- **Contracts and Abstraction**
- **Casts**
- **Checking a Type**
- **Interfaces**

Contracts

What is the contract for the **equals** method of **String**?

```
"hello".equals(...)
```

So far, we've pretended that it takes a **String** and produces a **boolean**

```
"hello".equals("bye") → false
"hello".equals(8)       contract mismatch
```

The truth is somewhat more complex:

```
"hello".equals(new Posn(1, 2)) → false
```

The Whole Truth

- The **`equals`** method takes an **`Object`** and returns a **`boolean`**
- Every class extends **`Object`**

```
class Posn {
  double x;
  ...
}
```

is a shorthand for

```
class Posn extends Object {
  double x;
  ...
}
```

- The **`equals`** method is defined in **`Object`**

The Default Equals Method

```
class Object {
  ...
  boolean equals(Object o) {
    return o == this;
  }
}
```

where **==** is like **eq?** in Scheme

Using Object for Abstraction

In Scheme, we eventually wrote abstractions for lists:

```
; A list-of-X is either
;   - empty
;   - (cons X list-of-X)
```

A precise translation to a Java-like notation:

```
abstract class ListOf<X> { }
class EmptyListOf<X> { ... }
class ConsListOf<X> {
  <X> first;
  ListOf<X> rest;
  ...
}

new ConsListOf<String>("apple", ...)
```

But Java doesn't support this, *yet*

Using Object for Abstraction

In Scheme, we eventually wrote abstractions for lists:

```
; A list-of-X is either
;    - empty
;    - (cons X list-of-X)
```

A usable translation to Java:

```
abstract class List { }
class Empty { ... }
class Cons {
  Object first;
  List rest;
  ...
}

new Cons("apple", ...)
```

Object Lists

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```
abstract class List {
  abstract boolean isMember(Object o);
}

class Empty extends List {
  Empty() { }
  boolean isMember(Object o) { return false; }
}

class Cons extends List {
  Object first;
  List rest;
  Cons(Object first, List rest) {
   this.first = first; this.rest = rest;
  }
  boolean isMember(Object o) {
    return this.first.equals(o) || this.rest.isMember(o);
  }
}
```

Extracting Objects

- Implement the `List` method `nth`, which takes a number *n* and returns the first item in the list after skipping *n* items, or an empty list if no items are left

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Using Extracted Objects

```
new Cons(new Posn(1, 2), new Empty()).nth(0)
→ Posn(x = 1,y = 2)
```

```
new Cons(new Posn(1, 2), new Empty()).nth(0).x
```
contract error

The contract error occurs becuase `nth` promises merely to return an `Object`, not necessarily a `Posn`

Java provides a way around this weakness in the contract system...

Casts

A ***cast*** is a dynamic request for an improved contract

General syntax:

```
(Class)expr
```

The parentheses are required

Examples:

```
(Posn)(new Cons(new Posn(1, 2), new Empty()).nth(0))

Path escapePath(Person p) {
  Path lp = this.left.escapePath(p);
  if (lp.isOk())
    return new Left((Success)lp);
  ...
}
```

Using A Cast to implement equals

A problem with **Posn**:

```
new Posn(1, 2).equals(new Posn(1, 2))
→ false
```

To fix this, we need to override **equals**:

```
class Posn {
  double x;
  double y;
  Posn(double x, double y) {
    this.x = x; this.y = y;
  }
  boolean equals(Object o) {
    return (this.x == ((Posn)o).x)
           && (this.y == ((Posn)o).y);
  }
}
```

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Checking Types

A remaining problem:

```
"hello".equals(new Posn(1, 2)) → false
new Posn(1, 2).equals("hello") → cast failed
```

Our **`equals`** should only cast if the argument really is a **`Posn`**

The **`instanceof`** operator tests whether a cast will succeed

```
boolean equals(Object o) {
  if (o instanceof Posn)
    return (this.x == ((Posn)o).x)
           && (this.y == ((Posn)o).y);
  else
    return false;
}
```

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Using instanceof

The **`instanceof`** operator is only in **Advanced Java** because it's rarely the right way to implement something

Example bad use:

```
class Cons extends List {
  ...
  boolean isMember(Object o) {
    if (this.first.equals(o))
      return true;
    else if (this.rest instanceof Empty)
      return false;
   ...
  }
}
```

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Named Doors

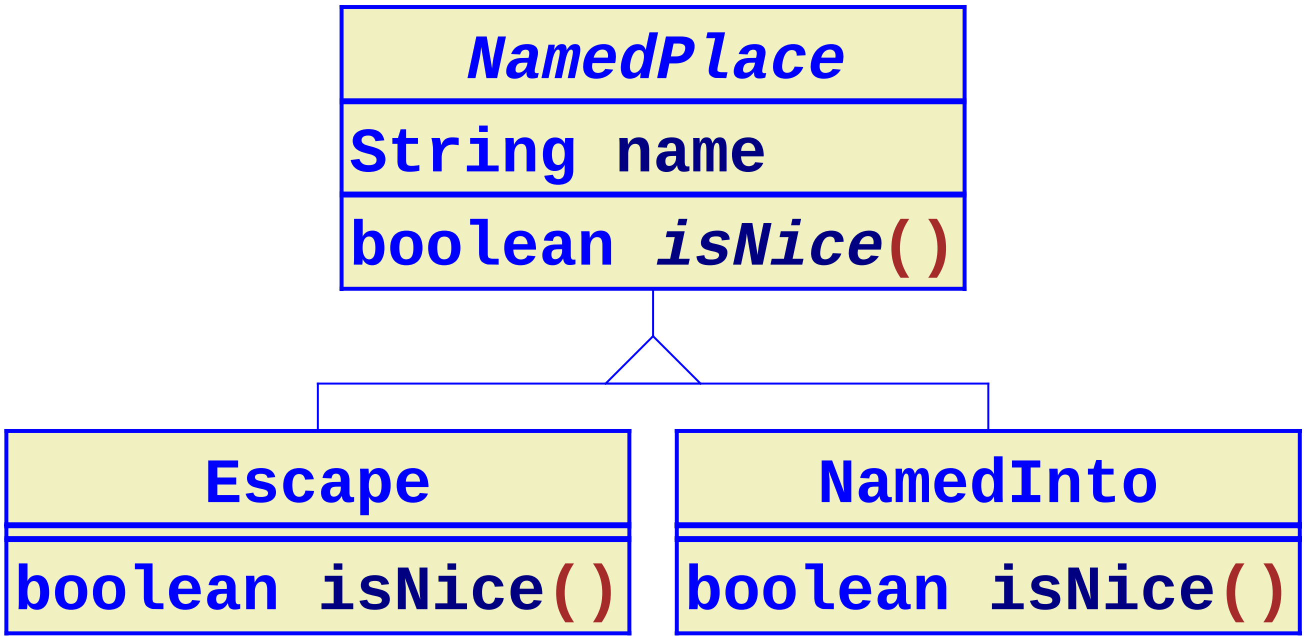
Suppose that we want to make the following improvements to our maze game:

- Some doors will have names
- We want to get all of the named places in a maze, including both escapes and named doors
- We'll need certain methods on named places, such as **`isNice`**
- We don't want to add named-place methods to all doors
- We refuse to use **`instanceof`**

```
abstract class Door {
  ...
  abstract List places();
}
```

A NamedPlace Abstract Class

Like this?



`NamedPlace` can't be an abstract class, because **`Escape`** already extends **`Door`**, and **`NamedInto`** should extend **`Into`**

A class must extend exactly one class

However, **`NamedPlace`** can be an interface...

Interface

An ***interface*** is like an **`abstract class`** with no fields and all abstract methods

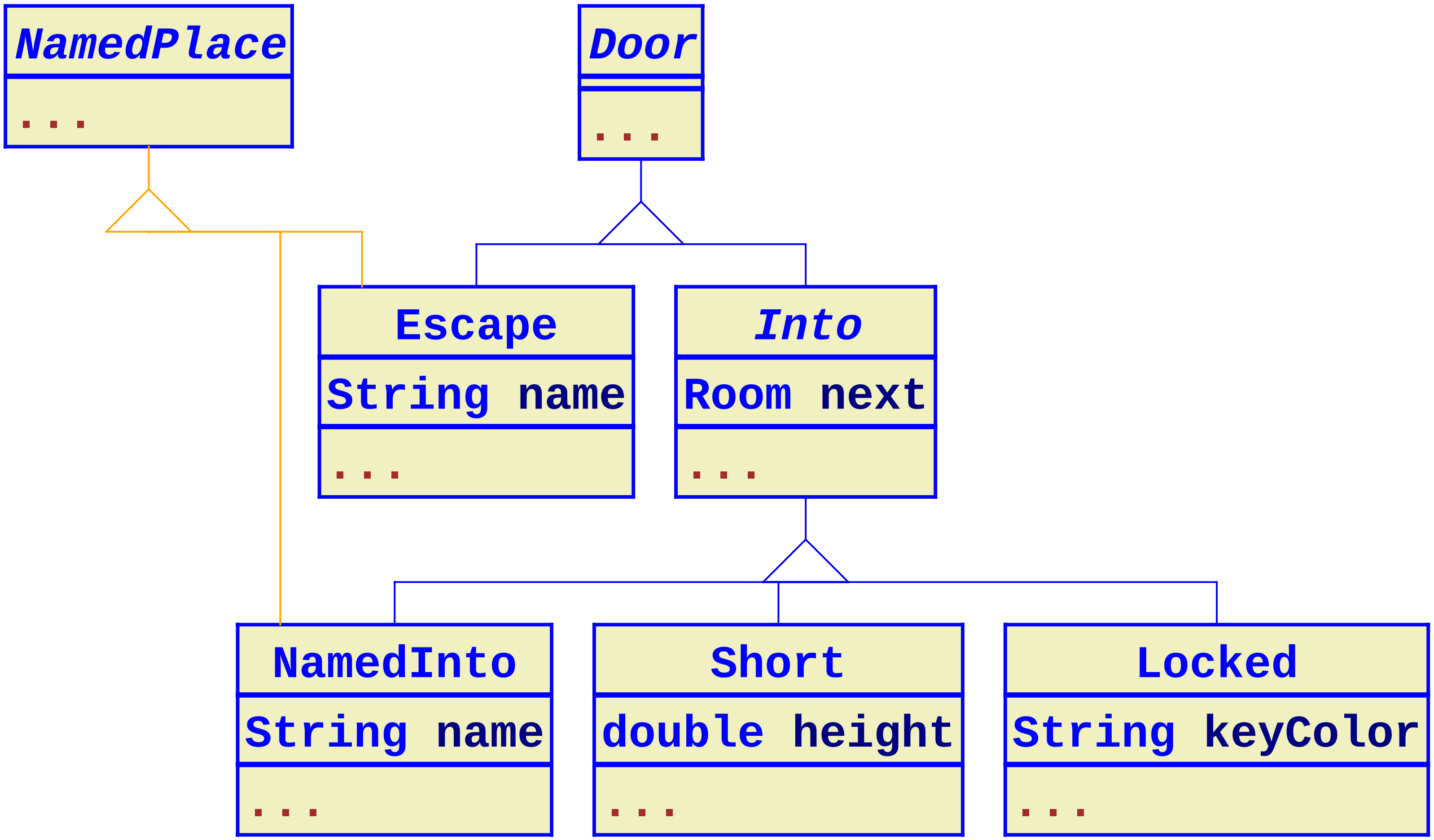
```
interface NamedPlace {
  boolean isNice();
}
```

Instead of **`extend`**ing an interface, classes **`implement`** it

```
class Escape extends Door implements NamedPlace {
  ...
  boolean isNice() { return true; }
}

class NamedInto extends Into implements NamedPlace {
 ...
  boolean isNice() { return false; }
}
```

Door Hierarchy with Interfaces



Single vs. Multiple, Implementation vs. Interface

A class must extend only one class

- This is ***single inheritance*** of ***implementation***

A class interface can implement any number of interfaces

- This is ***multiple inheritance*** of ***interface***