Class and Interface Design

Dirk Riehle, FAU Erlangen

ADAP B02

Agenda

1. Classes vs. interfaces
2. Abstract state model
3. Program to an interface
4. Design by primitives
5. Simple class design
6. Inheritance interface
7. Class design evolution

Homework

1. Classes vs. Interfaces

Objects and Classes

The modeling perspective (historically: Simula)

- An object is the representation of a phenomenon from a domain
- A class is a description of the commonalities of similar objects

The technology perspective (historically: Smalltalk)

- An object is an encapsulation of some program state
- A class is the implementation of how to change that state

We focus on the technology perspective

Classes and Interfaces

An interface is

- The abstract description of some object behavior

An abstract class is

- A partial implementation of an interface's behavior

An implementation class is

- A concrete (complete) implementation of an interface's behavior

Types of Interfaces

Use-client interfaces

Inheritance interfaces

Interfaces

Have an abstract state model and state transitions

Are to be implemented by abstract and/or concrete classes

Abstract Classes

Set up algorithmic scaffolding for concrete subclasses

Are used to implement an interface, to be extended by subclasses

Concrete Classes

Include implementation state (fields)

Directly implement an interface or extend an abstract class

When paired with an interface, are also known as implementation classes

In Typescript

A Typescript interface is a (use-client) interface

Any Typescript class has an (implicit) interface

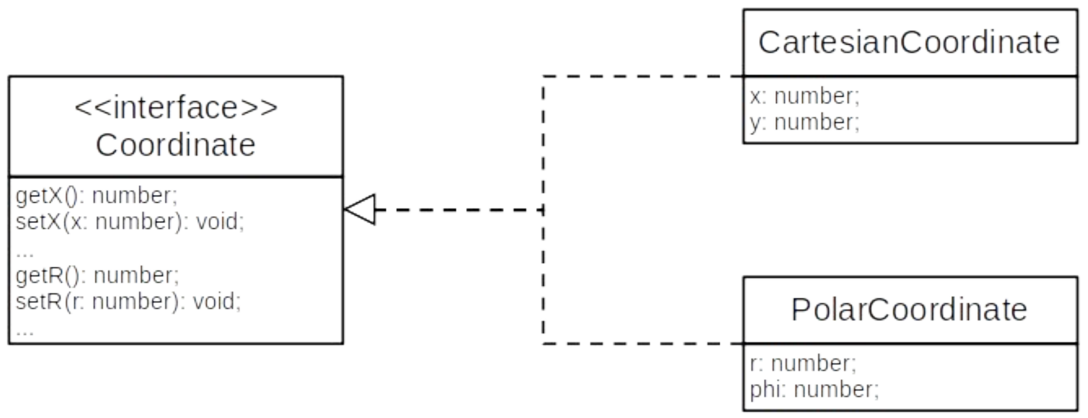
- The interface is conceptually separate from the implementation
- In other languages, e.g. C, interface and implementation are split in files

A Typescript class can implement a Typescript interface

A Typescript class can be an abstract class

- The marked as abstract in its definition

Class Model of Coordinates Example



2. Abstract State Model

Abstract State Model

An abstract state model is

- A model of the valid state space of objects conforming to the model

An interface expresses an abstract state model

- An abstract state model does not map 1:1 on implementation fields

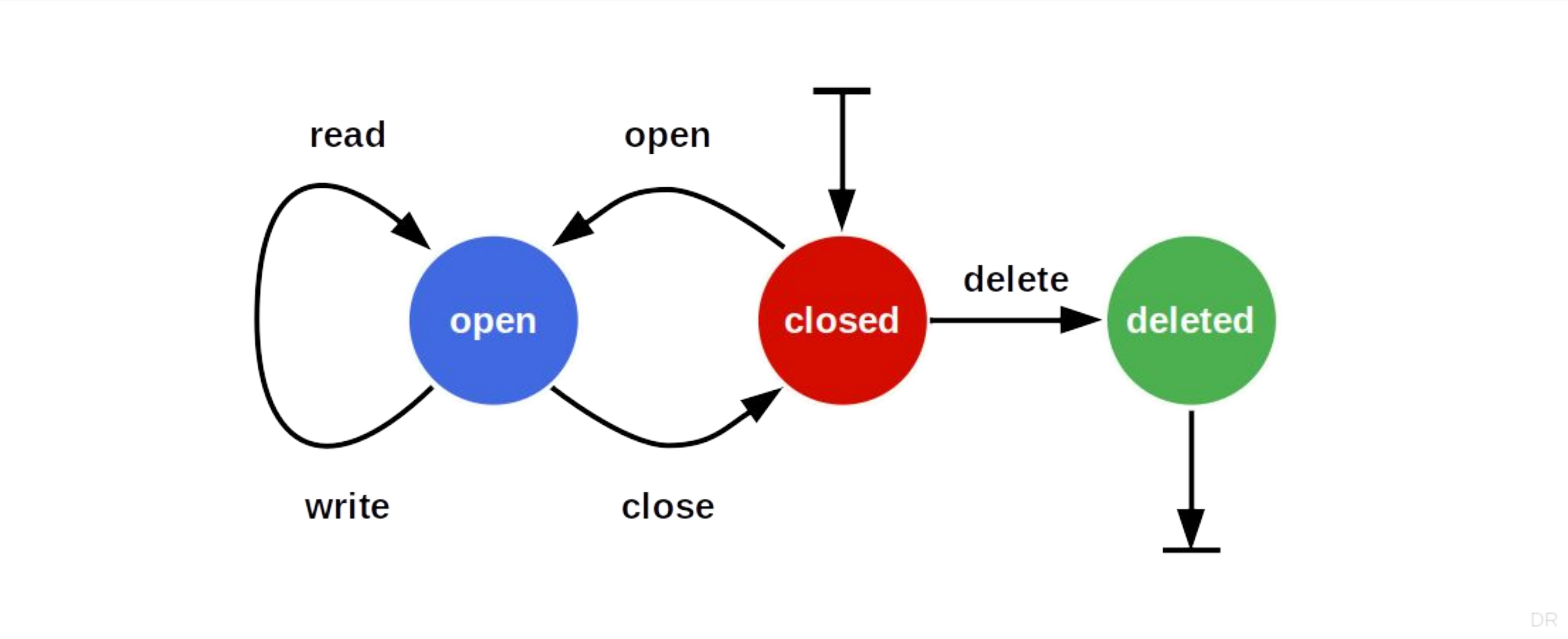
The abstract state model can be expressed using get methods

- Alternatively, it can be expressed as finite state machines

State Model of Coordinate Example

```
import { Equality } from "./Equality";
import { Cloneable } from "./Cloneable";

export interface Coordinate extends Equality, Cloneable {
    ...

    getX(): number;
    getY(): number;
    ...

    getR(): number;
    getPhi(): number;
    ...

}
```

State Model of File Example



File as Class (+ Interface)

```
export class File {
    public isOpen(): boolean { ... }
    public isClosed(): boolean  { ... }

    public read(): any[] {
        this.assertIsOpenFile();
        ...
    }

    public delete(): void {
        this.assertIsClosedFile();
        ...
    }

    protected assertIsOpenFile(): void  { ... }
    protected assertIsClosedFile(): void { ... }
    ...
}
```

File Interface and ObjFile Implementation

```
export interface File {

    isEmpty(): boolean;
    isOpen(): boolean;
    isClosed(): boolean;

    read(): any[];
    write(data: any[]): void;
    delete(): void;

}
```

```
export class ObjFile implements File {

    protected data: Object[] = [];
    protected length: number = 0;

    public isEmpty(): boolean {
        return this.length == 0;
    }

    public read(): Object[] { ... }
    public write(data: Object[]): void { ... }
    public delete(): void { ... }

    ...
}
```

3. Program to an Interface

The Program to an Interface Principle

Program to an interface, not an implementation

How to Program to an Interface

Program to the abstract state model

- Do not program to the implementation state

Do not rely on what is not in the interface

- Do not expect implementation-generated side-effects
- Do not rely on specific performance unless guaranteed

Class Implementation

A concrete class (a.k.a. implementation class)

1. Has an interface that combines all interfaces it implements
2. Is a complete implementation of that interface
3. Implements an abstract state model

The implementation is by way of implementation state (fields)

4. Design by Primitives

Design by Primitives

Design by primitives is a programming principle in which

- The implementation state of a class is encapsulated by primitive methods
- All other methods should utilize these primitive methods

Do not change any fields outside the primitive methods

Use of Primitive Methods

```
public getX(): number {
    return this.doGetX();
}

protected doGetX(): number {
    return this.x;
}

public getR(): number {
    return Math.hypot(this.doGetX(), this.doGetY());
}

public setR(r: number): void {
    let phi: number = Math.atan2(this.doGetY(), this.doGetX());
    this.doSetX(r * Math.cos(phi));
    this.doSetY(r * Math.sin(phi));
}
```

The Purpose of Design by Primitive

The encapsulation of implementation field access creates an indirection level that

- Creates flexibility (subclasses can override)
- Makes design by contract more effective

5. Simple Class Design

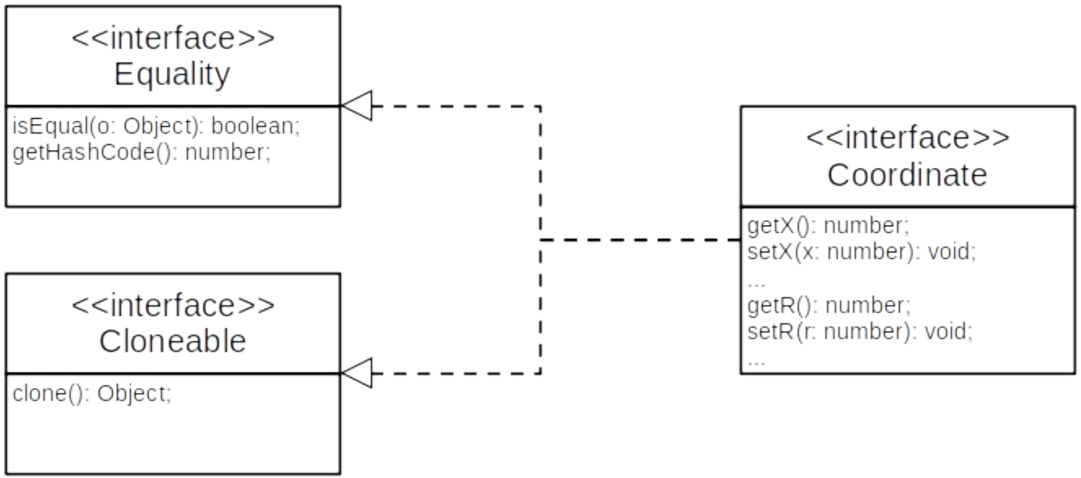
How to Structure a Class Interface

Group methods by trait or collaboration

- Get and set belong together, not getters and setters
- Methods of the same collaboration belong together
- Special purpose methods belong together

Break out reusable collaborations as interfaces

Multiple Interfaces



How to Structure a Class Implementation

Group fields together, across traits or collaborations

- At top of file (most common) or bottom (less common)
- Because implementation state works across collaborations

6. Inheritance Interface

Inheritance Interface

An inheritance interface is

- An internal abstract interface defined by a superclass for its own use
- To be implemented by subclasses to complete the implementation

Design of Inheritance Interfaces

The inheritance interface

- Typically consists of primitive methods
- Is protected (only for class internal use)

Inheritance Interface of AbstractCoordinate

```
export abstract class AbstractCoordinate implements Coordinate {
    ...

    protected abstract doGetX(): number;
    protected abstract doSetX(x: number): void;
    protected abstract doGetY(): number;
    protected abstract doSetY(y: number): void;
    protected abstract doGetR(): number;
    protected abstract doSetR(r: number): void;
    protected abstract doGetPhi(): number;
    protected abstract doSetPhi(phi: number): void;

}
```

Narrow Inheritance Interface Principle

Inheritance interfaces should be as small (narrow) as possible

Small = minimal number of methods needed to complete the implementation

This allows for expedient implementation of subclasses

Subclasses can still override more methods for more efficient implementations

Thinking the Class Hierarchy Bottom-up

Subclasses call methods of superclasses to use its functionality

This may be any kind of method including helper methods

Thinking the Class Hierarchy Top-down

Superclasses implement algorithms (for example, as template methods)

Superclasses call methods of subclasses through the inheritance interface

This reuses algorithms while allowing for behavior variation of the algorithms

The Open / Closed Principle

A class should be open for extension and closed for modification

Open for extension through a well-defined inheritance interface

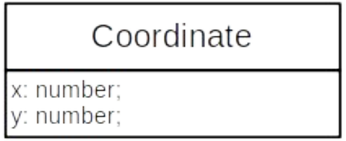
Closed for modification by not violating the use-client interface

7. Class Design Evolution

Typical Class and Interface Evolution

1. Simple class
2. Interface extraction
3. Addition of implementation classes
4. Introduction of reusable abstract superclass

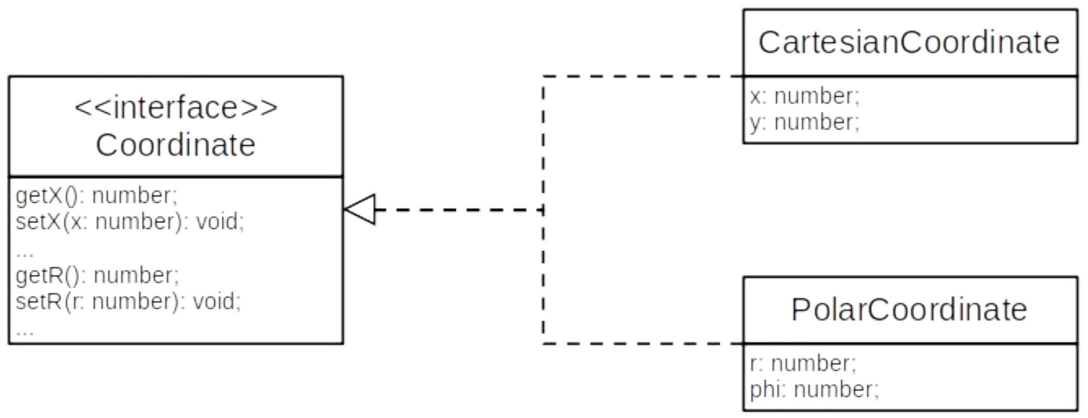
1. Simple Class



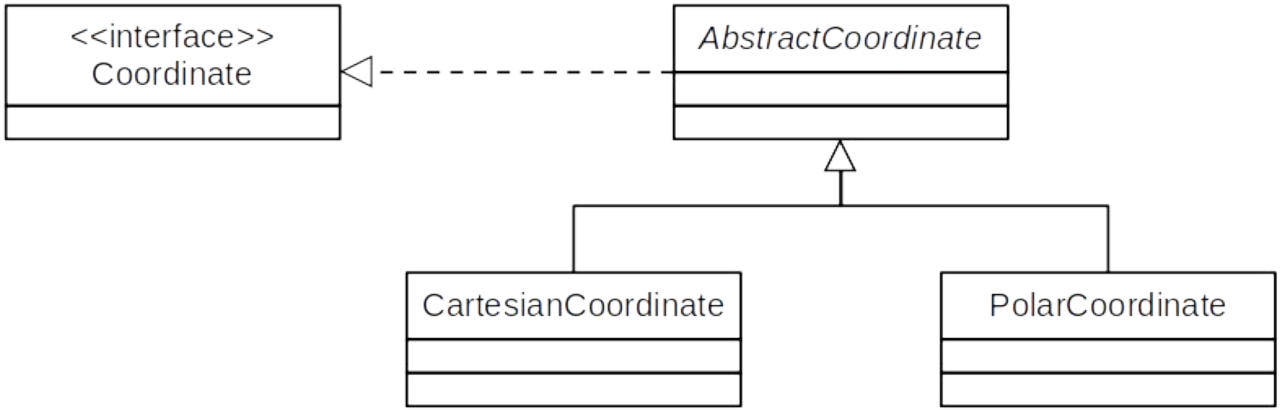
DR

2. Interface Extraction

3. Addition of Implementation Classes



4. Introduction of Abstract Superclass



Naming Conventions of Classes

Recommended

- Interfaces
  - Coordinate
- Abstract classes
  - AbstractCoordinate
- Concrete classes
  - DefaultCoordinate
  - GenericCoordinate
  - CartesianCoordinate
  - PolarCoordinate

Discouraged

- Interfaces
  - ICoordinate
- Abstract classes
  - CoordinateImpl
- Concrete classes
  - CartesianCoordinateImpl
  - ...

How to Name Classes (English Grammar)

It is best to go with the flow of the (English) language chosen by your project

- General rule: Adjective sequence + class name
- Ordering of adjective: By how strongly they bind
  - Opinion, size, age, shape, color, origin, material, purpose

Examples

- UglyLargeRipeStraightYellowJamaicanSoftEdibleBanana
- LargeEuropeanWoodenRockingChair

Homework

Homework Instructions

- Split Name class into Name interface and StringArrayName class
  - StringArrayName uses a string[] as the internal representation of a name
- Add a StringName class that represents a name as a single string
- Adapt your previous work to this homework as you see fit
- Commit homework by deadline to homework folder

Summary

1. Classes vs. interfaces
2. Abstract state model
3. Program to an interface
4. Design by primitives
5. Simple class design
6. Inheritance interface
7. Class design evolution

Thank you! Any questions?

dirk.riehle@fau.de – https://oss.cs.fau.de

dirk@riehle.org – https://dirkriehle.com – @dirkriehle

Legal Notices