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
Instructor:
Ruth Anderson

Teaching Assistants:
• Daniel Allen
• Ollin Boer Bohan
• Christopher Choi
• John Feltrup
• Zhe Han

• Richard Jiang
• Annie Mao
• Michal Piszczech
• Sherry Prawiro
• 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 460
  
  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 (2nd edition also o.k.)

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

• Course email list: cse332a_au18@uw
  cse332b_au18@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 3\textsuperscript{rd} Edition in Java
  › Good read, but only responsible for lecture/section/hw topics
  › 3\textsuperscript{rd} edition improves on 2\textsuperscript{nd}, but we’ll also support the 2\textsuperscript{nd}

- 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 8 and Eclipse, Gitlab
  › Done in partners, o.k. if partner is in other lecture section

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

• Midterm exam: Friday October 26, 2018 time TBA
• Final exam: Time and Date TBA
• 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 by 6pm TODAY**
1) Review Java & install Eclipse
2) Exercise #1 – **Due FRIDAY at 11:59pm**
3) Preliminary Survey: fill out by Thurs evening
4) **Reading** in Weiss (see handout)
• 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.
“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

Q: 0

b c d e f

front back

size - 1

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

// Basic idea only!
decqueue() {
    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?

9/26/18
Linked List Queue Data Structure

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

```
// Basic idea only!
dqueue() {
    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

Not in Queue ADT, but also:
- Constant-time access to k\textsuperscript{th} element
- For operation insertAtPosition, must shift all later elements

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

Not in Queue ADT, but also:
- No constant-time access to k\textsuperscript{th} element
- For operation insertAtPosition must traverse all earlier elements
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