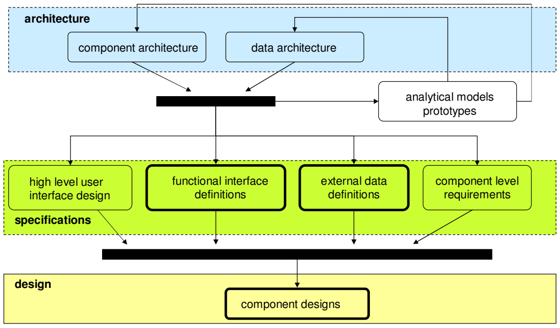
Component Level Design

- Components and Specifications
- Packages and Classes
  - elements of good class design
  - classes in non object oriented languages
  - elements of good packaging
- Routines
  - elements of good routine design
  - representing routine designs

Model Hierarchy/Succession



What is a “component”?

- A modular, deployable, and replaceable part of a system, that encapsulates implementation, and exposes a set of interfaces.
  - it is a defined piece of a larger system
  - it can be added or removed from that system (not necessarily a **F**ield **R**eplaceable **U**nit)
  - it contributes to the working of the system
  - its inner mechanisms may be hidden
  - its functionality is defined by an interface

Component Specifications

“The definition of what a program is expected to do”

- a description of a component's function
  - usually, in terms of its output values
    - for specified input values
    - under specified preconditions.
- this is different from
  - system requirements (focus on component)
  - system architecture (more complete)
  - component design (what, not how)

When to create a new class

- provide needed objects
  - obvious objects from the problem domain
- provide better behaved objects
  - kinder, gentler versions of real objects
- make applications more stable & portable
  - isolating implementation specifics in a class
  - abstraction protects app from future evolution
- compartmentalize complexity
  - bring all related code into a single place
  - simplify interface seen by rest of system

Characteristics of a good class

- it is well abstracted
- it is cohesive
- it exhibits good information hiding
- Other principles are tests of goodness
  - Open/Closed principle
    - open for extension, closed for modification
  - Liskov Substitution principle
    - derived sub-class can substitute for its parent
  - Dependency Inversion Principle
    - depend on abstraction – not implementation

OO Languages and Design

- OO languages provide valuable features
  - mechanisms to support class inheritance
  - mechanisms to encourage information hiding
  - explicit support for interface polymorphism
  - automatic object instantiation
- these help us design better software
  - organizing our designs into modular classes
  - consciously decide what is public/private
  - encourage us to reuse common components

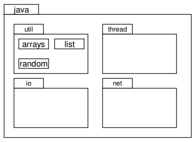
Classes in non-OO languages

- the basic principles of good design
  - apply to all software: C, FORTRAN, asm, perl
- <u>any module</u>, in <u>any language</u>, should
  - implement a general and intuitive “class”
  - export a well abstracted interface to that class
  - be cohesive with respect to that class
  - employ good information hiding
  - be usable, w/o change, for many purposes
  - be organized/grouped with related modules

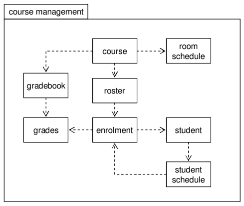
“Program <u>into</u> your language, not <u>in</u> it.”

UML Package Contents

Package Nesting



Contained Classes



Class Packages

- some classes make sense in isolation
  - stacks, queues, strings, input files
- some classes naturally come in groups
  - courses, rosters, programs, grades
- a <u>package</u> is a collection of classes
  - that is aggregated together into a group
  - that are added and removed as a group
- some OO languages support packages
  - not the same as install-time packages

Class Packaging Principles

- Release/Reuse Equivalency Principle

  “the granule of reuse is the granule of release”
  (keep your packages <u>cohesive</u>)

  if someone only needs classes A and B, don’t
  force him to take the unrelated class C as well.
- Common Closure Principle

  “classes that change together travel together”
  (avoid strong <u>inter-package coupling</u>)

  if changes to class A regularly break class B,
  deliver both of them in a single package.

Component Specification vs. Design

- Component/Class Specification
  - creates (relatively) fixed interfaces
  - is driven by encapsulation and abstraction
  - views every component as a black box
- Component/Class Implementation Design
  - very few things are ever cast in concrete
  - the public/private distinction becomes weaker
  - the user/implementer distinction vanishes
  - <u>what</u> routines do becomes a mere detail
  - <u>how</u> the component works is everything

Where do <u>routines</u> come from?

- many are already defined for us
  - our public methods (external entry points)
- some emerge naturally from our approach
  - just as ADTs emerge from problem domain
  - some methods and functions will be obvious
  - easier to specify because they are <u>private</u>
- many (most?) are artifacts of our solution
  - we create them to simplify the implementation
  - routines can do this in many ways

Why create a new routine?

- creating useful <u>private</u> classes
  - create better abstractions to work with
  - we may even derive private sub-classes
- detail encapsulation
  - move complex sequences out of main code
  - segregate portable from non-portable code
  - hide/wrap global data structures
- centralize a recurring computation
  - one copy of an oft-repeated code sequence
  - enable interception of key operations

elements of good routines

- simplicity and clarity
  - obvious what routine does, how to use it
- good abstraction is still important
  - a well thought out function is easier to use
- information hiding is still important
  - avoid shared data, distributed algorithms
  - interactions mean complexity and bugs
  - encapsulate nasty details within a routine
- cohesion is still valuable
  - shorter routines are easier to understand

Routine Level Designs

- all routines are not simple
  - many embody complex algorithms
  - many cases to handle, many decisions
- such designs must be put in writing
  - help designer flesh out, record the design
  - present design to others for review
  - basis for implementation, white-box testing
- such designs can still be high level
  - they need not spell out simple/obvious steps

Representing Routine Designs

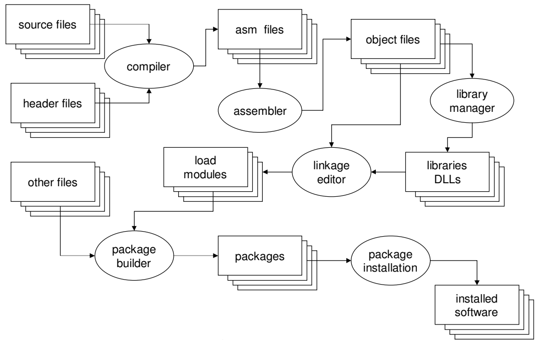
- there are many possible representations
  - prose: e.g. pseudo-code
  - graphical: e.g. UML activity or state diagrams
  - tabular: enumerating cases and handling
  - formal: e.g. Object Constraint Language
- none is intrinsically superior to the others
  - but each has advantages for some problems
  - some may have development tool support
- Choose one that makes sense
  - but, “when in Rome, do as the Romans do”

Mid-Term Exam

- Format
  - closed book, 12 question
- Scope
  - entirely based on key learning objectives (L1-15)
  - primarily (3/4) focused on <u>issues</u> and <u>concepts</u>
  - less (1/4) focus on <u>representations</u> and <u>techniques</u>
- Difficulty
  - 3 simple similar to quiz questions
  - 6 moderate similar to in-class discussion points
  - 3 moderate questions, not discussed in class
  - I prepared the answer sheet in about 30 minutes

Supplementary Slides

Whense all these components?


source files
header files
other files
compiler
asm files
assembler
object files
library manager
libraries DLLs
linkage editor
load modules
package builder
packages
package installation
installed software

Pseudo Code

```
If local request
        find the record
else
        do remote
if error
        return failure

create new transaction
        including record
return transaction ID

find record:
        hash the key
        run down the chain
        if end of chain
                allocate new record
                label with this key
        return record pointer

do remote:
        allocate request
        fill it out
        try 3x til response
                set timeout
                send request
                await response
        extract completion info
        if successful
                allocate new record
                insert into cache
                return record pointer
        else
                translate error
                return error
```

macros

#define BoundsCheck(s,x,y,z)

{if (x<y || x>z) log_error(“bounds”,s)}

- compile-time functions
  - expanded at compile time, duplicated code
- advantages
  - can be changed by compile time options
  - faster, no procedure calls, stack maintenance
- disadvantages
  - multiple copies, take up more space
  - can’t have local storage (static or dynamic)