

Some background before I start the lesson...

- Initial lessons use existing classes (String, ArrayList, Random, Swing)
 - Practice reading APIs
 - Practice instantiating objects
 - Practice invoking methods
 - Using Visual/IDE debugger to introduce concepts of objects, state, references
- Today's Lesson: Defining a new Java class
 - Initial emphasize on object state and object references
 - Visual debugger to clarify object concepts
(map static syntax to dynamic runtime model)
 - Introduce constructors/methods **after** introducing object references

Today's Lesson - Defining a new Java class

- We've seen how to use existing Java classes (String, ArrayList, Random, etc.) to solve a few interesting problems
- Today we'll learn how to define **new** classes to model the state and behavior of some real world objects

Review: Java is an Object-Oriented Language

| Object | State (properties) | Behavior (access & modify state) |
|----------------------------|-------------------------------|--|
| Mobile Phone | model is on volume, ... | toggle on/off adjust volume send text, ... |
| Random Number Generator | seed, multiplier,... | generate random integer, random boolean, ... |
| List | list elements | add element delete element get size, ... |

Defining a new Java class

A **Class** is a blueprint for describing similar objects

- fields (instance variables) describe object state
- methods implement object behavior (access and update state)

```
public class ClassName {  
    //Field declarations  
  
    //Method declarations  
  
}
```

Defining a new Java class

```
public class Fish {  
  
    //Field declarations  
    int age;  
    boolean isAggressive;  
    String species;  
  
}
```

An object is an **instance** of a class

Objects

Fish instance

| | |
|--------------|------------|
| age | 15 |
| isAggressive | false |
| species | "Goldfish" |

Fish instance

| | |
|--------------|------------------|
| age | 8 |
| isAggressive | true |
| species | "Red Tail Shark" |

Creating a new **Fish** instance

```
public class Fish {  
    int age;  
    boolean isAggressive;  
    String species;  
}
```

| Java Expression | Memory (Heap) | | | | | | | |
|-------------------------|---|-----|---|--------------|-------|---------|------|---|
| <code>new Fish()</code> | <p>Fish instance</p> <table><tr><td>age</td><td>0</td></tr><tr><td>isAggressive</td><td>false</td></tr><tr><td>species</td><td>null</td></tr></table> | age | 0 | isAggressive | false | species | null | <ol style="list-style-type: none">1. Memory is allocated to store fields2. Fields are initialize with default values based on data type3. Reference is returned |
| age | 0 | | | | | | | |
| isAggressive | false | | | | | | | |
| species | null | | | | | | | |

Quick Review: Variable declarations must specify data type

| Java Data Types | Examples | Variable |
|------------------------------------|--|---|
| Primitive Types | byte, short, int, long, float, double, boolean, char | Store primitive value (7, 3.5, true, 'a') |
| Reference Types (non-primitive) | String, ArrayList, Random, Fish, ... | Store object reference (info about memory location) |

A class is one kind of reference type (there are others as well)

Reference Variable

- Declared with a reference data type (such as class **Fish**).
- Stores an object reference or `null`.

```
Fish goldie = new Fish();  
Fish jaws = new Fish();
```

Call Stack

Frames



HEAP

Objects

Fish instance

| | |
|--------------|-------|
| age | 0 |
| isAggressive | false |
| species | null |

Fish instance

| | |
|--------------|-------|
| age | 0 |
| isAggressive | false |
| species | null |

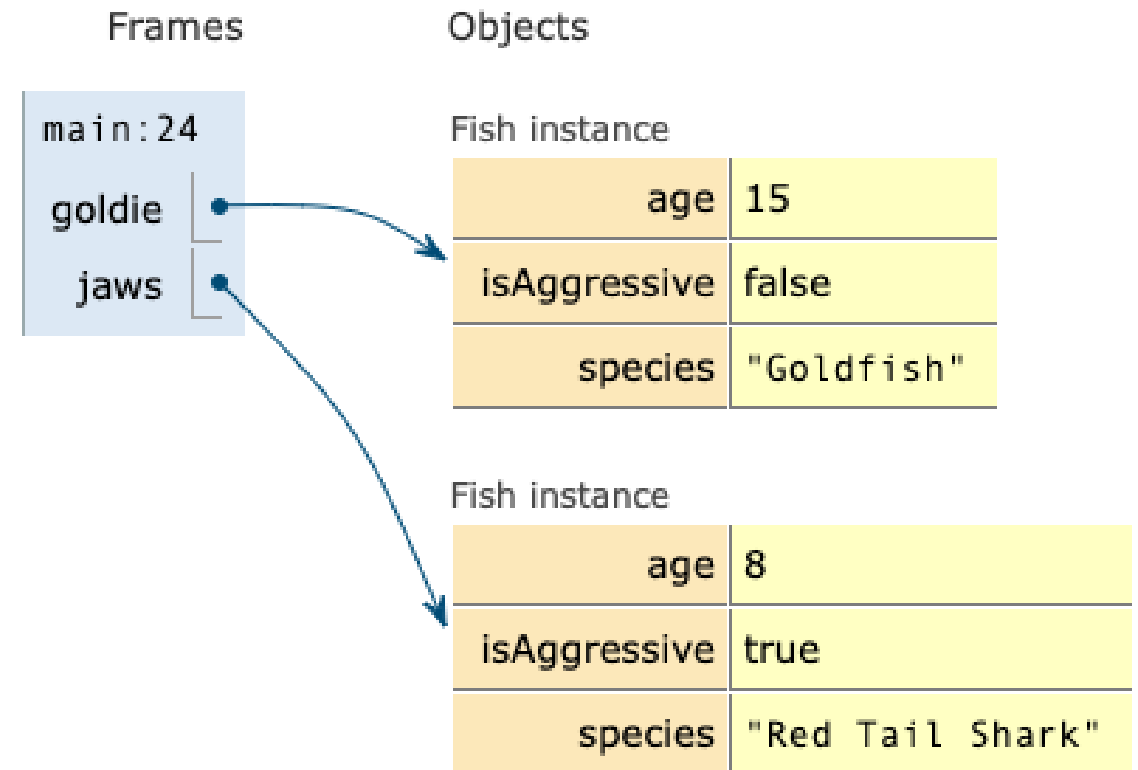
Updating object state

- Each fish instance has it's own variable named **age**.
- **Dot notation** is used to access a field through a reference.

`objectReference.fieldName`







```
goldie.age = 15;  
goldie.species = "Goldfish";  
  
jaws.age = 8;  
jaws.species = "Red Tail Shark";  
jaws.isAggressive = true;
```

pythontutor.com visualization



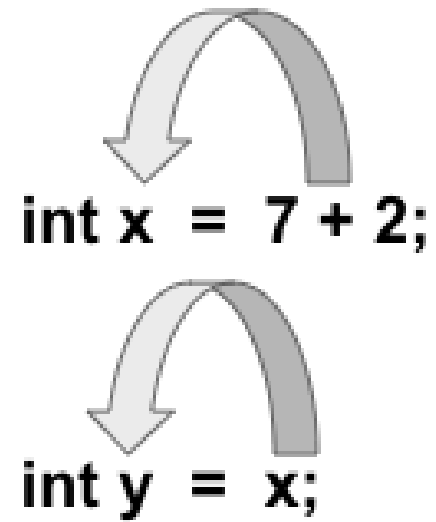
NOTE : **String** is a reference data type

species actually stores an object reference

| String Literal (default view) | String Reference | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|----|--------------|-------|---------|------------|-----|---|--------------|------|---------|------------------|--|-----|----|--------------|-------|---------|---|-----|---|--------------|------|---------|---|
| <p>Fish instance</p> <table><tr><td>age</td><td>15</td></tr><tr><td>isAggressive</td><td>false</td></tr><tr><td>species</td><td>"Goldfish"</td></tr></table> <p>Fish instance</p> <table><tr><td>age</td><td>8</td></tr><tr><td>isAggressive</td><td>true</td></tr><tr><td>species</td><td>"Red Tail Shark"</td></tr></table> | age | 15 | isAggressive | false | species | "Goldfish" | age | 8 | isAggressive | true | species | "Red Tail Shark" | <p>Objects</p> <p>Fish instance</p> <table><tr><td>age</td><td>15</td></tr><tr><td>isAggressive</td><td>false</td></tr><tr><td>species</td><td></td></tr></table> <p>Fish instance</p> <table><tr><td>age</td><td>8</td></tr><tr><td>isAggressive</td><td>true</td></tr><tr><td>species</td><td></td></tr></table> | age | 15 | isAggressive | false | species |  | age | 8 | isAggressive | true | species |  |
| age | 15 | | | | | | | | | | | | | | | | | | | | | | | | |
| isAggressive | false | | | | | | | | | | | | | | | | | | | | | | | | |
| species | "Goldfish" | | | | | | | | | | | | | | | | | | | | | | | | |
| age | 8 | | | | | | | | | | | | | | | | | | | | | | | | |
| isAggressive | true | | | | | | | | | | | | | | | | | | | | | | | | |
| species | "Red Tail Shark" | | | | | | | | | | | | | | | | | | | | | | | | |
| age | 15 | | | | | | | | | | | | | | | | | | | | | | | | |
| isAggressive | false | | | | | | | | | | | | | | | | | | | | | | | | |
| species |  | | | | | | | | | | | | | | | | | | | | | | | | |
| age | 8 | | | | | | | | | | | | | | | | | | | | | | | | |
| isAggressive | true | | | | | | | | | | | | | | | | | | | | | | | | |
| species |  | | | | | | | | | | | | | | | | | | | | | | | | |

Recall how an assignment statement works

1. evaluate expression on right hand side
2. copy value into variable on left hand side



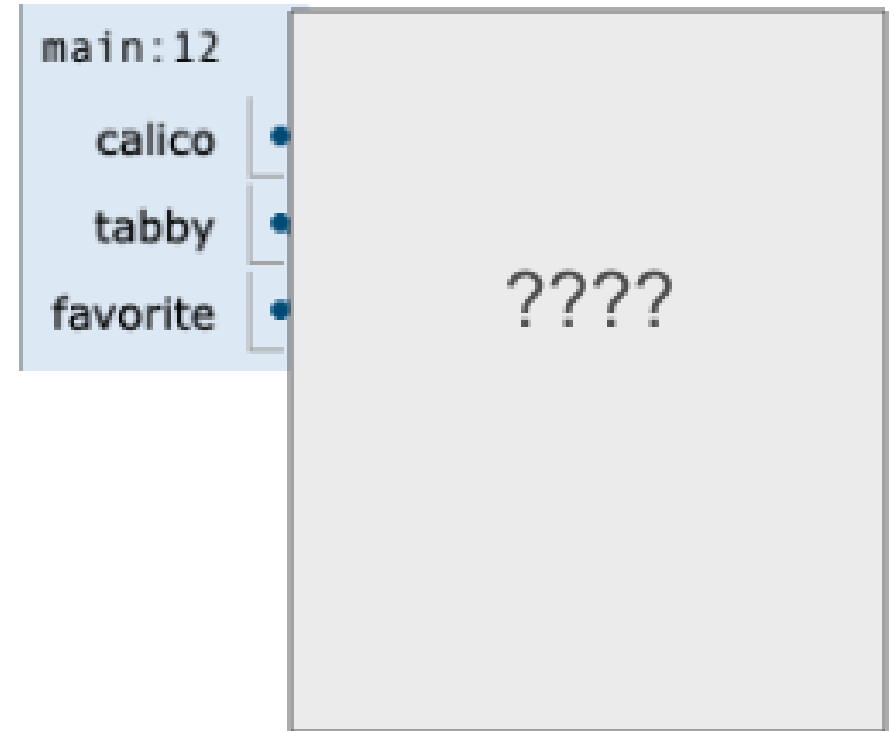
| | |
|--------|---|
| main:6 | |
| x | 9 |
| y | 9 |

CHALLENGE

```
public class Cat {  
    String name;  
    boolean isPurring;  
  
    public static void main(String[] args) {  
        Cat calico = new Cat();  
        Cat tabby = new Cat();  
        Cat favorite = calico;  
  
        tabby.name = "Maru";  
        calico.name= "Chestnut";  
        favorite.isPurring = true;  
  
        System.out.println(calico.name + "," + calico.isPurring);  
        System.out.println(tabby.name + "," + tabby.isPurring);  
        System.out.println(favorite.name + "," + favorite.isPurring);  
    }  
}
```

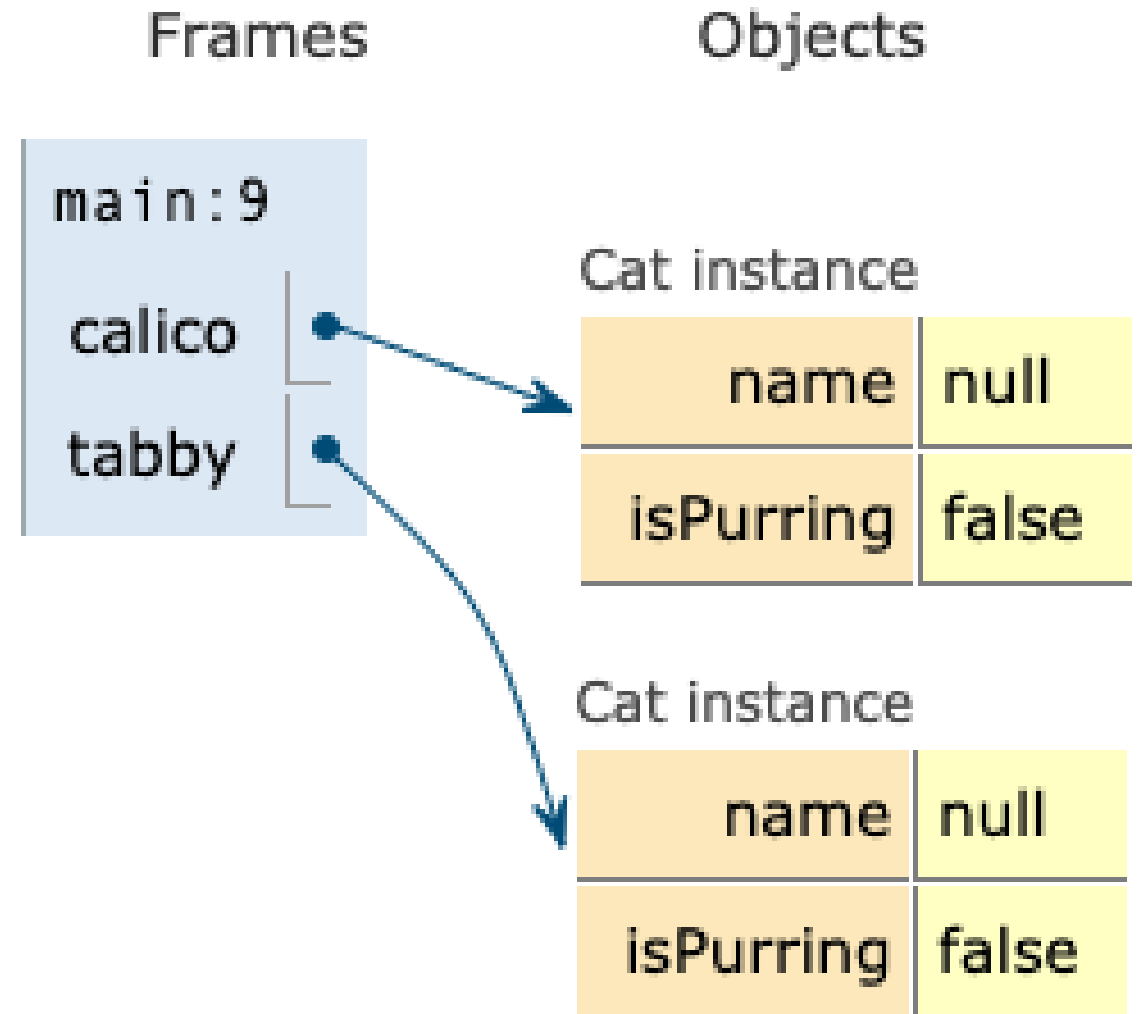
Frames

Objects



```
Cat calico = new Cat();  
Cat tabby = new Cat();
```

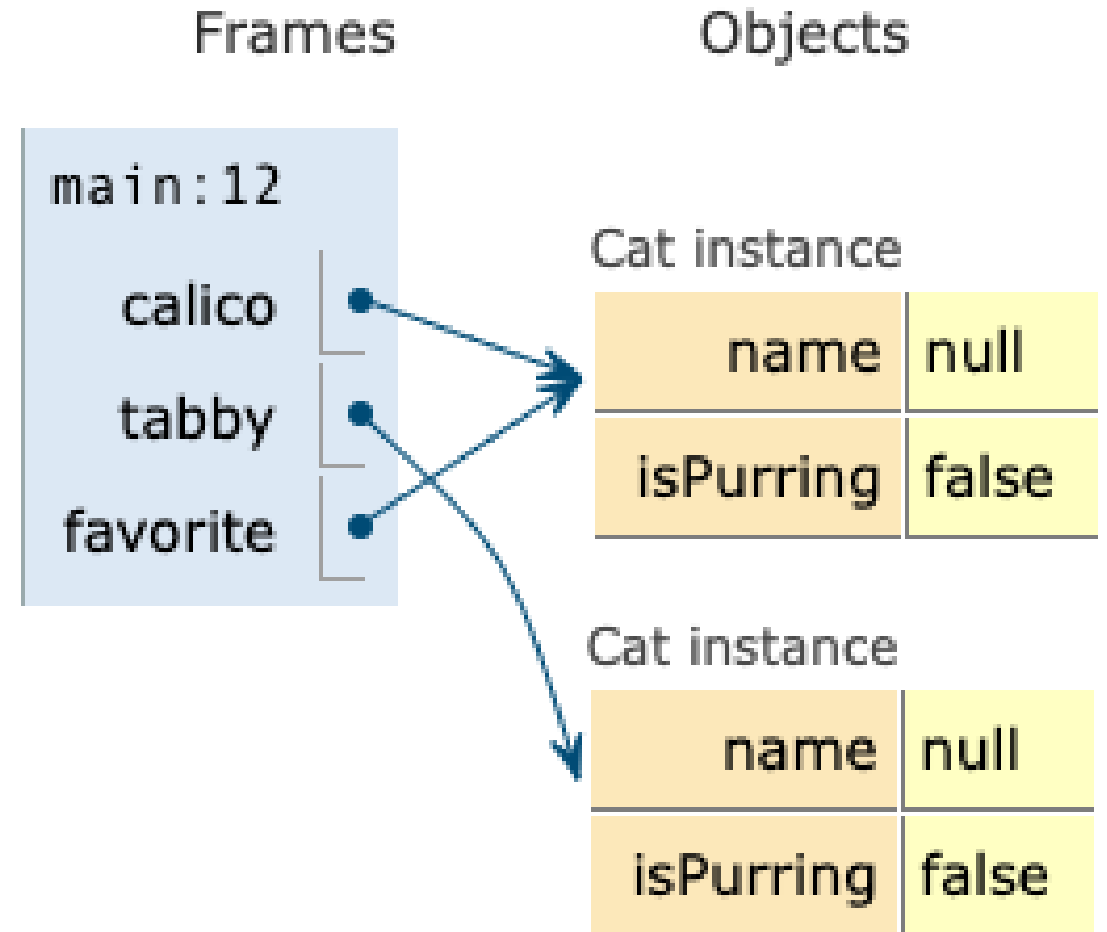
- `new Cat()` creates `Cat` instance with fields initialized to default values
- `calico` and `tabby` reference the new objects



Multiple variables can reference the same object

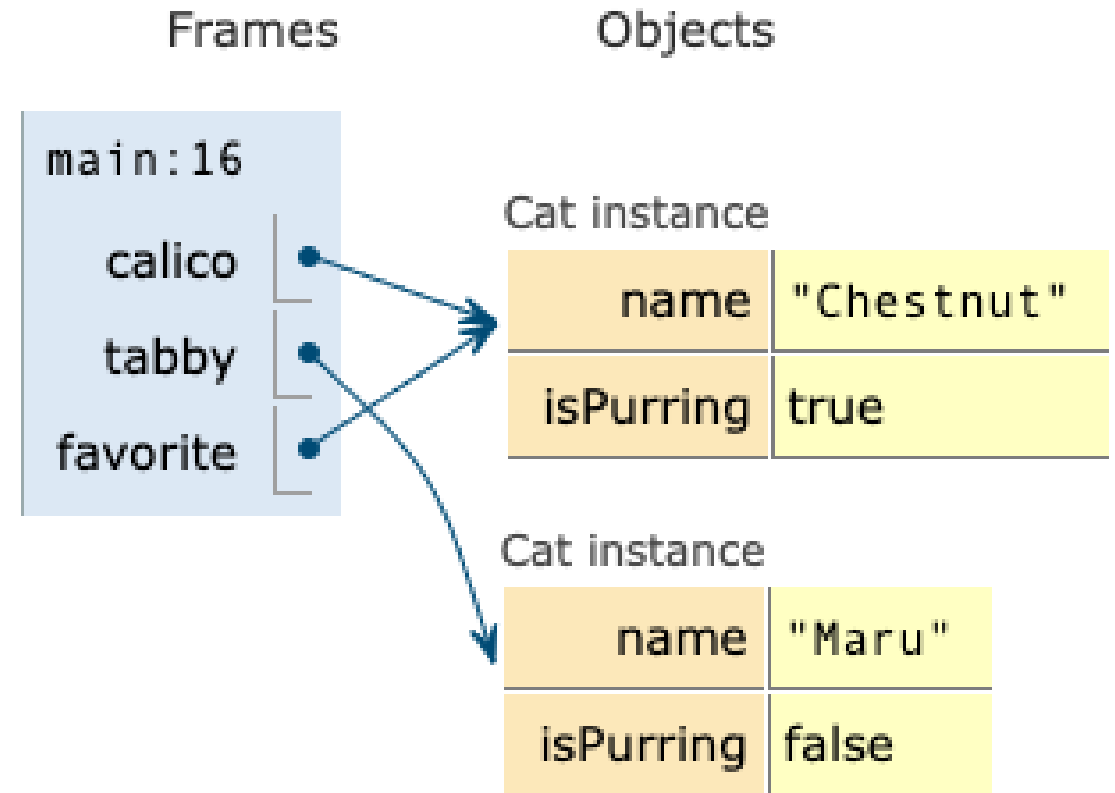
```
Cat calico = new Cat();  
Cat tabby = new Cat();  
Cat favorite = calico;
```

- Two primitive variables can store the same value.
- Two reference variables can store the same object reference.



Updating object state

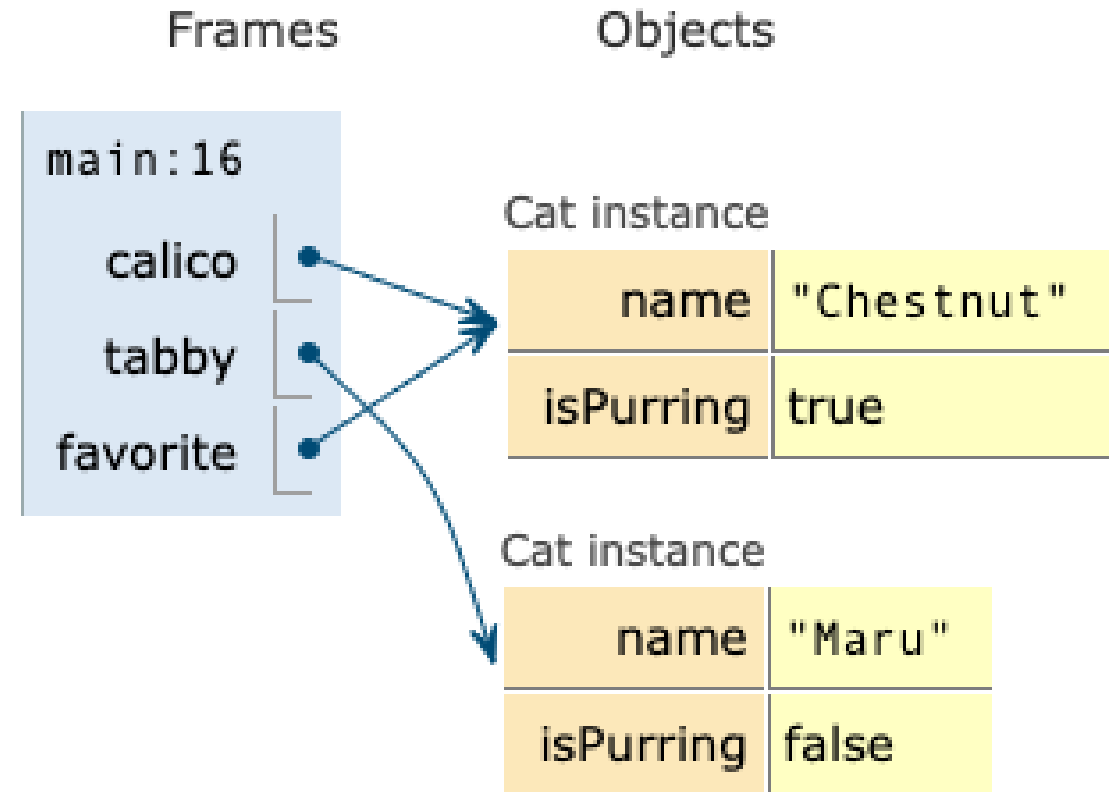
```
Cat calico = new Cat();  
Cat tabby = new Cat();  
Cat favorite = calico;  
  
tabby.name = "Maru";  
calico.name= "Chestnut";  
favorite.isPurring = true;
```



What get's printed?

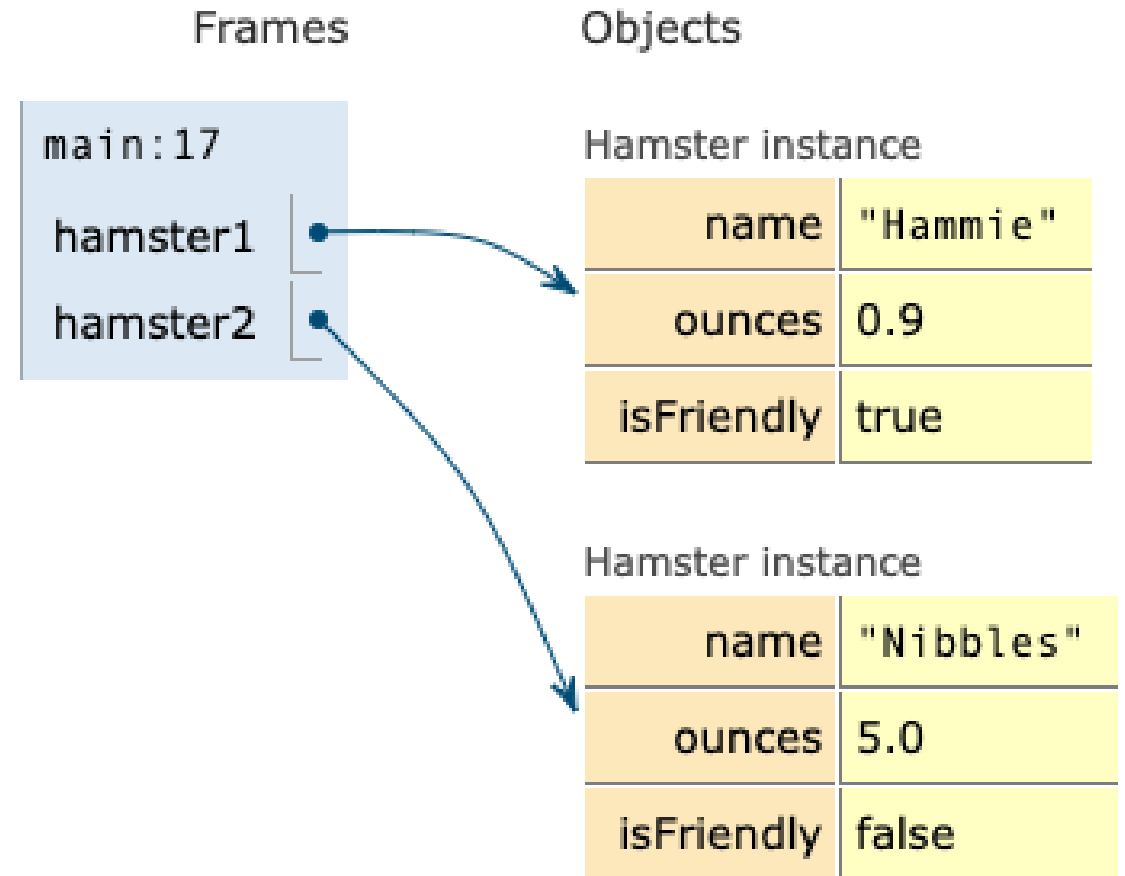
```
System.out.println(calico.name + "," + calico.isPurring);  
System.out.println(tabby.name + "," + tabby.isPurring);  
System.out.println(favorite.name + "," + favorite.isPurring);
```

Chestnut, true
Maru, false
Chestnut, true



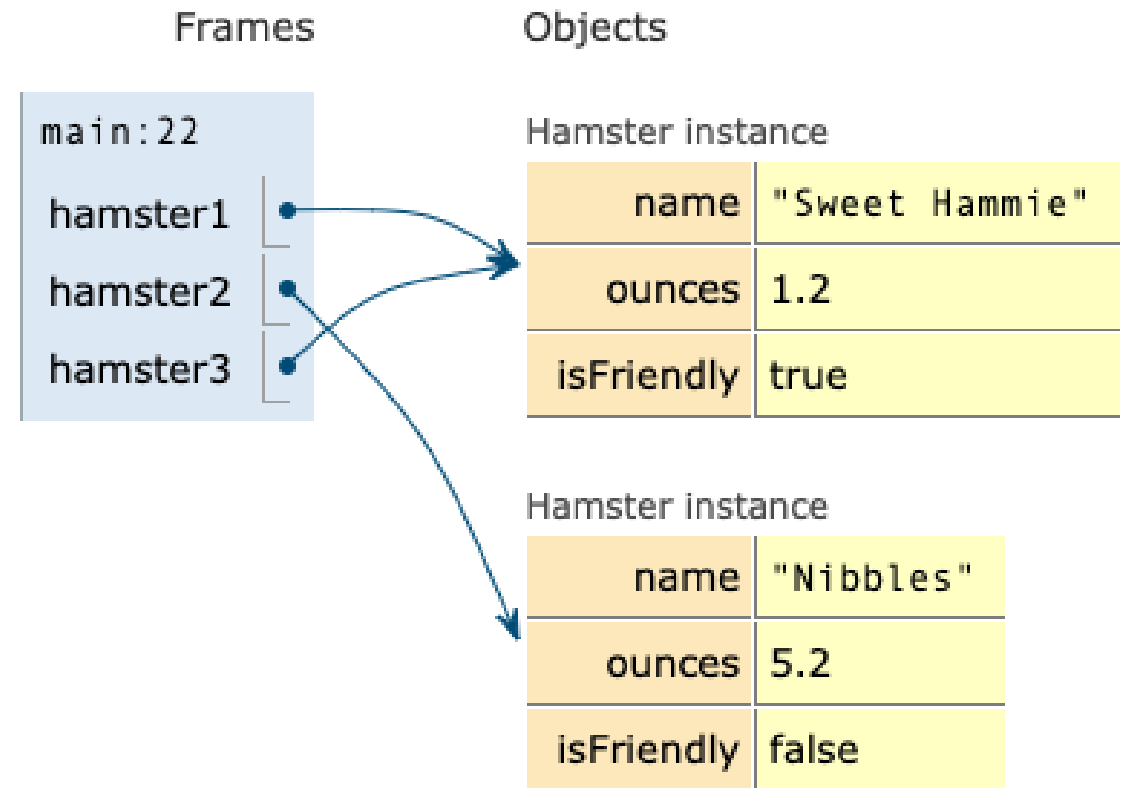
CHALLENGE

- Implement a class named `Hamster` with fields to store name, weight in ounces, and whether they are friendly.
- Implement a `main` method to instantiate two hamster and update their state as shown.



CHALLENGE:

- Edit the code to evolve the object state as shown in the diagram.
- Do not modify state using the variables `hamster1` or `hamster2`
- Use the variable `hamster3` to modify the `name` and `ounces`.



Solution

```
public class Hamster {  
  
    String name;  
    float ounces;  
    boolean isFriendly;  
  
    public static void main(String[] args) {  
        Hamster hamster1 = new Hamster();  
        Hamster hamster2 = new Hamster();  
  
        hamster1.name = "Hammie";  
        hamster1.ounces = 0.9f;  
        hamster1.isFriendly = true;  
  
        hamster2.name = "Nibbles";  
        hamster2.ounces = 5.2f;  
  
        Hamster hamster3 = hamster1;  
        hamster3.name = "Sweet Hammie";  
        hamster3.ounces = 1.2f;  
  
    }  
}
```

Methods - Implementing Object Behavior

```
public class Dog {  
  
    //Field declarations  
    private String name;  
    private boolean isWaggingTail, likesBaths;  
  
    //Method declarations  
    public void scold() {this.isWaggingTail = false;}  
    public void treat(int quantity) { this.isWaggingTail = quantity > 2; }  
    public void bathe() {this.isWaggingTail = this.likesBaths;}  
  
    public static void main(String[] args) {  
  
        Dog dog1 = new Dog();  
        Dog dog2 = new Dog();  
  
        dog1.name = "Bella";  
        dog2.name = "Pepper";  
        dog2.likesBaths = true;  
  
        //Call instance methods  
        dog1.treat(5); //wagging true  
        dog1.bathe(); //wagging false  
        dog2.bathe(); //wagging true  
        dog2.treat(1); //wagging false  
        dog2.treat(3); //wagging true  
        dog2.scold(); //wagging false  
    }  
}
```

What is `this`?

```
public void treat(int quantity) {  
    this.isWaggingTail = quantity > 2;  
}
```

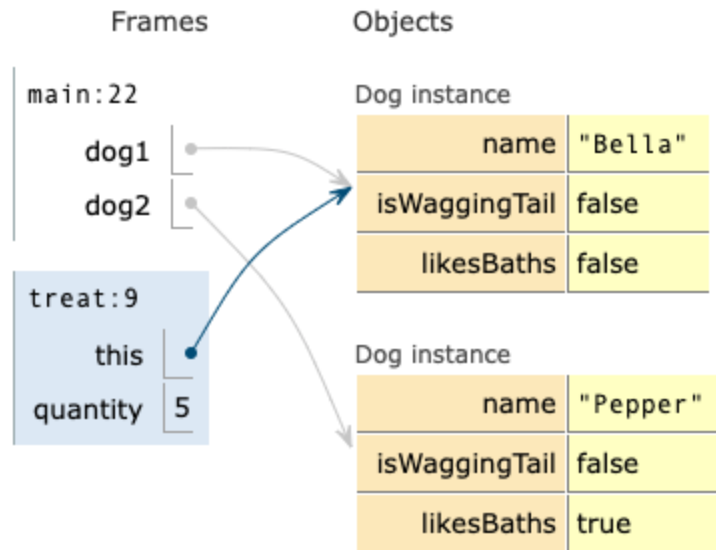
How does the treat method know which Dog's tail should wag or not?

We'll use the debugger to step through the code.

[pythontutor.com visualization](https://pythontutor.com/visualizations.html)

dog1.treat(5)

```
public void treat(int quantity) {  
    this.isWaggingTail = quantity > 2;  
}
```



dog2.treat(1)

```
public void treat(int quantity) {  
    this.isWaggingTail = quantity > 2;  
}
```

