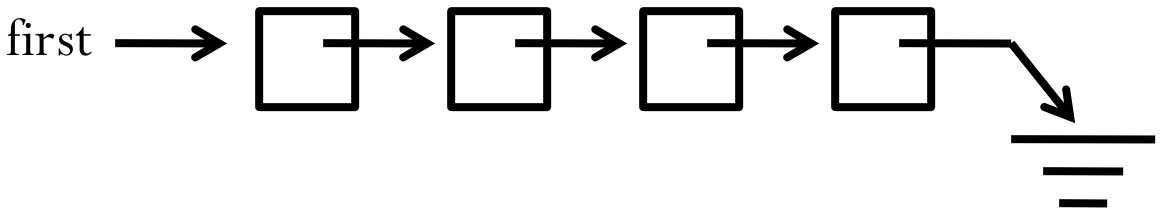
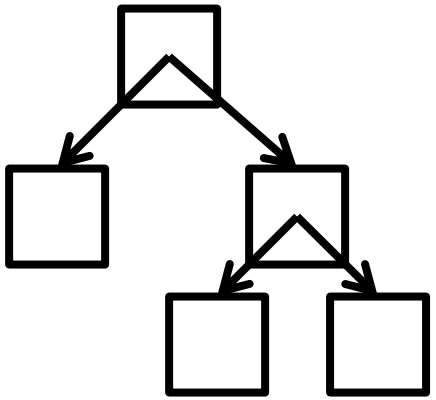
- Introduction

Data Structures and Algorithms

- Data structure is a particular way of organizing data in a computer so that it can be used efficiently.
  - Example: linked list



- We can store a set of records as a linked list
  - or as a tree (to be talked later).

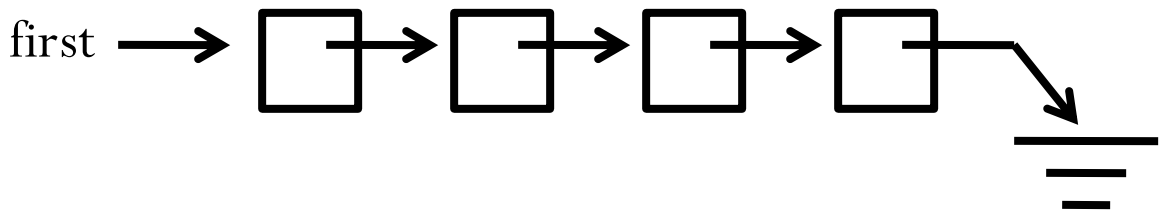


Logical versus Physical Form

- A data structure have both a **logical** and a **physical** form.
- Logical form: definition of the data structure at an abstraction level.
- Physical form: implementation of the data structure.

Data Structure Example: Linked List

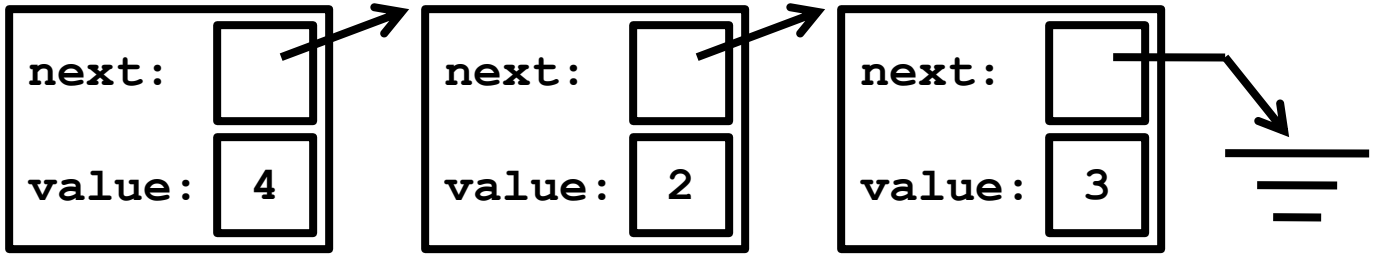
Logical Form



Physical Form

```
class IntList {
  node *first;
 public:
  ...
};
```

```
struct node {
  node *next;
  int   value;
};
```



Data Structures and Algorithms

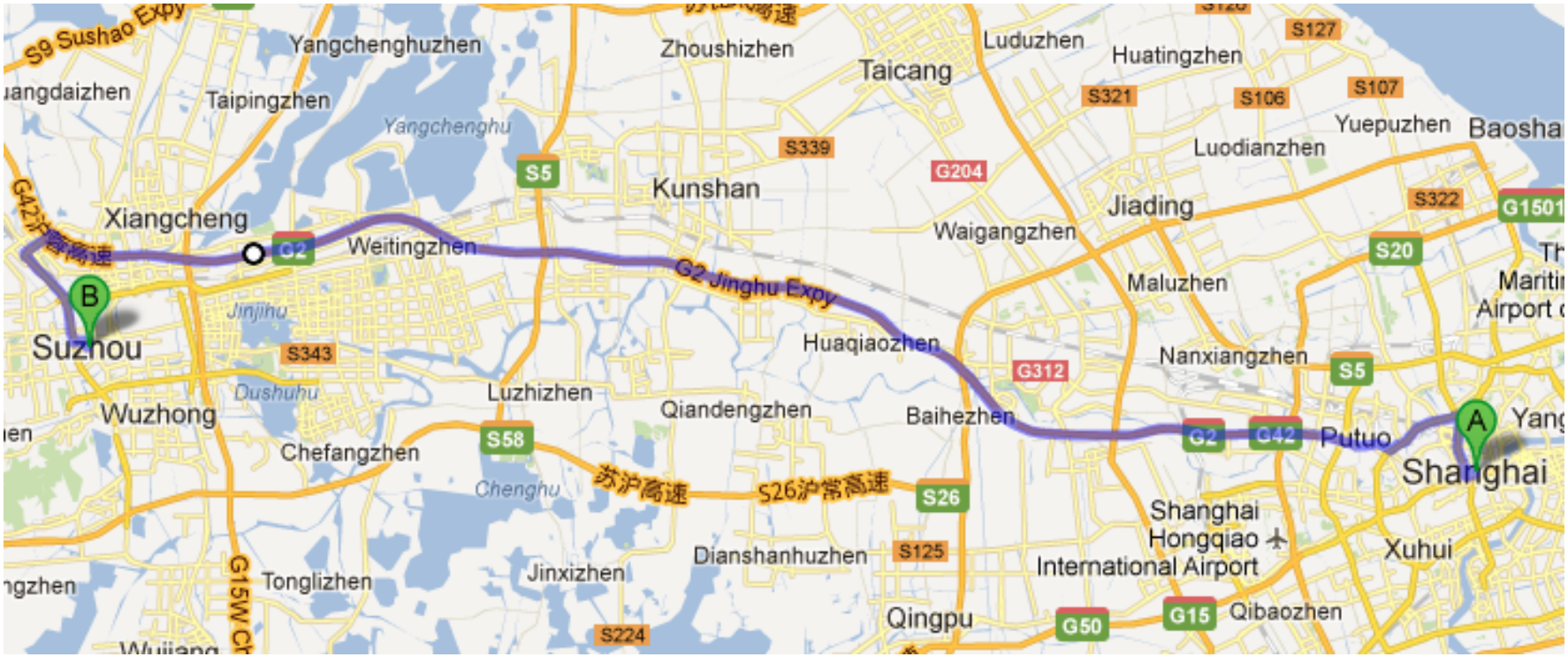
- Data manipulation requires an algorithm – a sequence of steps that solve a specific task.

- Data structures + Algorithms = Programs

- The study of data structures and algorithms is fundamental to Computer Science.
  - Database related to balanced binary search tree.
  - Computer networks related to shortest path algorithm.
  - …

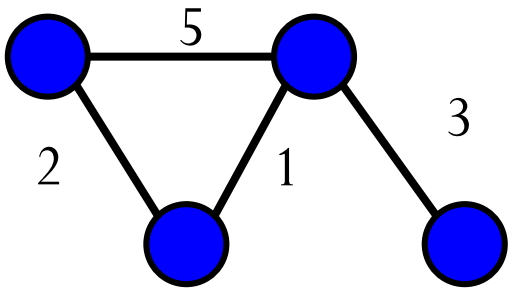
Real World Problem: Navigation

- Finding the shortest route from Shanghai to Suzhou



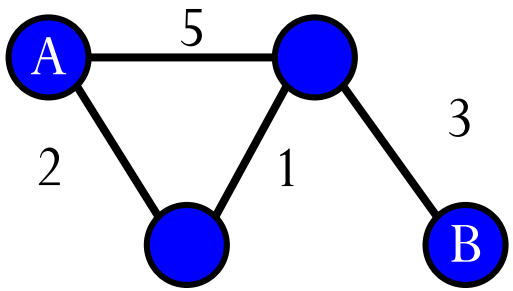
Real World Problem: Navigation

- What information do we need?
  - Streets.
  - Intersections of streets. (We assume that our departure place and destination are at certain intersections.)
- How do we store the information in computer?
  - Graph: consisting of "nodes" and "edges".
  - Each edge has a weight to denote the distance between two nodes.



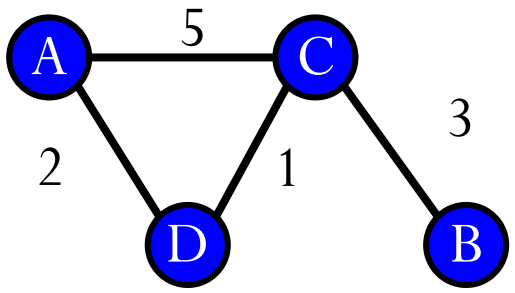
Real World Problem: Navigation

- The algorithm: finding the shortest path from a source node (A) to a sink node (B).



Challenges: Efficiency

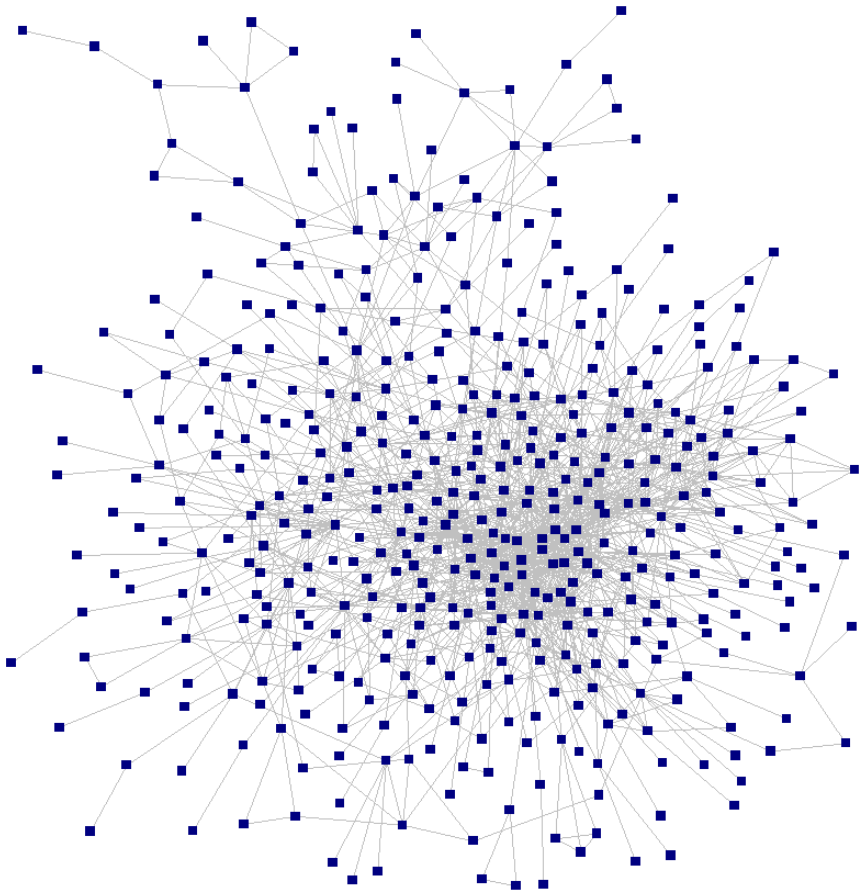
- For a small number of nodes, we can enumerate all the possible paths.



- Path A → C → B: 8;
- Path A → D → C → B: 6;
- The minimum is 6.

Challenges: Efficiency

- However, in real world, the graph is much more complicated.
- It is impossible to enumerate all the possible paths!
- How can we solve the problem?
  - Dijkstra's algorithm



More about Efficiency

- Choice of data structures or algorithms can make the difference between a program running in a few seconds or many days.
- Example: Number of comparisons for **linear search** and **binary search** (Worst Case)

Input Size	Linear	Binary	Ratio (L/B)
64	64	6	10.7
128	128	7	18.3
256	256	8	32
512	512	9	56.9
1024	1024	10	102.4

More about Efficiency

- A solution is said to be efficient if it solves the problem within its resource constraints.
  - Space, i.e. memory consumption
  - Time ✓ **Our major concern**

- The cost of a solution is the amount of resources that the solution consumes.

- We value efficiency of the data structures and algorithms!
- We will learn how to analyze their efficiency.

Course Objectives

- Learn the tool:
  - Common data structures and algorithms
  - And their efficiency

- Apply the tool
  - Solve a problem using existing data structures and algorithms.
  - Choose the right tool: some tools are better for certain tasks than other tools. Do performance analysis.

Topics

- Asymptotic Algorithm Analysis
- Data structures
  - Trees, including binary search tree, balanced binary search tree
  - Hash table
  - Heaps
  - Graphs
- Algorithms
  - Sorting and searching
  - Graph-related algorithms, such as minimum spanning tree, topological sorting
  - Dynamic programming

Questions?