CMSC201
Computer Science I for Majors

Lecture 18 – Program Design (cont)

Last Class We Covered

- Tuples
- Dictionaries
  - Creating
  - Accessing
  - Manipulating
  - Methods
- Dictionaries vs Lists

Any Questions from Last Time?

Announcement – Survey #2

- Available now on Blackboard
- Due by Sunday, November 13, at midnight
  - Check completion under “My Grades”
- Some statistics (from Fall 2015):
  - If they had taken the surveys…
    - 9 students would have gotten an A instead of a B
    - 4 students would have gotten a B instead of a C
    - 9 students would have gotten a C instead of a D

Today's Objectives

- To discuss the details of "good code"
- To learn how to design a program
- How to break it down into smaller pieces
  - Top Down Design
- To introduce two methods of implementation
  - Top Down and Bottom Up
- To learn more about Incremental Programming

Motivation

- We've talked a lot about certain 'good habits' we'd like you all to get in while writing code
  - What are some of them?

- There are two main reasons for this
  - Readability
  - Adaptability

“Good Code” – Readability

Readability

- Having your code be readable is important, both for your sanity and anyone else's
  - Your TA's sanity is important
- Having highly readable code makes it easier to:
  - Figure out what you're doing while writing the code
  - Figure out what the code is doing when you come back to look at it a year later
  - Have other people read and understand your code

Improving Readability

- Improving readability of your code can be accomplished in a number of ways
  - Comments
  - Meaningful variable names
  - Breaking code down into functions
  - Following consistent naming conventions
  - Programming language choice
  - File organization

Readability Example

- What does the following code snippet do?

```
def nS(p, c):
    l = len(p)
    if (l >= 4):
        c += 1
        print(p)
        if (l >= 9):
            return p, c
    # FUNCTION CONTINUES...
```

- There isn't much information to go on, is there?

Readability Example

- What if I added meaningful variable names?

```
def nS(p, c):
    l = len(p)
    if (l >= 4):
        c += 1
        print(p)
        if (l >= 9):
            return p, c
    # FUNCTION CONTINUES...
```

Readability Example

- What if I added meaningful variable names?

```
def nextState(password, count):
    length = len(password)
    if (length >= 4):
        count += 1
        print(password)
        if (length >= 9):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- And replaced the magic numbers with constants?

```
def nextState(password, count):
    length = len(password)
    if (length >= 4):
        count += 1
        print(password)
        if (length >= 9):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- And replaced the magic numbers with constants?

```
def nextState(password, count):
    length = len(password)
    if (length >= MIN_LENGTH):
        count += 1
        print(password)
        if (length >= MAX_LENGTH):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- And added vertical space?

```
def nextState(password, count):
    length = len(password)
    if (length >= MIN_LENGTH):
        count += 1
        print(password)
        if (length >= MAX_LENGTH):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- And added vertical space?

```
def nextState(password, count):
    length = len(password)


    if (length >= MIN_LENGTH):
        count += 1
        print(password)


        if (length >= MAX_LENGTH):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- Maybe even some comments?

```
def nextState(password, count):
    length = len(password)


    if (length >= MIN_LENGTH):
        count += 1
        print(password)


        if (length >= MAX_LENGTH):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- Maybe even some comments?

```
def nextState(password, count):
    length = len(password)

    # if long enough, count as a password
    if (length >= MIN_LENGTH):
        count += 1
        print(password)

        # if max length, don't do any more
        if (length >= MAX_LENGTH):
            return password, count
    # FUNCTION CONTINUES...
```

Readability Example

- Now the purpose of the code is a bit clearer!
  - You can see how small, simple changes increase the readability of a piece of code

- This is actually part of a function that creates a list of the passwords for a swipe-based login system on an Android smart phone
  - Dr. Gibson wrote a paper on this, available here

Commenting

Commenting is an "Art"

- Though it may sound pretentious, it's true

- There are NO hard and fast rules for when a piece of code should be commented
  - Only guidelines
  - NOTE: This doesn't apply to **required** comments like file headers and function headers!

General Guidelines

- If you have a complex conditional, give a brief overview of what it accomplishes

```
# check if car fits customer criteria
if color == "black" and int(numDoors) > 2 \
        and float(price) < 27000:
```

- If you did something you think was clever, comment that piece of code
  - So that “future you” will understand it!

General Guidelines

- If you have a complex conditional, give a brief overview of what it accomplishes

```
# check if car fits customer criteria
if color == "black" and int(numDoors) > 2 \
        and float(price)
```

This backslash symbol tells Python that the code will continue on the next line.

- If you did something yo
comment that piece of code
  - So that "future you" will understand it!

General Guidelines

- **Don't** write obvious comments

```
# iterate over the list
for item in myList:
```

- **Don't** comment every line

```
# initialize the loop variable
choice = 1
# loop until user chooses 0
while choice != 0:
```

General Guidelines

- **Do** comment "blocks" of code

```
# calculate tip and total - if a party is
# large, set percent to minimum of 15%
if (numGuests > LARGE_PARTY):
    percent = MIN_TIP

tip = bill * percent
total = bill + tip
```

General Guidelines

- **Do** comment nested loops and conditionals

```
listFib   = [0, 1, 1, 2, 3, 5, 8, 13, 21, 34]
listPrime = [2, 3, 5, 7, 11, 13, 17, 19, 23, 29]

# iterate over both lists, checking to see if each
# fibonacci number is also in the prime list
for num1 in listFib:
    for num2 in listPrime:
        if (num1 == num2):
            print(num1, "is both a prime and a \
                         Fibonacci number!")
```

General Guidelines

- **Do** comment very abbreviated variables names (especially those used for constants)
  - You can even put the comment at the end of the line!

```
MIN_CH    = 1      # minimum choice at menu
MAX_CH    = 5      # maximum choice at menu
MENU_EX   = 5      # menu choice to exit (stop)
P1_MARK   = "x"    # player 1's marker
P2_MARK   = "o"    # player 2's marker
```

Side Note: Global Constants

- Globals are variables declared outside of any function (including `main()`)
- Accessible to all functions and code in the file

- Your programs may not have global variables
- Your programs may use global **constants**
  - In fact, constants should generally be global

Side Note: Global Constants

- A constant defines a number (or string) once, and we use the constant instead of the value
- Constants are often used in multiple functions
  - Being global means they're available to all functions
- A global variable will show up in a different font color from regular variables or code

```
GLOBAL_VAR = 7

def main():
    localVar = 7
main()
```

“Good Code” – Adaptability

Adaptability

- Often, what a program is supposed to do evolves and changes as time goes on
  - Well-written flexible programs can be easily altered to do something new
  - Rigid, poorly written programs often take a lot of work to modify
- When coding, keep in mind that you might want to change or extend something later

Adaptability: Example

- Remember how we talked about not using "magic numbers" in our code?

Bad:

```
def makeSquareGrid():
    temp = []
    for i in range(0, 10):
        temp.append([0] * 10)
    return temp
```

Good:

```
def makeSquareGrid():
    temp = []
    for i in range(0, GRID_SIZE):
        temp.append([0] * GRID_SIZE)
    return temp
```

0 and **1** are not "magic" numbers – why?

Adaptability: Example

- We can change **`makeSquareGrid()`** to be an even more flexible function

Better:

```
def makeSquareGrid(size):
    temp = []
    for i in range(0, size):
        temp.append([0] * size)
    return temp

# call makeSquareGrid
grid = makeSquareGrid(GRID_SIZE)
```

Good:

```
def makeSquareGrid():
    temp = []
    for i in range(0, GRID_SIZE):
        temp.append([0] * GRID_SIZE)
    return temp
```

Solving Problems

Simple Algorithms

- Input
  - What information we will be given, or will ask for
- Process
  - The steps we will take to reach our specific goal
- Output
  - The final product that we will produce

More Complicated Algorithms

- We can apply the same principles of input, process, output to more complicated algorithms and programs

- There may be multiple sets of input/output, and we may perform more than one process

Complex Problems

- If we only take a problem in one piece, it may seem too complicated to even begin to solve
  - A program that recommends classes to take based on availability, how often the class is offered, and the professor's rating
  - Creating a video game from scratch

Top Down Design

Top Down Design

- Computer programmers often use a ***divide and conquer*** approach to problem solving:
  - Break the problem into parts
  - Solve each part individually
  - Assemble into the larger solution
- One component of this technique is known as ***top down design***

Top Down Design

- Breaking the problem down into pieces makes it more manageable to solve

- ***Top-down design*** is a process in which:
  - A big problem is broken down into small sub-problems
    - Which can themselves be broken down into even smaller sub-problems
      - And so on and so forth…

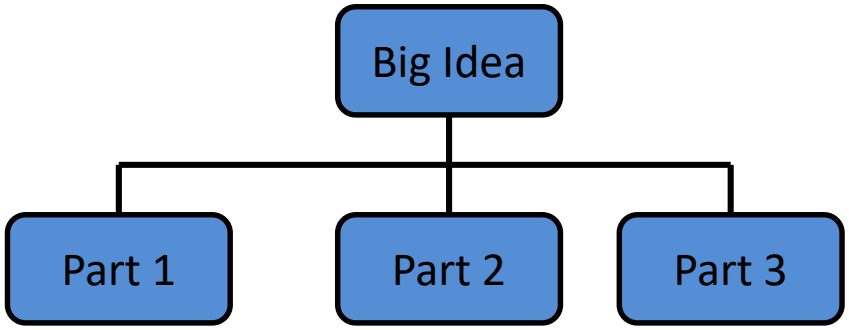
Top Down Design: Illustration

- First, start with a clear statement of the problem or concept

- A single big idea

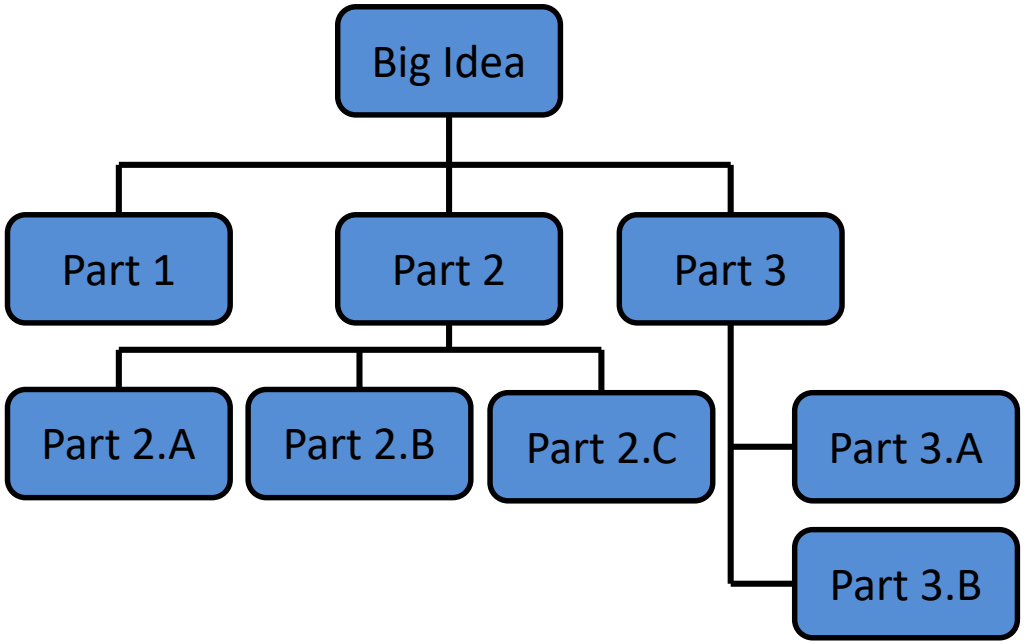
Top Down Design: Illustration

- Next, break it down into several parts



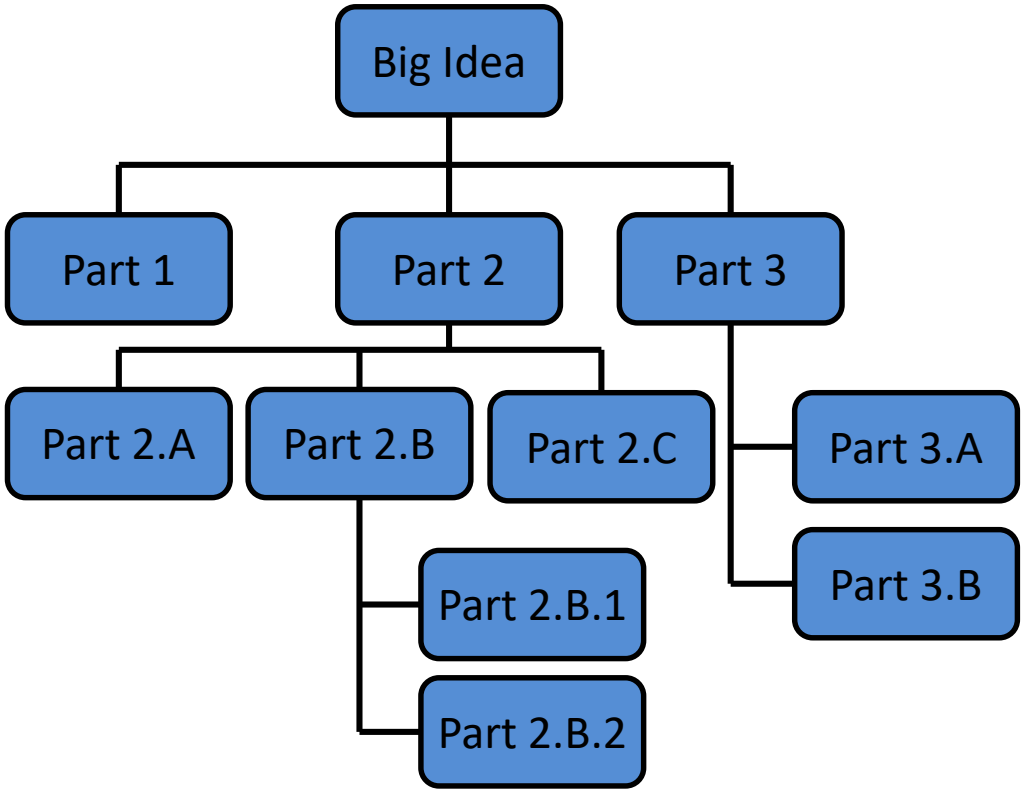
Top Down Design: Illustration

- Next, break it down into several parts
- If any of those parts can be further broken down, then the process continues…



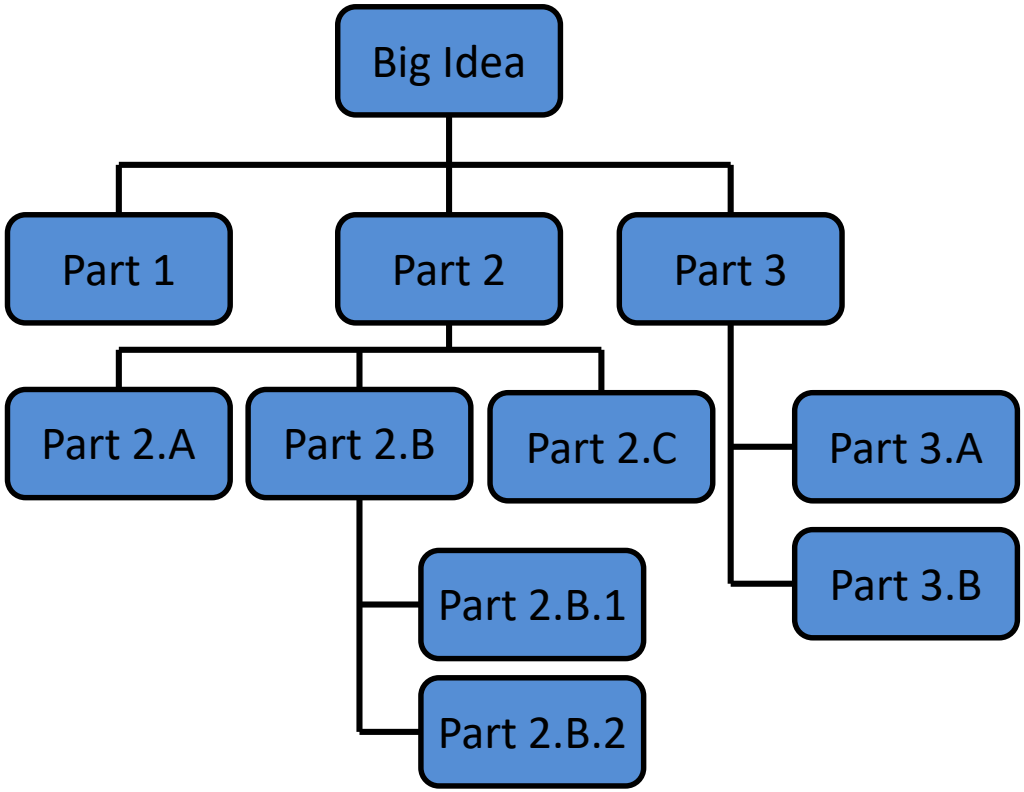
Top Down Design: Illustration

- And so on…



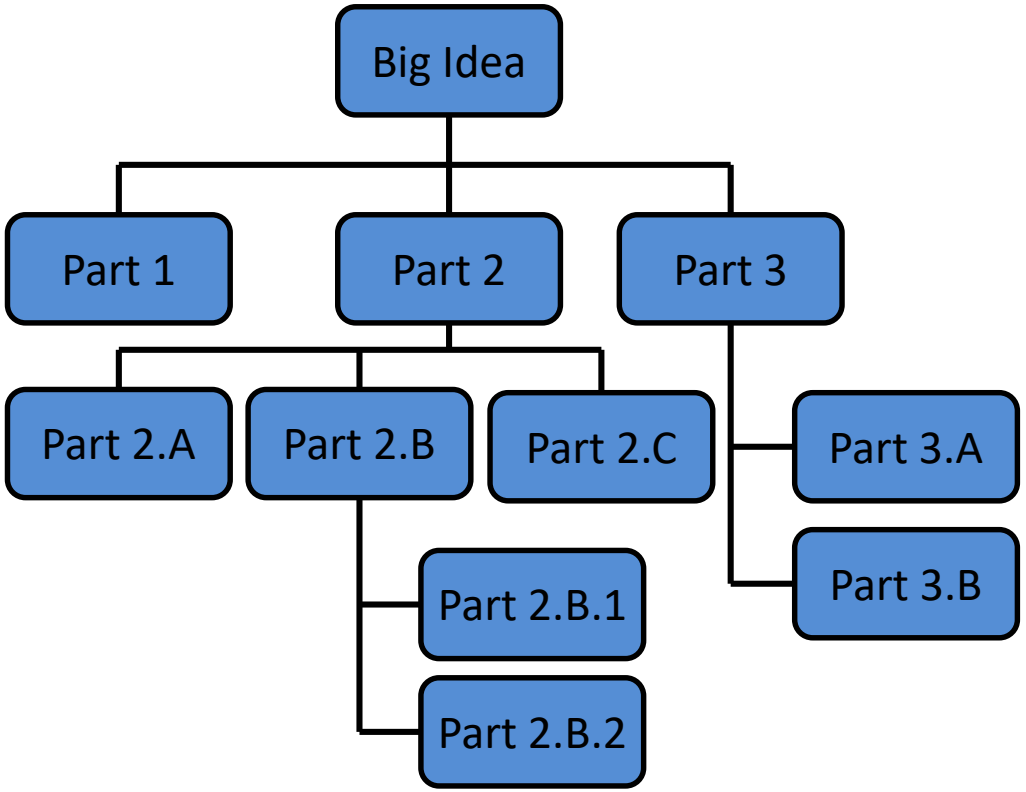
Top Down Design: Illustration

- Your final design might look like this chart, which shows the overall structure of the smaller pieces that together make up the “big idea” of the program



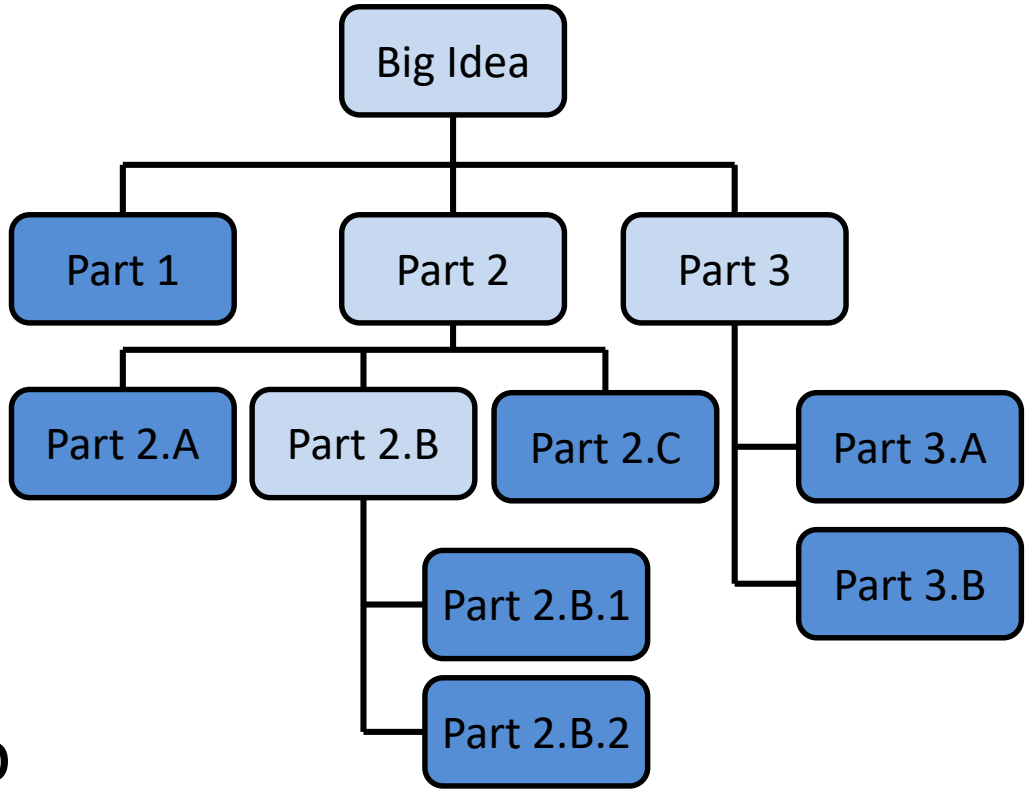
Top Down Design: Illustration

- This is like an upside-down "tree," where each of the nodes represents a process (or a function)



Top Down Design: Illustration

- The bottom nodes are “leaves” that represent pieces that need to be developed
- They are then recombined to create the solution to the original problem



Analogy: Paper Outline

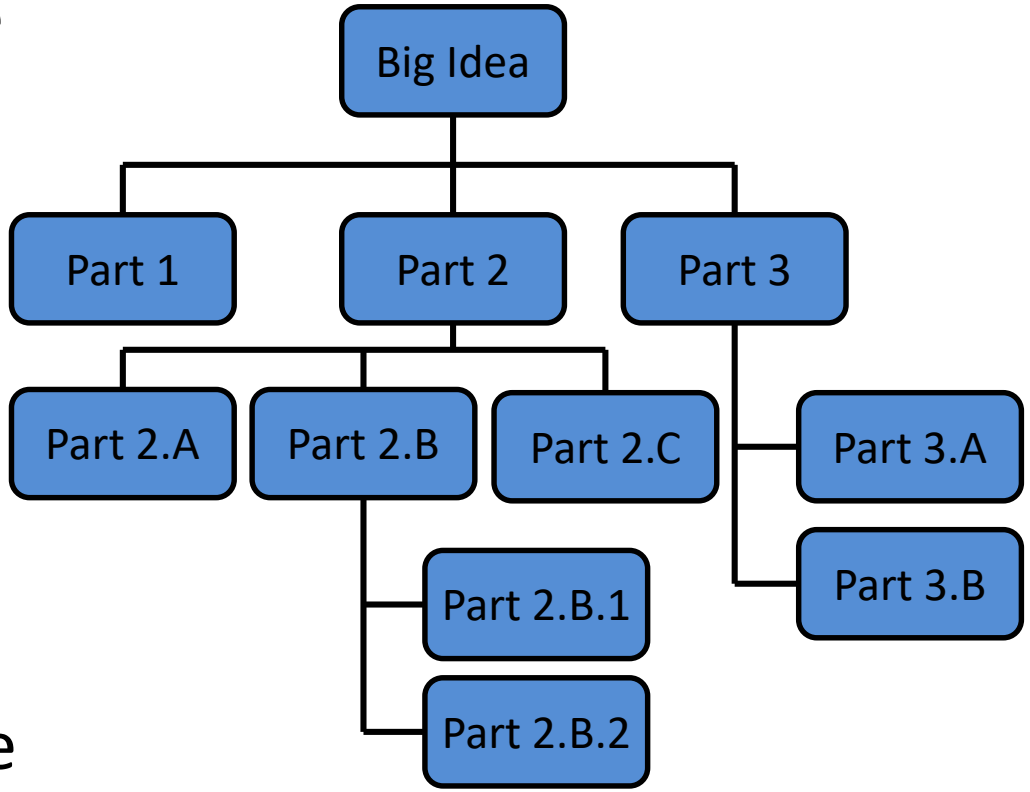
- Think of it as an outline for a paper you're writing for a class assignment

- You don't just start writing things down!
  - You come up with a plan of the important points you'll cover, and in what order
  - This helps you to formulate your thoughts as well

Implementing a Design in Code

Bottom Up Implementation

- Develop each of the modules separately
  - Test that each one works as expected
- Then combine into their larger parts
  - Continue until the program is complete



Bottom Up Implementation

- To test your functions, you will probably use **`main()`** as a (temporary) test bed
  - You can even call it **`testMain()`** if you want

- Call each function with different test inputs
  - How does function ABC handle zeros?
  - Does this **`if`** statement work right if XYZ?
  - Ensure that functions "play nicely" together

Top Down Implementation

- Create "dummy" functions that fulfill the requirements, but don't perform their job
  - For example, a function that is supposed to take in a file name and return the weighted grades; it takes in a filename, but then simply returns a 1
- Write up a "functional" **`main()`** that calls these dummy functions
  - Helps to pinpoint other functions you may need

Which To Choose?

- Top down? Or bottom up?
- It's up to you!
  - As you do more programming, you will develop your own preference and style
- For now, just use something – don't code up everything at once without testing anything!

Design Example

Questions when Designing

- What is the "big picture" problem?
- What sort of tasks do you need to handle?
  - What functions would you make?
  - How would they interact?
  - What does each function take in and return?
- What will your **`main()`** look like?

In-Class Example

- A program that recommends classes to take based on availability, how often the class is offered, and the professor's rating

- Spend a few minutes brainstorming now
  - "Big picture" problem
  - Tasks that need to be handled
  - What **`main()`** looks like

In-Class Example

- Specifics:
  - Get underlying data:
    - Availabilities (probably read in from a file)
    - Class offering frequency (again, from a file)
    - Professor rating (from, you guessed it, a file)
    - How to obtain this information in the first place?
  - Ask user what courses they want to take
  - Find out how many semesters they have left
  - etc…

Incremental Development

What is Incremental Development?

- Developing your program in small increments

1. Program a small piece of the program
2. Run and test your program
3. Ensure the recently written code works
4. Address any errors and fix any bugs
5. Return to step 1

Why Use Incremental Development?

- Incremental development:
  - Makes a large project more manageable
  - Leads to higher quality code
  - Makes it easier to find and correct errors
  - Is faster for large projects
    - May seem like you're taking longer since you test at each step, but faster in the long run

Debugging Woes

- Writing code is easy...
- Writing code that works correctly is HARD

- Sometimes the hardest part of debugging is finding out *where* the error is coming from
  - And solving it is the easy part (sometimes!)
- If you only wrote one function, you can start by looking there for the error

Announcements

- Survey #2 is out
  - Due Sunday, Nov 13 @ 11:59 PM
- Project 1 is due next Wednesday
  - It is much harder than the homeworks
  - No collaboration allowed
  - Start early
  - Think before you code
  - Come to office hours