CSE 373
Data Structures & Algorithms

Lecture 01

Introduction

Staff

- Instructor
  - Dan Suciu suciu@cs.washington.edu
- TAs
  - Sean Shih-Yen Liu syslu@cs.washington.edu
  - Saptarshi Bhattacharya saptarshi6@hotmail.com
  - Patrick Healy healy77@cs.washington.edu

Web Page

- All info is on the web
  - http://www.cs.washington.edu/373

- Lots of stuff already there, including Homework 1, all midterm dates, and all homework due dates
- Future topics are tentative

Office Hours

- Dan Suciu – 662 CSE (Allen Center)
  – Monday 2pm-3pm, or by appointment
- Sean Shih-Yen Liu
  – Tues & Thurs 11am-12pm, CSE 220
- Saptarshi Bhattacharya
  – Thurs 10-11am, CSE 220
- Patrick Healy
  – Wed 1:30-2:30pm, CSE 218

CSE 373 E-mail List

- If you are registered:
  - You will be automatically registered.
- Otherwise:
  - Subscribe by going to the class web page
- E-mail list is used for posting important announcements by instructor and TAs
- You may post too, but are responsible for anything sent here

CSE 373 Discussion Board

- There is a Catalyst e-post message board
- Use
  - General discussion of class contents
  - Hints and ideas about assignments (but not detailed code or solutions)
  - Other topics related to the course

Computer Lab

- College of Arts & Sciences Instructional Computing Lab
  - http://depts.washington.edu/aslab/
- Personal computer highly recommended
- Programming language: Java 5
  - Java 6 is also fine
  - Java 1.4 is ok for some things, but we will use generics which were introduced in Java 5.0

Programming Tools

- Eclipse, DrJava, Textpad, whatever…
  - Also may need JavaDoc, JUnit, which are easy to access from most tools
- We're not religious about this as long as your code is standard Java
  - But stay away from code-generating "wizards"
- Sun Java for Windows/Linux, Java 5 for OS X, and most tools are freely available on the web – easy to set up at home

Textbook

- Data Structures and Algorithm Analysis in Java, Mark Weiss, 2nd edition, Addison-Wesley, 2007.

Grading Breakdown

- Three midterms 50% (15%+15%+20%)
  - Oct.23, Nov.16, Dec.11
- Five assignments 50%
  - Three mini-projects, two *write-ups,* due on:
  - Oct. 8, *Oct. 17*, Nov. 5, *Nov. 13*, Dec. 3
  - Assignment 1 is posted !
- No final (replaced by the 3rd midterm)

Deadlines & Late Policy

- Exact times and dates will be given for each assignment

- Late policy: NONE
- Well, actually there is one, but you don't want to use it:
  - 25% off 1^{st} day, 50% off 2^{nd} day, 75% off 3^{rd} day,100% off 4^{th} day

Academic (Mis-)Conduct

- You are expected to do your own work
  - Group work, if any, will be clearly announced
- Sharing solutions, doing work for or accepting work from others will be penalized
- Integrity is a fundamental principle in the academic world (and elsewhere) – we and your classmates trust you; don't abuse that trust

Homework for Friday !!

- Reading in Weiss (see next slide)
  - For Friday and Monday

- Assignment #1: (posted)
  - The sound blast problem (see second next slide)

Reading

- Reading in Data Structures and Algorithm Analysis in Java, by Weiss

- Read by Friday:
  - Chapters 3.1, 3.2, 3.3

- Read by Monday:
  - Chapter 1 – Mathematics and Java
  - Chapter 3 – (whole thing) Lists, Stacks, & Queues
  - Chapter 2 – Algorithm Analysis

Assignment 1 – Sound Blaster!

Play your favorite song in reverse!

Aim:

1. Implement stack ADT two different ways
2. Use to reverse a sound file

Due: Thursday, October 8, 11:45pm

Example

- Towers of Hanoi: http://www.cut-the-knot.com/recurrence/hanoi.shtml or http://www.mazeworks.com/hanoi/

- Question to class: how long will it run for
  n = 3
  n = 10
  n = 20
  n = 50
  n =100

Example

- How many moves do we need to solve it for some n ?

$T(n) = 2^n – 1$

$T(1) = 1$
$T(n) = T(n-1) + 1 + T(n-1)$
$= 2\,T(n-1) + 1$

Proof: let S(n)=T(n)+1
Then S(n) = 2*S(n-1)
Hence $S(n) = 2^n *S(0) = 2^n$
(because T(0)=0, thus S(0)=1)

- We know T(3) = 7 runs in ≈ 1sec., hence

n	T(n)	Time (approx)
10	$2^{10} \approx 1000$	140 seconds
20	$2^{20} \approx 1M$	38 hours
50	$2^{50} \approx 10^{15}$	31 million years
100	$2^{100} \approx 10^{30}$	$3* 10^{22}$ years (only 10^{10} years since Big Bang)

Asymptotic Complexity

Consider a program that does something useful

- **Input:** n data items
  - a[0], a[1], …, a[n-1]
- **Computes**: crunch, crunch, crunch…
  - Time = T(n)
- **Output**: prints some result

Asymptotic complexity of T(n) (next slide).

Asymptotic Complexity

- This course is about O(f(n))

DEFINITION: The Big-O notation

$T(n) = O(f(n))$ if there exist constants
c and n' such that: $T(n) \le c\, f(n)$ for all $n \ge n'$

Example: Towers of Hanoi has $T(n) = O(2^n)$

Examples

Given n items a[0], a[1], . . ., a[n-1]

- Compute & print a[0]+a[1]+…+a[n-1]
  - $T(n) = O(n)$
- Compute & print (a[0] + a[n/2] + a[n-1]) / 3
  - $T(n) = O(1)$
- Print all permutations a[i[0]], a[i[1]],…a[i[n-1]]
  - $T(n) = O(n!) = O(2^{n*\log(n)})$ (why ?)

Quiz: Match problem with Big O

- Compute a[0]*a[1]*…*a[n-1]
- Remove duplicates from a[0], a[1], a[2], …, a[n-1]
- Return a[n/3]
- Find k ≥ 0, and positions i[0], i[1], …, i[k-1] such that: a[i[0]] + a[i[1]] +…+ a[i[k-1]] = n

- $T(n) = O(1)$
- $T(n) = O(n)$
- $T(n) = O(n^2)$
- $T(n) = O(2^n)$

Answers…

- Compute a[0]*a[1]*…*a[n-1]
- Remove duplicates from a[0], a[1], a[2], …, a[n-1]
- Return a[n/3]
- Find $k \geq 0$, and positions i[0], i[1], …, i[k-1] such that: a[i[0]] + a[i[1]] +…+ a[i[k-1]] = n

- $T(n) = O(1)$
- $T(n) = O(n)$
- $T(n) = O(n^2)$
- $T(n) = O(2^n)$

Don't worry yet !
We will study the Big O
in detail, starting on Monday

The Brainy Hacker

- This course is not about better coding, why take it ?

I don’t need 373 because:

- I’ll buy a faster laptop
- I’ll write clever code

The Apocalyptic Laptop

Seth Lloyd, SCIENCE, 31 Aug 2000

- A computer as powerful as the laws of physics will allow
- So energetic, like harnessing a thermonuclear reaction.
- Packed into so small a space that the whole thing would collapse and form a tiny black hole

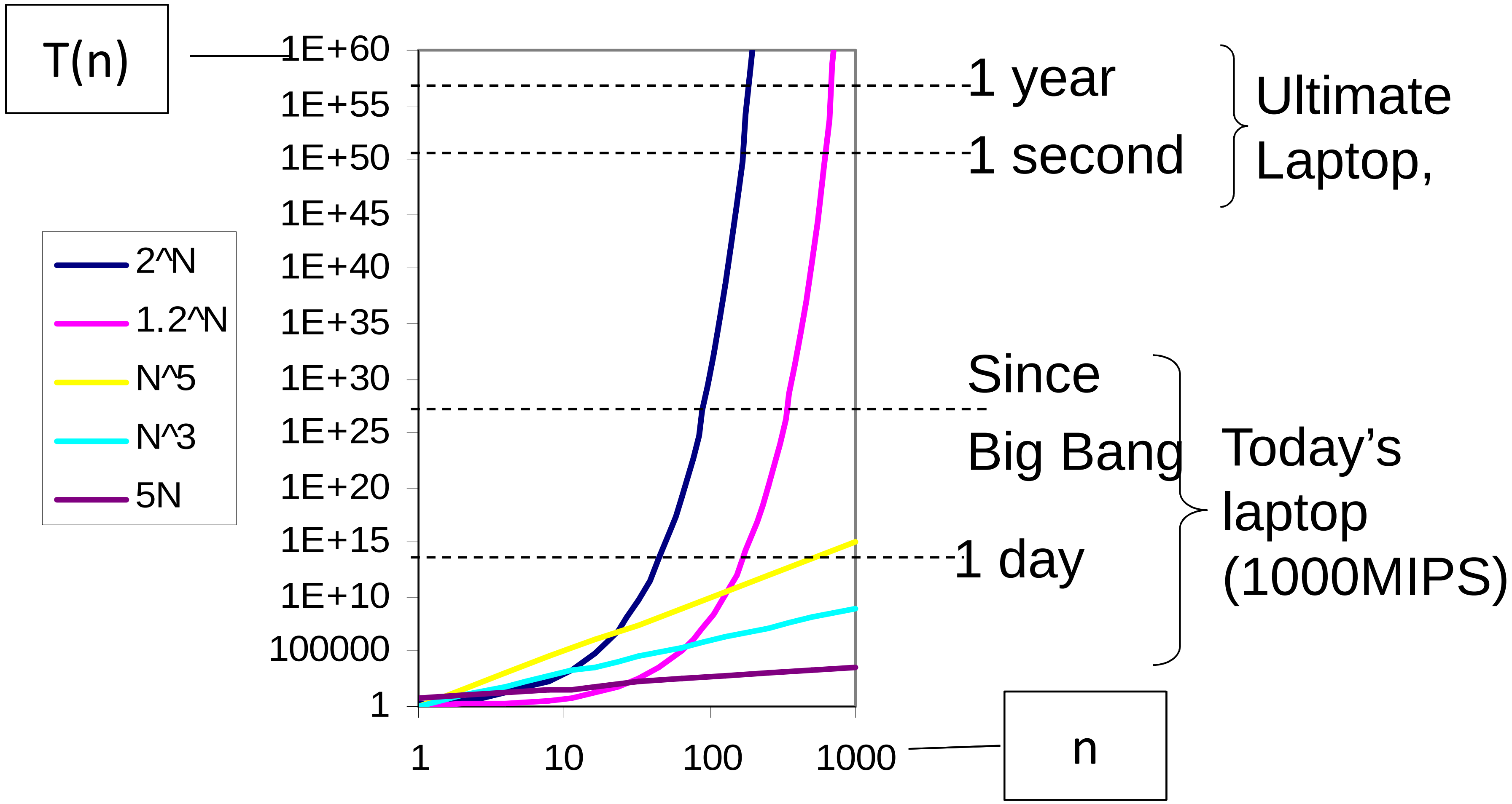
The Apocalyptic Laptop

Seth Lloyd, SCIENCE, 31 Aug 2000

5.4×10^{50} operations per second

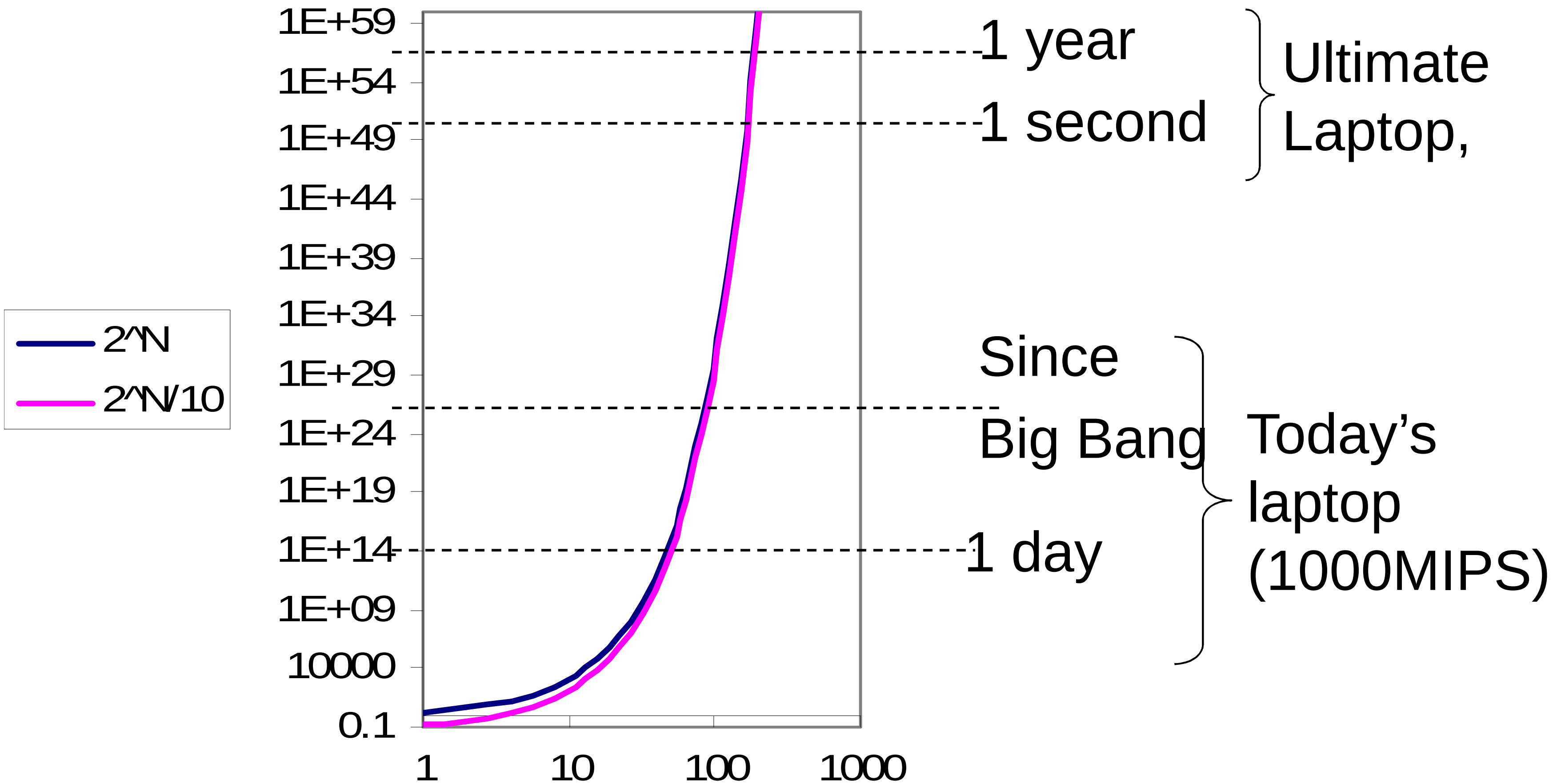
(Typical laptop today: 10^9 operations per second)

What a Better Laptop Buys You



A lot for the good Big O's, not much for the bad O's

What Better Coding Buys You



Ten times faster buys you…

… nothing (for a bad Big O)

A First Hurdle: Java

```
Public class Set_of_ints {
    Public void insert( int x );
    Public void remove( int x ); … }
```

Review the syntax

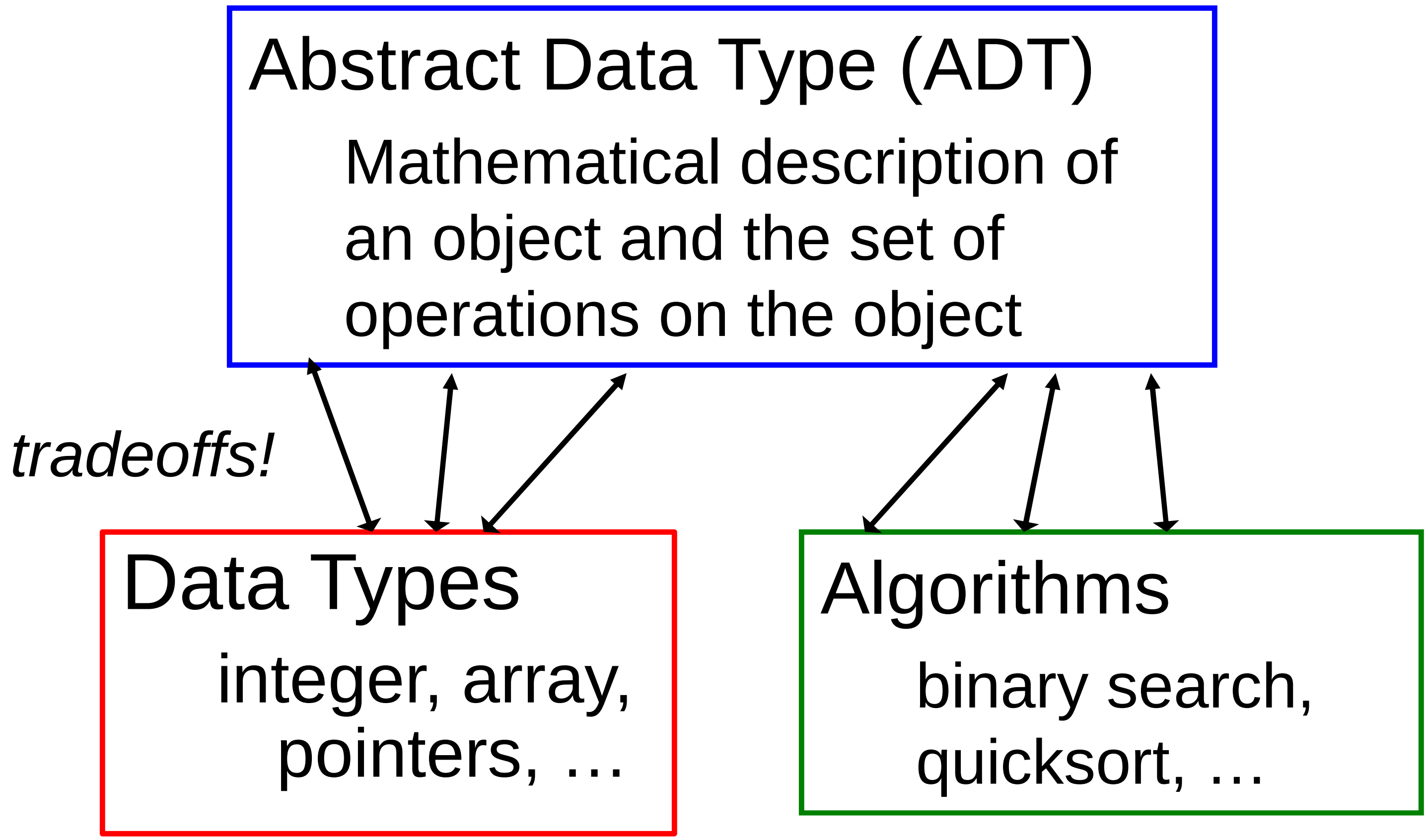
Review java, eclipse, java editor…

You'll need all that for assignment 1,
which is a mini-project, due in one week !

Java Resources

- See webpage for pointers
- Handy Library, from Weiss: http://www.cs.fiu.edu/~weiss/dsaajava/code/

Abstract Data Types



ADT Presentation Algorithm

- Present an ADT
- Motivate with some applications
- Repeat until it's time to move on:
  - develop a data structure and algorithms for the ADT
  - analyze its properties
    - efficiency
    - correctness
    - limitations
    - ease of programming
- Contrast strengths and weaknesses

First Example: Queue ADT

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

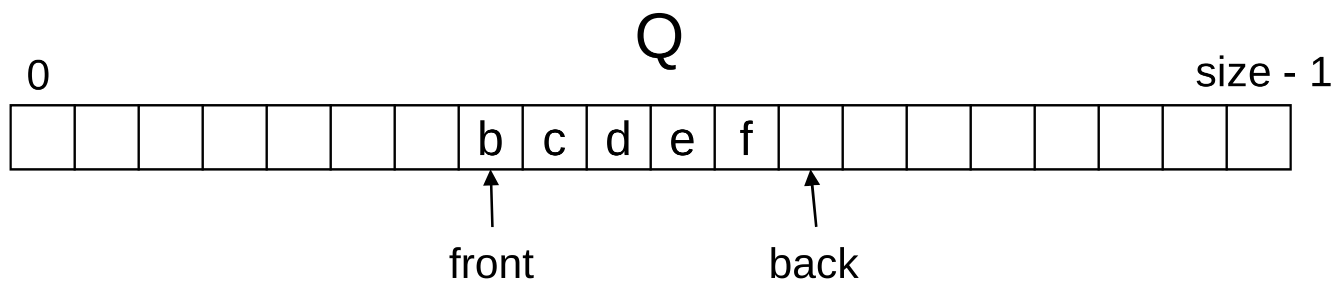
- Queue property:
  - if x is enQed before y is enQed, then x will be deQed before y is deQed
- FIFO: First In First Out

http://courses.cs.vt.edu/csonline/DataStructures/Lessons/QueuesImplementationView/applet.html

Applications of the Q

- Hold jobs for a printer
- Store packets on network routers
- Make waitlists fair
- Breadth first search

Circular Array Q Data Structure




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


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

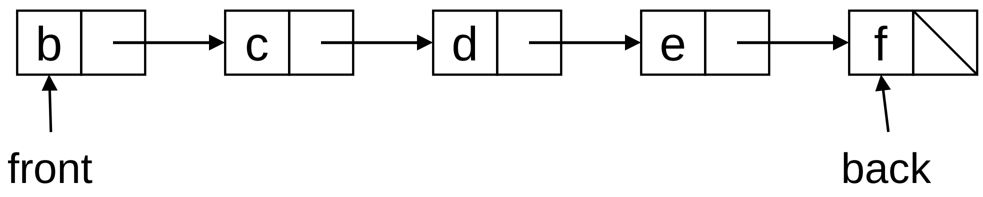
How test for empty list?

How to find K-th element in the queue?

What is complexity of these operations?

Limitations of this structure?

Linked List Q Data Structure




```
enqueue(Object x) {
    back.next = new Node(x);
    back = back.next; }

dequeue() {
    saved = front.data;
    temp = front;
    front = front.next;
    return saved;}
```

What are tradeoffs?

- simplicity
- speed
- robustness
- memory usage