Some Object-Oriented Design Principles

Naming Conventions

- Some of these have standard names, and some I just made up.
- I'll let you figure out which is which, if it matters.

Uniform Access Principle

- The interface for getting information from an object should be the same regardless of whether the information is:
  - stored, vs.
  - computed
- Related idea: Information hiding

UAP Corollary

- Don't allow public access to data members.

Centralization Principle

- Don't implement the same functionality in more than one place.
- Corollary: Don't cut-and-paste code.

Open/Closed Principle
(Robert C. Martin)

- Classes should be both "open" and "closed":
  - Open: means that the class can be **extended** through inheritance.
  - Closed: means that the functionality of a class, once set, should not be modified retroactively.
- In other words, add functionality by inheriting by new code, not rewriting existing code.

Liskov Substitution Principle (LSP)

As popularly stated:

A member of a derived class must also make sense when used as a member of the base class.

For example, if a method has an object of a class as an argument, the same method should be able to work with an object of a derived class.

As originally stated:

Let $\varphi(x)$ be a property provable about objects x of type T.
Then $\varphi(y)$ should be true for objects y of type S, where S is a subtype of T.

B. Liskov and J. Wing, A behavioral notion of subtyping, ACM TOPLAS, **16**, 6 (Nov. 1994), 1811-1841.

(Prof. Barbara Liskov, M.I.T.)

Clarification

- LSP applies to **behavioral**, rather than structural, properties of objects

LSP **Corollary**
(Robert C. Martin)

- Functions that use *pointers* or *references* to base classes must be able to use objects of derived classes **without differentiation** of whether the referenced object is base vs. derived.

Impact of LSP

- We should not have to make special-cases of behaviors of derived methods.

  This would be an indication that they are not behaving like members of the parent class; maybe rethink this membership.

Thought Questions

- Suppose we have a class RealValuedFunction and a sub-class DifferentiableFunction. Where should the method getDerivative() be placed?

- Should a class Bird have a method FlyDistance()?

- Suppose we have a class Year.
  Should we have a subclass LeapYear?

Thought Questions

- Should class Square be derived from class Rectangle; or vice-versa?

- Suppose we have a class FacultyMember, which has methods

  hire()

  fire()

  Should we have a sub-class TenuredFacultyMember?

Thought Questions

- Suppose we have two kinds of Employee:

  Agent

  LotAttendant

  Should both of these be classes extending a common base class: Employee?

- For more discussion of this kind:
  http://alistair.cockburn.us/crystal/articles/cdos/constructivedesconstructionofsubtyping.htm

Dependency-Inversion Principle (Robert C. Martin)

- **Details should depend on abstractions; abstractions should not depend on details.**
- High-level modules should not depend on low-level modules; both should depend on abstractions.
- In other words, don't let low-level modules "call the shots" for high-level ones. The high-level ones are where policies should be set.
- Succinctly: ***Specify the interface first***, then implement.

More Named Principles (1)

(cf. http://c2.com/cgi/wiki?PrinciplesOfObjectOrientedDesign)

- **The Interface Segregation Principle**: Having many client specific interfaces is better than having one general purpose interface.
- **The Reuse/Release Equivalency Principle**: The granule of reuse is the same as the granule of release. Only components that are released through a tracking system can be effectively reused.
- **The Common Reuse Principle**: Classes that aren't reused together should not be grouped together.
- **The Common Closure Principle**: Classes that change together, belong together.

More Named Principles

(cf. http://c2.com/cgi/wiki?PrinciplesOfObjectOrientedDesign)

- **The Acyclic Dependencies Principle**: The dependency structure for released components should be a directed acyclic graph.
- **The Stable Dependencies Principle**: Dependencies between released categories must run in the direction of stability. The dependee should be more stable than the depender.
- **The Stable Abstractions Principle**: The more stable a class category is, the more it should consist of abstract classes. A completely stable category should consist of nothing but abstract classes.

Law of Demeter

Law of Demeter

- This law seems generally worthwhile.
- It is not without controversy and difficulties in understanding, cf. http://c2.com/cgi/wiki?LawOfDemeterIsHardToUnderstand
- Therefore it should not be followed slavishly, but neither should it be ignored.

Law of Demeter (LoD)
colloquial version

- "Only talk to your immediate friends".
- [not meaning *friends* in the sense of C++ classes and methods]
- so named by Prof. Karl Lieberherr, Northeastern University:
- LoD home page:
  http://www.cs.neu.edu/home/lieber/LoD.html

Law of Demeter Principle as stated by its author

- Each unit [i.e. class, method] should only use a limited set of other units: only units "closely" related to the current unit.

- Main Motivation: Control information overload. We can only keep a limited set of items in our short-term memory.

- Secondary Motivation: maintainability: A class should not have to know much about distant classes.

Rumbaugh, Booch and the LoD

Rumbaugh: "Avoid traversing multiple links or methods. **A method should have limited knowledge of an object model.** A method must be able to traverse links to obtain its neighbors and must be able to call operations on them, but it should not traverse a second link from the neighbor to a third class."

Booch: "The basic effect of applying this Law is the creation of **loosely coupled classes**, whose implementation secrets are **encapsulated**. Such classes are fairly unencumbered, meaning that to understand the meaning of one class, you need not understand the details of many other classes."

LoD: More Specific OO Interpretation

- An object should only invoke methods of:
  - objects that are ***declared*** within the object's class
  - objects that are ***parameters*** *of the method*
  - ***itself***
  - objects that it ***creates***

- mnemonic DPIC ("depict")

Precluded by LoD

- Do not extract object B from an object A and perform an operation on it.

- Instead, **recast** what you want to do as an operation on A. That operation may call operations on B.

Example of Violating the Law of Demeter

- class Patron
  {
  void sendNotice();
  }

```
library.getBook("Ulysses").getBorrower().sendOverdueNotice();
```

- class Book
  {
  Patron getBorrower();
  };

The above statement is considered bad:
The client of library has to *know about* books and borrowers just to send this notice.

- class Library
  {
  map<Book> booksByTitle;

  Book getBook(string Title);
  };

Remedying the Violation

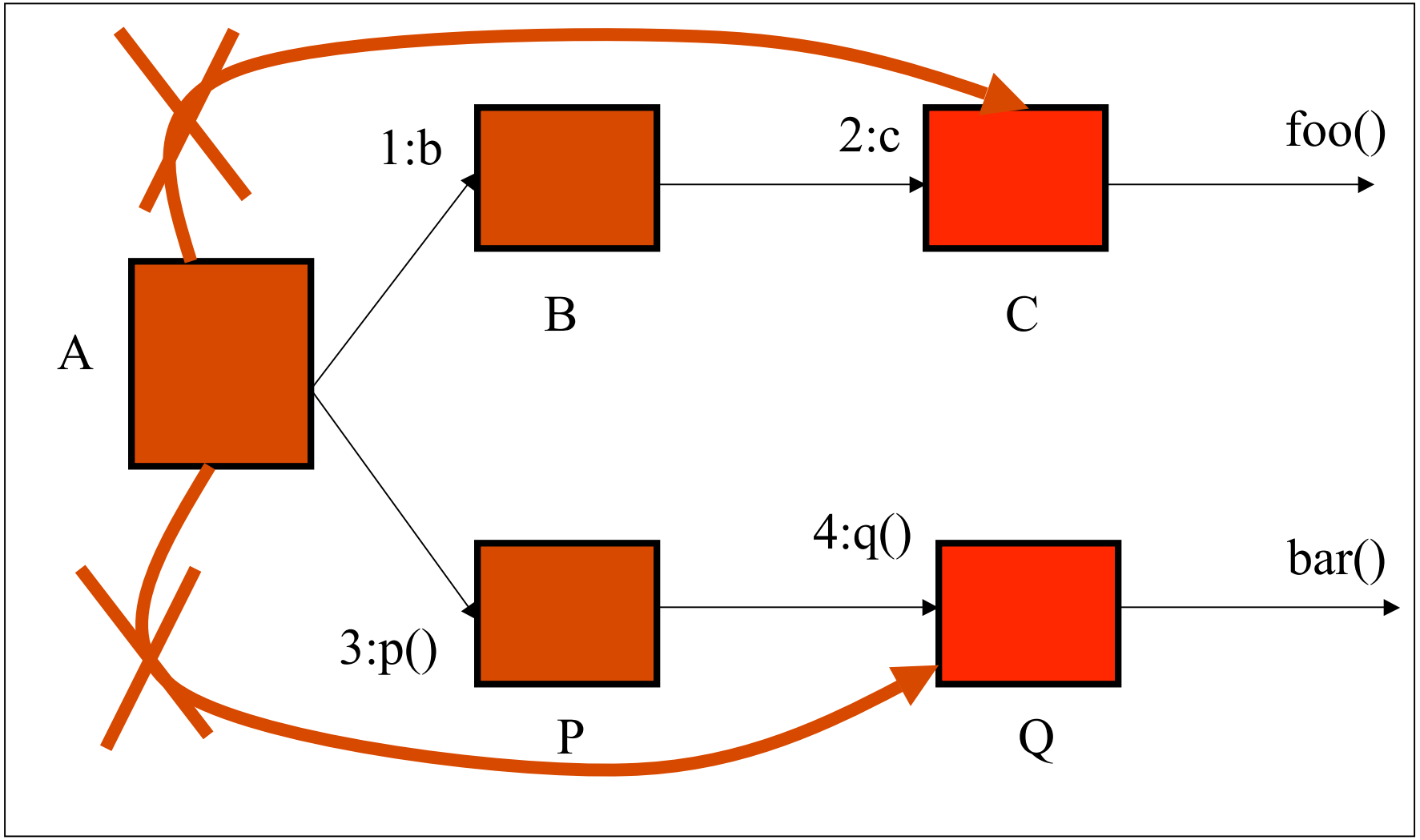
- class Library
  {
  map<Book> booksByTitle;

  void sendOverdueNotice(string Title);
  };

library.sendOverdueNotice(“Ulysses”);

Violations: Dataflow Diagram

(slide from Lieberherr)



More on Following the LoD

- General idea: Keep the structure as **loose** as possible (known as "late binding" in conventional system design).

- Specific incarnations:

  "Adaptive Plug-and-Play Components" (Liberherr)

Further Guidelines
related to LoD
will be seen when we
discuss "Design Patterns"

Related Hot Topic

- Aspect-Oriented Programming
  - Program implementation is sliced up by "aspects" which tend to **cut across** class boundaries.
  - Aspects are addressed separately in programming, the **woven** together with a weaver, using "**join points**".
- *Aspect-Oriented Programming*, Gregor Kiczales, et al., Xerox PARC, 1997

Example of Aspects

- For a mail-order company
  - Ordering aspect
  - Customer service aspect
  - Shipping aspect
  - Inventory aspect
  - Pricing aspect
  - Marketing aspect
  - Accounting aspect
  - Shareholder aspect
- These aspects can largely be treated separately in an enterprise application, yet they have various *join points* at specific products, customers, etc.