Inheritance vs. Composition

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Motivation

Motivation

We want to create a system where we have several different types of **fruits**.

Some fruits are **edible**, some are **peelable** and some are **sliceable**.

Examples:

- An **orange** is *edible* and *peelable* but not *sliceable*.
- An **apple** is *edible*, *peelable* and *sliceable*.
- A **watermelon** is *edible* and *sliceable* but not *peelable*.
- A **poisonberry** (a real thing) is neither *edible*, *sliceable* or *peelable*.

Motivation

All fruits have a **weight** and a **color**.

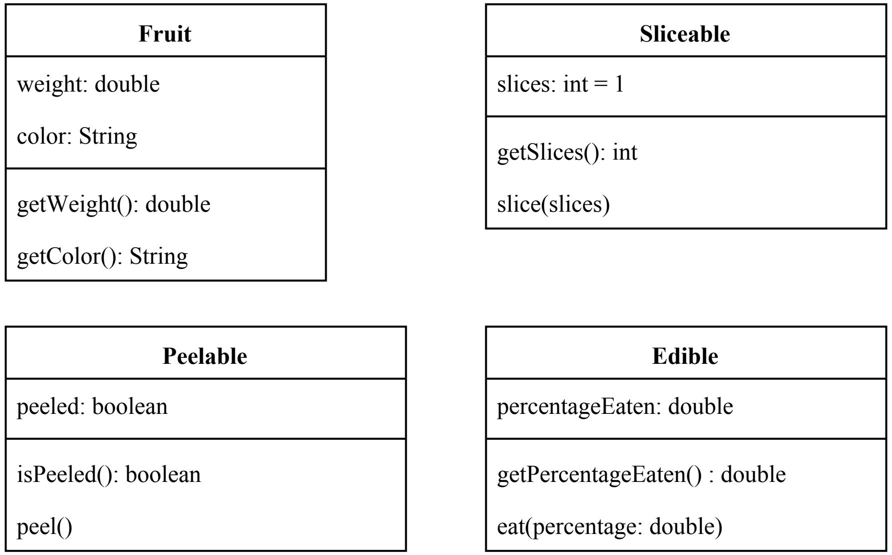
And we want something like this to be possible:

```java
public static void main(String[] args) {
    Fruit orange = new Orange(0.5);
    peelAndEat(orange);
}

private static void peelAndEat(Fruit fruit) {
    fruit.peel();
    while (fruit.getPercentageEaten() != 1)
        fruit.eat(0.2);
}
```

First Approach

We can start by imagining that we need classes **similar** to this:



Fruit

weight: double

color: String

getWeight(): double

getColor(): String

Sliceable

slices: int = 1

getSlices(): int

slice(slices)

Peelable

peeled: boolean

isPeeled(): boolean

peel()

Edible

percentageEaten: double

getPercentageEaten() : double

eat(percentage: double)

Code (Fruit)

```java
public class Fruit {
    private final double weight;
    private final String color;

    Fruit(double weight, String color) {
        this.weight = weight;
        this.color = color;
    }

    public double getWeight() {
        return weight;
    }

    public String getColor() {
        return color;
    }
}
```

Code (Edible)

```java
public class Edible {
    private double percentageEaten;

    public Edible() {
        this.percentageEaten = 0;
    }

    public void eat(double percentage) {
        percentageEaten += percentage;
        percentageEaten = Math.max(percentageEaten, 1);
    }

    public double getPercentageEaten() {
        return percentageEaten;
    }
}
```

Code (Peelable)

```java
public class Peelable {
    private boolean peeled;

    public Peelable() {
        this.peeled = false;
    }

    public boolean isPeeled() {
        return peeled;
    }

    public void peel() {
        this.peeled = true;
    }
}
```

Code (Sliceable)

```java
public class Sliceable {
    private int pieces;

    public Sliceable() {
        this.pieces = 1;
    }

    public void slice(int pieces) {
        this.pieces = pieces;
    }

    public int getPieces() {
        return pieces;
    }
}
```

Multiple Inheritance

Multiple Inheritance

One possible approach would be to use **multiple inheritance**.

Unfortunately multiple inheritance is **not supported** in many languages (including **Java**).

The argument behind this *controversial* decision, is that multiple inheritance adds **complexity** and suffers from **ambiguity** problems (namely the famous **diamond problem**).

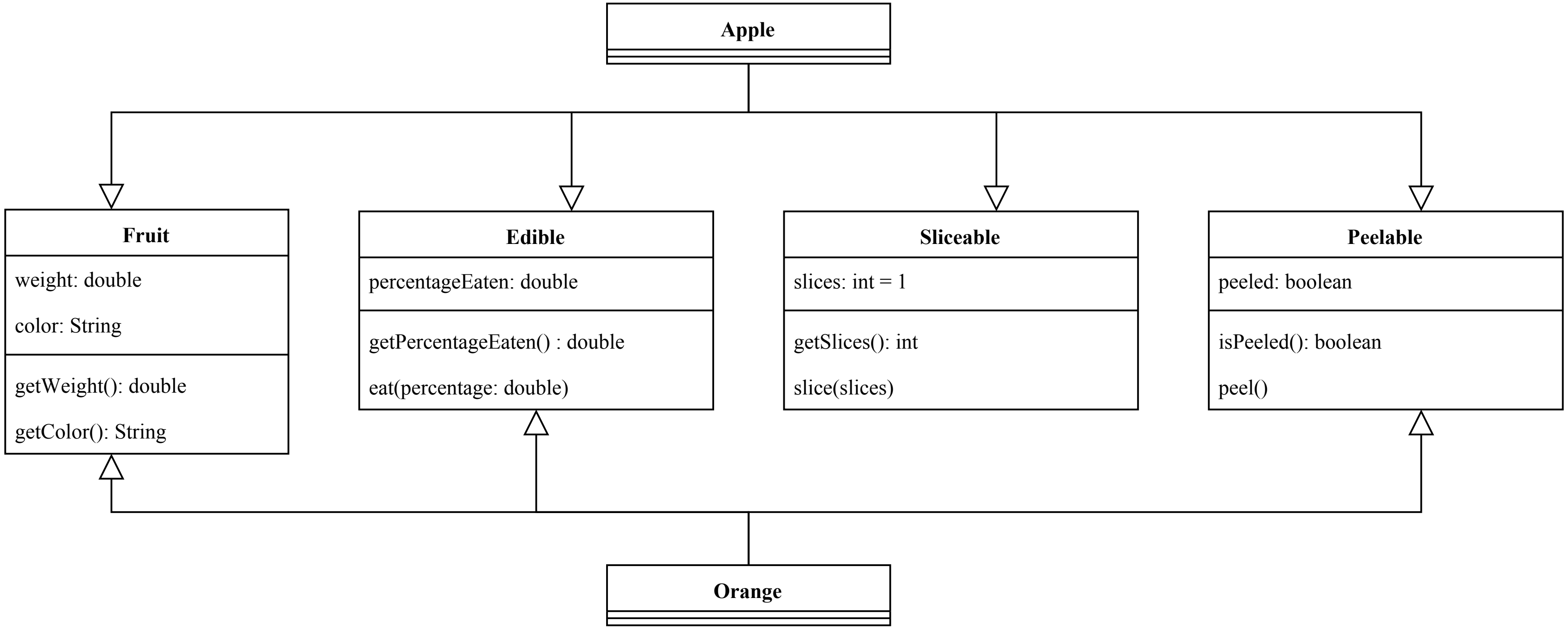
Disambiguation

Languages that **allow** *multiple inheritance* must have a **mechanism** to **disambiguate** which method should be called if two *super-classes* declare a method with the same signature.

This can be done in different ways:

- Not allowing multiple inheritance.
- Following the order they are declared.
- Explicitly by the developer.

Using Multiple Inheritance



Problems

Even if we could use *multiple inheritance*, this would not be possible:

```java
public static void main(String[] args) {
    Fruit orange = new Orange(0.5);
    peelAndEat(orange);
}

private static void peelAndEat(Fruit fruit) {
    fruit.peel();
    while (fruit.getPercentageEaten() != 1)
        fruit.eat(0.2);
}
```

As **not all** fruits are **peelable** and **edible**.

Interfaces

Interfaces

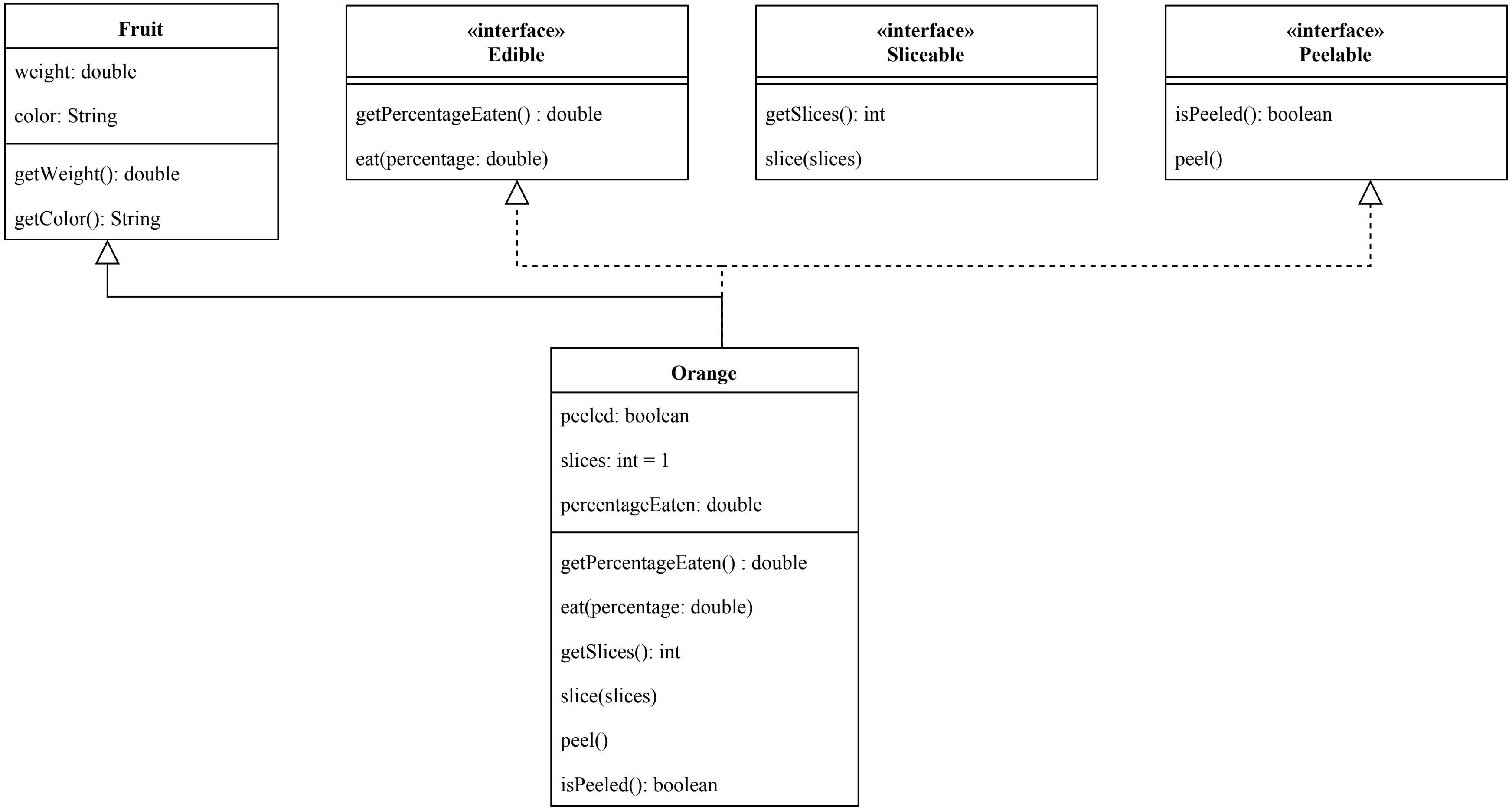
The alternative to *multiple inheritance* is to use **interfaces**.

Interfaces are structures that force classes to **implement** certain methods.

Methods in interfaces **don't have bodies**.

In Java, all variables declared inside interfaces are implicitly **public**, **static**, and **final**.

Using Interfaces



Fruit

weight: double

color: String

getWeight(): double

getColor(): String

«interface»
Edible

getPercentageEaten() : double

eat(percentage: double)

«interface»
Sliceable

getSlices(): int

slice(slices)

«interface»
Peelable

isPeeled(): boolean

peel()

Orange

peeled: boolean

slices: int = 1

percentageEaten: double

getPercentageEaten() : double

eat(percentage: double)

getSlices(): int

slice(slices)

peel()

isPeeled(): boolean

Problems

As **each class** must provide their own **implementation** of methods declared by the interfaces they implement, we end up with lots of **duplicate code**.

And we still **can't do** this:

```java
public static void main(String[] args) {
    Fruit orange = new Orange(0.5);
    peelAndEat(orange);
}

private static void peelAndEat(Fruit fruit) {
    fruit.peel();
    while (fruit.getPercentageEaten() != 1)
        fruit.eat(0.2);
}
```

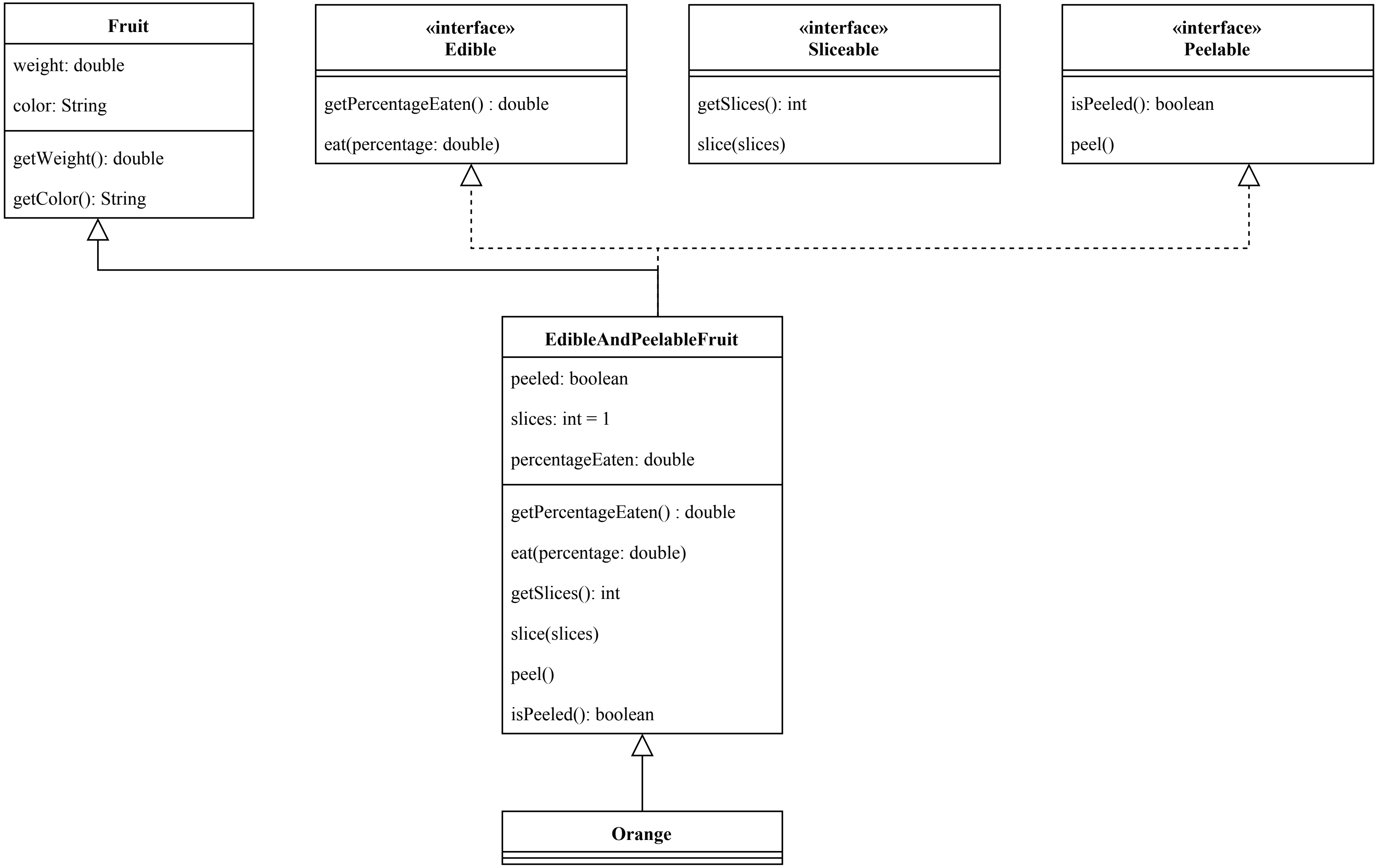
Combination Classes

Combination Classes

One solution would be to have abstract classes for all (or only those that we need) combinations of the *edible*, *peelable* and *sliceable* interfaces:

- EdibaleFruit, PeelableFruit and SliceableFruit.
- EdibaleAndPeelableFruit, EdibaleAndSliceableFruit and PeelableAndSliceableFruit.
- EdibalePeelableAndSliceableFruit.

Using Combination Classes



Fruit

weight: double

color: String

getWeight(): double

getColor(): String

«interface»
Edible

getPercentageEaten() : double

eat(percentage: double)

«interface»
Sliceable

getSlices(): int

slice(slices)

«interface»
Peelable

isPeeled(): boolean

peel()

EdibleAndPeelableFruit

peeled: boolean

slices: int = 1

percentageEaten: double

getPercentageEaten() : double

eat(percentage: double)

getSlices(): int

slice(slices)

peel()

isPeeled(): boolean

Orange

Problems

As the number of interfaces that we want to implement grows, this quickly becomes impractical.

But at least we can do this:

```java
public static void main(String[] args) {
    Orange orange = new Orange(0.5);
    peelAndEat(orange);
}

private static void peelAndEat(EdibleAndPeelableFruit fruit) {
    fruit.peel();
    while (fruit.getPercentageEaten() != 1)
        fruit.eat(0.2);
}
```

Defaults

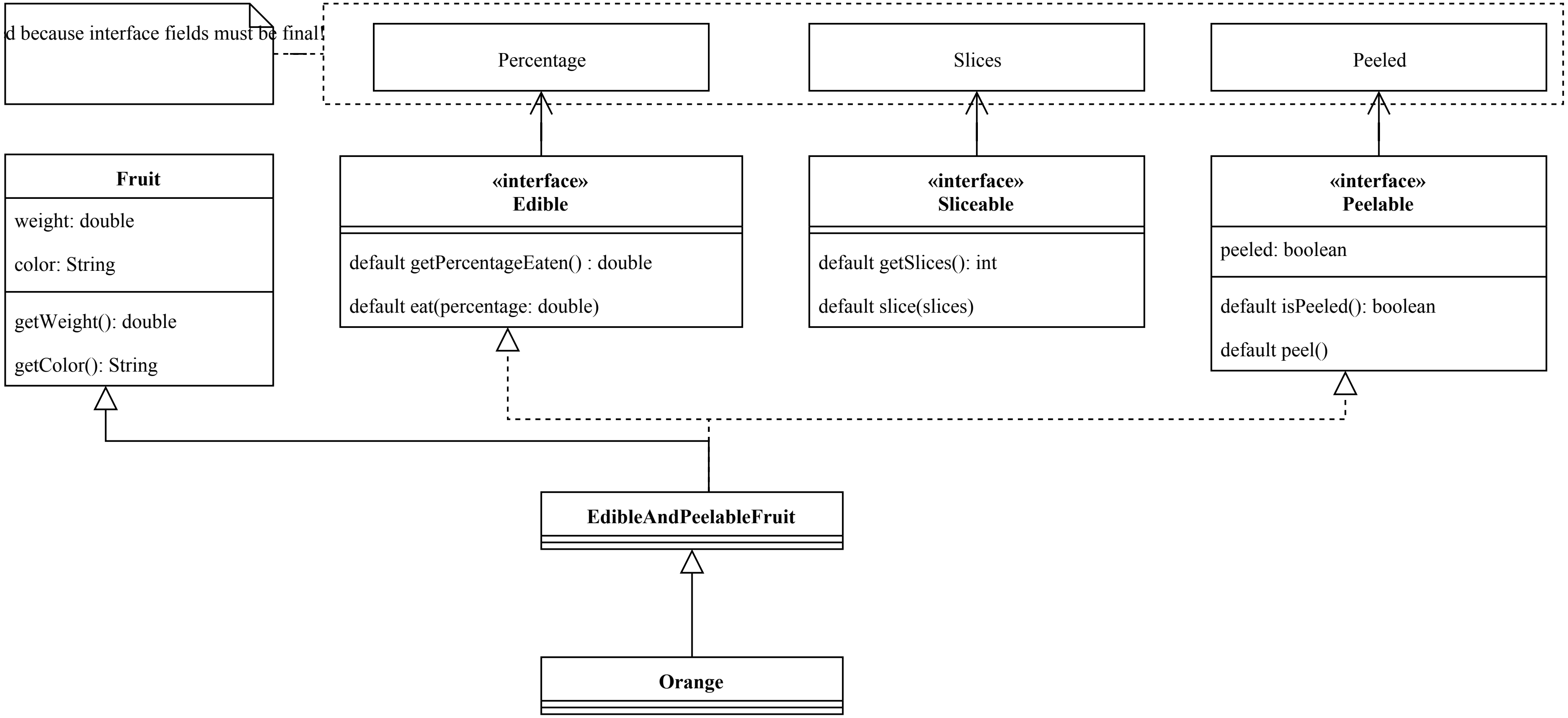
Defaults

Since Java 8, interfaces can have **default** implementations.

This means that interfaces **can** now **declare** method **bodies** that will be inherited by any classes implementing them.

But attributes still need to be **public**, **static**, and **final** (and this kind of defeats the purpose of having code in interfaces).

Using Defaults



Problems

We can **get around** the problem of all attributes being **final** by using **wrapper** classes.

But the only way to solve the **static** problem would be to have *maps* saving the data for each different instance. Which is overkill...

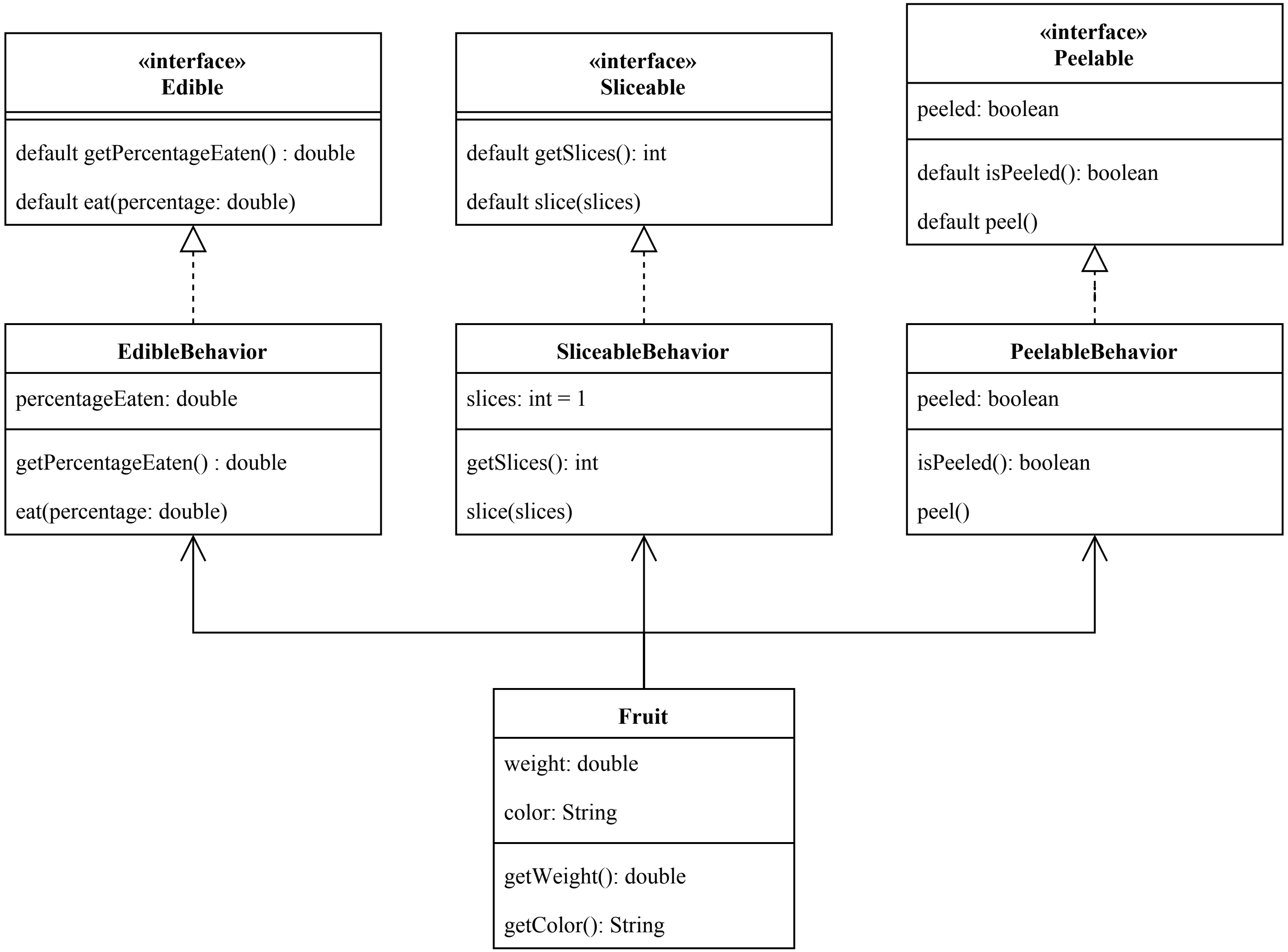
Composition

Composition

Composition over inheritance is the principle that classes should achieve **polymorphic** behavior and **code reuse** by their **composition** rather than by inheritance.

Instead of fruits inheriting from the *Edible*, *Peelable* and *Sliceable* base classes/interfaces, we can **inject** that behavior directly into them.

Using Composition



«interface»
Edible

default getPercentageEaten() : double

default eat(percentage: double)

«interface»
Sliceable

default getSlices(): int

default slice(slices)

«interface»
Peelable

peeled: boolean

default isPeeled(): boolean

default peel()

EdibleBehavior

percentageEaten: double

getPercentageEaten() : double

eat(percentage: double)

SliceableBehavior

slices: int = 1

getSlices(): int

slice(slices)

PeelableBehavior

peeled: boolean

isPeeled(): boolean

peel()

Fruit

weight: double

color: String

getWeight(): double

getColor(): String

Composition Code

```
public static void main(String[] args) {
  Orange orange = new Orange(0.5);
  peelAndEat(orange);
}

private static void peelAndEat(Fruit fruit) {
  fruit.getPeelableBehavior().peel();
  while (fruit.getEdibleBehavior().getPercentageEaten() != 1)
      fruit.getEdibleBehavior().eat(0.2);
}
```

Edible Behavior

The behavior of fruits that are Edible:

```java
public class EdibleBehavior implements Edible {
  private double percentageEaten;

  public EdibleBehavior() {
    this.percentageEaten = 0;
  }

  public void eat(double percentage) {
    percentageEaten += percentage;
    percentageEaten = Math.max(percentageEaten, 1);
  }

  public double getPercentageEaten() {
    return percentageEaten;
  }
}
```

Different Behaviors

Fruits can have different behaviors. One can be not to be Edible:

```
public class NotEdibleBehavior implements Edible {
  public void eat(double percentage) throws FruitNotEdibleBehavior {
    throw new FruitNotEdibleBehavior();
  }

  public double getPercentageEaten() {
    return 0;
  }
}
```

Orange Class

An orange is Edible, Peelable but isn't Sliceable:

```
public class Orange extends Fruit {
    Orange(double weight) {
        super(weight, "orange",
          new EdibleBehavior(),
          new PeelableBehavior(),
          new NotSliceableBehavior());
    }
}
```

Problems

- Might be overly **complex** for most cases.
- There is no **type-safety**. We can only know if a *Fruit* is *Edible* in **runtime**.
- We are calling the method on the behavior instead of on the class itself.

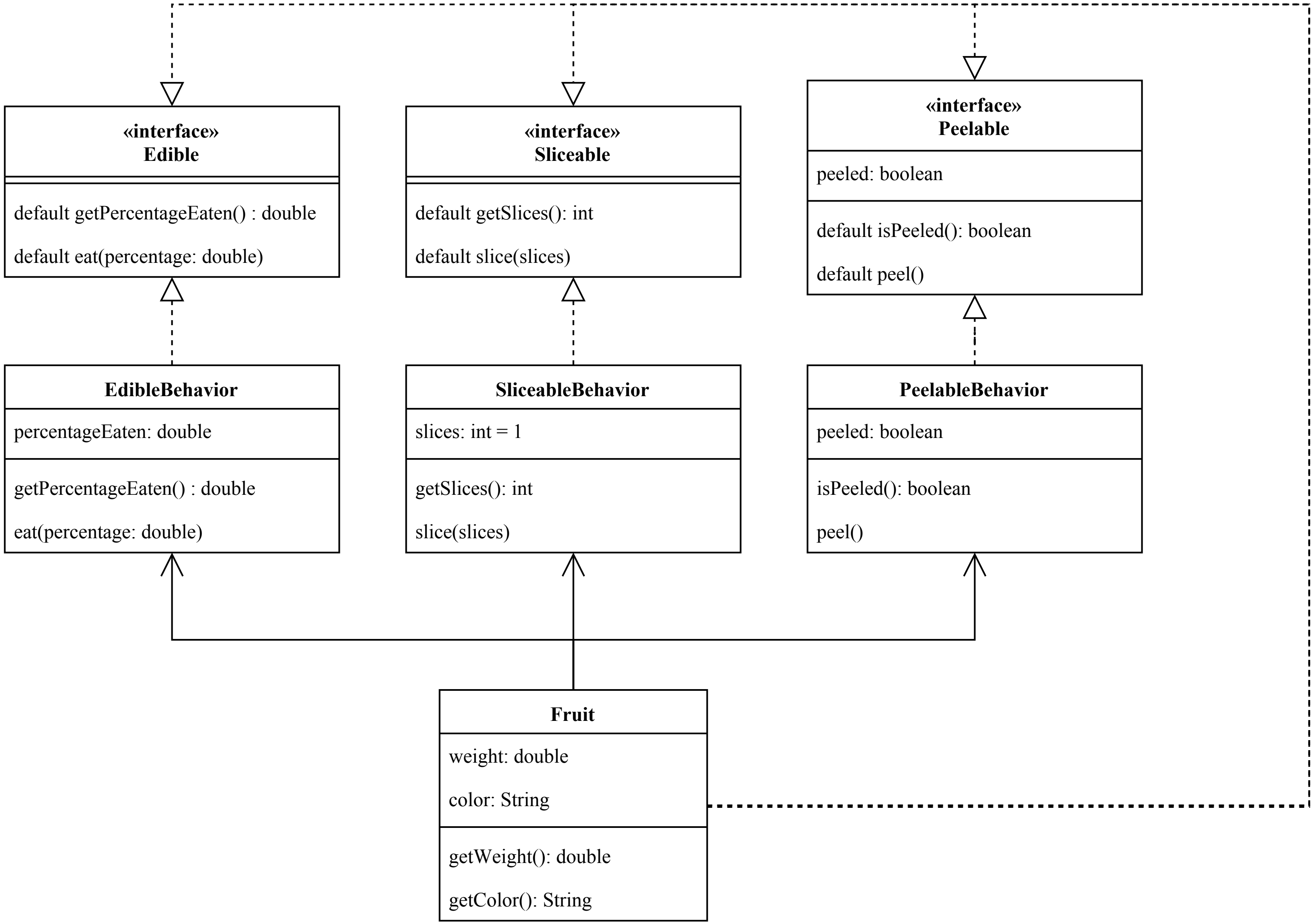
Delegation

Delegation

By having the *Fruit* class implement the different behaviors and *delegating* each method call to the corresponding one, we still get the benefits of *composition* but we now can **call** the methods **directly**.

All other **drawbacks** of simple composition are **still present**.

Using Delegation



Other Methods

Other Methods

- Monkey Patching (Javascript, Python, ...)
- Traits and Mixins (Scala, Ruby, ...)
- Extension Methods (C#, Kotlin, ...)