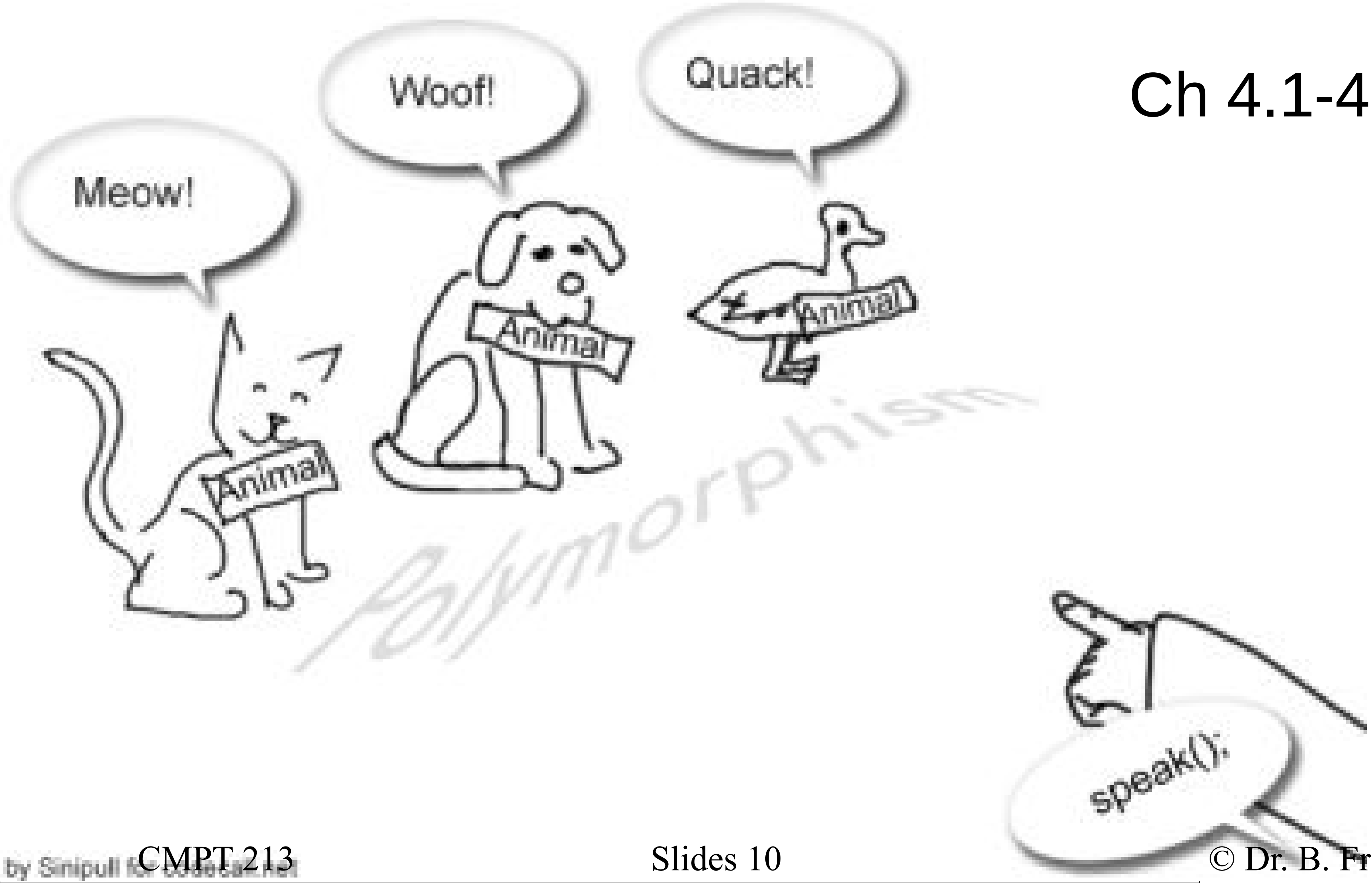
Interface Polymorphism

Ch 4.1-4.5



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Topics

1) How can we reduce coupling between classes?
2) How can one piece of code work on different types of objects?

-> we want to encapsulate the things change

Interface

- An Interface specifies a set of ***public*** methods, but.. does not normally implement them
    - It's a contract for providing methods.

```
public interface LetterGrader {
    String getGrade(double percent);
    double getMinPercentForGrade(String grade);
}
```

- "Interface" can refer to two things:
    - An interface in Java
      (such as "The LetterGrader interface")
    - The.. set of methods of a class
      (such as "The class's public interface")

Interface Usage

- To implement an interface, a class must both:
    - Say it "implements" the interface
    - implement all methods specified by the interface

```
public class EasyLetterGrader implements LetterGrader {
    private static final double BREAK_POINT = 70;

    @Override
    public String getGrade(double percent) {
        if (percent >= BREAK_POINT) {
            return "A+";
        } else {
            return "B";
        }
        // Code seems incomplete :)
    }

    @Override
    public double getMinPercentForGrade(String grade) {
        if (grade.compareToIgnoreCase("A+") == 0) {
            return BREAK_POINT;
        } else {
            return 0;
        }
    }
}
```

@Override is an..

annotation

Tells Java that this method..

MUST override a method in the base class/ interface

..

-takes a Logic error turns into Compile time error

-check if the spelling is correct

Concrete Types

- Concrete Type
  - the exact instantiated class of an object
    (not a more general interface or base class).
- Example
  - LetterGrader is an Interface (not instantiatable), so *not* a concrete type.
  - BAD: LetterGrader oops = new LetterGrader();

    compile time error
    bcuz LetterGrader is not a concrete type
- Example
  - EasyLetterGrader is an instantiatable class, so..is a concrete type
  - GOOD: LetterGrader good = new EasyLetterGrader();

Polymorphism

- Polymorphism Example:
  - A variable of type LetterGrade can reference any object of class type which..implements the LetterGrader interface

```
LetterGrader g = new EasyLetterGrader();
computeClassGrades(g);
g = new HardLetterGrader();
computeClassGrades(g);
```

- (Subtype) Polymorphism
  If *S* is a subtype of type *T*, then ..
  a variable of type T can safety reference
  an object of type S in any context

  - The exact method to execute is selected at runtime (late binding).
  - Ex: Does g.getGrade() call **EasyLetterGrader**.getGrade(), or **HardLetterGrader**.getGrade() ?

Polymorphism Example

```
class MarkingSystem {
    double[ ] marks = {74, 85, 25, 55, 93, 1};

    void printLetterGrades() {
        LetterGrader grader = new EasyLetterGrader();
        String[] grades = gradeEachStudent(grader);

        for (String grade : grades) {
            System.out.println("Grade: " + grade);
        }
    }

    String[ ] gradeEachStudent(LetterGrader grader) {
        String[ ] letterGrades = new String[marks.length];
        for (int i = 0; i < marks.length; i++) {
            letterGrades[i] = grader.getGrade(marks[i]);
        }
        return letterGrades;
    }
}
```

No idea what type of LetterGrader is passed; just that the object..

implements the LetterGrader interface

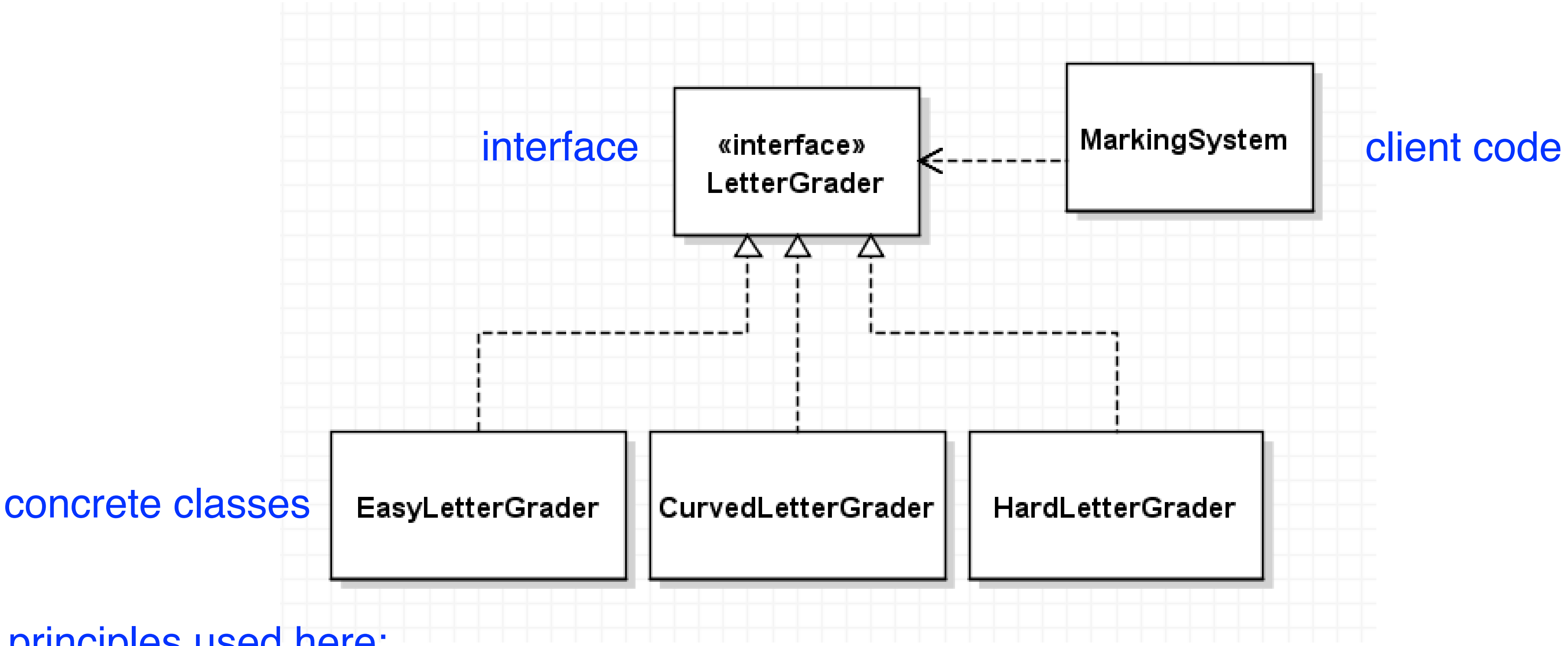
It can only use..

methods in the LetterGrader interface

gradeEachStudent is using strategy pattern:
have a hole in the algorithm

*note: it doesn’t care what types of grader its using,
if it cares -> it violates the Lioskv’s principle,
violates the subtype polymorphism

Terminology



interface

client code

concrete classes

principles used here:
-programming to interface, not implementation
-> code doesn’t depend on concrete classes
-encapsulate things that change (therefore we have different types of grading)

Why Use Polymorphism?

- late binding

  Exact method (concrete type) determined at runtime.

- give loose coupling

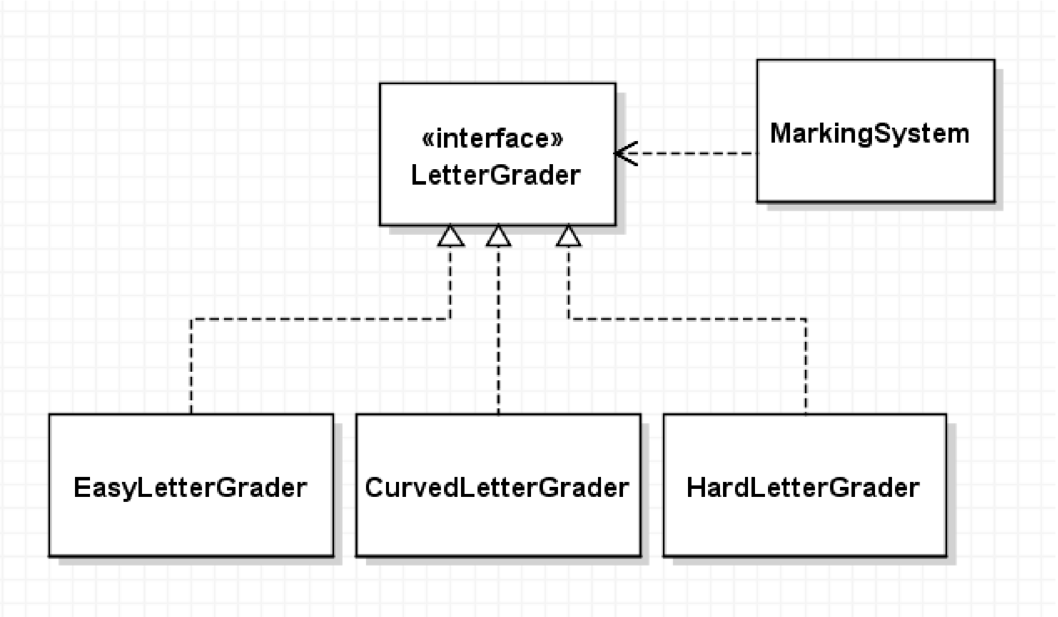
  works with any object implementing the Interface so independent of object's concrete type.

- Design Heuristic:

  code to an Interface,
  not a concrete type

  -> makes the code extensible

  - Extensible:
    Reuse code without re-write to support new classes.



NOTE: MarkingSystem only depends on the interface LetterGrader, not the other concrete types
-> this is called “programming to an interface, not implementation”
-> give loose coupling

Types of Polymorphism

- adhoc polymorphism (a form of static polymorphism)
  - Function or operator overloading
  - Write numerous functions, each for a different specific type
  - Compiler/interpreter picks the function to call based on the type of arguments.

```
void paint(Car c) {...};
void paint(House h){...};
...
Car myCar = ...
paint(myCar);

int a = 1 + 3;
String b = "hi" + "all";
```

Static
(not at runtime)

- parametric polymorphism
  - Java’s generics
  - Write one general implementation that can work for any type

```
class ArrayList<E> {
  void add(E element) {...
  E get(int idx) {...}
}
```

Static

- subtype polymorphism
  - Done using inheritance or interfaces with method overriding
  - The exact method to execute chosen at runtime (late binding).

```
Object obj = ...;
obj.toString();
```

Runtime

adhoc: write different versions for different things, and select between them in compile time

parametric: write once for everything

Interface Details

- Interface methods are ... automatically public
  - can provide “default” implementation of function.
- Can declare... constants (automatically public static final)

```
public interface CardDeck {
    int NUM_CARDS = 52;
    // ...
}
```

Comparable Review

- Can write algorithms for interface types.

```
interface Comparable<Type> {
    int compareTo(Type obj);
}
```

```
public class InOrder {
    public static void main(String[] args) {
        Long[] data = new Long[5];
        for (int i = 0; i < data.length; i++) {
            data[i] = i;
        }

        System.out.println("In order? "
            + isAscending(data));
    }

    public static boolean
    isAscending(Comparable[] array) {
        for(int i = 0; i < array.length - 1; i++) {
            Comparable first = array[i];
            Comparable second = array[i+1];
            if (first.compareTo(second) > 0) {
                return false;
            }
        }
        return true;
    }
```

This is not quite perfect.
Comparable is a generic type, so
isAscending() should have the heading

```
public static <T extends Comparable<T>>
        boolean isAscending(T[] array) {
```

this is subtype polymorphism bcuz elements are extended from Comparable
we can call the same function with different types of data

Comparator Review

- An idiom is.. a common practice
- For creating anonymous classes make a function which creates it.

```
public interface FileFilter {
        boolean accept(File path);
}
```

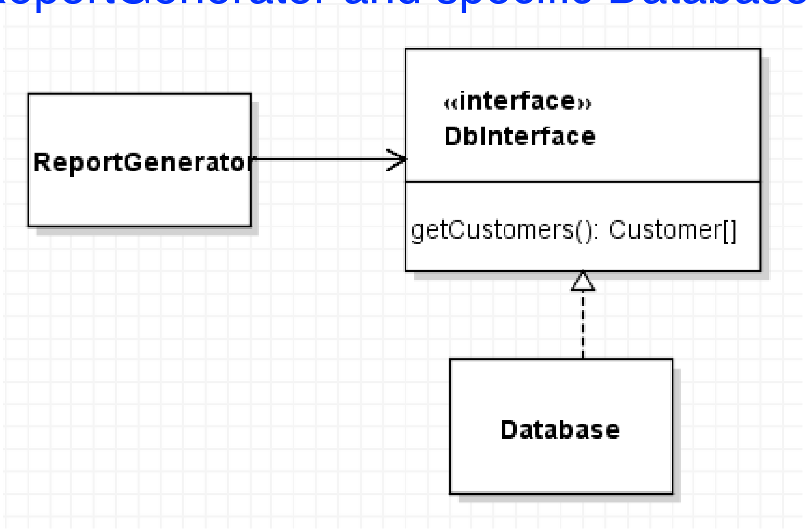
```
private void addFolder(File directory) {
        FileFilter filter = createExtensionFilter();
        File[] files = directory.listFiles(filter);
        //..
}

private FileFilter createExtensionFilter() {
        return new FileFilter() {
                @Override
                public boolean accept(File path) {
                        return path.isDirectory()
                                        || hasAcceptedExtension(path);
                }
        };
}
```

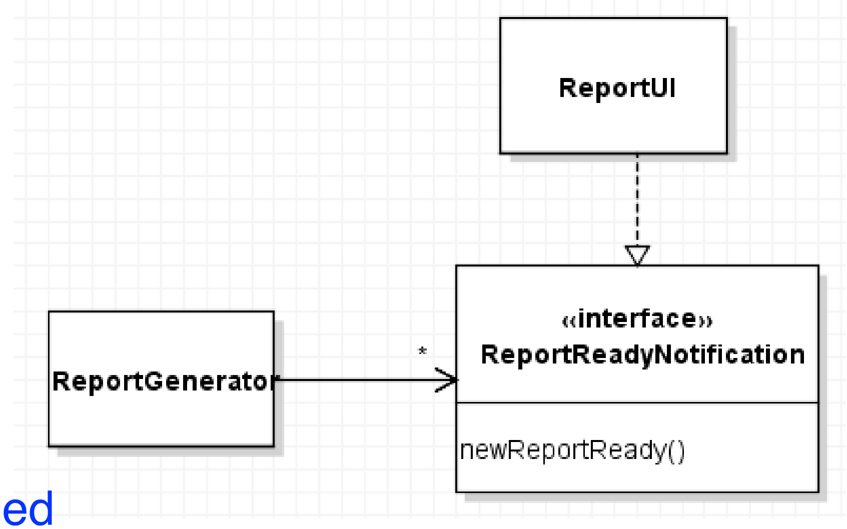
Using Interfaces

interface Dbinterface here isolates ReportGenerator and specific Database, give loose coupling, make it flexible

- Interface for Dependencies
  - A class may need the services of another object to do its job.
  - It can.. define the interface it needs



- Interface for Services Offered
  - A class may provide services to another object.
  - It can.. define the interface it provides



case 1. creating a service/interface that i need

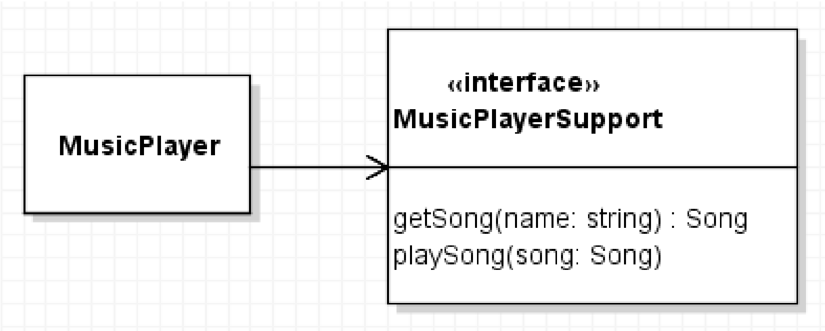
case 2.

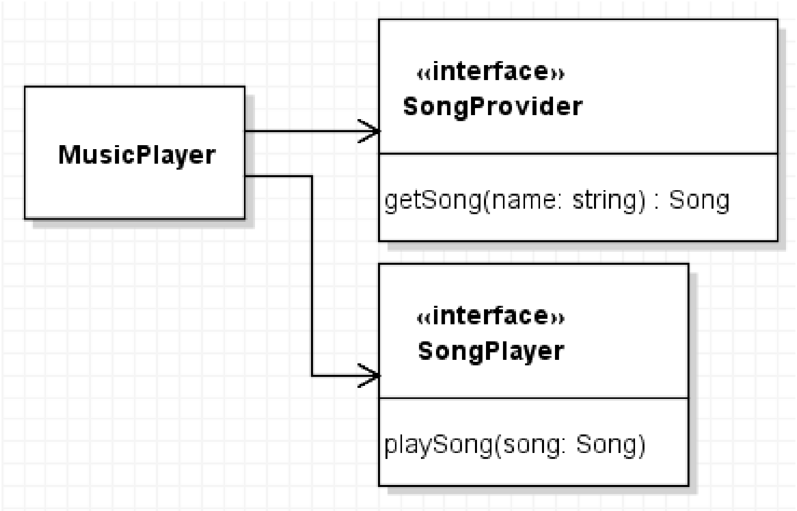
in any case, both provide abstraction

big idea: use interface for isolation

Narrow Interfaces

- Prefer using a few small interfaces rather than one big one:





- Design Principle:..interface segregation
  - Prefer small interfaces rather one large one.
  - Client code should not be forced to implement methods they do not need.
  - Client code can provide targeted functionality.

Review Questions

- Can the full type of an object be just an Interface type?
  - No: An object's concrete type cannot be an Interface. An Interface cannot be instantiated, only implemented by other classes.
- Are the following two ideas identical?
  - A class which has the same methods as an Interface
  - A class which implements the interface?
  - no: for polymorphism to work, a class must “implement” the interface as well

    1 + 2 is okay
    1 == 2, not correct

Interface Details

- An Interface can.. inherit from another interface

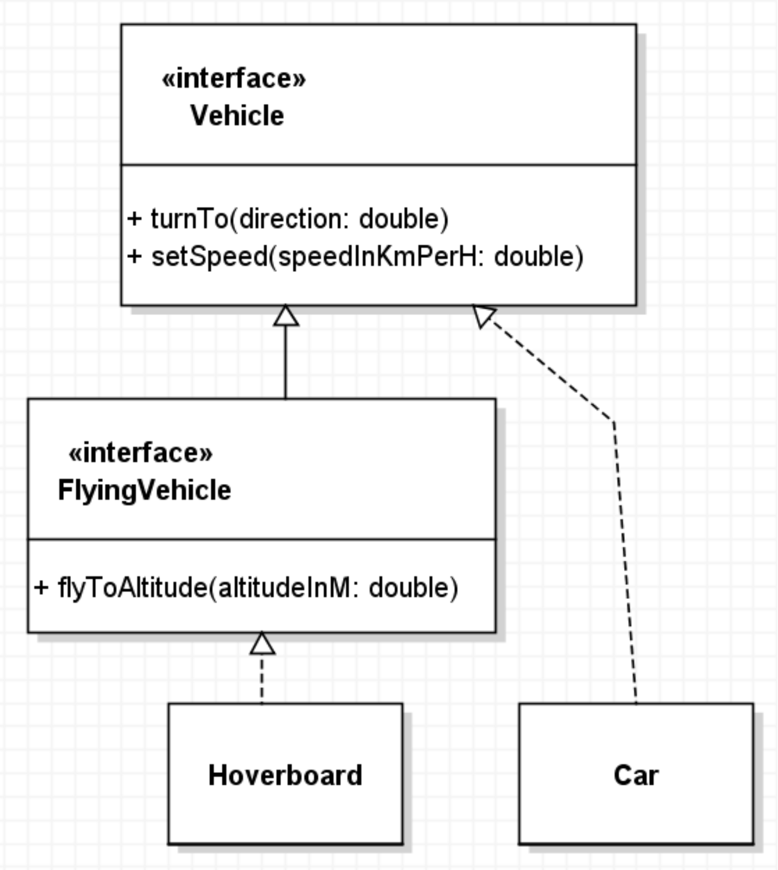
```
public interface Vehicle {
    void turnTo(double direction);
    void setSpeed(double speedInKmPerH);
}

public interface FlyingVehicle extends Vehicle {
    void flyToAltitude(double altitudeInM);
}
```

  - A class implementing FlyingVehicle must also implement all of Vehicle's methods too.

Exercise

- Which of the following statements work?


«interface»
Vehicle
+ turnTo(direction: double)
+ setSpeed(speedInKmPerH: double)
«interface»
FlyingVehicle
+ flyToAltitude(altitudeInM: double)
Hoverboard
Car

```
public static void main(String[] args) {
    Vehicle v1;
    v1 = new Vehicle(); not work
    v1 = new Car();yes bcuz support subtype polymorphism
    v1 = new Hoverboard(); yes

    FlyingVehicle v2;
    v2 = new Vehicle(); not work
    v2 = new Car();not work
    v2 = new Hoverboard(); yes

    Car v3;
    v3 = new Vehicle(); not work
    v3 = new Car(); yes
    v3 = new Hoverboard(); not work
}
```

Summary

- Interface: A set of methods & constants
  - How to define, implement, and use an interface
- Concrete Type: the instantiated type of an object
- Polymorphism
  - Static (compile time): Ad-hoc and parametric polymorphism
  - Runtime: subtype polymorphism
  - Example uses
- Interface Segregation Principle
  - Define narrow interfaces which provide targeted functionality