Adapting Our Design Recipe to Java

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`if` and Other Statements

- Java is a statement based language rather than an expression language.
- `if` statements are used to express explicit conditional control in most OO languages including Java. Note: **if** statements are used much less frequently in well-written OO code than they are in functional or procedural code.

An **if** statement has the following syntax:

```
if (test) statement
else statement
```

- What other forms of statements have we used implicitly up to this point?
  - Variable definition: `type var = expr;`
  - Return: `return expr;`

Method Definition Revisited

```
class Entry {
  /* fields */
  String name;
  String address;
  String phone;

  /** @return true iff name matches keyName.*/
  Entry match(String keyName) {
    if (keyName.equals(name)) return true;
    else return false;
  }
}
```

Reprise: the Design Recipe (Scheme)

How should I go about writing programs?

- Analyze problem, which includes:
  - defining any data types (and templates) that are not primitive;
  - determining what top-level (visible) functions must written.
- For each top-level function *f* to be written:
  - State contract (type signature) and purpose of *f*.
  - Give input-output examples for *f* written as tests
  - Select and instantiate a template for the function body. Code the function by filling in the template
  - Run the tests and confirm that they succeed.
- Writing a function may require help functions. Add these functions to the list of functions to be written. Use **`local`**? Perhaps.

The Design Recipe for Java

How should I go about writing programs?

- Analyze problem, which includes:
  - defining any classes ***C*** for data types that are not primitive;
  - determining what visible methods should appear in each class.
  - Write Javadoc contracts (purpose statements in HTDP terminology) for these methods
- For each visible method ***m*** in each class ***C***:
  - Write the header (type signature) and contract (purpose) for ***m***.
  - Create a test class for ***C*** (or the set of tightly coupled classes including ***C)*** if it does not already exist and write a test method for ***m*** that checks its behavior on representative inputs.
  - Select and instantiate a template for the method body.
  - Code the method by filling in the template.
  - Writing a method ***m*** may require help methods. Add these methods to the class ***C*** containing ***m***. Use **`private`**? Perhaps, but it makes testing less convenient (but not impossible).
- Run the tests and confirm that they succeed.

Note: recent versions of JUnit, the dominant testing framework for Java, allow tests to be embedded in any class, but placing tests in separate classes has some significant advantages (which can conceivably could be nullified by appropriate environment support. Separate test classes makes targeted testing easy.

Java Data Types

- Primitive types: `int long short byte double float char boolean`
- Important primitive operations discussed in monograph and lab. Written in conventional infix/prefix notatin following C conventions
- Object types
  - Organized in a strict hierarchy with `Object` at the top.
  - Every class ***C*** except `Object` has an immediate *superclass*, which is the parent of ***C*** in the hierarchy.
  - A descendant in the class hierarchy is called a *subclass*. ***B*** is a subclass of ***A*** iff ***A*** is a superclass of ***B***.
  - Subclassing implies subtyping and vice-versa: if ***B*** is a subclass of ***A***, then ***B*** is a subtype of ***A***. If class ***B*** is a subtype of class ***A***, then ***B*** is a subclass of ***A***
  - An object ***o*** is an instance of only one class but belongs to a hierarchy of types.
  - Each subclass ***C*** *inherits* (includes) all of the members of its superclass. Declared members of ***C*** augment the inherited members with *one exception*: if ***C*** declares a method **m** defined in the superclass, new definition *overrides* old.

OO style

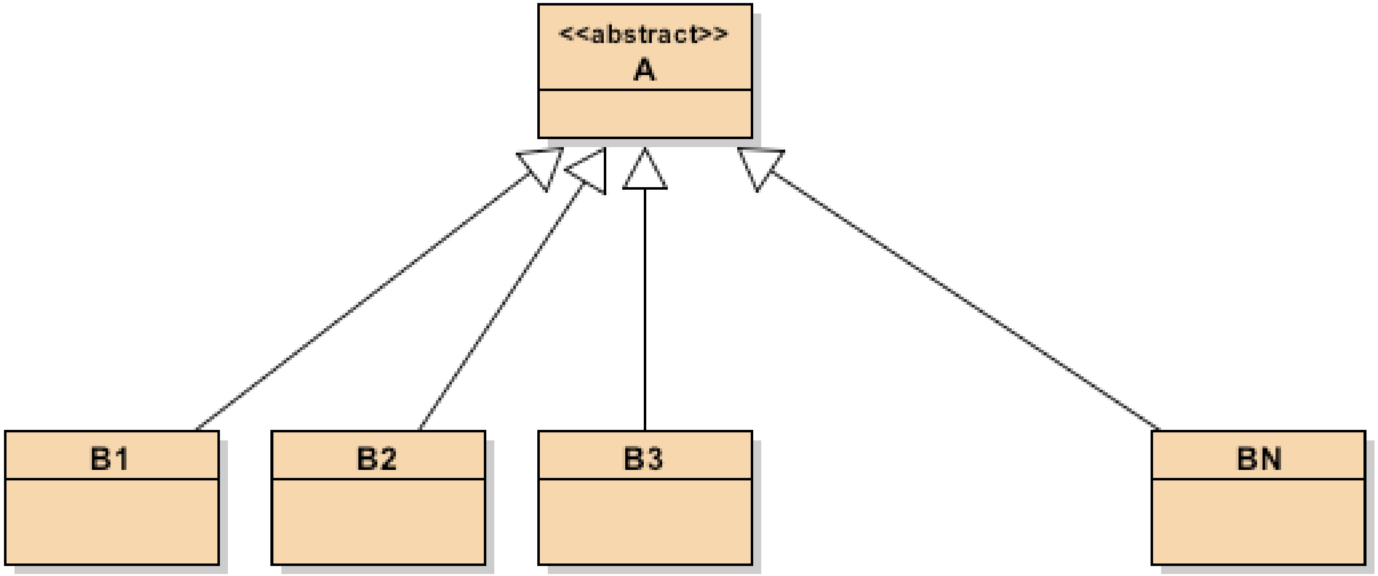
OO languages are designed to support writing programs in which *dynamic dispatch* is the principal control mechanism. Dynamic dispatch refers to the fact that in a method invocation ***o.m()***, the method code executed depends on the *class* of ***m***. Recall that the method ***m*** is conceptually part of the object ***o***. This idea is astonishingly powerful.

The essence of OO design is representing data and computations in a form that leverages dynamic dispatch.

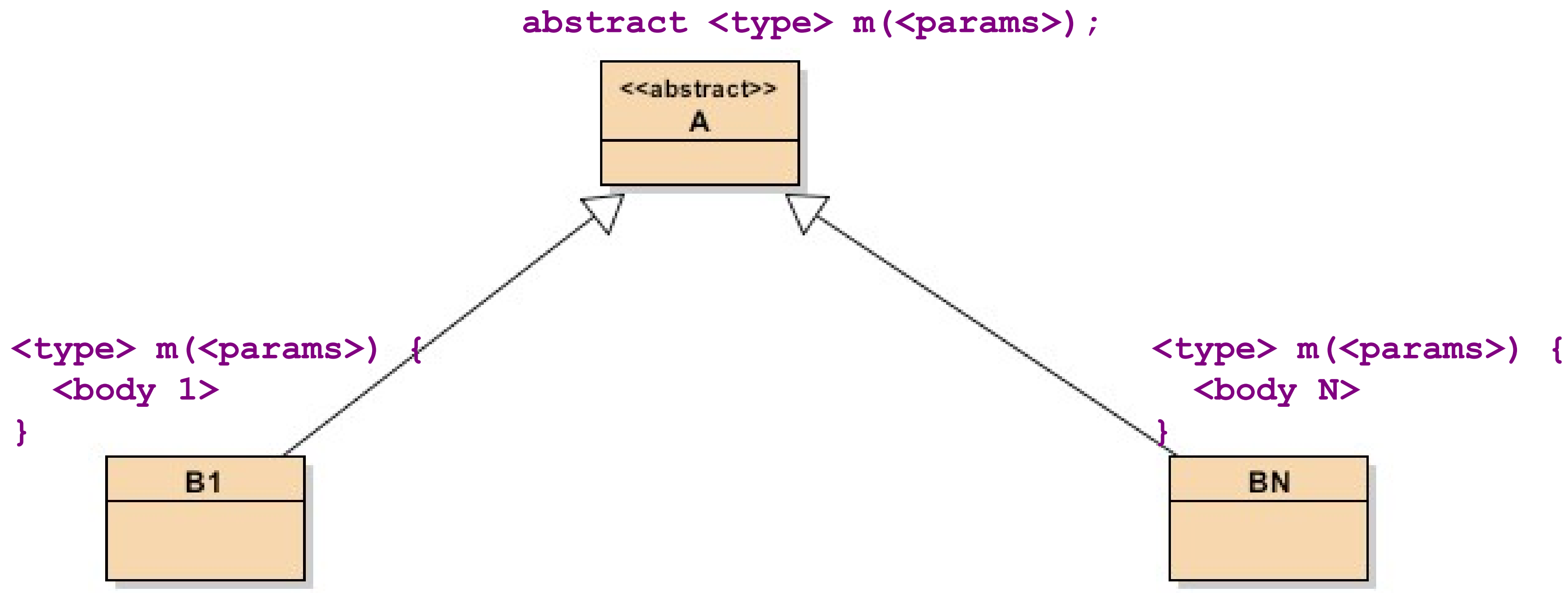
Union Pattern

- The *union pattern* is used to represent *different forms* of *related* data with some common behavior.
- The pattern consists of an **abstract** class A together with a collection of *variant* subclasses B_1, ..., B_N extending A. An **abstract** class cannot be instantiated using **new**. Note: if A is concrete then it is not the union of B_1, ..., B_N because A has additional members that are instances of A
- The collection of classes A, B_1, ..., B_N is called a union hierarchy and A is called the *root* class of the hierarchy.
- The common behavior is codified by a set of methods in A, which may be **abstract** Each such method m has an associated contract that that the implementation in each variant class must obey.

Class Diagram of Union Pattern



Defining a Method on a Union



City Directory Example

- Assume that we want to design the data for an online city phone book. In contrast to our **DeptDirectory** example, such a directory will contain several different kinds of listings: businesses, residences, and government agencies.
- The entry data for such a directory is represented by using the union pattern to identify the common behavior among the various kinds of listings.

Definition of `CityEntry`

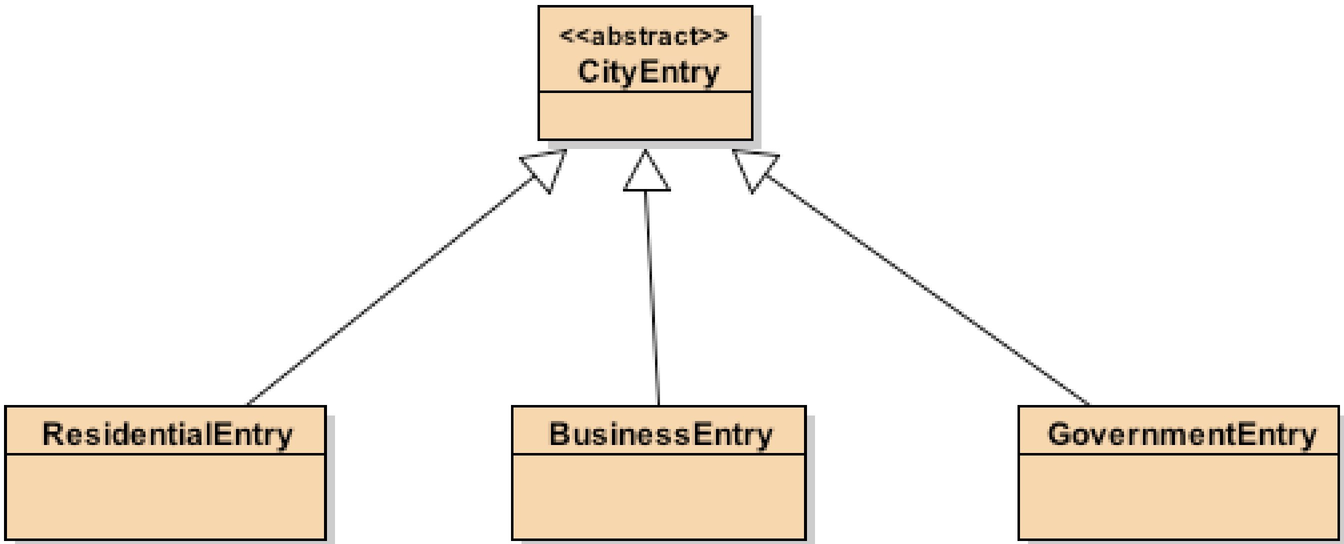
A `CityEntry` is either:

- a `ResidentialEntry(name, address, phone)`
- a `BusinessEntry(name, address, phone, city, state)`
- a `GovernmentEntry(name, address, phone, city, state, government)`

Examples:

```
ResidentialEntry("John Doe","3310 Underwood", "713-664-
   8809")
BusinessEntry("ToysRUs","2101 Old Spanish Trail",
   "713-664-1234","Houston", "TX")
GovernmentEntry("Federal Drug Administration",
   "800-666-9000", "Washington", "DC", "Federal")
```

Class Diagram of `CityEntry` Union



Crude Code for `CityEntry`

```
abstract class CityEntry { }

class BusinessEntry extends CityEntry {
  String name, address, phone, city, state;
}

class GovernmentEntry extends CityEntry {
  String name, address, phone, city, state, government;
}

class ResidentialEntry extends CityEntry {
  String name, address, phone;
}
```

Defining Methods on Unions

- Assume that we want to define a method on a union. The method will typically require a separate implementation for each variant (subclass) of the union. But each implementation will satisfy the same (description of behavior).
- In Java, the method must not only be defined in each variant of the union, it must be declared as **`abstract`** in the root class of the union hierarchy. Otherwise, Java will not allow the method to be invoked on objects of the union type.

Defined Method for **`CityEntry`**

- Let's illustrate the definition of a plausible method for **`CityEntry`** :

```
abstract class CityEntry {

  /** Returns true if key is a prefix of name. */
  abstract boolean nameStartsWith(String key);

}
```

Expanded Code for `CityEntry`

```
abstract class CityEntry {
  /** Returns true if key is a prefix of name. */
  abstract boolean nameStartsWith(String key);
}

class BusinessEntry extends CityEntry {
  String name, address, phone, city, state;
  boolean nameStartsWith(String key) { return name.startsWith(key); }
}
class GovernmentEntry extends CityEntry {
  String name, address, phone, city, state, government;
  boolean nameStartsWith(String key) { return name.startsWith(key); }
}
class ResidentialEntry extends CityEntry {
  String name, address, phone;
  boolean nameStartsWith(String key) { return name.startsWith(key); }
}
```

Member Hoisting

- In a union hierarchy, the same code may be repeated in every variant.
- A cardinal rule of software engineering is **never duplicate code**. We can eliminate code duplication in a union hierarchy by hoisting duplicated code (code that is *invariant* within the union) into the abstract class at the route of the hierarchy.

Revised Code for `CityEntry`

```
abstract class CityEntry {
 /* common fields */
 String name, address, phone;

  /** Returns true if key is a prefix of name. */
 boolean nameStartsWith(String key) { return name.startsWith(key); }
}

class BusinessEntry extends CityEntry {
  String city, state;
}
class GovernmentEntry extends CityEntry {
  String city, state, government;
}
class ResidentialEntry extends CityEntry { }
```

Usage Unchanged By Refactoring

```
CityEntry be = new BusinessEntry("ToysRUs", "2101 Old Spanish Trail",
                                 "713-664-1234","Houston", "TX");
CityEntry ge = new GovernmentEntry("Federal Drug Administration",
                    "800-666-9000", "Washington", "DC", "Federal");
CityEntry re = new ResidentialEntry("John Doe", "3310 Underwood",
                                    "713-664-8809");
boolean b = be.nameStartsWith("Toys"); // true
boolean g = ge.nameStartsWith("Drug"); // false
boolean r = re.nameStartsWith("J");    // true
```

For Next Class

- Exams and Optional Homework due Wednesday after break
- Reading: OO Design Notes, Ch 1.1 - 1.4.1.