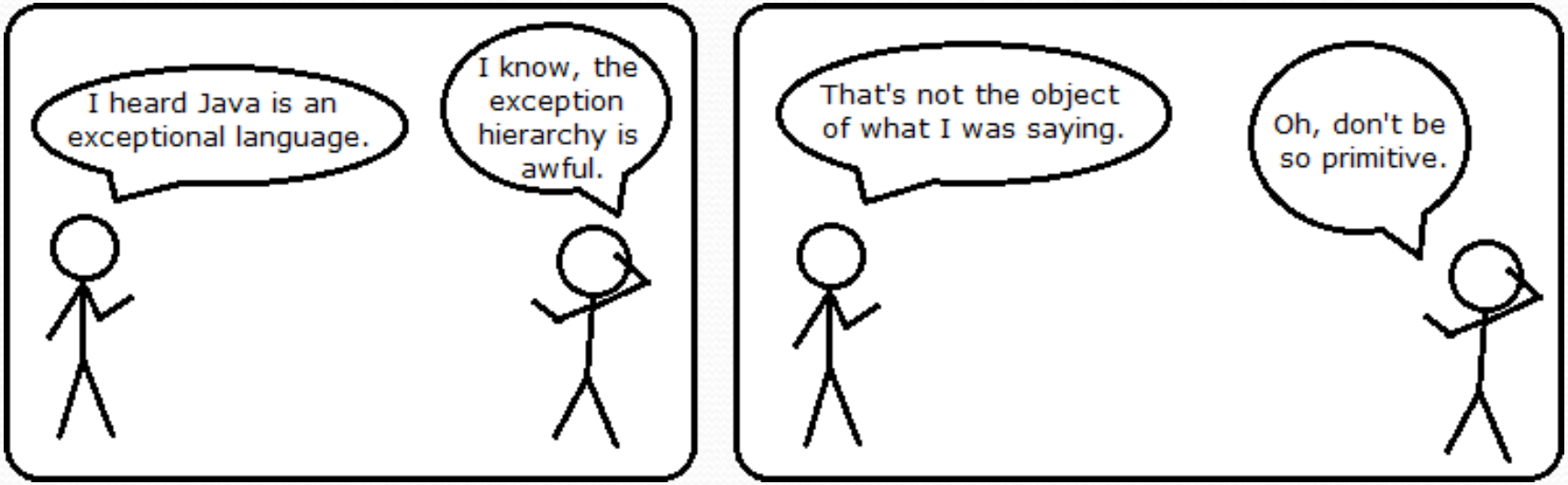
CS 142

Lecture 23: Interfaces; Abstract Classes



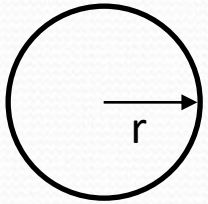
Thanks to Marty Stepp and Stuart Reges for parts of these slides

Related classes

Consider classes for shapes with common features:

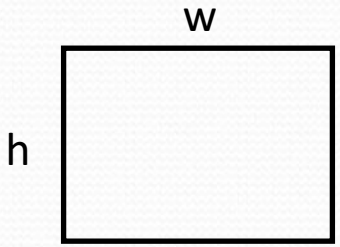
- Circle (defined by radius *r*):

  area $= \pi r^2$, perimeter $= 2 \pi r$



- Rectangle (defined by width *w* and height *h*):

  area $= w\,h$, perimeter $= 2w + 2h$

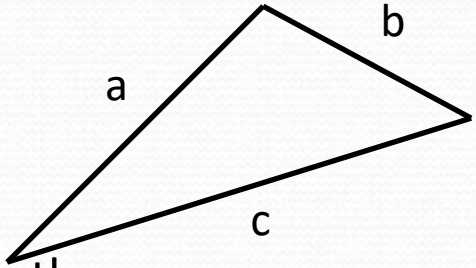


- Triangle (defined by side lengths *a*, *b*, and *c*)

  area $= \sqrt{(s\,(s-a)\,(s-b)\,(s-c))}$

  where $s = \frac{1}{2}\,(a + b + c)$,

  perimeter $= a + b + c$



  - Every shape has these, but each computes them differently.

Storing Multiple Types

- It would be nice if we could store shapes of different types in a list. What do we need in order to do this?

- Are there any downsides?

Solution: Interfaces

- **interface**: A list of methods that a class can promise to implement.
  - Inheritance gives you an is-a relationship *and* code sharing.
    - A `Lawyer` can be treated as an `Employee` and inherits its code.
  - Interfaces give you an is-a relationship *without* code sharing.
    - A `Rectangle` object can be treated as a `Shape` but inherits no code.
  - Analogous to non-programming idea of roles or certifications:
    - "I'm certified as a CPA accountant.
      This assures you I know how to do taxes, audits, and consulting."
    - "I'm 'certified' as a Shape, because I implement the Shape interface.
      This assures you I know how to compute my area and perimeter."

Interface syntax

```
public interface name {
    public type name(type name, …, type name);
    public type name(type name, …, type name);
    …
    public type name(type name, …, type name);
}
```

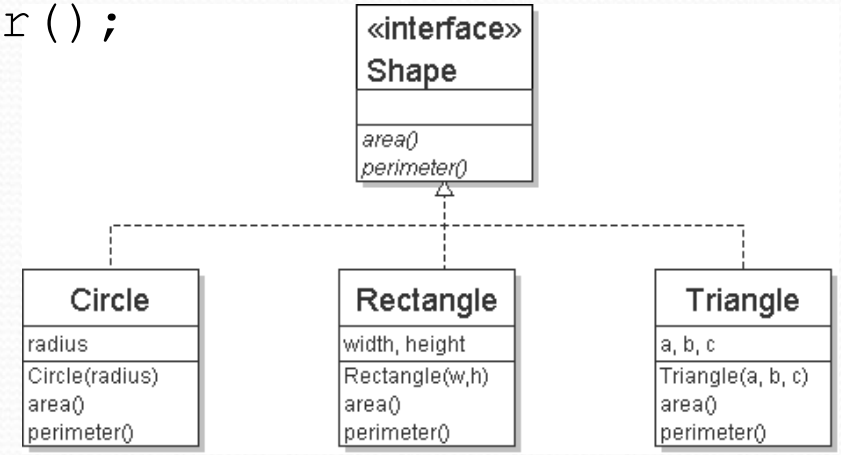
Example:

```
public interface Vehicle {
    public int getSpeed();
    public void setDirection(int direction);
}
```

Shape interface

```
// Describes features common to all shapes.
public interface Shape {
    public double area();
    public double perimeter();
}
```

- Saved as `Shape.java`



- **abstract method**: A header without an implementation.
  - The actual bodies are not specified, because we want to allow each class to implement the behavior in its own way.

Implementing an interface

```
public class name implements interface {
    …
}
```

- A class can declare that it "implements" an interface.
  - The class must contain each method in that interface.

```
public class Bicycle implements Vehicle {
    …
}
```

(Otherwise it will fail to compile.)

```
Banana.java:1: Banana is not abstract and does not
override abstract method area() in Shape
public class Banana implements Shape {
                ^
```

Interfaces + polymorphism

- Interfaces benefit the *client code* author the most.
  - They allow **polymorphism**.
    (the same code can work with different types of objects)

```
public static void printInfo(Shape s) {
    System.out.println("The shape: " + s);
    System.out.println("area : " + s.area());
    System.out.println("perim: " + s.perimeter());
    System.out.println();
}
...
Circle circ = new Circle(12.0);
Triangle tri = new Triangle(5, 12, 13);
printInfo(circ);
printInfo(tri);
```

Maps – again!

- We did an example in lecture with a `HashMap`.
- In lab we did an exercise with a `TreeMap`.
- They had the same methods and seemed to be used for the same tasks.
- Why do we need both?

Lists

- We implemented an `ArrayIntList` class so we could create a list that changed size as data was added

index	0	1	2	3
value	42	-3	17	9

- Is there any other way we could have created a list structure?

Abstract data types (ADTs)

- **abstract data type (ADT)**: A specification of a collection of data and the operations that can be performed on it.
  - Describes *what* a collection does, not *how* it does it

- We don't know exactly how other types of lists are implemented, and we don't need to.
  - We just need to understand the idea of the list and what operations it can perform.

Using ADT interfaces

When using Java's built-in collection classes:

- It is considered good practice to always declare collection variables using the corresponding ADT interface type:

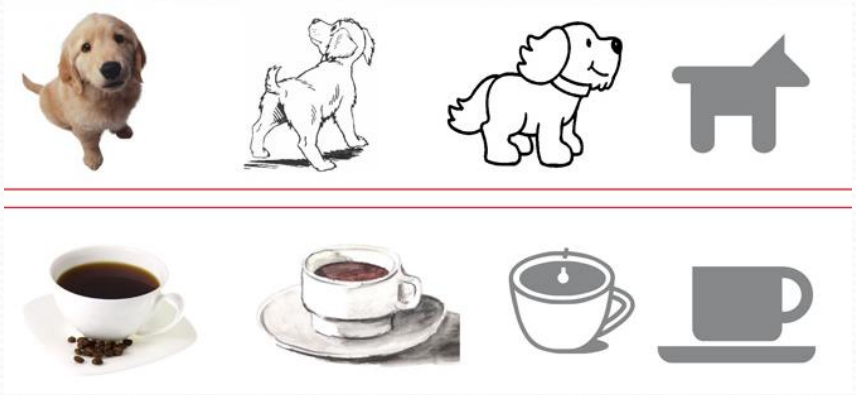
```
List<String> list = new ArrayList<>();
```

- Methods that accept a collection as a parameter should also declare the parameter using the ADT interface type:

```
public void stutter(List<String> list) {
    ...
}
```

Abstract Classes

- A mix between a class and an interface
  - Contains some abstract methods (unimplemented)
  - Contains some fully implemented methods
  - Other classes can **inherit** from it not extend it
  - All abstract methods **must** be overridden



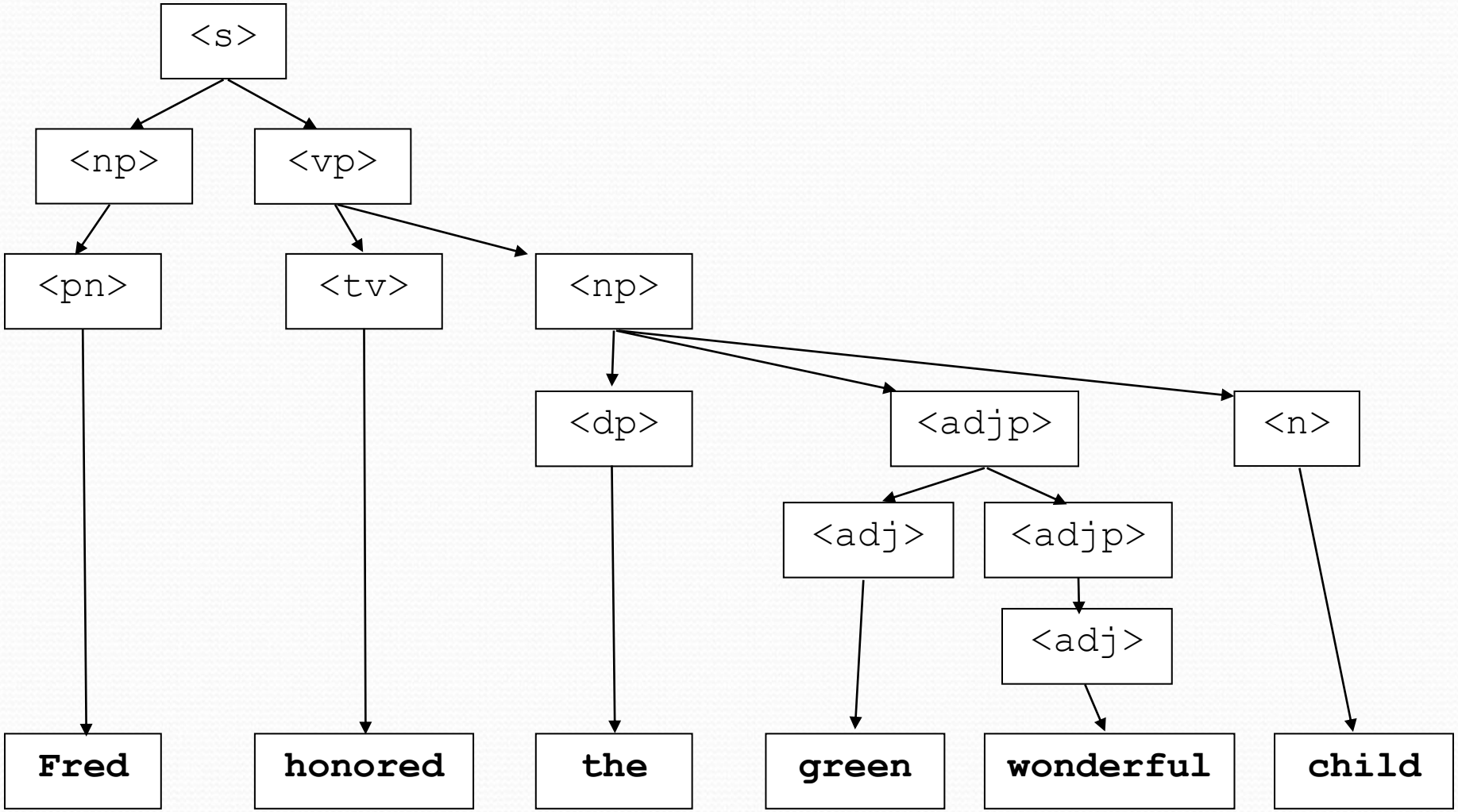
Languages and Grammars

Languages and grammars

- (formal) **language**: A set of words or symbols.

- **grammar**: A description of a language that describes which sequences of symbols are allowed in that language.
  - describes language *syntax* (rules) but not *semantics* (meaning)
  - can be used to generate strings from a language, or to determine whether a given string belongs to a given language

Sentence generation



Backus-Naur (BNF)

- **Backus-Naur Form (BNF)**: A syntax for describing language grammars in terms of transformation *rules*, of the form:

  <symbol> : : = **<expression>** | **<expression>** ... | **<expression>**

  - **terminal**: A fundamental symbol of the language.
  - **non-terminal**: A high-level symbol describing language syntax, which can be transformed into other non-terminal or terminal symbol(s) based on the rules of the grammar.

  - developed by two Turing-award-winning computer scientists in 1960 to describe their new ALGOL programming language

An example BNF grammar

```
<s>::=<n> <v>
<n>::=Marty | Allison | Stuart | Jessica
<v>::=cried | slept | belched
```

- Some sentences that could be generated from this grammar:

```
Marty slept
Jessica belched
Stuart cried
```

BNF grammar version 2

```
<s>::=<np> <v>
<np>::=<pn> | <dp> <n>
<pn>::=Marty | Allison | Stuart | Jessica
<dp>::=a | the
<n>::=ball | hamster | carrot | computer
<v>::=cried | slept | belched
```

- Some sentences that could be generated from this grammar:

```
the carrot cried
Jessica belched
a computer slept
```

BNF grammar version 3

```
<s>::=<np> <v>
<np>::=<pn> | <dp> <adj> <n>
<pn>::=Marty | Victoria | Stuart | Jessica
<dp>::=a | the
<adj>::=silly | invisible | loud | romantic
<n>::=ball | hamster | carrot | computer
<v>::=cried | slept | belched
```

- Some sentences that could be generated from this grammar:

```
the invisible carrot cried
Jessica belched
a computer slept
a romantic ball belched
```

Grammars and recursion

```
<s>::=<np> <v>
<np>::=<pn> | <dp> <adjp> <n>
<pn>::=Marty | Victoria | Stuart | Jessica
<dp>::=a | the
<adjp>::=<adj> <adjp> | <adj>
<adj>::=silly | invisible | loud | romantic
<n>::=ball | hamster | carrot | computer
<v>::=cried | slept | belched
```

- Grammar rules can be defined *recursively*, so that the expansion of a symbol can contain that same symbol.
  - There must also be expressions that expand the symbol into something non-recursive, so that the recursion eventually ends.

Grammar, final version

```
<s>::=<np> <vp>
<np>::=<dp> <adjp> <n>|<pn>
<dp>::=the|a
<adjp>::=<adj>|<adj> <adjp>
<adj>::=big|fat|green|wonderful|faulty|subliminal
<n>::=dog|cat|man|university|father|mother|child
<pn>::=John|Jane|Sally|Spot|Fred|Elmo
<vp>::=<tv> <np>|<iv>
<tv>::=hit|honored|kissed|helped
<iv>::=died|collapsed|laughed|wept
```

- Could this grammar generate the following sentences?

  `Fred honored the green wonderful child`

  `big Jane wept the fat man fat`

- Generate a random sentence using this grammar.