CSE 326: Data Structures

Dave Bacon

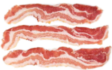
Winter Quarter 2007

Lecture 1

Who?

Dave Bacon

› Research Assistant Professor in CSE



› Sorry, no relation to Kevin Bacon

CSE 326 Course Staff

Section A Instructor: Dave Bacon

Section B Instructor: Ruth Anderson

Teaching Assistants:

- Ethan Phelps-Goodman (Section A)
- Jonah Cohen (Section B)
- David Wu (all over the place)

Sections for Lecture A

- AA, Th 9:30-10:20 am MGH 251
- AB, Th 12:30-1:20 pm MEB 246
- There WILL be section this week!

Today's Outline

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

Course Information

- **Instructor**: Dave Bacon, CSE 460
  dabacon@cs.washington.edu
- **Text**: *Data Structures & Algorithm Analysis in Java*, (Mark Allen Weiss), 2^{nd} Edition, 2007
- **Course Web page**:
  `http://www.cs.washington.edu/326`
- **Mailing List for course announcements:**
  - *cse326-announce@cs.washington.edu*
  - Subscribe *yourself* using web interface, see course web page

Course Mechanics

- Written Homeworks (7 total)
  - Due at the start of class on due date (Fridays)
  - No late homeworks accepted
  - Lowest homework grade dropped
- Programming Projects (3 total)
  - In Java
  - Turned in electronically (Wed eve) and on paper
  - Once per quarter: use your “late day” for extra 24 hours – **Must email TA**
- Work in teams only on explicit team projects
  - Appropriate *discussions* encouraged – see website

Course Mechanics(2)

- Approximate Grading

  25% - Written Homework Assignments

  25% - Programming Projects

  20% - Midterm Exam (**in class**)

  25% - Final Exam (common – **different time than listed in UW exam schedule**, more coming on this)

  5% - Best of the four items above.

Office Hours

- Dave Bacon, Tu 4:00-5:00, CSE 460
- Ruth Anderson, M 3:30-4:30, CSE 360

- Ethan Phelps-Goodman, Th 10:30-11:30, CSE 218
- Jonah Cohen, W 1:30-2:30, TBA

- David Wu, W 4:00-5:00 (in lab CSE 002/003), Th 3:30-4:30 (in CSE 218)

Homework for Today!!

1) **Sign up for mailing list (immediately)**
2) **Project #1:** (read before section tomorrow)
3) **Preliminary Survey**: fill out by evening of Friday January 5th (link from webpage)
4) **Information Sheet**: bring to lecture on Friday January 5th
5) **Reading** in Weiss (see next slide)

Reading

- Reading in *Data Structures and Algorithm Analysis in Java*, 2nd Ed., 2007 by Weiss
- For this week (on handout)
  - Chapter 1 – (review) Mathematics and Java (pp. 1-25)
  - Chapter 3 – (Project #1) Lists, Stacks, & Queues
    - Lists (pp. 57-81, heavy on Java, much of this should be review)
    - Stacks (pp. 82-83)
    - Applications of Stacks (pp. 83-91, sections on "Postfix Expressions" and "Infix to Postfix Conversion" can be skipped, but read "Method Calls")
    - Queues (pp. 91-95)
  - Chapter 2 – (Topic for Friday) Algorithm Analysis (pp. 29-50)

Bring to Class on Friday:

- Name Dave Bacon
- Email address dabacon@cs.
- Year (1,2,3,4) ∞
- Major Physics & Literature
- Hometown Yreka, CA
- Interesting Fact or what I did over winter break. Planed wedding

1OR

CG

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Class Overview

Introduction to many of the basic data structures used in computer software

- › Be exposed to a variety of data structures
- › Know when to use them
- › Practice mathematical techniques for analyzing the algorithms that use them
- › Practice implementing and using them by writing programs

Goal:

be able to make good design choices as a developer, project manager, or system customer

Goals

Get a job at Google?

- Interview question: Design and describe a system/application that will most efficiently produce a report of the top 1 million Google search requests. These are the particulars.

  * You are given 12 servers to work with. They are all dual-processor machines with 4Gb of RAM, 4x400GB hard drives and networked together. (Basically, nothing more than high-end PC's)

  * The log data has already been cleaned for you. It consists of 100 Billion log lines, broken down into 12 320 GB files of 40-byte search terms per line.

Goals

Master of the programming universe?

› "I will, in fact, claim that the difference between a bad programmer and a good one is whether he considers his code or his data structures more important. Bad programmers worry about the code. Good programmers worry about data structures and their relationships."

-Linus Torvalds, 2006

Data Structures

"Clever" ways to organize information in order to enable efficient computation

- › What do we mean by clever?
- › What do we mean by efficient?

Data Structures?

Array — List

Binary Tree

Binary Search Tree

Stack

Hash Table

Queue

Deque

Picking the best Data Structure for the job

- The data structure you pick needs to *support* the operations you need
- Ideally it supports the operations you will use most often in an *efficient* manner
- Examples of operations:
  - List ADT with operations `insert` and `delete`
  - Stack ADT with operations `push` and `pop`

Terminology

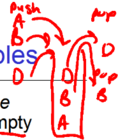
Abstract

- Abstract Data Type (ADT) Queue 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 family of algorithms for implementing an abstract data type. array implement Queue
- Implementation of data structure JAVA
  - › A specific implementation in a specific language

Concrete

A

Terminology examples



- A stack is an *abstract data type* supporting push, pop and isEmpty operations
- A stack *data structure* could use an array, a linked list, or anything that can hold data

- One stack *implementation* is found in java.util.Stack

Concepts vs. Mechanisms

- Abstract
- Pseudocode
- Algorithm
  - A sequence of high-level, language independent operations, which may act upon an abstracted view of data.
- Abstract Data Type (ADT)
  - A mathematical description of an object and the set of operations on the object.

- Concrete
- Specific programming language
- Program
  - A sequence of operations in a specific programming language, which may act upon real data in the form of numbers, images, sound, etc.
- Data structure
  - A specific way in which a program's data is represented, which reflects the programmer's design choices/goals.

Why So Many Data Structures?

Ideal data structure:

"fast", "elegant", memory efficient

Generates tensions:

- time *vs.* space
- performance *vs.* elegance
- generality *vs.* simplicity
- one operation's performance *vs.* another's

The study of data structures is the study of tradeoffs. That's why we have so many of them!

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Priority

First Example: FIFO Queue ADT

Array

- Queue operations
  - create
  - destroy
  - enqueue
  - dequeue
  - is_empty

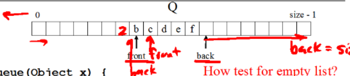
DB

FIFO: First in, first out

dequeue() → DB
enq(DB) → TC DB → dequeue() → TC
enq(TC)

Circular Array Queue Data Structure

Array size




```
enqueue(Object x) {
    Q[back] = x ;
    back = (back + 1) % size
    }
dequeue() {
    x = Q[front] ;
    front = (front + 1) % size;
    return x ;
    }
```

Move back over

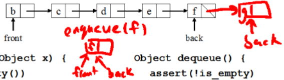
How test for empty list?

How to find K-th element in the queue?

What is complexity of these operations?

Limitations of this structure?

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
}
```

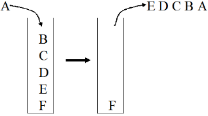
Circular Array vs. Linked List

space array fixed size
  LL variable size

allocation time

Second Example: Stack ADT

- Stack operations
  - › create
  - › destroy
  - › push
  - › pop
  - › top
  - › is_empty



LIFO
Last In First Out

Stacks in Practice

- Function call stack
- Removing recursion
- Balancing symbols (parentheses)
- Evaluating Reverse Polish Notation

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