CSE 326: Data Structures

Introduction

Class Overview

- Introduction to many of the basic data structures used in computer software
  - Understand the data structures
  - Analyze the algorithms that use them
  - Know when to apply them
- Practice design and analysis of data structures.
- Practice using these data structures by writing programs.
- Make the transformation from programmer to computer scientist

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 can
  - make good design choices as a developer, project manager, or system customer
- You will be able to
  - *Justify* your design decisions via formal reasoning
  - *Communicate* ideas about programs clearly and precisely

Goals

"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

Goals

"Show me your flowcharts and conceal your tables, and I shall continue to be mystified. Show me your tables, and I won't usually need your flowcharts; they'll be obvious."

Fred Brooks, 1975

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?

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:
  - A *List* with operations `insert` and `delete`
  - A *Stack* with operations `push` and `pop`

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 family of algorithms for implementing an abstract data type.
- Implementation of data structure
  - A specific implementation in a specific language

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 java.util.Stack; another is java.util.LinkedList

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!

Today's Outline

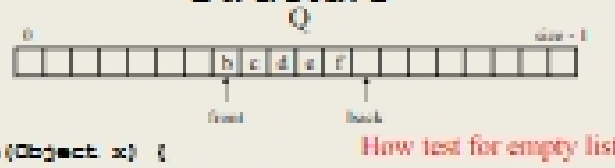
- Introductions
- Administrative Info
- What is this course about?
- Review: Queues and stacks

First Example: Queue ADT

- FIFO: First In First Out
- Queue operations

  create
  destroy
  enqueue
  dequeue
  is_empty

Circular Array Queue Data Structure




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

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

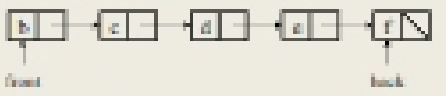
How test for empty list?

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
}
```

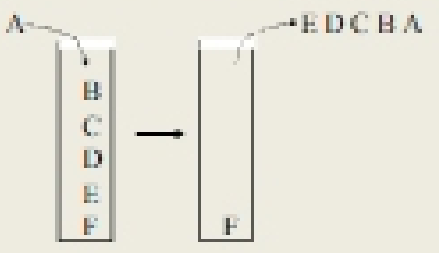
```
Object dequeue() {
   assert(!is_empty)
   return_data = front->data
   temp = front
   front = front->next
   delete temp
   return return_data
}
```

Circular Array vs. Linked List

- Too much space
- Kth element accessed "easily"
- Not as complex
- Could make array more robust
- Can grow as needed
- Can keep growing
- No back looping around to front
- Linked list code more complex

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 Reverse Polish Notation