CPSC 427a: Object-Oriented Programming

Michael J. Fischer

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Interacting Classes and UML (continued)

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Interacting Classes and UML (continued)

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Association Relationship

The **association** relationship can be diverse. Some developers label text describing the relationship on the edge connecting two associated classes.

Later in the course we will explore and see more examples.

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Accessing B in A's methods

Access patterns:

- parameter, local variable, or return has type B/B&/B*
- a method in A accesses B's data members: B::var or b.var
- a method in A invokes B's methods: B::func() or b.func()
- indirect: c.b.func()

If A knows B only through parameter or local variables, we also say that A **uses** B. The **use** relationship is generally considered to be a weak relationship.

"Law" of Consistency/Encapsulation

Relation of B::var or b.var in A is typically not recommended because it violates encapsulation and may lead to inconsistent state.

Why is the design below not desirable?

```
class SpeedDataCollection{
...
// add a new data value
public void addValue(int speed);
// return average speed
public double averageSoFar;
...
```

};

Limiting coupling between classes

Chaining such as c.b.func() is typically not recommended as it increases coupling.

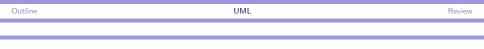
For example, assume class A has a data member Dog* dog. One way to ask the dog object to move is dog->leg()->walk(). But this is less desirable than calling dog->walk().

In OO design, this is called the **"Law" of Demeter**, also called **"Law" of Least Knowledge**:

"the method of a class should not depend on any way on the structure of any class, except the immediate (top-level) structure of its own class."

This principle has other names such as **Delegation** and **Do not** talk to Strangers.

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"Law" of Demeter

Formally, the "Law" of Demeter for functions requires that a method M of an object A may only invoke the methods of the following kinds of objects:

- A itself
- M's parameters
- any objects created/instantiated within M
- A's direct component objects
- ▶ a global variable, accessible by A, in the scope of M

One can consider layered architecture of many systems (e.g., the layered network architecture) as following this design guideline.

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Goals of OO Programming

- Efficient reusable code
- Modularity and code isolation
- Modeling tool
- Large-scale software construction
- Safe and reliable code

Insertion sort example

- Illustrates use of class to build a sortable collection of data (DataPack).
- Example of multifile program: main.cpp, datapack.hpp, datapack.cpp.
- Shows use of dynamic memory management paradigm, where constructor allocates and destructor deletes.
- Illustrates use of inline and out-of-line functions.
- Example of how to manage persistent data—realize an internal data structure from a file.
- Poor man's example of a generic collection (using typedef instead of templates).
- Visibility, data hiding, and const.

Compiling and linking

Stages of compilation:

- Each . cpp file is run through the preprocessor, which processes the #-directives.
- The result is compiled to a .o object file.
- The .o files are linked together with the libraries to form an executable file.

Compiler errors

Errors produced at each stage:

- Preprocessor errors: Missing #include files, mismatched #ifndf...#endif pairs, etc.
- Compilation errors: Syntax, semantics, missing/erroneous declarations. Sometimes the file produced by the preprocessor and seen by the compiler is not what the programmer intended.
- Linker errors are generally methods that were declared but never defined, often because of mismatched signatures.
 Duplicate definitions from different modules also detected here, e.g., multiple definitions of main().

Tool set

- ▶ valgrind
- ▶ make
- ▶ eclipse
- ▶ g++

What does each of these tools do? When should they be used?

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C++ goodies

- Operator extensions.
- Adding new methods to a function.
- Member functions and implicit argument; this.
- Supplying comparison function for sort using operator extension instead of functional parameter.

Stream I/O

- Opening and closing streams.
- Testing for successful open.
- Reading data from streams.
- Writing data to streams.
- Manipulators.
- End-of-file and error handling.

Functions and methods

- Passing parameters to functions
- Passing results back from functions
- Parameter types and calling mechanisms
- When to use which parameter type
- The implicit argument

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Variables and data

- Parts of a variable: name, type, storage register.
- Simple variables: declaration, initialization, assignment.
- L-values and R-values.
- Reference values ("pointers") and pointer variables.
- Creating and following pointers.
- References: types, uses, comparison with pointers.

BarGraph demo

- ► Illustrates tightly-coupled classes (Row and Cell).
- Example of aggregated data member (Row::head, Cell::Item).
- Illustrates use of class-type data items (type Item) in an array (Graph::bar).
- Illustrates use of delegation (e.g., Graph::print()).
- Illustrates private nested class definition (in file rowNest.hpp).

More on variables

Properties

- sizeof operator.
- Visibility of variables.
- Lifetime of variables.
- Anonymous variables.
- Storage classes: auto, static, dynamic.
- How to use static variables.
- Assignment and copying
 - Shallow and deep copies.
 - Aliasing.

Five kinds of memory errors

- 1. **Memory leak**—Dynamic storage that is no longer accessible but has not been deallocated.
- 2. Amnesia—Storage values that mysteriously disappear.
- 3. **Bus error**—Program crashes because of an attempt to access non-existent memory.
- Segmentation fault—Program crashes because of an attempt to access memory not allocated to your process.
- 5. Waiting for eternity—Program is in a permanent wait state or an infinite loop.

C++ bells and whistles

- Optional parameters and overloading
- const variables
- const parameters
- const implicit variables
- Operator extensions

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Derivation

Derived classes

- Base class, derived class, syntax.
- Purpose.
- Overriding data and function members.
- Construction and initialization.
- Ctors.
- Destruction.
- Structure of a derived class instance.
- Copy constructors.
- Referencing data and function members in the base class and in the derived class.

Polymorphic derivation

- Polymorphic pointers.
- Virtual functions.
- Runtime type tags and vtables.
- Virtual destructors.
- Pure virtual functions.
- Abstract classes.
- Visibility keywords: public, protected, private.
- ▶ Kinds of derivation: public, protected, private.
- Visibility rules.
- Declaration context and reference context: inside and outside references.
- Inaccessible base class.