Lecture 1: Welcome!

CSE 373: Data Structures and Algorithms

Agenda

- Introductions
- Syllabus
- Dust off cob webs
- Meet the ADT

Course Staff

Instructor:
Robbie Weber

rtweber2@cs.washington.edu
Office: CSE 330
Office Hours:
M,W 2:20-3:30 and by appointment

Ph.D. student in CSE
Research in algorithm design

2nd time as instructor
TAed 15 times
(3 times for this course)

Amazing Teaching Assistants:

Brian Chan
Zach Chun
Kevin Son
Oscar Sprumont
Matthew Taing
Howard Xiao
Blarry Wang
Xin Yang
Velocity Yu

Class Style

Please come to lecture (yes, there will be panoptos)

- Warm Ups -> Extra Credit
- Discuss with other students
- Ask questions! Point out mistakes!

Sections

- TAs = heroes
- Practice problems
- Different Explanations
- Sections start **this** week

Class Style

Summer Quarter is weird.

We have fewer class meetings

But they're all 60 minutes, not 50 minutes.

We've rearranged (and cut) things to account for the schedule

But things are more cramped.

Please start on assignments early and ask for help early

TAs are amazing – we can help A LOT 3 days before an assignment is due.

There's only so much we can do 3 hours before it's due.

Course Administration

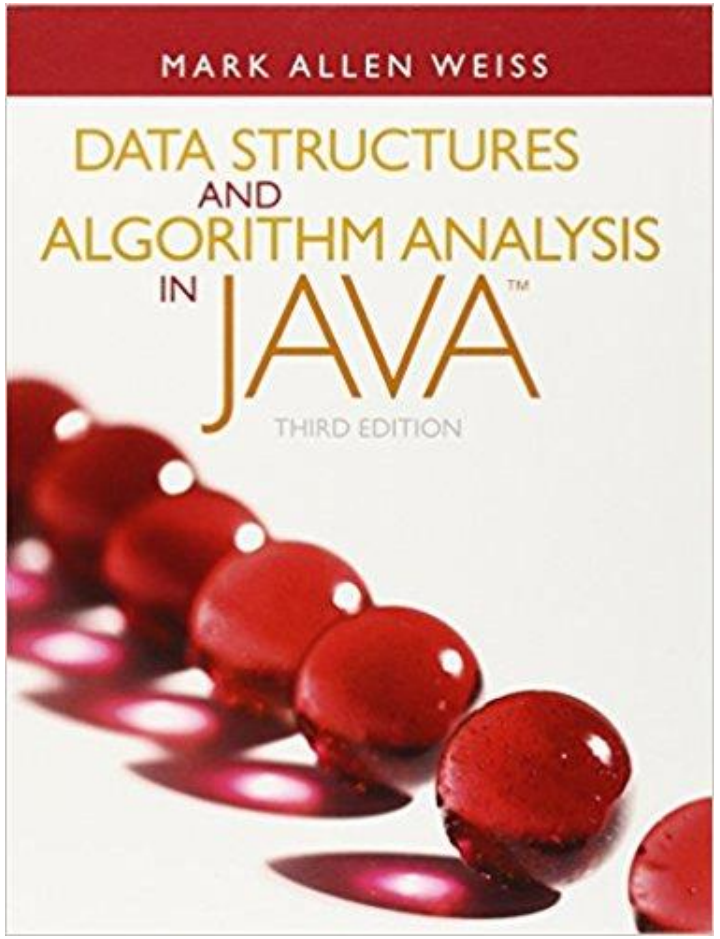
Course Page cs.washington.edu/373
- Course content posted here
- Pay attention for updates!

Canvas
- Grades will be posted to Canvas at end of quarter

Office Hours
- Will be posted on Course Page
- Will start next week (at the latest)

Piazza
- If you were signed up for the course before this morning, you were added already.
- If not, you can find an add code on Canvas (or ask a member of staff)
- Announcements made via Piazza
- Great place to discuss questions with other students
- Will be monitored by course staff
- No posting of project code!

Textbook
- **Optional**
- Data Structures and Algorithm Analysis in Java by Mark Allen Weiss



Grade Break Down

Homework (55%)
- Programming Projects (35%)
- 1 Individual Project (review of 14X)
- 4 Partner Projects
  - Partners **GREATLY** encouraged
  - Graded automatically
  - Regrades available on some parts
  - Some projects are two connected one-week assignments; others are just one week.
- Written Assignments (20%)
  - Written assignments graded by TAs

Exams (45%)
- Midterm Exam – Friday July 26th in class (15%)
- Final Exam (30%)
  - Two one-hour parts:
    - In place of final section Thursday August 22
    - In place of final lecture Friday August 23

If you have a conflict with any of those dates, email Robbie as soon as possible.

Syllabus

Homework Policies

- 4 late days
  - Both partners must use one for pair projects
  - When you run out you will forfeit 20% each 24 hour period an assignment is late
  - No assignment will be accepted more than 2 days late

Regrades

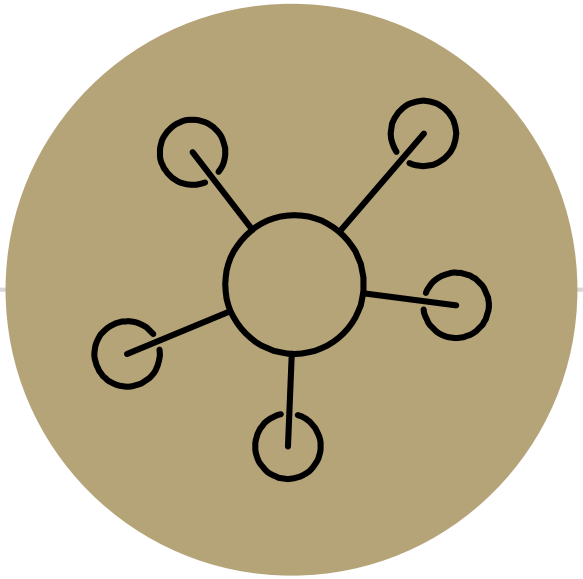
- For assignments with two parts: automatically get back half missed points for part 1 when you turn in part 2
- If you think we made a mistake grading (or the autograder did something unreasonable):
  - Fill out a regrade request on gradescope for written work
  - Fill out the google form for programming projects

Academic Integrity

- Discussing concepts and high-level ideas for problems is strongly encouraged, but submitted work must be your own.
- Read policy on the webpage.
- No posting code on discussion board or ANYWHERE online
- We do run MOSS
- No directly sharing code with one another (except for partners)

Extra Credit

- Available for attending lecture, by filling out PollEverywhere questions
  - Based on completion not correctness.
- Worth up to 0.05 GPA bump



Questions?

Clarification on syllabus, General complaining/moaning

What is this class about?

DATA STRUCTURES

How do we organize our data most effectively?

And how do we justify those decisions

Actually implement data structures

Not just use them

ALGORITHMS

Some classic, fundamental algorithms

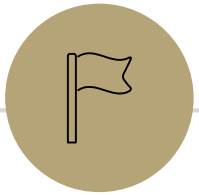
How they work

How do we get them use them to solve problems

TOOLS TO MAKE AND ANALYZE DS&ALGS

Basic Software Engineering Practices
Debugging
Testing
Version Control

Basic Theoretical Computer Science
Modelling Code/Big-O
Analyzing Recurrences



Data Structures and Algorithms

What are they anyway?

Basic Definitions

Data Structure

- A way of organizing, storing, accessing, and updating a set of data
- Examples from CSE 14X: arrays, linked lists, binary search trees

Algorithm

- A series of precise instructions **guaranteed** to produce a certain answer
- Examples from CSE 14X: binary search, merge sort

Abstract Data Types (ADT)

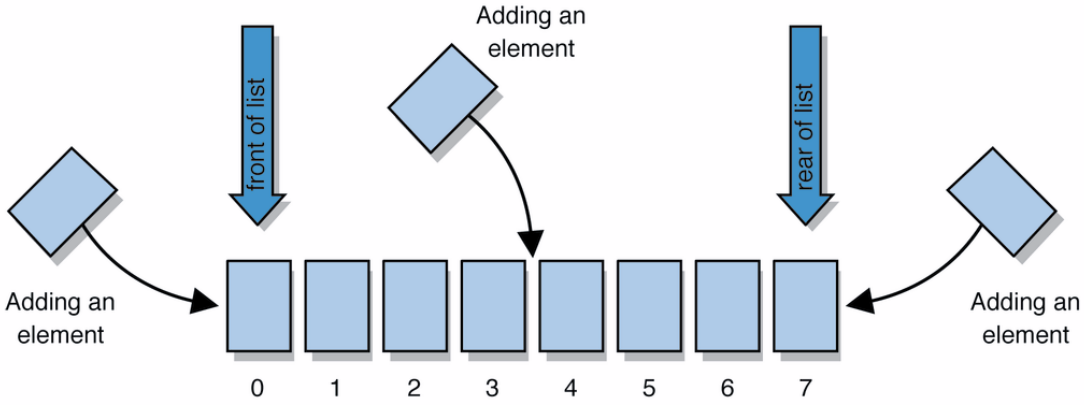
Abstract Data Types

- A definition for expected operations and behavior

Start with the operations you want to do then define how those operations will play out on whatever data is being stored

Review: List - a collection storing an ordered sequence of elements

- each element is accessible by a 0-based index
- a list has a size (number of elements that have been added)
- elements can be added to the front, back, or elsewhere
- in Java, a list can be represented as an ArrayList object



Review: Interfaces

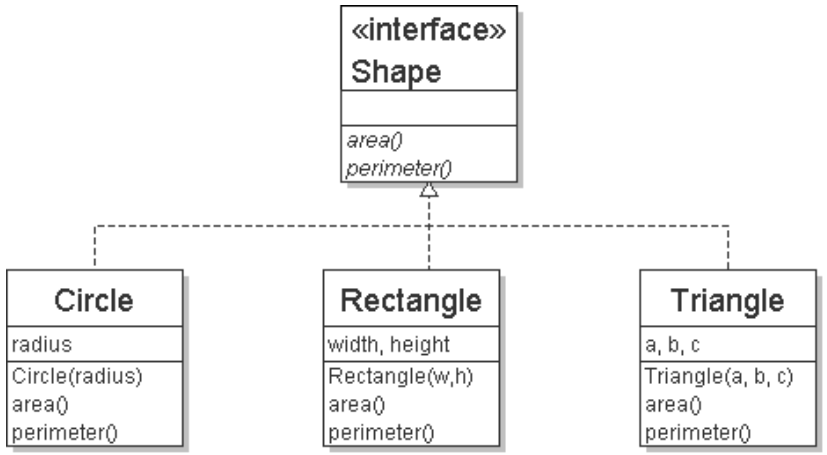
interface: A list of methods that a class promises to implement.

- Interfaces give you an is-a relationship *without* code sharing.
  - A `Rectangle` object can be treated as a `Shape` but inherits no code.
- Analogous to non-programming idea of roles or certifications:
  - "I'm certified as a CPA accountant.
    This assures you I know how to do taxes, audits, and consulting."
  - "I'm 'certified' as a Shape, because I implement the Shape interface.
    This assures you I know how to compute my area and perimeter."

```
public interface name {
    public type name(type name, ..., type name);
    public type name(type name, ..., type name);
    ...
    public type name(type name, ..., type name);
}
```

Example

```
// Describes features common to all
// shapes.
public interface Shape {
    public double area();
    public double perimeter();
}
```



Review: Java Collections

Java provides some implementations of ADTs for you!

You used:

Lists `List<Integer> a = new ArrayList<Integer>();`

Stacks `Stack<Character> c = new Stack<Character>();`

Queues `Queue<String> b = new LinkedList<String>();`

Maps `Map<String, String> d = new TreeMap<String, String>();`

Full Definitions

Abstract Data Type (ADT)

- *A definition for expected operations and behavior*
- A mathematical description of a collection with a set of supported operations and how they should behave when called upon
- Describes what a collection does, **not** how it does it
- Can be expressed as an interface
- Examples: List, Map, Set

Data Structure

- *A way of organizing and storing related data points*
- An object that implements the functionality of a specified ADT
- Describes exactly how the collection will perform the required operations
- Examples: LinkedIntList, ArrayIntList

ADTs we'll discuss this quarter

- List
- Set
- Map
- Stack
- Queue
- Priority Queue
- Graph
- Disjoint Set

Case Study: The List ADT

list: stores an ordered sequence of information.

- Each item is accessible by an index.
- Lists have a variable size as items can be added and removed

List ADT
state Set of ordered items Count of items **behavior** get(index) return item at index set(item, index) replace item at index append(item) add item to end of list insert(item, index) add item at index delete(index) delete item at index size() count of items

supported operations:

- **get(index):** returns the item at the given index
- **set(value, index):** sets the item at the given index to the given value
- **append(value):** adds the given item to the end of the list
- **insert(value, index):** insert the given item at the given index maintaining order
- **delete(index):** removes the item at the given index maintaining order
- **size():** returns the number of elements in the list

Case Study: List Implementations

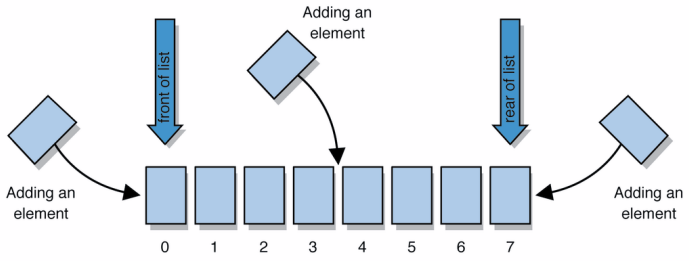
List ADT

state

Set of ordered items
Count of items

behavior

get(index) return item at index
set(item, index) replace item at index
append(item) add item to end of list
insert(item, index) add item at index
delete(index) delete item at index
size() count of items



ArrayList

uses an Array as underlying storage

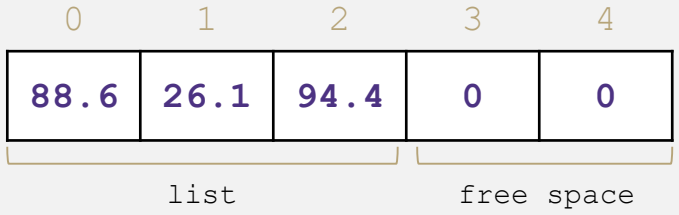
ArrayList<E>

state

data[]
size

behavior

get return data[index]
set data[index] = value
append data[size] = value, if out of space grow data
insert shift values to make hole at index, data[index] = value, if out of space grow data
delete shift following values forward
size return size



LinkedList

uses nodes as underlying storage

LinkedList<E>

state

Node front
size

behavior

get loop until index, return node's value
set loop until index, update node's value
append create new node, update next of last node
insert create new node, loop until index, update next fields
delete loop until index, skip node
size return size

Implementing ArrayList

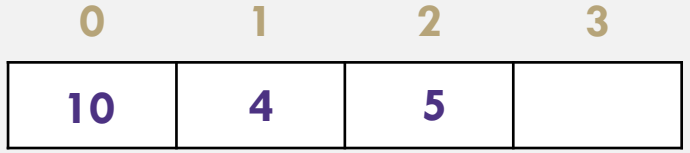
ArrayList<E>

state
- data[]
- size

behavior
- get return data[index]
- set data[index] = value
- append data[size] = value, if out of space grow data
- insert shift values to make hole at index, data[index] = value, if out of space grow data
- delete shift following values forward
- size return numberOfItems

`insert(element, index)` with shifting

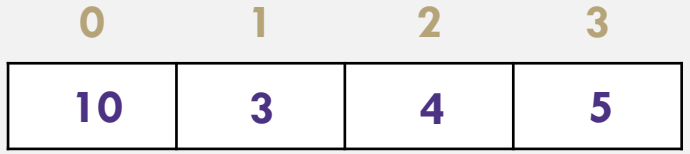
`insert(10, 0)`



`numberOfItems` = 4

`delete(index)` with shifting

`delete(0)`



`numberOfItems` = 3

Take 2 Minutes

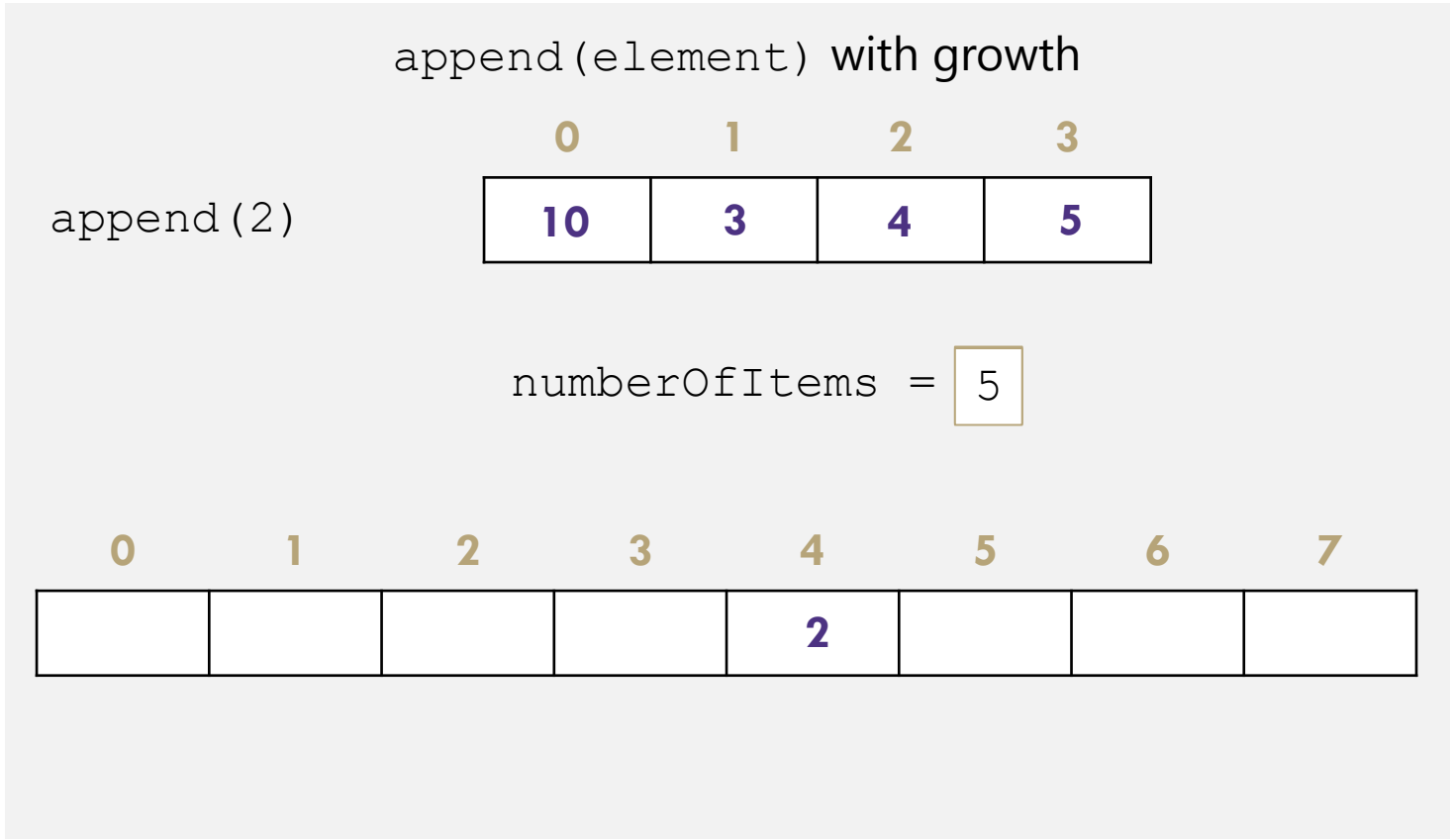
Should we overwrite index 3 with null?

Implementing ArrayList

ArrayList<E>

state
- data[]
- size

behavior
- get return data[index]
- set data[index] = value
- append data[size] = value, if out of space grow data
- insert shift values to make hole at index, data[index] = value, if out of space grow data
- delete shift following values forward
- size return size



Design Decisions

For every ADT there are lots of different ways to implement them

Based on your situation you should consider:

- Memory vs Speed
- Generic/Reusability vs Specific/Specialized
- One Function vs Another
- Robustness vs Performance

This class is all about implementing ADTs based on making the right design tradeoffs!

> A common topic in interview questions

Case Study: List Implementations

List ADT

state
- Set of ordered items
- Count of items

behavior
- get(index) return item at index
- set(item, index) replace item at index
- append(item) add item to end of list
- insert(item, index) add item at index
- delete(index) delete item at index
- size() count of items

Take 2 Minutes

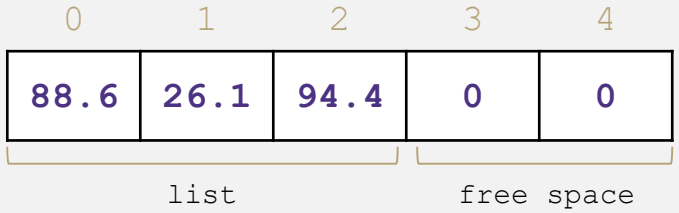
What method will be much faster for LinkedList than for ArrayList?

ArrayList
uses an Array as underlying storage

ArrayList<E>

state
- data[]
- size

behavior
- get return data[index]
- set data[index] = value
- append data[size] = value, if out of space grow data
- insert shift values to make hole at index, data[index] = value, if out of space grow data
- delete shift following values forward
- size return size



LinkedList
uses nodes as underlying storage

LinkedList<E>

state
- Node front
- size

behavior
- get loop until index, return node's value
- set loop until index, update node's value
- append create new node, update next of last node
- insert create new node, loop until index, update next fields
- delete loop until index, skip node
- size return size

Design Decisions

Take 2 Minutes

Dub Street Burgers is implementing a new system for ticket (i.e. food order) management.

When a new ticket comes in, it is placed at the end of the set of tickets.

Food is prepared in approximately the same order it was requested, but sometimes tickets are fulfilled out of order.

Let's represent tickets as a list. Which of our ADT implementations should we use?

Why?

Design Decisions

Let's represent tickets as a list. Which of our ADT implementations should we use?

Why?

ArrayList

Creating a new ticket is very fast (as long as we don't resize), and I want the cooks to be able to see all the orders right away.

LinkedList

We'll mostly be removing from the front of the list, which is much faster for the linkedlist (no shifting), and I want finished orders to be removed fast so they aren't distracting.

Design Decisions

Both ArrayList and LinkedList implementations have pros and cons.

Neither is strictly better than the other.

Some major objectives of this course:

Evaluating pros and cons

Deciding on a design

Defending that design decision

Especially when there's more than one possible answer.