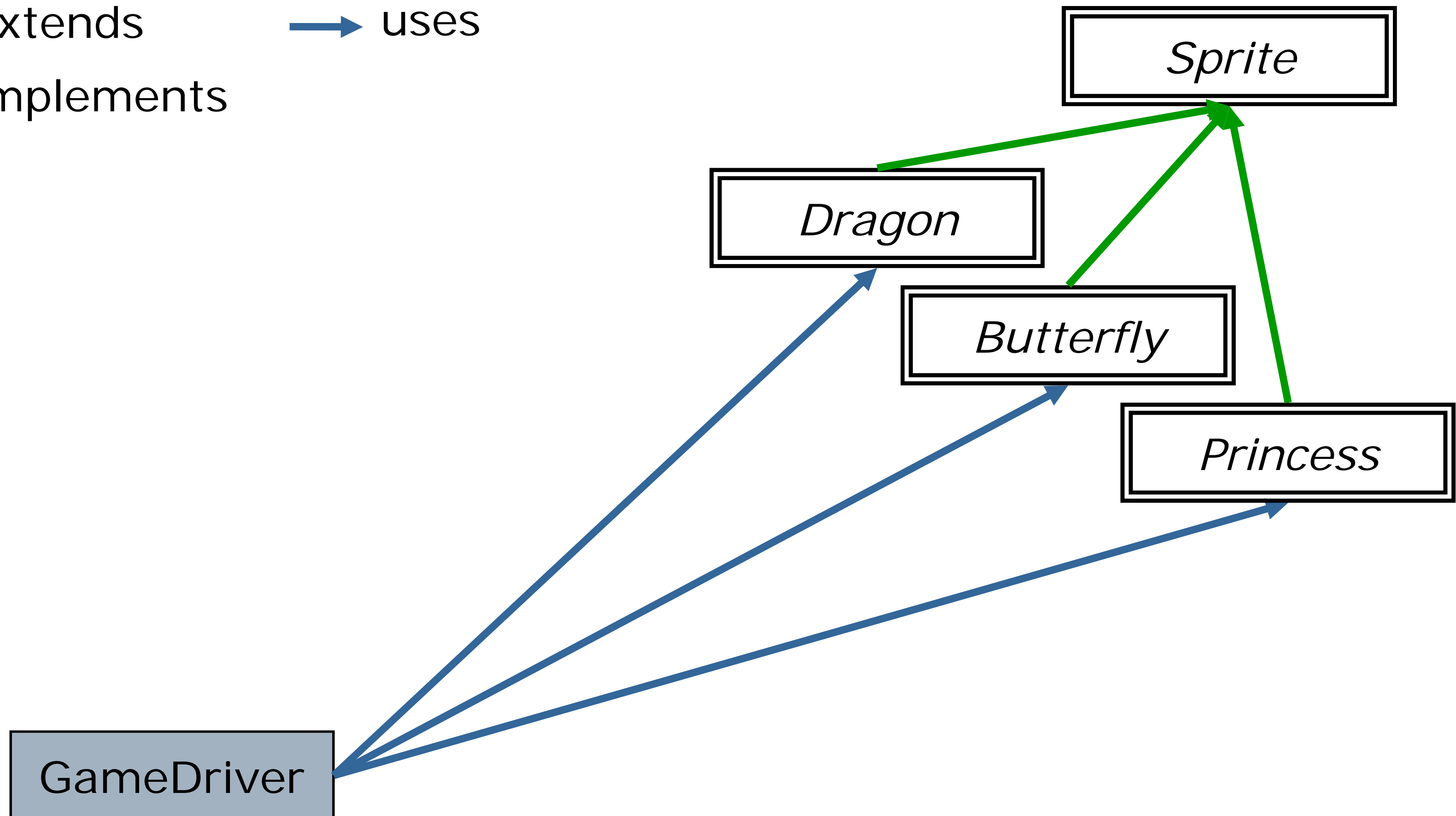
Factories

Lecture 26

A Game of Sprites

- Consider a game consisting of sprites
  - Dragons, butterflies, princesses
- Main class: GameDriver
  - Populates the world with sprites
  - Responds to user events (eg mouse clicks)
  - Draws, erases, and moves sprites
  - Keeps track of score
- GameDriver is coded to the interface
  - Sprite interface promises generic drawing and moving abilities
  - Specific kinds of sprites have more behaviors (eg breathing fire)

Sprites Hierarchy



Instantiating Objects

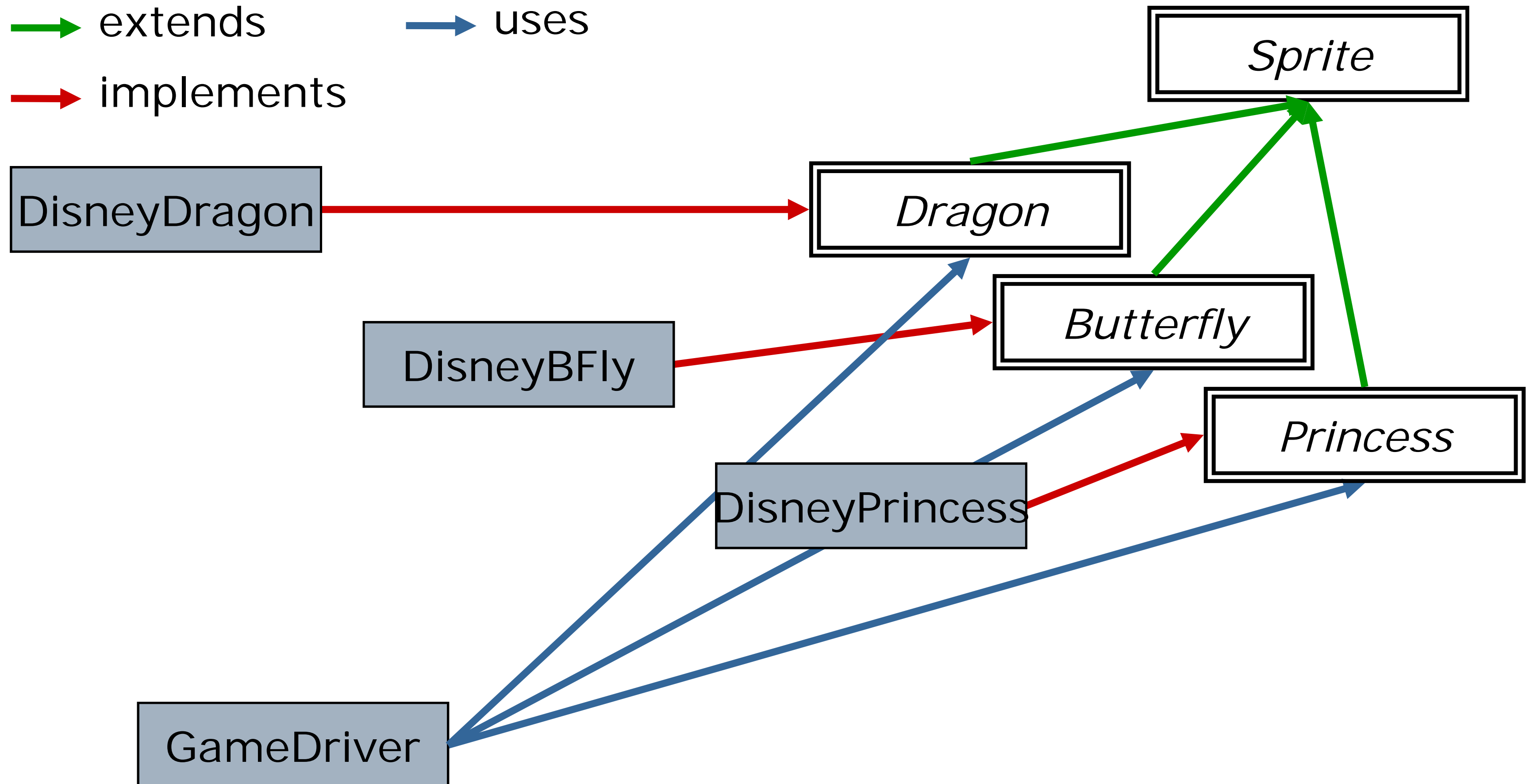
- GameDriver is general (coded to the interface)

```
class GameDriver {
  private List<Dragon> dragons;
  private List<Butterfly> butterflies;
  . . .
  public boolean isQueen(Princess p) {...}
}
```

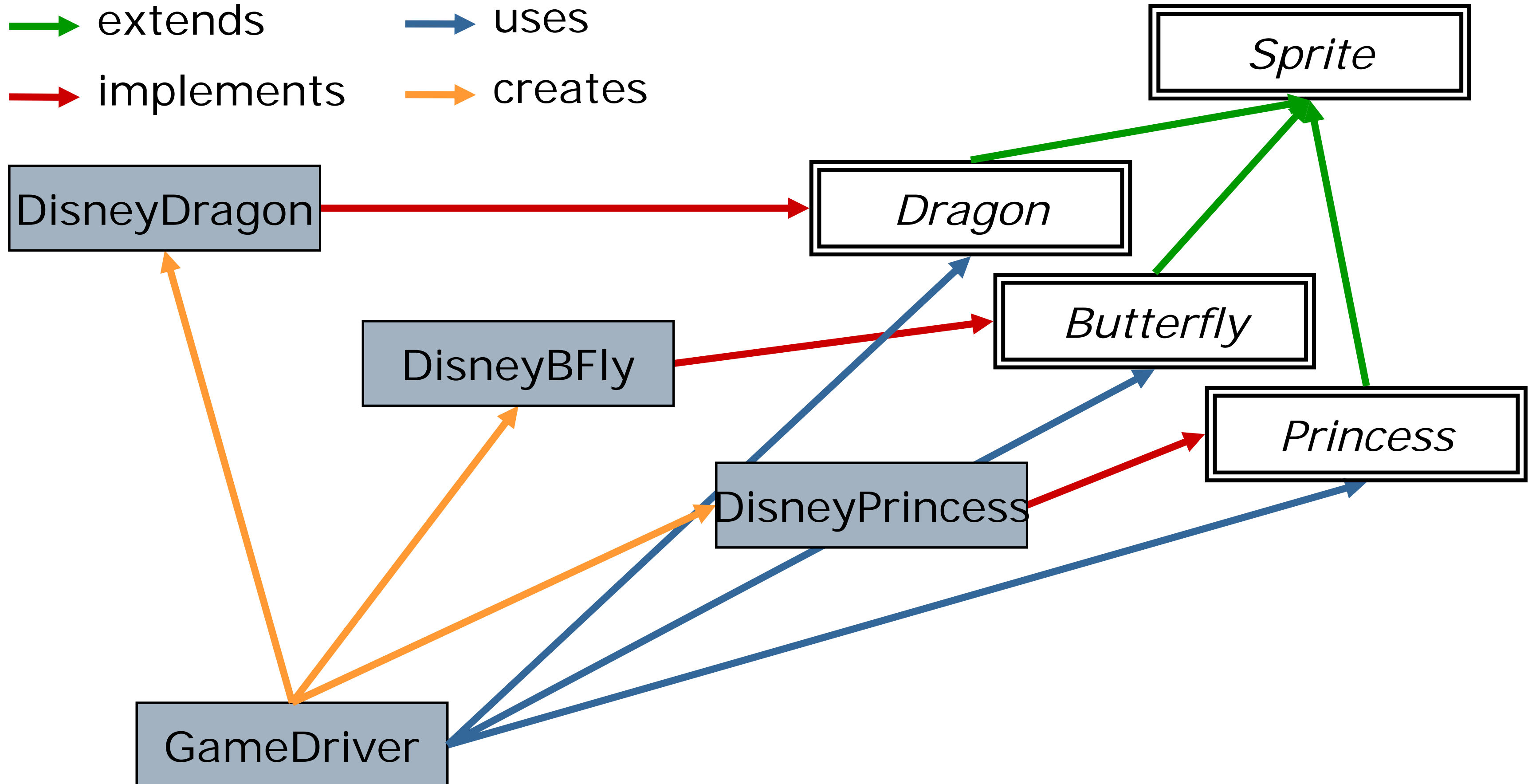
- But every call to new requires a *class*

```
public void populate() {
  Dragon villain = new DisneyDragon(35);
  . . .
}
```

Sprites Hierarchy



Sprites Hierarchy



Product Lines

- Object creation may occur in many different places
  - Across the program, every method that creates a sprite
  - Across a method, every line that creates a sprite
- Some classes may be designed to work best with other classes
  - An example of concrete-concrete coupling (generally a bad thing)
  - Example: themes for our game of sprites
    - Disney characters vs Magic characters
- Goal: Single-point-of-control over which product line is used
  - Every instantiation should be a Disney character
  - Should be easy to switch to all Magic characters

Sprites Hierarchy

Sprite

Dragon

Butterfly

Princess

DisneyDragon

MagicDragon

DisneyBFly

MagicBFly

DisneyPrincess

MagicPrincess

GameDriver

Solution: Factory Component

- Add a level of indirection
- Responsibility for instantiation of sprites encapsulated in one place: a factory
  - Factory object can create Dragon, Butterfly, and Princess objects

```
interface Factory {
  Dragon createDragon(int size);
  Butterfly createButterfly();
  Princess createPrincess(String name);
}
```

  - Each implementation of Factory creates a single product line

```
class MagicFactory implements Factory {
  public Dragon createDragon(int size) {
    return new MagicDragon(size);
  }
  . . .
}
```

- Known as the "Factory Pattern" (a creational design pattern)

Sprites Hierarchy with Factory

Sprite

Dragon

Butterfly

Princess

Factory

DisneyDragon

MagicDragon

DisneyBFly

MagicBFly

DisneyPrincess

MagicPrincess

GameDriver

DisneyFactory

MagicFactory

Person Hierarchy with Factory

Person

OSUStudent

Student

UMStudent

Faculty

OSUProf

UMProf

Staff

OSUStaff

UMStaff

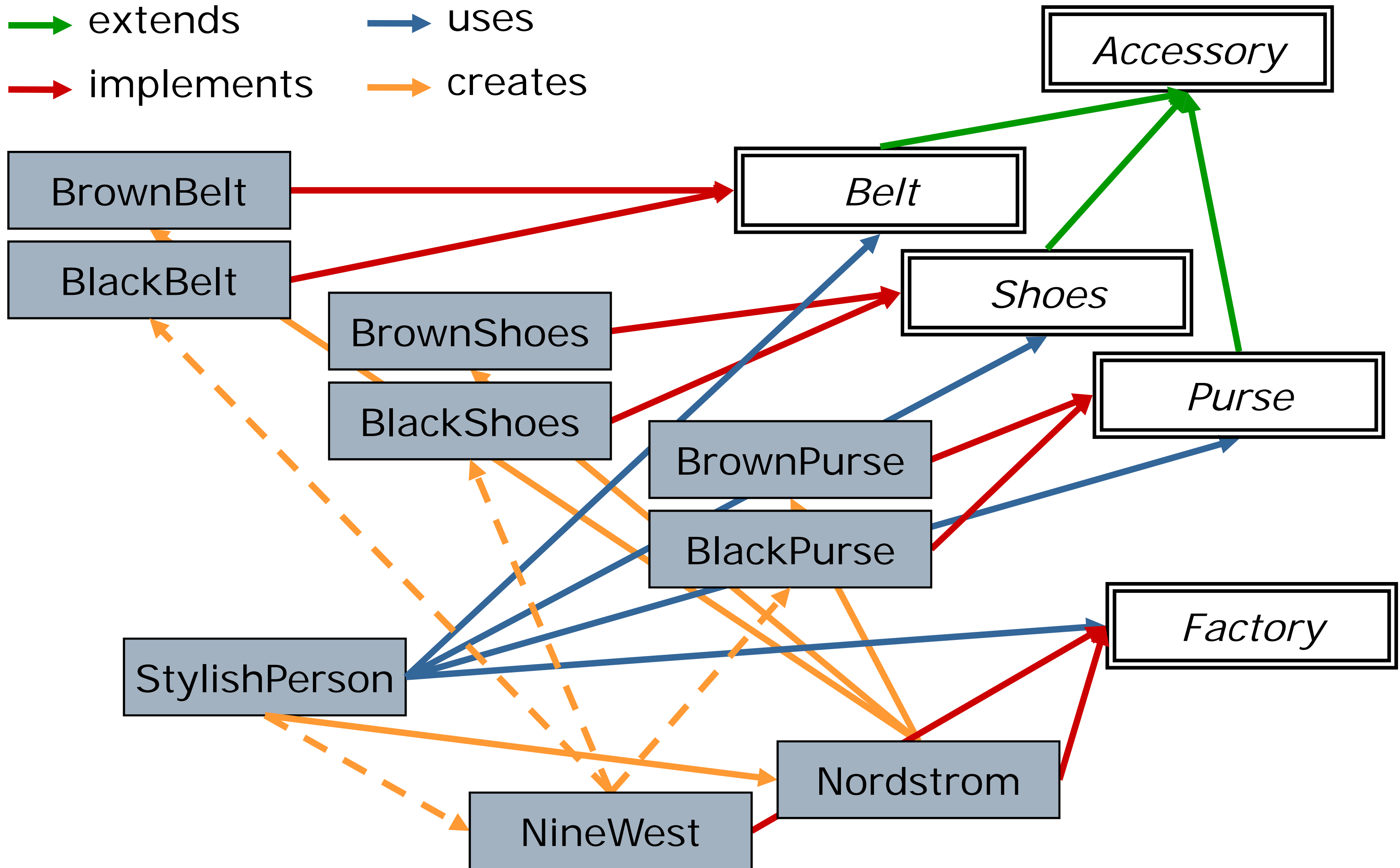
Factory

Provost

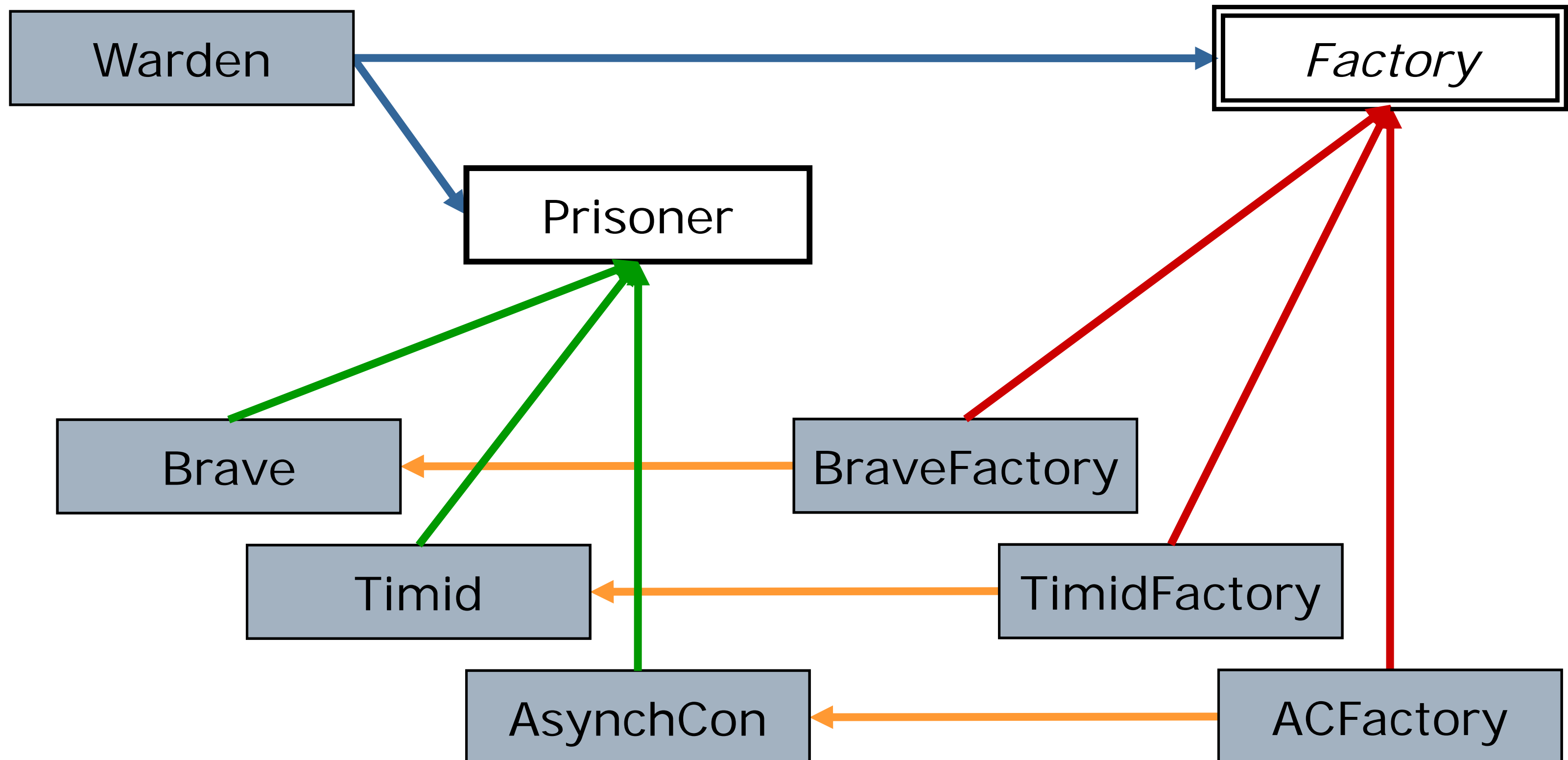
OSUDirectory

UMDirectory

Accessory Hierarchy with Factory



Warden and Prisoners



Alternative: Factory Method

- A different creational pattern
- Instantiation encapsulated in *method*
  - Class can have larger responsibilities
- This method designed to be overridden
  - Subclasses differ in the product line from which the overridden method creates new instances
- Distinction between these two patterns:
  - In abstract factory pattern, the factory class is responsible *only* for creation
  - In factory method pattern, the class containing the factory method is responsible for *both* creation and use/assembly

GameDriver with Factory Method

Sprite

DisneyDragon

Dragon

MagicDragon

Butterfly

DisneyBFly

Princess

MagicBFly

DisneyPrincess

MagicPrincess

GameDriver

DisneyGame

MagicGame

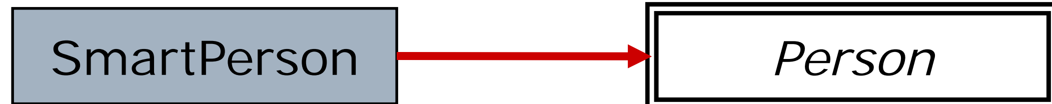
Recall Basic JUnit Recipe

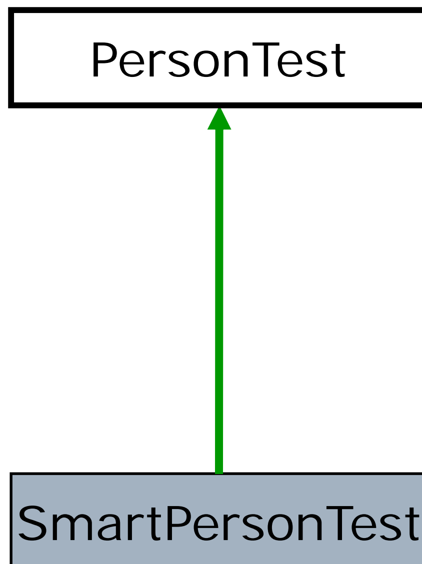
- Given class SmartPerson implements interface Person
- Separate fixture into:
  - Base class testing behavior promised in Person
  - Derived class testing implementation-specific behavior of SmartPerson
- Base class contains:
  - Protected member of (declared) type Person
  - Abstract @Before method to initialize this member
- Derived class contains:
  - Overridden version of @Before to instantiate a SmartPerson

JUnit with Inheritance

extends

implements






```
protected Person p;
@Before
public abstract void setUp();
@Test
public void someTest1() {...}
@Test
public void someTest2() {...}
```

```
@Override @Before
public void setUp() {
  p = new SmartPerson();
}
```

Base Class Test Fixture


```
class PersonTest {
  protected Person p1;
  protected Person p2;
  @Before
  public abstract void setUp();

  @Test
  public void doesSum() {
    int actual = p1.add(3,4);
    int expected = 7;
    assertTrue((actual - expected <= 2)
        && (actual - expected >= -2));
  }
}
```

Derived Class Test Fixture


```
class SmartPersonTest extends PersonTest {
  @Override
  @Before
  public void setUp() {
    p1 = new SmartPerson();
    p2 = new SmartPerson("Evariste Galois");
  }

  @Test
  public void doesSumAccurately() {
    assertEqual(7, p1.add(3,4));
  }
}
```

JUnit with Factory Methods

- Current recipe resembles a factory method
  - @Before method overridden and responsible for instantiation
- Limitation: JUnit fixture methods (like setup) can not have arguments
  - Derived class instantiates the members
  - Constructor arguments are fixed in body of setup
- Goal: Permit test cases to construct their *own* instances for testing
  - Desirable when there are many boundary conditions not easily covered by a small number of statically-instantiated objects

New Base Class Test Fixture


```
class PersonTest {
  protected Person p;

  protected abstract Person
    createFromString(String name);

  @Test
  public void doesSum() {
    p = createFromString("Galileo Galilei");
    int actual = p.add(3,4);
    int expected = 7;
    assertTrue((actual - expected <= 2)
        && (actual - expected >= -2));
  }
}
```

New Derived Class Test Fixture


```
class SmartPersonTest extends PersonTest {
  @Override
  protected Person
    createFromString(String name) {
      return new SmartPerson(name);
  }

  @Test
  public void doesSumAccurately() {
    p = createFromString("Galileo Galilei");
    assertEqual(7, p1.add(3,4));
  }
}
```

Good Practice: Static Factories

- Class provides a public *static* factory method
  - Return type is an instance of the class

    ```
    public static Integer valueOf(int i);
    ```
- Advantages:
  - Factories can have descriptive names

    ```
    BigInteger p = BigInteger.probablePrime(128,rnd);
    ```
  - Need not create a *new* instance!
    - For immutables, return reference to *existing* instance
    - For example, which is better?

      ```
      Integer i1 = new Integer(1);
      Integer i2 = Integer.valueOf(1);
      ```
  - Advanced technique: return instance of a private class
    - Client knows nothing about class, only the interface
- Disadvantages:
  - No public/protected constructor means no subclassing
  - No real distinction from any other static method
- Naming conventions: valueOf(), getInstance()

Summary

- Creation with new() gives concrete-to-concrete coupling
  - Product lines difficult to enforce/support
- Abstract factory pattern
  - Creation delegated to special-purpose class
  - Factory class designed to be extended
  - Each subclass creates objects from one product line
- Factory method pattern
  - Specific creational methods designed to be overridden
  - Each subclass overrides method to create objects from one product line
- Implications for JUnit
- Static factory methods