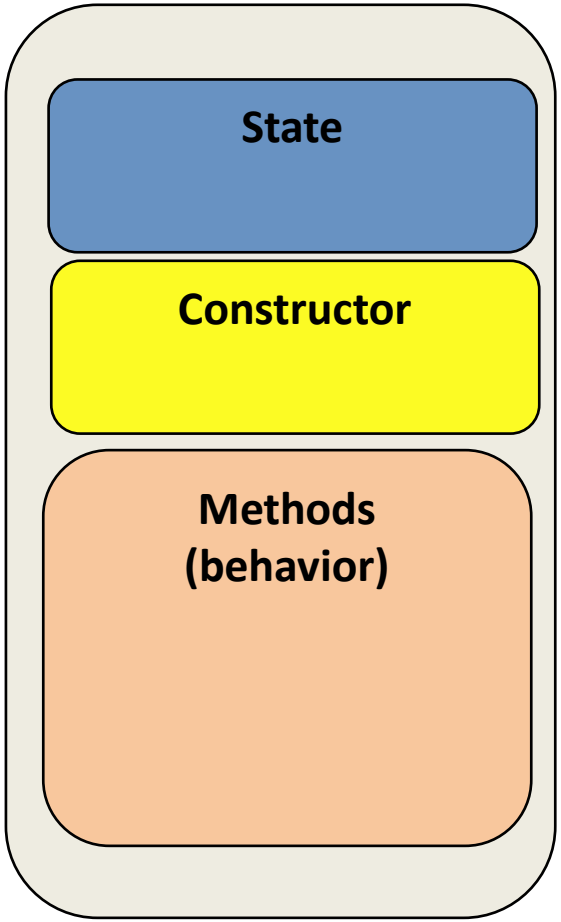
Compsci 201
Classes, Arrays, APIs



Susan Rodger

January 17, 2020

Be in the know …

- **Add yourself to compsci@duke.edu**
  - Duke University mailing lists – add yourself

    https://lists.duke.edu/sympa
  - Compsci related events, jobs, research opportunities
- **Apply for Data+, CS+, Code+**
  - summer research at Duke, paid, hire lots of 1st year students, 2cd year, etc.
  - Apply in January!

  https://www.cs.duke.edu/undergrad/summer_research

`C` is for …

- **Class**
  - Framework for creating objects
- **Collections and Collection**
  - See **`java.util.*`** for details

- **Collaboration**
  - Review the policy

Plan for the Day

- Review Object concept: classes, P0
  - What is a class, object, instance variable
- Review arrays in Java: methods and concepts
  - Required for APTs due next week
  - Move toward ArrayList and other collections
- Coding and helper functions
  - Efficient programming and not efficient programs

Strings: Example from last time

- You can't modify a string, always create new String

```
String s = new String("joy");


String t = s;


s = t + t;
```

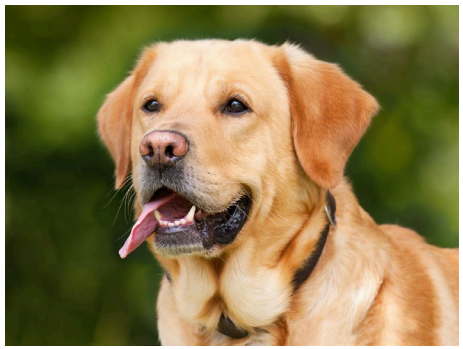
Class

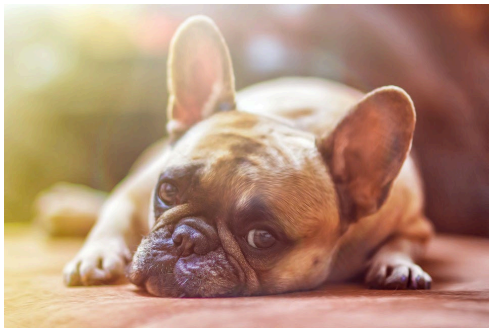
- Adjective, noun, close to a verb
  - Show some ___ you're in a great ___, that's a ___ act, let's ___-ify that

- Fundamental part of object-oriented programming
  - All Java code is in a class, alas the primitives
  - In Python int is a class, has no upper bound
  - In Java int is a primitive, 2^{31}-1 maximal value

Class encapsulates state and behavior

- **Class is a template, object has characteristics**
  - Dogs have fur, speed, temperament, size, …
- **Typically we don't use examples like this, but they can help build intuition and understanding**
  - Class dog, retriever extends dog, method bark()





Class and Object

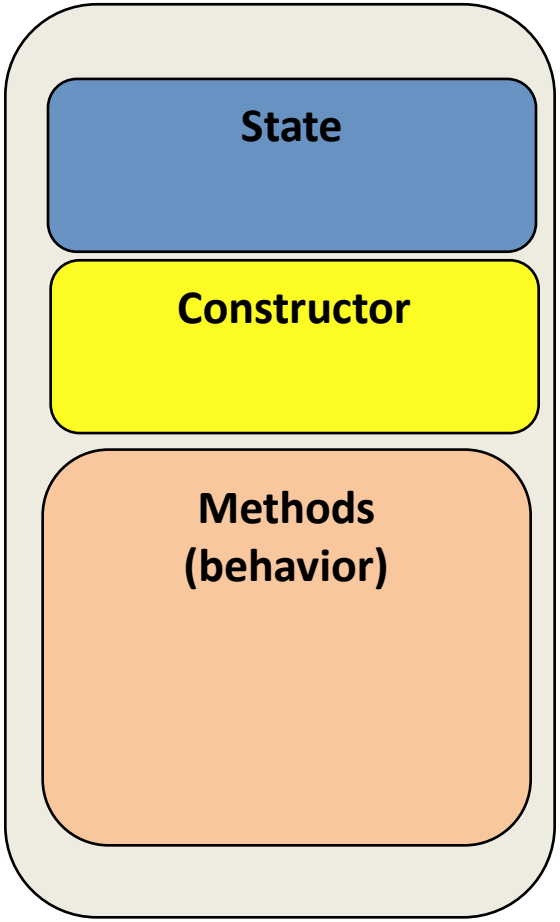
- If we had a Retriever class we could *instantiate an instance of the class, i.e., create an object*

```
Retriever ks = new Retriever("kelsey");
```

- Class is an *object factory*, calling new creates a new object that is an instance of the class
  - We could call a method: **`ks.bark()`**

Classes in Java

- Define class **`Foo`** in **`Foo.java`**
- Create object by calling **`new Foo(..)`**
- Access object by calling methods: **`obj.doSomething()`**
- Some methods return a value, use it!



Classes in Java

- **State**: instance variables: private
- **Constructors**: initialize instance variables
- **Methods**: functions aka behavior
- **Documentation**: Javadoc and other comments

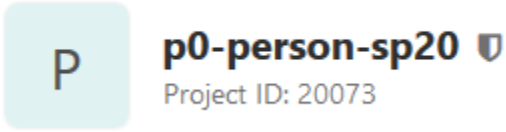
```
 9   public class Person {
10
11       private String myName;
12       private int myAge;
13
14       /** Construct a Person object with a name and age ...*/
19
20   @   public Person(String name, int age) {...}
24
25       /** Construct a default Person, identifier ...*/
29
30   @   public Person() { this( name: "NoName", age: 13); }
33
34       /** Returns this object's identifier/name ...*/
38       public String getName() {...}
42
43       /** Returns age of this person ...*/
47       public int getAge() { return myAge; }
50
51       @Override
52       public String toString() {
53           return String.format("%s %d", getName(), getAge());
54       }
55   }
```

Work-Flow for Assignments

- **What is the work-flow for P0 and Assignments?**
  - Login to gitlab

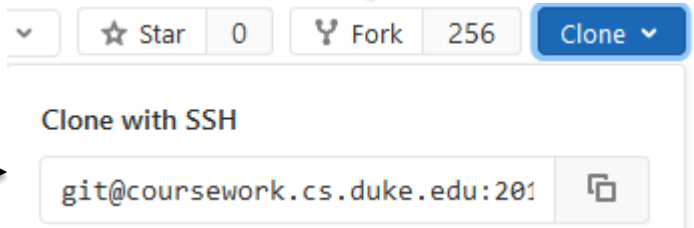
  - Code URL to P0 in gitlab

https://coursework.cs.duke.edu/201spring20/p0-person-sp20



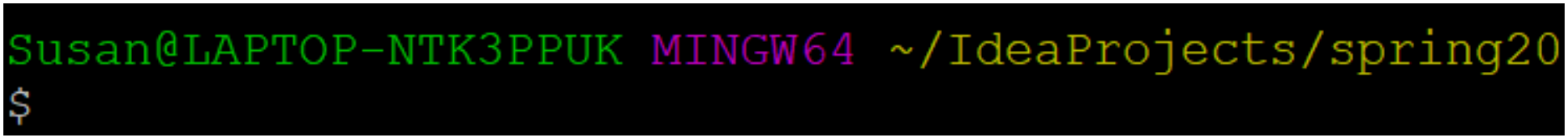
  - Fork it (makes a copy in the cloud)

  - Clone with ssh



Using a shell

- *Place to type shell commands*
- *On Mac use Terminal, Windows use Bash Git*
- *What is this?*



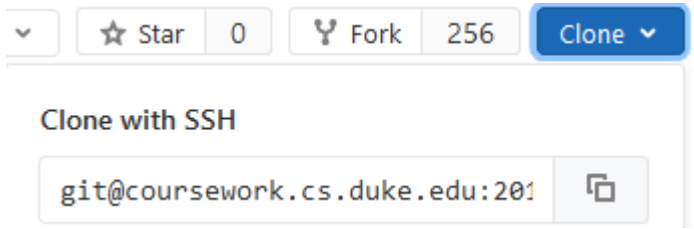
A few shell commands

- *pwd – display current path*
- *cd – change into main folder/directory*
- *cd name -- change into folder named name*
- *cd .. – change back into parent folder*
- *ls -- show files in current folder*

- *Let's see some of those….*

Back to Work-Flow for Assignments

- **Clone with ssh**



- **Go to your shell**
  - cd (to folder you want to put your P0 in)
  - git clone (SSH URL you copied)
  - ls (will show your files)
- **Using IntelliJ complete the assignment**
  - Save code often to gitlab!

Work-Flow for Assignments (cont)

- Send code back to gitlab (DO OFTEN)
  - cd (into project folder)
  - git add .
  - git commit –m “comment on what you did”
  - git push
- Now to Gradescope and submit project
  - Don’t like results - fix code, push code, run on Gradescope again

Classes and P0

- How many Person objects created?
  - Each has a name and an age, different for each instance. Thus: instance variables

```
public class PersonDriver {
    public static void main(String[] args) {
        Person p = new Person();
        Person q = new Person( name: "Sam", age: 21);

        System.out.println(p.getName());
        System.out.println(q.getName());
        System.out.println(p.getAge());
        System.out.println(q.getAge());
        System.out.println(p);
        System.out.println(q);
    }
}
```

Classes and P0

- How many Person objects created?
  - Each has a name and an age, different for each instance. Thus: instance variables
- To create? Call new which invokes a constructor
  - No return type, initialize instance variables
- Access levels: private only within class, public from other classes
  - Technically there is a package access, we ignore

```java
public class Person {
    private String myName;
    private int myAge;

    public Person(String name, int age) {
        myName = name;
        myAge = age;
    }
    public Person() { this( name: "NoName", age: 13); }

    public String getName() { return myName; }
    public int getAge() { return myAge; }

    @Override
    public String toString() {
        return String.format("%s %d", getName(), getAge());
    }
}
```

Constructor

- Same name as class
  - No return type

- Overload with different parameters
  - Each should initialize all instance variables

- Factor out common code into helper method if lengthy
  - Can call another constructor using **`this(…)`**

What is **`this`**?

- An object instance refers to itself
  - Method or constructor: object references itself
  - Every reference to an instance variable **`myVar`** could be written as **`this.myVar`**

- Code for an object to pass itself:
  - **`callMethod(this,"hello");`**
- Constructor can call other constructor
  - **`this("hello");`**

Running a Java Program

- On laptop/desktop launch/run point is the main method in any class
  - Driver programs in P0, runs/drives the code
  - Method signature *required* to run program

```
2  public class PersonDriver {
3      public static void main(String[] args) {
4          Person p = new Person();
5          Person q = new Person( name: "Sam", age: 21);
6
7          System.out.println(p.getName());
8          System.out.println(q.getName());
9          System.out.println(p.getAge());
10         System.out.println(q.getAge());
11         System.out.println(p);
12         System.out.println(q);
13     }
14 }
```

WOTO (3 minutes)

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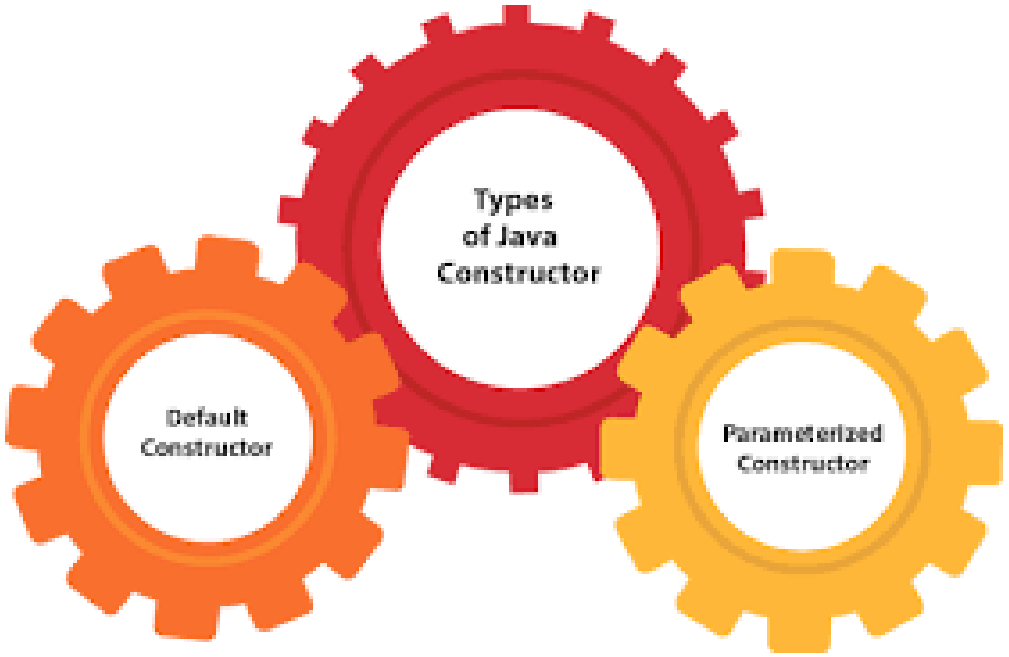


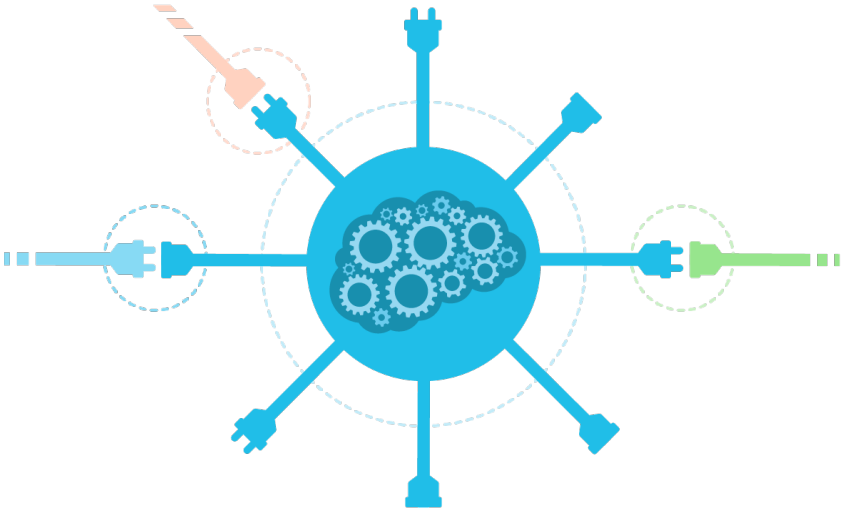
Luis von Ahn

- Duke 2000, Math
- Duke Honorary Degree 2017
- CEO Duolingo
- Macarthur Award, 2006
- MIT-Lemelson Prize, 2018

"It's amazing how motivating it is to sit with somebody and say, 'What you're doing is really important.' I use that a lot."

Arrays, APTs, and APIs

- Why is alliteration important in writing?
- Why are these important in programming?
- APIs create possibilities



Array Details

- Once array created, it's size is fixed, can't grow!
  - Indexable elements can be changed

- Using **`a[k]`** we can read/write values
  - Instance variable **`a.length`** is size of array
    - No parentheses, hence not a method
  - Notice dot notation: object dot name

Indexing for loops and arrays

- Constructing and initializing …

```
int[] a = new int[100];
for(int k=0; k < a.length; k += 1){
    a[k] = 99;
}
```

- Let an API-call fill in array: **`java.util.Arrays`**
  - **`Arrays.fill(a,99);`**
  - https://docs.oracle.com/en/java/javase/11/docs/api/java.base/java/util/Arrays.html

For each loops and arrays

- For each loop: no index, no changing what's stored

```
int[] a = {1,2,3,4,5,6,7,8,9,10};
int sum1 = 0; int sum2 = 0;
for(int k=0; k < a.length; k += 1){
    sum1 += a[k];
}
for(int value : a){
    sum2 += value;
}
System.out.println(sum1 == sum2);
```

For Loop Summary

- **`for(init; boolean guard; update) {…}`**
- **`for(int k=0; k < a.length; k+=1) {…}`**
  - Initialization happens once, *before guard checked for the first time, never again*
  - Initialization can introduce variables: *loop scope*
  - Guard checked, if true loop body executes
  - After loop body, update executes, guard checked

Control Construct Summary

- **`if (boolean) {…}`**
  - Block executed when guard is true
  - {.} not needed for single statement, use anyway
- **`if (boolean) {…} else {…}`**
  - Code in else block when negation true
- **`while(boolean) {…}`**
  - Check boolean guard, execute body, repeat
  - Guard checked again after body executed

From Control to APIs

- List and ArrayList similar to array, but ….
  - Grow as needed, can't use [k] to access
  - Powerful APIs, e.g., as follows

```
jshell> for(int k=0; k < f.length; k+=1){
   ...>     if (f[k].equals(a)) System.out.printf("found %d\n",k);
   ...> }
found 2

jshell> f
f ==> String[4] { "apple", "cherry", "banana", "melon" }

jshell> a
a ==> "banana"

jshell> Arrays.asList(f).indexOf(a)
$6 ==> 2
```

Solving an APT Together

- Totality (see APT page on course site)

http://www.cs.duke.edu/csed/newapt/totality.html

- Solve by hand: a = {20,30,40,50,60} stype="odd"

- Use what you know, but implement in Java
  - *Check ideas using jshell* (Java 9 and later)
  - Command line is your friend!

Think Before You Code

- Solve by hand … Check your understanding of examples … think about solution you'll write ...
  - Then think before fingers on keys

Coding Interlude

- Working on Totality APT in IntelliJ
  - Odd? Even?
  - Control: if, if-else, …

LIVE CODING

WOTO (3 minutes)

http://bit.ly/201spring20-0117-2

Josh Bloch

- Led design of Java Collections Framework
- Formerly Java Chief Architect at Google
- Professor of the Practice CMU

APIs should be easy to use and hard to misuse. *It should be easy to do simple things; possible to do complex things; and impossible, or at least difficult, to do wrong things.*

Visualizations Help Understanding?

- Javatutor to visualize code: http://pythontutor.com/java.html
  - Using the java.awt.Color class
  - Both String and Color are *immutable*
    - Once created, cannot every change

```
1  import java.awt.*;
2
3  public class ObjectColorDemo {
4      public static void main(String[] args) {
5        Color c = Color.RED;
6        Color d = c;
7        Color e = c.darker();
8        Color f = new Color(255,0,0);
9
10       System.out.printf("%s\n%s\n%s\n%s\n",c,d,e,f);
11     }
12 }
```

Summary of Java-isms

- Loop using indexes over an array
  - The for-loop: initialize; guard/check; update
- Totality: loop over odd indexes only?
  - In some cases, …
- How do we check for String equality?
  - .equals compared to ==

- How do we submit an APT?
  - Test, Grade, REFLECT
  - APTS – one grace day, NO LATE AFTER THAT