

EECS2030 Fall 2021

Additional Notes

Static Types, Expectations, Dynamic Types, and Type Casts

CHEN-WEI WANG

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1 Inheritance Hierarchy

Consider the following definitions of Java classes

<pre>class A { int a; A() {} }</pre>	<pre>class B extends A { int b; B() {} }</pre>	<pre>class C extends A { int c; C() {} }</pre>	<pre>class D extends C { int d; D() {} }</pre>
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which form the class hierarchy as shown in Figure 1:

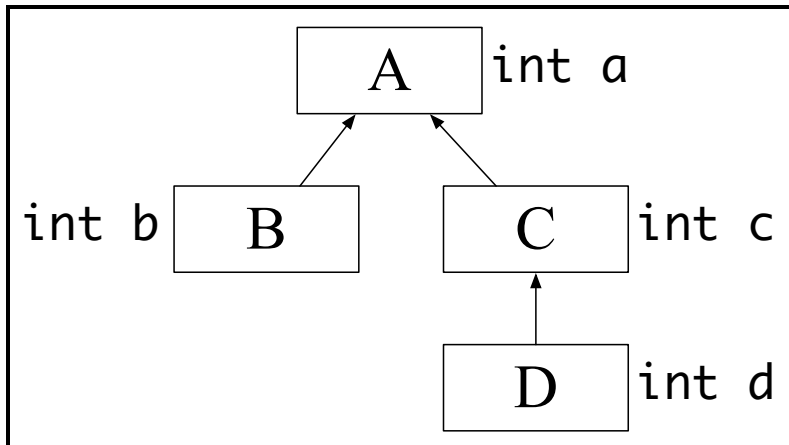


Figure 1: Class Inheritance Hierarchy

2 Static Types Define Expected Usages

Consider the following line of Java code, declaring class **C** as the type of a reference variable **oc**:

```
C oc;
```

After the above declaration, we say that **C** is the *static type* of variable **oc**. The static type of variable **oc** constrains that, at runtime, **oc** stores the address of some **C** object. Consequently, only attributes and methods that are defined and inherited in class **C** are expected to be called via **oc** as the context object:

- **oc.a**
- **oc.c**

Recall that a class only inherits code (i.e., attributes and methods) from its ancestor classes. Therefore, it is **not** expected to call **oc.b** (: class **B** is not an ancestor class of **C**), and **not** expected to call **oc.d** (: class **D** is actually a child class of **C**).

From the inheritance hierarchy in Figure 1 (page 1), we have the following expectations for variables of the various types:

DECLARATION	EXPECTATIONS
A oa;	oa.a
B ob;	ob.a ob.b
C oc;	oc.a oc.c
D od;	od.a od.c od.d

Figure 2: Declarations of Static Types and Expectations

3 Dynamic Types

Because a reference variable's static type defines its expected usages at runtime, that variable's **dynamic type must be consistent with the expectations**. As an example, the following assignments are not valid:

```
1 C oc1 = new A();  
2 C oc2 = new B();
```

Both of the above assignments are not valid:

- For **Line 1**, if we allowed **oc1** to point to an **A** object (which only possesses the attribute **a**), then one of the expectations of **oc**, which is **oc.c** (see Figure 2), would not be met.
- Similarly, for **Line 2**, if we allowed **oc2** to point to a **B** object (which possesses attributes **a** and **b**), then one of the expectations of **oc**, which is **oc.c** (see Figure 2), would not be met.

Instead, the following assignments are valid:

```
C oc3 = new C();  
C oc4 = new D();
```

In the above assignments, the expectations of static type `C` can be met by dynamic types `C` and `D`, which are both descendant classes of `C`.

4 Creating an Alias with a Different Static Type via a Cast

Always remember:

- To judge if a line of Java code **compiles** or not, you **only** need to consider the static types of the variables involved (Section 4.1).
- To judge if a line of compilable Java code causes an exception at **runtime**, you need to then consider the dynamic types of the variable involved (Section 4.2).

4.1 Does a Cast Compile?

Principles:

- Casting a reference variable does not change its static type. Instead, the cast creates an alias whose static type matches the **cast type**.
- A reference variable may be cast to any class that is either a descendant or an ancestor class of that variable's declared static type.
- Casting a reference variable to a descendant class allows a **wider** range of expectations (∵ a class' descendant class contains at least as many attributes and methods as does that class).
- Symmetrically, casting a reference variable to a ancestor class of its allows a **narrower** range of expectations.

For example, given a variable `oc` whose declared static type is `C`, the following casts are compilable:

1. `(D) oc`

Since `D` is a descendant class of `oc`'s static type (`C`), performing this cast allows a **wider** range of expectations: we can now expect `((D) oc).d`, whereas `oc.d` cannot be expected.

2. `(C) oc`

Since `C` is both a descendant and an ancestor class of `oc`'s static type (`C`), performing this cast results in the same expectations: `((C) oc).a` and `((C) oc).c`.

3. `(A) oc`

Since `A` is an ancestor class of `oc`'s static type (`C`), performing this cast allows a **narrower** range of expectations: we can no longer expect `((A) oc).c`, but only `((A) oc).a` can be expected.

On the other hand, the following cast does not compile:

- `(B) oc`

This cast does not compile because **B** is neither a descendant nor an ancestor class of **oc**'s static type (**C**).

The above example is summarized in Figure 3.

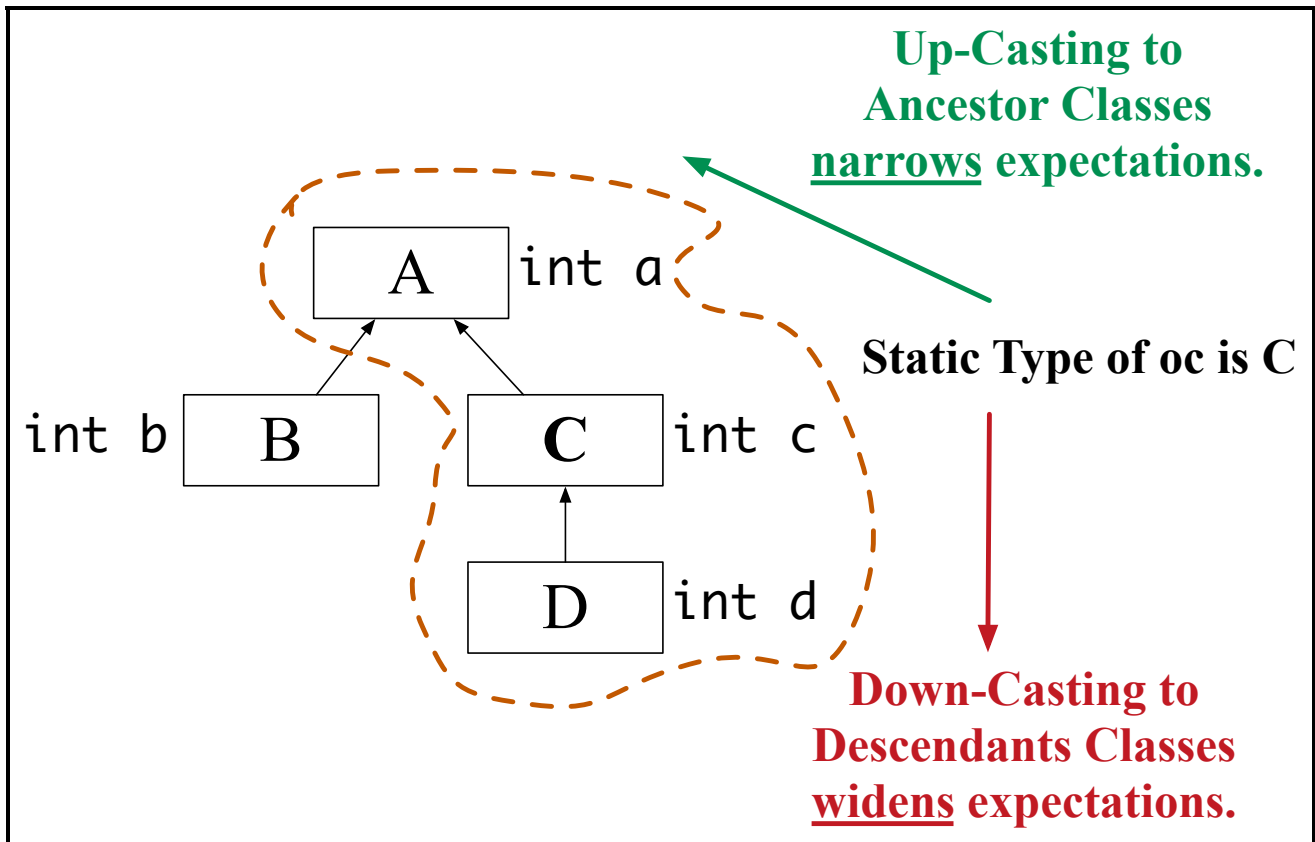


Figure 3: Compilable Casts Given **oc**'s Static Type is **C**

4.2 Does a (Compilable) Cast Cause a **ClassCastException** at Runtime?

Consider the following line of Java code

```
A oa = new C();
```

which declares variable **oa**'s static type as **A** and initializes its **dynamic type** as **C**. According to the principle in Section 4.1, we know that the following casts (where each class being cast into is either a descendant class or an ancestor class of **oa**'s static type, i.e., **A**) are compilable:

- (A) **oa**
- (B) **oa**
- (C) **oa**
- (D) **oa**

However, **a cast being compilable does not mean that it will not result in error at runtime.** To determine if there will be a **runtime** error or not, we need to also consider **oa**'s **dynamic type** (i.e., **C**):

- (A) oa

You can use a C object as if it were an A object. This is because A only expects a, whereas C provides a and c.

- (B) oa

You cannot use a C object as if it were a B object. This is because B expects both a and b, but attribute b is not declare in class C.

- (C) oa

You can use a C object as if it were a C object. This is because C has the same expectations as itself.

- (D) oa

You cannot use a C object as if it were a D object. This is because D expects both a, c, and d, but attribute d is not declare in class C.

The above example is summarized in Figure 4.

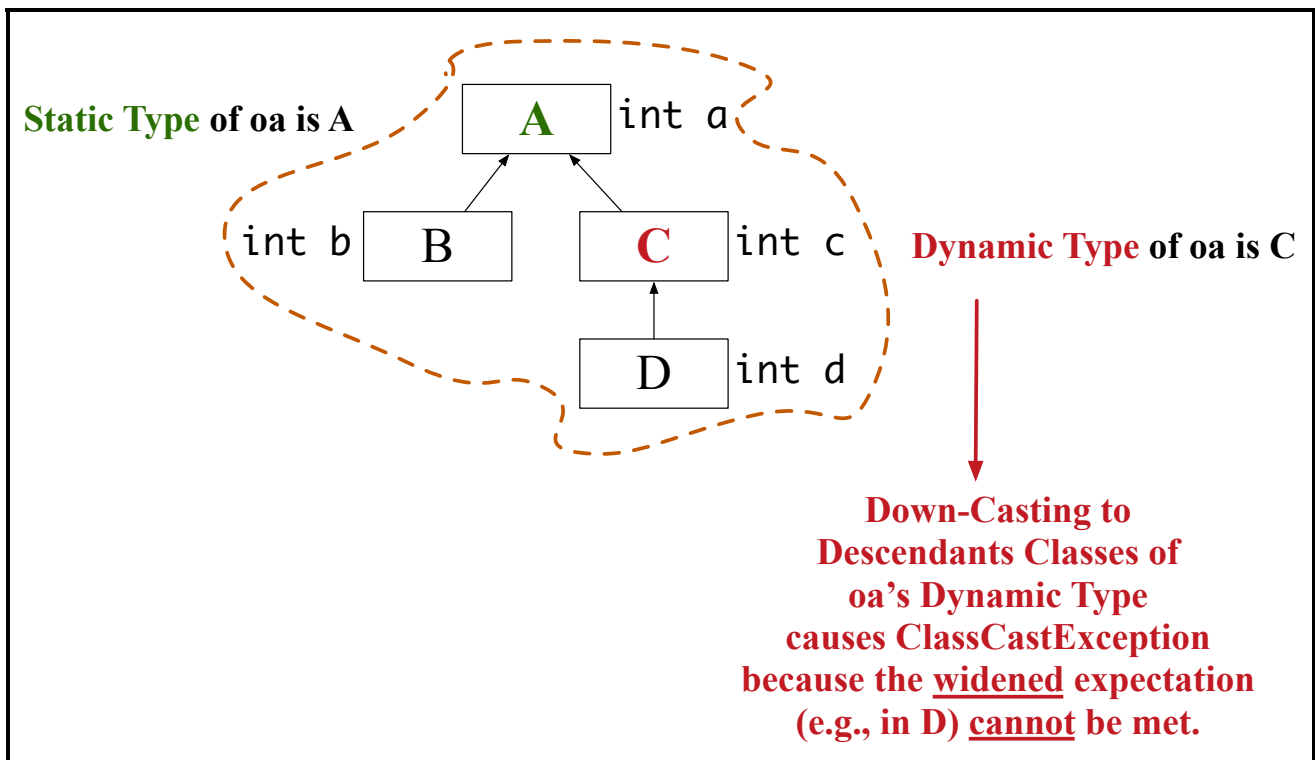


Figure 4: Compilable but Exceptional Casts Given oa's Static Type is A and Dynamic Types is C

Again, at runtime there is a **ClassCastException** when the **dynamic type** cannot meet the expectations of the reference variable, determined by either its **declared static type** or **temporary static type** resulted from a `cast`.