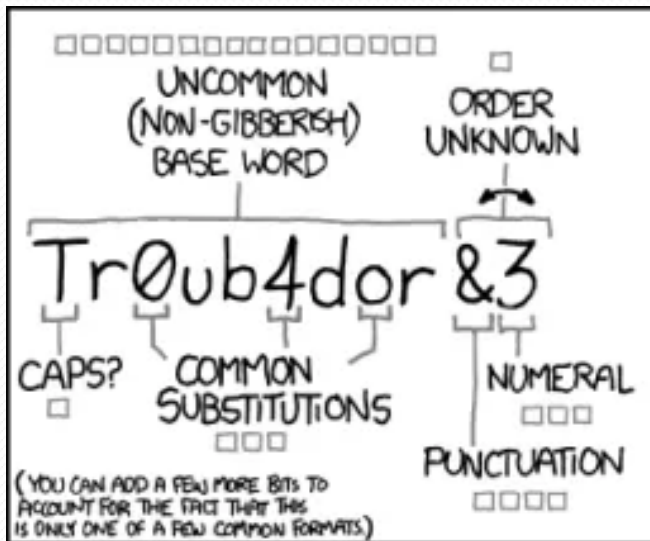




Building Java Programs

Chapter 9 Polymorphism

reading: 9.3 – 9.4



~28 BITS OF ENTROPY

$2^{28} = 3 \text{ DAYS AT } 1000 \text{ GUESSES/SEC}$

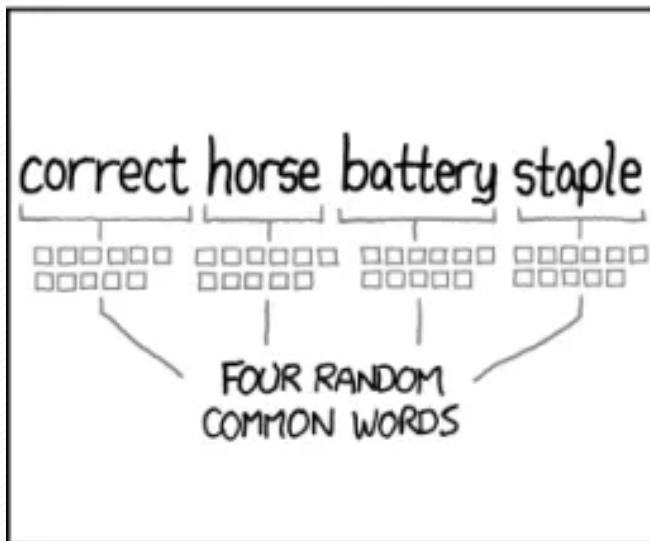
(PLAUSIBLE ATTACK ON A WEAK REMOTE WEB SERVICE. YES, CRACKING A STOLEN HASH IS FASTER, BUT IT'S NOT WHAT THE AVERAGE USER SHOULD WORRY ABOUT.)

DIFFICULTY TO GUESS: **EASY**

WAS IT TROMBONE? NO, TROUBADOR. AND ONE OF THE 0s WAS A ZERO?

AND THERE WAS SOME SYMBOL...

DIFFICULTY TO REMEMBER: **HARD**



~44 BITS OF ENTROPY

$2^{44} = 550 \text{ YEARS AT } 1000 \text{ GUESSES/SEC}$

DIFFICULTY TO GUESS: **HARD**

THAT'S A BATTERY STAPLE.

CORRECT!

DIFFICULTY TO REMEMBER: YOU'VE ALREADY MEMORIZED IT

THROUGH 20 YEARS OF EFFORT, WE'VE SUCCESSFULLY TRAINED EVERYONE TO USE PASSWORDS THAT ARE HARD FOR HUMANS TO REMEMBER, BUT EASY FOR COMPUTERS TO GUESS.

Polymorphism

- **polymorphism**: Ability for the same code to be used with different types of objects and behave differently with each.
 - `System.out.println` can print any type of object.
 - Each one displays in its own way on the console.

Coding with polymorphism

- A variable of type T can hold an object of any subclass of T .

```
Employee ed = new Lawyer();
```

- You can call any methods from the `Employee` class on `ed`.
- When a method is called on `ed`, it behaves as a `Lawyer`.

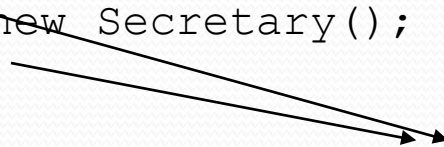
```
System.out.println(ed.getSalary());           // 50000.0  
System.out.println(ed.getVacationForm());     // pink
```

Polymorphism and parameters

- You can pass any subtype of a parameter's type.

```
public class EmployeeMain {
    public static void main(String[] args) {
        Lawyer lisa = new Lawyer();
        Secretary steve = new Secretary();
        printInfo(lisa);
        printInfo(steve);
    }

    public static void printInfo(Employee empl) {
        System.out.println("salary: " + empl.getSalary());
        System.out.println("v.days: " + empl.getVacationDays());
        System.out.println("v.form: " + empl.getVacationForm());
        System.out.println();
    }
}
```



OUTPUT:

```
salary: 50000.0      salary: 50000.0
v.days: 15           v.days: 10
v.form: pink         v.form: yellow
```

Polymorphism and arrays

- Arrays of superclass types can store any subtype as elements.

```
public class EmployeeMain2 {
    public static void main(String[] args) {
        Employee[] e = { new Lawyer(), new Secretary(),
                       new Marketer(), new LegalSecretary() };

        for (int i = 0; i < e.length; i++) {
            System.out.println("salary: " + e[i].getSalary());
            System.out.println("v.days: " +
                e[i].getVacationDays());
            System.out.println();
        }
    }
}
```

Output:

```
salary: 50000.0
v.days: 15

salary: 50000.0
v.days: 10

salary: 60000.0
v.days: 10

salary: 55000.0
v.days: 10
```

A polymorphism problem

- Suppose that the following four classes have been declared:

```
public class Foo {
    public void method1() {
        System.out.println("foo 1");
    }

    public void method2() {
        System.out.println("foo 2");
    }

    public String toString() {
        return "foo";
    }
}

public class Bar extends Foo {
    public void method2() {
        System.out.println("bar 2");
    }
}
```

A polymorphism problem

```
public class Baz extends Foo {
    public void method1() {
        System.out.println("baz 1");
    }
    public String toString() {
        return "baz";
    }
}

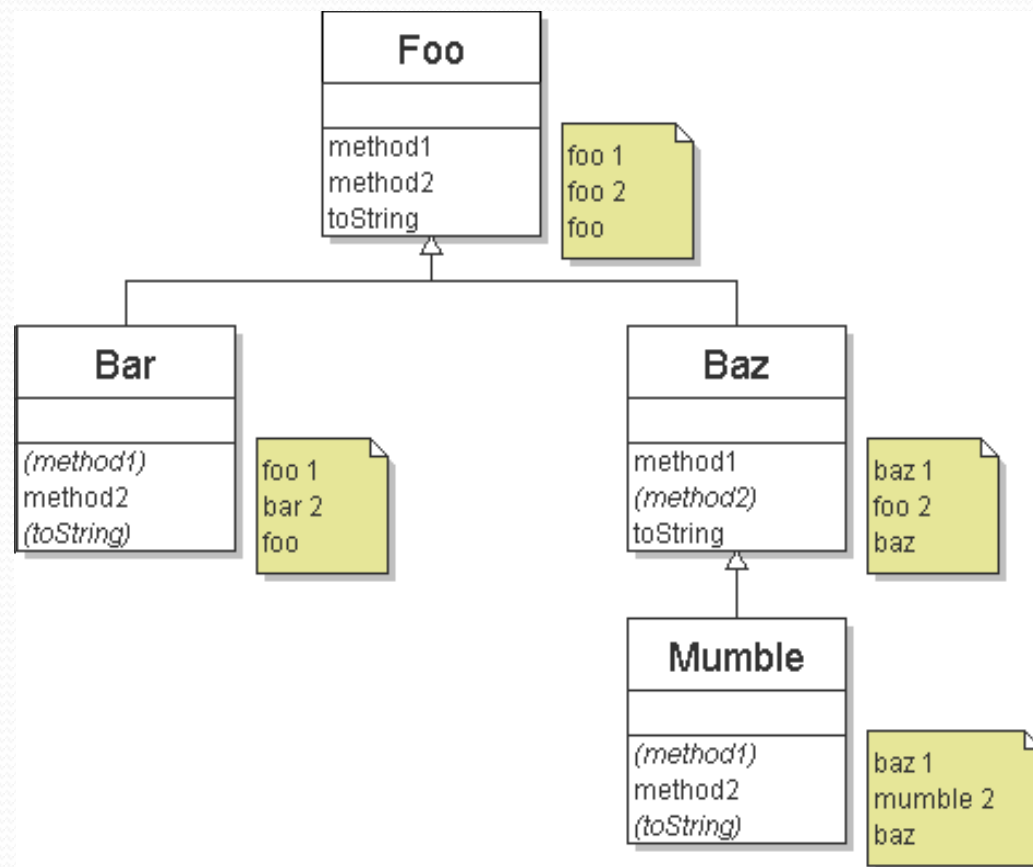
public class Mumble extends Baz {
    public void method2() {
        System.out.println("mumble 2");
    }
}
```

- What would be the output of the following client code?

```
Foo[] pity = {new Baz(), new Bar(), new Mumble(), new Foo()};
for (int i = 0; i < pity.length; i++) {
    System.out.println(pity[i]);
    pity[i].method1();
    pity[i].method2();
    System.out.println();
}
```


Diagramming the classes

- Add classes from top (superclass) to bottom (subclass).
- Include all inherited methods.



Finding output with tables

method	Foo	Bar	Baz	Mumble
method1	foo 1	<i>foo 1</i>	baz 1	<i>baz 1</i>
method2	foo 2	bar 2	<i>foo 2</i>	mumble 2
toString	foo	<i>foo</i>	baz	<i>baz</i>

Polymorphism answer

```
Foo[] pity = {new Baz(), new Bar(), new Mumble(), new Foo()};  
for (int i = 0; i < pity.length; i++) {  
    System.out.println(pity[i]);  
    pity[i].method1();  
    pity[i].method2();  
    System.out.println();  
}
```

- **Output:**

```
baz  
baz 1  
foo 2  
  
foo  
foo 1  
bar 2  
  
baz  
baz 1  
mumble 2  
  
foo  
foo 1  
foo 2
```

Another problem

- The order of the classes is jumbled up.
- The methods sometimes call other methods (tricky!).

```
public class Lamb extends Ham {
    public void b() {
        System.out.print("Lamb b  ");
    }
}

public class Ham {
    public void a() {
        System.out.print("Ham a  ");
        b();
    }

    public void b() {
        System.out.print("Ham b  ");
    }

    public String toString() {
        return "Ham";
    }
}
```

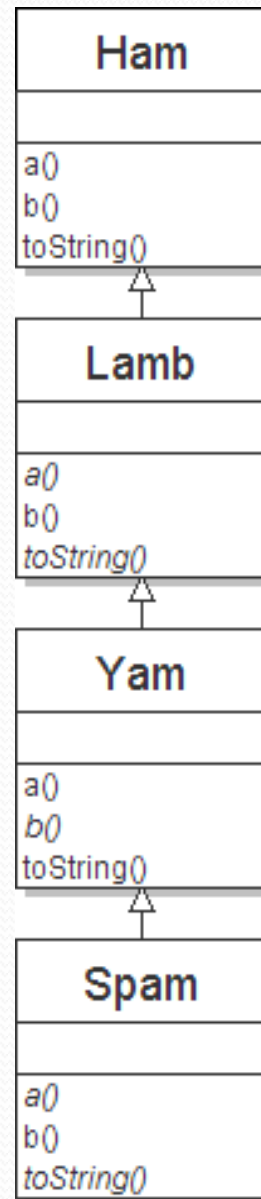
Another problem 2

```
public class Spam extends Yam {
    public void b() {
        System.out.print("Spam b   ");
    }
}
public class Yam extends Lamb {
    public void a() {
        System.out.print("Yam a   ");
        super.a();
    }
    public String toString() {
        return "Yam";
    }
}
```

- What would be the output of the following client code?

```
Ham[] food = {new Lamb(), new Ham(), new Spam(), new Yam()};
for (int i = 0; i < food.length; i++) {
    System.out.println(food[i]);
    food[i].a();
    System.out.println();           // to end the line of output
    food[i].b();
    System.out.println();           // to end the line of output
    System.out.println();
}
```

Class diagram



Polymorphism at work

- Lamb inherits Ham's a. a calls b. But Lamb overrides b...

```
public class Ham {
    public void a() {
        System.out.print("Ham a  ");
        b();
    }
    public void b() {
        System.out.print("Ham b  ");
    }
    public String toString() {
        return "Ham";
    }
}

public class Lamb extends Ham {
    public void b() {
        System.out.print("Lamb b  ");
    }
}
```

- Lamb's output from a:

Ham a **Lamb b**

The table

method	Ham	Lamb	Yam	Spam
a	Ham a b()	<i>Ham a</i> b()	Yam a Ham a b()	<i>Yam a</i> <i>Ham a</i> b()
b	Ham b	Lamb b	Lamb b	Spam b
toString	Ham	<i>Ham</i>	Yam	<i>Yam</i>

The answer

```
Ham[] food = {new Lamb(), new Ham(), new Spam(), new Yam()};  
for (int i = 0; i < food.length; i++) {  
    System.out.println(food[i]);  
    food[i].a();  
    food[i].b();  
    System.out.println();  
}
```

- **Output:**

```
Ham  
Ham a    Lamb b  
Lamb b  
  
Ham  
Ham a    Ham b  
Ham b  
  
Yam  
Yam a    Ham a    Spam b  
Spam b  
  
Yam  
Yam a    Ham a    Lamb b  
Lamb b
```

Casting references

- A variable can only call that type's methods, not a subtype's.

```
Employee ed = new Lawyer();  
int hours = ed.getHours(); // ok; this is in Employee  
ed.sue(); // compiler error
```

- The compiler's reasoning is, variable `ed` could store any kind of employee, and not all kinds know how to `sue`.
- To use `Lawyer` methods on `ed`, we can type-cast it.

```
Lawyer theRealEd = (Lawyer) ed;  
theRealEd.sue(); // ok  
  
( (Lawyer) ed ).sue(); // shorter version
```

More about casting

- The code crashes if you cast an object too far down the tree.

```
Employee eric = new Secretary();  
((Secretary) eric).takeDictation("hi");           // ok  
((LegalSecretary) eric).fileLegalBriefs();      // exception  
  
//           (Secretary object doesn't know how to file briefs)
```

- You can cast only up and down the tree, not sideways.

```
Lawyer linda = new Lawyer();  
((Secretary) linda).takeDictation("hi");         // error
```

- Casting doesn't actually change the object's behavior.
It just gets the code to compile/run.

```
((Employee) linda).getVacationForm()           // pink (Lawyer's)
```