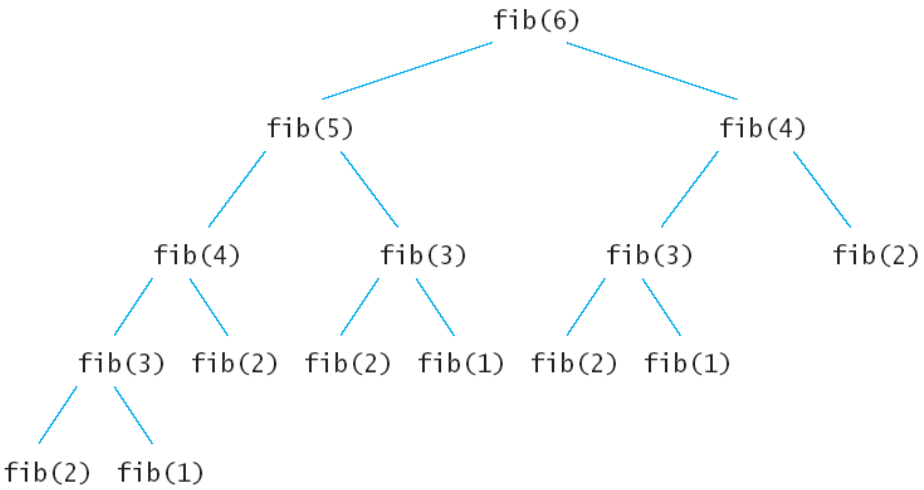


CSSE 230 Day 7

Recursion Again (and again …)

http://www.math.ucla.edu/~wittman/10a.1.10w/ccc/ch14/images/fib_tree.png

Check out from SVN: *Recursion* and *Trees* projects

Agenda

- Student questions about anything!

- Hardy/Evaluator
- Recursion review
- Recursion programming exercise

Note: The next seven days are likely to be the busiest of the term in this course. Two medium-sized programs to write, and challenging written problems. Start early (especially on the programming projects).

Hardy Part 2

- Do a slightly different Hardy calculation
- With certain space constraints
- Make it as fast as you can without violating the problem constraints
  - Mainly, that you can make no pre-assumptions about the sizes of the numbers other than that they are smaller than Java's longest long integer
- Carefully select data structures to use
- When you can correctly find n^{th} Hardy numbers, you are probably halfway done
  - Then comes efficiency

Evaluator

An exercise in writing cool algorithms that evaluate mathematical expressions:

Infix: 6 + 7 * 8
Postfix: 6 7 8 * +

Both using **stacks**.

Meet your partner

- Plan when you'll be working
- Pair programming, but I suggest that each of you take the "research lead" for one of the programs
- Begin thinking about both

Q1-3

Weiss's Recursion Principles

1. **Base Case:** Always have at least one case that can be solved without recursion.
2. **Make Progress:** Every recursive call must progress toward some base case.
3. **"You gotta believe"**: Always assume that the recursive call does what it is supposed to do.
   - Use that result in building the "higher-level" solution

Q4

Recursive List Size

```java
public class ListNode<T> {
   T element;
   ListNode<T> next;

   public ListNode(T e,
         ListNode<T> n) {
      this.element = e;
      this.next = n;
   }

   public ListNode(T e) {
      this(e, null);
   }

   public ListNode() {
      this(null, null);
   }
}
```

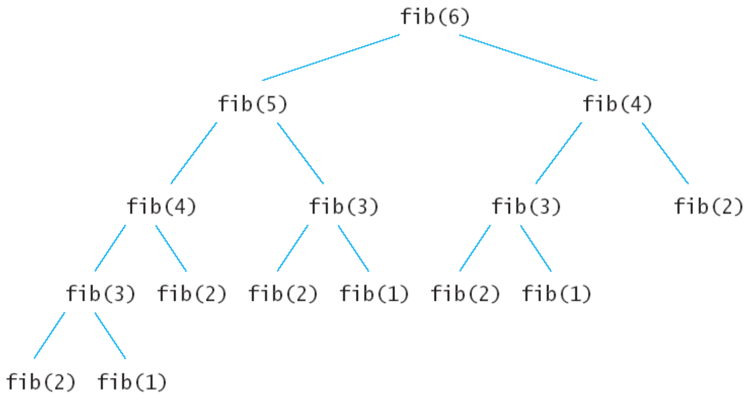
```java
public class LinkedList<T> {
private ListNode<T> head,
private ListNode<T> tail;


// lots of other stuff.
// Write a size() method.





}
```

Fibonacci Numbers

- Each Fibonacci number (except the first two) is the sum of the previous two Fibonacci numbers.

i	0	1	2	3	4	5	6	7	8
F_i	0	1	1	2	3	5	8	13	21

- $F_0=0, \; F_1=1, \; F_{i+2} = F_i + F_{i+1}$




```java
public static int fib(int n) {
        if (n < 2)
                return n;
        return fib(n-2) + fib(n-1);
}
```

The Trouble with Fib

Easy to program!

Expensive!

```
public static int fib(int n) {
      if (n < 2)
            return n;
      return fib(n-2) + fib(n-1);
}
```

Q5, Q6

Weiss's Fourth Recursion Principle

- **Compound Interest rule**: Don't recursively recompute the same things over and over in separate recursive calls.

- Alternatives:
  - Cache previously computed values in an array (memoization)
  - Use a loop

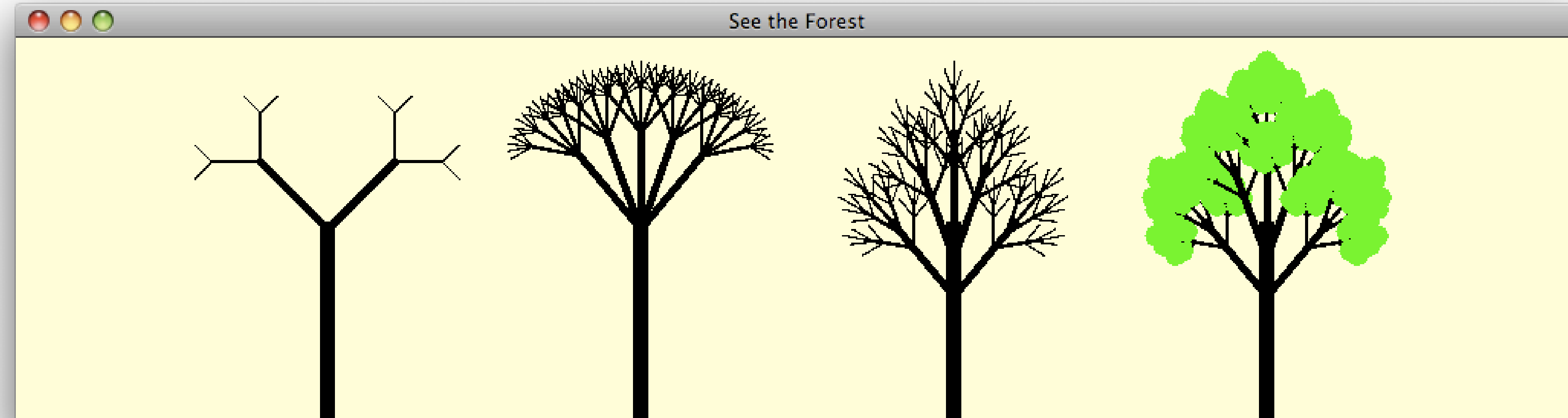
- This is a reminder from 220/221.

Q7

Recursive binary search is elegant

- Input: an array of integers and an element for which to search.
- Output: the index where it was found.
  - -1 if not found
- Big-Oh runtime of binary search?

Trees



- Read assignment linked from schedule, WA3
- Check out *Trees* project from individual SVN repository
- Work on it if you haven't