CS 247 Midterm Review

ADT Design

- Bullet point here

Documentation

- **Interface specification**
  - Provides expectations about a module's operation/behaviour
  - **Specification fields**: client's view of the object's fields (including private members)
  - **Requires**: preconditions
    - Can throw exception immediately if preconditions are not satisfied
  - **Modifies**: objects/members that are changed
  - **Ensures**: effects on the changed objects/members
    - e.g. `// this = this@pre + next`
  - **Throws**: exceptions that may be thrown, and their conditions
  - **Returns**: return value & type
  - Preconditions $\implies$ postconditions
  - Spec A is stronger than spec B (i.e. A $\implies$ B) if & only if:
    - A's preconditions are equal or weaker than B
    - A's postconditions are equal or stronger than B
    - A modifies equal or more objects than B
    - A throws equal or fewer exceptions than B
- **Representation invariant**
  - A predicate in an ADT that must be true at all times
  - e.g. structural invariants
    - Two tree nodes cannot share the same child node
    - Trees cannot have cycles
  - e.g. value invariants
    - No duplicate data elements
    - A value cannot be null
  - Should be checked on exit of constructor, and on entry & exit of accessors and mutators
- **Abstraction function**
  - Maps concrete values to abstract values in an ADT

Exceptions & Smart Pointers

- **Assertion**: use to check a certain condition
  - Terminates program immediately
  - Should not have side effects, program state needs to be preserved as it was when it terminated
  - Use to report programming errors
- **Exception**:
  - Object representing an error that can be thrown and caught
  - Usually extend `std::exception`
  - The call stack is popped/unwinded down to the nearest matching `catch` block
    - Destructors of all stack objects are called
      - i.e. heap objects are handled properly if they are deleted in a stack object's destructor
- **Smart pointer**: object that acts like a pointer (encapsulated pointer)
  - Object itself is stack-based; holds reference (points) to a heap-based object
  - Heap object is deleted in pointer object's destructor
  - So if exception is raised, heap object is deleted by the pointer's destructor
  - `unique_ptr<T>`: exclusive ownership of the heap object it points to (referent); ownership can be transferred
  - `shared_ptr<T>`: shared ownership of referent
    - Object is deleted when the # of `shared_ptrs` pointing to it reaches 0
  - `weak_ptr<T>`: same as `shared_ptr`, but doesn't contribute to reference count
    - Need to check if expired, and then convert into `shared_ptr` before dereferencing

RAII Idiom

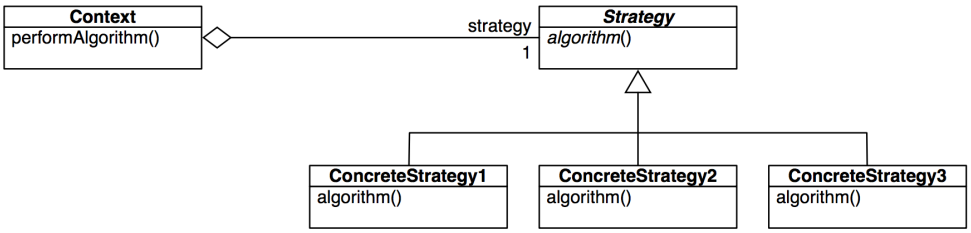
- **Resource Acquisition is Initialization**: resource management is coupled with lifetime of object
  - Allocate resource in constructor; deallocate resource in destructor
  - `Class (param) : res_( allocate (param); ) { }`
  - `~Class() { release (res_); }`

UML

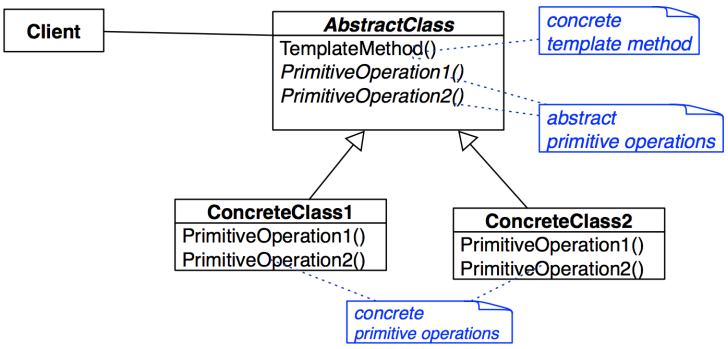
- **Unified Modelling Langauge**
- Class diagrams
  - Attributes
    - `[visibility] name: [type] [multiplicity] = [default value] {property}`
  - Operations
    - `[visibility] name (parameter list) : [return type] {property}`
    - + public; - private; # protected; static; *pure virtual*
    - `property` = read-only (aka. const), query (aka. accessor), abstract, etc.
- Associations: physical or conceptual links between classes
  - Classes being associated may have role names
  - Navigability: direction of association; e.g. A *has* B
- Multiplicity (of attributes or associations)
  - a: exactly a
  - $m..n$: between m and n
  - $*$: many (at least zero)
- Aggregate: a collection of members
  - Collection has many members
  - Member can belong to many collections, or exist independently
  - Collection is not responsible for its members
- Composition: a stricter collection of members
  - Member cannot exist without its collection
  - Member belongs to exactly one collection
  - Collection is responsible for its members
- Generalization = inheritance
- Sequence diagrams: describe how information is passed between objects (e.g. via function calls), throughout execution of a program

Design Patterns

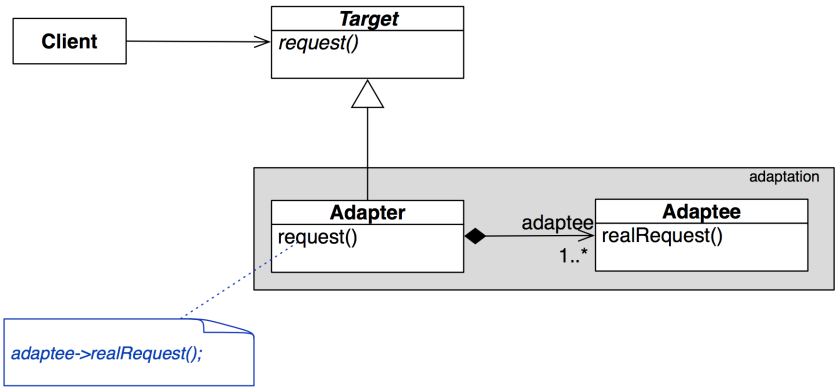
- **Inheritance**
  - Parent class's methods are inherited by child classes
    - Classes' methods share the same implementation structure
    - Only differences are the data values
  - Downside: not all subclasses may want to inherit parent behaviour
  - Downside: code duplication
- **Strategy pattern**
  - Allows the implementation of an algorithm/method to be changed at runtime (encapsulation of algorithm)
  - Allows the algorithm vary independently from clients that use it
  - e.g. data structure holds an instance of base Strategy class, calls the algorithm/method (which is *pure virtual* in base class)
    - Concrete methods with differing behaviour are implemented in Strategy subclasses
    - Strategy can be changed (to other subclasses) at runtime, changing the method's behaviour



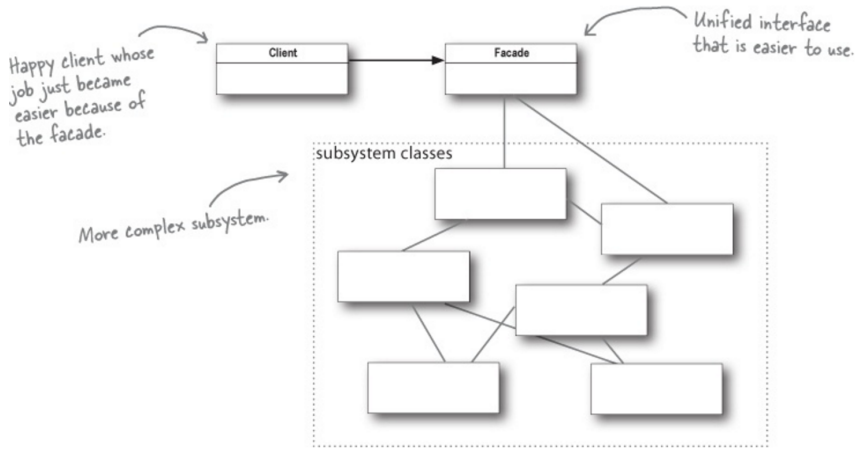
- **Template pattern**
  - **Template method** is a method in a base class that defines code structure but leaves holes to be defined by subclasses
  - Holes are operations defined as *pure virtual* in the base class, but have varying implementations in subclasses



- **Adapter pattern**
  - Adapter maps one interface to another
  - e.g. interfaces of an existing module does not match with a new module
  - e.g. wrapping an existing data structure interface to create a new data structure

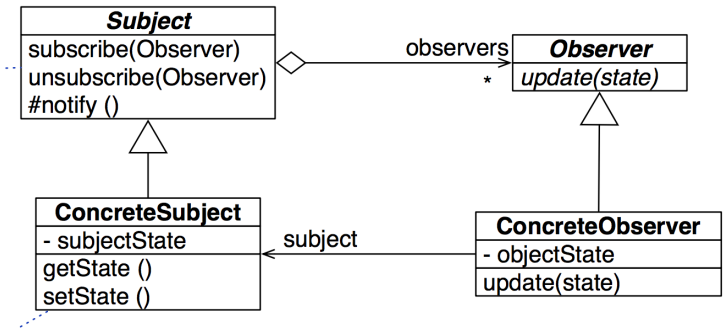


- **Facade pattern**
  - Simplies and unifies classes and interfaces in a subsystem into only a high-level interface and hides individual interfaces within the subsystem
  - Subsystem components and interfaces can be changed without affecting client



- **Singleton pattern**
  - Ensures only one instance of a class can exist
  - Private constructor; only instantiated through static `getInstance()` method

- **Observer pattern**
  - Subject → (one-to-many) Observers
  - Subject can notify all subscribed observers to update
  - Observers can subscribe/unsubscribe at runtime
  - **Push model**: subject pushes state information to observers through `notify(State)`
  - **Pull model**: subject notifies observers, who request information via subject's accessors
  - **Loose coupling**: subjects and observers only know about each other's interfaces, not the concrete classes that implement them



- **MVC pattern**
  - UI code is abstracted into the **view**
    - Composite pattern: all view elements use the same base class (uniform interfaec)
  - **Controller** translates user input (from the view) into operations on the model
    - Strategy pattern: controller provides the view with a strategy; controller behaviour can be changed by swapping for a different strategy
  - **Model** holds data, state, and application logic
    - Observer pattern: model = subject; views = observers; model sends out notification on state change, triggering views to update accordingly

OOP Principles

- **Open Closed Principle**
  - Modules should be open for extension but closed for modification
  - "Program to an interface, not an implementation"
  - e.g. provide an abstract base class (may have default implementation) that can be extended by the client
- **Composition Over Inheritance**
  - Composition = include base class in new subclass as a complex attribute
    - i.e. "has-a" instead of "is-a"
  - Choose inheritance when subtyping, or when base class's original interface is required
  - Choose composition for non-overriding extension or when new required interface is different from original, because the base component can be changed at runtime
  - Composite object can delegate operations to component objects
- **Single-Responsibility Principle**
  - Each changeable design decision should be encapsulated in a module
  - Each module should only have one axis of change
- **Liskov Substitutability Principle**
  - A derived class must be substitutable for its base class
    - Must accept the same messages (method signatures match the base class)
    - Derived methods must require no more (weaker or same preconditions) and promise no less (stronger or same postconditions) than base class methods
    - Derived class must preserve properties of base class (e.g. invariant, performance)
- **Law of Demeter**
  - An object should only "talk to its neighbours"
  - A method `C::m()` can only call methods of:
    - C
    - C's members
    - m's parameters
    - Any object constructed by A's methods
  - Prevents calling a chain of methods to perform an operation/retrieve information