About domain “controllers”

- Not usually a domain concept
  - Added to the model during design
- They tie the system to external events
  - e.g., classes a GUI will know about
- Common types:
  - Façade controller – represents whole system, overall business, “world” – e.g., an application coordinator
  - Role controller – mimics a real-world role
  - Use case controller – handles sequences of events, monitors use case progress
    - e.g., setEnabled(false) in Swing – means not ready yet

Interaction diagrams

- Dynamic views of interacting objects
  - Starts by system event (external message)
  - Receiving object either handles alone, or passes message along (internal messages)
    - Links in diagrams indicate visibility between classes
- Why bother diagramming?
  - Easier to change drawing than code
  - Get big picture – better design, code, system
- Do together with class diagrams/specifications
- 2 basic types: sequence and communication

Sequence diagrams

- Use for simpler interactions – sequence easily shown as top-to-bottom interactions

Communication diagrams

- Handy for more complicated interactions – show sequences by numbering the interactions

Notation for interactions

- Class vs. instance –
  - Sale – class name for static methods only
    - mySale:Sale – object name:type for other
- Messages – shown along link line
  - Must number in communication diagram
  - Show parameters too (with optional types)
    - And return values if not void
      - e.g., 1.1: items:count():int
- Iteration – use * and optional [iteration clause]
  - e.g., 3*: [i=1..10]li:=item(i):LineItem

More notation for interactions

- Conditions – [condition:boolean]
  - e.g., 1:[new sale]create() \rightarrow \text{POST} \rightarrow \text{Sale}
  - See fig. 15.30 (p. 244) for mutually exclusive conditions
- Use “stack” icon for multi-objects (collections)
  - Note: message may be to the collection object itself (e.g., a list), or to the individual elements if *
- Show algorithms as notes (dog-ear symbol)
  - But only need if tricky or otherwise relevant
Design principles

- Not exactly “rules” – things to consider
  - Should lead to high quality designs
    - Easier to maintain, understand, reuse, and extend
  - e.g., expert, low coupling, high cohesion, do-it-myself
- Note: Larman labels some as “patterns”
  - General Responsibility Assignment Software Patterns
    - Larman: assigning responsibilities = “desert island skill”
    - Also notes: “one person’s pattern is another’s primitive building block”
    - “Design patterns” usually are more specific

The expert principle

- Assign responsibility to class that has the necessary information
  - i.e., the “information expert”
- Avoids passing info between objects
- Still have collaboration as objects help others
  - e.g., Sale knows about all LineItems, and LineItems know quantity (and get price from Specs)
    - So let Lineitem calculate subtotal!
    - Sale accumulates total from subtotals
- Main benefit: encapsulation maintained
  - Easier to program, maintain, extend independently

Low coupling

- Minimize dependencies between classes
  - Note how expert principle does this too
    - e.g., Sale does not contact ProductSpecification directly – LineItem does that instead; otherwise, Sale needs parallel collection of ProductSpecifications
- So fundamental it influences all design decisions
  - Is an “evaluative” pattern – used to rate design quality
- Supports independent classes
  - More reusable, less subject to changes elsewhere, easier to program, …

High cohesion

- Refers to functional cohesion
  - Means no class does too much work – especially not a bunch of unrelated things
  - Basically should avoid “bloated” classes
    - Hard to understand, maintain, reuse, …
    - Usually means other classes should take some responsibilities
      - Like an overworked manager – should delegate more
  - Rule of thumb: insure all parts of a class are somehow related – all attributes and operations
    - Working together to provide “well-bounded behavior”
  - Benefits – the usual list, plus greater simplicity

Events, states, and transitions

- Event – a significant occurrence
  - e.g., telephone receiver taken “off hook”
- State – condition of an object at a moment in time (the time between events)
  - e.g., telephone “idle” between being placed on hook and taken off hook
- Transition – relationship between two states as an event occurs
  - e.g., when “off hook” event occurs, transition from “idle” to “active” state

Statechart diagrams

- Purpose: to model the changing states of complex objects
Utility of statechart diagrams

- Normally not useful for internal events
  - Internal event – caused by an object inside the system boundary
  - Because interaction diagrams already cover it
- Useful for system as a whole
  - Especially to model changing system states during the course of a use case
    - Larman calls it a use case statechart diagram
- Note: many prior CS 50 students discovered this usefulness on their own
  - This quarter, we ask all of you to consider them

A use case statechart diagram

- Helps designer insure things are done in the correct order
- Other notation: transition actions, guards, nested states – see text figures 29.2 and 29.3 (pp. 489-90)

More GRASP principles

- Polymorphism – if behavior varies by type
  - Assign responsibility for the variation to the types
    - Do not test for type or use other conditional logic!
- Indirection – to reduce coupling
  - Assign responsibility to intermediate class or interface
- Pure fabrication – artificial, non-domain class
  - Assign cohesive set of responsibilities to a fabrication
- Protected variations – for variable/unstable parts
  - Assign responsibilities to stable interfaces

Software realities

- Do-it-myself principle (a.k.a., animation pattern)
  - Objects must do for themselves what normally is done to the real world objects they represent
    - e.g., in real world, somebody draws the figure – in software, figure draws itself `figure.draw()`
    - e.g., `trajectory.map()` – normally mapped by outside observer if at all
- Assume basic services are always available
  - i.e., get/set for attributes, add/remove/… for lists, …
  - So no need to include in class diagrams or specs

Inheritance – a software idea

- An object-oriented software construct for implementing generalization relations
  - Can reuse code by inheriting it with new code
- Allows consistent handling of different subtypes
  - As long as they have a common supertype
- But can be overdone!
  - Common error: forcing an “is a” relationship
    - e.g., `class Easel extends Canvas` – okay, but limited, because Easel cannot inherit from any other class now
    - Alternative is composition
      - More flexible to let Easel have a Canvas to draw on

Diagramming generalization

- See figure 31.9 (p. 512)
- Note: can overdo diagramming hierarchies
  - Show lower levels only if it helps communication
  - Adding hierarchical levels increases complexity
    - Harder to understand/explain
    - Opens door to team misinterpretation
    - e.g., see figure 31.10 (p. 513)
  - Another note: application of Bridge pattern (to be discussed) could simplify the design of fig. 32.9
  - Question: what to do if new payment type like Debit card?
  - Solution involves abstract types
Abstract types

- Always supertypes, by definition
  - Have no concrete existence in model
  - Definition – class A is an abstract type if every instance of A must be a subtype of A
    - e.g., Thing – an abstract type
      - How to draw a Thing? Describe a Thing? …
    - Certain operations must be implemented by subtypes
  - Abstract types are central to many design patterns
    - pure abstractions are more flexible than concrete types
    - actually just define interfaces for “families” of types

A note about subtypes & states

- Avoid using subtypes of a concept to represent changing states of that concept
  - Usually better to consider a State concept
    - State is an abstract type – with concrete subtypes
    - The original concept “is in” one State or another
      - See Figure 31.13 (p. 515)
  - Exception is when it really makes sense to do
    - e.g., a Caterpillar becomes a Butterfly
    - i.e., a complete metamorphosis – change in state results in different attributes and associations

Design patterns introduction

- “Tricks of the trade” for OO designers
  - Tried and true solutions to recurrent problems
  - Usually reflect basic design principles
    - “Gang of Four” (GoF) patterns – seminal catalog
      - Four essential elements:
        1. A meaningful name – elevates thought to higher abstraction
        2. A problem description – where the pattern can apply
        3. The solution – like a template to apply the pattern
        4. Consequences – results and trade-offs
  - Recurring theme: “encapsulate what varies most”

Types of GoF design patterns

- 7 are structural patterns – composition of classes/objects
  - e.g., Adapter
    - Problem: tool has interface X, client prefers interface Y
    - Solution: Adapter satisfies X, but looks like Y
    - Consequences: don’t reprogram X, and don’t distort Y to satisfy X
  - Bridge, Composite, Decorator, Façade, Flyweight and Proxy
- 5 are creational patterns – for creating objects
  - Abstract Factory, Builder, Factory Method, Prototype, Singleton
- 11 are behavioral patterns – ways classes/objects interact
  - e.g., Chain of Responsibility, Command, and … 9 more
- See cs.ucsb.edu/~mikec/cs50/misc/Design_Class_Diagrams.htm

Inheritance with Java

- class B extends A
  - B is an A – so can always refer to a B as an A
    - But cannot refer to an A as a B (without an explicit cast)
  - B cannot also be a C, unless C is an A too
    - abstract class A
      - Has some abstract methods
      - Concrete subclasses must implement them
      - Cannot say “new A” – even if A has a constructor
    - interface A
      - Completely abstract – just defines services
      - So okay to inherit multiple interfaces

User interface design

- Major goal: match the skills, experience and expectations of its anticipated users
- Consider “human factors” – People have limited short-term memory, they make mistakes, and they are not all the same
- Are some basic principles of UI design
  - User-oriented, not computer-oriented
  - Consistency – and especially minimal surprise
  - Recoverability, and guidance
User Interface issues

- Two fundamental problems to solve
  - How should information from the user be provided to the computer system?
  - How should information from the computer system be presented to the user?
- Many interaction styles – each has a place
  - Direct manipulation
  - Menu selection
  - Form fill-in
  - Commands – and (ideally) natural language

Sometimes multiple interfaces

UI design process

Figure from Ian Sommerville, Software Engineering 8th edition, Chapter 16