CSE 332: Data Structures

Spring 2016

Richard Anderson

Lecture 1

CSE 332 Team

- Instructors: Richard Anderson
  - anderson at cs
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  - lia4 at cs

Today’s Outline

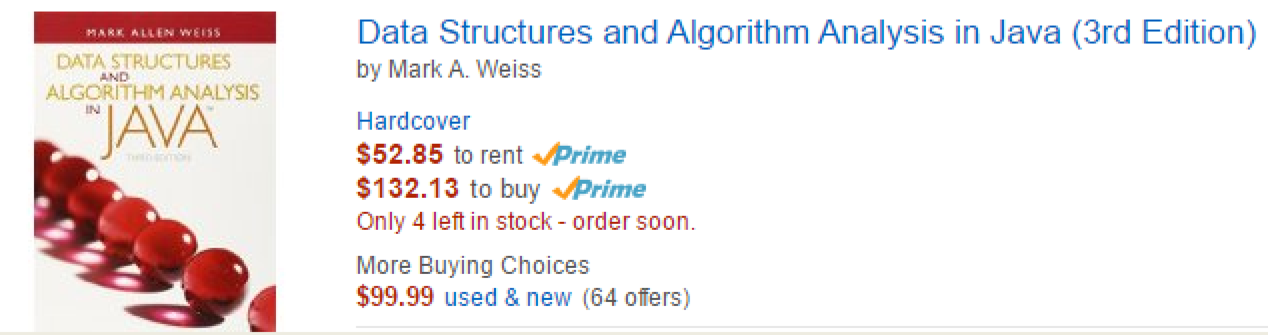
- Introductions
- Administrative Info
- What is this course about?
- Review: queues and stacks

Course Information

http://www.cs.washington.edu/332

Weiss, *Data Structures & Algorithm Analysis in Java*, 3nd Edition, 2012.

(or buy 2nd edition—1/3 price on Amazon!)



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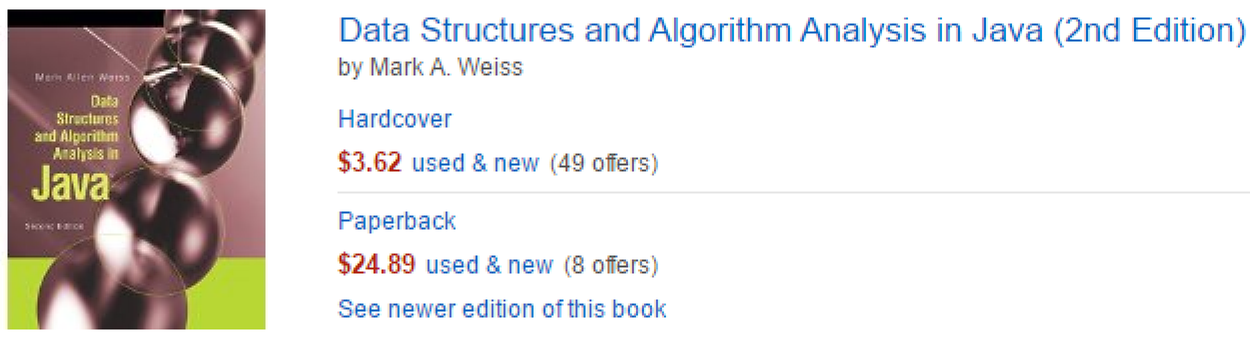

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Communication

Staff

- cse332-staff@cs.washington.edu
- (or our individual addresses)

Announcements

- cse332a_sp16@u
- (you are automatically subscribed @u)

Written homeworks

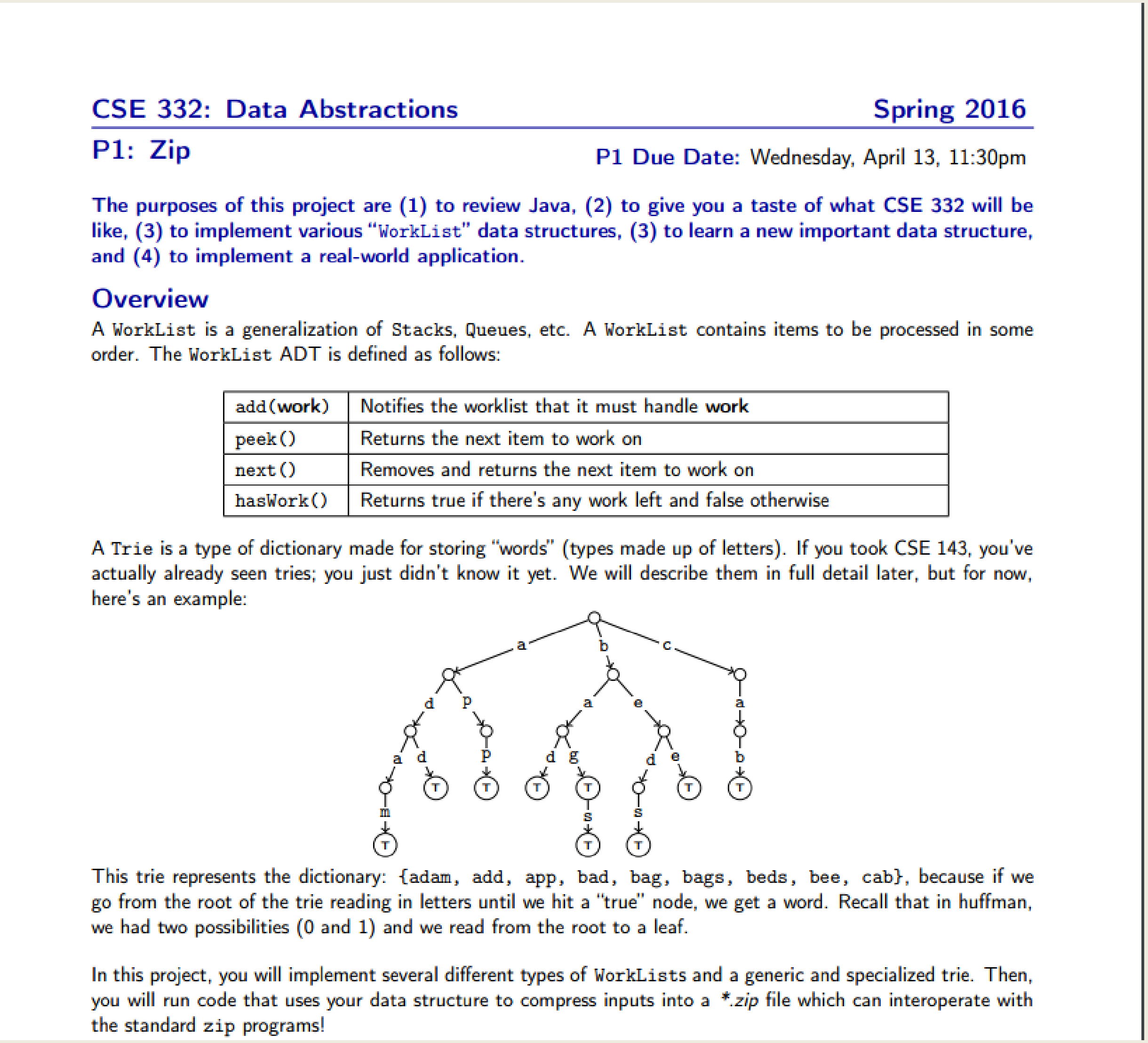
Written homeworks (8 total)

- Assigned weekly
- Due at the **start of class** on due date
- No late homeworks accepted

Projects

- Programming projects (3 total, some with phases)
  - In Java
  - Eclipse encouraged
  - Turned in electronically
  - Work on individually
  - Start work early
    - You have two to three weeks on the projects
    - They are going to be very hard to get done in two to three days
  - Issue to watch out for: Java generics

Project 1 out today



CSE 332: Data Abstractions Spring 2016

P1: Zip

P1 Due Date: Wednesday, April 13, 11:30pm

The purposes of this project are (1) to review Java, (2) to give you a taste of what CSE 332 will be like, (3) to implement various "WorkList" data structures, (3) to learn a new important data structure, and (4) to implement a real-world application.

Overview

A WorkList is a generalization of Stacks, Queues, etc. A WorkList contains items to be processed in some order. The WorkList ADT is defined as follows:

add(**work**)	Notifies the worklist that it must handle **work**
peek()	Returns the next item to work on
next()	Removes and returns the next item to work on
hasWork()	Returns true if there's any work left and false otherwise

A Trie is a type of dictionary made for storing "words" (types made up of letters). If you took CSE 143, you've actually already seen tries; you just didn't know it yet. We will describe them in full detail later, but for now, here's an example:

This trie represents the dictionary: {adam, add, app, bad, bag, bags, beds, bee, cab}, because if we go from the root of the trie reading in letters until we hit a "true" node, we get a word. Recall that in huffman, we had two possibilities (0 and 1) and we read from the root to a leaf.

In this project, you will implement several different types of WorkLists and a generic and specialized trie. Then, you will run code that uses your data structure to compress inputs into a **.zip* file which can interoperate with the standard zip programs!

Overall grading

Grading

20% - Written Homework Assignments

30% - Programming Assignments

20 % - Midterm Exam (Apr 29)

30% - Final Exam (June 6, 2:30-4:20 pm)

Collaboration

- HWs and Projects must be done solo
  - But you can discuss problems with others as long as you follow the Gilligan's island rule

Section

Meet on Thursdays

What happens there?

- Answer questions about current homework
- Previous homeworks returned and discussed
- Discuss the project (getting started, getting through it, answering questions)
- Finer points of Java, eclipse, etc.
- Reinforce lecture material

Homework for Today!!

Reading in Weiss

Chapter 1 – (Review) Mathematics and Java

Chapter 2 – (Next lecture) Algorithm Analysis

Chapter 3 – (Project #1) Lists, Stacks, & Queues

Today's Outline

- Introductions
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- Review: Queues and stacks

Common tasks

- Many possible solutions
  - Choice of algorithm, data structures matters
  - What properties do we want?

Why should we care?

- Computers are getting faster
    - No need to optimize

- Libraries: experts have done it for you

Program Abstraction

Problem defn:

Algorithm:

Implementation:

Data Abstraction

Abstract Data Type (**ADT**):

Data Structure:

Implementation:

Terminology

- Abstract Data Type (ADT)
  - Mathematical description of an object with set of operations on the object. Useful building block.
- Algorithm
  - A high level, language-independent, description of a step-by-step process.
- Data structure
  - A specific organization of the data to accompany algorithms for an abstract data type.
- Implementation of data structure
  - A specific implementation in a specific language.

A starting problem: Prefix Sum

- Input: Array arr of size n
- Methods:
  - arr.sum(i) – find the sum of arr[0]…arr[i]
  - arr.update(i, value) – update arr[i] to value

Solutions

- Naïve
  - arr.sum(i): Loop through and add values
  - arr.update(i, value): arr[i] = value;

- Prefix array
  - Compute pre[i] = arr[0] + . . . + arr[i] for all i
  - arr.sum(i): return pre[i]
  - arr.update(i, value): recompute prefix array

Examples

- Naïve:

1	3	-4	6	3	5	-4	9

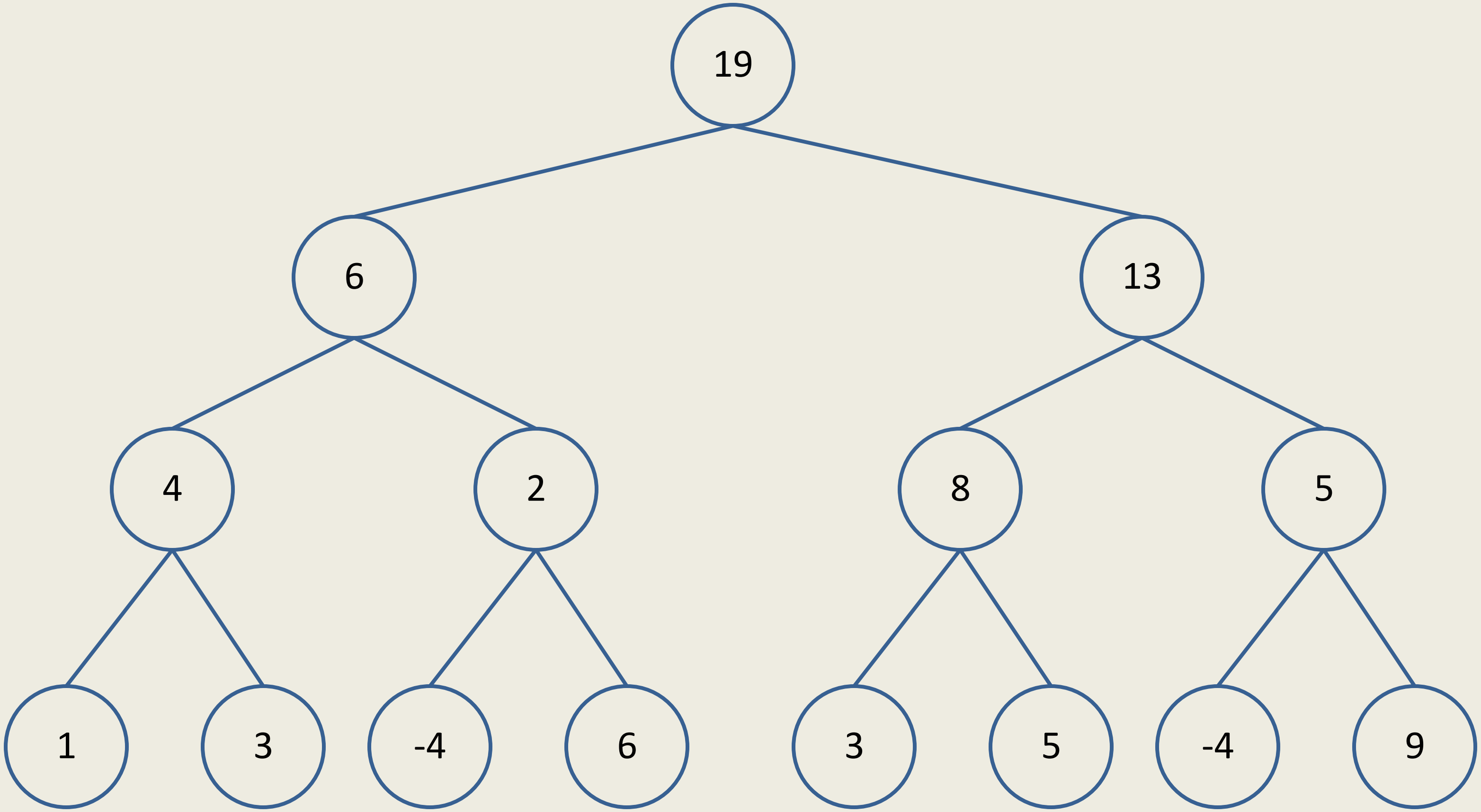
- Prefix Array:

1	3	-4	6	3	5	-4	9

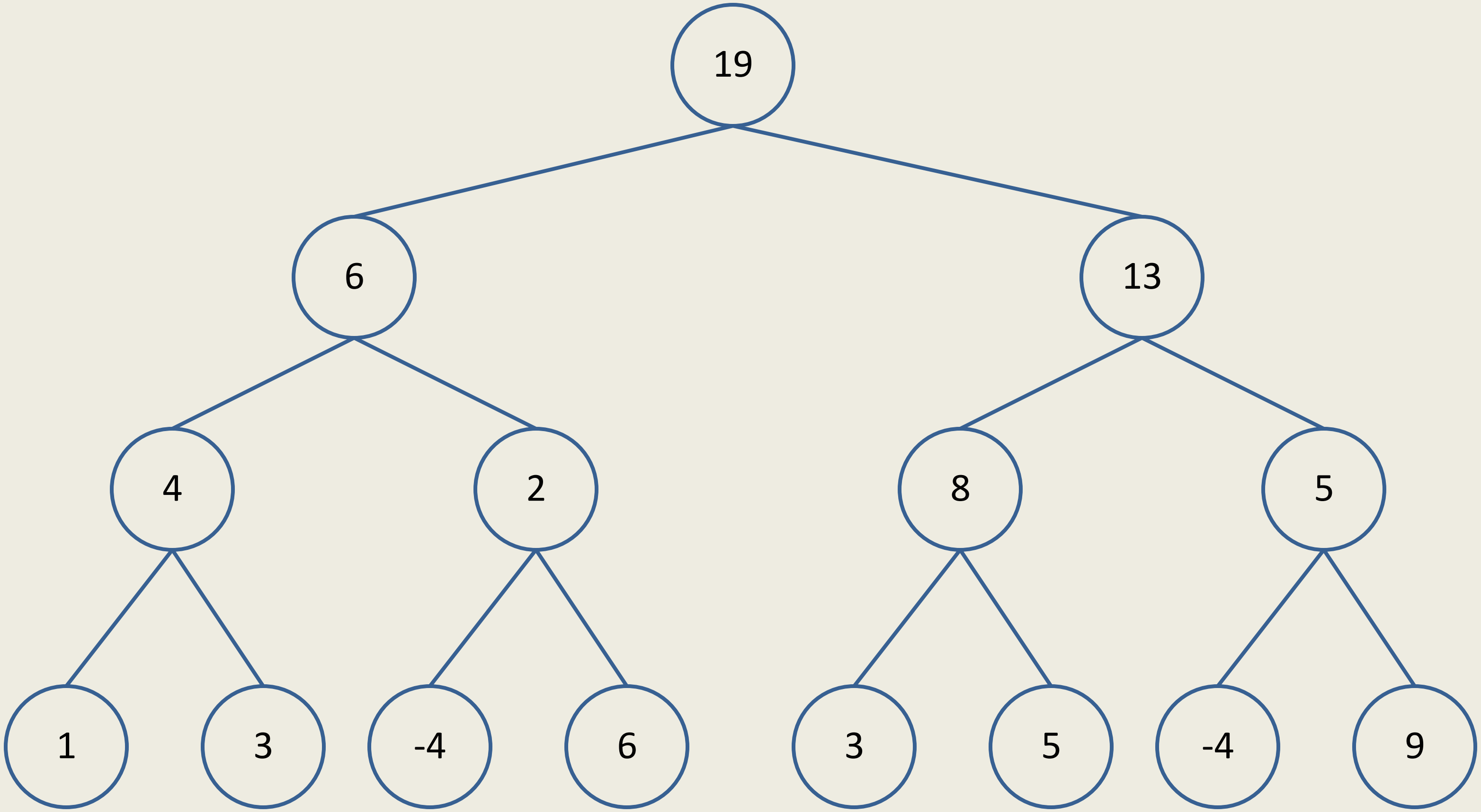
1	4	0	6	9	14	10	19

Better solution: Tree of partial sums

1	3	-4	6	3	5	-4	9



Sum and Update in O(log n) time



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First Example: Queue ADT

- FIFO: First In First Out
- Queue operations

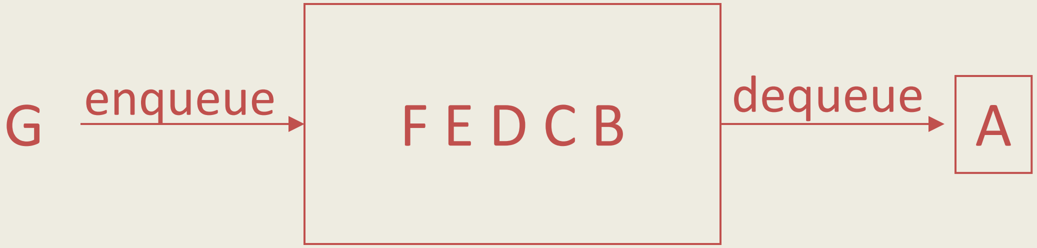
  create

  destroy

  enqueue

  dequeue

  is_empty

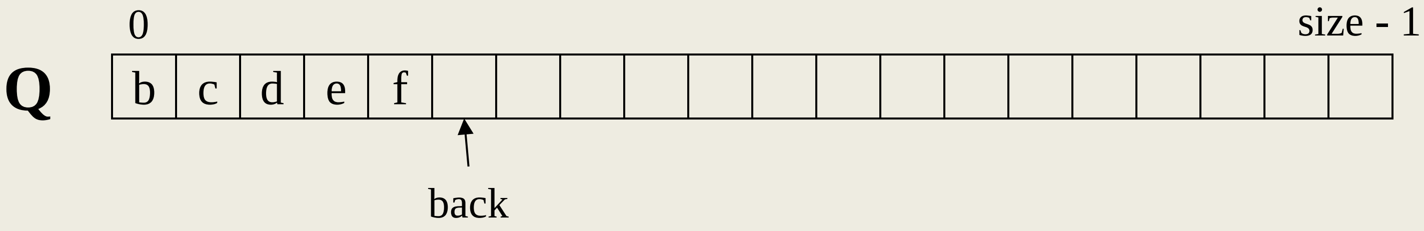


Queues in practice

- Print jobs
- File serving
- Phone calls and operators

(Later, we will consider “priority queues.”)

Array Queue Data Structure

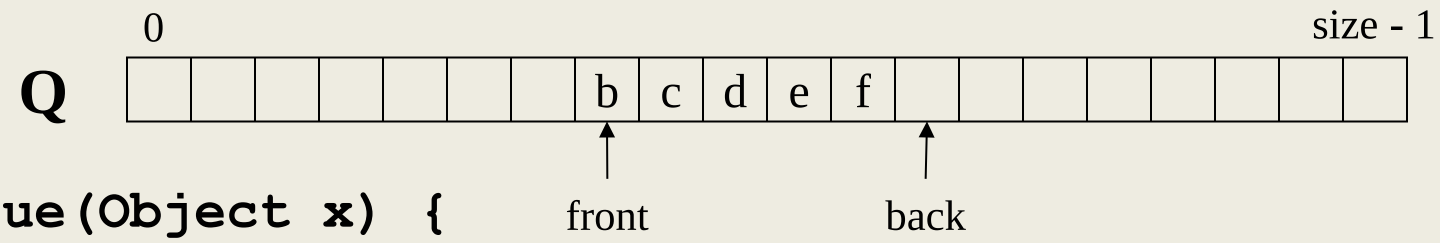


```
enqueue(Object x) {
    Q[back] = x
    back = (back + 1)
}

dequeue() {
    x = Q[0]
    shiftLeftOne()
    Back = (back - 1)
    return x
}
```

What’s missing in these functions?

How to find K-th element in the queue?

Circular Array Queue Data Structure



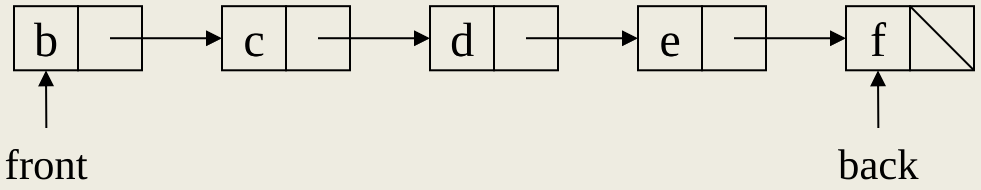
```
enqueue(Object x) {
    assert(!is_full())
    Q[back] = x
    back = (back + 1)
}

dequeue() {
    assert(!is_empty())
    x = Q[front]
    front = (front + 1)
    return x
}
```

How test for empty/full list?

How to find K-th element in the queue?

What to do when full?

Linked List Queue Data Structure



```
void enqueue(Object x) {
   if (is_empty())
        front = back = new Node(x)
   else {
        back->next = new Node(x)
        back = back->next
  }
}
bool is_empty() {
   return front == null
}
```

```
Object dequeue() {
   assert(!is_empty())
   return_data = front->data
   temp = front
   front = front->next
   delete temp
   return return_data
}
```

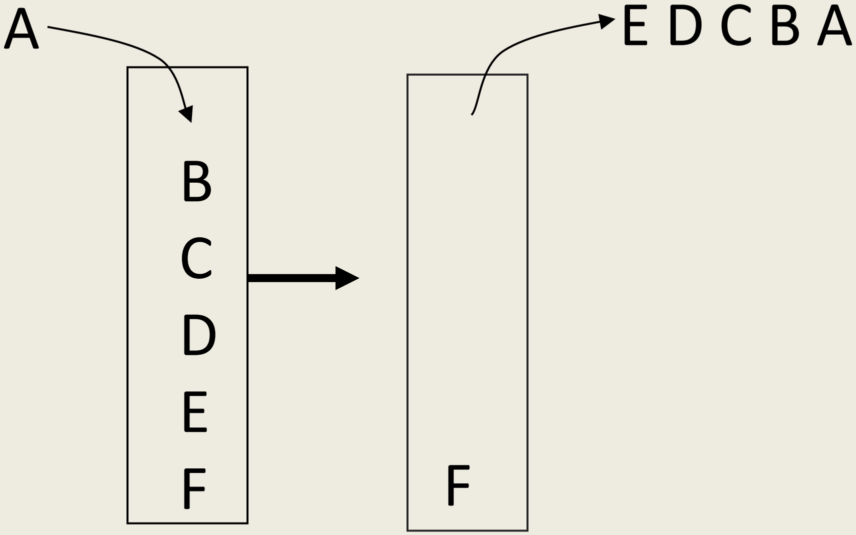
Circular Array vs. Linked List

- Advantages of circular array?

- Advantages of linked list?

Second Example: Stack ADT

- LIFO: Last In First Out
- Stack operations
  - create
  - destroy
  - push
  - pop
  - top
  - is_empty



Stacks in Practice

- Function call stack
- Removing recursion
- Balancing symbols (parentheses)
- Evaluating postfix or “reverse Polish” notation

Assigned readings

Reading in Weiss

- Chapter 1 – (Review) Mathematics and Java
- Chapter 2 – (Next lecture) Algorithm Analysis
- Chapter 3 – (Project #1) Lists, Stacks, & Queues