Software Design and Construction 2
SOFT3202 / COMP9202

Advanced Design Patterns (GoF)

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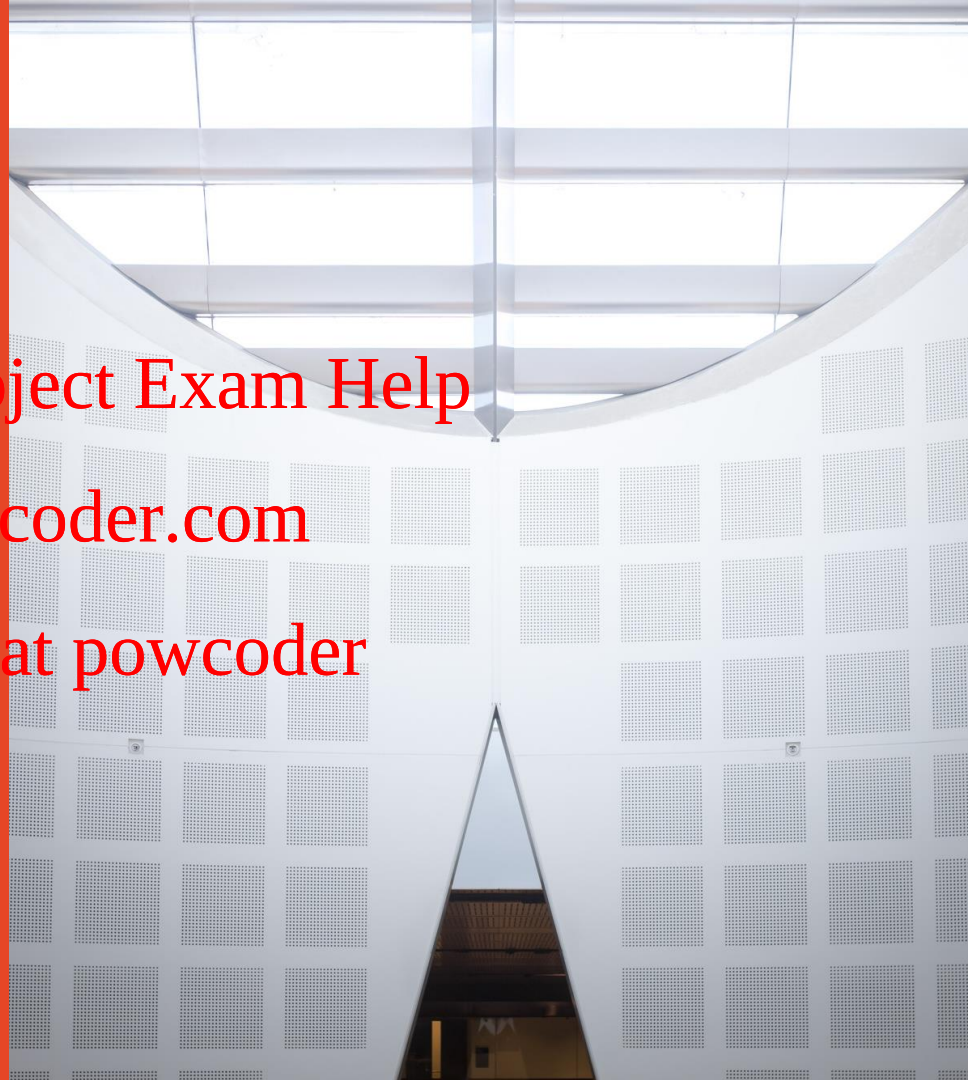

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Agenda

- GoF Design Patterns
  - Flyweight
  - Bridge
  - Chain of Responsibility

Flyweight Design Pattern

Object Structural

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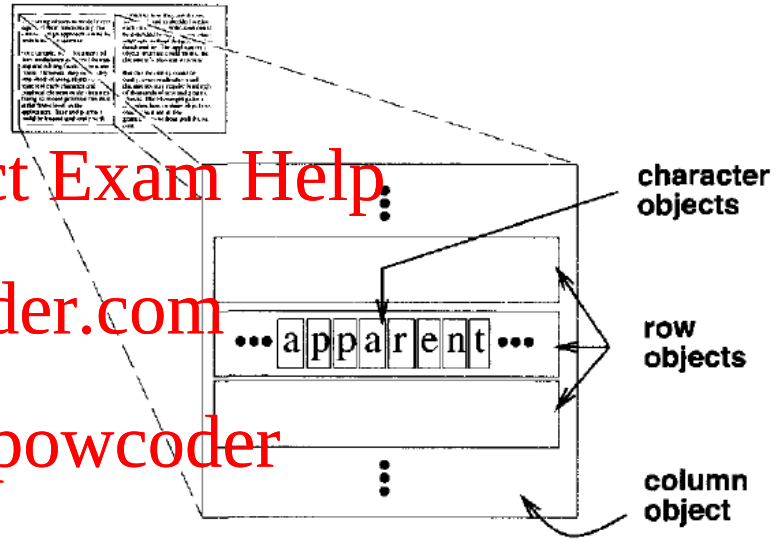
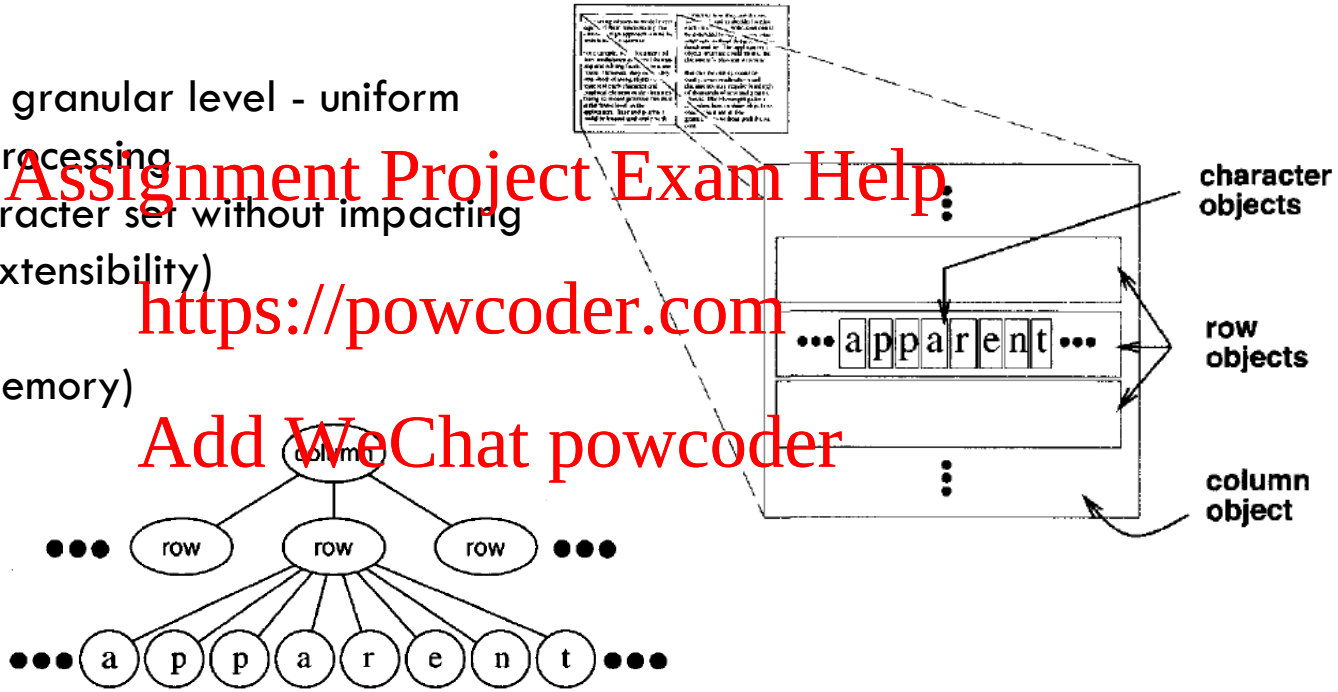
Motivation – Text Editor Application

- Design of document editor system
- Use objects to represents tables/figures
- Use object for each character
- Discuss benefits and drawbacks?



Flyweight – Motivation

- Flexibility at fine granular level - uniform formatting and processing
- Support new character set without impacting other functions (extensibility)
- Very high cost (memory)



Motivation – Text Editor Application

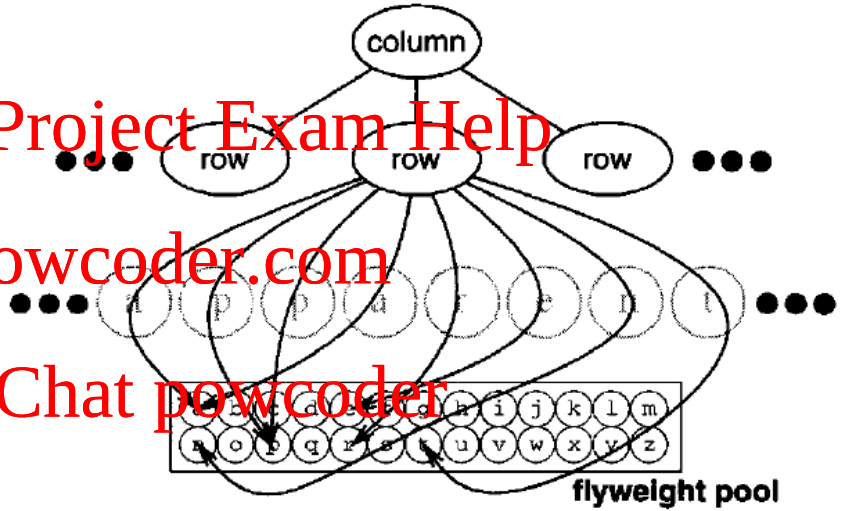
- An object for each letter of the alphabet
- Shared object than can be used in multiple contexts simultaneously
- What about object's state?
  - Character code
  - Character position (coordinates)
  - Typographic style
- Given the sharing aspect, how the above states should be stored?

Motivation – Text Editor Application

- An object for each letter of the alphabet
- Shared object than can be used in multiple contexts simultaneously
- What about object's state?
  - Character code (intrinsic/shared)
  - Character position (extrinsic/not shared)
  - Typographic style (extrinsic/not shared)
- Given the sharing aspect, how the above states should be stored?
- Intrinsic state: shared and thus stored in the shared object
- Extrinsic state: cannot be shared as it depends on the context (client's responsibility)

Text Editor Application – Flyweight Objects

- One shared flyweight object per character which can appear in different contexts in the document structure



Text Editor Application – Flyweight Design

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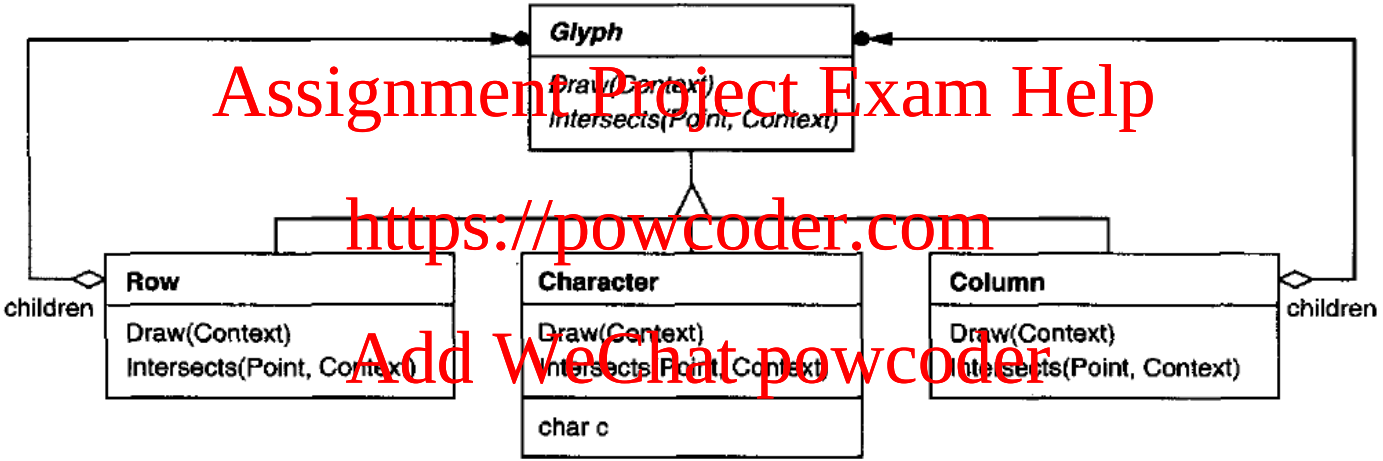
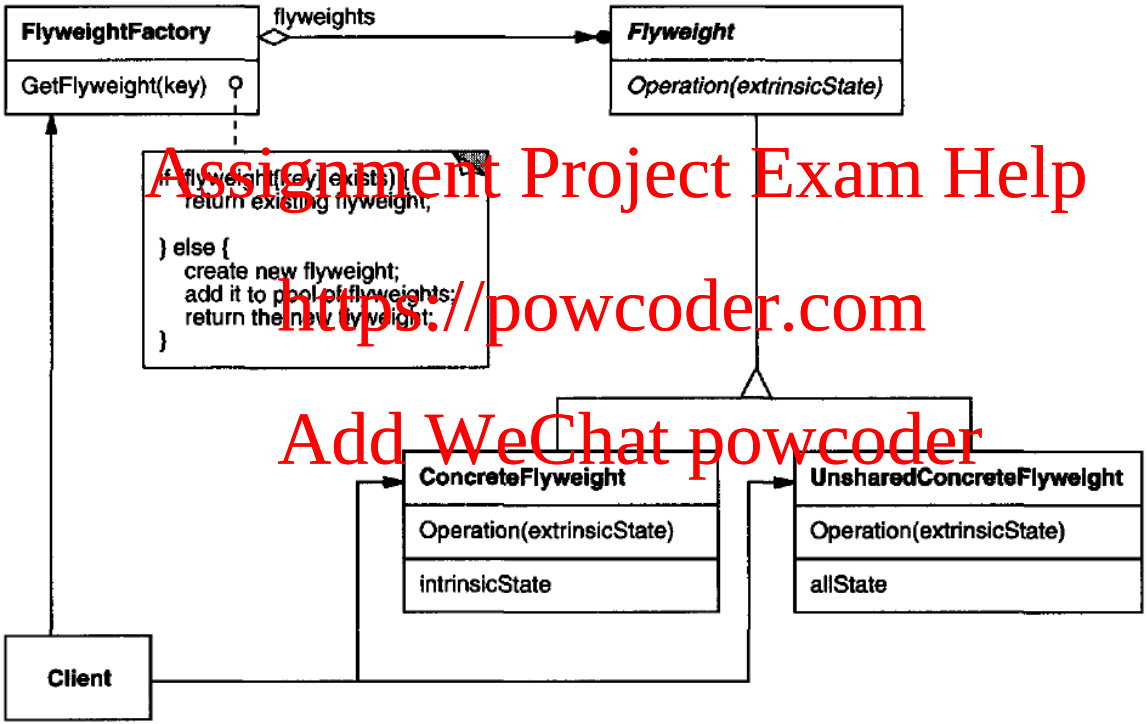


Flyweight Pattern

- Object structural
- Intent:
  - Use sharing to support large numbers of fine-grained objects efficiently
- Applicability:
  - Large number of objects are used
  - Storage costs are high
  - Most object state can be made extrinsic
  - Many groups of objects may be replaced by relatively few shared objects once extrinsic state is removed
  - The application does not depend on object identity

Flyweight – Structure



Flyweight – Participants & Collaboration

- Flyweight (Glyph)
  - Interface for extrinsic state
- ConcereteFlyweight (Charcterer)
  - Implements Flyweight interface adding intrinsic state
- UnsharedConcereteFlyweight (Row, Column)
  - Make some concrete flyweight subclasses unshared
- FlyweightFactory
  - Creates and manages flyweight objects and ensure proper sharing
- Client
  - Maintains a reference to flyweights

Flyweight Consequences

- Benefits
  - Efficiency: save memory at run-time (sharing objects, intrinsic state)
  - Consistency: centralized objects' state
- Drawback
  - Un-time costs to transfer find and/or compute extrinsic stae
  - All objects are controlled identically

Flyweight – Implementation

- Extrinsic state and efficient storage
  - If there are as many different kinds of extrinsic state as there are objects before sharing, then removing it from shared objects won't reduce storage costs
- Managing shared objects
  - FlyweightFactory objects often use an associative store to let clients look up flyweight of interests
  - Sharing implies reference counting or garbage collection to reclaim a flyweight's storage when it's no longer needed, especially when number of flyweights is large

Flyweight – Related Patterns

- Composite
  - Flyweight often combined with the *composite* pattern to implement a hierarchical structure as a graph with shared nodes
    - Leaf nodes cannot store a pointer to their parent (passed)
- State and Strategy Patterns
  - Flyweight often implement *state* and *strategy* objects as flyweights

Bridge

Object Structural

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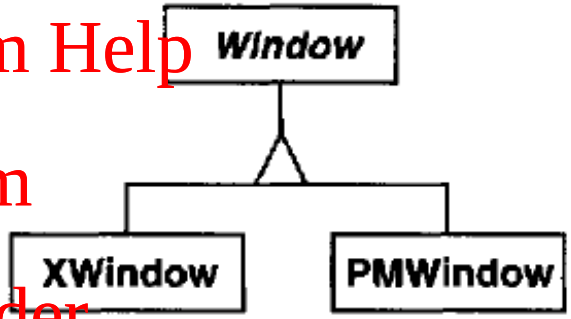
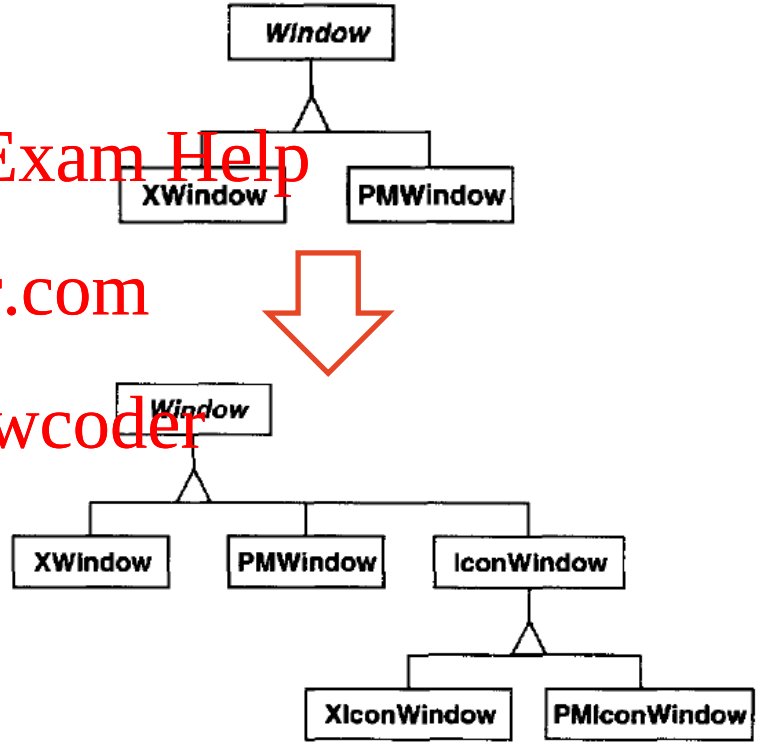
Motivating Scenario

- Portable window abstraction in a user interface toolkit
- Abstraction to allow writing applications that work in different platforms (e.g., Windows, IBM)
- Design using inheritance (right diagram)
- Good/bad design? Why/Why not?

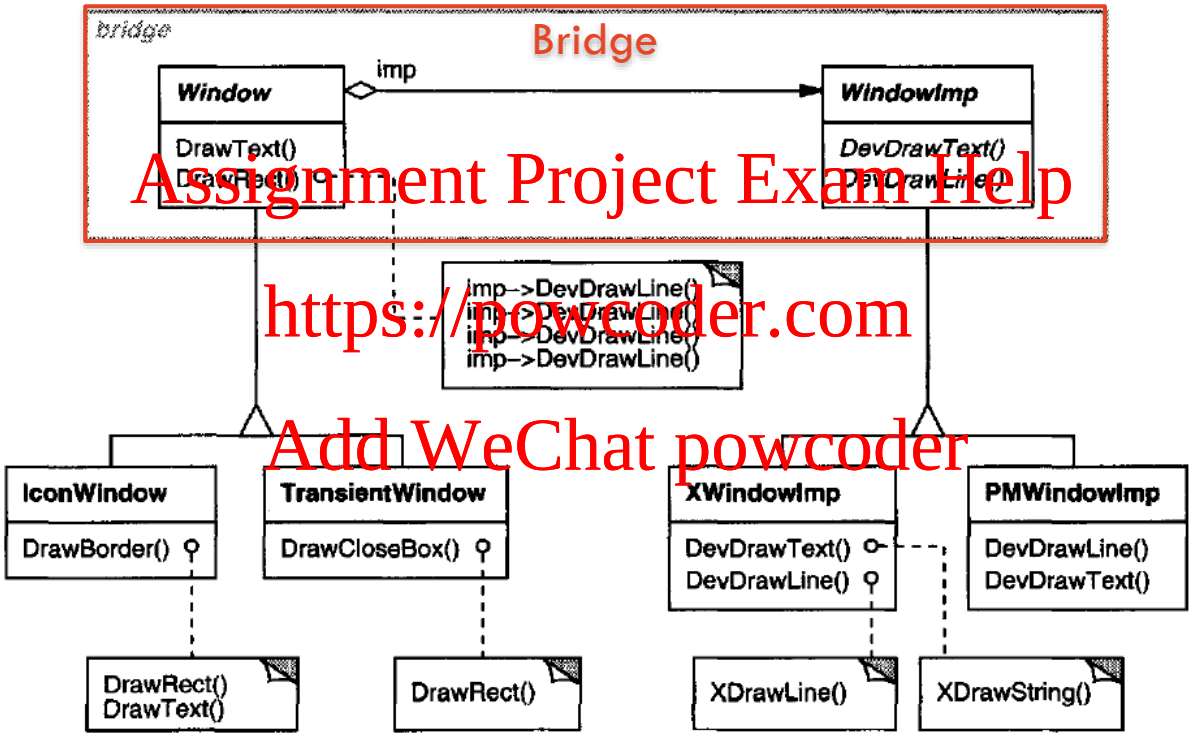


Motivating Scenario – Design with Inheritance

- Extend window abstraction to cover different implementation, BUT:
- Implement many classes in the hierarchy
- Strong binding between abstraction and binding(client code is platform-dependent)



Better Design – using the Bridge



Bridge Pattern (Handle or Body)

- Avoid permanent binding between an abstraction and its implementation
- Abstractions and their implementations should be extensible
- Changes in an abstraction's implementation should not impact its client
- Large number of classes involved
  - Split into two class hierarchies ("nested generalization")
- Share an implementation on multiple objects and make the client unaware of it

Bridge Pattern – Participants and Collaboration

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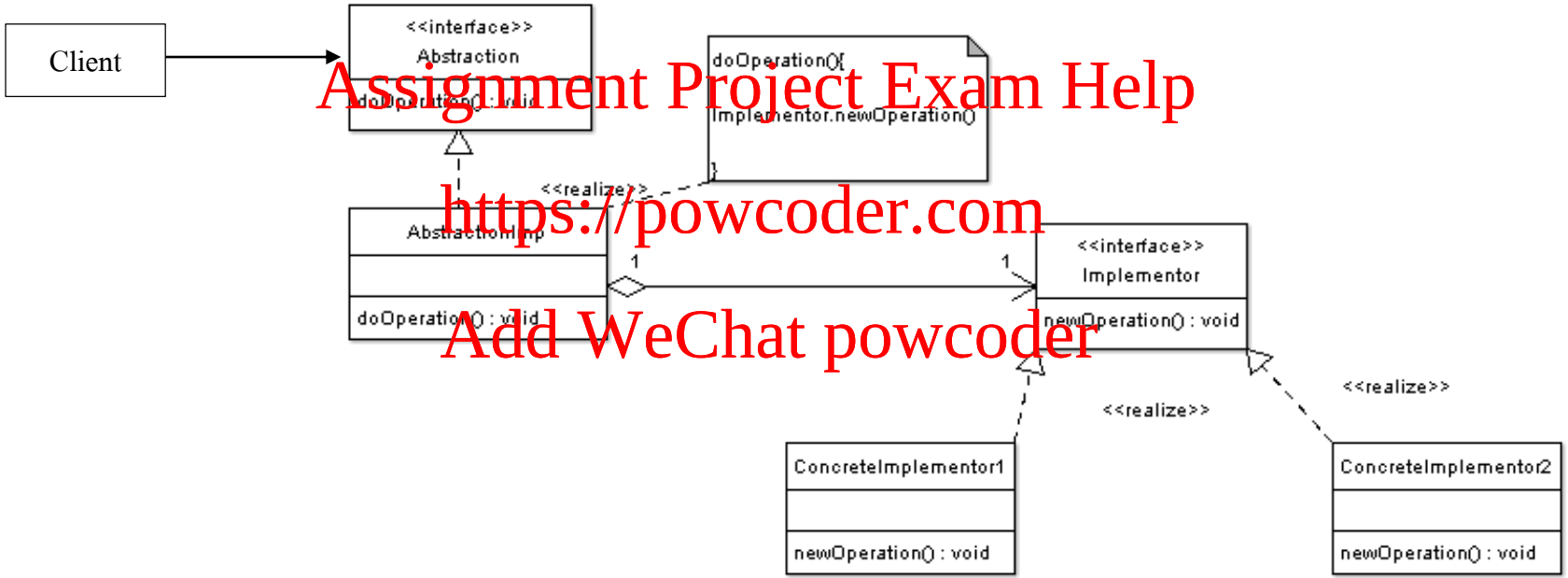

Bridge Pattern – Participants and Collaboration

- Abstraction (Window)
  - Defines the abstraction's interface and maintains a reference to an object of type Implementor
- RefinedAbstraction (IconWindow)
  - Extends the interface defined by Abstraction
- Implementor (WindowImp)
  - Defines the interface for implementation classes.
  - The Implementor interface provides only primitive operations, and Abstraction defines higher-level operations based on these primitives
- ConcreteImplementor (XWindowImp, PMWindowImp)
  - Implements the Implement or interface and defines its concrete implementation.
- Client
  - Abstraction forwards client requests to its Implementor object.

Bridge Pattern – Consequences

- Decoupling interface and implementation
  - Implementation can be configured at run-time
  - Reduce compile-time dependencies on implementation
  - Better structured design
- Improve extensibility
  - Abstraction and implementor can be extended independently
- Hiding implementation details from clients
- Increased complexity!
  - Two hierarchies to grow and to manage

Bridge Pattern – Implementation

- One implementor
  - Abstract implementor class isn't necessary if there's only one implementation
  - It's still useful when a change in the implementation of a class must not affect its existing clients

- Creating the right implementor object when there is more than one
  - Abstraction's constructor if it knows about all ConcreteImplementor classes
  - A collection class supports multiple implementations, decide by the collection's size
    - Use linked list for a small collection
    - Use a hash table for a large collection
  - Default implementation which can be changed according to usage

Bridge Pattern – Related Patterns

- Abstract Factory
  - Can create and configure particular Bridge
- Adapter
  - Aims at making un-related classes work together (after design consideration)
  - Bridge focuses on making abstraction and implementations vary independently (during design)

Chain of Responsibility (CoR)

Object Behavioural

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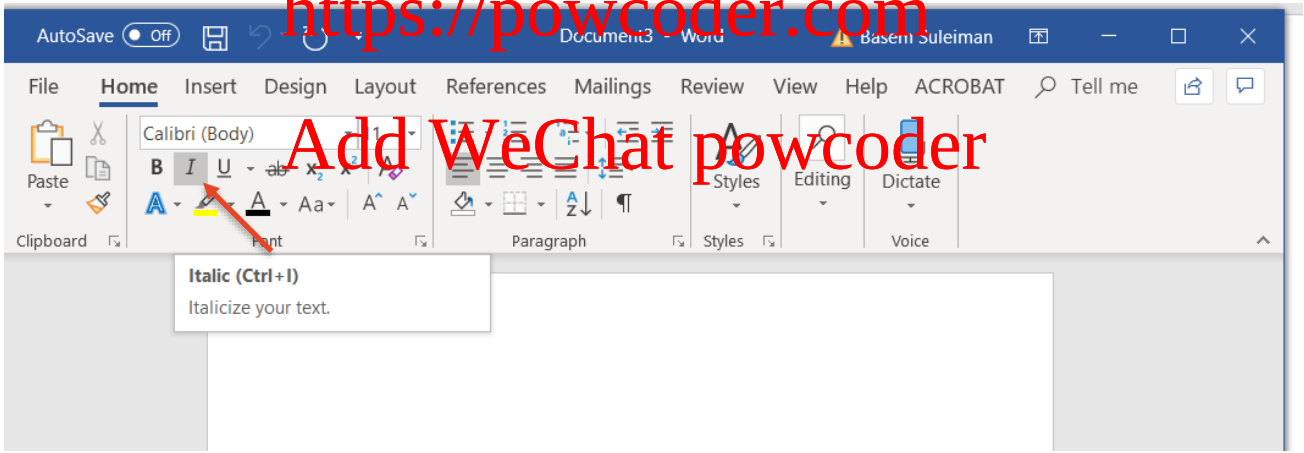
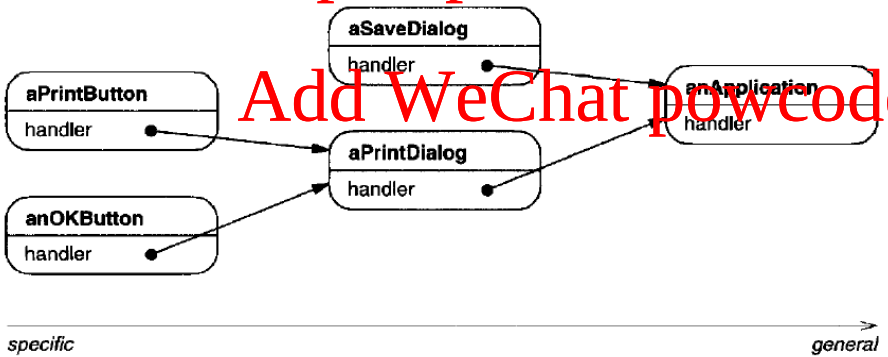
Motivating Scenario – GUI with Help

- GUI with a help facility where a user gets help information by clicking on it
- Help information dependent on the interface's context (context-sensitive)
  - Button in dialog box vs. button in a window
  - Display general help info. About the immediate context in case no specific help exits



GUI with Help – Potential Design

- Organize help info. according from the most specific to the most general
- Several UI objects, one per help request
- **Discuss the prose/cons of this design.**



GUI with Help – Potential Design

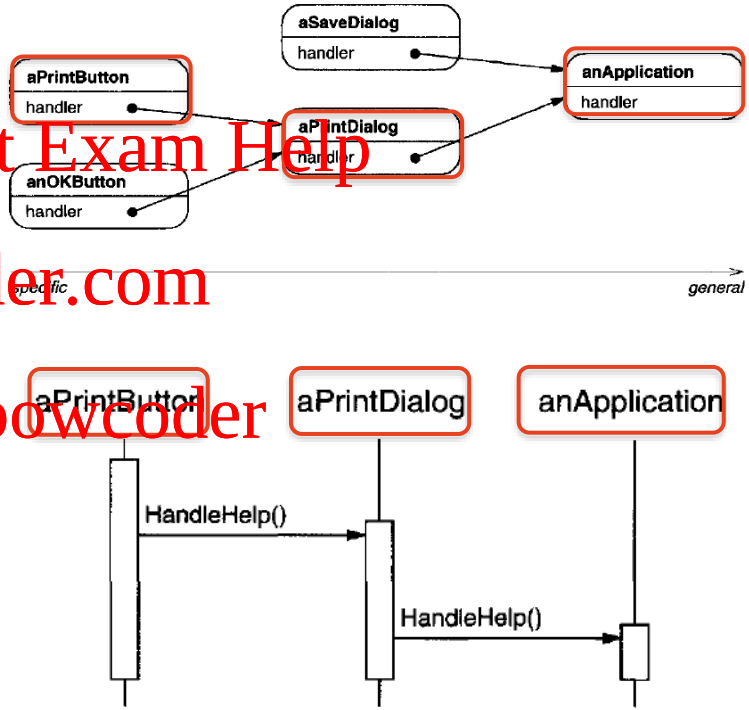
- It helps to serve different types of help requests
- However, the object that ultimately provides the help isn't known explicitly to the object that initiates the help request (strong coupling)
- So, we need a way to decouple the object that initiates the help request from those that might provide the help information

Better Design – Chain of Responsibility (CoR)

- Provide multiple objects a chance to handle a request
  - Pass the request along a chain of objects until one handles it
- First object receives the request either handles it or forward it to the next candidate on the chain, and so on so forth
- The request has an ***implicit receiver*** as the requester object has no explicit knowledge of the handler object

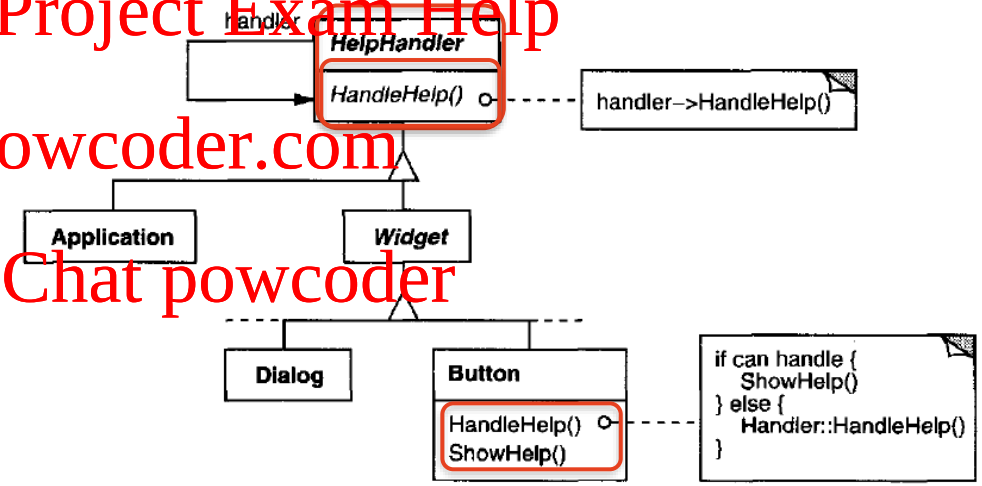
Better Design – Chain of Responsibility (CoR)

- Solution details
  - User clicks the "*Print*" button's help (contained in *PrintDialog* instance)
  - PrintDialog knows the object it belongs to
  - The client (request issuer) has no direct reference to the object that ultimately realizes it



Better Design – Chain of Responsibility (CoR)

- How to ensure implicit receiver?
  - Each object shares *common interface* for handling requests and accessing its successors on the chain
- Classes that want to handle help requests can make HelpHandler a parent
- HelpHandler's HandleHelp forwards the request to the success by default
- Subclasses can override this operation to provide help under the right conditions

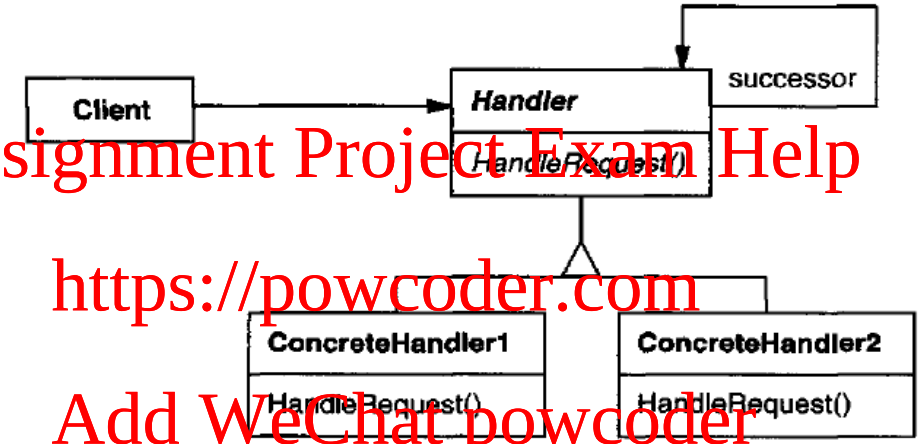


Chain of Responsibility Pattern

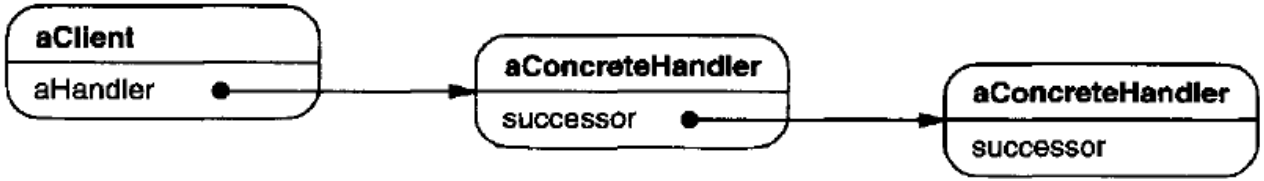
- Intent
  - Avoid coupling the sender of a request to its receiver
  - It allows more than one object a chance to handle the request
  - Chain the receiving objects and pass the request along the chain until an object handles it
- Use
  - More than one object may handle a request, and the handler should be ascertained dynamically
  - Hide the receiver (explicitly) when a request should be issued to one of several objects
  - The handling behavior should be specified dynamically

CoR Pattern – Structure

Class structure



Typical object structure



CoR Pattern – Participants and Collaboration

- Handler (HelpHandler)
  - Defines interface for handling requests
  - May implement the successor line
- ConcreteHandler (PrintButton, PrintDialog)
  - Handles requests it is responsible for
  - forwards the request to its successor if it cannot handle it
- Client
  - Initiates a request which will be propagated along the chain until a ConcereteHandler takes responsibility for handling it

CoR Pattern – Consequences

- Reduced Coupling
  - Objects in the chain does not have explicit knowledge about each other
- Flexibility in distributing responsibilities among objects
  - Can add/change responsibilities at run-time
- Requests could be unhandled
  - There's no guarantee that a request could be handled

CoR Pattern – Implementation (1)

- Declaring child management operations: which classes declare the child management operations (add, remove) in the composite class hierarchy:
  - Define child management interface at the class hierarchy's root
    - Allows treating all components uniformly (transparent)
    - Clients may add/remove objects from leaves (not safe)
  - Child management in the composite class
    - Add/remove objects at the compile-time in statically typed languages (safe)
    - Leaves and composites have different interfaces (not transparent
  - Transparency over safety

CoR Pattern – Implementation (2)

- Child ordering
  - Ordering on the children of composite is important in some designs
  - Composites represents parse trees then compound statements can be instances of a composite whose children must be ordered to reflect the program
  - Design child access and management interfaces carefully to manage the sequence (use iterator pattern)

CoR Pattern – Related Patterns

- Composite
  - In CoR pattern, a component's parent can act as its successor and hence the use of Composite pattern

References

- Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides. 1995. *Design Patterns: Elements of Reusable Object-Oriented Software*. Pearson.
- OO Design, Online: [https://www.oodesign.com/bridge-pattern.html]

W7 Tutorial: Practical Exercises/coding
W7 Lecture: Enterprise Design Patterns
Testing Assignment A2

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