Recursion and Recursive Structures

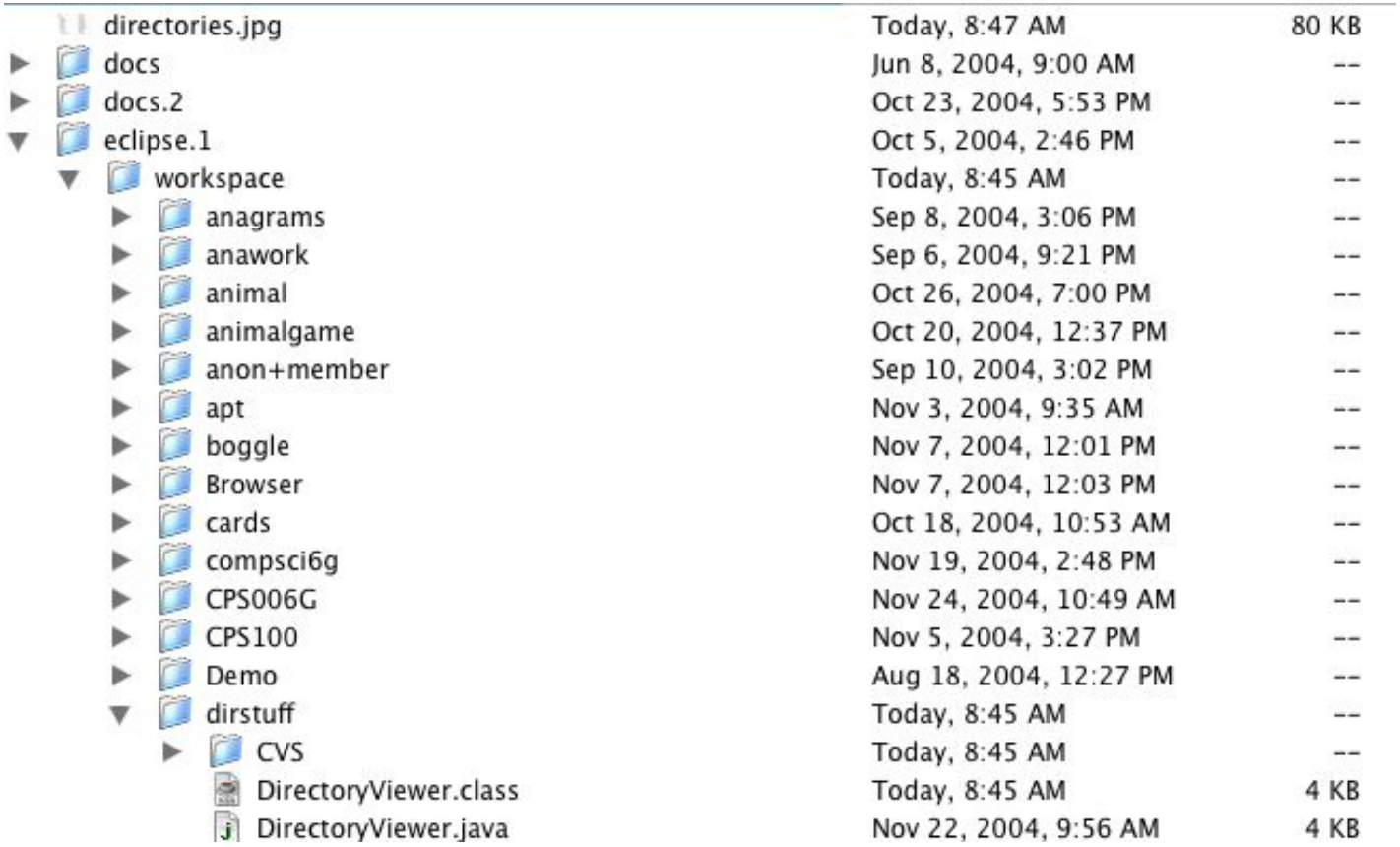
- Definition in the dictionary: in mathematics an expression in which a value is calculated by using preceding terms of the expression
  - Pretty worthless, doesn't convey details or power

- Consider folders and files in a computer, what's in a folder?
  - Files, other folders, anything else?
  - Is there a distinction between a folder and a file?

- Viewpoint is everything, who is the viewer? The viewee?
  - What does this have to do with physics?
  - How do we look at files via programming

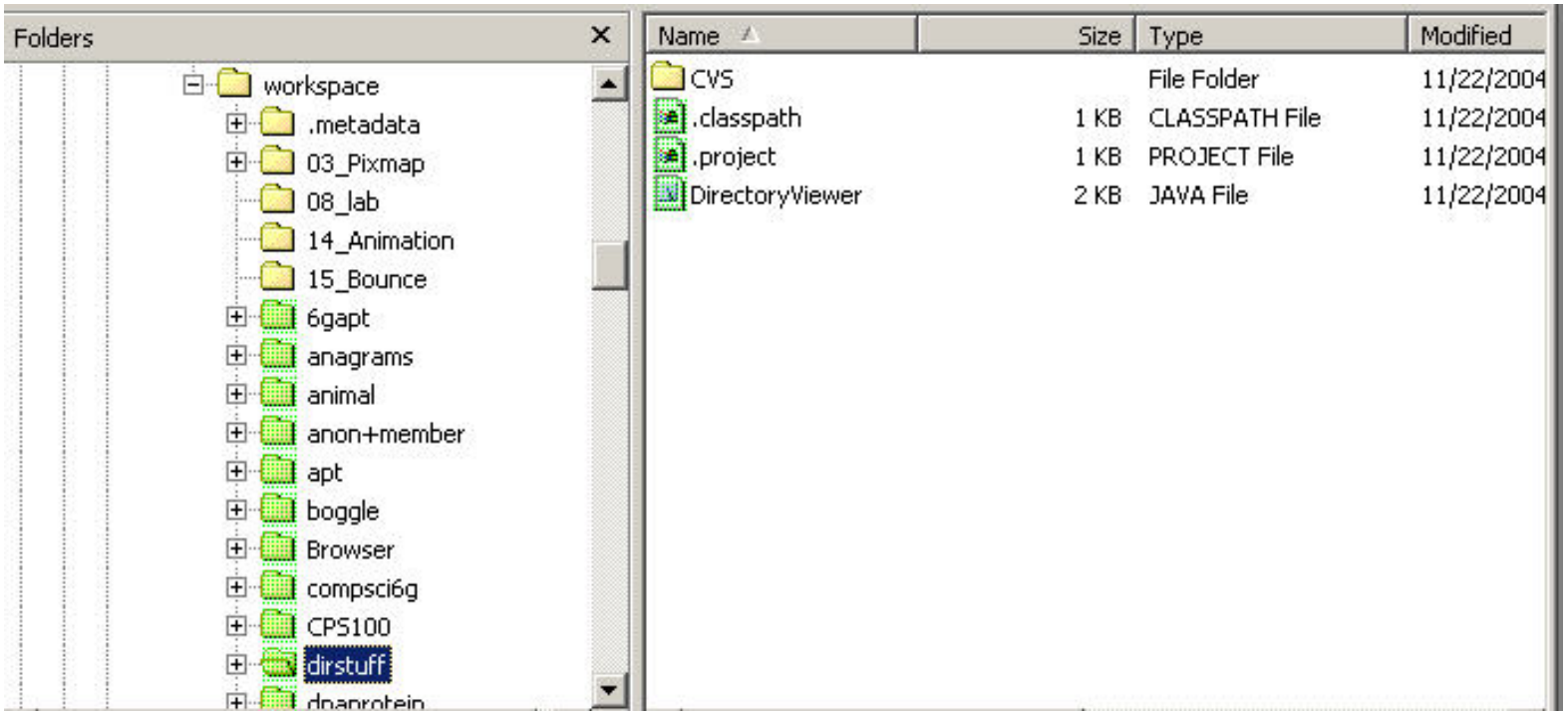
Files and Folders: Files and Directories

- **OS X view of *Directory Structure***



Different OS, Same View

- **Windows 2000 Files and Directories**



java.io.File

- An abstract representation of file and directory pathnames
  - C:\eclipse\workspace\dirstuff\DirectoryViewer.java
  - /Users/ola/Desktop/eclipse/workspace/dirstuff/DV.java

- What is a pathname?
  - Given the path, can you find/navigate to the file/folder?
  - Is there more than one way to get to a folder? Why?

- What accessor methods exist for Files/Directories
  - `getName()`
  - `length(), lastModified()`
  - `isDirectory(), isFile()`

Problem? How 'large' is a directory?

- The size accessor method and file-system view tells how much diskspace the directory entry needs
  - This is small, it requires name, date, list-of-files
  - The list-of-files isn't really part of the directory size, but it doesn't matter, we want SIZE

- How does the 'search' command work to find a file?
  - Search everything from scratch each time
  - Cache results with indexing to avoid re-searching

- How do interact programmatically with file system in platform independent way?
  - Need an abstraction (hint: see java.io.File)

Code to visit a Folder (dirstuff)

```
public void visit(File f, int level){
   if (f.isDirectory()){
     System.out.println(tab(level)+f.length()
                        + " **** " + f.getName());
     File[] files = f.listFiles();
     for(int k=0; k < files.length; k++){
        visit(files[k],level+1);
     }
  }
  else {
      System.out.println(tab(level)+f.length()
                         + "\t" + f.getName());
  }
}
```

Reasoning about File/Directory code

- What is the purpose of the method `visit`?
  - What does `visit` do?
  - What methods does `visit` call?
  - How does `visit` use `java.io.File`?

- Does the method call itself?
  - No, but it calls a method named visit, with a different parameter
  - Think of hundreds of little visit clones, do some work, pass other work off to clone
  - How can we modify the method to print directory last?
  - How can we modify method to calculate "real" size?

Who is Alan Perlis?

- It is easier to write an incorrect program than to understand a correct one
- Simplicity does not precede complexity, but follows it
- If you have a procedure with ten parameters you probably missed some
- If a listener nods his head when you're explaining your program, wake him up
- Programming is an unnatural act
- Won first Turing award

http://www.cs.yale.edu/homes/perlis-alan/quotes.html

What is recursion (revisited)?

- Structure in which a container can hold/use other containers
  - A directory holds file and directories
  - A Russian doll holds other russian dolls?
  - A method that calls 'itself' or clones

- Do russian dolls nest infinitely?
- Do folders hold infinite subfolders?
- Can a method call methods infinitely?

- We need a way out of the mess
  - Last doll, directory with no subdirectories
  - Method that makes no calls

Mathematical Definition of Factorial

- 6! = 1 x 2 x 3 x 4 x 5 x 6
- What's n!
  - If n equals 1 or 0, then it's 1
  - Otherwise it's n x (n-1)!

- Does this get the job done? Is it constructive?
  - What does the method below return for 5?
  - What about –1?

```
public static int factorial(int n){
   if (n == 1 || n == 0) return 1;
   else return n * factorial(n-1);
}
```

Recursive Structure and Methods

- There must be some way out of the recursion
  - A structure with no substructure
  - A method with no recursive method calls
  - This is the *base-case* of the recursion

- The substructure must be similar to the original structure
  - Russian dolls don't hold machine guns (recursively)
  - Each russian doll holds a smaller doll
  - Each call of `visit()` gets closer "to the bottom"
  - Each call of `factorial()` gets closer to 0 or 1
  - Ensure the base case is eventually reached

Recursion and Bioinformatics

- Methods we "studied" for sequence alignment
  - How do we align sequences optimally?
  - What about lots of sequences?
  - Dynamic programming is related to recursion (often implement DP recursively)

- How do we find CG rich regions in a sequence?
  - Divide sequence in half, look for CG rich regions in each half and the overlap of halves
  - How do look for CG rich regions in halves?

Fred Brooks

- … on computing pioneer Howard Aiken *"the problem was not to keep people from stealing your ideas, but to make them steal them."*
- Duke valedictorian 1953, started UNC Computer Science Dept in 1964, won Turing Award in 1999
- Mythical-Man Month, *"Adding man-power to a late project makes it later", … "There is no silver-bullet for Software Engineering… [because of essential complexity]"*
- Highest paid faculty in UNC Arts and Sciences