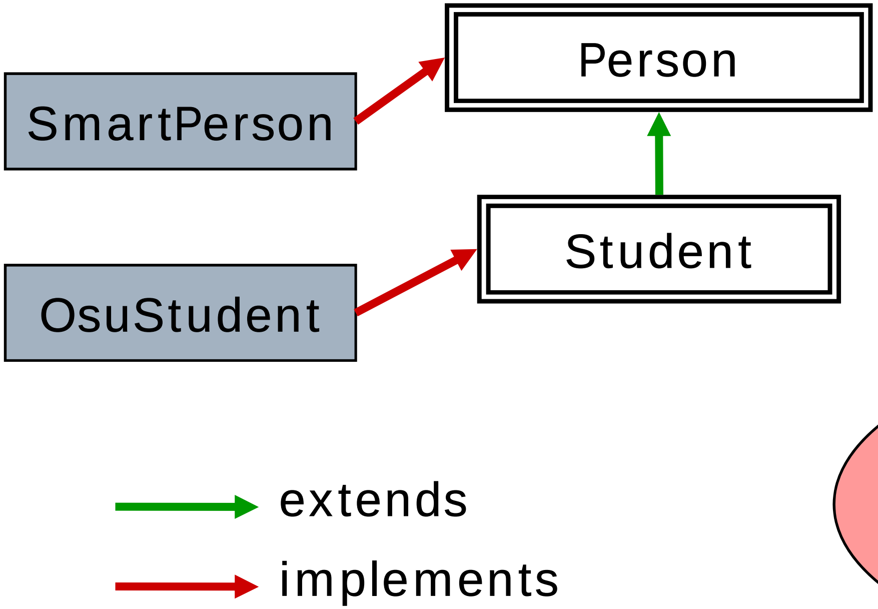
# Implementation Inheritance

Computer Science and Engineering ■ College of Engineering ■ The Ohio State University

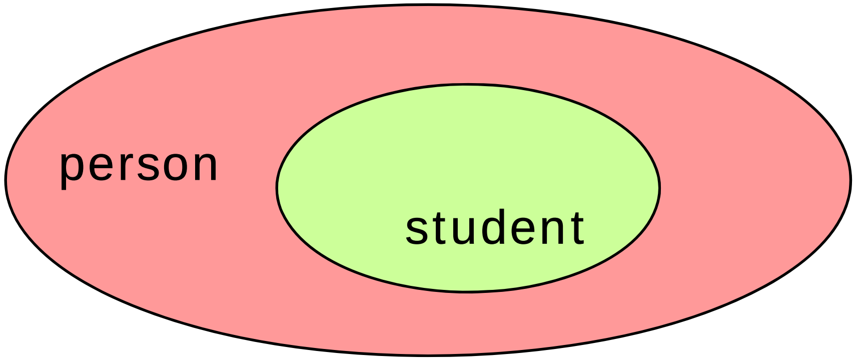
Lecture 12

# Recall: Interface Inheritance

```
void select (Person p) {
   //declared type of p is:
   //dynamic type of p is:
```



Every student is a person



# Recall: Behavioral Subtyping

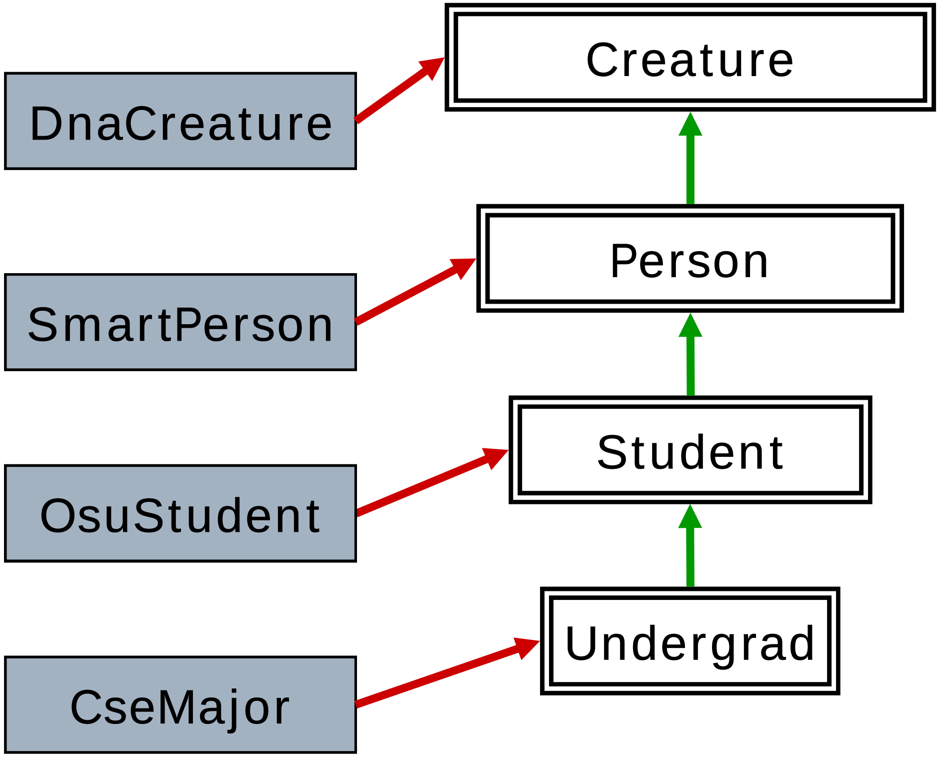
- A Student can do everything a Person can do
- Everywhere a Person is expected, a Student can be used instead

```
void select (Person p) {
  if (p.getAge() > 18)  {
    p.summons(trialDate);
    ... etc ...
```

- Every method promised in Person interface:
  - Is implemented in SmartPerson class
  - Is promised in Student interface
  - Is implemented in OsuStudent class
- Are two separate implementations of getAge really necessary (or even a good idea)?

# More Extreme Example

- Every method promised in Creature interface:
  - Also promised in Person, Student, and Undergrad interfaces
  - Must be implemented in DnaCreature, SmartPerson, OsuStudent, and CseMajor classes!

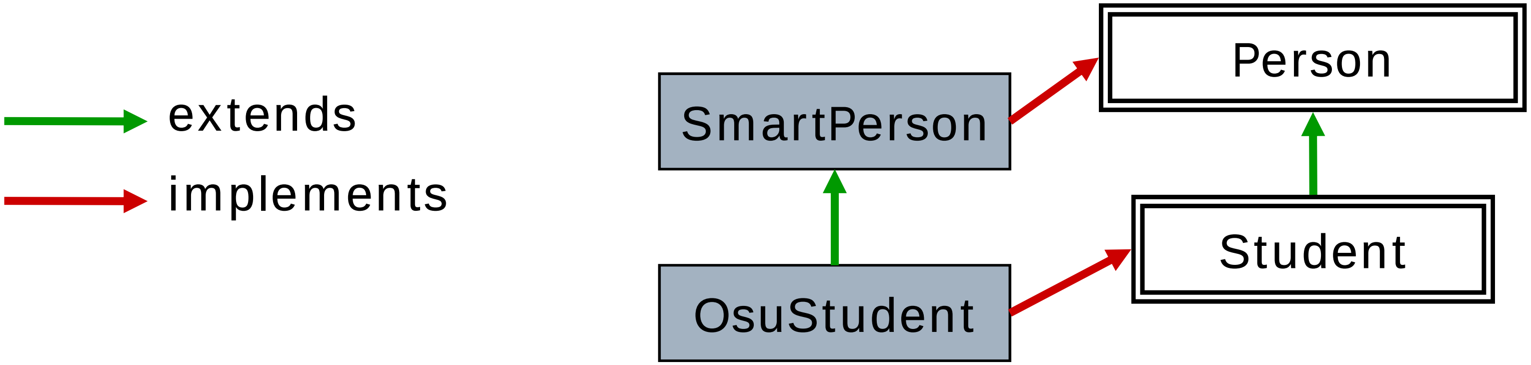


# Implementation Inheritance

- Keyword: extends

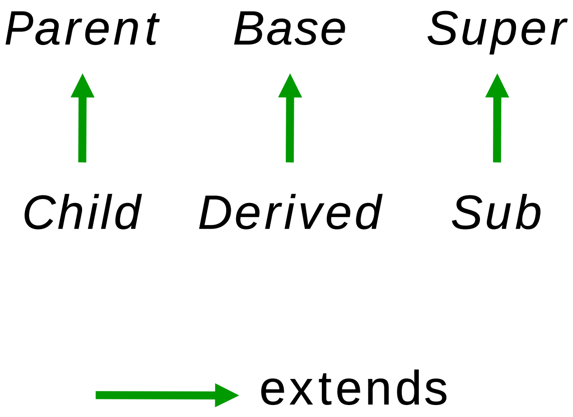
```
public class OsuStudent extends SmartPerson {
   . . .
}
```

  - OsuStudent has SmartPerson's members (fields + methods, including *implementation*)
  - If omitted, java.lang.Object is implicit



# Class Hierarchy

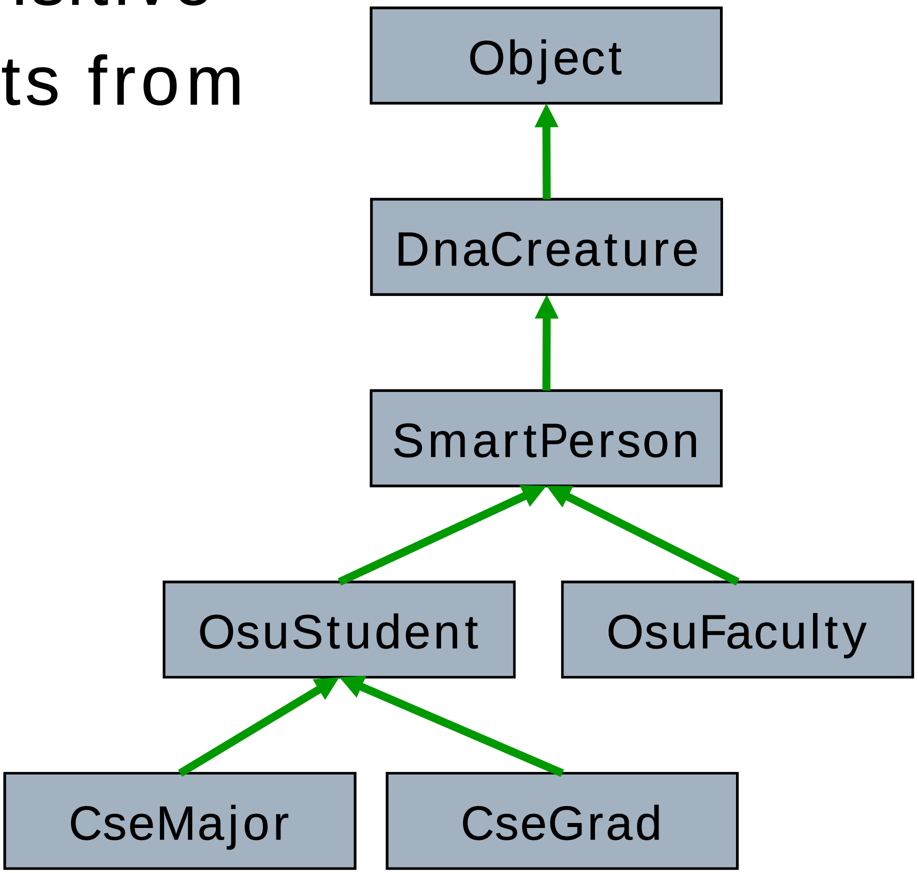
- Inheritance is transitive
- Every class inherits from java.lang.Object



*Parent* *Base* *Super*

*Child* *Derived* *Sub*

extends



Object

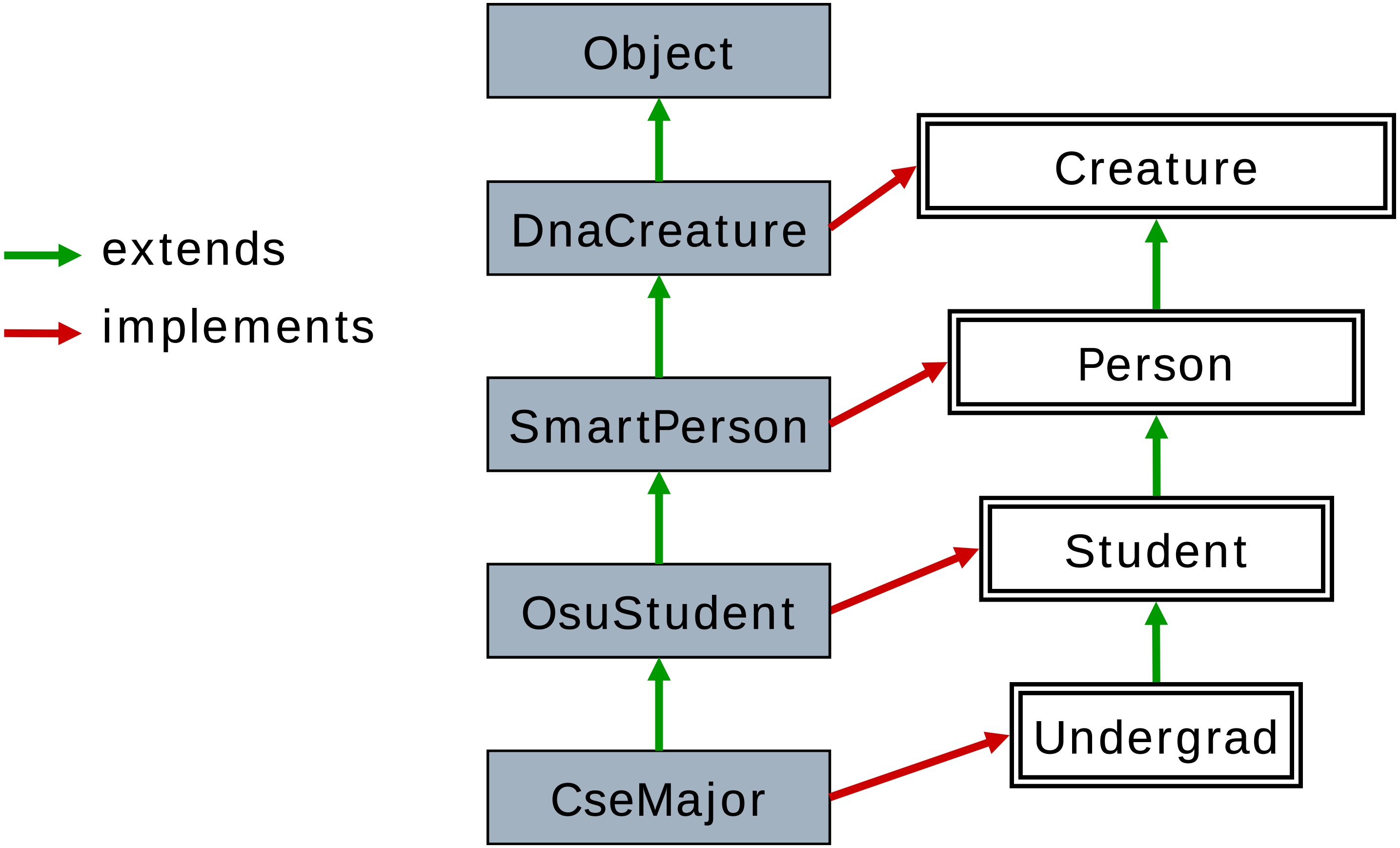
DnaCreature

SmartPerson

OsuStudent OsuFaculty

CseMajor CseGrad

# Class and Interface Hierarchies



→ extends

→ implements

Object

DnaCreature

SmartPerson

OsuStudent

CseMajor

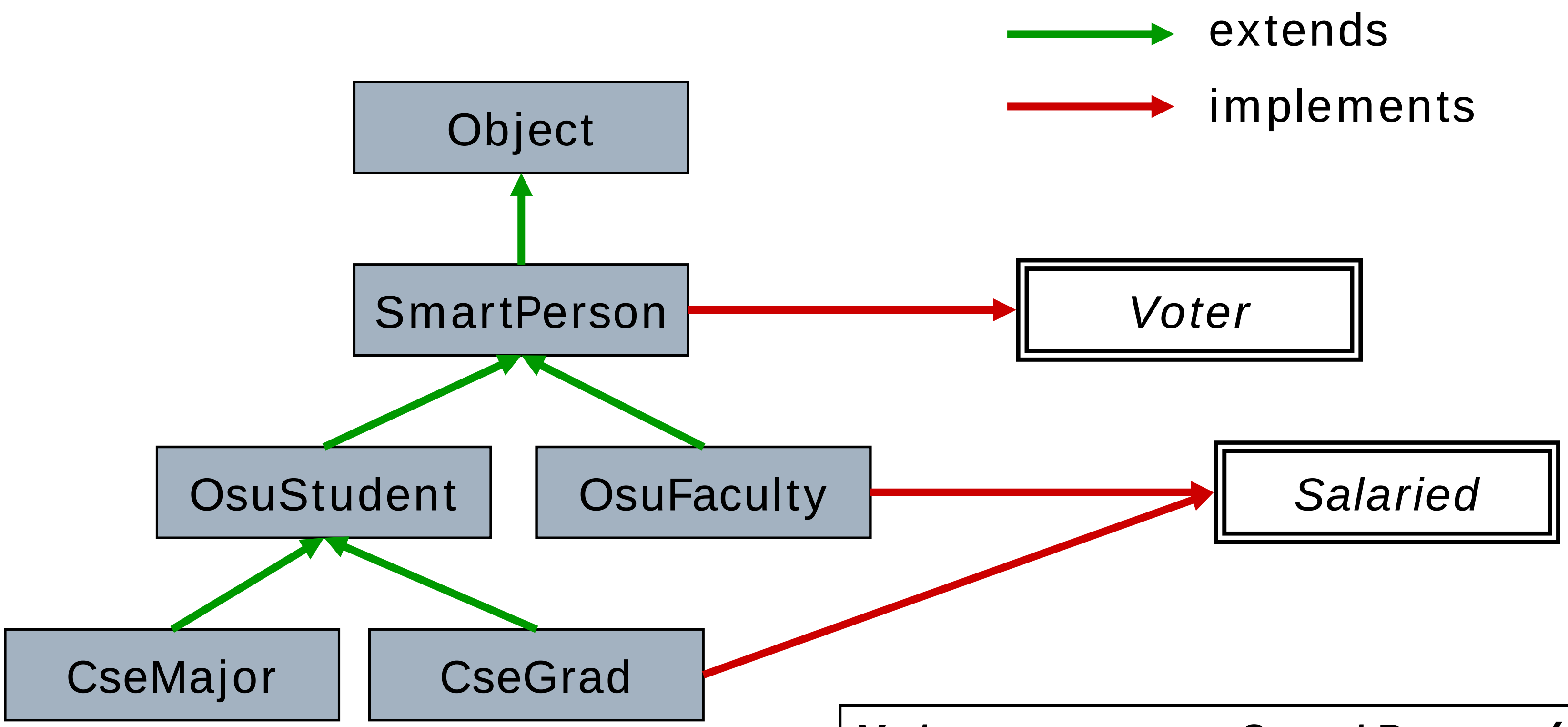
Creature

Person

Student

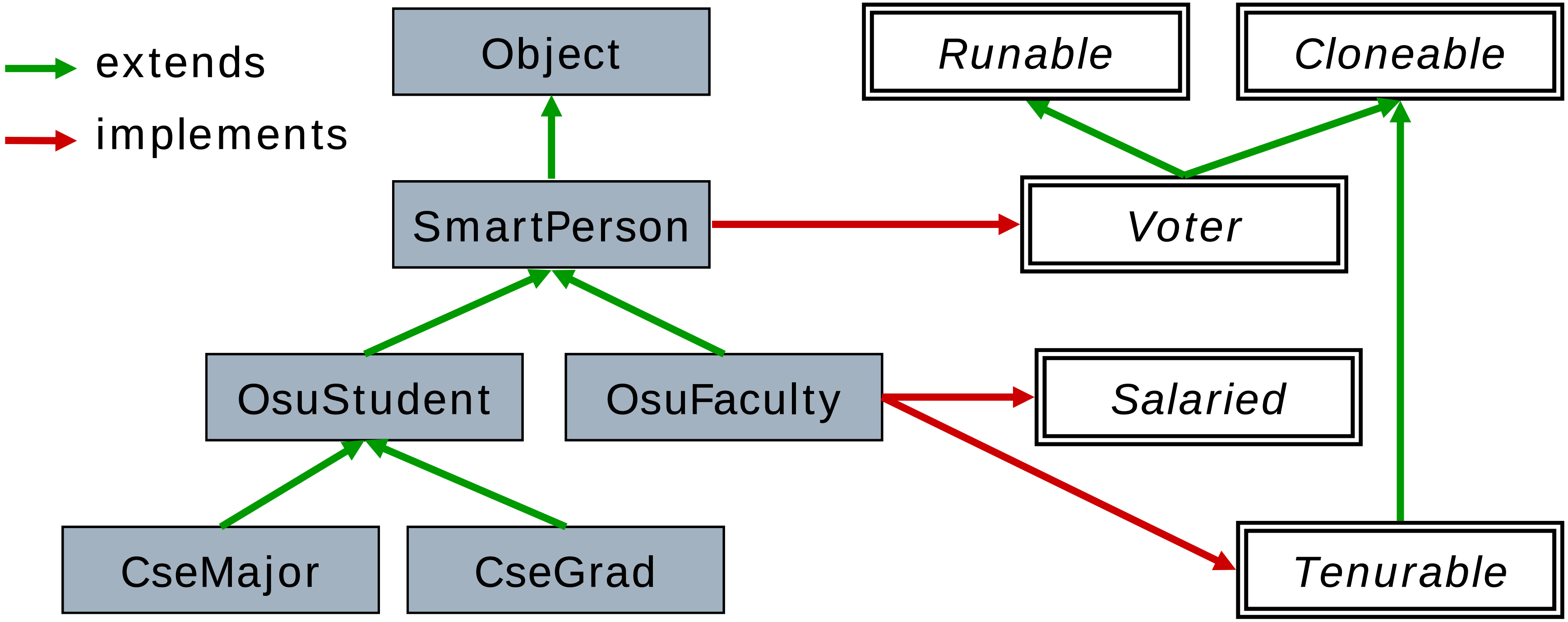
Undergrad

# Class and Interface Hierarchies



```
Voter v = new SmartPerson();
v = new OsuStudent();
v = new CseGrad();
v = new OsuFaculty();
```

# Class and Interface Hierarchies



OsuFaculty extends SmartPerson, Object
OsuFaculty implements Salaried, Tenurable, Voter, Runable, Cloneable

# Mechanics

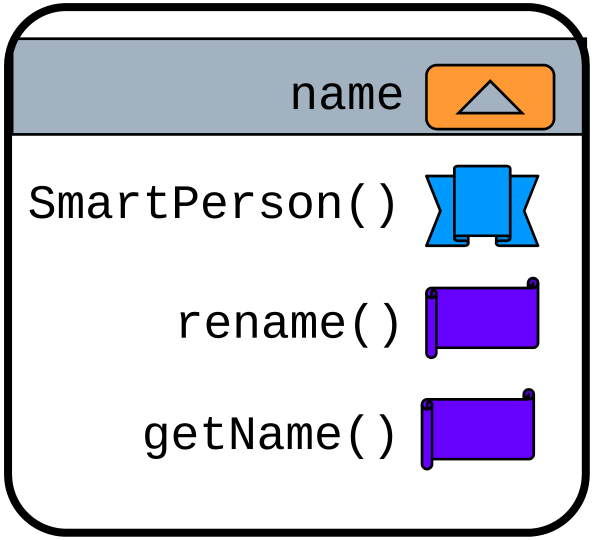
- A class extends *exactly one* other class
  - "single inheritance" (unlike C++ "multiple inheritance")
- A subclass has all the members of its superclass
  - Not the private members
  - Not the constructors (ie just fields and methods)
- Subclass can add new members (hence "extends")
  - New fields and new methods
  - Defines its own constructor(s)
- Subclass can modify inherited methods
  - Changes behavior
  - "overriding"

# Example: Code

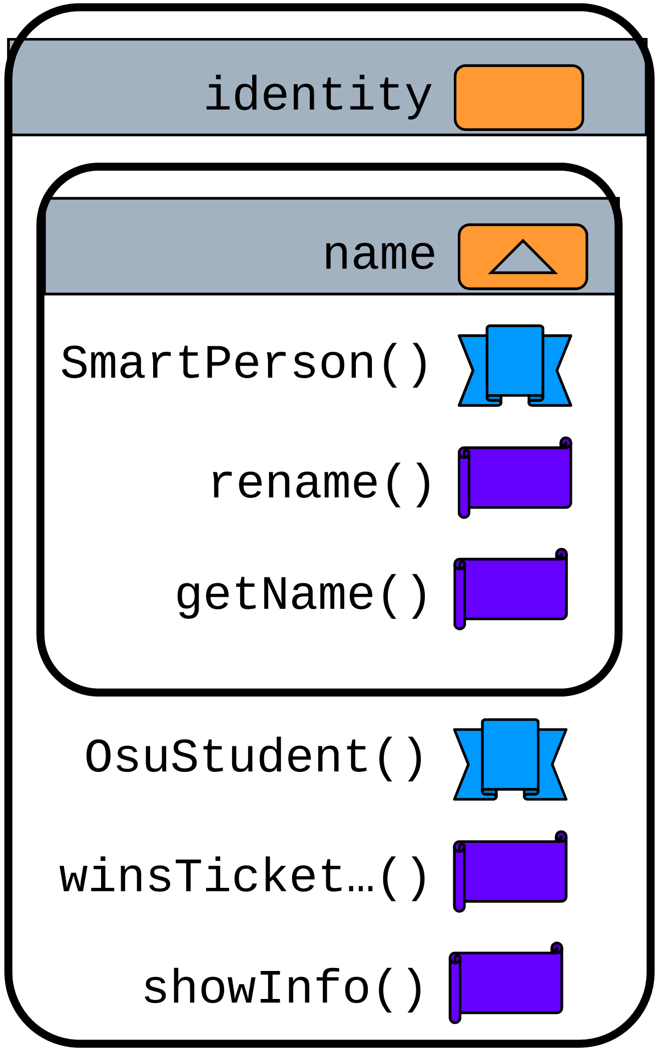
```
class SmartPerson implements
    Person {

  private String name;

  SmartPerson() {
    name = “Baby Doe”;
  }

  SmartPerson(String name) {
    this.name = name;
  }

  void rename(String name) {
    this.name = name;
  }

  String getName() {
    return name;
  }
}
```

```
class OsuStudent implements
    Student extends SmartPerson {
  private int identity;

  OsuStudent() {
    identity = 0;
  }

  OsuStudent(String name, int
    identity) {
    super(name);
    this.identity = identity;
  }

  boolean winsTicketLottery () {
    return (identity % 13 == 0);
  }

  String showInfo () {
    return “ [” + getName() +
           identity + “]”;
  }
}
```

# Example: Graphical View



```
SmartPerson p = new SmartPerson()

OsuStudent s = new OsuStudent()
```



# Constructing New Instances

- Members of OsuStudent:
  - Its own: identity, winsTicketLottery(), showInfo()
  - Its parent's: rename(), getName()
  - Its parent's parent's: see java.lang.Object
    - eg clone(), equals(), hashCode(),…
- When a new instance is created:
  - First, the parent's constructor is invoked
    - Can be done explicitly with super()
    - Otherwise, parent's default constructor is called
  - Next, any initialization blocks are executed
  - Finally, the child's constructor is executed

# Overriding Methods

- *Overriding*: a subclass declares a method that is already present in its superclass
- Note: signatures must match (otherwise it is just overloading)

```
class SmartPerson {
  String showInfo() {
    return getName();
  }
}
class OsuStudent extends SmartPerson {
  String showInfo() {
    return “ [” + getName() + identity + “]”;
  }
}
```

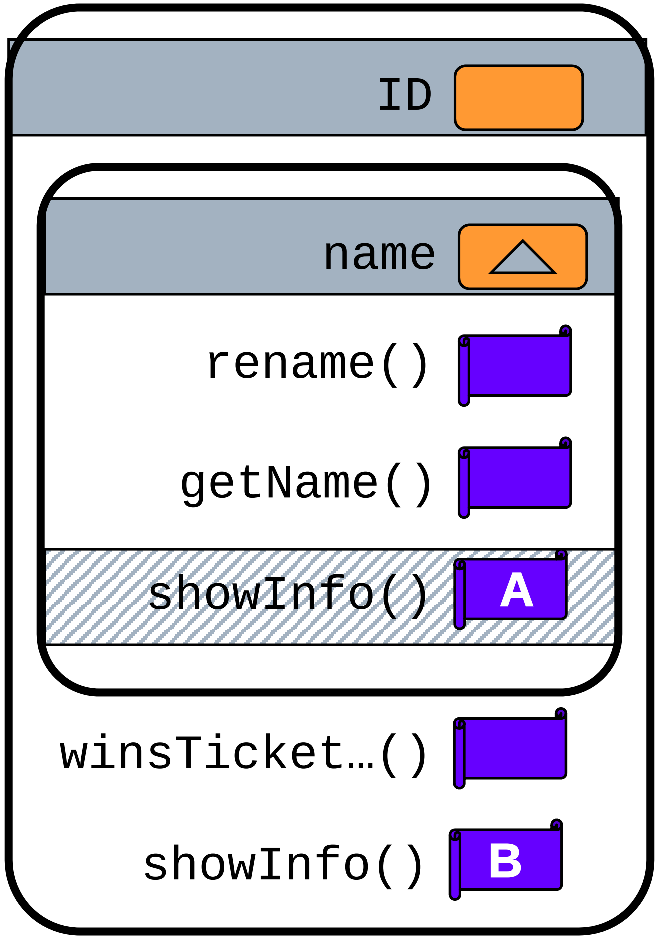
- Question: which method is called?

```
SmartPerson p = new OsuStudent();
System.out.println(p.showInfo());
```

  - Declared type: SmartPerson, dynamic type: OsuStudent

# Overriding: Graphical View

```
OsuStudent s = new OsuStudent()
s.showInfo();   //impl: B

SmartPerson p = s;
p.winsTicketLottery(); //error
p.showInfo();   //impl: A or B?
```



# Polymorphism

- Answer: The *dynamic type* determines which method is called

```
SmartPerson p = new OsuSudent();
p.showInfo() //calls OsuStudent version
```

- Informal model:
  - Method invocation is a run-time message to the object
  - That (run-time) object receives the request, performs the action, and returns the result
- Goal: we get the right behavior regardless of which specific actual (ie run-time, ie dynamic) type we have

```
Person[] csePeople = … //students & faculty in CSE
for (int i = 0; i < csePeople[].length; i++) {
  ...csePeople[i].showInfo()...;
}
```

- Note: This applies to methods only, not fields
  - Fields can not be overridden, only hidden

# Good Practice: @Override

- Use *@Override* annotation with all methods intended to override a method in a superclass

```
class OsuStudent extends SmartPerson {
  @Override
  String getInfo() {
    . . .
  }
}
```

- Compiler complains if there is no matching method in superclass
  - Prevents accidental overloading if a mistake is made in the signature
- Beware: Differences between Java 5 & 6

# Hook methods

- Dynamic type of *this* controls which method executes
- Hook method: Called internally, intended to be overridden

```
class Course {
  void enroll(Student s) {
    if (this.checkEligibility(s)) { … }
  }
  boolean checkEligibility(Student s) {
    //determines whether s has prereqs for this course
  }
}

class Tutorial extends Course {
  boolean checkEligibility(Student s) {
    //determines whether s has paid fees
  }
}
```

- Yo-yo problem:
  - Must trace up & down class hierarchy to understand code

```
Course workshop = new Tutorial();
workshop.enroll(s);
```

# Protected

- We have seen three levels of visibility
  - private: concrete representation
  - default (ie package): trusted and co-located
  - public: abstract interface to all clients
- Writing a subclass often requires:
  - *More* access than a generic client
  - *Less* access than whole concrete representation
- Solution: new visibility level
  - Keyword: *protected*
  - Protected members *are* inherited but are *not* part of the public interface to generic clients
  - Warning: anyone can extend your class and then has access to protected members

# Good Practice: Limited Use

- Getting it right is hard
- Unless you have an explicit *need* for an open (ie extendable) class hierarchy, prevent others from extending your classes
- Keyword *final* prevents extensions

```
public final class Faculty {
  . . .
}

public class Administrator extends Faculty {
  . . .  //compiler complains
}
```

- If you do have a specific need to allow extensions, design for it carefully
  - Use protected diligently and carefully (it's a huge *increase* in visibility over private or even over package!)
  - Chances are, it will still be broken

# Summary

- Implementation (class) inheritance
  - Declaration syntax: extends just like interfaces
  - Vocabulary: super/sub, base/derived, parent/child
- Class and interface hierarchies
  - Constructing new instances
- Overriding and polymorphism
  - Signature must match exactly (use @Override)
  - Dynamic type controls implementation
  - Hook methods: dynamic type of this
- Protected visibility
- Limiting extension: final