Object Oriented Programming in Java

5: Abstract classes and interfaces

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- The samples and slides are inspired by the Object Oriented Programming course at the University of Zagreb, Faculty of Electrical Engineering and Computing, Zagreb, Croatia.
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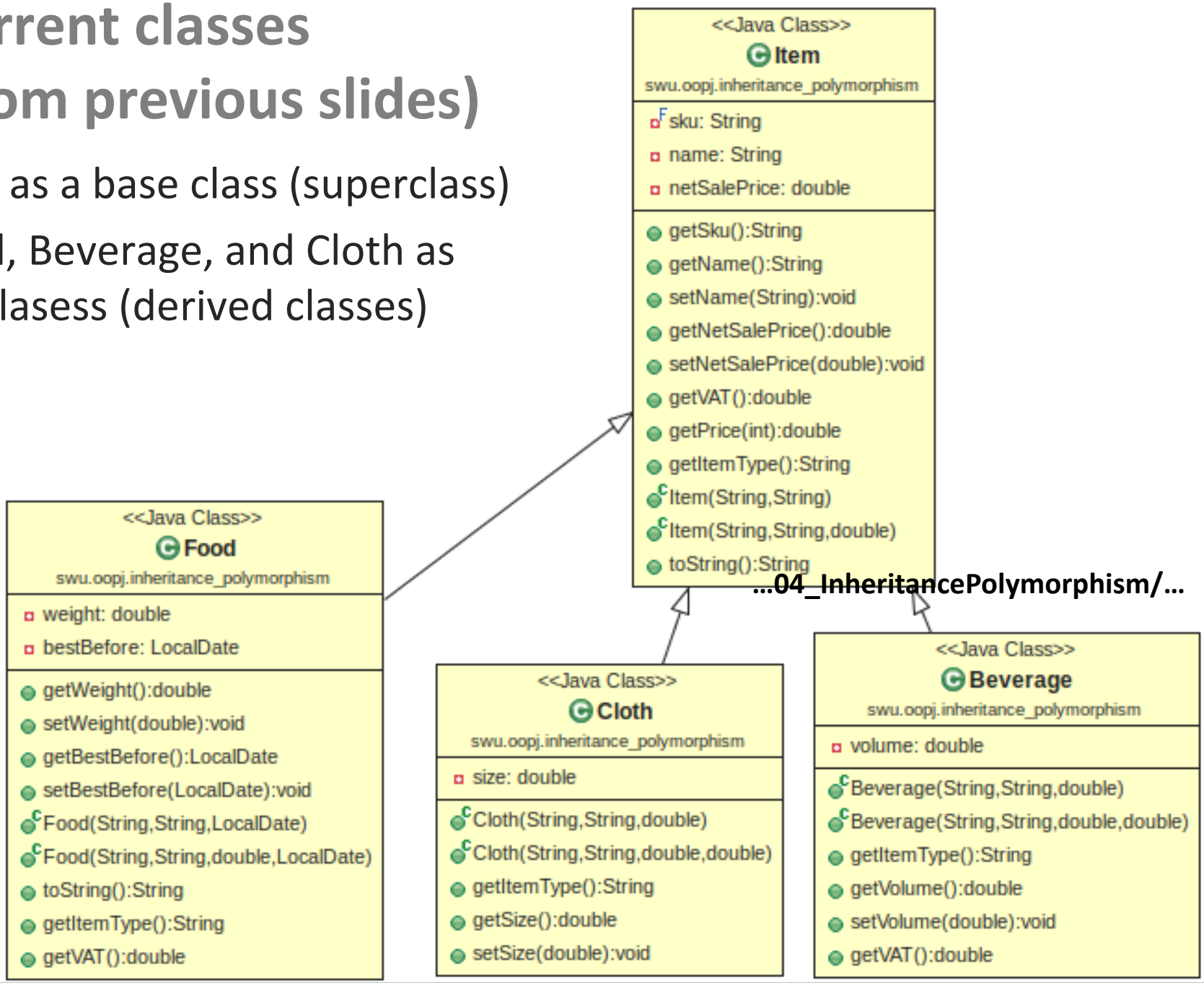
Current classes (from previous slides)

- Item as a base class (superclass)
- Food, Beverage, and Cloth as subclasess (derived classes)



(Reminder) Printing item type

…04_InheritancePolymorphism/…/swu/oopj/inheritance_polymorphism/Main.java

- In the introductory example we had created clothing item as an object of type *Item* that is not good for several reasons
  - Item type was empty string (we cannot know item type in advance)
  - If *Cloth* override getVAT this leads to incorrect price calculation
  - This also allows creating items that are neither food, beverage or cloth

```
Item item = new Item("1256", "T-shirt");
item.setNetSalePrice(50);
System.out.format("%s, price: %.2f, type: %s%n", item,
                                item.getPrice(1), item.getItemType());
Food food = new Food("777", "Home cookies", 2.5,
                                        LocalDate.of(2020,5, 11));
System.out.format("%s, price: %.2f, type: %s%n", food,
                           food.getPrice(1), food.getItemType());
```

```
1256 - T-shirt, price: 56.50, type:
777 - Home cookies, best before: 11.05.2020., price: 2.65, type: Food
```

Abstract classes

- We can prevent creation of objects of type Item and enforce creating object of derived types using keyword *abstract*

  public abstract class Item

- Instance of abstract class cannot be created with *new Item(…)*
  - This is desired behavior as we would like to enforce using only know item types such as food, beverage, and cloth
  - Other unknown types are not allowed
    - we can always define new class for some other item types
- What is the purpose of our abstract Item class
  - It provides common variables and methods of all item types
- We can still use Item as reference, e.g. *Item item = new Food(…*
  - Allows holding different object types in same array as long as their types are derived from *Item*

Abstract methods

- How to implement common methods (in abstract classes) when behavior is not known in advance?
  - Returning empty string looks ok for now, but what happens if we calculate some value (i.e. area of the shape, minimal value, …)
    - Return 0, -1, or some magic number?
    - Write a message?
    - Cause exception and/or crash a program
- Opposite to *getItemType*, *getVAT* and *getPrice* has reasonable implementation that can be overridden but does not have to
- How to enforce derived class to override some methods (i.e. *getItemType*)?
  - By not implementing the method at all and marking it as *abstract*

…05_Abstract_Interfaces/…/Item.java

```
public abstract class Item {
        public abstract String getItemType();
        ...
```

Abstract classes and abstract methods

- A class that contains at least one abstract method must be abstract
- Abstract class does not have to have abstract methods
- A class that is derived from abstract class
  - must implement abstract methods from base class

  or
  - must be also marked as abstract
    - In this case it may implement 0 or more abstract methods
- Abstract classes may have constructors
  - It initialize parts that belong to members of abstract class
  - It may be public, but there is no much use of it, as it can be used from derived classes (using *super* keyword)

Invoking abstract methods (1)

- Can abstract method be invoked if the reference is of abstract type?
  - Yes! - Abstract methods are virtual methods (polymorphism)
- Can abstract method be invoked from another method in the same abstract class?
  - Yes, except in constructors of the classes above in hierarchy tree!
    - This also hold for virtual methods in general and leads to undefined behavior as classes in inheritance tree are still not initialized (remember the order of constructor executing!)
  - It looks we are calling method that does not exist, but that method is virtual, and must be implemented in (non-abstract) derived class

Invoking abstract methods (2)

- *Item's* non abstract method invokes abstract *Item's* method
- What happens if we have *Item item = …* and then *item.toString() ?*
  - We cannot do something like *item = new Item(…)* but we can have item = new Cloth(…
  - Cloth does not have to override *toString*, but must implement (override) *getItemType*

…05_Abstract_Interfaces/…/Item.java

```
public abstract class Item {
	public abstract String getItemType();
	...

	@Override
	public String toString() {
		return String.format("%s - %s (%s)",
				getSku(), getName(), getItemType());
	}
```

Further specialization of *Beverage*

- We can extend beverage in various ways, e.g. alcoholic beverage (with alc% and higher VAT rate), …
- … or as milk that is beverage that defines milk fat percentage and milk type
  - We shall limit possible milk types by using set of enumerated values

```
public enum MilkType { COW, SHEEP, GOAT, DONKEY }
```

…05_Abstract_Interfaces/…/MilkType.java

  - Note: enumerations are types that are derived from *java.lang.Enum*
- Additionally we would like to stop further deriving form Milk by making it *final*

```
public final class Milk extends Beverage
        private MilkType type;
        …
```

Common behavior in different part of inheritance tree

- Some beverages (like milk) must be consumed before some date, but it is not the case with all beverages
- Notice that food also must be used before some date
- Ad hoc ideas
  - Can we add a new class into hierarchy between Item and Food for perishable items?
    - Yes!
  - Can Milk extends Beverage and the newly introduces class for perishable items?
    - This would be called multiple inheritance and the answer depends on the programming language!
    - Yes in C++, but not in Java and C#

Multiple inheritance

- Scott Meyers, Effective C++

  "Depending on who's doing the talking, multiple inheritance (MI) is either the product of divine inspiration or the manifest work of the devil."

- At the first sight, it looks we need to extends both classes, but …
- Do we really need to inherit both classes, or we just need to define some common behavior?
  - Inherit if you need common implementation (variables, constructors, methods implementation)
  - Perishable items are determined by the existence of expiry date and behavior that that value must be set and retrieved

Interfaces (1)

- Interfaces specifies list of methods that a class must have
  - Those methods does not have a code (like abstract methods)
    - An exception are default methods (discussed later)
- Interfaces are modeled not as classes, but as interfaces (keyword ***interface***)
- Interface names could be various, but often their suffix is *able*
  - *E.g. Iterable, Enumerable, …*
    - but does not have to be, e.g. in case of interfaces that specifies methods for data collections *List*, *Set*, ..

Interfaces (2)

- Classes extends other classes and implements interfaces
- An interface can extend another interface
  - It extends the list of methods that a class that should implement the interface must have
- A class in Java can explicitly extends only one class and implements multiple interfaces
- If the base class of a class implements an interface, then its subclass automatically (indirectly) implement that interface
  - E.g. if class C extends B, and B extends A, and A implements interfaces I1, and I2, then object of type C can be upcasted to reference of type B, A, I1, and I2
    - C indirectly extends A (and Object), and indirectly implements I1, I2
    - C can override methods from A that implements I1 and I2

Introducing *Perishable* interface

- Perishable defines methods for getting and settings expiry date.

```
package swu.oopj.inheritance_polymorphism;
import java.time.LocalDate;

public interface Perishable {
	public LocalDate getBestBefore();
	public void setBestBefore(LocalDate bestBefore);
}
```

Implementing *Perishable* interface

- Classes Food and Milk should implement this interface
  - Food already have them, and we must write them in class Milk
  - We use *@Override* annotation for the same reasons we done that when overriding methods (to tell compiler that we didn't just accidentally used same names as in interfaces that we implement)

```
public final class Milk extends Beverage implements Perishable {
        private LocalDate bestBefore;

        @Override
        public LocalDate getBestBefore() {
                return bestBefore;
        }
        @Override
        public void setBestBefore(LocalDate bestBefore) {
                this.bestBefore = bestBefore;
        } ...
```

Operator *instanceof*

- An example Primjer: print perishable items from an array of items
  - Items could be Food, Beverage, Milk, Cloth, …
- To check if downcast is possible operator *instanceof*
  - downcasting an Cloth object to Perishable would crash our program

```
private static void printPerishableItems(Item[] items) {
  DateTimeFormatter formatter =
              DateTimeFormatter.ofPattern("dd.MM.yyyy.");
  for(Item item:items){
       if (item instanceof Perishable){
              Perishable perishable = (Perishable) item;
              System.out.format("%s, type: %s, use before: %s %n",
                                  item, item.getItemType(),
                           perishable.getBestBefore().format(formatter));
       }
  }
}
```

…05_Abstract_Interfaces/…/ShowPerishableItems.java

Default interface methods

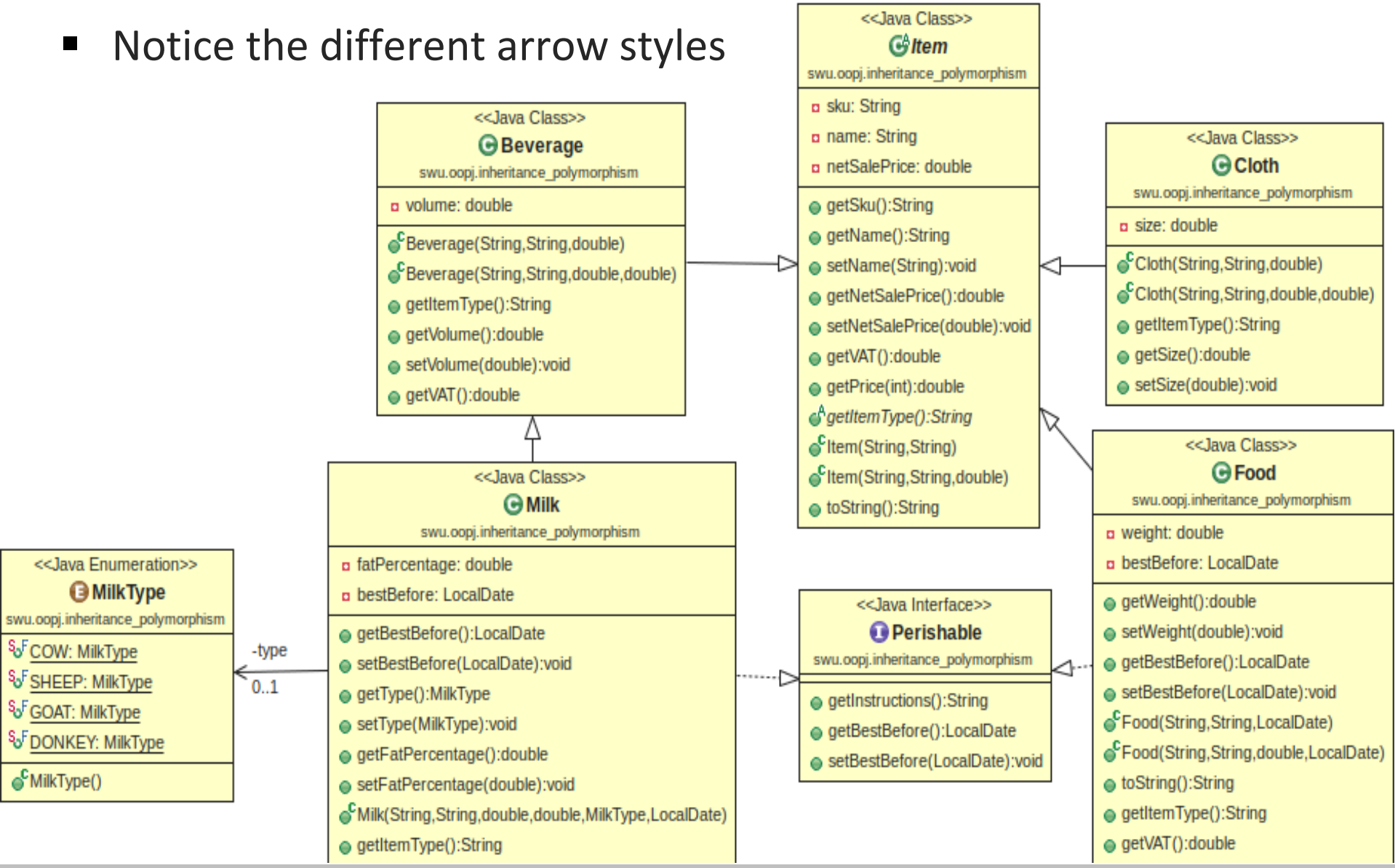
- Suppose we would like to extend *Perishable* interface with a method for keeping introductions
  - All classes that already had implemented *Perishable* must be updated or existing code would not compile
  - Creating new interface forces changes in code
- Java ≥ 8 allows writing default (implementation of such) methods
  - Allows existing code to compile and run successfully
  - Enables classes to override default implementation

…05_Abstract_Interfaces/…/Perishable.java

```
public interface Perishable {
        default public String getInstructions(){
                return "Keep in dry and cool place";
        }
        public LocalDate getBestBefore();
        public void setBestBefore(LocalDate bestBefore);
}
```

Class diagram with *Perishable* interface

- Notice the different arrow styles



Static methods and variables in interfaces

- Interface cannot enforce that implementing class must have specific variables or constructors
  - Interface is specifications od methods that class must have
- However, interface can have member variables
  - Defined as “normal” variables, but they are static and final by default
- Since Jave 8, interface can have static methods with appropriate code
  - Like class static methods, run as *InterfaceName.staticMethod(…)*

Interfaces, inheritance, semantics, JavaDoc

- Interface semantics defined by its Java documentation
  - Compiler does check (and it is not able to check) whether the semantics is obeyed
    - Compiler can only check syntax
- *JavaDoc* inherited regardless if it is implementation of interface or class deriving
  - no need to write it again
- What if a class implements two interfaces with the same method?
  - In Java only common implementation of these two methods can be created
  - Thus the methods semantics should be the same
    - otherwise it leads to inconsistency

Some possible problems with default methods*

- Using default methods and implementing interfaces with methods of the same signature can cause “problems”
  - Enumerated for the sake of completeness and curiosity
- Source: Java Complete Reference
  - First, in all cases, a class implementation takes priority over an interface default implementation.
  - In case in which a class implements two interfaces that both have the same default method, but the class does not override that method, then an error will result.
  - In case in which one interface inherits another, with both defining a common default method, the inheriting interface’s version of the method takes precedence.
  - It is possible to explicitly refer to a default implementation in an inherited interface by using a new form of super:
    ParentInterfaceName.super.methodName()