Classes
& Objects

Data Structures

Thus far, all of our data has been stored in variables or arrays

- one variable holds one piece of data
- one array holds multiple pieces of data of the same datatype

Data structures enable our programs to organize our data in more efficient, sensible ways

We'll see three types of data structures this semester

- variables (all semester)
- arrays (remainder of semester)
- classes (this week)

Classes

Allows us to group together pieces of data that define a real world concept

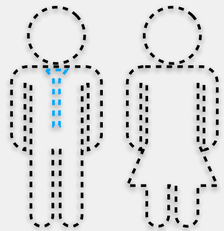
- even if they are of different datatypes!
- e.g., a professor is made up of a first/last name, courses they teach...

A *class* provides a definition of what pieces of data define a real world concept

An *object* defines a particular *instance* of that class

UWL as Object-Oriented Data

class



Professor

(*name*, *list of classes*, *office*)

objects

Allie Sauppé
CS120, CS364
Wing 214

Marty Allen
CS120, CS227
Wing 210

Elliot Forbes
CS272, CS370
Wing 219

Jason Sauppe
CS225, CS270
Wing 207

Sam Foley
CT100, CS441
Wing 220

Tom Gendreau
CS340, CS470
Wing 211

Components of Classes

Identifier

- name of the class
- should be singular, start with a capital letter (e.g., Professor, Student)

Attributes

- data that defines every object of that class type

Methods

- define the actions that can be taken with objects of that class type

Object-oriented programs are comprised of **objects** from multiples classes **interacting**.

Java is made up of **thousands** of classes. But, we can **create our own classes** for our needs too.

Classes in Java

```
public class Professor {

    private String firstName;
    private String lastName;
    private String dept;
    private Course[] courses;

    public Professor(String fn, String ln) {
      this.firstName = fn;
      this.lastName = ln;
    }

    public String getDept() {
      return dept;
    }

    public void setDept(String dept) {
      this.dept = dept;
    }

}
```

only part of the class
(missing many details)

Classes in Java: Identifier

```
public class Professor {

    }

}
```

Name of the class

Should be singular

Should start with a capital letter (e.g., Professor, Student)

Classes in Java: Attributes

```
public

    private String firstName;
    private String lastName;
    private String dept;
    private Course[] courses;



    }









}
```

Data that defines every object of that class type

Variable declarations at a minimum

- can also initialize/instantiate if needed

Also referred to as *global variables*

- have scope throughout the class

New concept: visibility

- `public`, `private`, `protected`

Classes in Java: Methods

```
public

    public Professor(String fn, String ln) {
      this.firstName = fn;
      this.lastName = ln;
    }

    public String getDept() {
      return dept;
    }

    public void setDept(String dept) {
      this.dept = dept;
    }

}
```

Define the actions that can be taken with objects of that class type

Work like methods from last week

Key differences

- lack of `static` keyword
- use of `this` keyword
- no `main` method

Classes in Java: Constructor Method

```
public

    public Professor(String fn, String ln) {
      this.firstName = fn;
      this.lastName = ln;
    }

}
```

Method to create (*instantiate*) an object of this class type

Named the same as the class

Lacks a return type

Seen these throughout the semester

```
Scanner scan = new Scanner(System.in);
```

Example: Constructor

```
public class UWL {
    public static void main(String[] args) {
        Professor aSauppe = new Professor("Sauppe", "Allie");
    }
}
```

```
public class Professor {

    private String firstName;
    private String lastName;

    public Professor(String ln, String fn) {

        firstName = fn;
        lastName = ln;

    }
}
```

Example: Constructor

```
public class UWL {
    public static void main(String[] args) {
      > Professor aSauppe = new Professor("Sauppe", "Allie");
    }
}
```

```
public

    private
    private

    public




    }
}
```

Example: Constructor

```
public
    public
      >                    new Professor("Sauppe", "Allie");
    }
}
```

```
public class Professor {

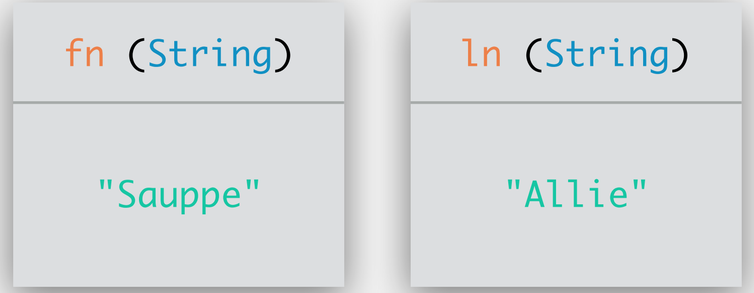
    private String firstName;
    private String lastName;

  > public Professor(String ln, String fn) {

        firstName = fn;
        lastName = ln;

    }
}
```

memory



Example: Constructor

```
public
    public
      >                    new Professor("Sauppe", "Allie");
    }
}
```

```
public class Professor {

    private String firstName;
    private String lastName;

    public Professor(String ln, String fn) {

        firstName = fn;
        lastName = ln;
      >

    }
}
```

memory

fn (String)
"Sauppe"

ln (String)
"Allie"

(Professor)
firstName = "Allie" lastName = "Sauppe"

Example: Constructor

```
public class UWL {
    public static void main(String[] args) {
        Professor aSauppe = new Professor("Sauppe", "Allie");
    } >
}
```

```
public

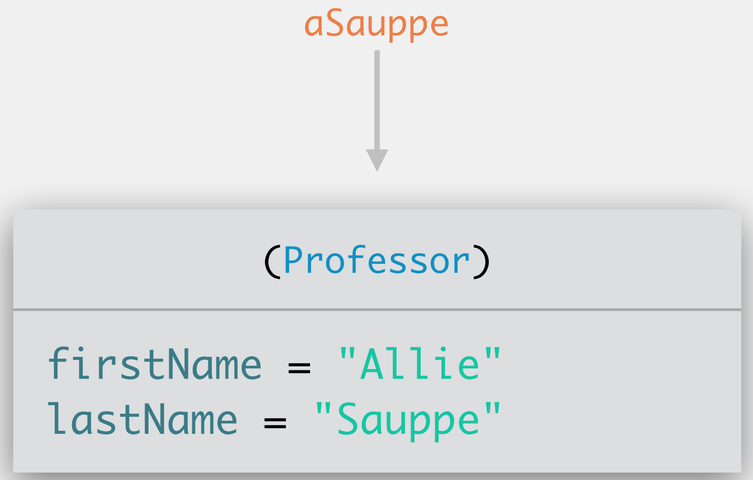
    private
    private

    public




    }
}
```

memory



Classes & Methods

Methods are *always* affiliated with a class

Available data

- variables declared in the method
- parameters
- global variables for that class

calculateAge: Before

What we saw previously...

```
public static int calculateAge(int bYear, int bMonth, int bDay, int tYear, int tMonth, int tDay) {

    int age = tYear - bYear;

    if(bMonth > tMonth || (bMonth == tMonth && bDay > tDay)) {
      age--;
    }

    return age;
}
```

calculateAge: After

```
public class Student {
    private String firstName;
    private String lastName;
    private int bYear;
    private int bMonth;
    private int bDay;

    // ...

    public int calculateAge(int tYear, int tMonth, int tDay) {
        int age = tYear - bYear;

        if(bMonth > tMonth || (bMonth == tMonth && bDay > tDay)) {
            age--;
        }

        return age;

    }
}
```

Example: Methods

```
public class UWL {
    public static void main(String[] args) {
        // ...
        // students have already been instantiated
        // Josh born 11/1/1997, Eliza born 12/2/1997
        int jamesAge = james.calculateAge(2017, 11, 7);
        int elizaAge = eliza.calculateAge(2017, 11, 7);
    }
}
```

```
public class Student {
   // ...
   public int calculateAge(int tYear, int tMonth, int tDay) {
       int age = tYear - bYear;
       if(bMonth > tMonth || (bMonth == tMonth && bDay > tDay)) {
           age--;
       }
       return age;
   }
}
```

memory

james (Student)

```
bYear = 1997
bMonth = 11
bDay = 1
```

eliza (Student)

```
bYear = 1997
bMonth = 12
bDay = 2
```

Visibility

Used to control access to classes, methods, and attributes

Three options

- public: can be accessed from any class
- private: can only be accessed from its own class
- protected: we'll get to this later

Visibility applies to classes, method, and global variables

- public class Professor
- public static void printArray(char[] arr)
- private String firstName

Visibility Rules of Thumb

Classes are usually public

- tend to only be useful to us if they can be accessed from other classes

Attributes are usually private

- don’t want people to change them at will
- forces change through methods, which provide guarantees

Methods are most likely public, but private is also common

- public methods used to work with objects of that type
- private methods used to help internal class functionality

Getter and Setter Methods

Since attributes are usually private, need some way to access them

Getter methods get the value of an attribute

Setter methods set the value of an attribute

- can be used to ensure the attribute is only set to sensible values
- e.g., only possible values for birth month are 1-12

Example for firstName attribute

- public String getFirstName()
- public void setFirstName(String fn)

final Keyword

Modifier used for classes, methods, and variables

- we'll only talk about variables

Variables with the final keyword can only be assigned a value once

Examples from Math class

- Math.PI (3.14159...)
- Math.E (2.71828...)

Final variables are written in all uppercase, with underscores for spaces

- e.g., MAX_COURSE_LOAD

Static vs Non-Static Methods

The *static* keyword controls whether a resource (e.g., method, variable) belongs to the *class* or an *object* of that class type

- static: do not need to have instantiated an object of that class type to use it
- non-static: must have an object instantiated of that class type

Overarching question: Do I need to know one or more attribute values from an object to use this?

- yes? non-static
  - default should be non-static
- no? static

Static Rules of Thumb

Generally, methods/variables will be non-static

- conforms to object-oriented principles

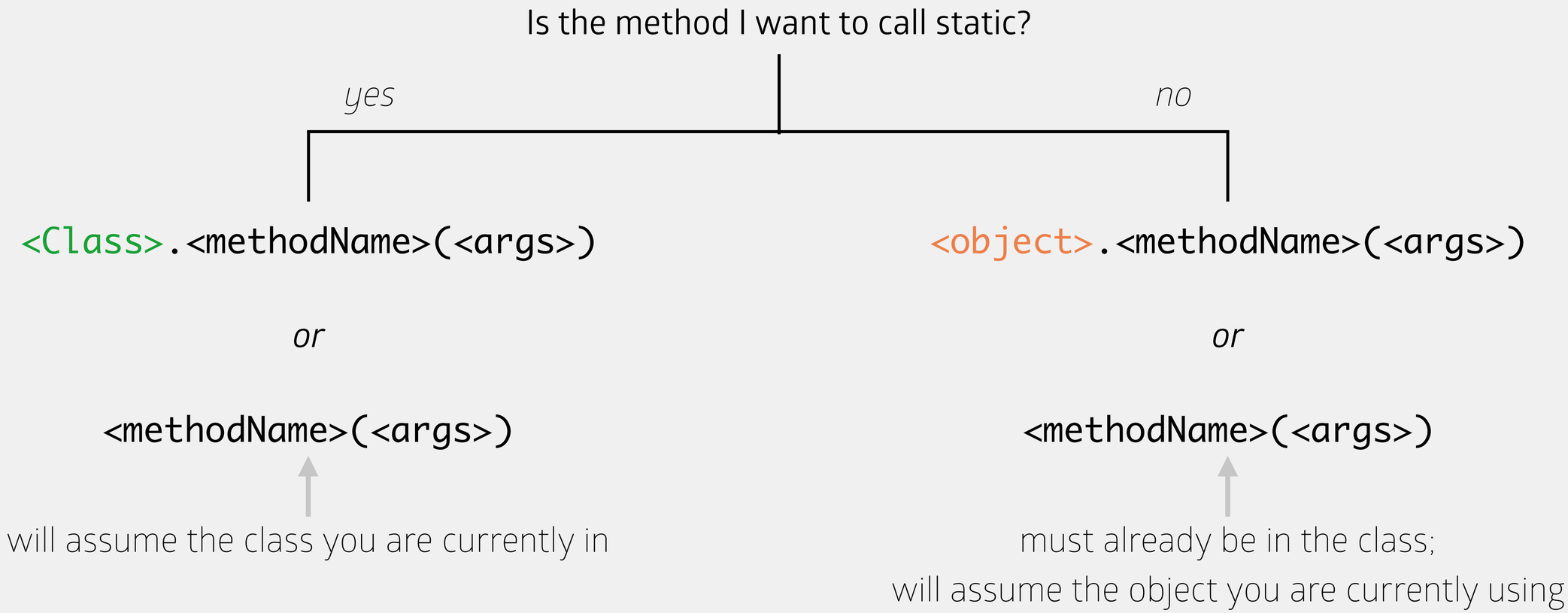
Static methods can only access static attributes

- non-static methods can access all attributes

Examples of static methods from Java:

- everything from the Math class
- Math.pow(double x, int y)
- Math.max(double x, double y)

How to Call Methods



Steps to Creating a New Class

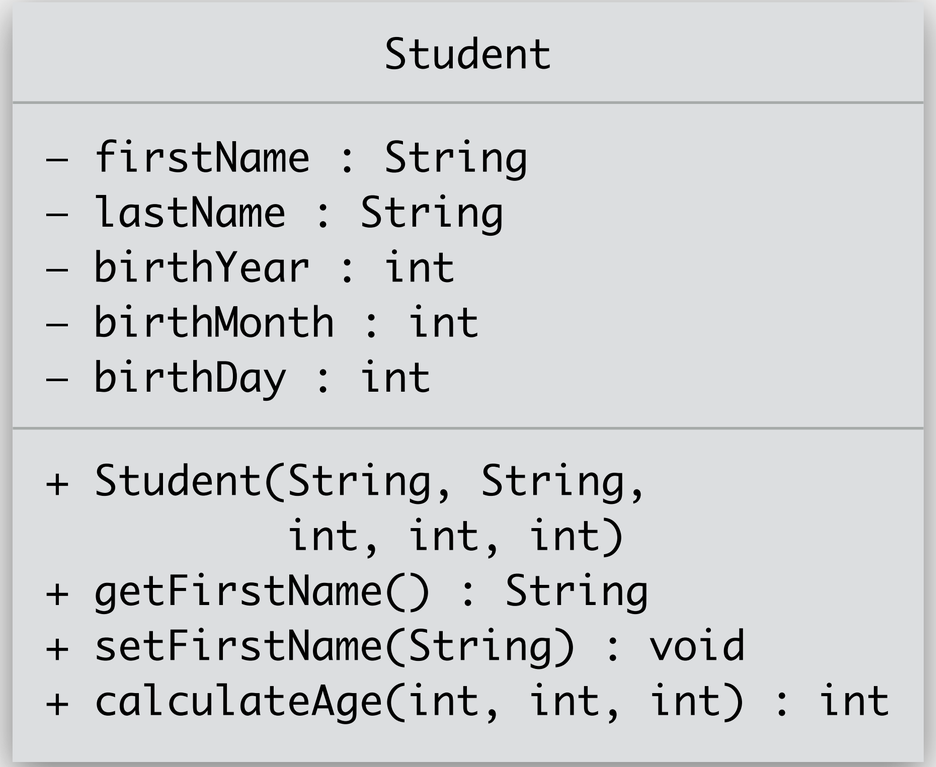
1. Class name
2. Attributes

   name, type, visibility, initialization/instantiation?
3. Constructor method

   parameters come from attributes
4. Other methods

   getters/setters, methods specified in requirements

Class Diagram



Easy way to represent basic components of a class (name, attributes, methods)

Part of *unified modeling language* (*UML*)

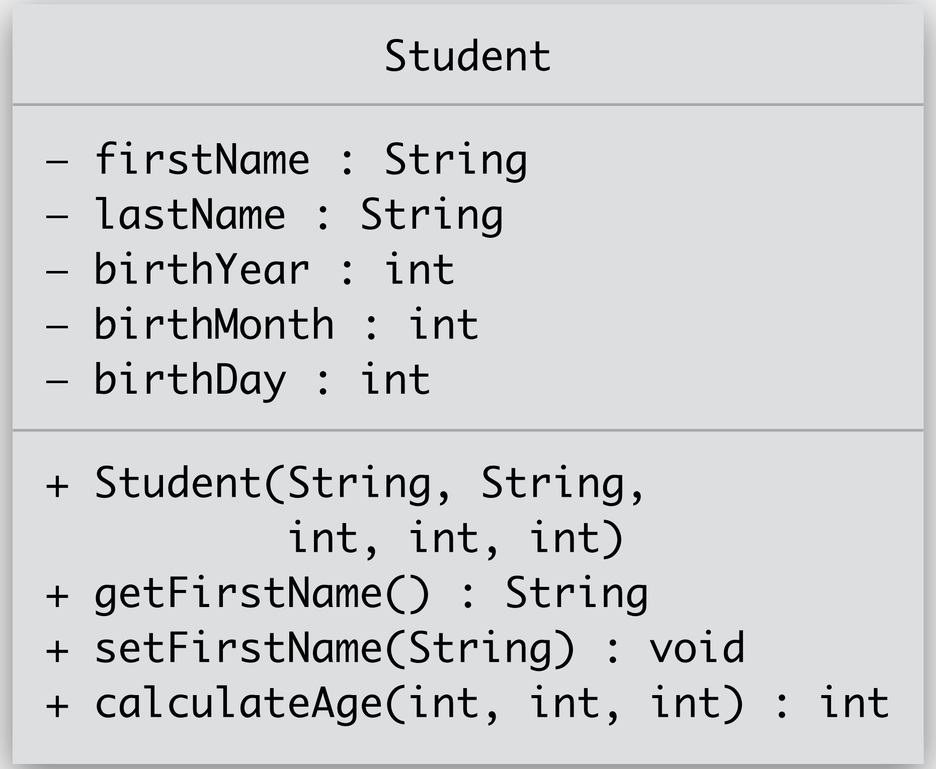
- used to communicate structure of programs

Visibility prefaces identifier

- \+ for public
- — for private
- # for protected

Static attributes/methods are underlined

Class Diagram



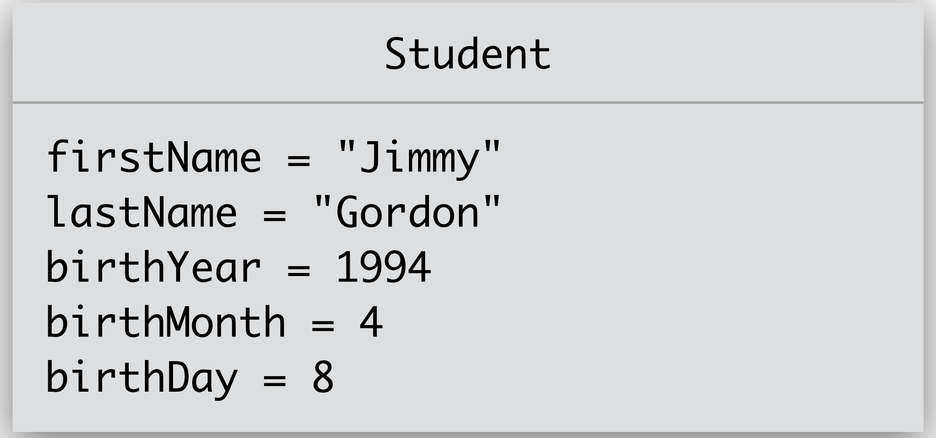
Attributes list type after colon

Methods list only parameter types

Return type appears after method, prefaced with a colon

- constructor will not list a return type
- list void if no return type

Object Diagram



Used to identify current state of object

Lists current values for each attribute

Does not list methods

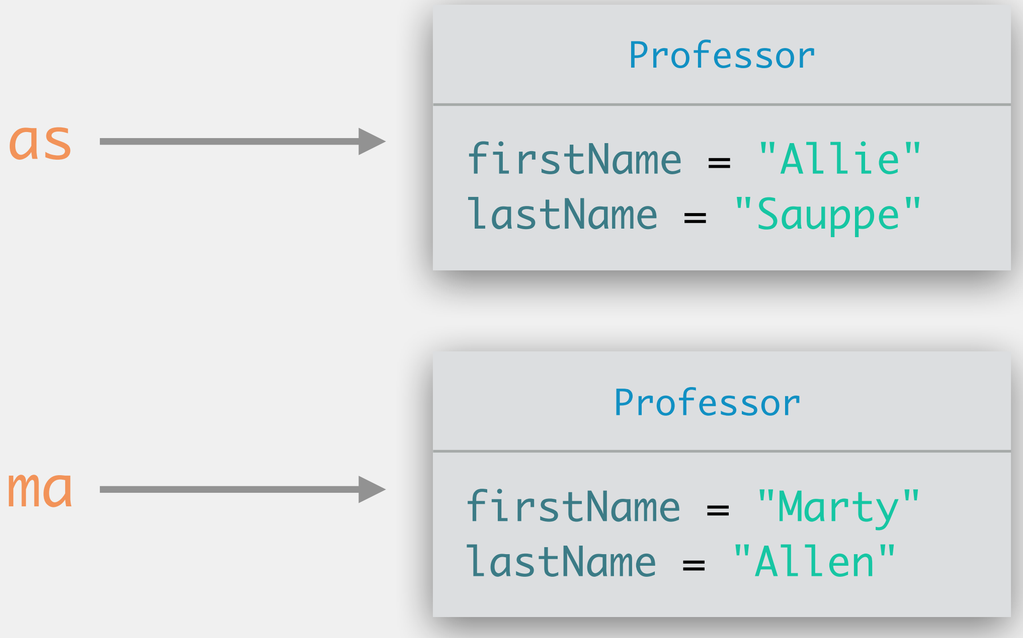
Object Tracing

```
> Professor as = new Professor("Sauppe", "Allie");

> Professor ma = new Professor("Allen", "Marty");

> ma = as;

  System.out.println(as.getFirstName() +
      " " + ma.getFirstName());
```



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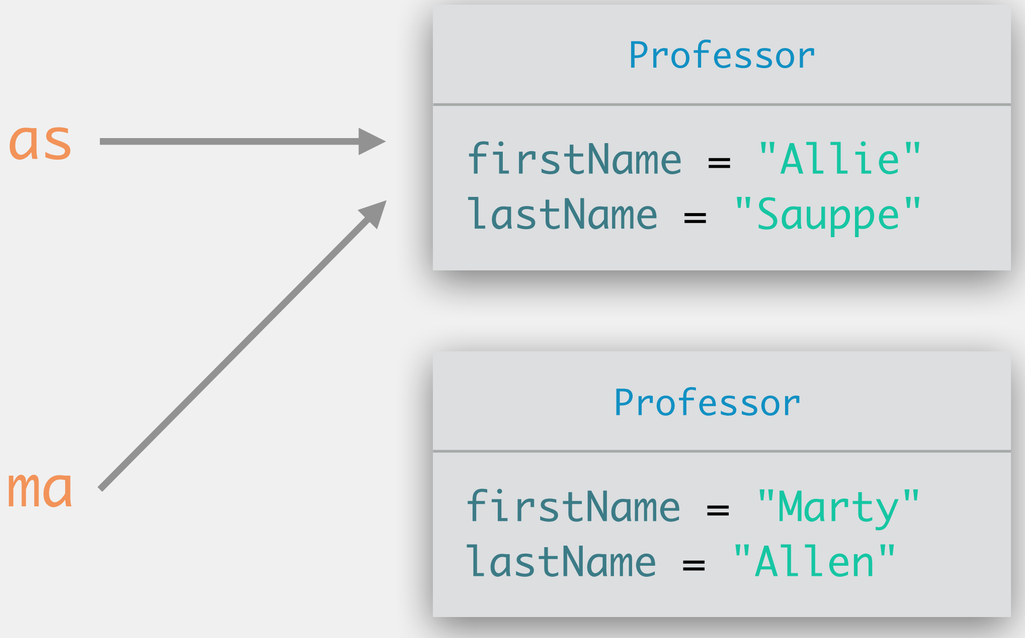

no longer any variable referring to this object!

(*orphaned object*)

Object Tracing

```
  Professor as = new Professor("Sauppe", "Allie");

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  ma = as;

> System.out.println(as.getFirstName() +
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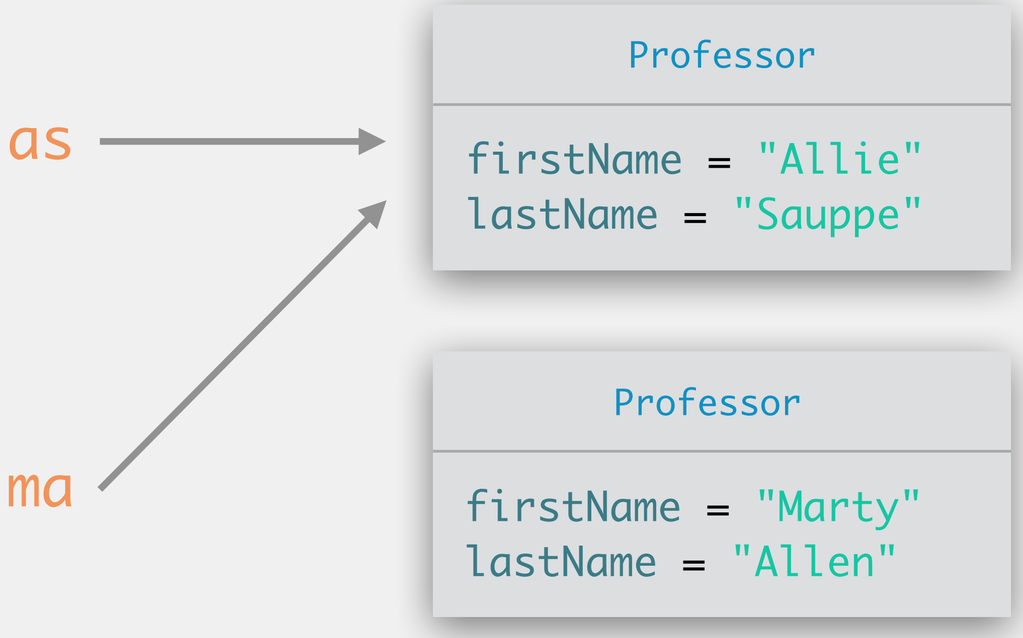


cannot reestablish a reference to this object; collected by Java's garbage collector

Object Tracing

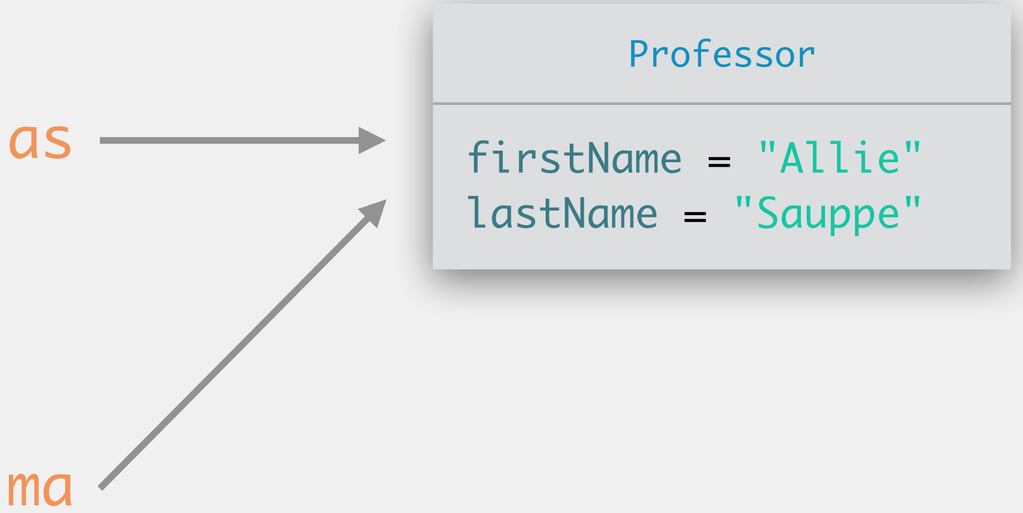
```
  Professor as = new Professor("Sauppe", "Allie");

  Professor ma = new Professor("Allen", "Marty");

  ma = as;

  System.out.println(as.getFirstName() +
      " " + ma.getFirstName());
>
```

```
Allie Allie
```



Object Tracing

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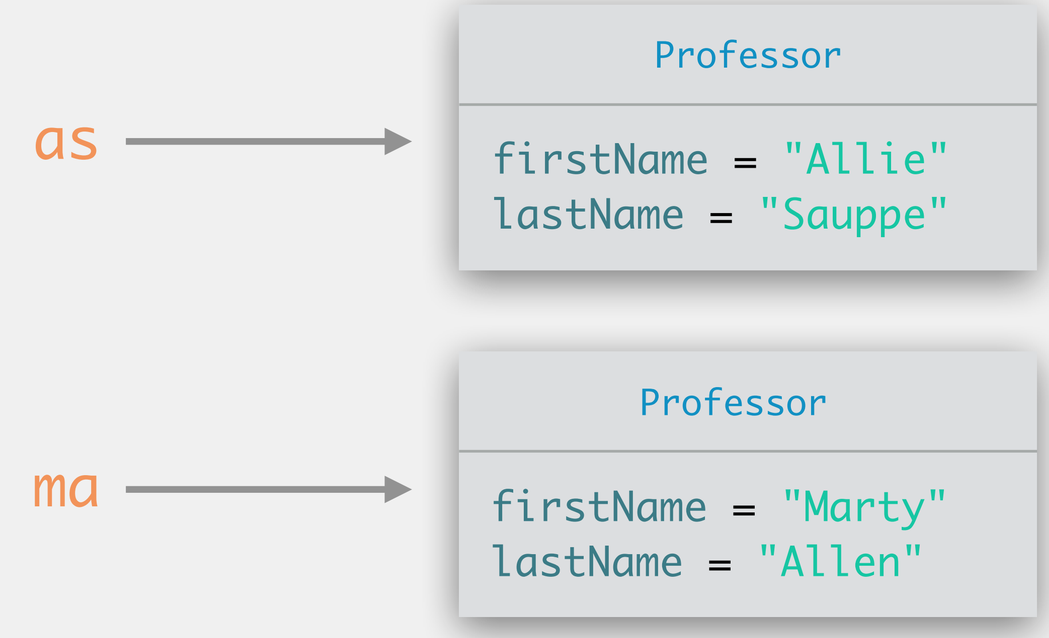
> Professor ma = new Professor("Allen", "Marty");

> Professor temp;

> temp = as;
  as = ma;
  ma = temp;
  temp = null;
  System.out.println(as.getFirstName() +
      " " + ma.getFirstName());
```



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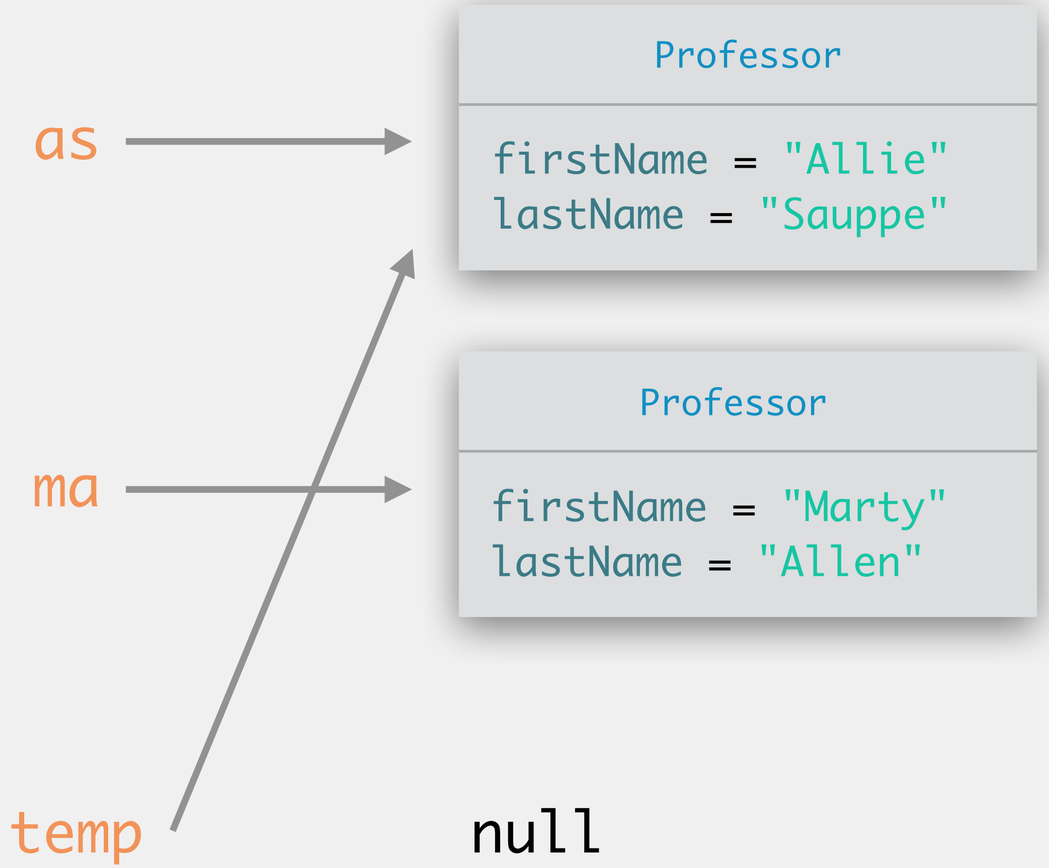

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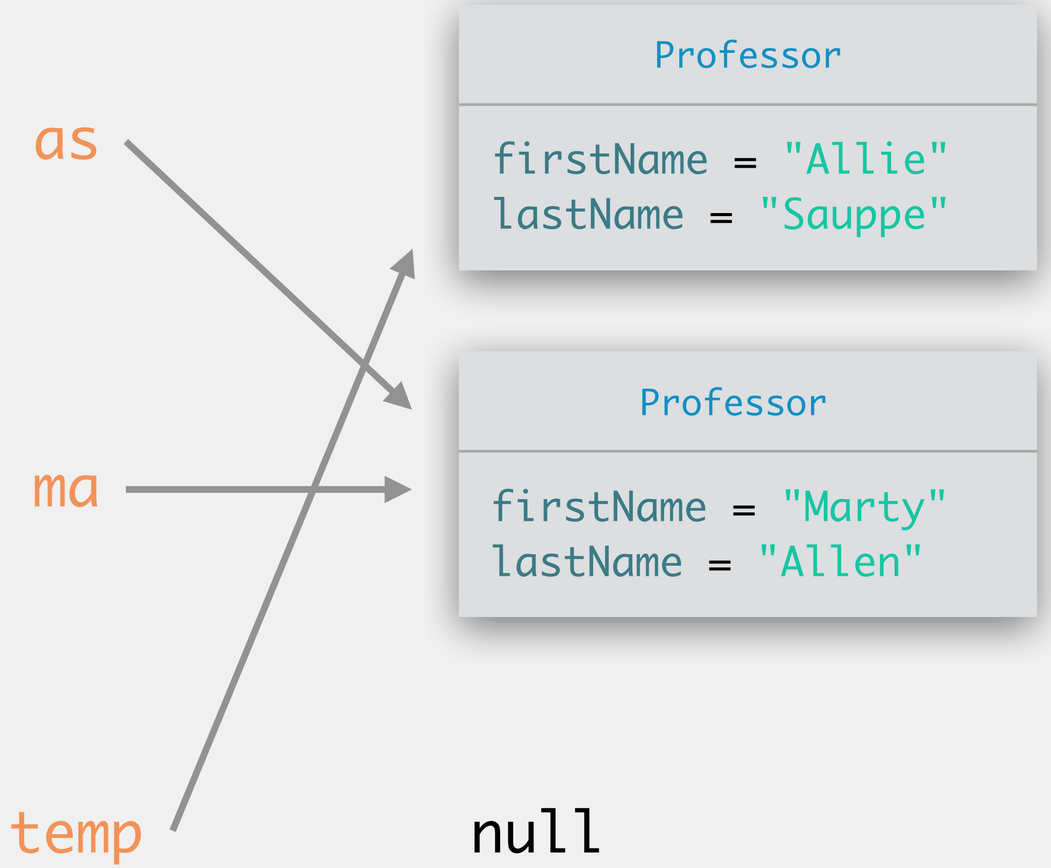

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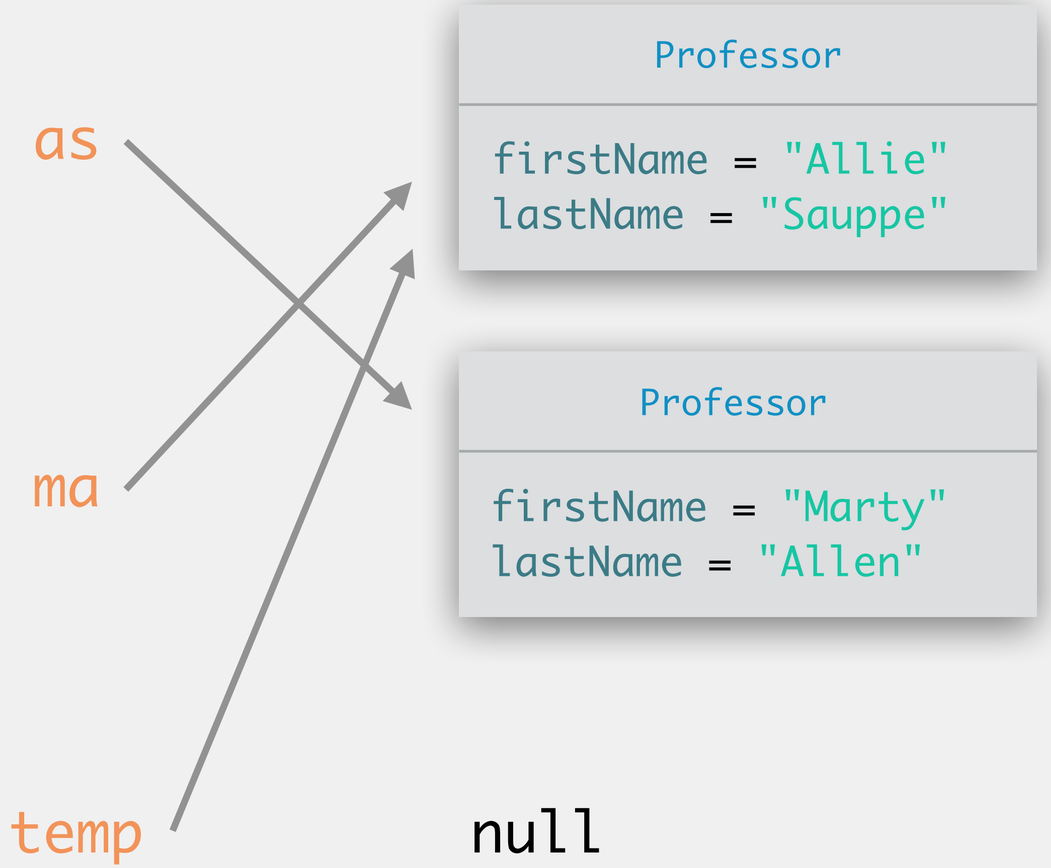

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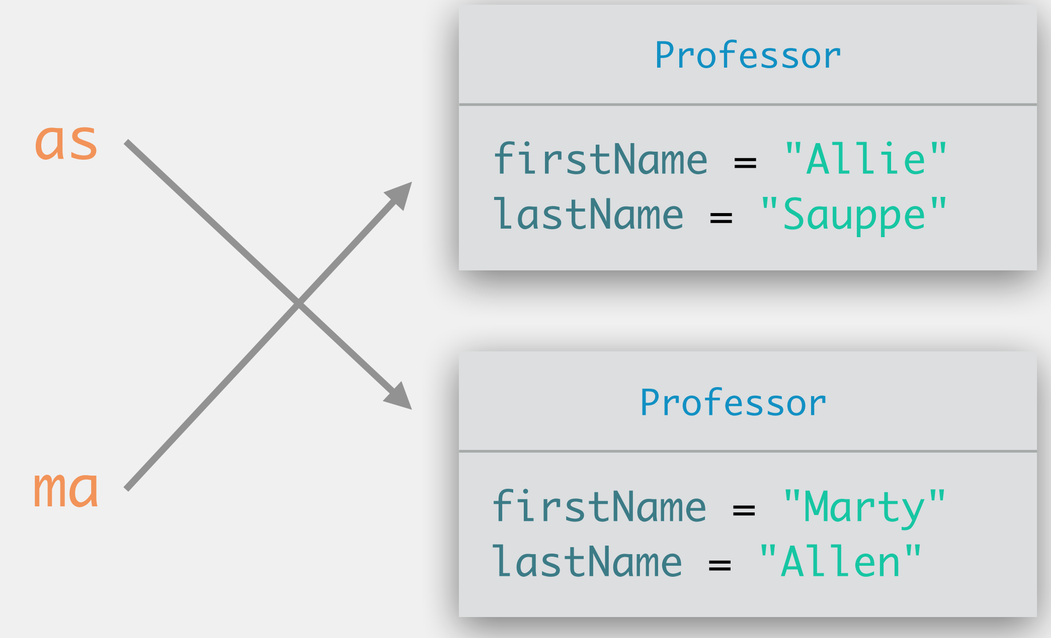

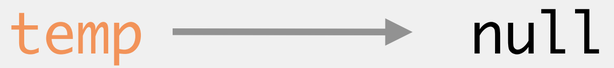

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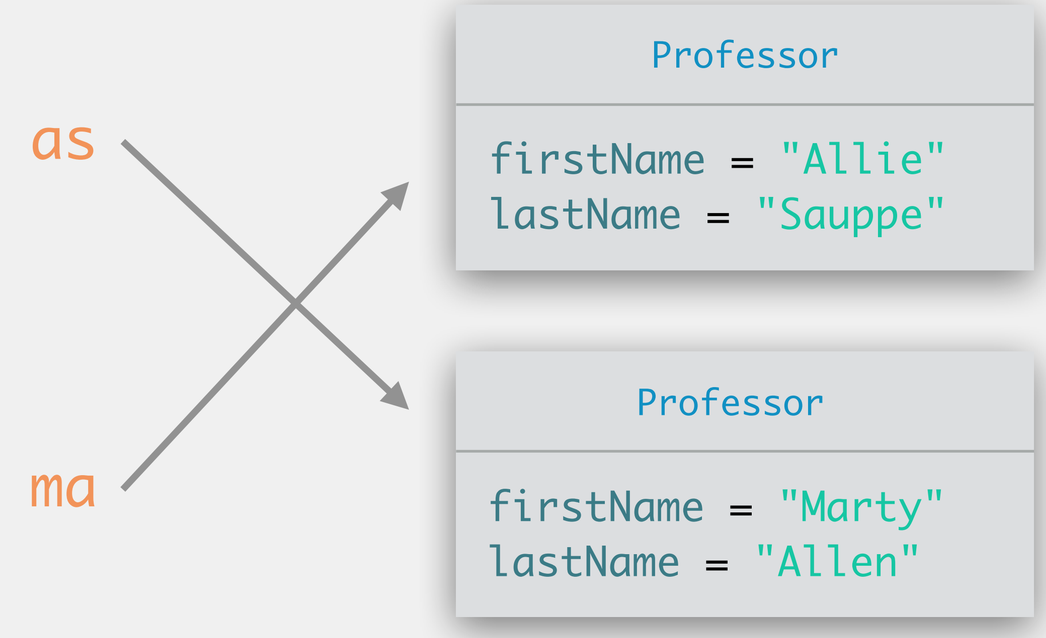
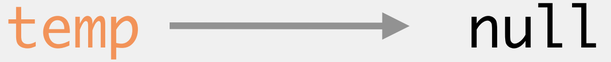
```

```
Marty Allie
```





always treat variables of a class type and the objects they refer to as two separate entities

Object Tracing

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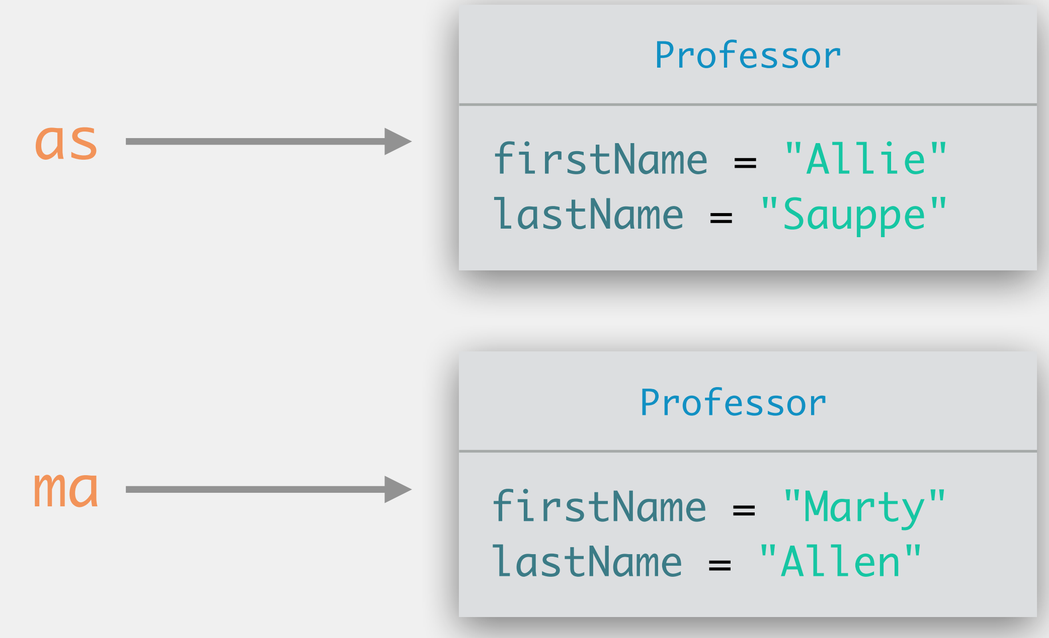

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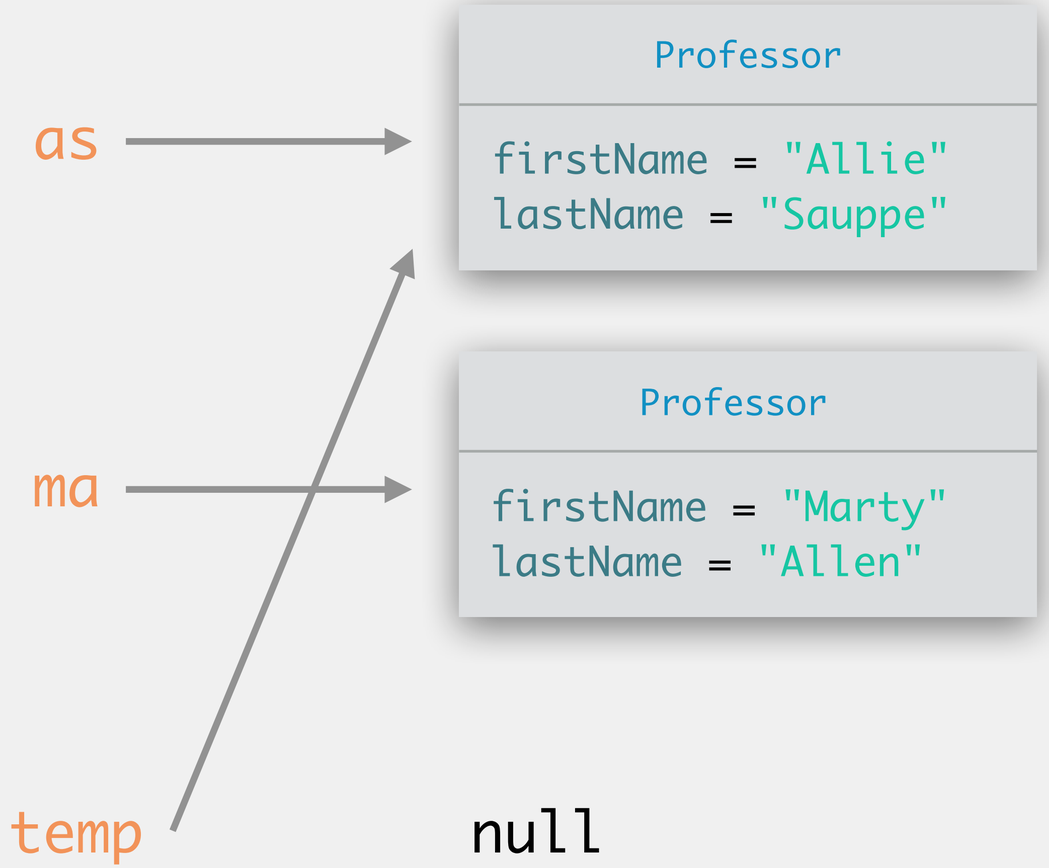

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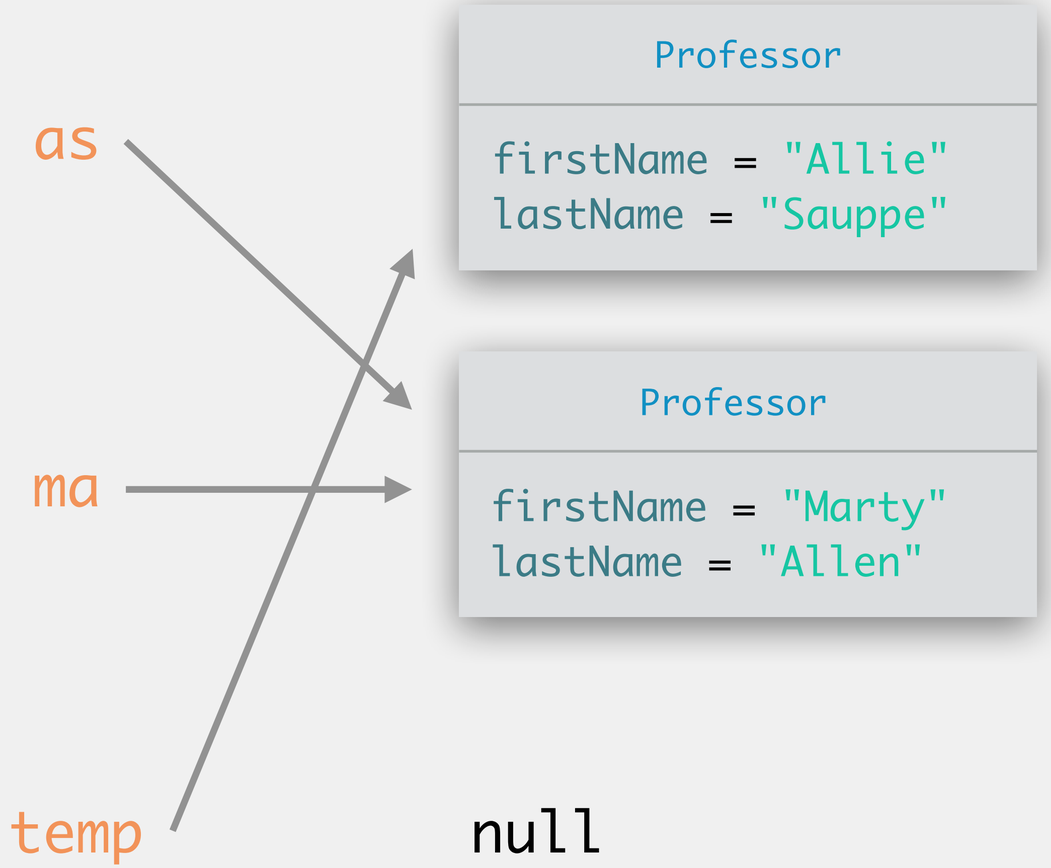

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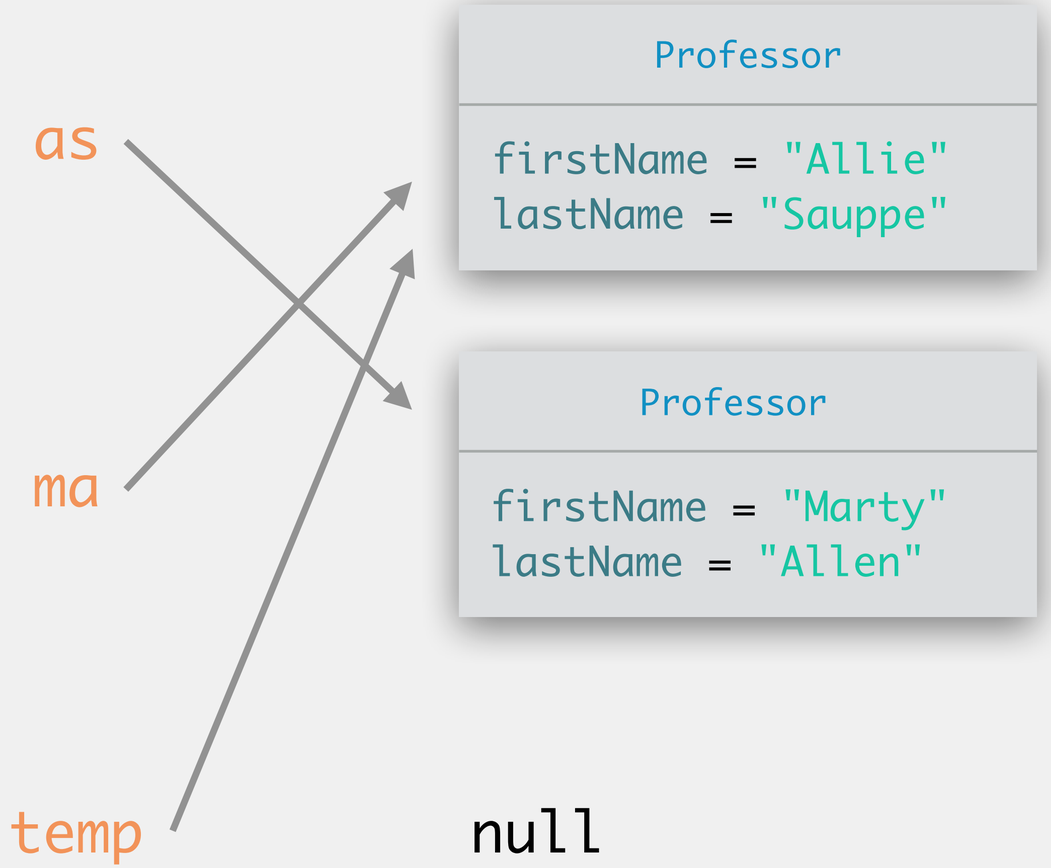

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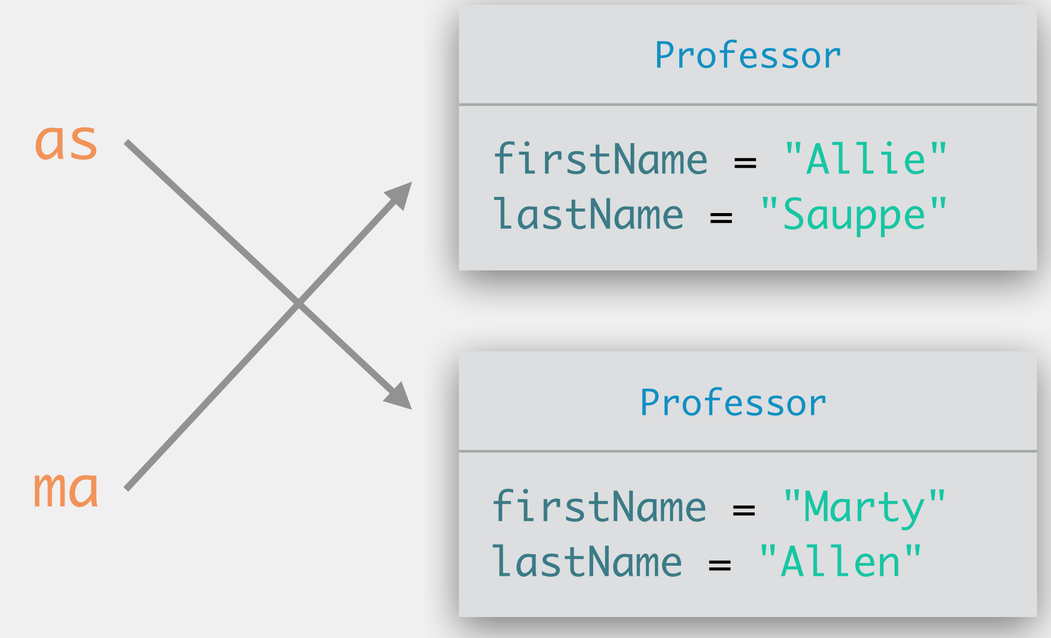

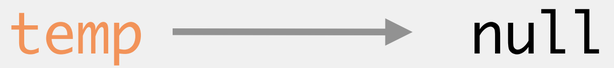

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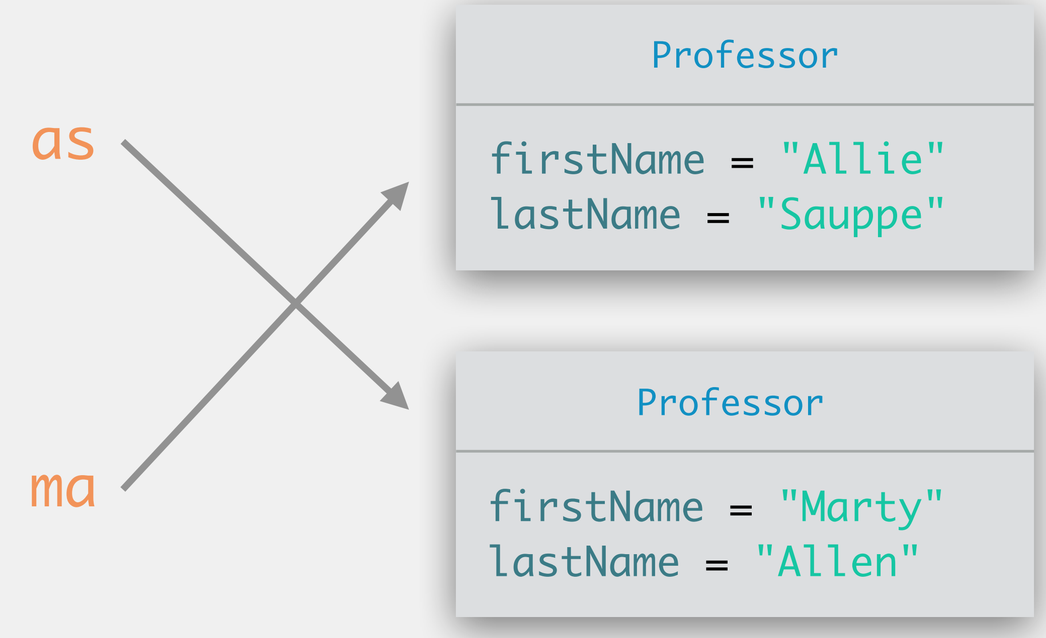
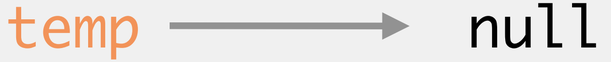
```
Marty Allie
```





Objects/Arrays & Methods

```
> int[] array = {3, 1, 2, 5, 9};

> swap(array, 1, 4);
```

```
public static


    arr
}
```

Objects/Arrays & Methods

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public static void swap(int[] arr, int i1, int i2) {
  > int temp = arr[i1];
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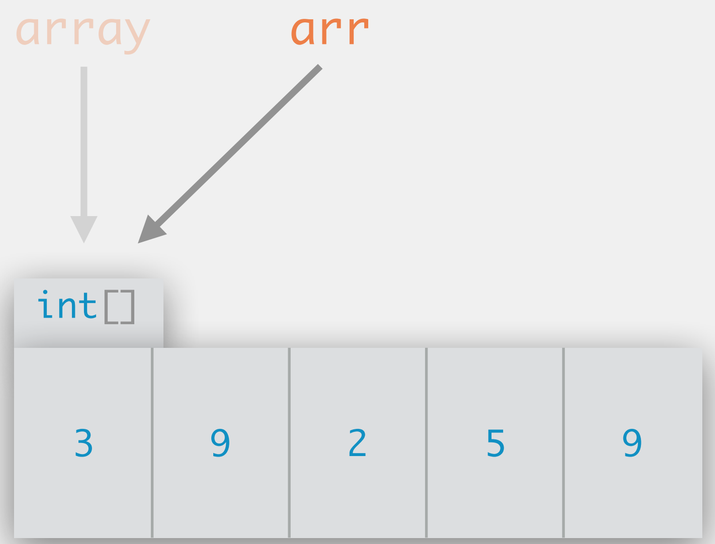

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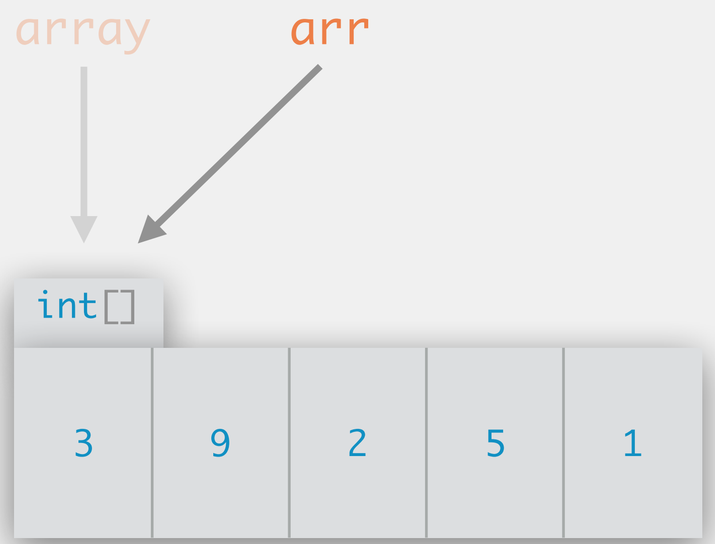

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this Keyword

Used to refer to the object we are currently using

- e.g., *this* object

Can be used just like any other object

Object Tracing With Methods

```
Professor as = new Professor("Sauppe", "Allie");

Professor ma = new Professor("Allen", "Marty");

as.renameProf("Allison");

ma.renameProf("Martin");
```

```
public void renameProf(String newName) {
    this.firstName = newName;
}
```

method contained
in the Professor class

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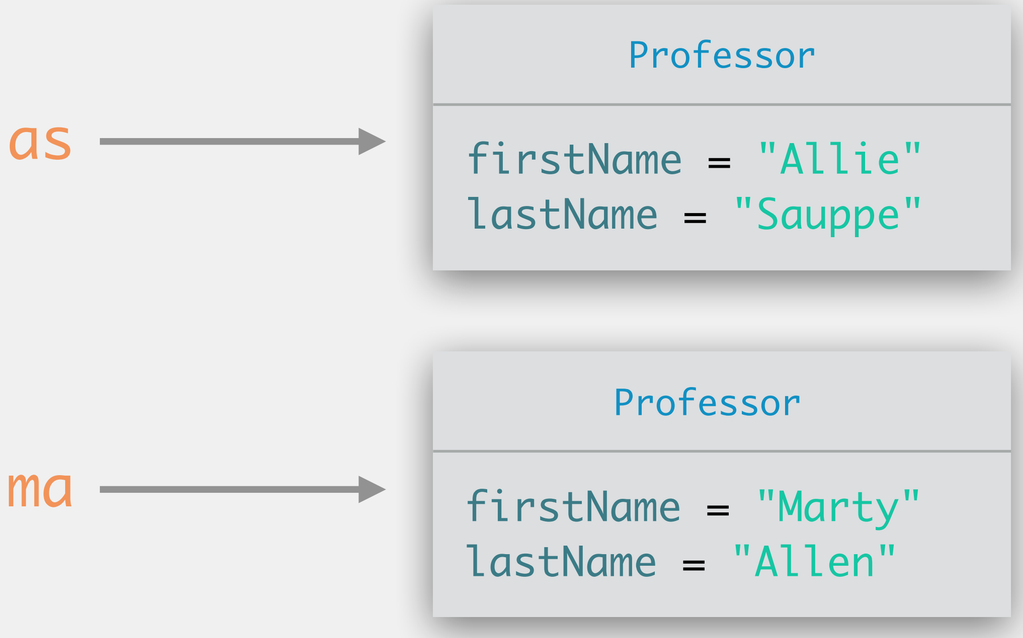

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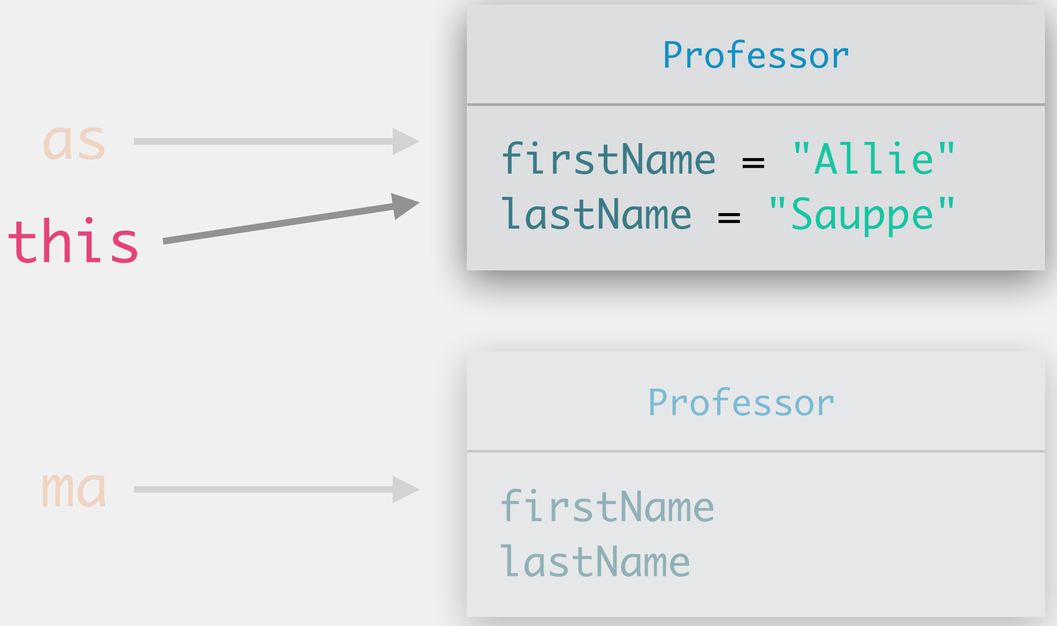

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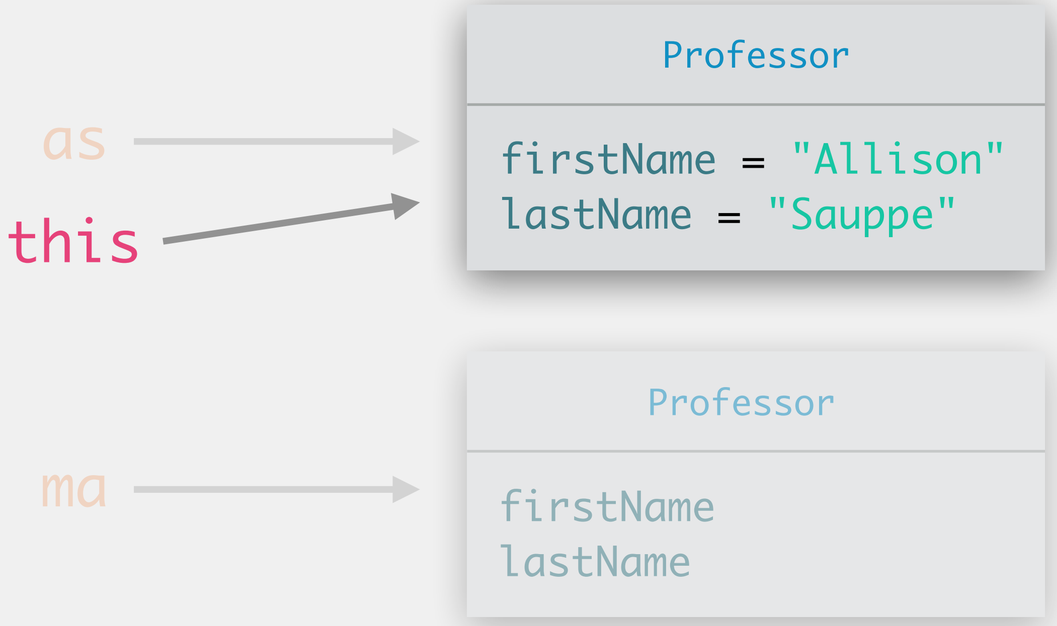

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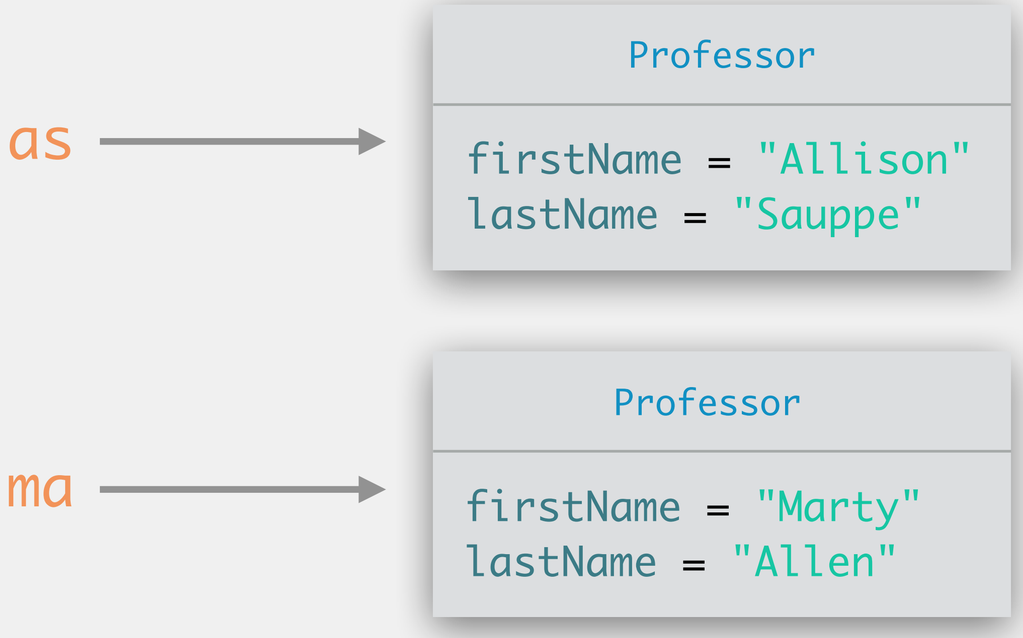

Object Tracing With Methods

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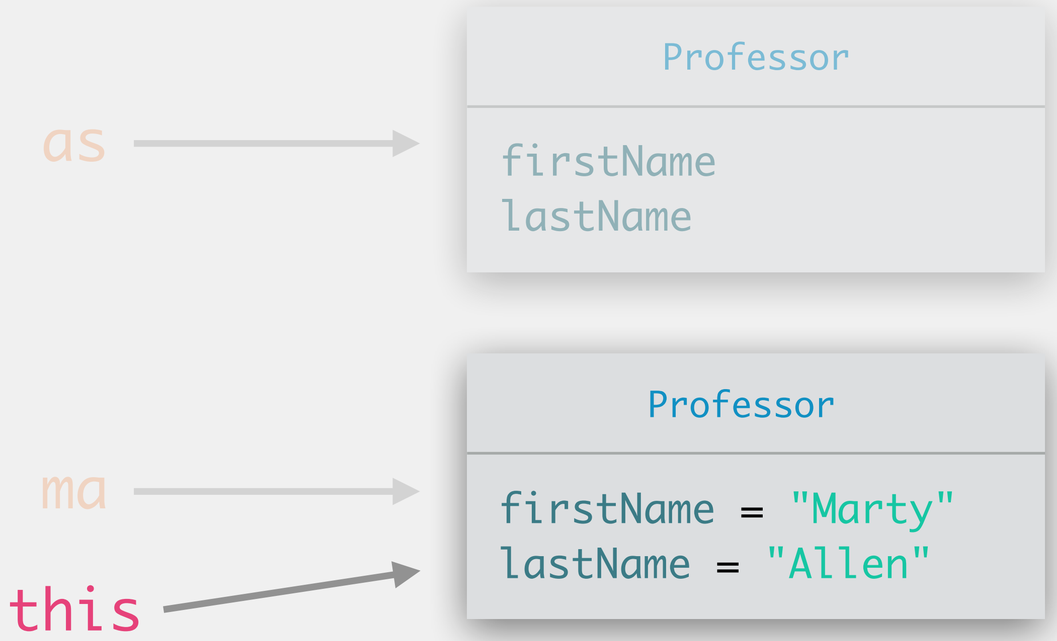

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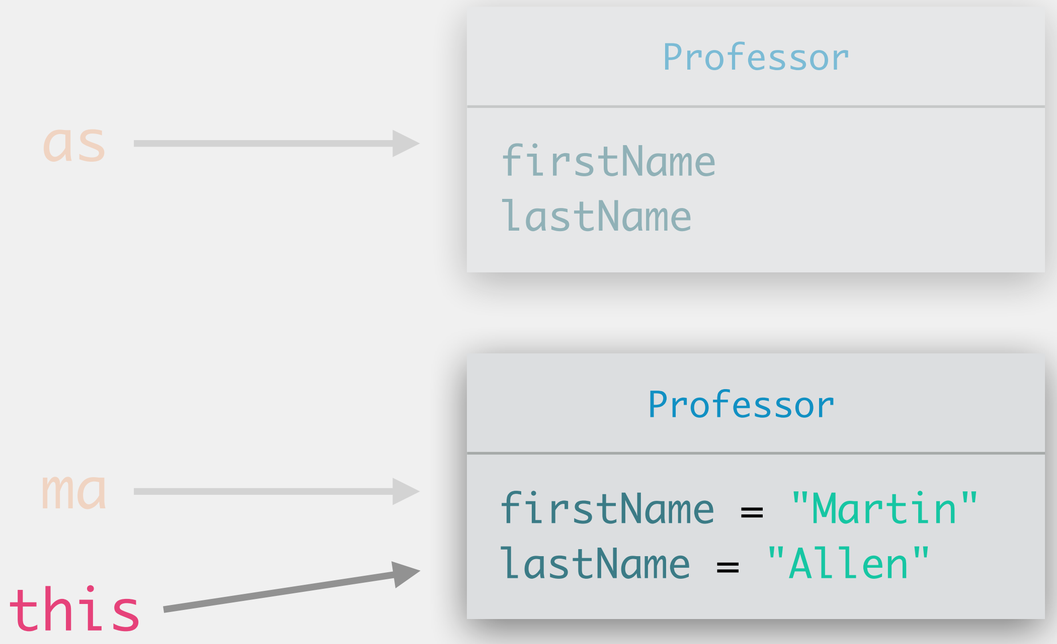

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