LEC 02

CSE 123

Polymorphism; Abstract Classes

Questions during Class?
Raise hand or send here

sli.do #cse123

BEFORE WE START

Talk to your neighbors:

Coffee or tea? Or something else?

Respond on sli.do!

Instructor: Brett Wortzman

TAs:

Arohan	Jonah	Kavya	Eeshani	Trien
Ashar	Brice	Misha	Aidan	Evan
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Chloe	Elden	Sahana	Dixon	Katharine
Jenny	Ishita	Anirudh	Nhan	Anya
Nate	Kuhu	Crystal		

Now playing: CSE 123 26wi Lecture Tunes

Announcements

- Creative Project 0 due tonight, Wednesday, January 14 at 11:59pm!
  - See generic Creative Project rubric posted on website
- Programming Assignment 0 will be released tomorrow, Thursday, January 15 and is due Wednesday, January 21
  - Focused on inheritance and abstract classes
- Recruiting students for a research study about the self-placement
  - See Ed post #68 for details

Lecture Outline

- Polymorphism
- Compiler vs. Runtime Errors
- Abstract Classes

Polymorphism

- `DeclaredType x = new ActualType()`
  - All methods in `DeclaredType` can be called on x
  - We've seen this with interfaces (`List<String>` vs. `ArrayList<String>`)
  - Can also be to inheritance relationships
  - **Important:** The `ActualType` determines what method is actually called!

```
Animal[] arr = {new Animal(), new Dog(), new Husky()};
for (Animal a : arr) {
    a.speak();
}
```

Polymorphism

```
Animal[] arr = {new Animal(), new Dog(), new Husky()};
for (Animal a : arr) {
    a.speak();
}
```

- `DeclaredType x = new ActualType()`
  - **Important:**

    The `ActualType` determines what method is actually called!

Declared Type and Actual Type

```
DeclaredType varName = new ActualType(…);
```

`ActualType` must be a subclass of (or same as) `DeclaredType`

```
Animal rufus = new Dog("Rufus");
```

Declared Type: Animal
Actual Type: Dog

Can call methods that makes sense for EVERY Animal
If Dog overrides a method, uses the Dog version

```
Dog rufus = new Dog(”Rufus");
```

Declared Type: Dog
Actual Type: Dog

Can call methods that makes sense for EVERY Dog
If Dog overrides a method, uses the Dog version

Polymorphism

Typical Problem

```
Animal[] arr = {new Animal(), new Dog(), new Husky()};
for (Animal a : arr) {
    a.speak();
}
```

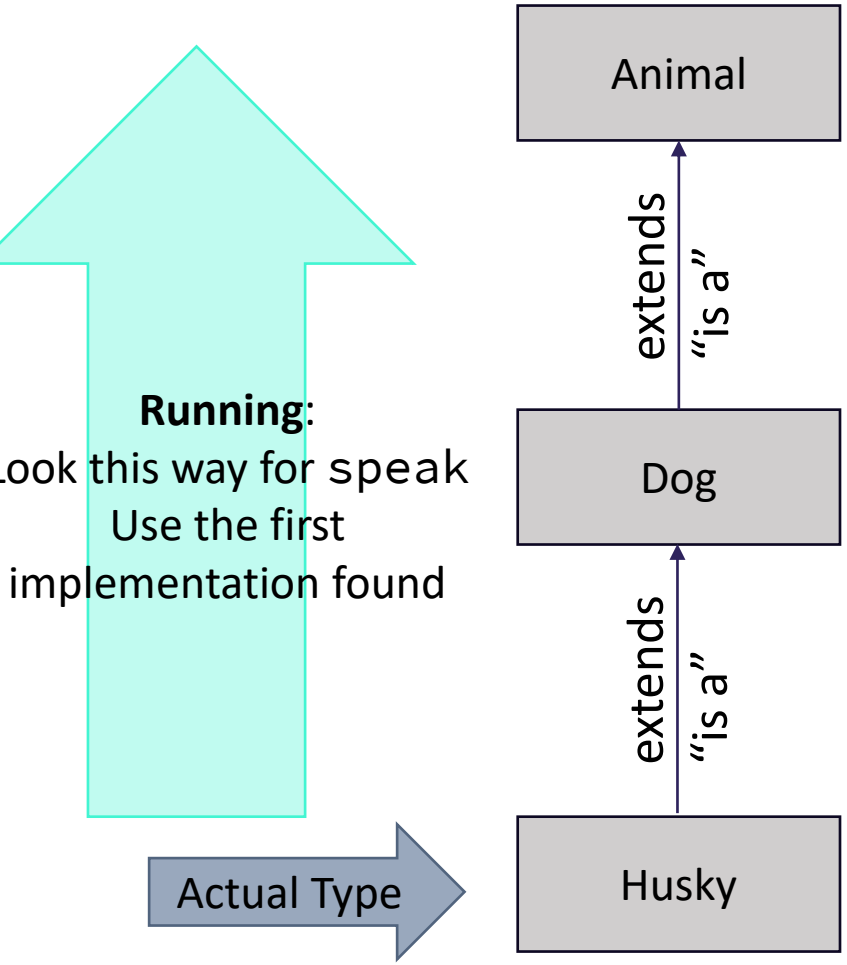
Suppose `Animal`, `Dog`, and `Husky` all implement speak.

Which version gets called on each iteration of the loop?

Overrides and Method Calls

Solution Technique

```
Animal dubs = new Husky();
dubs.speak();
```



When running:

Use the *most specific* version of the method call starting from the actual type.

Start from the actual type, then go "up" to super classes until you find the method. Run that first-discovered version.

In this example:

If the Husky class overrides speak, then we'll use the implementation in Husky. If not, we'll look in Dog and use that one if found. If not, then we'll look in Animal.

Lecture Outline

- Polymorphism
- **Compiler vs. Runtime Errors**
- Abstract Classes

Compiler vs. Runtime Errors

- `DeclaredType x = new ActualType()`
  - At compile time, Java only knows `DeclaredType`
  - Compiler error: trying to call a method that isn't present

```
Animal a = new Dog();
a.bark();                    // No bark() -> CE
```

  - Can cast to change the `DeclaredType` of an object

```
Dog d = (Dog) a;
d.bark();                    // No more CE
```

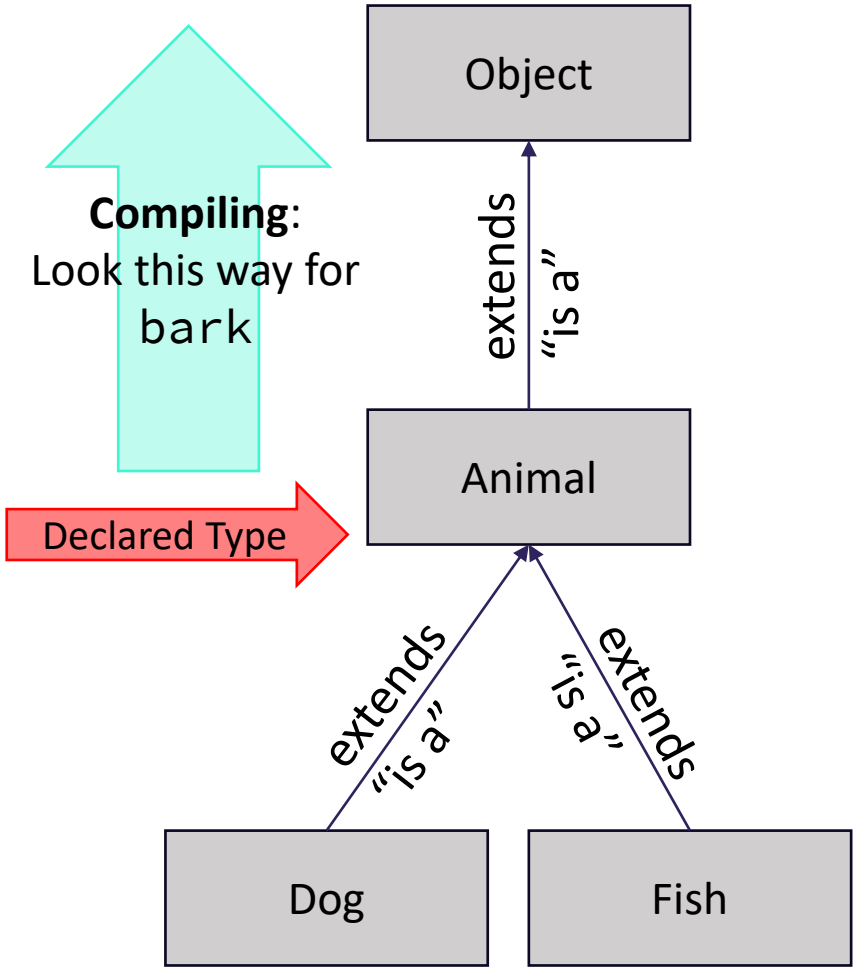
  - Runtime error: attempting cast to type that is not a superclass of actual type

```
Animal a = new Fish();
Dog d = (Dog) a;             // Can't cast -> RE
d.bark();
```

  - Order matters! Compilation before runtime

Compiling Method Calls

```
Animal rufus = new Dog();
rufus.bark();
```



When compiling:

Can we *guarantee* that the method exists for the declared type?

Does the declared type or one of its super classes contain a method of that name?

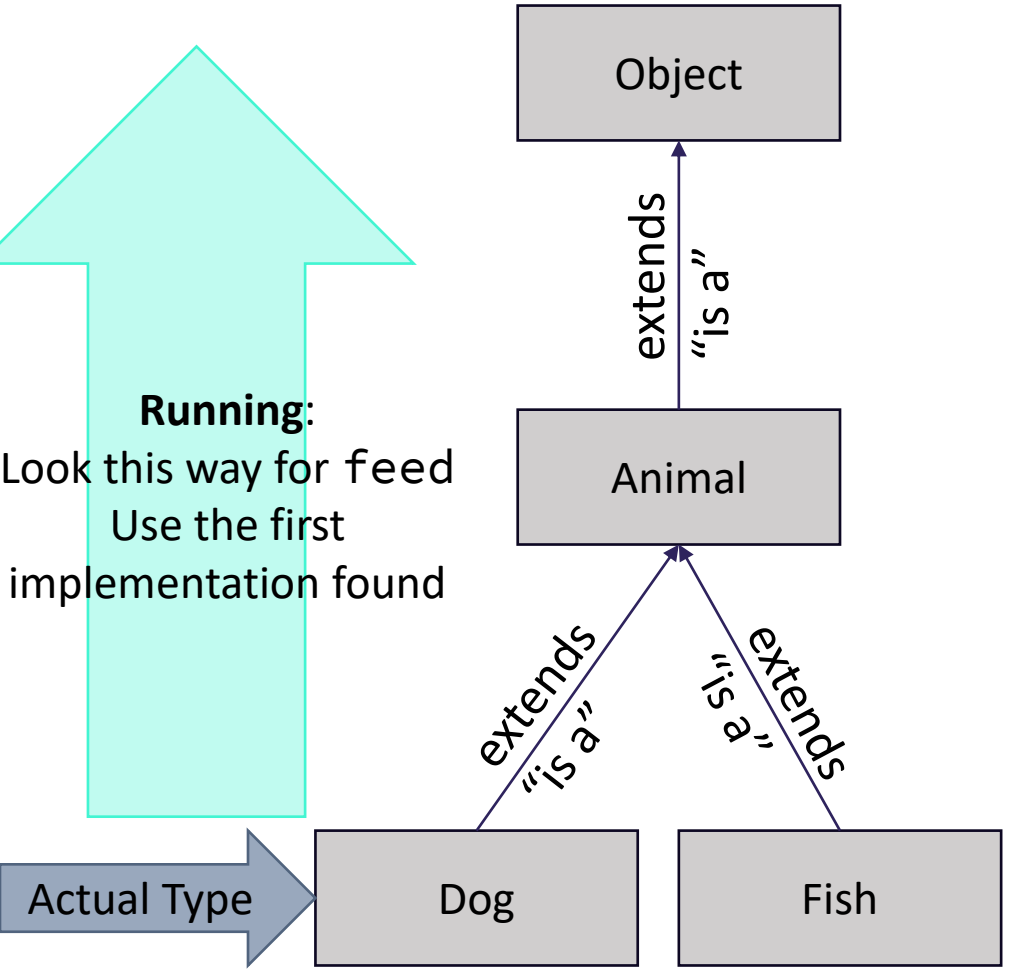
If not… Compile Error!

In this example:

When compiling, neither Animal nor Object have a bark method, so we have a compile error!

Running Method Calls

```
Animal rufus = new Dog();
rufus.feed();
```



When running:

Use the *most specific* version of the method call starting from the actual type.

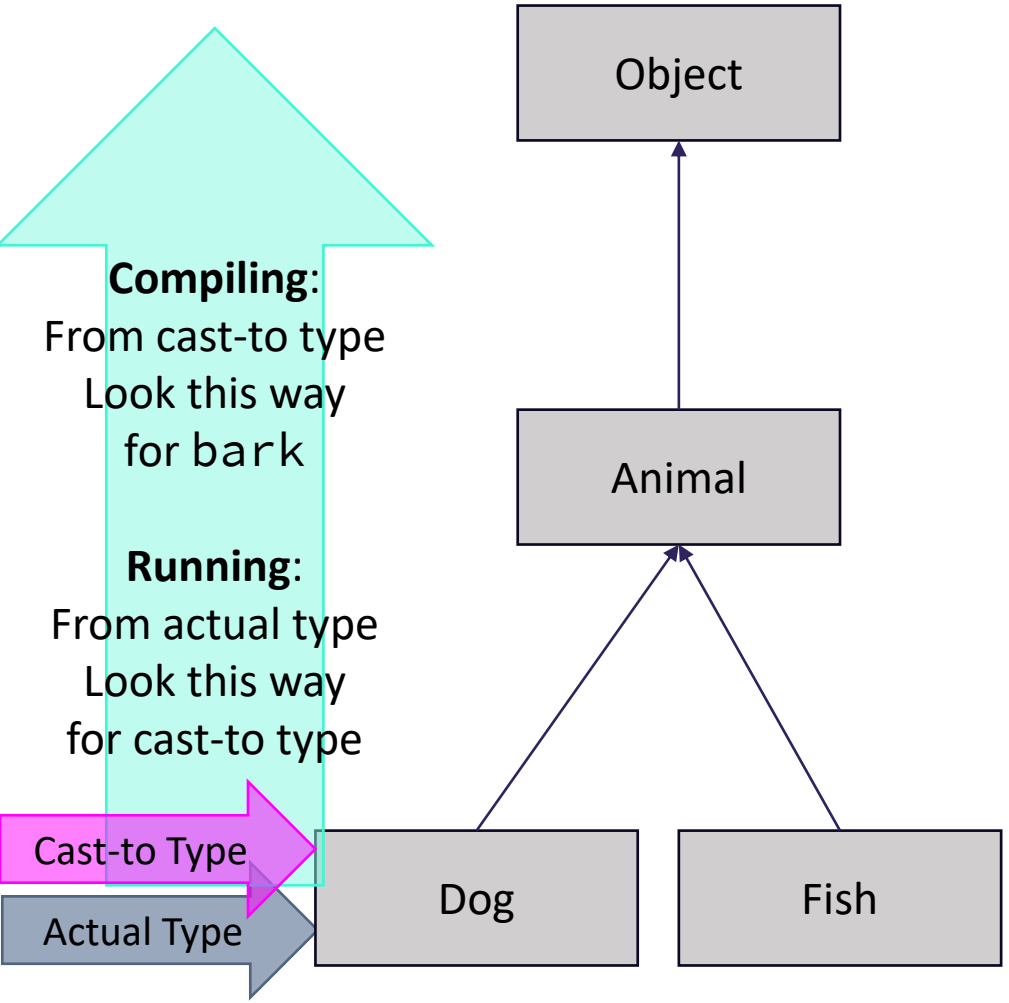
Start from the actual type, then go "up" to super classes until you find the method. Run that first-discovered version.

In this example:

If the Dog class overrides feed, then we'll use the implementation in Dog. Otherwise we'll use the one in Animal

Casts and Method Calls

```
Animal rufus = new Dog();
Dog d = (Dog) rufus;
d.bark();
```



When compiling:

Can we *guarantee* that the method exists for the Cast-to type?

Does the Cast-to type or one of its super classes contain a method of that name?

If not… Compile Error!

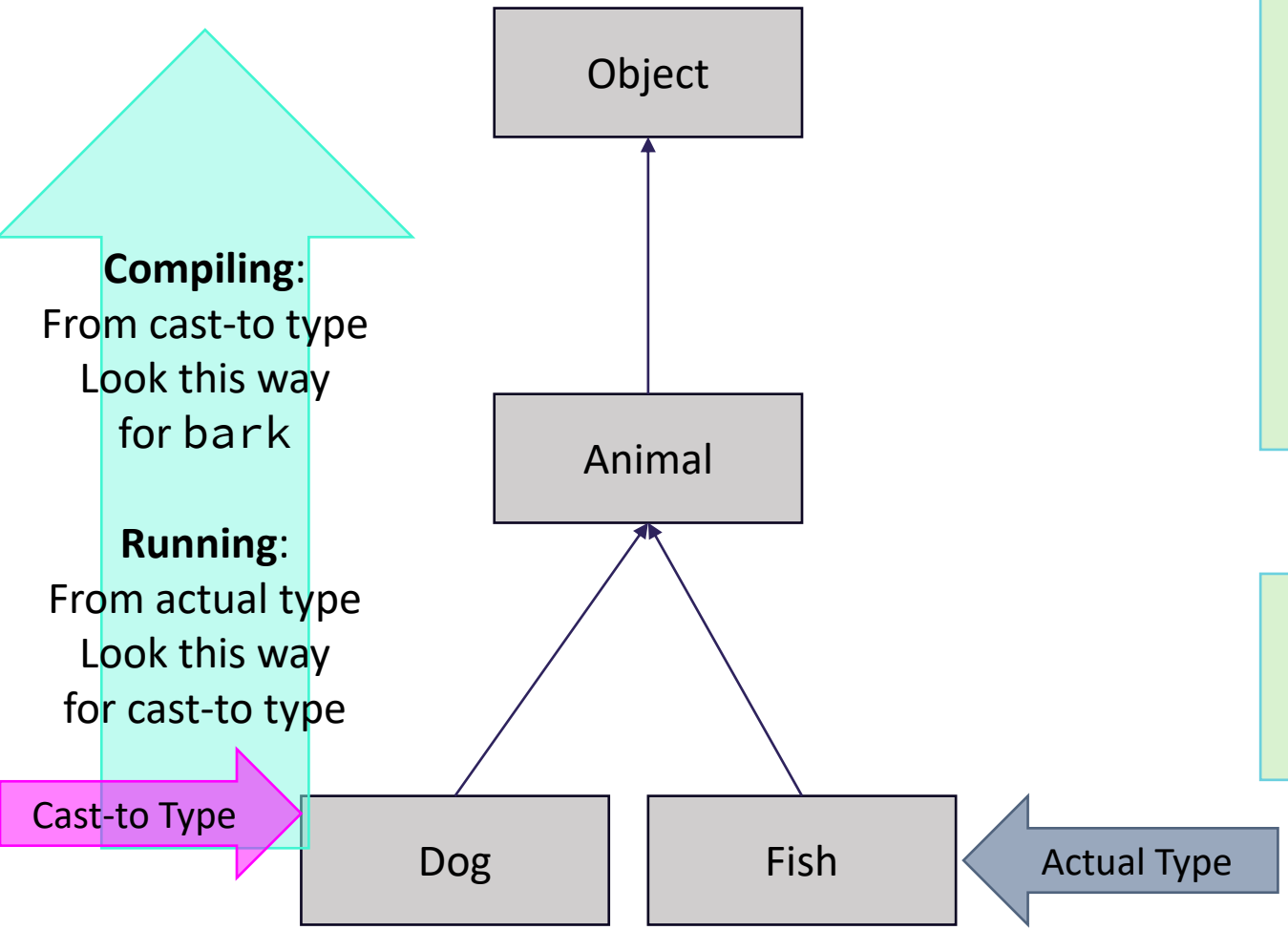
When Running:

Check that the Cast-to Type is either the Actual Type, or one of its super classes

This example has no error

Casts and Method Calls

```
Animal rufus = new Fish();
Dog d = (Dog) rufus;
d.bark();
```



When compiling:

Can we *guarantee* that the method exists for the Cast-to type?

Does the Cast-to type or one of its super classes contain a method of that name?

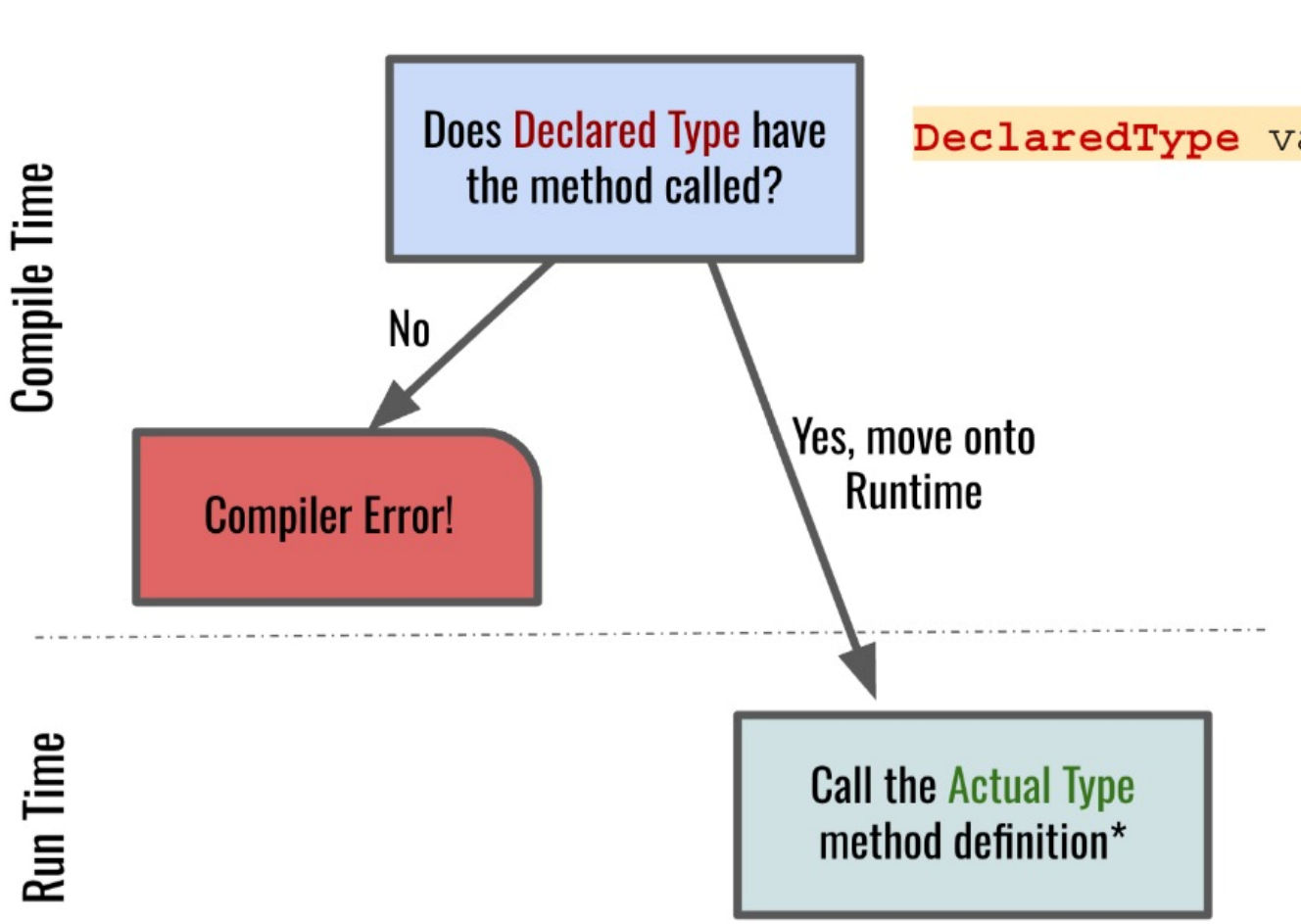
If not… Compile Error!

When Running:

Check that the Cast-to Type is either the Actual Type, or one of its super classes

This example has a runtime error

Compiler vs. Runtime Errors: Method Calls



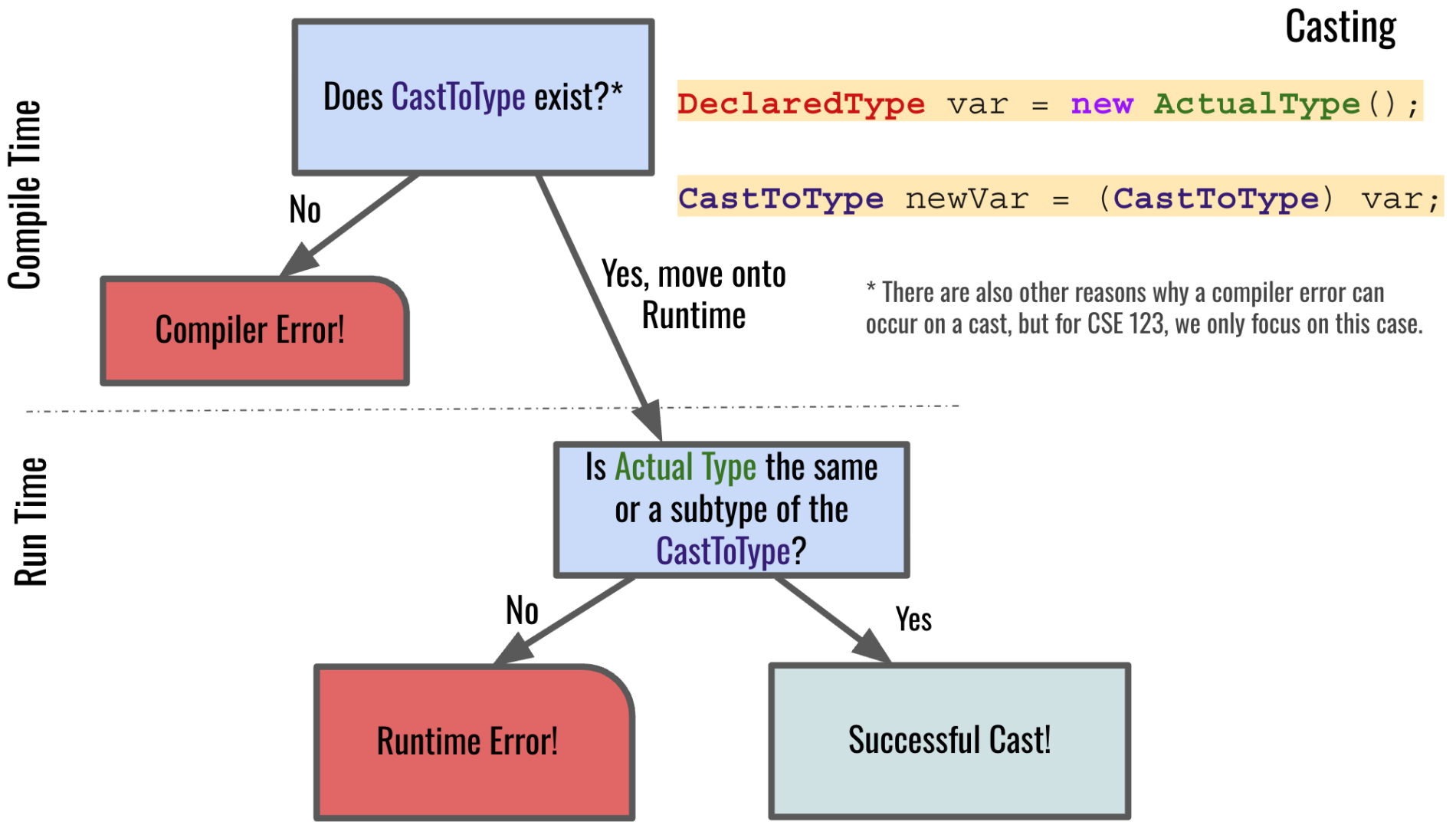
Method Calls

```
DeclaredType var = new ActualType();
```

```
Ex. var.method()
```

* Start at the Actual Type at run time. If it doesn't exist in Actual Type, trace up the inheritance tree to find the nearest inherited method definition

Compiler vs. Runtime Errors: Casting



Casting

```
DeclaredType var = new ActualType();

CastToType newVar = (CastToType) var;
```

* There are also other reasons why a compiler error can occur on a cast, but for CSE 123, we only focus on this case.

Practice : Think

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What is the result of the following code?

```
Teacher socrates = new Teacher("Socrates", 2400);
System.out.println(socrates.getEmployeeName());
System.out.println(socrates.getYearsExperience());
```

A. Compiler Error

B. Runtime Error

C. No error– runs to completion

Practice : Pair

sli.do #cse123

What is the result of the following code?

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Teacher socrates = new Teacher("Socrates", 2400);
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```

A. Compiler Error

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C. No error– runs to completion

Practice : Think

sli.do #cse123

What is the result of the following code?

```
Employee anthony = new Chef("Anthony Bourdain");
System.out.println(anthony.getEmployeeName());
anthony.cookFood("shrimp");
```

A. Compiler Error

B. Runtime Error

C. No error– runs to completion

Practice : Pair

sli.do #cse123

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Practice : Think

sli.do #cse123

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Chef c = (Chef) anthony;
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Practice : Think

sli.do #cse123

What is the result of the following code?

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Employee anthony = new Chef("Anthony Bourdain");
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Teacher t = (Teacher) anthony;
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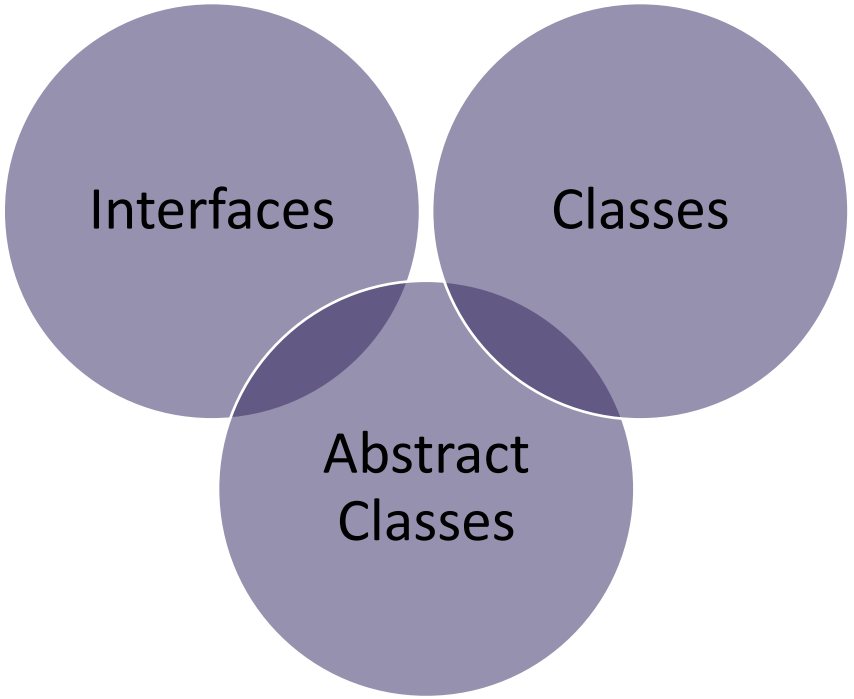
Lecture Outline

- Polymorphism
- Compiler vs. Runtime Errors
- **Abstract Classes**

Abstract Classes

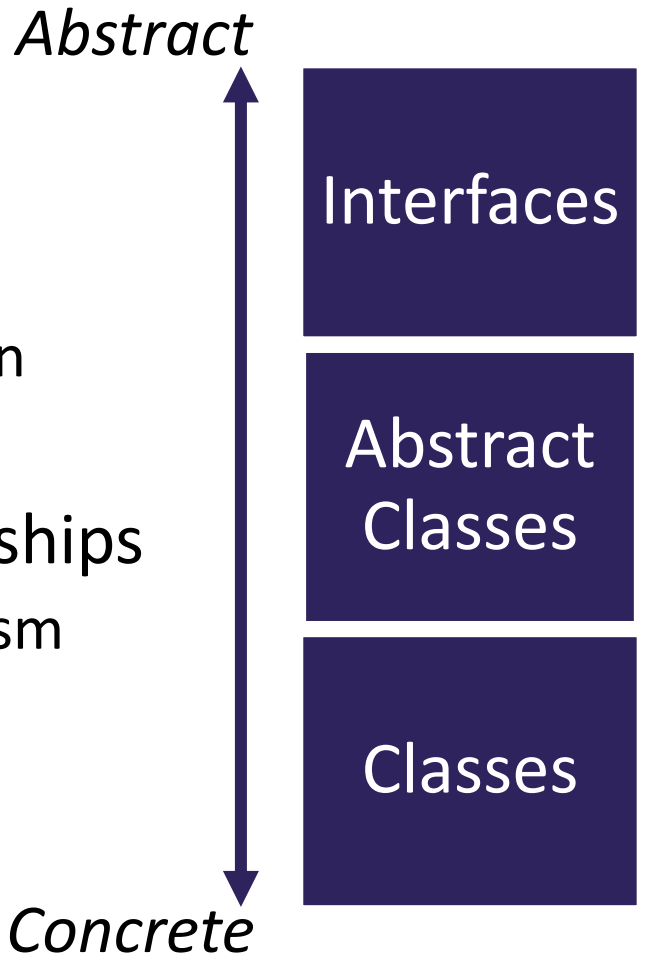
- Mixture of `Interfaces` and `Classes`
  - `Interface` similarities:
    - Can contain (`abstract`) method declarations
    - Can't be instantiated
  - `Class` similarities:
    - Can contain method implementations
    - Can have fields
    - Can have constructors



- Is there identical / nearly similar behavior between classes that shouldn't inherit from one another?

Advanced OOP Summary

- Allow us to define differing levels of abstraction
  - Interfaces = high-level specification
    - What behavior should this type of class have
  - Abstract classes = shared behavior + high-level specification
  - Classes = individual behavior implementation
- Inheritance allows us to share code via “is-a” relationships
  - Reduce redundancy / repeated code & enable polymorphism
    - Still might not be the “best” decision!
  - Interfaces extend other interfaces
  - (abstract) classes extend other (abstract) classes



- You’re now capable of designing some pretty complex systems!

Design in the "real world"

- In this course, we'll always give you expected behavior of the classes you write
  - Often not the case when programming for real
  - Clients don't really know what they want (but programmers don't either)

- My advice:
  - Clarify assumptions before making them (do I really want this functionality?)
  - **There's no one right answer**
    - Weigh the options, make a decision, and provide explanation
    - Iterative development: make mistakes and learn from them
    - Be receptive to feedback and be willing to change your mind

Interface versus Implementation

- Interface: what something *should* do
- Implementation: *how* something is done
- These are different!
- Big theme of CSE 123:

    choose between different implementations of same interface