Welcome!

We have 10 weeks to learn *fundamental data structures and algorithms for organizing and processing information*

› “Classic” data structures / algorithms and how to analyze rigorously their efficiency and when to use them
› Queues, dictionaries, graphs, sorting, etc.
› Parallelism and concurrency (!)
Today’s Outline

• Introductions
• Administrative Info
• What is this course about?
• Review: Queues and stacks
CSE 332 Course Staff!!

Instructor:
Ruth Anderson

Teaching Assistants:
• Bella Bai
• Gavin Cai
• Chris Choi
• Joy He
• Preston Jiang
• Richard Jiang
• Annie Mao
• Kevin Pham
• Sherry Prawiro
• Connie Wang
• Kat Wang
Me (Ruth Anderson)

- **Grad Student at UW** in Programming Languages, Compilers, Parallel Computing
- **Taught Computer Science** at the University of Virginia for 5 years
- **Grad Student at UW**: PhD in Educational Technology, Pen Computing
- **Current Research**: Computing and the Developing World, Computer Science Education
- **Recently Taught**: data structures, architecture, compilers, programming languages, 142 & 143, data programming in Python, Unix Tools, Designing Technology for Resource-Constrained Environments
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Course Information

- **Instructor**: Ruth Anderson, CSE 558
  Office Hours: see course web page, and by appointment, (rea@cs.washington.edu)

- **Text**: *Data Structures & Algorithm Analysis in Java*, (Mark Allen Weiss), 3rd edition, 2012
  (2\textsuperscript{nd} edition also o.k.)

- **Course Web page**: http://www.cs.washington.edu/332
Communication

• Course email list: cse332a_au19@uw
cse332b_au19@uw
  › You are already subscribed
  › You must get and read announcements sent there

• Piazza Discussion board
  › Your first stop for questions about course content & assignments

• Anonymous feedback link
  › For good and bad: if you don’t tell me, I won’t know!
Course Meetings

• Lecture
  › Materials posted (sometimes afterwards), but take notes
  › Ask questions, focus on key ideas (rarely coding details)

• Section
  › Practice problems!
  › Answer Java/project/homework questions, etc.
  › Occasionally may introduce new material
  › An important part of the course (not optional)

• Office hours
  › Use them: please visit us!
Course Materials

- Lecture and section materials will be posted
  - But they are visual aids, not always a complete description!
  - If you have to miss, find out what you missed

- Textbook: Weiss 3rd Edition in Java
  - Good read, but only responsible for lecture/section/hw topics
  - 3rd edition improves on 2nd, but we’ll also support the 2nd

- Parallelism / concurrency units in separate free resources designed for 332
Course Work

• ~20 Weekly individual homework exercises (25%)
• 3 programming projects (with phases) (30%)
  › Use Java 11 and IntelliJ, Gitlab
  › Done in partners, o.k. if partner is in other lecture section

• Midterm - (20%)
• Final Exam - (25%)

• Midterm exam: Friday Oct 25, 2019, time TBA (after 3:30pm)
• Final exam: Thursday Dec 12, 2019, 12:30-2:20pm, KNE 130
• Locations TBA. Contact the instructor immediately if you have a conflict with either of these times.
Collaboration & Academic Integrity

• Read the course policy very carefully
  › Explains quite clearly how you can and cannot get/provide help on homework and projects
  › Looking at solutions from previous quarters is cheating
  › Gilligan’s Island rule applies.

• Always proactively explain any unconventional action on your part. When it happens, (not when asked)
Homework for Today!!

0) Project #1: (released later today) Fill out partner request survey(s) by 5pm TOMORROW

1) Review Java & install IntelliJ

2) Exercise #1 – Due FRIDAY at 11:59pm

3) Preliminary Survey: fill out by Thurs evening

4) Reading in Weiss (see handout)
Reading

• Reading in Data Structures and Algorithm Analysis in Java, 3rd Ed., 2012 by Weiss

• For this week:
  › (Topic for Project #1) Weiss 3.1-3.7 – Lists, Stacks, & Queues
  › (Fri) Weiss 2.1-2.4 – Algorithm Analysis
  › (Useful) Weiss 1.1-1.6 – Mathematics and Java (Not covered in lecture – READ THIS)
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Data Structures + Parallelism

• About 70% of the course is a “classic data-structures course”
  › Timeless, essential stuff
  › Core data structures and algorithms that underlie most software
  › How to analyze algorithms

• Plus a serious first treatment of programming with *multiple threads*
  › For *parallelism*: Use multiple processors to finish sooner
  › For *concurrency*: Correct access to shared resources
  › Will make many connections to the classic material
What 332 is about

• Deeply understand the basic structures used in all software
  › Understand the data structures and their trade-offs
  › Rigorously analyze the algorithms that use them (math!)
  › Learn how to pick “the right thing for the job”

• Experience the purposes and headaches of multithreading

• Practice design, analysis, and implementation
  › The elegant interplay of “theory” and “engineering” at the core of computer science
Goals

• You will understand:
  › what the tools are for storing and processing common data types
  › which tools are appropriate for which need

• So that you will be able to:
  › make good design choices as a developer, project manager, or system customer
  › justify and communicate your design decisions
One view on this course

• This is the class where you begin to think like a computer scientist
  › You stop thinking in Java code
  › You start thinking that this is a hashtable problem, a stack problem, etc.
Data Structures?

“Clever” ways to organize information in order to enable *efficient* computation over that information.
A data structure strives to provide many useful, efficient operations.

But there are unavoidable trade-offs:

› Time vs. space
› One operation more efficient if another less efficient
› Generality vs. simplicity vs. performance

That is why there are many data structures and educated CSEers internalize their main trade-offs and techniques:

› And recognize logarithmic < linear < quadratic < exponential
Getting Serious: Terminology

• Abstract Data Type (ADT)
  › Mathematical description of a “thing” with set of operations on that “thing”

• Algorithm
  › A high level, language-independent description of a step-by-step process

• Data structure
  › A specific *organization of data* and family of algorithms for implementing an ADT

• Implementation of a data structure
  › A specific implementation in a specific language
The Stack **ADT**

- Stack Operations:
  - push
  - pop
  - top/peek
  - is_empty
Terminology Example: Stacks

• The Stack ADT supports operations:
  › push: adds an item
  › pop: raises an error if isEmpty, else returns most-recently pushed item not yet returned by a pop
  › isEmpty: initially true, later true if there have been same number of pops as pushes
  › ... (Often some more operations)

• A Stack data structure could use a linked-list or an array or something else, and associated algorithms for the operations

• One implementation is in the library java.util.Stack
Why useful

The **Stack ADT** is a useful abstraction because:

- It arises **all the time** in programming (see Weiss for more)
  - Recursive function calls
  - Balancing symbols (parentheses)
  - Evaluating postfix notation: 3 4 + 5 *
  - Clever: Infix ((3+4) * 5) to postfix conversion (see Weiss)

- We can code up a **reusable library**

- We can **communicate** in high-level terms
  - “Use a stack and push numbers, popping for operators…”
  - Rather than, “create a linked list and add a node when…”
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The Queue ADT

Queue Operations:

enqueue

dequeue

is_empty
Circular Array Queue Data Structure

// Basic idea only!
enqueue(x) {
    Q[back] = x;
    back = (back + 1) % size
}

// Basic idea only!
derqueue() {
    x = Q[front];
    front = (front + 1) % size;
    return x;
}

- What if queue is empty?
  › Enqueue?
  › Dequeue?
- What if array is full?
- How to test for empty?
- What is the complexity of the operations?
Linked List Queue Data Structure

```
// Basic idea only!
enqueue(x) {
    back.next = new Node(x);
    back = back.next;
}

// Basic idea only!
derqueue() {
    x = front.item;
    front = front.next;
    return x;
}
```

- What if queue is empty?
  - Enqueue?
  - Dequeue?
- Can list be full?
- How to test for empty?
- What is the complexity of the operations?
Circular Array vs. Linked List
Circular Array vs. Linked List

Array:
- May waste unneeded space or run out of space
- Space per element excellent
- Operations very simple / fast

Operations not in Queue ADT, but also:
- Constant-time “access to k\text{th} element”
- For operation “insertAtPosition”, must shift all later elements

List:
- Always just enough space
- But more space per element
- Operations very simple / fast

Operations not in Queue ADT, but also:
- No constant-time “access to k\text{th} element”
- For operation “insertAtPosition” must traverse all earlier elements
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