cture #8: Object-Oriented Mechanisms

cture: the bare mechanics of "object-oriented programming."

topic is: Writing software that operates on many kinds

Overloading

to get System.out.print(x) to print x, regardless of

r Python, one function can take an argument of any type,
t the type (if needed).

hods specify a single type of argument.

ion: *overloading*—multiple method definitions with the
nd different numbers or types of arguments.

out has type java.io.PrintStream, which defines

```
n()  Prints new line.
n(String s)  Prints S.
n(boolean b)  Prints "true" or "false"
n(char c)  Prints single character
n(int i)  Prints I in decimal
```

e is a different function. Compiler decides which to call
of arguments' types.

Generic Data Structures

to get a "list of anything" or "array of anything"?

blem in Scheme or Python.

lists (such as IntList) and arrays have a single type of

ort answer: any *reference* value can *cast* as (converted
ect and back, so we can use Object as the "generic
type":

```
ings = new Object[2];
 new IntList(3, null);
 "Stuff";
ngsList = (IntList) things[0];  // A cast to IntList
ntList) things[0]).head and thingsList.head == 3;
ring) things[1]).startsWith("St") is true
].head               Illegal
].startsWith("St")  Illegal
```

nce casts don't change the value of a pointer, but rather
iler how to treat it.

And Primitive Values?

ues (ints, longs, bytes, shorts, floats, doubles, chars,
) are not really convertible to Object.

roblem for "list of anything."

oduced a set of *wrapper types*, one for each primitive

ef.	Prim.	Ref.	Prim.	Ref.
yte	short	Short	int	Integer
ong	char	Character	boolean	Boolean
oat	double	Double		

ate new wrapper objects for any value (*boxing*):

```
hree = new Integer(3);
reeObj = Three;
```

sa (*unboxing*):

```
 = Three.intValue();
```


Autoboxing

xing are automatic (in many cases):

```
ee = 3;
 Three;
hree + 3;

omeInts = { 1, 2, 3 };
 someInts) {
out.println(x);

println(someInts[0]);
s Integer 1, but NOT unboxed.
```

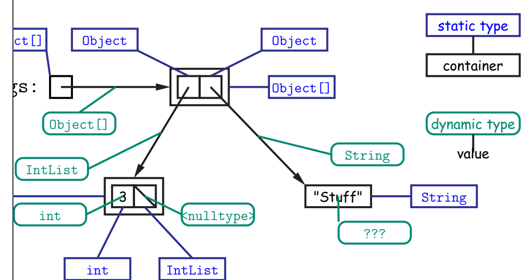

Dynamic vs. Static Types

has a type—its *dynamic type.*

ner (variable, component, parameter), literal, function
rator expression (e.g. x+y) has a type—its *static type*.

very *expression* has a static type.

```
gs = new Object[2];
ew IntList(3, null);
Stuff";
```



Type Hierarchies

with (static) type T may contain a certain value only if
s a" T—that is, if the (dynamic) type of the value is a
T. Likewise, a function with return type T may return
hat are subtypes of T.

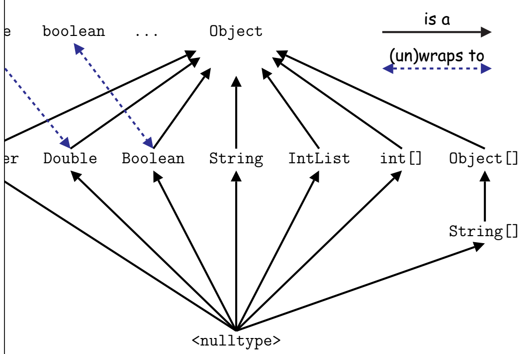
are subtypes of themselves (& that's all for primitive

types form a *type hierarchy;* some are subtypes of

is a subtype of all reference types.

nce types are subtypes of `Object`.

a Library Type Hierarchy (Partial)



The Basic Static Type Rule

gned so that any expression of (static) type T always
that "is a" T.

are "known to the compiler," because you declare them,

```
        // Static type of field
t s)  { // Static type of call to f, and of parameter
        // Static type of local variable
```

re-declared by the language (like 3).

sts that in an assignment, `L = E`, or function call, `f(E)`,

```
SomeType L) { ... },
```

pe must be a subtype of L's static type for reference

ere static-type requirements for other operations: E
array type in `E[i]`; actual parameters must have subtypes
al parameters,

Primitive Types and Coercions

es live outside the hierarchy of reference types.

values of type `short`, for example, are a subset of
, we *don't* say that `short` is a subtype of `int`, because
ite behave the same.

ues of type `short` can be *coerced* (converted) to a value
using the same cast syntax as for reference types:

```
 = (short) 3002;
= 10000L;
 (int) y;
= 1000000000000L;
 (int) q;
out.println(r);  // Prints -727379968 (?????)
```

s of `r` shows, coercions of primitive types, unlike those
types, are computations that can change values.

Automatic Coercions, Promotions

cions, such converting from `short` to `int`, are considered
therefore intrusive.

age silently coerces "smaller" integer types to larger
o `double`, and integer types to `float` or `double`.

lled *promotions*.

the compiler can obviously tell what the value of an **int**
will convert integer literals to shorter integer types if
t:

```
 = 127;
y = -1024;
 = 0x0398;     // ☹
```


quences of Compiler's "Sanity Checks"

conservative rules. The last line of the following, which
ink is perfectly sensible, is illegal:

```
ew int[2];
A; // All references are Objects
   // Static type of A is array...
   // But not of x: ERROR
```

ures that not every `Object` is an array.

know that `x` contains array value!?

till must tell the compiler, like this:

```
) x)[i+1] = 1;
```

type of cast `(T) E` is T.

isn't an array value, or is null?

ve have runtime errors—exceptions.

Overriding and Extension

- far is clumsy.
- Object variable x contains a String, why can't I write,
h("this")?
- th is only defined on Strings, not on all Objects, so the
t sure it makes sense, unless you cast.
- eration *were* defined on all Objects, then you *wouldn't*
casting.
- oString() is defined on all Objects. You can always say
) if x has a reference type.
- .toString() function is not very useful; on an IntList,
e string like "IntList@2f6684"
- ubtype of Object, you may *override* the default definition.

Overriding toString

- , if s is a String, s.toString() is the identity function
).
- you define, you may supply your own definition. For
ntList, could add

```
 // Compiler checks that Object really has a toString.
ng toString() {
uffer b = new StringBuffer();
d("[");
tList L = this; L != null; L = L.tail)
ppend(" " + L.head);
d("]");
b.toString();
```

- IntList(3, new IntList(4, null)), then x.toString()
- , various operations requirihg Strings call .toString()
or an IntList x, you can write:

```
 " + x   System.out.println(x)   System.out.printf("%s", x);
```


Extending a Class

- class B is a direct subtype of class A (or A is a *direct*
f B), write

```
 extends A { ... }
```

- lass ... extends java.lang.Object.
- *inherits* all fields and methods of its direct superclass
them along to any of its subtypes).
- u may *override* an instance method (*not* a static method),
a new definition with same *signature* (name, return
nt types).
- **Rule of Instance Method Calls:**

is an instance method, then the call x.f(...) *calls
overriding of* f *applies to the dynamic type of* x,
s of the static type of x.

Illustration

```
class Worker {
  void work() {
    collectPay();
  }
}
```

```
ds Worker {       | class TA extends Worker {
rk()              |   void work() {
                  |     while (true) {
                  |       doLab(); discuss(); officeHour();
                  |     }
                  |   }
                  | }
```

```
Prof();      | paul.work()  ==> collectPay();
TA();        | daniel.work()  ==> doLab(); discuss(); ...
aul,         | wPaul.work() ==> collectPay();
 daniel;     | wDaniel.work() ==> doLab(); discuss(); ...
```

stance methods (only), select method based on *dynamic*
state, but we'll see it has profound consequences.

t About Fields and Static Methods?

```
                      class Child extends Parent {
                        String x = "no";
 1;                     static String y = "way";
) {                     static void f() {
printf("Ahem!%n");        System.out.printf("I wanna!%n");
                        }
nt x) {               }
```

```
ew Child();  | tom.x    ==> no       pTom.x    ==> 0
tom;         | tom.y    ==> way      pTom.y    ==> 1
             | tom.f()  ==> I wanna! pTom.f()  ==> Ahem!
             | tom.f(1) ==> 2        pTom.f(1) ==> 2
```

hide inherited fields of same name; static methods
f the same signature.
ding causes confusion; so understand it, but don't do it!

What's the Point?

- sm described here allows us to define a kind of *generic*
- s can define a set of operations (methods) that are
any different classes.
- an then provide different implementations of these
hods, each specialized in some way.
- s will have at least the methods listed by the superclass.
- write methods that operate on the superclass, they will
work for all subclasses with no extra work.