Subclassing

• In many ways, OOP is “all about” subclasses overriding methods
  – Often not what you want, but what makes OOP fundamentally different from, say, functional programming (Scheme, ML, Haskell, etc., cf. CSE413)

• C++ gives you lots more options than Java with different defaults, so it’s easy to scream “compiler bug” when you mean “I’m using the wrong feature”…
Subclassing in C++

• Basic subclassing:
  
  ```
  class D : public C { ... }
  ```

• This is *public inheritance*; C++ has other kinds too (won’t cover)
  – Differences affect visibility and issues when you have multiple superclasses (won’t cover)
  – So **do not forget** the `public` keyword
More on subclassing

• Not all classes have superclasses (unlike Java with Object)
  – (and classes can have multiple superclasses — more general and complexity-prone than Java)
• Terminology
  – Java (and others): “superclass” and “subclass”
  – C++ (and others): “base class” and “derived class”
• Our example code: House derives from Land which derives from Property (read the code, no time for detailed presentation)
• As in Java, can add fields/methods/constructors, and override methods
Constructor and destructors

- Constructor of base class gets called before constructor of derived class
  - Default (zero-arg) constructor unless you specify a different one after the : in the constructor
  - Initializer syntax:
    ```cpp
    Foo::Foo(...): Bar(args); it(x) { ... }
    ```
    - Needed to execute superclass constructor with arguments; also works on instance variables and is preferred in production code (slogan: “initialization preferred over assignment”)
- Destructor of base class gets called after destructor of derived class
- So constructors/destructors really extend rather than override, since that is typically what you want
  - Java is the same
Method overriding, part 1

• If a derived class defines a method with the same method name and argument types as one defined in the base class (perhaps because of an ancestor), it overrides (i.e., replaces) rather than extends.

• If you want to use the base-class code, you specify the base class when making a method call (\texttt{class::method(...)})
  – Like \texttt{super} in Java (no such keyword in C++ since there may be multiple inheritance).

• Warning: the title of this slide is \textit{part 1}
Casting and subtyping

• An object of a derived class cannot be cast to an object of a base class.
  – For the same reason a struct T1 {int x,y,z;} cannot be cast to type struct T2 {int x, y;}
    (different size)
• A pointer to an object of a derived class can be cast to a pointer to an object of a base class.
  – For the same reason a struct T1* can be cast to type struct T2* (pointers to a location in memory)
    – (Story not so simple with multiple inheritance)
• After such an upcast, field-access works fine (prefix), but what do method calls mean in the presence of overriding?
An important example

class A {
public:
    void m1() { cout << "a1"; }
    virtual void m2() { cout << "a2"; }
};
class B : public A {
    void m1() { cout << "b1"; }
    void m2() { cout << "b2"; }
};
void f() {
    A* x = new B();
    x->m1();
    x->m2();
}
In words…

• A non-virtual method-call is *resolved* using the (compile-time) type of the *receiver* expression

• A virtual method-call is *resolved* using the (run-time) class of the *receiver object* (what the expression evaluates to)
  – Like in Java
  – Called “dynamic dispatch”

• A method-call is virtual if the method called is marked *virtual* or overrides a virtual method
  – So “one virtual” somewhere up the base-class chain is enough, but it’s probably better style to repeat it
More on two method-call rules

• For software-engineering, virtual and non-virtual each have advantages:
  – Non-virtual – can look at the code to know what you’re calling (even if subclass defines the same function)
  – Virtual – easier to extend code already written
• The implementations are the same and different:
  – Same: Methods just become functions with one extra argument `this` (pointer to receiver)
  – Different:
    • Non-virtual: linker can plug in code pointer
    • Virtual: At run-time, look up code pointer via “secret field” in the object
Destructors revisited

class B : public A { ... }
...
B * b = new B();
A * a = b;
delete a;

• Will B::~B() get called (before A::~A())?
• Only if A::~A() was declared virtual
  – Rule of thumb: Declare destructors virtual; usually what you want
Downcasts

Old news:
• C pointer-casts: unchecked; better know what you are doing
• Java: checked; may raise `ClassCastException` (checks “secret field”)

New news:
• C++ has “all the above” (several different kinds of casts)
• If you use single-inheritance and know what you are doing, the C-style casts (same pointer, assume more about what is pointed to) should work fine for downcasts
• Worth learning about the differences on your own
Pure virtual methods

A C++ “pure virtual” method is like a Java “abstract” method.
• Some subclass must override because there is no definition in base class
• Makes sense with dynamic dispatch
• Unlike Java, no need/way to mark the class specially
• Funny syntax in base class; override as usual:
  ```cpp
class C {
    virtual t0 m(t1,t2,...,tn) = 0;
    ...
};
```
• Side-comment: with multiple inheritance and pure-virtual methods, no need for a separate notion of Java-style interfaces
C++ summary

• Lots of new syntax and gotchas, but just a few new concepts:
  – Objects vs. pointers to objects
  – Destructors
  – virtual vs. non-virtual
  – pass-by-reference
  – Plus all the stuff we didn’t get to, especially templates, exceptions, and operator overloading.
  – Later (if time): why objects are better than code-pointers – coding up object-like idioms in C